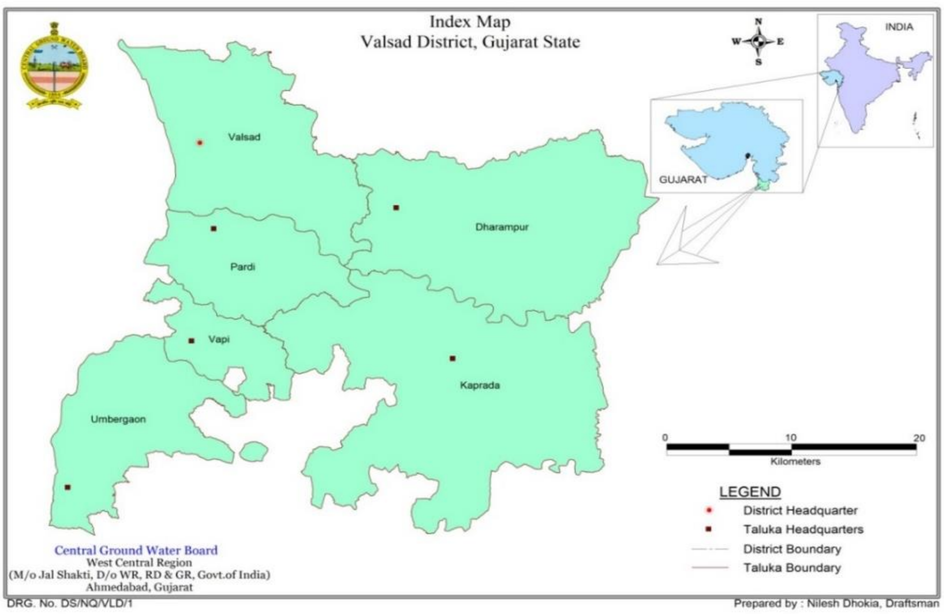
केंद्रीय भूमि जल बोर्ड
जल संसाधन विभाग, नदी विकास और गंगा संरक्षण विभाग
जल शक्ति मंत्रालय
भारत सरकार

जलभृत मानचित्र और भूजल प्रबंधन योजना, वलसाड जिला, गुजरात राज्य

Report on
Central Ground Water Board
Department of Water Resources, River Development and Ganga Rejuvenation
Ministry of Jal Shakti
Government of India

AQUIFER MAPS AND GROUNDWATER MANAGEMENT PLAN, VALSAD DISTRICT, GUJARAT STATE



October 2022

Contributor's page…

Name	Designation
Author:	
Shri Kamar Ujjam Khan	Scientist B (Hg.) CGWB WCR, Ahmedabad
Other Contributors (Hydrogeology / Groundwater Management Plan):	
Sh. Ramesh Jena ***Miss Ariba Kamaal***	Scientist B (Hg.) CGWB WCR, Ahmedabad Scientist B (Hg.) CGWB WCR, Ahmedabad
Suggested maps Preparation:	
Shri Nilesh Dhokia	Draftsman
Report Scrutiny:	
Dr. A.K. Jain	Consultant & Scientist D (Retired) CGWB WCR, Ahmedabad

Under the overall Supervision and Guidance

Shri G. Krishnamurthy

Regional Director

CGWB WCR, Ahmedabad

ACKNOWLEDGEMENT

I would like to take an opportunity to thank Shri G. Krishnamurthy, Regional Director, CGWB, West Central Region, for offering such an opportunity of a detailed study of the district. I am also very much thankful to Shri Sanjeev Mehrotra, Sc-D, CHQ Faridabad (Ex-Head of Office, WCR Ahmedabad) for providing all necessary support and guidance for the detailed study of the district.

I am very much delighted to express my deep sense of gratitude and regards to my respected colleagues/ seniors Dr. A K Jain Scientist –D (Retired), Sh Ramesh Jena, Scientist –B., Shri Ankit Vishwakarma, Scientist-B, Shri Himesh Pandya, Scientist-B, Smt. Dharmshila Singh, Scientist –B, Smt. Ariba Kamaal, Scientist-B, Shri Gajanan Ramteke, Scientist-B, Shri. K.M. Nayak, Scientist-B, Mis Aliya Bano, Scientist-B, and Sh Avinash Chandra STA (HG), WCR, Ahmedabad for their valuable and meticulous guidance and support during the study. I am also thankful to Shri Saddam Husain, AHG, Shri Subhash Singh, AHG, Shri Shah Izhar Ahmed, AHG and Shri Abdurrahman, AGH for all necessary support for preparation of this report.

I also would like to thank Shri Meghnath Bhatt, YP, WCR for necessary field work of post monsoon water sample collection and other required information collection for the preparation of final report.

I am deeply thankful to Smt Puja Mehrotra, Scientist-D, CHQ Faridabad (Ex-OIC Chemical Lab, WCR Ahmedabad, Dr.H.B Meena Asst Chemist and Smt Adiba Khan STA (Chem), and all other scientists of the chemical team for timely analysis of the water samples of the district.

I would like to extend my gratitude to Shri Nilesh Dhokia, Draftsman, for suggested map preparation.

The help and co-operation of all Scientists, staffs and MTS of CGWB, WCR, Ahmedabad is greatly recognizable.

Last but not least, I would like to acknowledge my wife, family members for their unselfish sacrifices, constant blessing and moral support at every stage in my life.

Kamar Ujjam Khan
Scientist-B
Central Ground Water Board
West Central Region, Ahmedabad

Contents

List of Figures

List of Tables

VALSAD DISTRICT AT A GLANCE

S. No.	Particular / Items
1	**General Information** i. Geographic Area (Sq km): 3055 Sq Km. ii. Administrative Units: 6 Taluakas – Dharampur, Kaparda, Pardi, Umagam Vapi & Valsad. iii. No of Villages / Towns: 434 Villages; 5 Statutory Towns and 19 other Census Towns & Industrial Notified Areas. iv. Population (2011 Census): 17,03,068; 73 % Rural & 23 % Urban;Decennial Growth Rate of population 21 %. v. Climate: Sub tropical with moderate to high humidity. **vi.** Average Annual Rainfall (2012-21): District Average (2002-2021)-2325 mm, Maximum -2863 mm (Kaprada) , Minimum-2032 mm (Umargam)
2	**Physiographic Features** i. Physiographic Zones: High Land plateau, Piedmont Zone, Intermediate LowRelief Plain & Coastal Plain. ii. Topography: Hilly Terrain –Elevation > 500 m to Coastal zone 8-2 m amsl. iii. Drainage: Damanganga, Kolak, Par, Auranga, Kalu & Valori. **iv.** Hydro Geomorphic Zones: High to Moderate dissected plateau, Piedmont Zone, Alluvial Plain & Coastal Tidal – Mudflat zones.
3	**Agriculture & Irrigation** i. Irrigation, in Hectares (as per district statistical report 2017, GOG) ii. Net Irrigated area 61751 iii. Percentage of cropped area irrigation 32.85 iv. Canal 15449 v. Pond 1397 vi. Well 28232 vii. other sources 16673 viii. Gross irrigated area 61751.00
4	**Geology & Hydrogeology** i. Major Geological Formation: Deccan Trap & Alluvium. ii. Aquifer System: Both Unconfined & Semi Confined to Confined system in DeccanTrap and Alluvium Formation. iii. Groundwater Monitoring: 16 Open wells & 3 Piezometers. iv. Depth to water level: 0 to 45 m bgl Pre monsoon and 0 to 30 m bgl postmonsoon (2021) **v.** Groundwater Quality: Fresh to moderate in Deccan trap area and moderate tobrackish in Alluvium area.

AQUIFER MAPS

AND

GROUNDWATER

MANAGEMENT PLAN

OF

VALSAD DISTRICT,

GUJARAT STATE

CHAPTER I
INTRODUCTION

1.1. INTRODUCTION

Various development activities over the years have adversely affected the groundwater regime in many parts of the country. There is a need for scientific planning in the development of ground water under different hydrogeological situations and to evolve effective management practises with the involvement of the community for better ground water governance. Though a vast amount of hydrological and hydrogeological data has been generated through scientific investigations by the Central Ground Water Board and other central and state agencies, these mostly pertain to administrative units and have addressed the issues of the whole aquifer systems in very few cases. In view of the emergent challenges in the ground water sector in the country, there is an urgent need for comprehensive and realistic information pertaining to various aspects of ground water resources available in different hydro-geological settings through a process of systematic data collection, compilation, data generation, analysis, and synthesis.

Systematic aquifer mapping is expected to improve our understanding of the geologic framework of aquifers, their hydrologic characteristics, water levels in the aquifers and how they change over time, and the occurrence of natural and anthropogenic contaminants that affect the potability of ground water. The results of these studies will contribute significantly to resource management tools such as long-term aquifer monitoring networks and conceptual and quantitative regional ground-water-flow models used by planners, policy makers, and other stakeholders. Aquifer mapping at the appropriate scale can help prepare, implement, and monitor the efficacy of various management interventions aimed at long-term sustainability of our precious ground water resources, which, in turn, will help achieve drinking water security, improved irrigation facilities, and sustainability in water resource development in the country as a whole. Various on-going activities of the Central Ground Water Board, such as ground water monitoring, ground water resource assessment, artificial recharge, and ground water exploration in drought, water scarcity, and vulnerable areas can also be integrated into the aquifer mapping project.

Systematic mapping of an aquifer encompasses a host of activities such as collection and compilation of available information on aquifer systems; demarcation of their extents and characterization; analysis of data gaps; generation of additional data for filling the identified data gaps; and finally, preparation of aquifer maps at the desired scale. This manual attempt to evolve uniform protocols for these activities to facilitate their easy integration into the country as a whole.

1.2. OBJECTIVE AND SCOPE OF THE STUDY

The primary objective of the aquifer mapping exercise can be summed up as "Know your Aquifer, Manage your Aquifer." The essence of the project is the demystification of science and, as a result, the involvement of stakeholders. The involvement and participation of the community will infuse a sense of ownership amongst the stakeholders.

This is an activity where the government and the community work in tandem. The greater the harmony between the two, the greater the chances of successful implementation and achievement of the goals of the project. As per the Report of the Working Group on Sustainable Ground Water Management, "It is imperative to design an aquifer mapping programme with a clear-cut groundwater management purpose. This will ensure that aquifer mapping does not remain an academic exercise and that it will seamlessly flow into a participatory groundwater management programme. The aquifer mapping approach can help integrate groundwater availability with groundwater accessibility and quality aspects.

The major objectives of aquifer mapping are:

1. Delineation of lateral and vertical disposition of aquifers and their characterization
2. Quantification of ground water availability and assessment of its quality to formulate aquifer management plans to facilitate sustainable management of ground water resources at appropriate scales through participatory management approach with active involvement of stakeholders.

The groundwater management plan includes groundwater recharge, conservation, harvesting, development options, and other protocols for 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 main activities under NAQUIM are as follows:

- 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.

The demarcation of aquifers and their potential will assist water supply agencies in determining how much 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.

1.3. APPROACH AND METHODOLOGY

The methodology involves the creation of a database for each of the principal aquifers. Delineation of aquifer extent (vertical and lateral). standard output for effective scientific integration of hydrogeological, geophysical, geological, and hydro chemical data facts on the GIS platform; identification of issues; manifestation of issues; and formulation of strategies to address issues through possible interventions at the local and regional levels

The National Aquifer Mapping Programme aims to characterise the geometry, parameters, and behaviour of ground water levels, as well as the status of ground water development in various aquifer systems, in order to facilitate sustainable management planning. The major activities involved in this process include compilation of existing data, identification of data gaps, and generation of data for filling data gaps and preparing aquifer maps. Once the maps are prepared, plans for sustainable management of ground water resources in the aquifers mapped are formulated and implemented through a participatory approach involving all stakeholders.

The on-going activities of NAQUIM include hydrogeological data acquisition supported by geophysical and hydro-chemical investigations, supplemented with ground water exploration down to a depth of 200 meters.

Considering the objectives of the NAQUIM, the data on various components was segregated, collected and brought onto the GIS platform by geo-referencing the available information for its utilisation for the preparation of various thematic maps. The approach and methodology followed for aquifer mapping are as given below:

1. Compilation of existing data (Central & State Govt.)
2. The generation of different thematic layers
3. Identification of the Primary Aquifer
4. Identification of data gaps
5. Data generation (water level, exploration, and geophysical)
6. Aquifer Maps with 3D disposition
7. Preparation of an Aquifer Management Plan
8. Capacity building in all aspects of ground water through IEC activities

The activities of Aquifer Mapping can be grouped as follows:

1.3.1 Data Compilation & Data Gap Analysis

One of the important aspects of the aquifer mapping programme was the synthesis of the large volume of data already collected during specific studies carried out by the Central Ground Water Board and various government organizations with a new data set generated that broadly describes an aquifer system. The data was compiled from various sources, analyzed, examined, synthesized, and interpreted. These sources were predominantly non-computerized data, which were converted into computer-based GIS data sets, and on the basis of available data, data gaps were identified.

1.3.2 Data Generation

There is an urgent need to generate additional data in order to fill data gaps and complete the task of aquifer mapping. This was achieved by multiple activities such as data gap analysis, site selection, exploratory drilling, PYT, pumping tests, geophysical techniques, hydro-geochemical analysis, remote sensing, and hydrogeological surveys to delineate multi-aquifer systems to bring out the efficacy of various geophysical techniques and a protocol for the use of geophysical techniques for aquifer mapping in different hydrogeological environs.

1.3.3 Aquifer Map Preparation

On the basis of the integration of data generated from various studies of hydrogeology and geophysics, aquifers have been delineated and characterized in terms of quality and potential. Various maps have been prepared bringing out details of aquifers; these are termed "aquifer maps", providing spatial variation (lateral & vertical) in reference to aquifer extremities (i.e., quality & quantity).

1.3.4 Aquifer Management Plan Formulation

An aquifer response model has been utilised to identify a suitable strategy for sustainable development of the aquifer in the area.

All the above activities under the National Aquifer Mapping programme are depicted/elaborated in Annexure –I and presented in Figure 1.

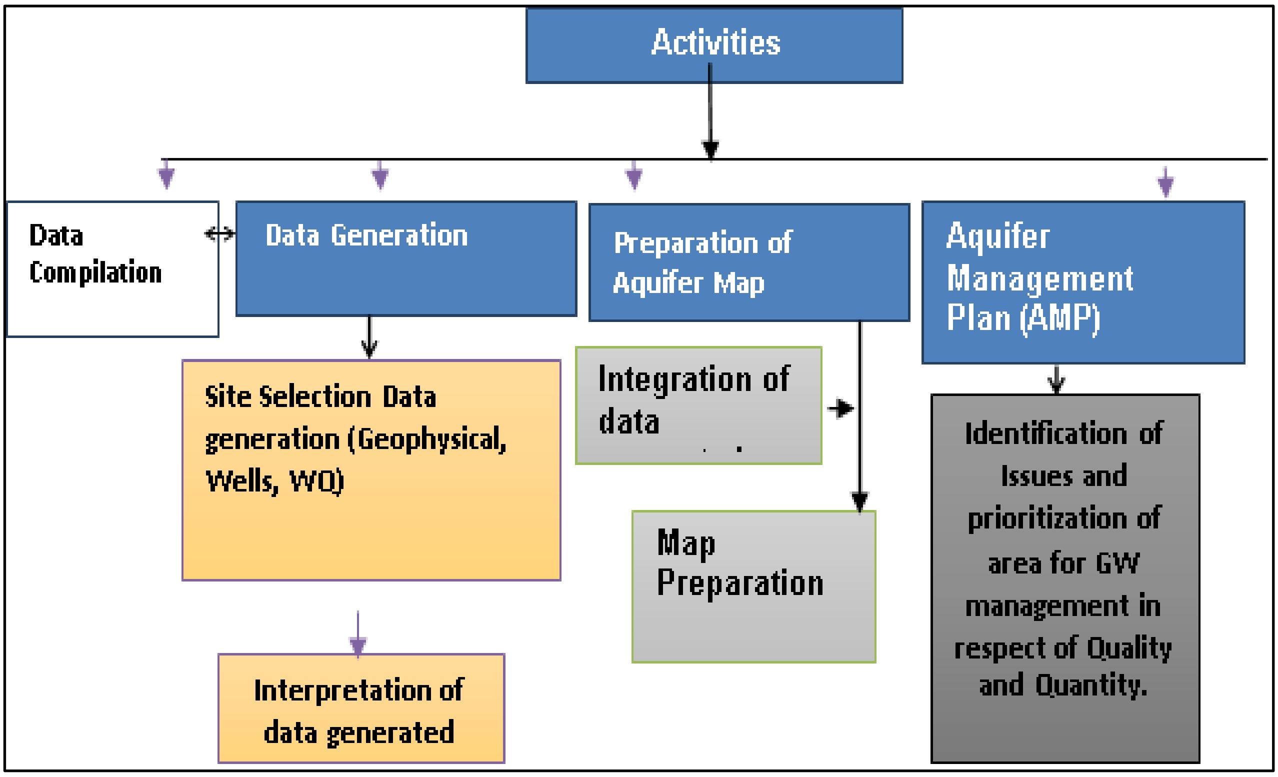


Figure 1- Activity Under National Aquifer Mapping Programme

1.4 AREA DETAILS AND BRIEF DESCRIPTION

Valsad district is one of the important tribal districts of Gujarat State. It has a rich cultural background with affluent forest areas endowed with vivid fauna and flora. It is famous for its orchard plantations. There has been rapid growth in agriculture as well as in industries in the district during the recent past. Earlier (1951), it was a part of the unified Surat District under Bombay Province. After the formation of Gujarat State in 1960, it was separated from Surat district. Later on, in the year 1997, for administrative convenience, Valsad district was divided into two districts, namely Navsari, comprising taluka areas of Navsari, Gandevi, Chikhali, and Vansada, while the new Valsad district comprises taluka areas of Vapi, Valsad, Pardi, Dharampur, and Umergam.

Valsad district is located in the southern part of Gujarat State. It has a total geographical area of 3055 sq km, extended by the north latitude of 20°07’ to 20°45’ and the east longitude of 72°43’ to 73°29’. It falls in the Survey of India sheets no. 46-D/12, D/14, D/15, D/16 & 46-H/2, H/3, H/6, H/7. The district is bounded in the north and northeast by Navsari district and by Nasik district of Maharashtra in the east and south. The Union territory of Dadra-Nagar Haveli lies in the south, while the UT of Daman lies in the west. The Arabian Sea forms the western boundary.

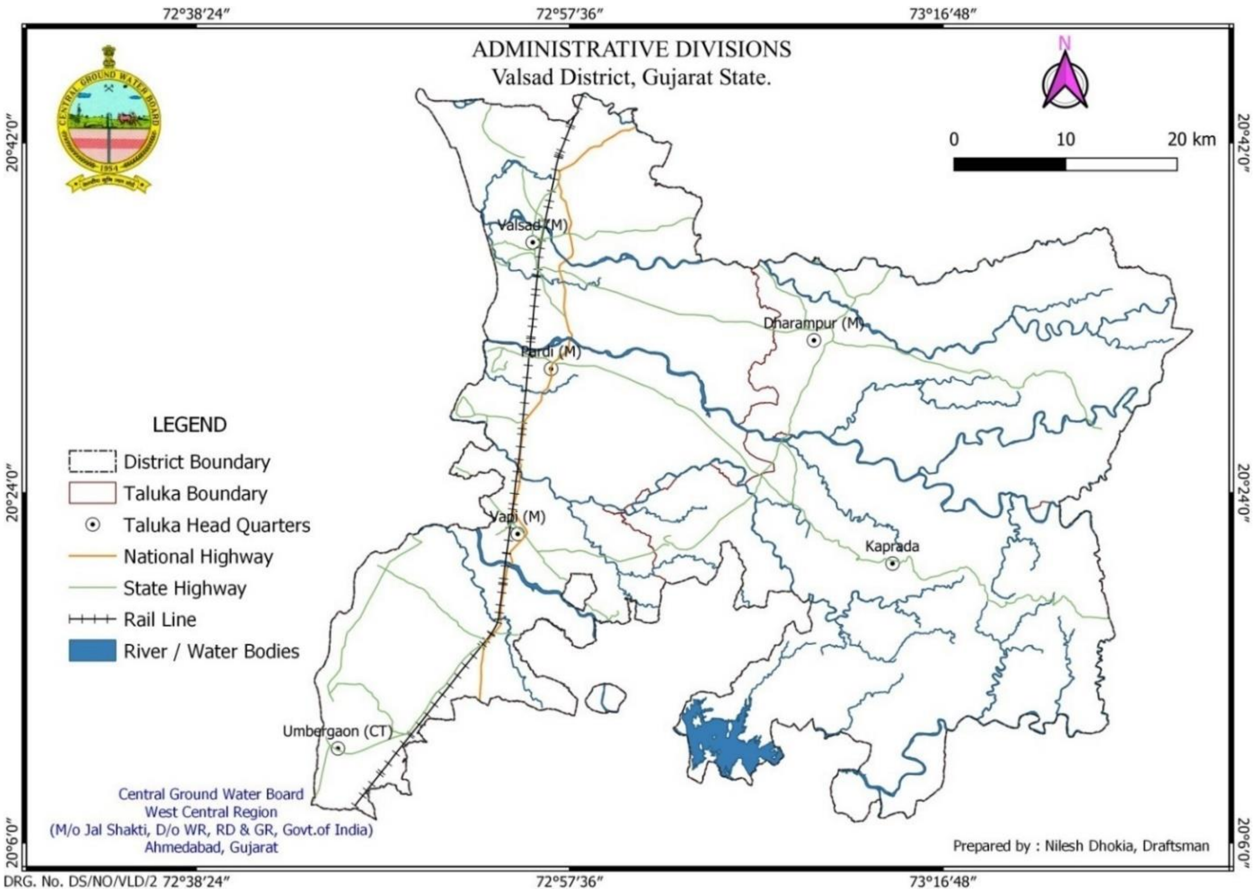


Figure 2 Administrative Map of Valsad District

1.5 DEMOGRAPHY

As per 2011 census of India, Valsad District has a population of 17,05,678 in 2011 out of which 8,87,222 are male and 8,18,456 are female. People living in Jamnagar District depend on multiple skills. Jamnagar District sex ratio is 939 females per 1000 of males.

Table 1 Demography of Valsad District As Per Census Of India 2011

Gujarat, Valsad District		
No. of households: 3,64,403		
Indicator	**All/ Urban/ Rural**	**Value**
Number of households	All	364403
	Rural	216948
	Urban	147455
Total population - Person	All	1705678
	Rural	1070177
	Urban	635501
Total population - Males	All	887222
	Rural	542644
	Urban	344578

Total population - Females	All	818456
	Rural	527533
	Urban	290923
Persons aged 0 to 6	All	215439
	Rural	142109
	Urban	73330
Males aged 0 to 6	All	111889
	Rural	72995
	Urban	38894
Females aged 0 to 6	All	103550
	Rural	69114
	Urban	34436
Scheduled Castes - Persons	All	38237
	Rural	20777
	Urban	17460
Scheduled Castes - Males	All	19557
	Rural	10537
	Urban	9020
Scheduled Castes - Females	All	18680
	Rural	10240
	Urban	8440
Scheduled Tribes - Persons	All	902794
	Rural	785002
	Urban	117792
Scheduled Tribes - Males	All	450976
	Rural	392473
	Urban	58503
Scheduled Tribes - Females	All	451818
	Rural	392529
	Urban	59289
Literate population - Person	All	1170657
	Rural	671205
	Urban	499452
Literate population - Males	All	655528
	Rural	372309
	Urban	283219
Literate population - Females	All	515129
	Rural	298896
	Urban	216233
Illiterate population - Person	All	535021
	Rural	398972
	Urban	136049
Illiterate population - Males	All	231694
	Rural	170335

	Urban	61359
Illiterate population - Females	All	303327
	Rural	228637
	Urban	74690
Total worker population - Person	All	743245
	Rural	493434
	Urban	249811
Total worker population - Males	All	516188
	Rural	311849
	Urban	204339
Total worker population - Females	All	227057
	Rural	181585
	Urban	45472
	Rural	31323
	Urban	31409
Non-working population - Person	All	962433
	Rural	576743
	Urban	385690
Non-working population - Males	All	371034
	Rural	230795
	Urban	140239
Non-working population - Females	All	591399
	Rural	345948
	Urban	245451

Source: Census of India, 2011

1.6 STUDIES / ACTIVITY BY CGWB

Central Ground Water Board has carried out number of studies in the district. A number of exploratory wells were constructed for groundwater development India the district.

Public interaction programme was also organized by Central Ground Water Board India AAP 2022-23 to aware the people for the conservation and judicial use of groundwater by knowing the local area aquifer.

1.7 HYDROMETEOROLOGY / RAINFALL AND CLIMATE

Valsad district is located in south of *tropic of Cancer*, comes under heavy rainfall areas of South Gujarat, having sub-tropical climate with moderately high humidity. The main seasons prevailing in the district are

(a) monsoon - mid of June to October,
(b) winter - November to February, and
(c) summer – March to June.

Various climatological data recorded over many decades (1987-2021) are analyzed and presented in table No 2 and also depicted graphically in figure –3

Table 2 Taluka Wise Rainfall Distribution for Valsad District From 1987 To 2021

Taluka	Dharampur	Kaprada	Pardi	Umergam	Valsad	Vapi	Overall District
1987	1750	1750	1421	1264	127	1421	1289
1988	2754	2754	2555	2303	2269	2555	2532
1989	1824	1824	1776	1400	1713	1776	1719
1990	2397	2397	1628	1627	1563	1628	1873
1991	2157	2157	1865	1772	1532	1865	1891
1992	2085	2085	2193	1542	2026	2193	2021
1993	2981	2981	2215	2456	2079	2215	2488
1994	4282	4282	3391	3076	3212	3391	3606
1995	1745	1745	1645	1367	1550	1645	1616
1996	2460	2460	1402	1635	1518	1402	1813
1997	2461	2461	1350	1473	1577	1350	1779
1998	3033	4634	2015	1889	1729	2015	2553
1999	3441	2880	2050	1265	1572	2050	2210
2000	2468	2050	1677	1408	1432	1677	1785
2001	2110	2267	2234	1690	2192	2234	2121
2002	1734	2131	2067	1518	1624	2067	1857
2003	2707	2605	2567	1796	2101	2567	2391
2004	2522	3692	2586	1899	2246	2586	2589
2005	3927	4008	2957	1905	2858	2957	3102
2006	2659	3727	1903	2029	1919	1903	2357
2007	1997	2769	2216	2178	2064	2216	2240
2008	2743	3006	2190	1744	2080	2190	2326
2009	1772	2288	1742	2316	1553	1742	1902
2010	2049	2878	2122	2354	2672	2122	2366
2011	2037	2834	2482	2074	1988	2482	2316
2012	1798	1908	2770	1236	1418	2770	1983
2013	2672	3159	2872	2491	3178	2872	2874
2014	1858	2203	2052	1545	2046	2059	1961
2015	1459	1692	1405	1324	1455	1494	1472
2016	2463	3124	2422	2617	1746	2630	2500
2017	2659	3328	2048	2144	2189	2748	2519
2018	2473	2667	2034	2267	2220	1986	2275
2019	3148	4067	2947	2542	2884	3465	3176
2020	1853	2023	1504	2202	2074	1676	1889
2021	2227	3160	1959	2460	2250	2382	2406
Minimum	1459	1692	1350	1236	127	1350	1289
Maximum	4282	4634	3391	3076	3212	3465	3606
Average (1987-2021)	2420	2743	2122	1909	1962	2181	2223
Average (1987-2000)	2560	2604	1942	1748	1707	1942	2084
Average (2002-2021	2338	2863	2242	2032	2128	2346	2325

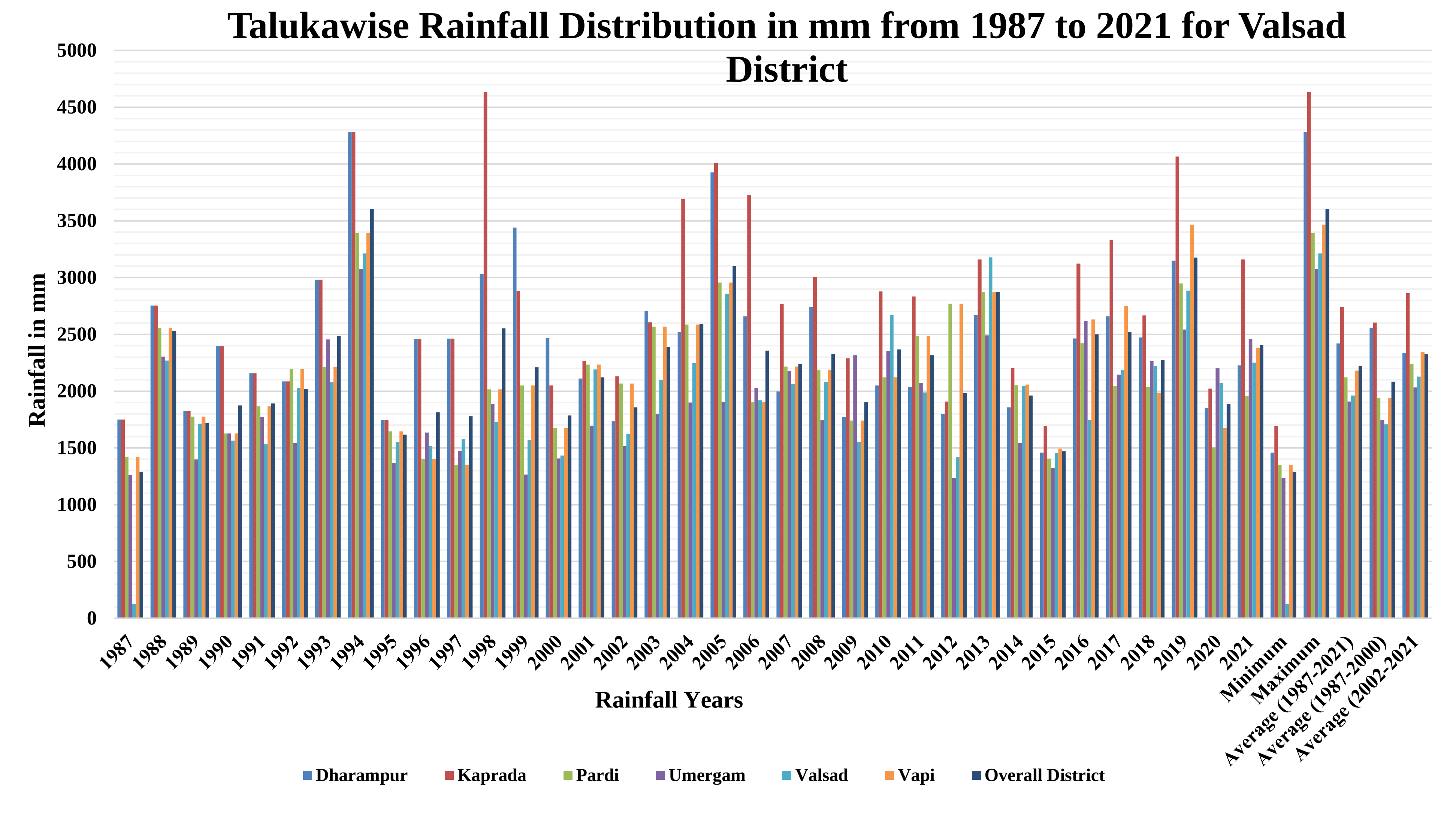


Figure 3 Graph Representing Taluka Wise Rainfall Distribution for Valsad District

Valsad district receives much of its rainfall from the south-west monsoon during the period between June & September; its maximum intensity being in the month of July & August. Total rainy days ranges from 40 to 55 days / year. Long term annual rainfall data of 11 rain-gauge stations of the district from year 1981-2012 are statistically analyzed and presented in table No 8. The distribution of mean annual rainfall over the Valsad district, as isohyets is given in Figure 4

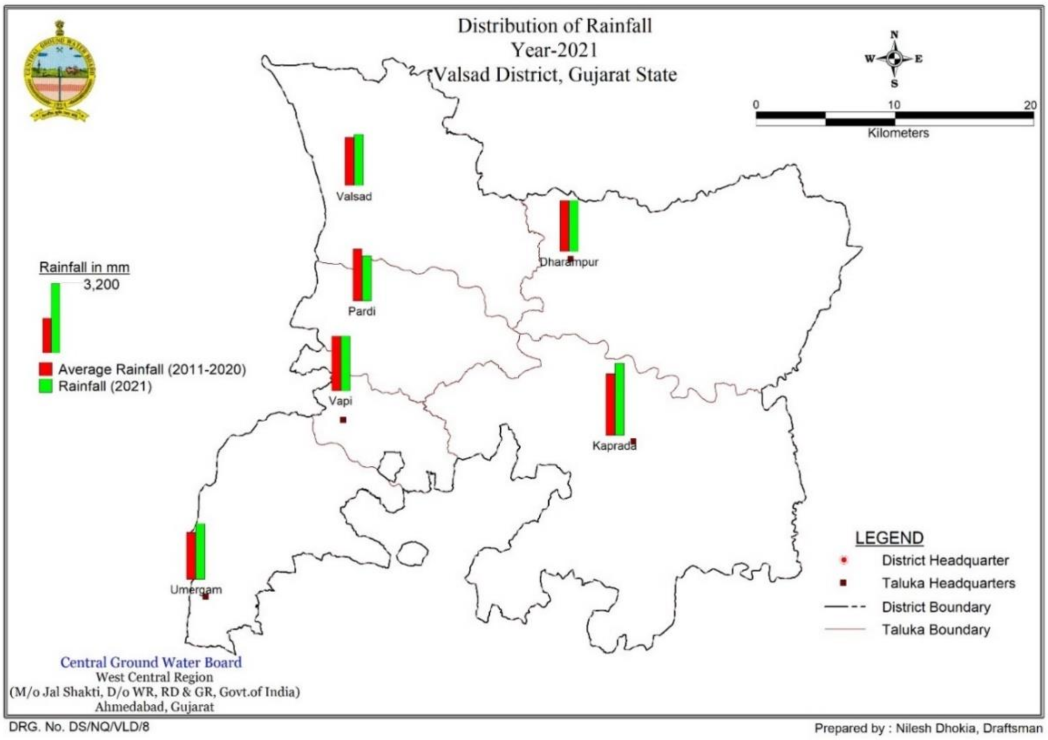


Figure 4 Rainfall Distribution Of Valsad District Year 2021 Vs Average Rainfall (2011-2020)

1.8 IRRIGATION PRACTICES

Valsad district has huge potential of surface water resources in the form of perennial river system comprising of Par, Wanki, Kolak, Damanganga and Varoli rivers and associated tributaries & springs in hilly terrains. Parts of Valsad district is covered by irrigation command of Daman Ganga Project and Ukai Project, and more than 50,000 ha area is irrigated in all three, Kharif, Rabi and Summer period through network of lined / unlined canal system. The canal network is also utilized for supply water for domestic and Industrial uses. Perusal of water release data of Daman Ganga Reservoir for year 2008-09 shows that nearly 15 % of water released through canal is used for industries. In year 2008-09, 4218 ha of area irrigated by 157.45 MCM of water during all three Kharif, Rabi & Hot season (table 3). In the same way nearly 16,000 ha area is under ground water irrigation and dug well are the main structures for ground water irrigation.

Table 3 Irrigational/Rain Fed Area of Valsad District

Irrigation	Area ('000 ha)
Net irrigated area	58.8
Gross irrigated area	91.2
Rain fed area	104.588

(Source Agriculture Contingency Plan for District: VALSAD)

Table 4 Table Representing The Source Of Irrigation

Irrigation, in Hectares (as per district statistical report 2017, GOG)	
Net Irrigated area	61751
Percentage of cropped area irrigation	32.85
Canal	15449
Pond	1397
Well	28232
other sources	16673
Gross irrigated area	61751.00

(Source-Ankadiya Roop Rekha for District: VALSAD)

1.9 LAND USE/LAND COVER

As per *Seasons & Crops Record*, 1,58,990 hectares of land, excluding all type of forest & hillyterrain areas,is accounted forland use record. Brief account of land use classification for Valsad district is given in table 5 and Land use pattern of the district is given in table 6 and landuse/Land Cover map of district is represented by figure .5

Table 5 Details of Land Use – Valsad District

Land Use, in Hecatres (as per district statistical report 2017, GOG)	
Forest	85616.00
Barren and uncultivated land	6504.00
Land used for non-agricultural purpose	34493.00
Arable land	152115.00
Permanent pasture and grazing land	2249.00
Current fallow	11496.00
Other fallow	1939.00
Net sown area	165330.00
Area sown more than once	17517.00
Gross sown area	182847.00

(Source-Ankadiya Roop Rekha for District: VALSAD)

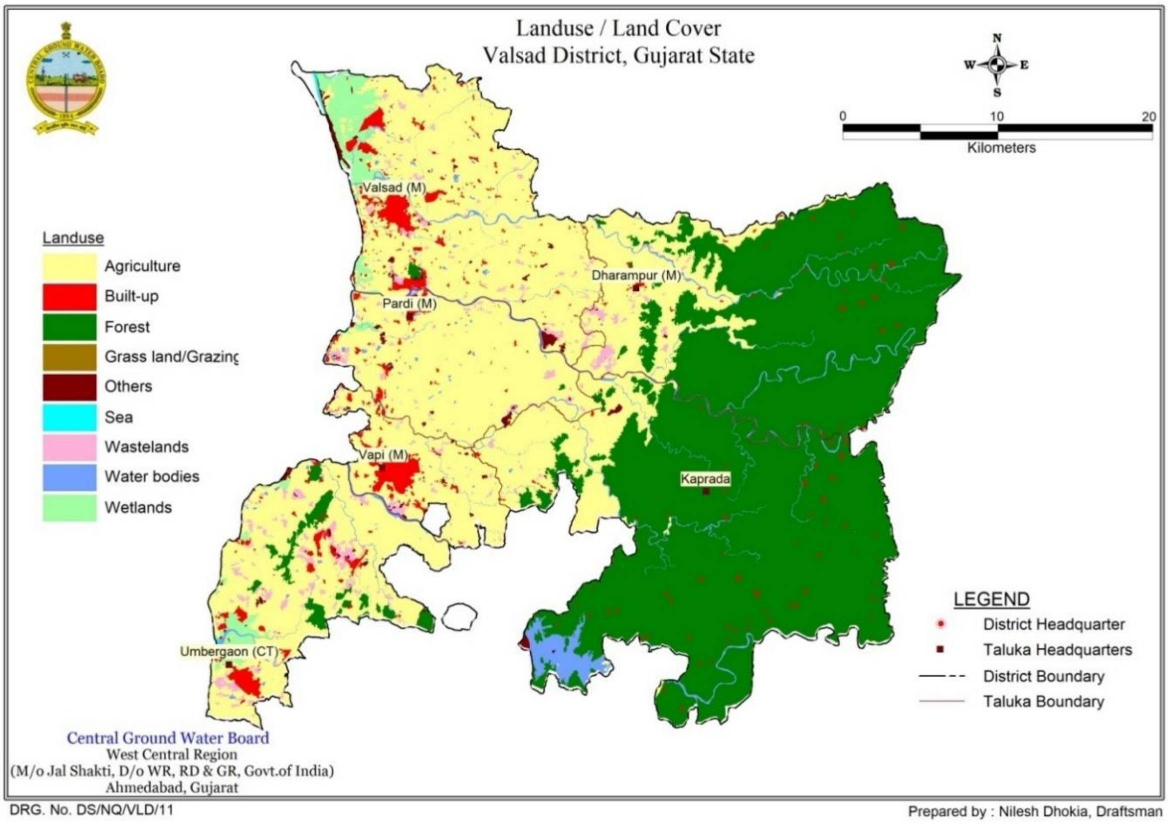


Figure 5 Land Use/Land Cover Map of Valsad District

1.10 PEDOLOGY

Based upon the works of Soil Survey Organization of State Government, the soils of the district have been classified into four major group such as i) Bilimora – Bedmal Series of hilly area ii) Baldha – Vadhawania Series of piedmont slope area, iii) Ena- Jalalpur – Sisodra Series in the midland and flood plain areas of the district and iv) Jal– AH – Dandi Series of soil along the coastal region

District have mainly five types of soils viz. Clayey, Fine, Loamy, Loamy Skeletal and Sandy soil. Nearly half of the district in eastern part is covered by loamy soil and rest half part of the district in western part is covered by fine grain soil and middle part in between loamy and fine soil is covered by clayey soil as represented in Figure 6.

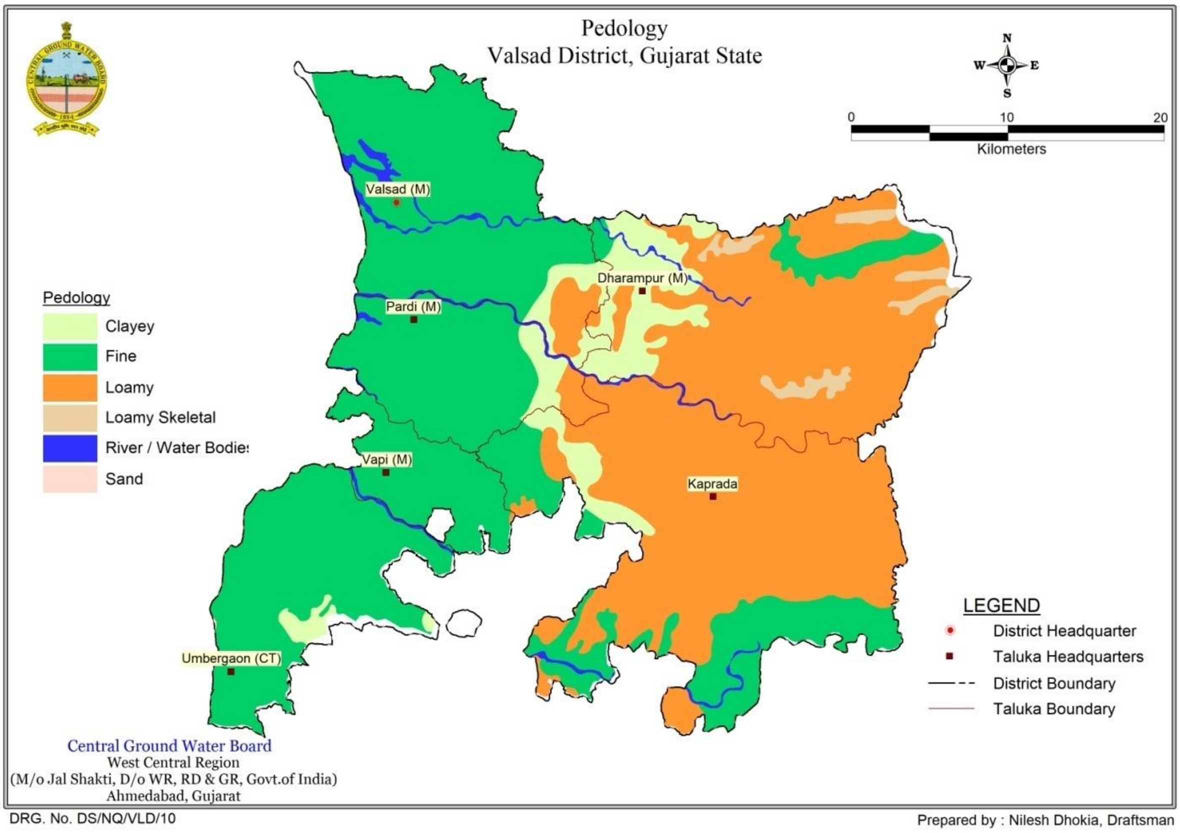


Figure 6 Pedology Map Of Valsad District

1.11 DRAINAGE

The Auranga, Par, Kolak , Daman Ganga and Kalu river forms main drainage basin in Valsad district. All the rivers originate in the eastern highland and flow towards west direction to the Arabian Sea. The rivers are perennial in nature. The flow of the water in the rivers is more during the rainy season. The drainage is dendrite to sub-dendrite type (Figure 7).

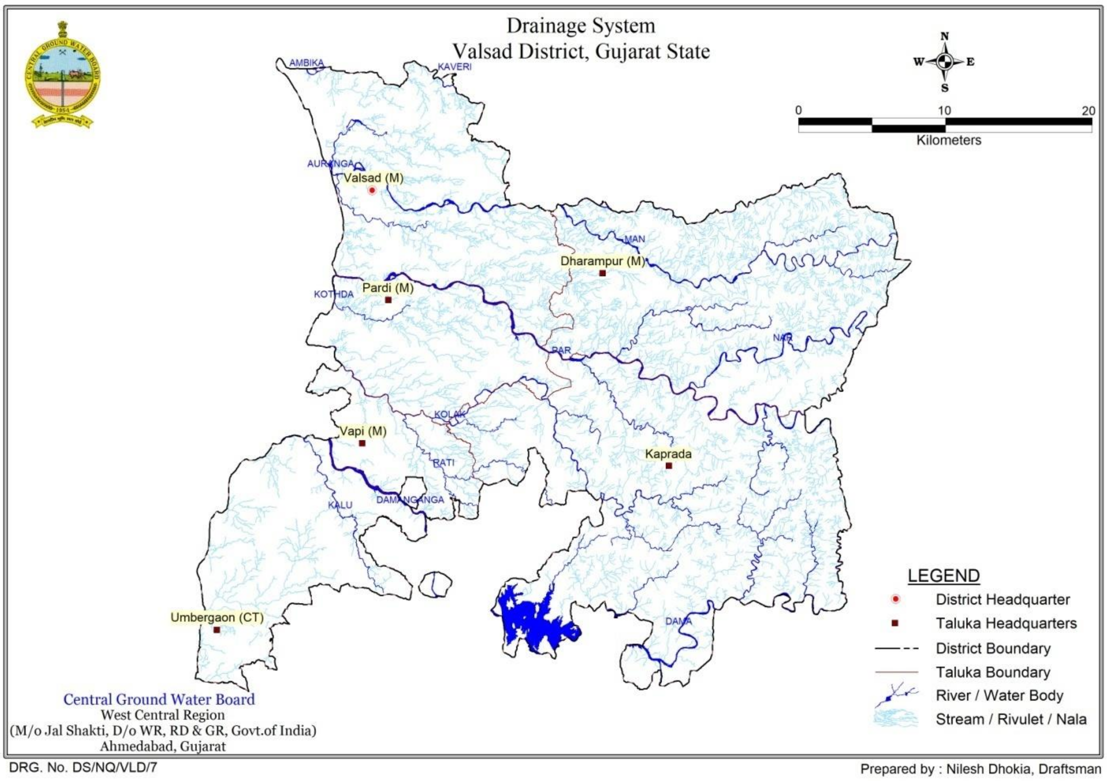


Figure 7 Drainage Map Of Valsad District

1.12 GEOMORPHOLOGY

Valsad has an average elevation of 13meters (42 feet). The old city is about 4 km inland from the Arabian sea. Major geomorphic units are shown in figure 8.

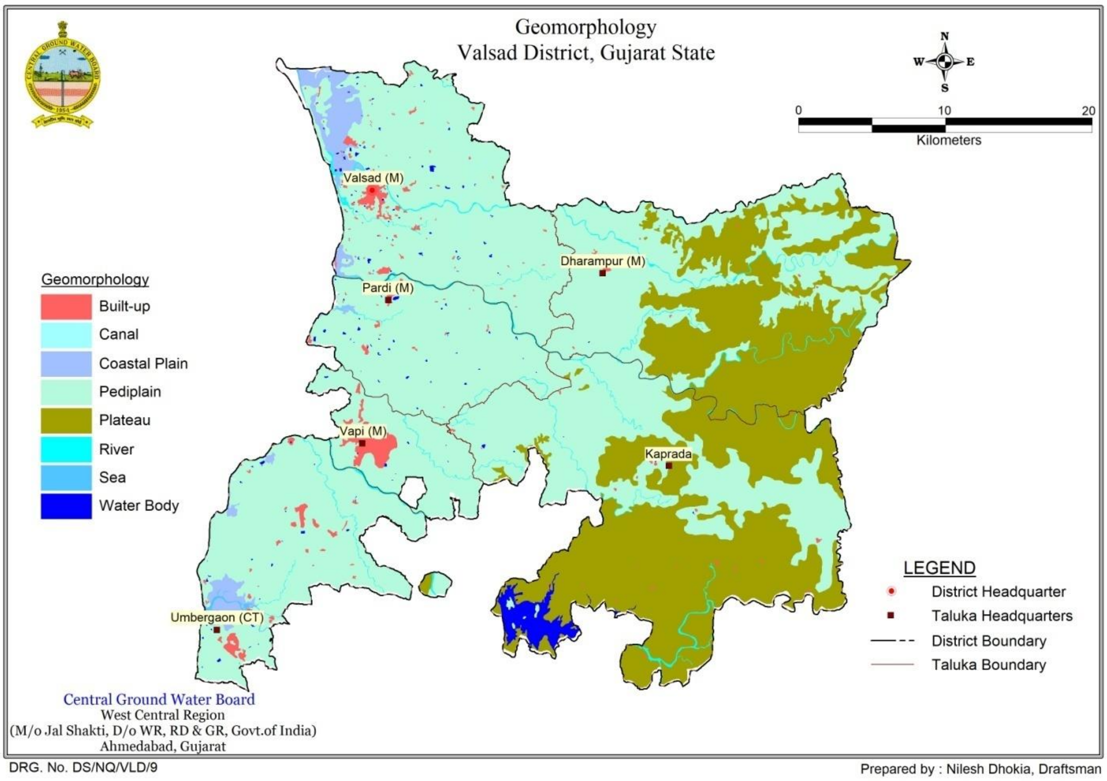


Figure 8 Geomorphologic Map of Valsad District

CHAPTER II
GEOLOGY

Geologically Valsad district is a northern extension of Deccan Plateau of Central India, belonging to late Cretaceous – early Eocene age and here, it is followed by Quaternary sediments. Map showing major geological formations and tectonic features are shown in figure 9, and the stratigraphy of Valsad district is presented in table 6

Table 6 Stratigraphy Of Valsad District

Geological Age	Formation	Group	Lithology
Holocene	Mahuva Formation		Younger tidal formation, spit / bar and shoal deposit
	Akhaj Formation		Coastal dune deposit
	Rann Clay Formation		Older tidal flat deposit
	Katpur Formation		Flood plain deposit
Upper Cretaceous to Eocene	Extrusive	Deccan Volcanic	Granophyre and other basic dykes, sills & plugs
	Intrusive		Basalt & Dacite

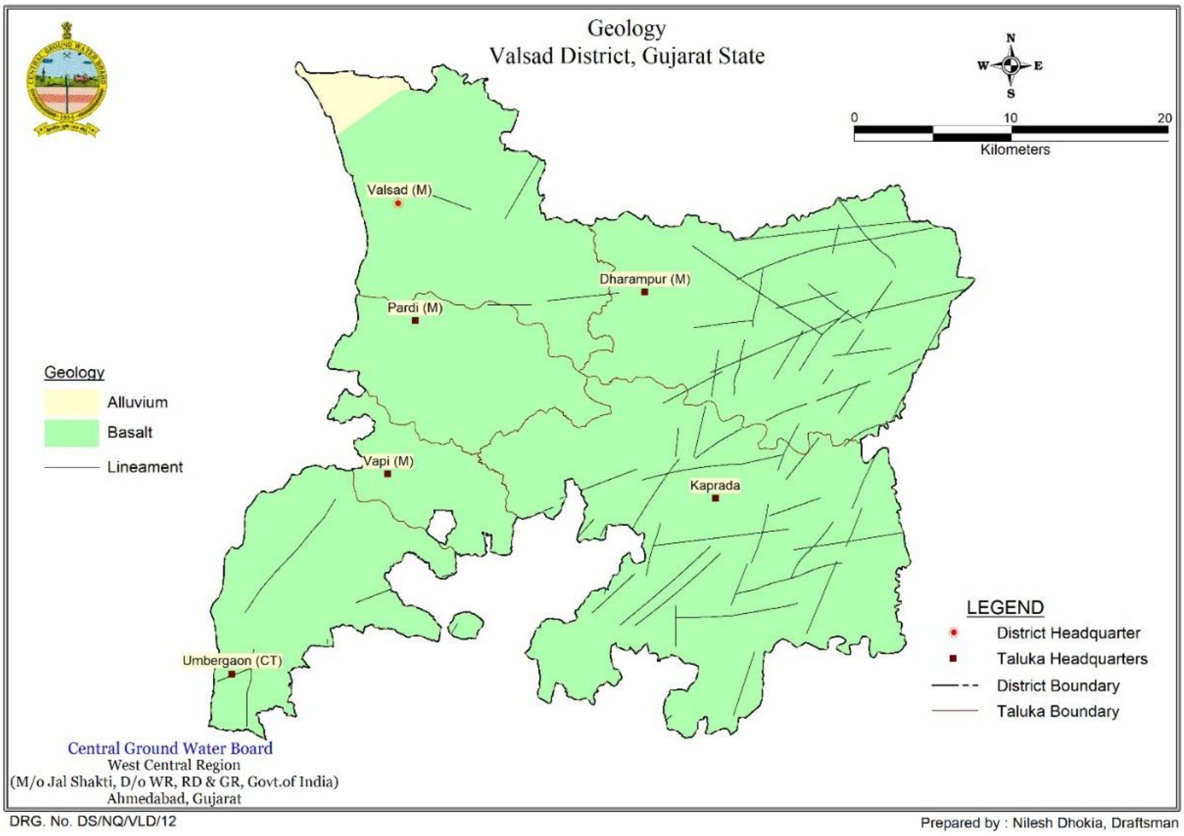


Figure 9 Geology of Valsad District

Deccan trap rocks are the oldest rocktype, exposed in theValsad district area.They are a direct result of the Deccanvolcanism of late Cretaceous period,and are made up ofa thick pile of near- horizontal beddedlava flows. The exposed thicknessof the basalt here is more than 600 m. The weathered part of the Deccan trapis locally known as *muram.* It is soft and easily crumbles into pieces. The thickness and arealextent of theweathered portionis very erratic; itranges from 1 tomore than 18 m at places. Laterised and weathered basaltic outcrop in the form of hummocks of about 3 to 8 m height are observed near Pardi, west of Vapi and in many interior parts of Dharampur & Kaparada taluka areas.

The Valsad district area is best represented by the marine Quaternary sediments of early Holocene coastal deposits, comprising raised mudflats, stabilized (inland) coastal ridges and shelly beach rocks. River mouth shows raised mudflats that interrupt the sand ridges. The continental Quaternary sediments are underlain bybasement rock, the Deccan trap. In river section of Daman ganga, fluvial sediments, sands with cobbles and pebbles are resting over Deccan trap, represent lower portion of Quaternary continental deposits. The total exposed sequence is about 10 m. The youngest continental deposits are represented by the unconsolidated soil sand covers over low-lying basalt rock in valleys & plains and also by the present-day flood plains along the various river courses of the district area. Another distinct continental deposit in aeolian environment is in the form of costal dunes and raised beach landforms, in Umargam taluka area. The coast line is fringed with fine shore deposits forming sand hills and dunes. These dunes are 3 to 6 m high and exhibits false bedding due to aeolian action.

CHAPTER III
HYDROGEOLOGY

The groundwater in Valsad district occurs in porous unconsolidated formations and fissure formations both under water table conditions as well as under confined conditions. The unconsolidated formations comprise gravel, sand, silt, clay and *kankars* while the fissure formations mainly consist of basaltic rock. Generally, the water table follows topographic configuration. The depth to water is greater in upland areas whereas in valley portion and shallow grounds, the levels are very close to surface. In hilly terrain of eastern, north-eastern and southeastern part of the district, spring zones are seen in river section and also along the section of the Daman Ganga, Kolak, Par & Auranga rivers of the district.

In major part of the district, basalt rock units form aquifers whereas alluvium deposits form aquifer system in north western part and in central part along river courses and also all along narrow coastal stripes of the district. The weathered basalts formations are covered by soil / *muram* , valley fill and piedmont deposits forming potential aquifers in the vicinity of rivers and in the vast undulating plains adjacent to hilly terrain. But their regional continuity and extension are limited due to heterogeneous nature of deposits with limited thickness and lateral extension. As such they rarely exceed a few square kilometers. The alluvium formation of Northwest along coastal area has major constraint of quality, which have high TDS in ground water. The interior patches have limited thickness and they form unique contiguous unconfined system of alluvium portion and underlying weathered basalt rock units. Map showinggeneral hydrogeology of the district is given as figure 10.

3.1 AQUIFER SYSTEM

Two major aquifer systems exist in Valsad district up to 200-meter depth. Major aquifer bearing formation is weathered and fractured/fissures basalt.

3.1.1 Unconfined Aquifer System

Unconfined aquifer {comprised of Weathered basalt (0-21 meter below ground level) and shallow fracture zone (2 & 90 meter below ground level)} ranges from 0 to 90 m bgl. Thickness of this aquifer is 2 to 90 meters. It lies in almost entire district. Quality of water is fresh. In some areas alluvium aquifer also exit but it is in very limited in extent (Northern east part of Valsad taluka).

3.1.2 Semi-confined to confined aquifer System

Deeper aquifer lies in Fractured Basalt ranges in between 90 & 200 mbgl.

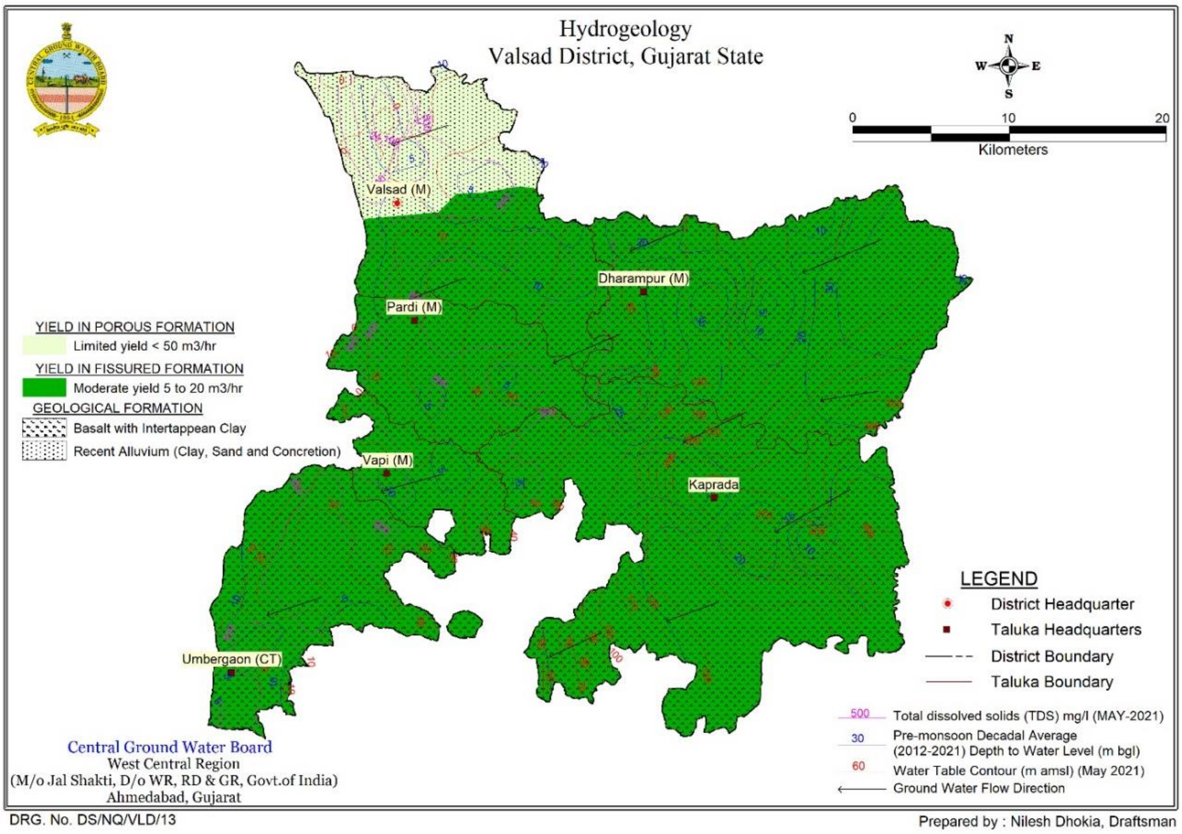


Figure 10 Hydrogeology Of Valsad District

3.2 AQUIFER PARAMETERS

Movement and abstraction of groundwater in the geological formations are dependent on the hydrogeological parameters of the aquifers. The purpose of any aquifer test is to determine the hydrogeological parameters. Among the basic parameters are the Storativity, transmissivity and leakage coefficients.

3.3 GROUNDWATER SCENARIO

Groundwater occurs both in hard rock and alluvium. Though ground water occurs in all types of formations, the most productive aquifers are the fractured and weathered basalts of the Deccan traps and alluvium formations.

Systematic and regular monitoring of groundwater levels brings out the changes taking place in the groundwater regime. The maps so generated are of immense help for regional groundwater flow modelling, which serves as a groundwater management tool to provide the necessary advance information to the user agencies to prepare contingency plans in case of an unfavourable groundwater recharge situation. The data also has immense utility in deciding the legal issues arising out of conflicting interests of groundwater users.

The monitoring of groundwater levels has been carried out at groundwater monitoring wells four times a year simultaneously throughout the State during the following periods.

1. May - 20th to 30th (water level of pre-monsoon period).
2. August - 20th to 30th (peak monsoon water level).
3. November - 1st to 10th (water levels of post-monsoon period).
4. January - 1st to 10th (the recession stage of water level).

Water level data of the ground water monitoring wells collected during the year 2021-22 has been utilized to prepare various maps showing depth to water level and fluctuation of water level. Depth to water level maps is useful in dealing with problems of water logging and artificial recharge where the relative position of water level with reference to the ground surface is of critical importance. Water level fluctuation maps (rise or fall) are indispensable for estimation of changes in storage in the aquifer.

The data is analysed for each set of measurements, and a report is prepared, which includes the following maps to understand the groundwater regime in the state.

1. Depth to water level
2. Decadal Average Depth to Water Level
3. Decadal fluctuation - water level fluctuation in the month of measurementwith reference to the decadal average for the same month.
4. Water table contour
5. Groundwater level trend

3.3.1 Depth to Water Level

In the recent past, the population growth and overexploitation of groundwater resources have led to rapidly declining groundwater levels (Aggarwal et al., 2009). The aquifers are under tremendous pressure and are vulnerable to depletion, particularly in semi-arid and arid regions where the natural recharge is not adequate to balance the withdrawals (Vörösmarty and Sahagian, 2000). This is further aggravated by uncertain and uneven rainfall patterns causing overdependence of agriculture on groundwater resources.

The depth to water level in the district ranges from 0 to 45.56 mbgl during the pre-monsoon period and some patches shows that water level in deep in Dharampur and Kaprada talukas of District (Figure.11). Bhimpor k.falia, Lakadmal, Mandwa, Valsad1, Amba-Talat, Nana-Pondha, Dumalav, Dungra villages has recorded the shallowest water level whereas the deepest water level was recorded at Sidhumbar village. During the post monsoon period the depth to water level ranged from 0 mbgl at many places including Bhimpor k.falia village to 29.86 mbgl at Sidhumbar.

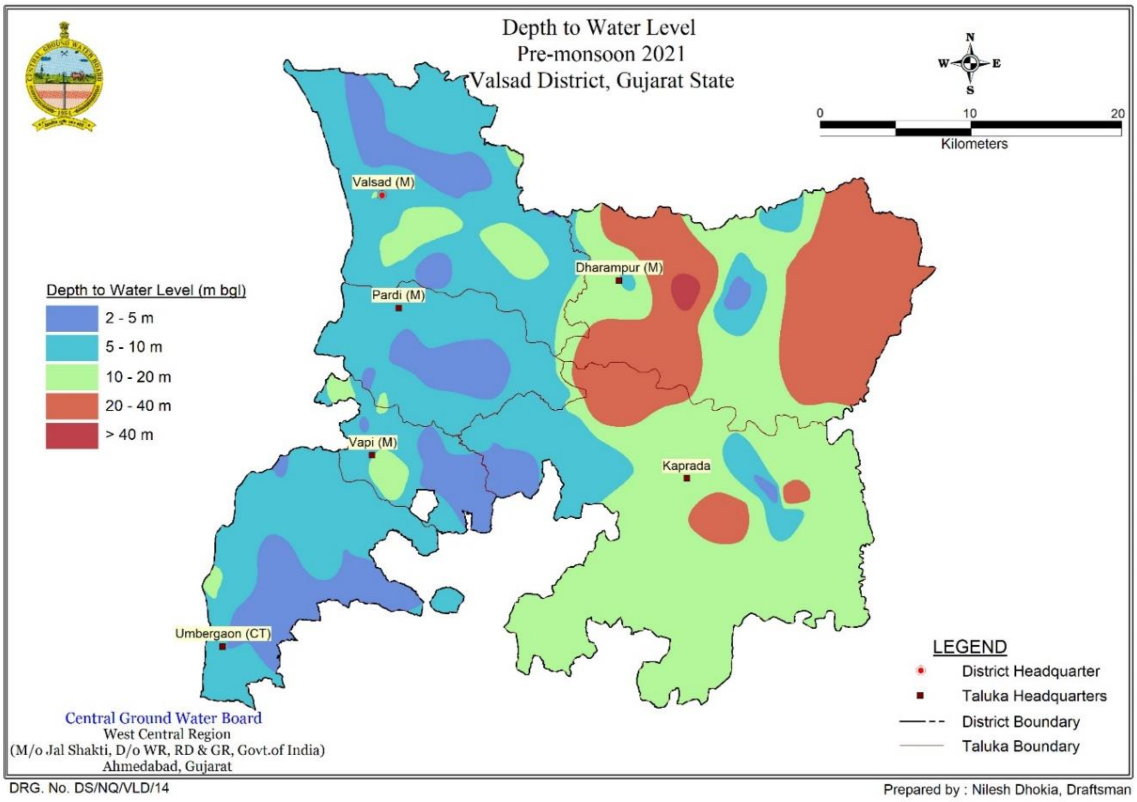


Figure 11 Depth To Water Level Map Pre-Monsoon 2021

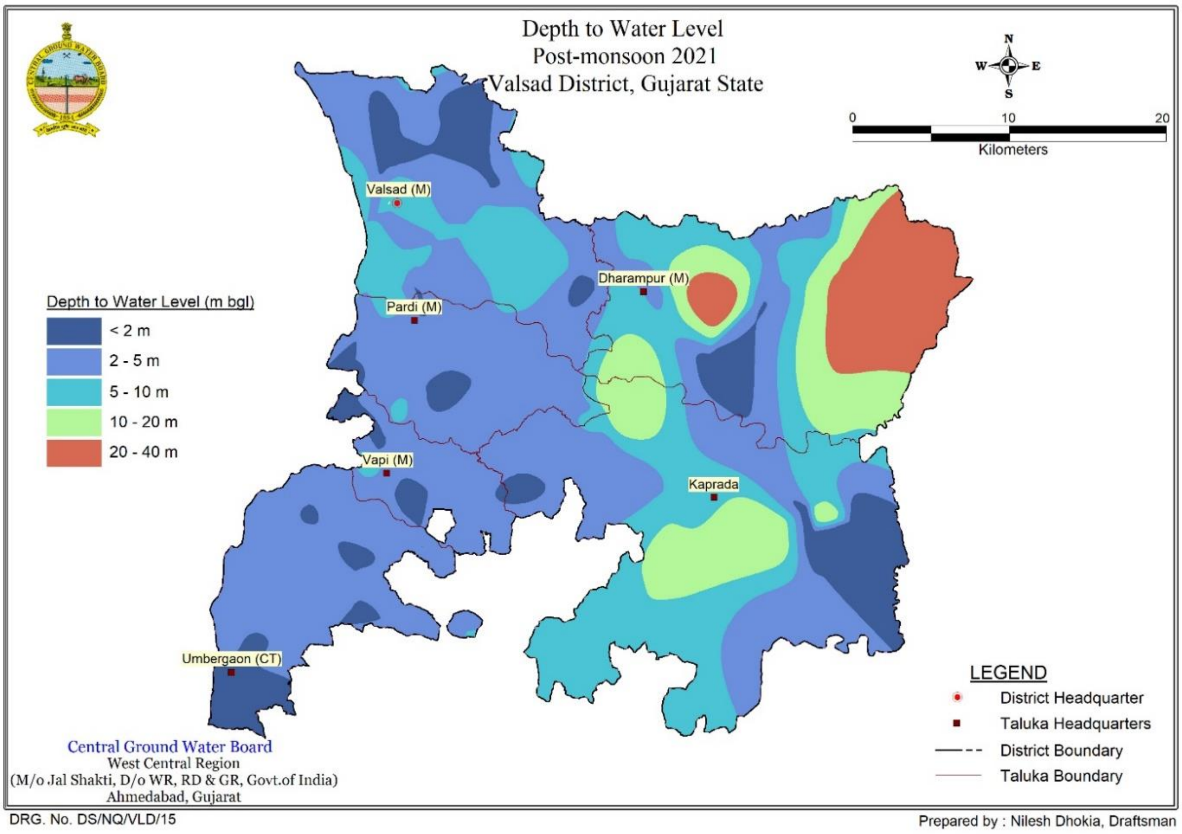


Figure 12 Depth To Water Level Map Post-Monsoon 2021

3.3.2 Depth to Water Level Decadal Mean

India is the largest groundwater consumer globally, with an estimated usage of about 251 km^3/yr (UNESCO, 2012). The demand of water for irrigation in India will rise up to 56 % by the year 2050 (i.e. 1072 BCM) as indicated by the Ministry of Water Resources (Baweja et al., 2017; CWC, 2000). In the past few decades, most northern states in India have experienced a severe depletion of groundwater due to over-exploitation of groundwater for various purposes (CGWB, 2016).

Decadal average water level for the year 2012 to 2021 for the pre-monsoon and post-monsoon period have been presented in Fig. 13 and 14. Major part of the district observed water level between 5 to 20 m bgl. Water level more than 20 m bgl are shown in isolated patches mostly in Dharampur taluka. Decadal average of post- monsoon period is mostly ranges 5 to 10 m bgl in most of the area. Water level more than 10 m bgl is shown in isolated patches and located in the north eastern part of the district.

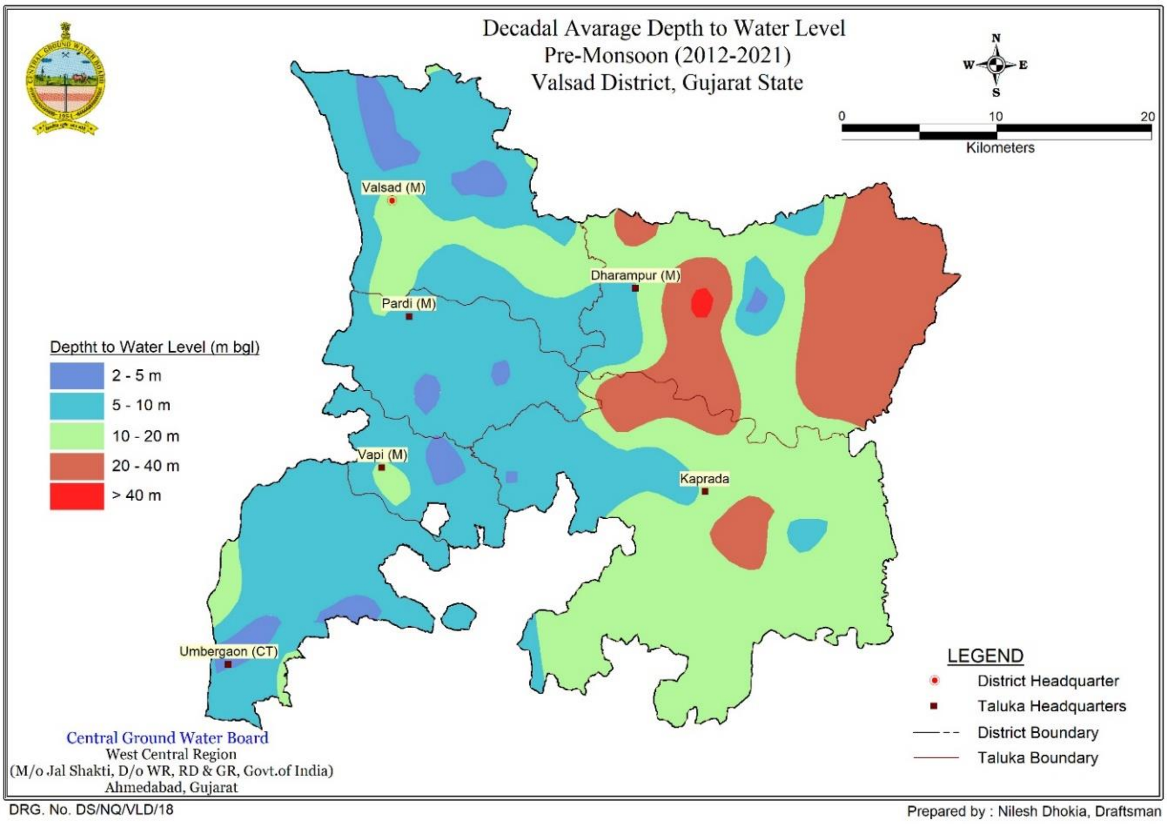


Figure 13 Pre-Monsoon Decadal Mean Map of Valsad District

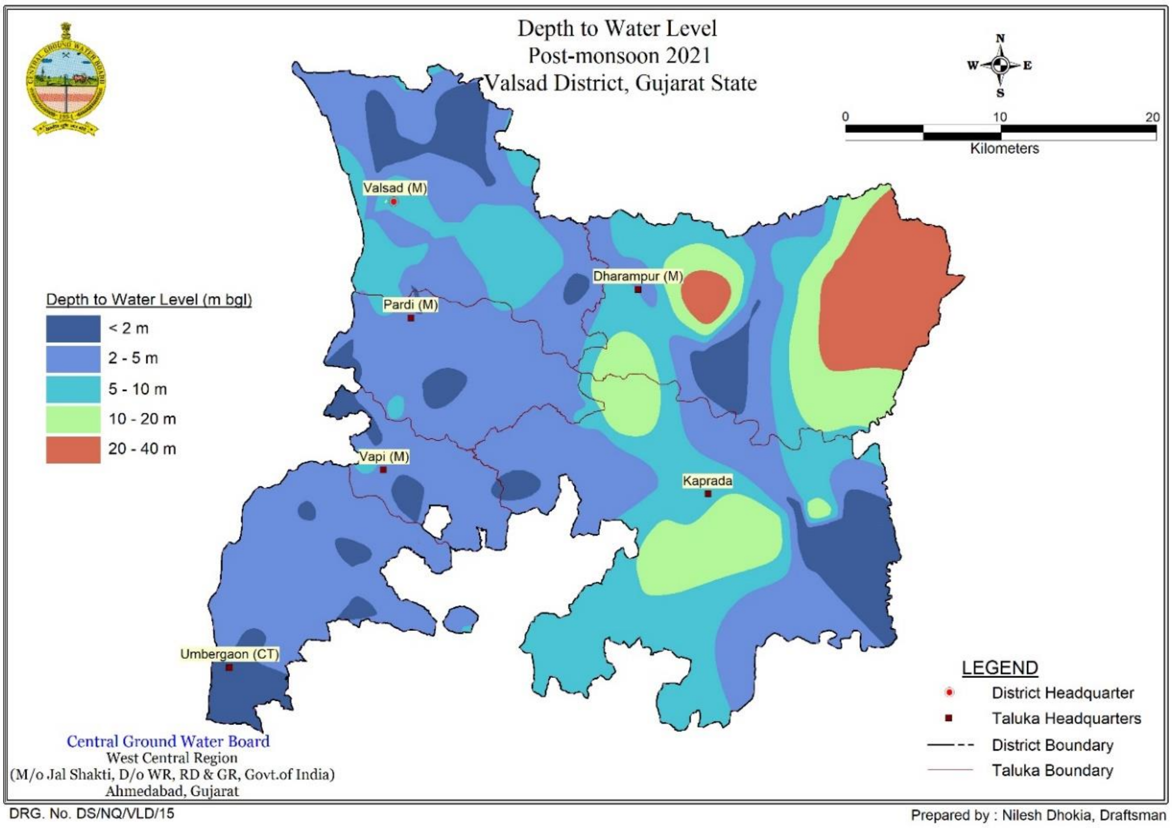


Figure 14 Post-Monsoon Decadal Mean Map Of Valsad District

3.3.3 Water Table Fluctuation

The groundwater fluctuations result mostly due to withdrawal from bore wells, less recharge compared to discharge, water uptake by the vegetation, and periodic moisture disparity (Rajaveni et al., 2014). Though there is an urgent need to study the impact of groundwater exploitation under climate change, very few studies exist in the literature (Malakar et al., 2021), mostly due to the lack of large spatial and temporal datasets.

In major parts of Kaprada and Dharmpur Talukas of district water level rises more than 4 meters. Overall, below map indicates that water is recharging during to groundwater in monsoon.

Pre-monsoon and post-monsoon water level fluctuation for the year 2021 is presented in Fig. 15. Entire district observed in the rise of water level whereas Eastern half of the district experience rise of water level more than 4m mostly in the taluka of Dharampur and Kaprada.

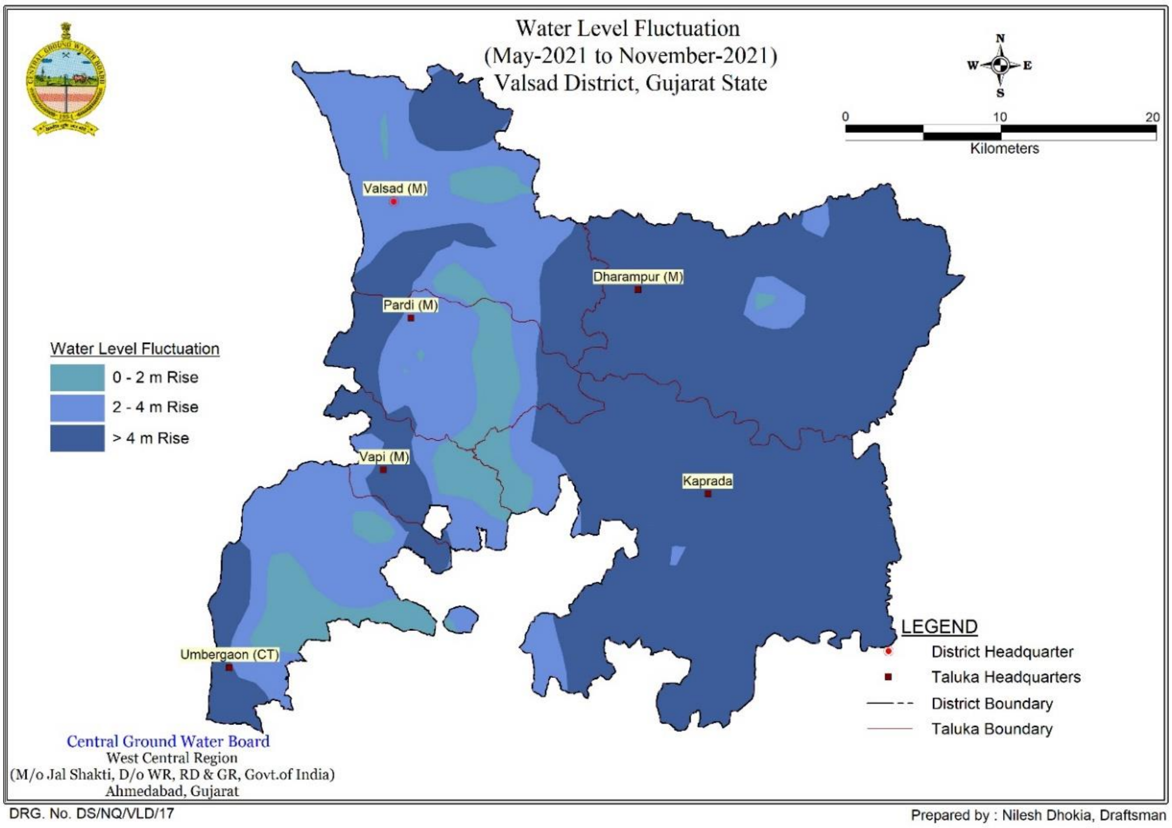


Figure 15 Pre Vs Post Monsoon2021 Water Level Fluctuation Map

3.3.4 Water Table-Contour Map /Groundwater Flow

A water table-contour map is an important tool in groundwater investigations because, from it, one can derive the gradient of the water table and the direction of groundwater flow, which is perpendicular to the water table-contour lines.

A line drawn on a map to represent an imaginary line in the water table of a definite level. These contours are constructed from the data provided by the water-table levels, corrected for differences in surface level at the respective boreholes. A ground water contour map provides important information about ground water movement and flow directions. Different regions facing water scarcity will be identified.

In general groundwater flows from NE to SW direction for Valsad District. Gradient of groundwater flow steeper in the eastern hilly part of the district whereas it gradually gentle when approaches to coastal plan of the district in weatern side. (Figure 16)

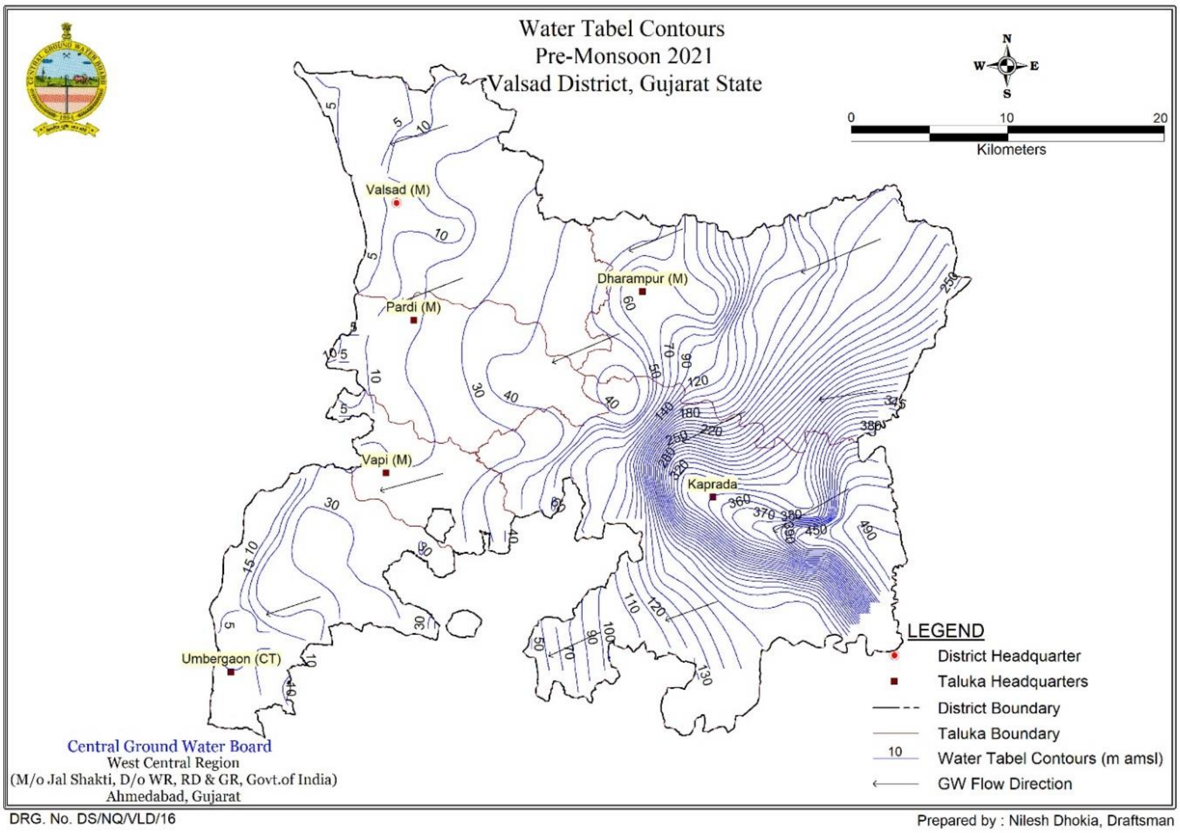
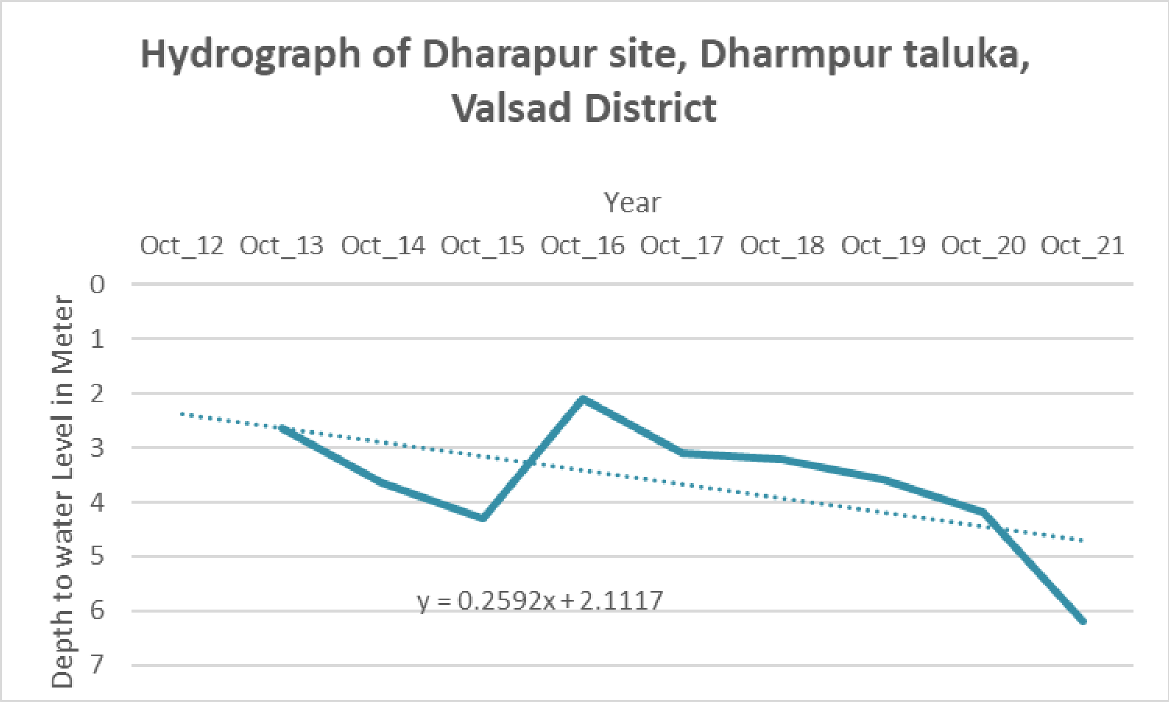
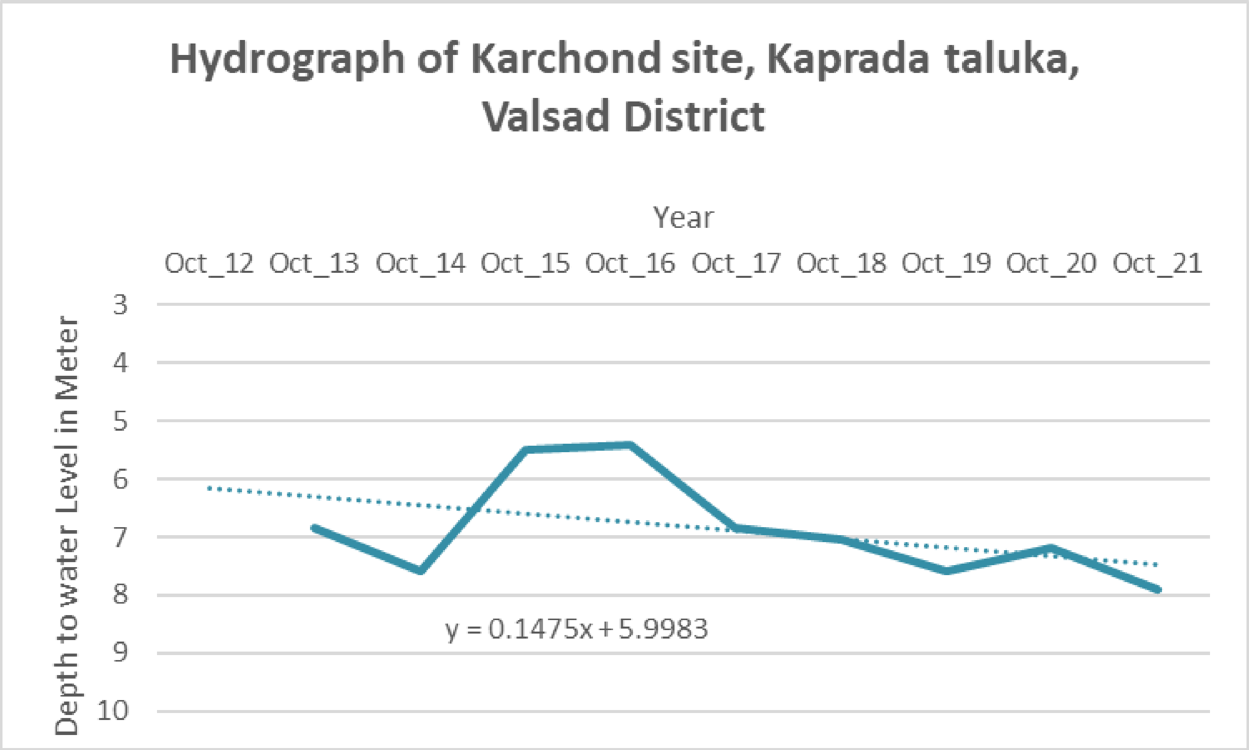


Figure 16 Water Table Elevation With Groundwater Flow Direction Map Of Valsad District

3.4.5 Water Level Trend

Hydrograph depicting Groundwater Declining trend (in m/yr) for Post monsoon period (2012-2021) in Dharampur and Kaprada Talukas of Valsad District


Hydrograph of Dharapur site, Dharmpur taluka, Valsad District
Year
Oct_12 Oct_13 Oct_14 Oct_15 Oct_16 Oct_17 Oct_18 Oct_19 Oct_20 Oct_21
0
1
2
3
4
5
6
7
Depth to water Level in Meter
y = 0.2592x + 2.1117


Hydrograph of Karchond site, Kaprada taluka, Valsad District
Year
Oct_12 Oct_13 Oct_14 Oct_15 Oct_16 Oct_17 Oct_18 Oct_19 Oct_20 Oct_21
3
4
5
6
7
8
9
10
Depth to water Level in Meter
y = 0.1475x + 5.9983

CHAPTER IV
DATA INTEGRATION, INTERPRETATION, AND AQUIFER MAPPING

4.1 INTRODUCTION

Collection and compilation of data for aquifer mapping studies is carried out in conformity with Expenditure Finance Committee (EFC) document of XII plan of CGWB encompassing various data generation activities (Table-7).

Table 7 Brief Activities Showing Data Compilation and Generation

Sr. No.	Activity	Sub-activity	Task
1	Compilation of existing data/ Identification of Principal aquifer Units and Data Gap	Compilation of Existing data on groundwater	Preparation of base map and various thematic layers, compilation of information on Hydrology, Geology, Geophysics, Hydrogeology, Geochemical etc. Creation of data base of Exploration Wells, delineation of Principal aquifers (vertical and lateral) and compilation of Aquifer wise water level and draft data etc.
2		Identification of Data Gap	Data gap in thematic layers, sub-surface information and aquifer parameters, information on hydrology, geology, geophysics, hydrogeology, geochemical, in aquifer delineation (vertical and lateral) and gap in aquifer wise water level and draft data etc.
3	Generation of Data	Generation of geological layers (1:50,000)	Preparation of sub-surface geology, geomorphologic Analysis, analysis of land use pattern.
		Surface and sub-surface geo-electrical and	Vertical Electrical Sounding (VES), bore-hole logging, 2-D imaging etc.

		gravity data generation	
		Hydrological Parameters on groundwater recharge	Soil infiltration studies, rainfall data analysis, canal flow and recharge structures.
		Preparation of Hydro geological map (1:50, 000 scale)	Water level monitoring, exploratory drilling, pumping Tests, preparation of sub-surface hydro geological sections.
		Generation of additional water quality parameters	Analysis of groundwater for general parameters Including fluoride.
4	Aquifer Map Preparation (1:50,000 scale)	Analysis of data and preparation of GIS layers and preparation of aquifer maps	Integration of Hydro geological, Geophysical, Geological and Hydro-chemical data.
5	Aquifer Management Plan	Preparation of aquifer management plan	Information on aquifer through training to Administrators, NGO's, progressive farmers and stakeholders etc. and putting in public domain.

4.2 DATA GENERATION

In order to establish the three-dimensional disposition of aquifer system in the area, the existing data of litho logical logs and Electrical logs of 17 exploratory wells studies carried out and used in preparation of stratigraphic cross sections, Fence diagram and 3D Model.

Table 8: Data Generation And Integration In Respect To Valsad District

Type of Data & source	No of Wells
Aquifer Disposition	**17**
CGWB	**17**
Long term Fluctuation	

CGWB+GWRDC	**50**
Depth to Water Level	
CGWB+GWRDC	**113**
Analysis of water Quality	
CGWB+GWRDC	**74**

Table 9 Data Compilation and Integration

S.No.	Data	Aquifer	Total Data Points	Source	
				CGWB	GWRDC
1	**3D Aquifer Disposition Map**	2	17	17	0
2	**Hydro geological Cross Sections**	6	17	17	0
3	**Fence Diagrams**	1	17	17	0
4	**Depth of weathering**	24	17	17	0
5	**Depth of fracturing**	24	17	17	0
7	**Depth to Water Level Maps (2021)**	2	144	107	37
8	**Water quality pre-2021**	2	74	46	28

4.3 AQUIFER DISPOSITION

The data has been analyzed using Rockworks 17 software and is presented below in the Hydrogeological cross sections A-A' to E-E' and Solid Model of the district showing the depiction of Weathered & fractured basalts (Aquifers) and Massive Basalts. The stratigraphic sections depicting weathered Zone fractured Zone (Shallow aquifer) for Basaltic rock with massive basalt are placed at Figures (18, 19 to 24) Stratigraphic index for cross-sectional map Is shown in Figure 19. Fence Diagram and 3D Solid Stratigraphic Model of district is depicted in Fig. 25, and 26 respectively.

Table 10 Table Depicting Aquifer Disposition of Valsad District

Stratigraphy	Aquifer Nomenclature	Lithology/ Aquifer material	Occurrence of weathering / fracture (meter) in depth between
Upper Cretaceous- Lower Eocene	Unconfined Weathered Basalt	Deccan Basalt	0 & 21
	Fractured Basalt		2 & 90

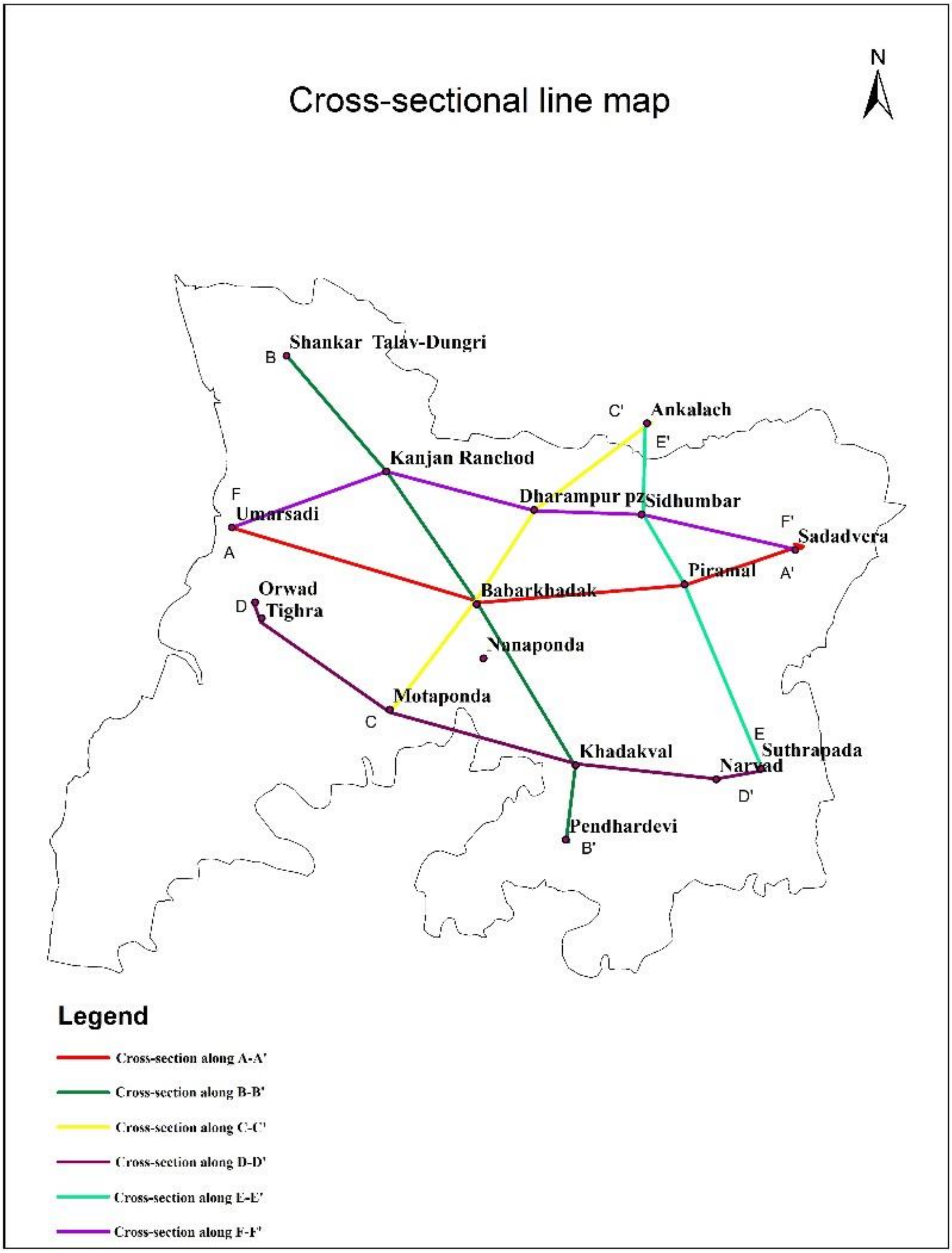


Figure 17 Cross-Section Line Map of Valsad District

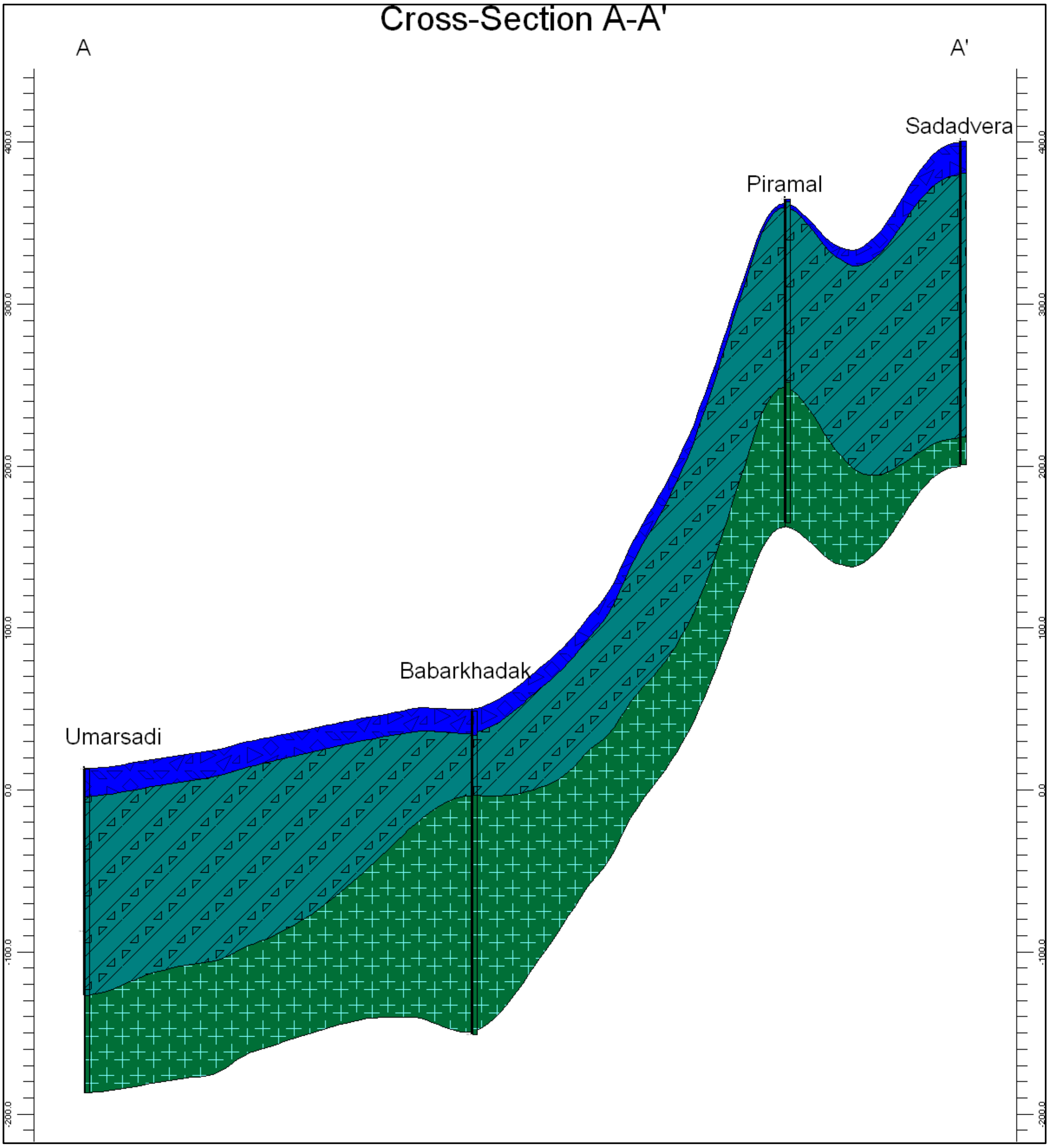


Figure 18 Cross Section Along A-A'

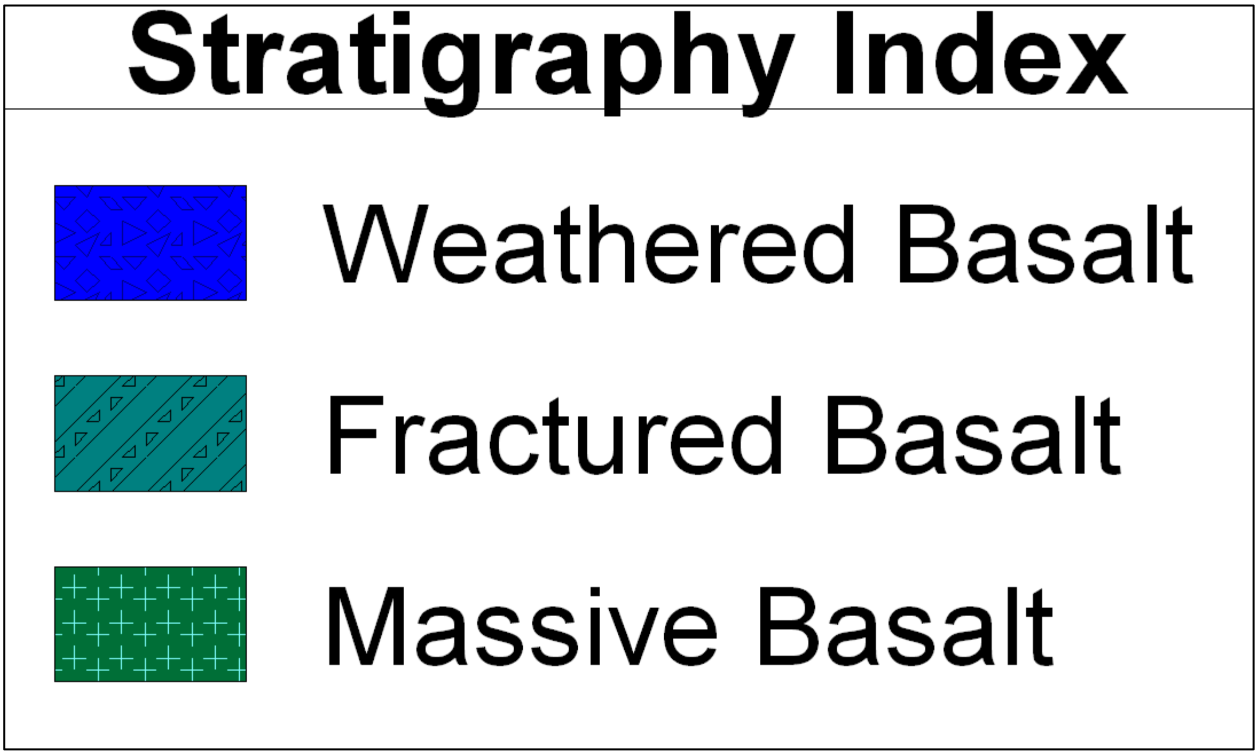


Figure 19 Stratigraphic Legend/Index Map for Cross Sections

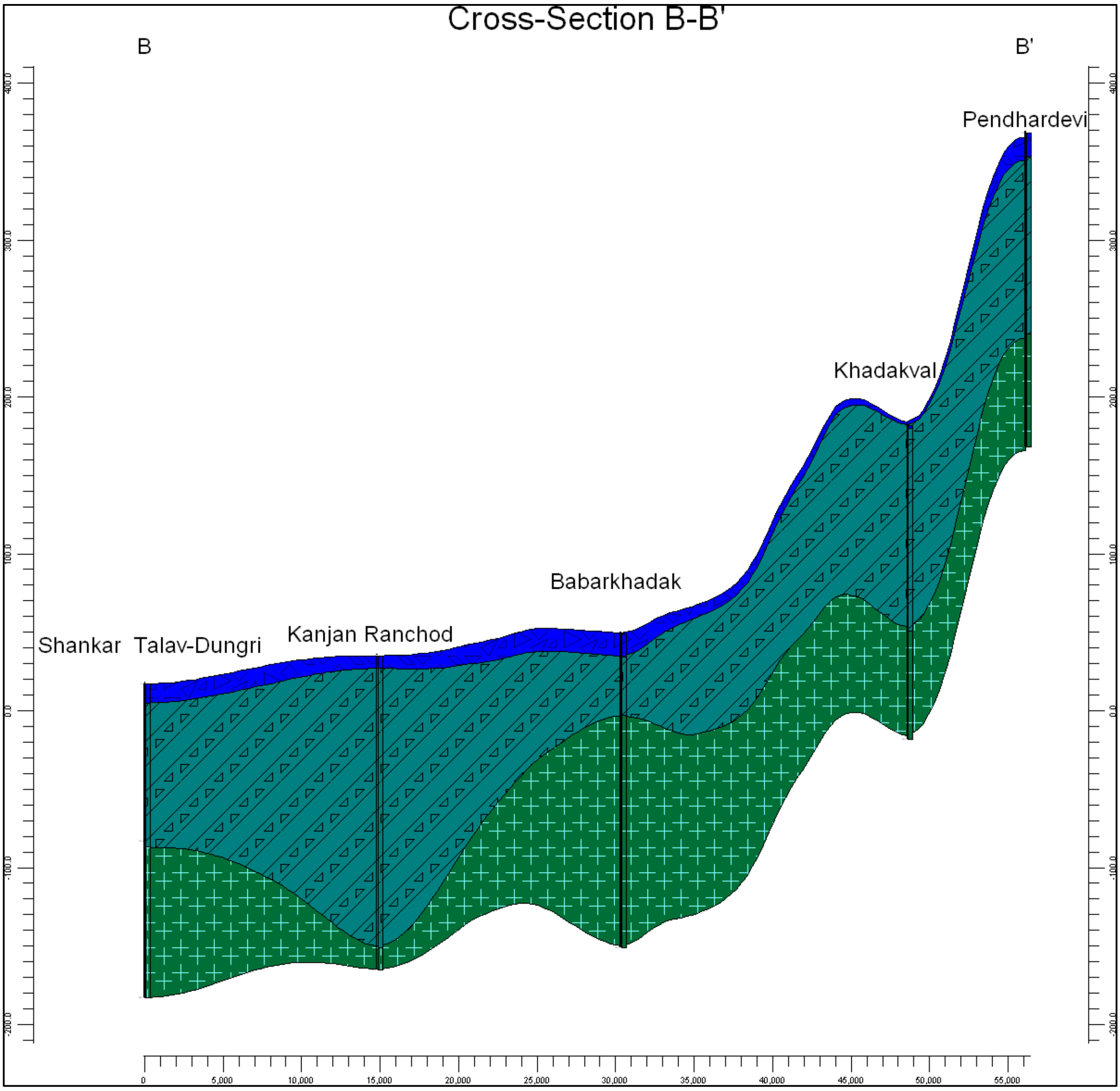


Figure 20 Cross Section Along B-B'

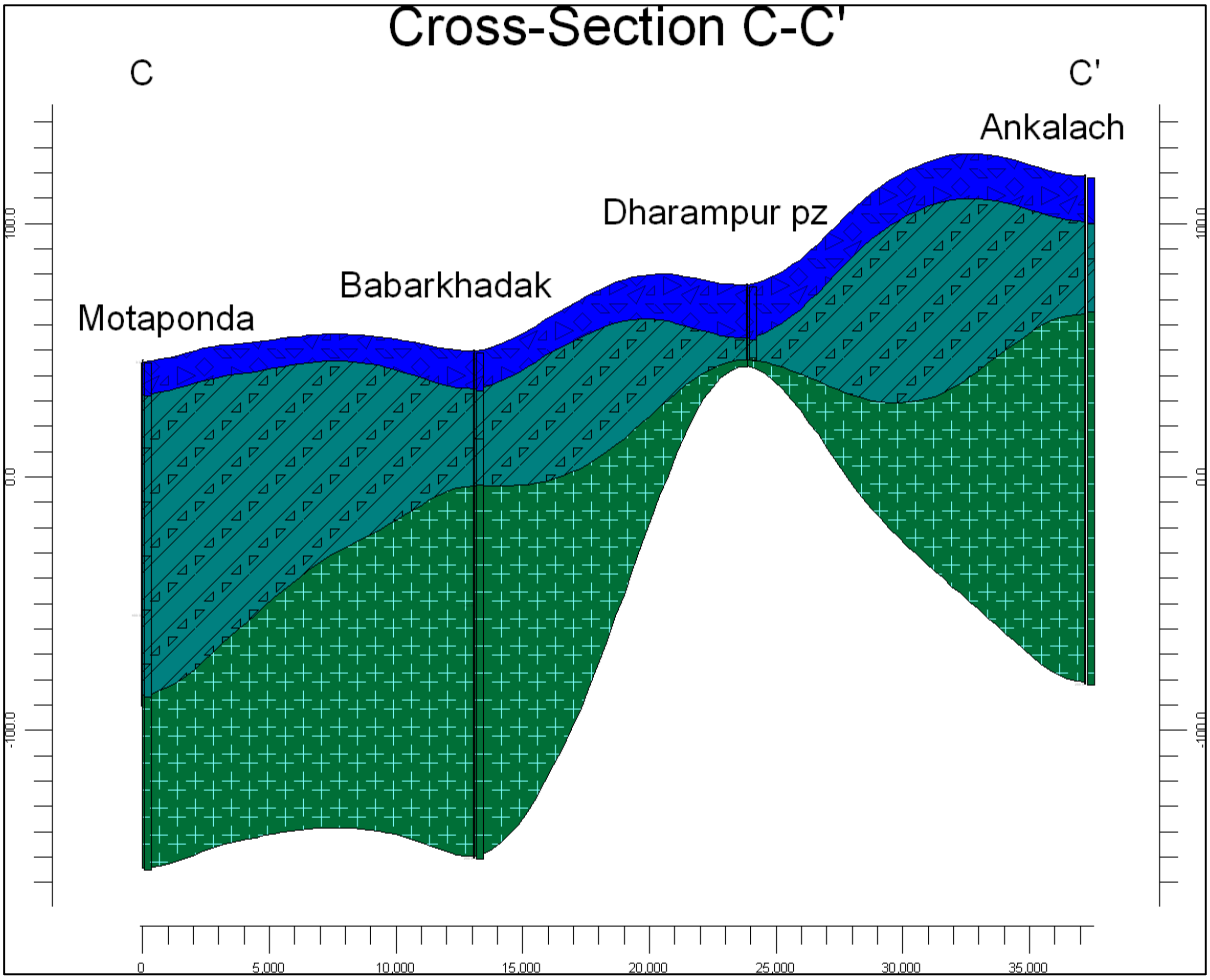


Figure 21 Cross Section Along C-C'

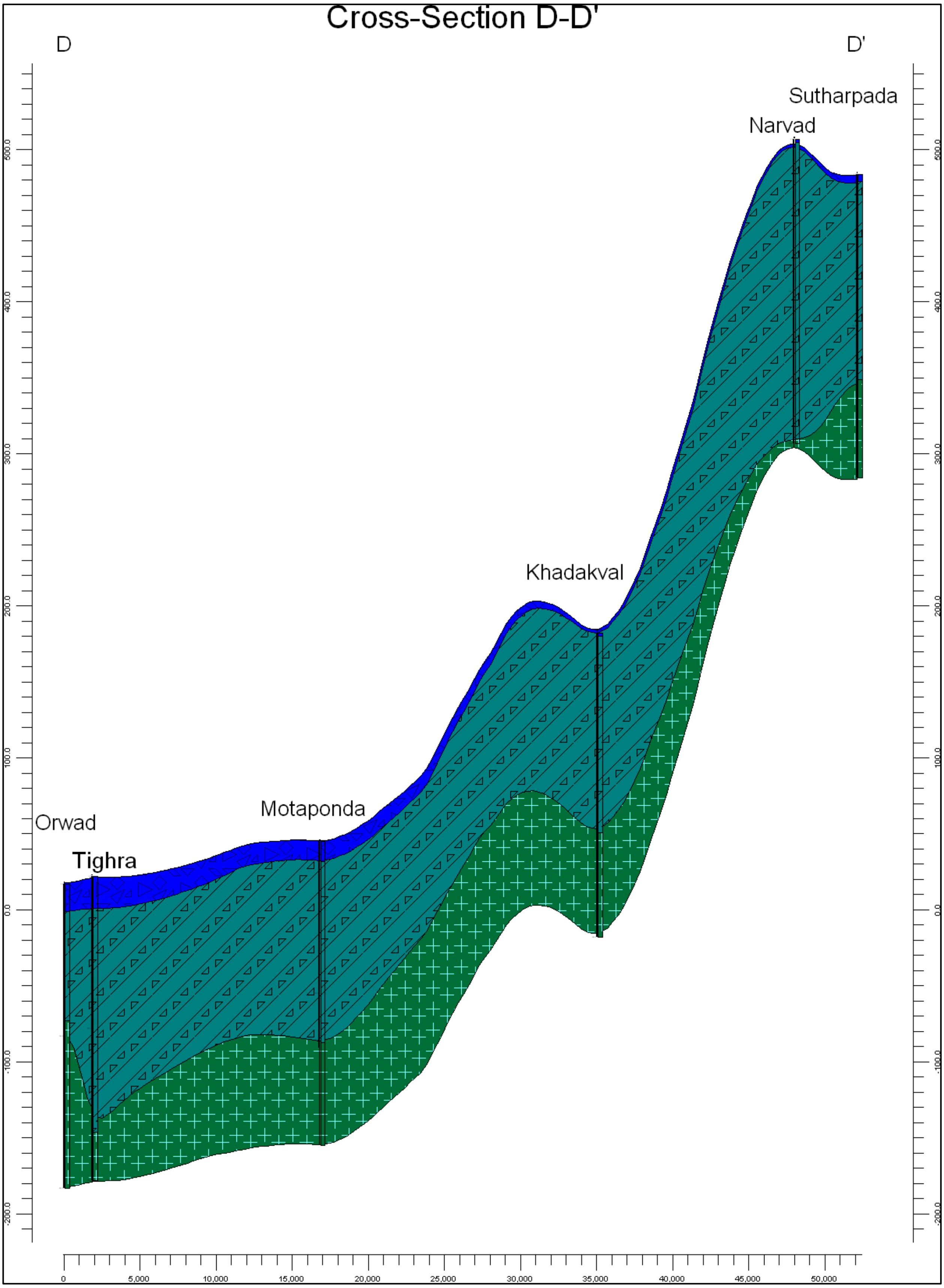


Figure 22 Cross Section Along D-D'

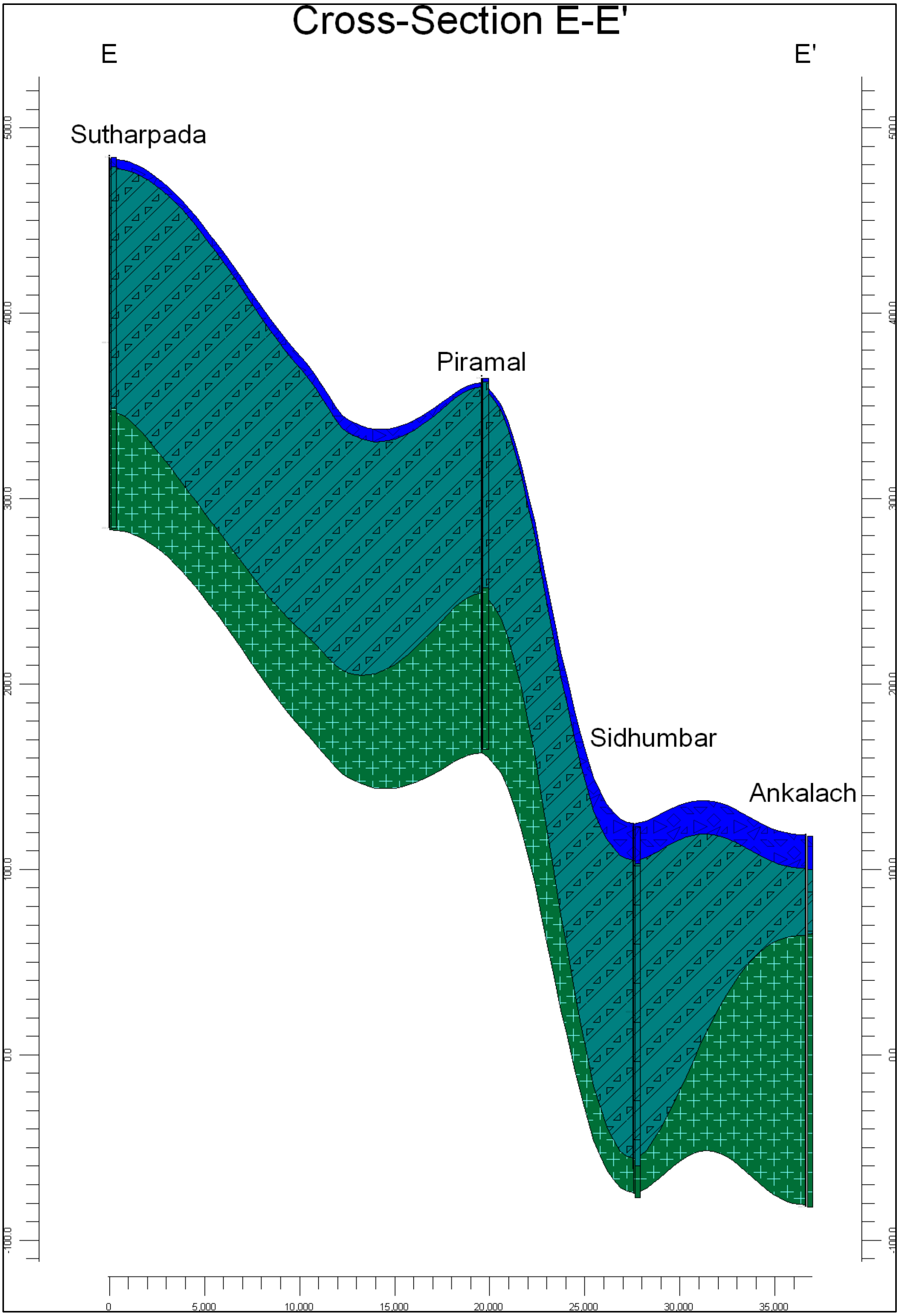


Figure 23 Cross Section Along E-E'

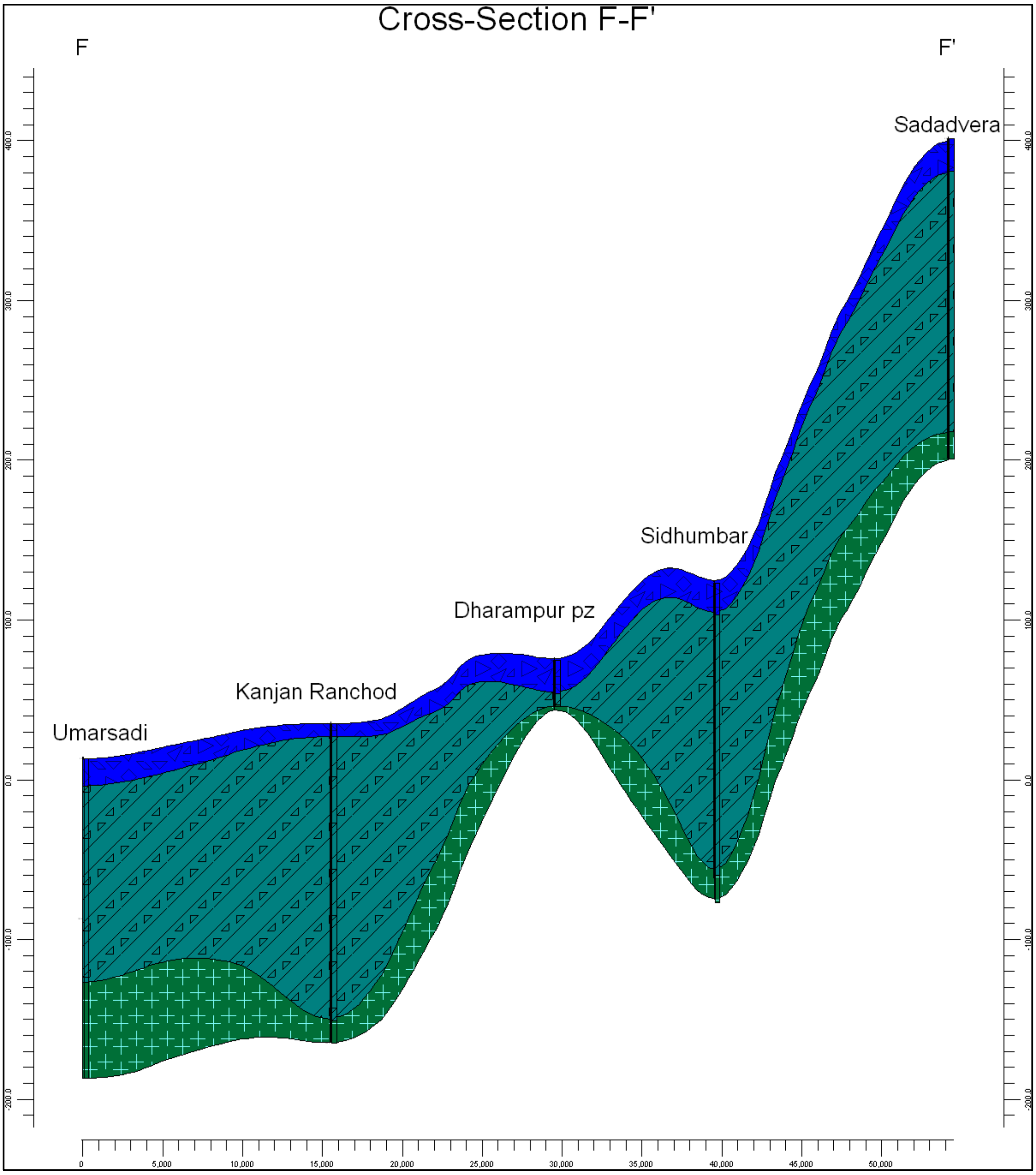


Figure 24 Cross section along F-F'

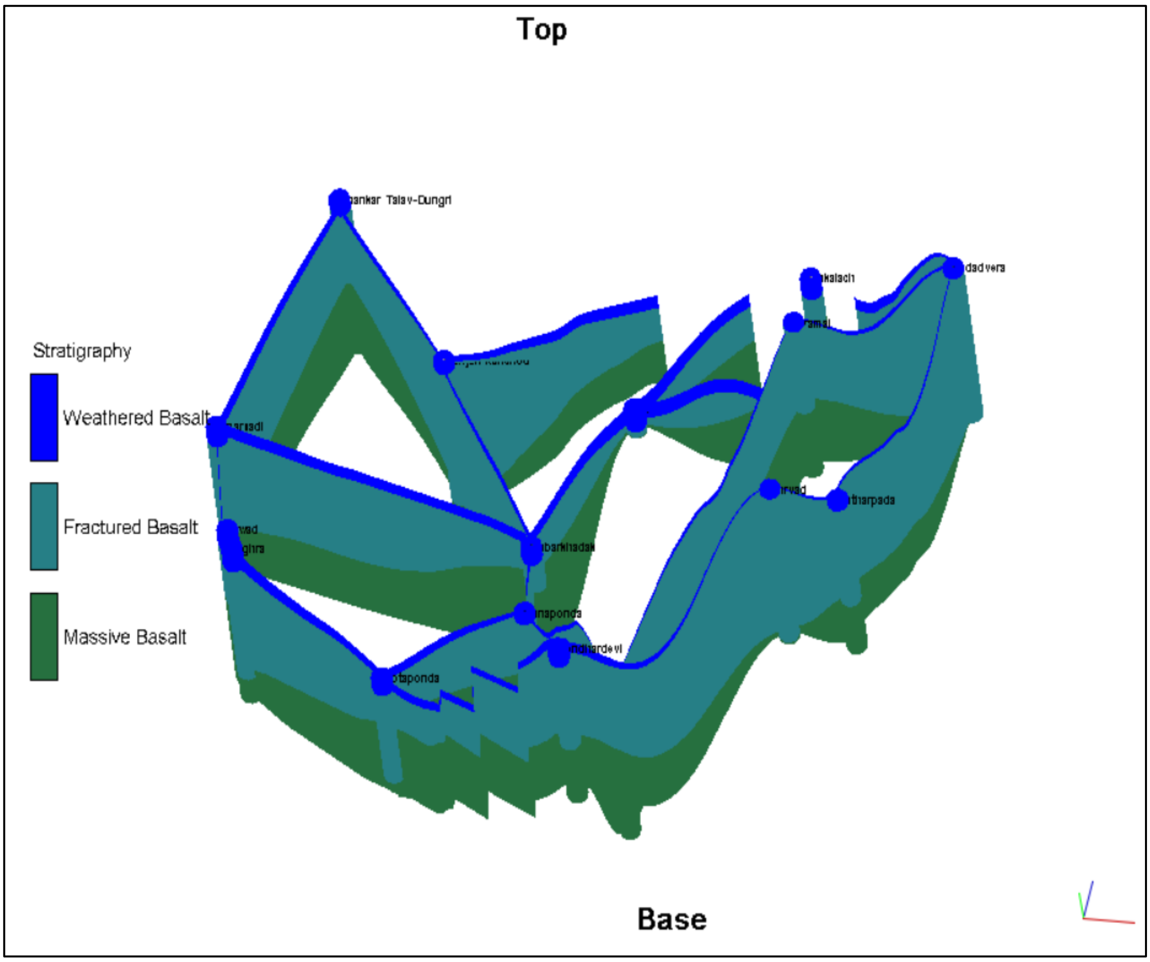


Figure 25 Fence diagram of Valsad District

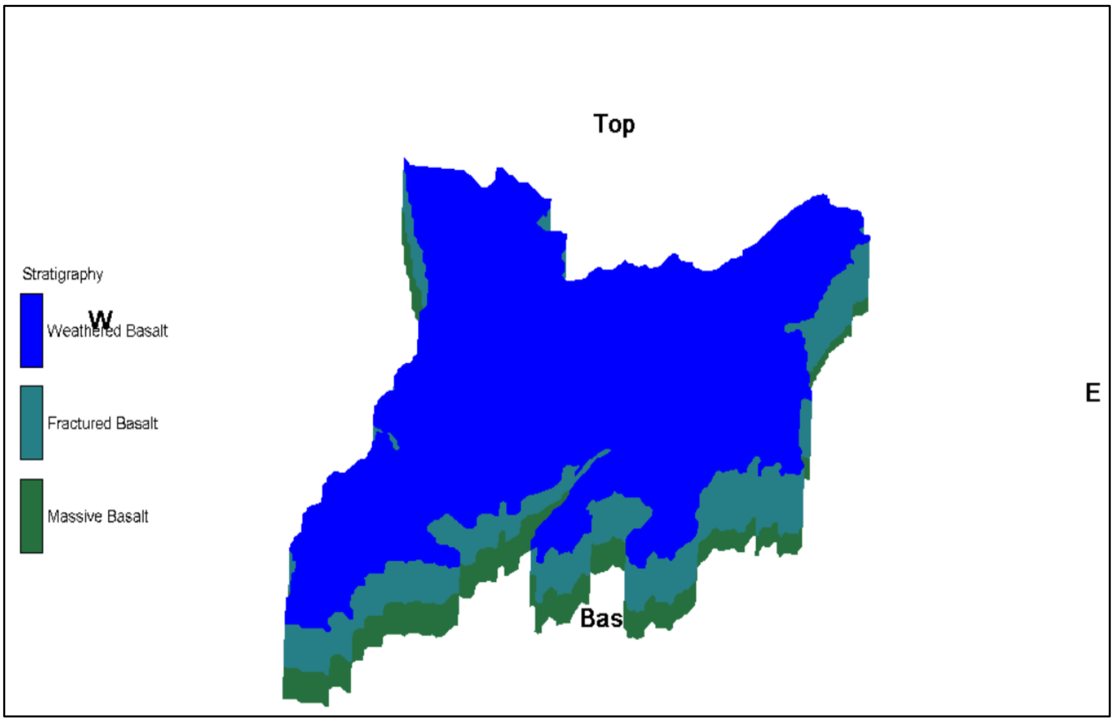


Figure 26 3D Solid Stratigraphic Model of Valsad District

4.3 CONCEPTUALIZATION OF AQUIFER SYSTEM IN 2D

A total of 17 exploratory wells lithologs are utilized to decipher the subsurface geometry of the aquifer by using Rockworks 17 software prepared hydro geological cross sections and 3D Model (Figure 26) up to the depth of 200 mbgl. And six hydrogeological cross sections (2D) are drawn in different direction to cover entire area as per the availability of data point in the district and represented in figure 18 (A-A'), 20 (B-B') to figure 24(F-F').

4.3.1 Section A-A' (Fig. 18)- Section is drawn roughly W-E direction from Umarsadi to Sadadvera, passing through Babarkhadak and Piramal Section, and represented stratigraphically. It is deciphered that Hard rock formation (weathered &fractured) forms the major aquifer sysptem in the district and rested on massive rock along drawn section line.

4.3.2 Section B-B' (Fig. 20) - Section is drawn roughly NW-SE direction and in between Shankar Talav Dungri and Pendhardevi passing through Karjan Ranchhod, Babarkhadak and Khadakvel and Section is represented stratigraphically. From section it is deciphered that that Hard rock formation (weathered & fractured) forms the major aquifer system in the district and rested on massive rock along drawn section line.

4.3.3 Section C-C' (Fig. 21)- Section is drawn roughly SW-NE direction and in between Motaponda and Ankalach, passing through Babarkhadak, Dharampur pz and section is represented stratigraphically. From section it is deciphered that that Hard rock formation (weathered & fractured) forms the major aquifer system in the district and rested on massive rock along drawn section line.

4.3.4 Section D-D' (Fig. 22) - Section is drawn roughly W-E direction and in between Orwad and Sutharpada, passing through Tighra, Motaponda, Khadakvel, Narvad and section is represented stratigraphically. From section it is deciphered that that Hard rock formation (weathered & fractured) forms the major aquifer system in the district and rested on massive rock along drawn section line.

4.3.5 Section E-E' (Fig. 23) - Section is drawn roughly S-N direction and in between Sutharpada and Ankalch, passing through Piramal and Sidhumber, and section is represented stratigraphically, from section it is deciphered that that Hard rock formation (weathered & fractured) forms the major aquifer system in the district and rested on massive rock along drawn section line.

4.3.6 Section F-F' (Fig. 24)- Section is drawn roughly W-E direction in between Umarsadi and Sadadvera, passing through Karjan Ranchod, Dharampur pz and Sidhumbar. From section it is deciphered that that Hard rock formation (weathered & fractured) forms the major aquifer system in the district and rested on massive rock along drawn section line.

4.4 AQUIFER DISPOSITION AND ITS HYDRAULIC CHARACTERISTICS

Phreatic aquifer lies from zero to 90 meter below ground level and water level ranges from 0 to 45.56 mbgl. Quality of water is potable with minimum and maximum EC values are 225 to 3950 microS/cm respectively.

Table 11 Aquifer Characterization And Disposition For Valsad District

Aquifer Characteristics and Disposition					
Stratigraphy	Aquifer Nomenclature	Lithology/ Aquifer material	Occurrence of weathering / fracture (meter) in depth between	SWL (mbgl)	Quality (EC) microS/cm
Upper Cretaceous-Lower Eocene	Unconfined Weathered Basalt	Deccan Basalt	0 & 21	0-45.56 (Weathered and shallow fracture zone)	225-3950
	Fractured Basalt		2 & 90		

CHAPTER V
HYDROCHEMISTRY

5.1 INTRODUCTION

The results of chemical analysis of the ground water samples collected during AAP 2021-22 of key wells established and the ground water network monitoring in Valsad district is tabulated in the Table -14 in entire district as per data.

The ground water in major part of the district is suitable for domestic, irrigation and industrial purposes. Groundwater in the district is in general potable and fresh, both in phreatic and confined aquifers. Map representing Groundwater quality well locations of Valsad district is shown in figure 27.

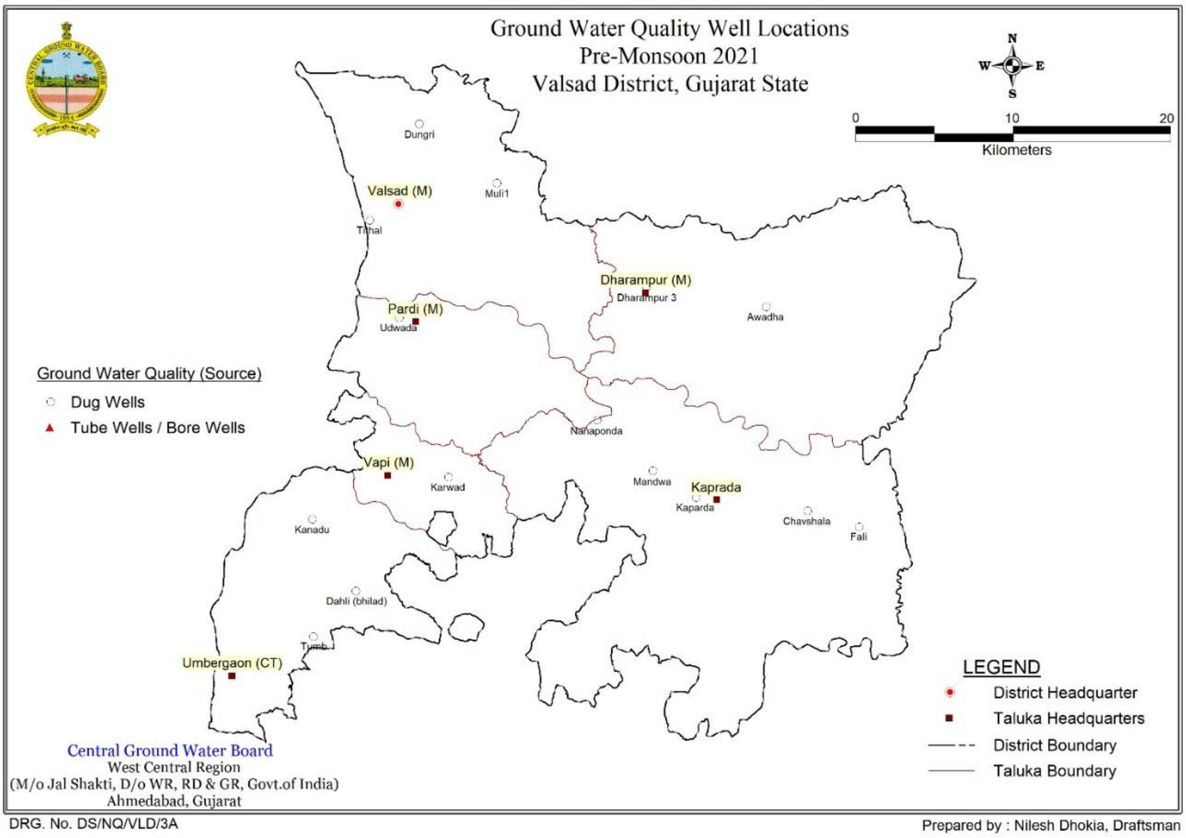


Figure 27 Groundwater Quality Well Locations Of Valsad District

The chemical quality of groundwater of the district has been analyzed based on the water samples collected during National Hydrographs Monitoring Stations (NHS) in pre-monsoon 2021 and Pre-monsoon National Aquifer Mapping field survey form CGWB as presented in **Table-12.**

Table 12 Range of Different Chemical Constituents of Groundwater in Valsad District

Constituents	Unit	Minimum	Maximum	Average
pH		7.14	9.08	8.10095238
EC	µS/cm at 25˚C	225	3950	894.47619
TDS	mg/l	150.75	2646.5	599.299048
CO3		0	168	15.7142857
HCO3		48.8	414.8	214.371429
Cl		14.2	1079.2	150.790476
NO3		0	60	10.5357143
S04		1.36	225	42.3592857
F		0.07	0.92	0.37214286
Alkalinity		60	560	200.952381
Ca		16	152	54.952381
Mg		0	148.352	28.952381
TH		80	990	257.380952
Na		6.14	750	100.235238
K		0.03	30.55	3.78
SiO2		22.33	78.88	46.9092857
SAR		0.217969087	36.45763007	3.33437517

5.2 HYDROGEN ION CONCENTRATION (PH)

The pH is an indicator of acidity of the water. The shallow ground water in the district is generally alkaline with pH more than 7. The value of pH ranges between 7.14 (Bhavada Jagiri) & 9.08 (Tadgam Mangalwad) in the district.

5.3 ISO CONDUCTIVITY MAP

As per the BIS standards [IS 10500: 2012] for drinking water, acceptable limit and permissible limit of Total Dissolve Solid (TDS) are 500 mg/l and 2000 mg/l respectively.

The Electrical conductance of ground water is generally ranges from 225-3950 micromhos/cm at 25°c, for the entire district.

TDS Map of the district shown below in Fig.28, EC in the district is mostly lie within Permissible limit except some small patches.

5.4 TOTAL DISSOLVED SOLID (TDS)

Total Dissolved Solid is an overall parameter indicating salinity of ground water. The

Total Dissolved Solid of ground water varies from 150.75 (Kosimpada) to 2646.5 mg/l (Magod) (Figure 28)

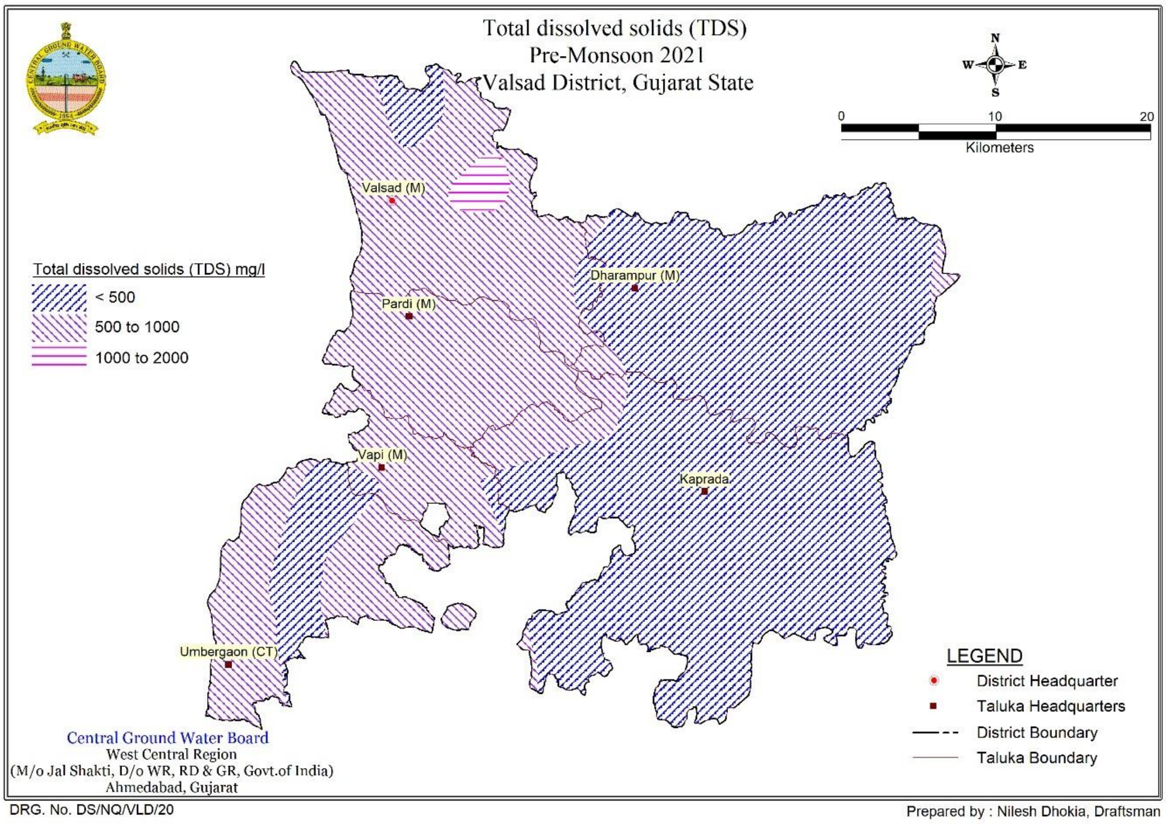


Figure 28 TDS Map Of Valsad District

5.5 CARBONATE (CO3) AND BICARBONATE (HCO3)

The shallow ground water in Jamnagar district does not contain any Carbonate. The carbonate concentration in district is varies from 0 to 168 mg/l and averages at 15.7142857 mg/l. Out of 40 samples 34 samples shows carbonate concentration zero (0), four samples show more than zero to 100 mg/l and two represents more than 100 mg/l.

The Bicarbonate concentration in district is varies in between 48.8 (Eklera) to 414.8 mg/l (Tadgam Mangalwad and Gorgam Ishwar Faliya.

5.6 MAP OF CHLORIDE (CL)

As per the BIS standards [IS 10500: 2012] for drinking water, Acceptable limit and Permissible limit of Chloride (mg/l) are 250 mg/l and 1000 mg/l respectively. It is depicted from the map shown in figure-29, that in major part of district chloride concentration is below 250 mg/l. only small patch in Valsad taluka (6 locations out of 40) shows Cl concentration above 250 mg/l. (figure 36).

Chloride concentration in district ranges from 14.2-1079.2 mg/l as shown in table no 14 above.

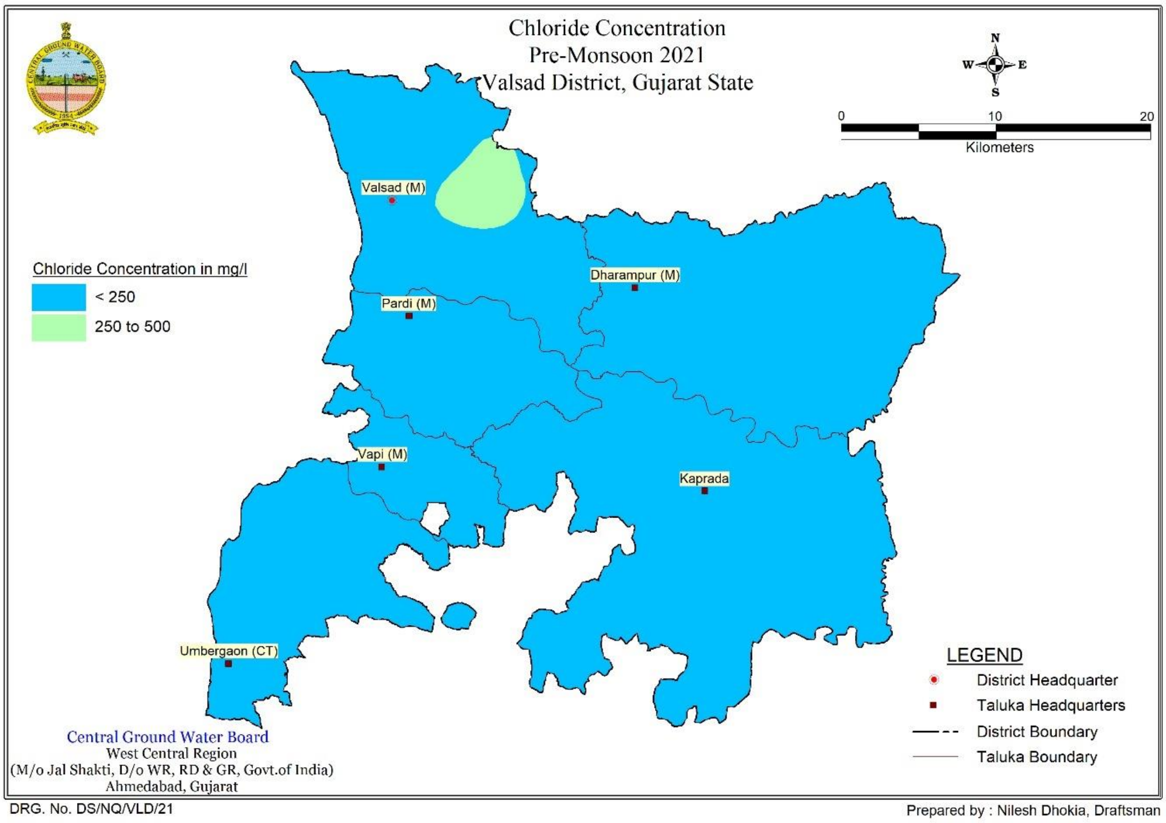


Figure 29 Chloride Concentration Map Of Valsad District

5.7 NITRATE (NO_3)

As per the BIS standards [IS 10500: 2012] for drinking water, acceptable limit is 45 mg/l (maximum) and there is no relaxation in permissible limit.

Nitrate concentration in the ground water in district varies from 0 to 60 mg/l, Out of 40 samples only 2 samples shows Nitrate above 45 mg/l. Minimum Value found in Takuniya (Mandva), Govada, Tumbi, Chasmandava and Max Value in Ghanveri (Figure. 37)

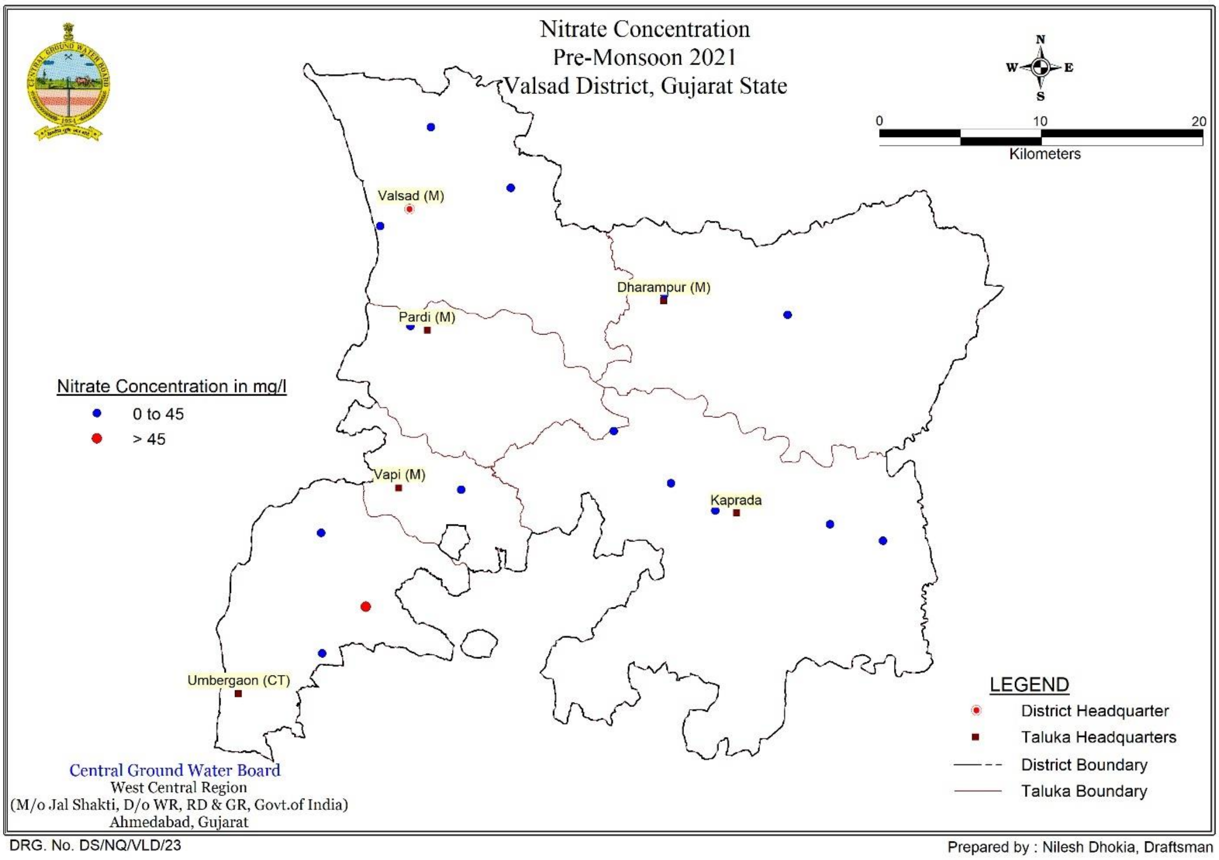


Figure 30 Nitrate Concentration Map Of Valsad District

5.8 SULPHATE (SO4)

In the district, Sulphate concentration varies from 1.36 mg/l (Karvad) to 225 mg/l (Ghotan).

5.9 FLUORIDE (F)

As per the BIS standards [IS 10500: 2012] for drinking water, Acceptable limit and Permissible limit of Fluoride (mg/l) are 1 mg/l and 1.5 mg/l respectively. Fluoride concentration in Jamnagar district ranges from 0.07 to 0.92 mg/l. All samples fall within permissible range (Figure 31)

5.10 CALCIUM (CA)

Calcium concentration in district varies between 16 mg/l and 152 mg/l. The concentration of calcium is found within permissible limits in the entire district (permissible limit as per BIS norms is 200 mg/l).

5.11 MAGNESIUM (MG)

The Concentration of Magnesium in areas ranges from 0 mg/l (Eklera and

Valsad) to 148 mg/l (Magod). The concentration of magnesium is found within permissible limits in the entire district except in one location that is Magod (Permissible limits of

Magnesium of 100 mg/l -as per BIS norms).

5.12 SODIUM (NA)

Sodium concentration in the district varies between 6 mg/l (Chasmandava) and 750 mg/l (Tadgam Mangalwad).

5.13 POTASSIUM (K)

The concentration of Potassium in shallow ground water ranges from 0.030 mg/l (Karambeli) to 31 mg/l (Valsad (Lilapore)).

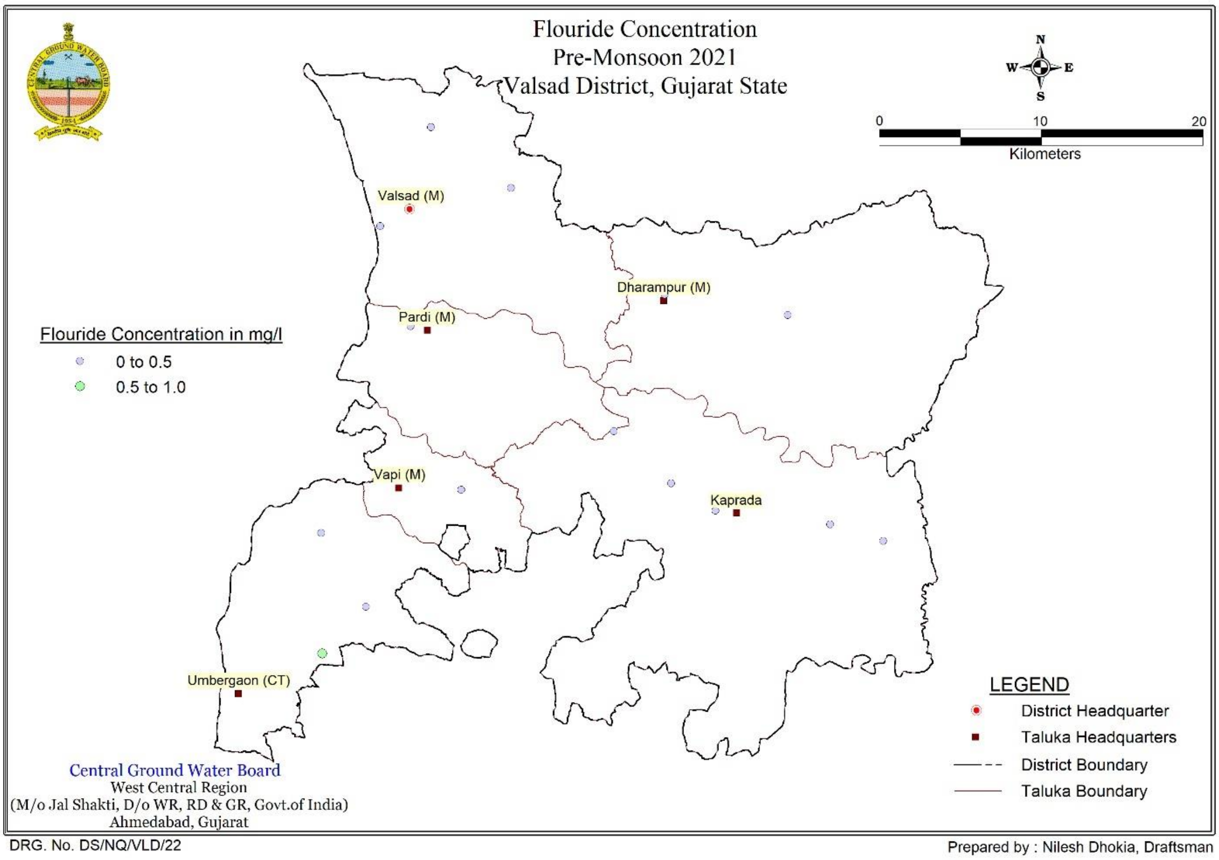


Figure 31 Fluoride Concentration Map Of Valsad District

CHAPTER VI
GROUND WATER RESOURCE POTENTIAL

The ground water resources of the district were calculated as on March 2020 in collaboration with the Government of Gujarat using the GEC-2015 methodology suggested by Ground Water Resource Estimation Committee (GWRE-20**17**). These resources were computed after reorganization of the districts, talukas of the district are considered as Assessment Units (AU) and total area of 3256 sq km are taken as area of assessment of the district including 06 talukas. It may be observed from the Table Number 15 that all the assessment units (Talukas) fall under safe category and the stage of ground water development of the district is 30.62%.

As per GWRE 2020 the total dynamic ground water resources of the district was in the order of 60801.57 ham/year. The net annual draft of 18619.1 ham year leaves a balance of 41513.84 ham/year of ground water available for future development. The stage of ground water extraction all over the district is low (30.62 %) and there is good scope for further ground water development.

Computed resource are presented in tabulated form below in Table Number 13.

Table 13- Taluka Wise Ground Water Resources, Availability, Utilization And Stage Of Ground Water Development.

Taluka Wise Ground Water Resources, Availability, Utilization and Stage of Ground Water Development (2020)																
District: VALSAD																
Sr. No.	Taluka	ANNUAL REPLENISHABLE GROUND WATER RESOURCE(Ham)					Natural Discharge during non-monsoon season (mcm) (5 % of 7 WTF &10 % RIF)	Net Annual Ground Water Availability (Ham) (7- 8)	ANNUAL GROUND WATER DRAFT (Ham)				Annual GW Allocation for Domestic Use as on 2025 (Ham)	Net Ground Water Availability for future use (Ham)	Stage of Ground Water Development (%) (13/9) * 100	Category
		Monsoon		Non-Monsoon		Total Annual Ground Water Recharge (3+4+5+6)			Irrigation	Industrial uses	Domestic uses	Total (10 +11+12)				
		Recharge from rainfall	Recharge from other sources	Recharge from rainfall	Recharge from other sources											
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	DHARAMPUR	11668.64	904.96	0	1134.35	13707.95	1370.8	12337.15	3147.5	0	615.05	3762.55	693.85	8495.8	30.5	safe
2	KAPRADA	13609.57	637.45	0	1133.64	15380.66	1538.06	13842.6	1670.6	0	745.45	2416.05	840.97	11331.03	17.45	safe
3	PARDI	12178.94	348.18	0	1333.62	13860.74	1386.07	12474.67	1521.6	15.7	1525.35	3062.64	1720.79	9216.59	24.55	safe
4	UMERGAM	6457.78	209.29	0	1124.01	7791.08	779.11	7011.97	1252.4	0	738.08	1990.48	832.65	4926.92	28.39	safe
5	VALSAD	9623.57	936.75	0	2205.46	12765.78	638.29	12127.49	5393.6	40.15	953.22	6386.97	1103.15	5618.39	52.67	safe
6	VAPI	2695.57	112.36	0	533.94	3341.87	334.18	3007.69	359.1	0	641.32	1000.41	723.49	1925.11	33.26	safe
District: Total		56234.07	3148.99	0	7465.02	66848.08	6046.51	60801.57	13344.8	55.85	5218.47	18619.1	5914.9	41513.84	30.62	safe

6.1 GROUND WATER RECHARGE

Total Annual Ground Water Recharge from Rainfall and other sources for both monsoon and non-monsoon season for the district is 66848.08 ham. And ground water recharge in talukas varies from 15380.66 ham (Kaprada) to 3341.87 ham (Vapi).

6.2 NET GROUND WATER AVAILABILITY

Annual Extractable Ground Water Resource/ Net Ground Water Availability of the district is 60801.57 ham which computed after deducting total natural discharge of 6046.51 ham from total annual ground water recharge.

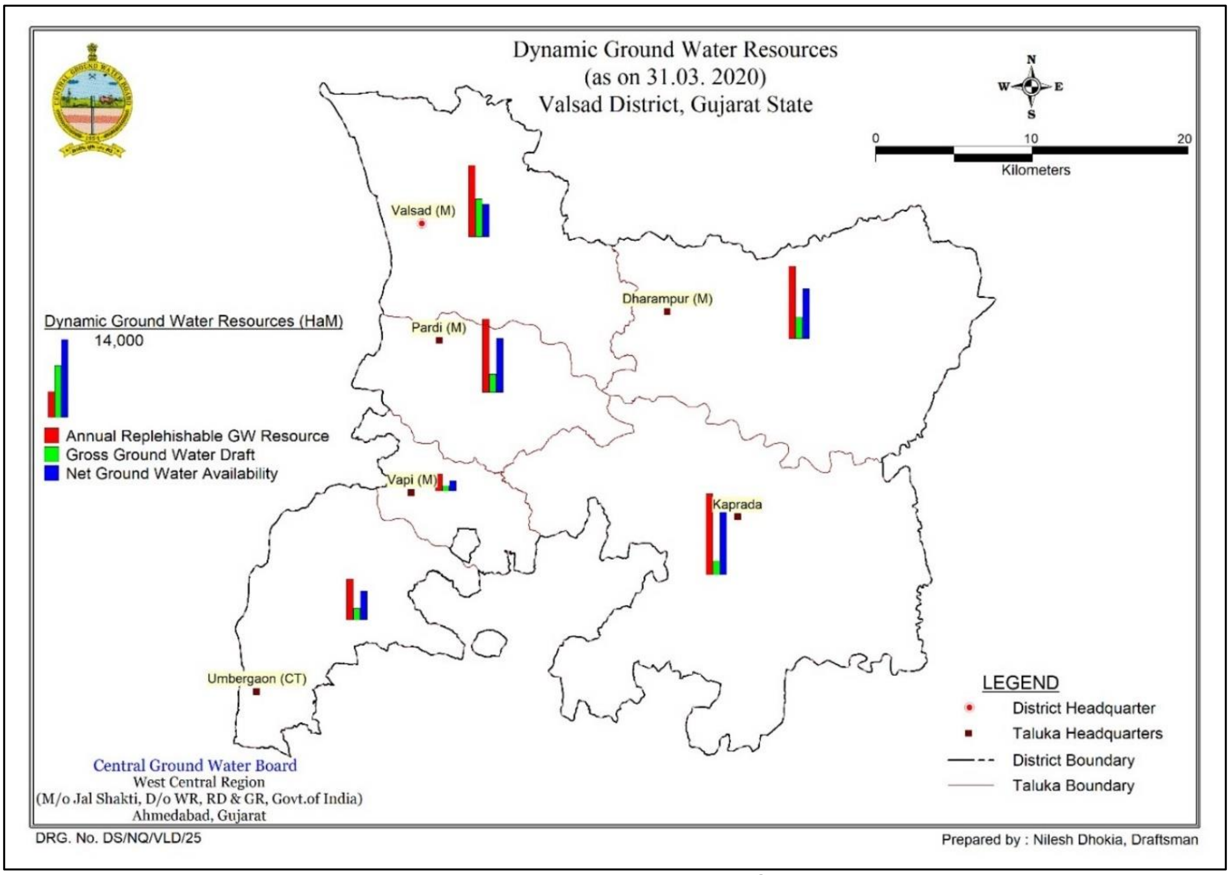


Figure 32 Dynamic Groundwater Resources Of Valsad District 2020

6.3 ANNUAL GROUND WATER DRAFT

The gross ground water draft for all uses (i.e., Irrigation, Domestic and Industrial uses) in the district is 18619.1 ham. The existing gross ground water extraction for all uses varies from 6386.97 ham (Valsad taluka) to 1000.41 ham (Vapi Taluka). Approximately 99.7 % of ground water extraction is used for irrigation & domestic purposes (Irrigation 71.67%, Domestic 28.02 %) and remaining 0.3% are being extracted for Industrial purposes (very less).

6.4 Annual GW Allocation for Domestic Use as on 2025 (Ham)

The total projected demand of ground water for Domestic and Industrial uses in the district is 59.23 mcm. Projected demand for domestic uses varies from 7.23 mcm

(Vapi) to 17.20 mcm (Pardi taluka).

6.5 GROUND WATER AVAILABILITY FOR FUTURE USE

Net ground water availability for future use in the district is 41513.84 ham. Taluka wise it varies from 11331.03 ham (Kaprada taluka) to 1925.11 ham (Vapi taluka).

6.6 STAGE OF GROUND WATER EXTRACTION

As per the Ground Water Resource Estimation (GWRE-2020), the stage of Ground Water extraction of the district is 30.62% which categorized as Safe. Whereas in taluka it varies varies from 52.67 % (Valsad taluka) to 17.45% (Kaprada taluka) and all the 06 talukas of the district are categorized as SAFE.

CHAPTER VII
GROUNDWATER RELATED ISSUES

7.1 INTRODUCTION

I. In overall district stage of groundwater development is below 70%.
II. Overall dependency of agriculture on groundwater (94%).
III. Uniformity in pumping pattern is required.
IV. People need to be aware of the aquifer system existing in the area.
V. Demand vis-a vis supply management.
VI. Awareness among local people regarding water conservation measures required.

7.2 LOW GROUND WATER DEVELOPMENT

All talukas of district have low ground water development i.e., under 70%. Controlled development may be started in supervision of official to provide water for the creation of irrigation potential to uplift the economic status of the farmers.

7.3 SUSTAINABILITY

Most part of the district has secondary porosity in the form of weathered & fractured rock which forms the good repository or major aquifer of groundwater. Yield in these formation varies from very low yield. The yield from bore wells have reduced in a lean period, recoupment time in some phreatic aquifer is very low that's the reason people residing there constructed large daimeter of well for maximum storage.

7.4 REASONS FOR ISSUES

Absence of primary porosity and very low development of secondary porosity, de-saturation of weathered zone and permeability and low groundwater extraction.

CHAPTER VIII
SUSTAINABLE GROUNDWATER DEVELOPMENT AND PARTICIPATORY GROUND WATER MANAGEMENT

8.1 INTRODUCTION

Objectives of Participatory Ground Water Management (PGWM) are Capacity Building of farmers and ground water users for efficient monitoring of ground water regime, Capacity building of groundwater using farmers for increasing water use efficiency and Efficient management of groundwater and informed decision making on cropping pattern and application of water at a collective level so as to benefit all groundwater user farmers.

The outputs that are expected to accrue from PGWM are as follows-

I. Enhanced capacity of the farmers in utilizing groundwater efficiently Increased groundwater use efficiency in irrigation.
II. Sustainable exploitation and stabilization of the groundwater by adopting a suitable cropping pattern.

8.2 MANAGEMENT STRATEGIES

Predominantly, district is covered by Deccan basaltic rocks. Mainly groundwater occurs in weathered basalt connected with small fractures. In view of the favorable geological, geomorphic and tectonic setup, there exists vast scope for large scale development of ground water resources by dug wells (20m depth). Groundwater quality in terms of Salinity is major issue in district. EC value varies from 225 to 3950 micro-Siemen/cm. Strategy for regular monitoring for planned development and pollution control with adequate enforcement directive is essential to prevent occurrence of pollution incident in future. The central part of the district is highly industrialized. Periodic monitoring of ground water along with quality should be mandatory for post-monsoon and pre-monsoon.

As per master plan of Artificial recharge to India 2020, area identified for artificial recharge (AR) in district is 14.66 km^2, volume of unsaturated zone is 43.98 mcm, available subsurface space for AR is 1.32 mcm, water required for recharge is 1.76 mcm and surplus available for recharge is 497.87 mcm.

8.3 MANAGEMENT PLAN

The uneven distribution of groundwater availability and its utilization indicates that a single management strategy cannot be adopted and requires integrated hydrogeological aspects along with socio-economic conditions to develop appropriate management strategy. The study suggests notable measures for sustainable groundwater management, which involves a combination of various measures given below.

I. Supply side measures
II. Demand side measures
III. Regulatory measures
IV. Institutional measures

8.3.1 Supply Side Measures

8.3.1.1 Artificial Recharge to ground water and Water conservation plan

As per Master plan 2020 for Artificial Recharge to Ground Water in Gujarat state, 497.87 MCM of surplus surface water is provisioned for artificial recharge through various recharge structures in Valsad district whereas available subsurface space for AR is only 1.32 mcm for this only 1.76 mcm water is required for recharge.

8.3.1.2 Identification of Areas Feasible for Managing Aquifer Recharge

There are two major water hydrogeological units bearing geological formations occurring in the district have been categorized broadly in two hydrogeological units, namely, Weathered& Fractured Basalt of Deccan traps. The thickness of available unsaturated zone (below 6 m bgl) is computed on basis of Post monsoon (2012-21) decadal average depth to water level map (Figure no 34) and Similarly, Post monsoon (2012-21) decadal water level trend map of Valsad District is presented in hydrogeology chapter above (Chapter no 3). On basis of these two maps, area suitable for artificial recharge in Valsad District is identified taking into consideration of following four categories, and presented as figure 37.

District is having total area of 3055 Square Km. The geological formations in the area are mainly Basaltic formation. The average post monsoon water level (2012-2021) ranges from less than 6.00 to 30 m below ground level. The trend of post monsoon water level show both rising and decline trend in the entire district. The quality of ground water in the major part of the district is having TDS less than 2500 mg/l. The area feasible for artificial recharge is the area where groundwater level is below 6 m bgl and quality of water is fresh (TDS< 2500 mg/l) as shown in Fig. 37.

It is estimated that an area of 908.37 km^2 having depth to water table more than 6 m below ground level is feasible in which total volume of vadose zoneof this area is 2250.51 mcm (Table - 1). Further in an area of 108.61 km^2 the area is under decline trends and volume of vadose zone in this area is 54.30 mcm (Table - 14). Thus, the total volume of de-saturated zone feasible for recharge in the basin is 162.91 mcm. Considering the co-efficient of replenishment of different formations, it isestimated that around 26.99 mcm of water is required to recharge to bring the water level up to 6.00 m and it is estimated that around 4.31 mcm of water is required to control annual depletion. Taluka wise in different formations, the requirement of water is computed and shown in table 15. Thus, total volume of water requirement is 31.30 mcm in district.

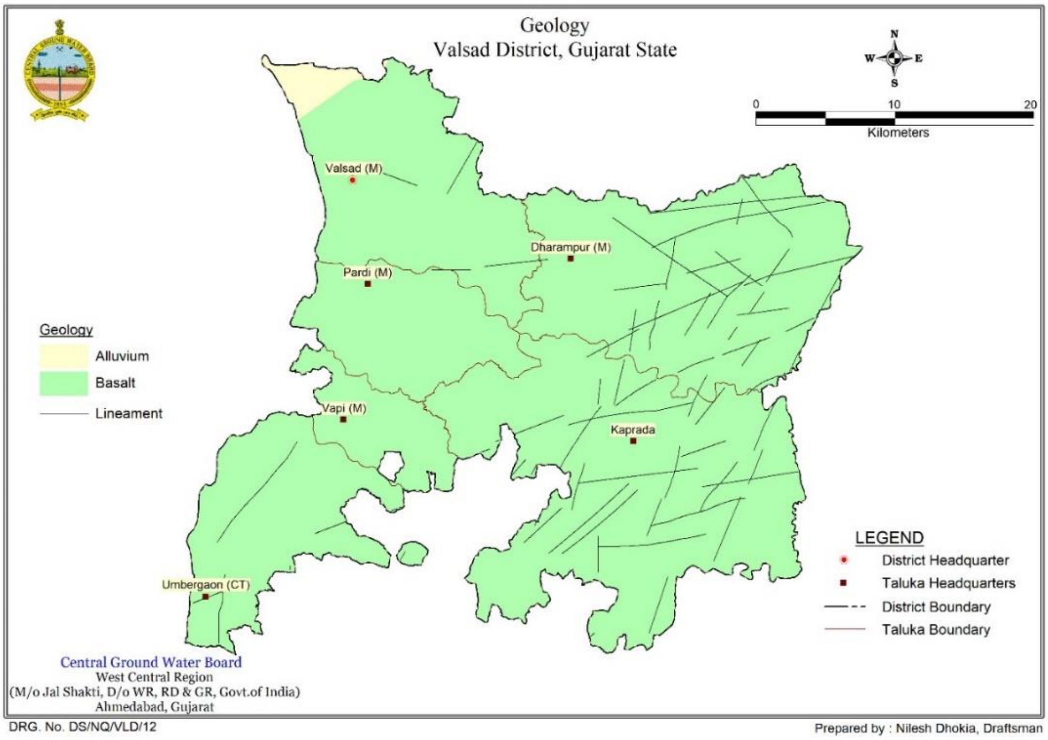


Figure 33 Aquifer disposition in Valsad district, Gujarat

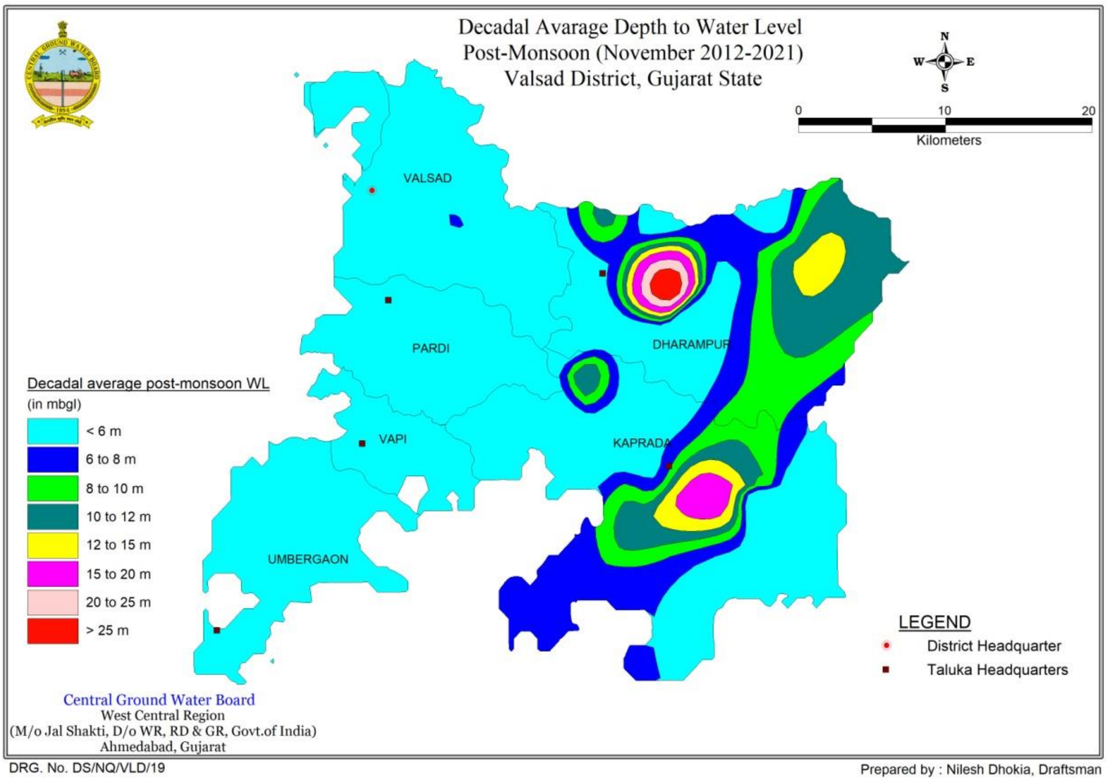


Figure 34 ***Decadal average post-monsoon depth to water level from the period of Nov 2012 to 2021.***

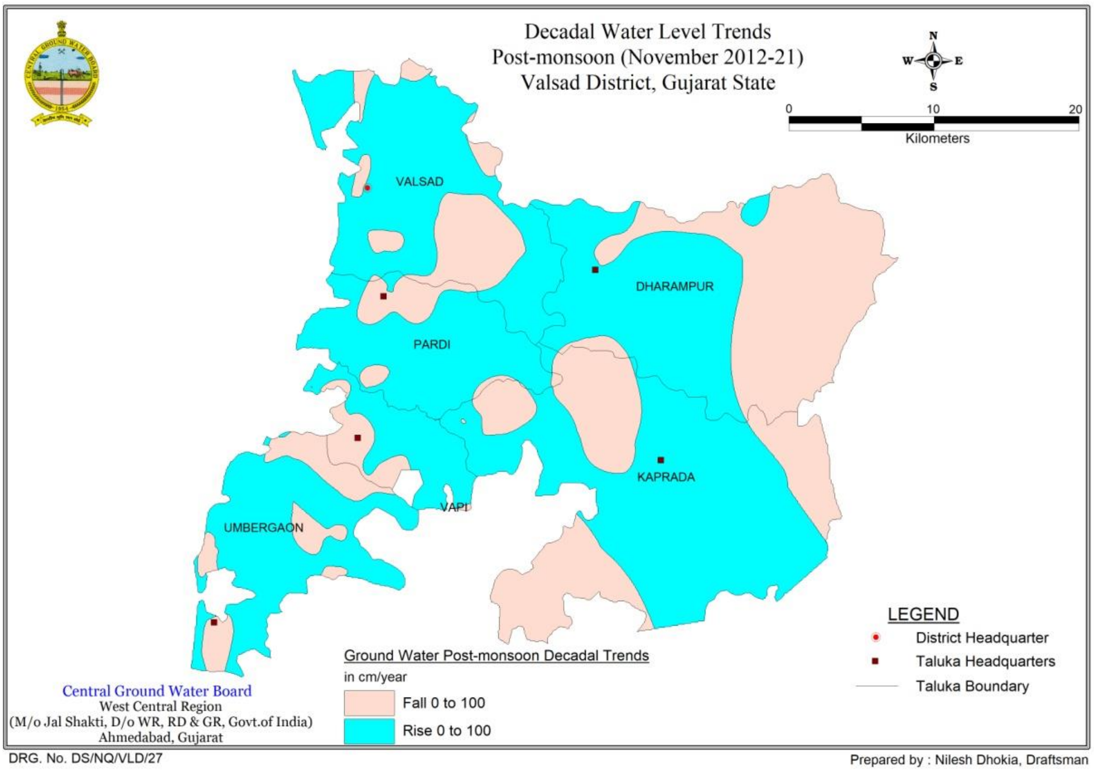


Figure 35 ***Post monsoon groundwater trends in year 2012 to 2021***

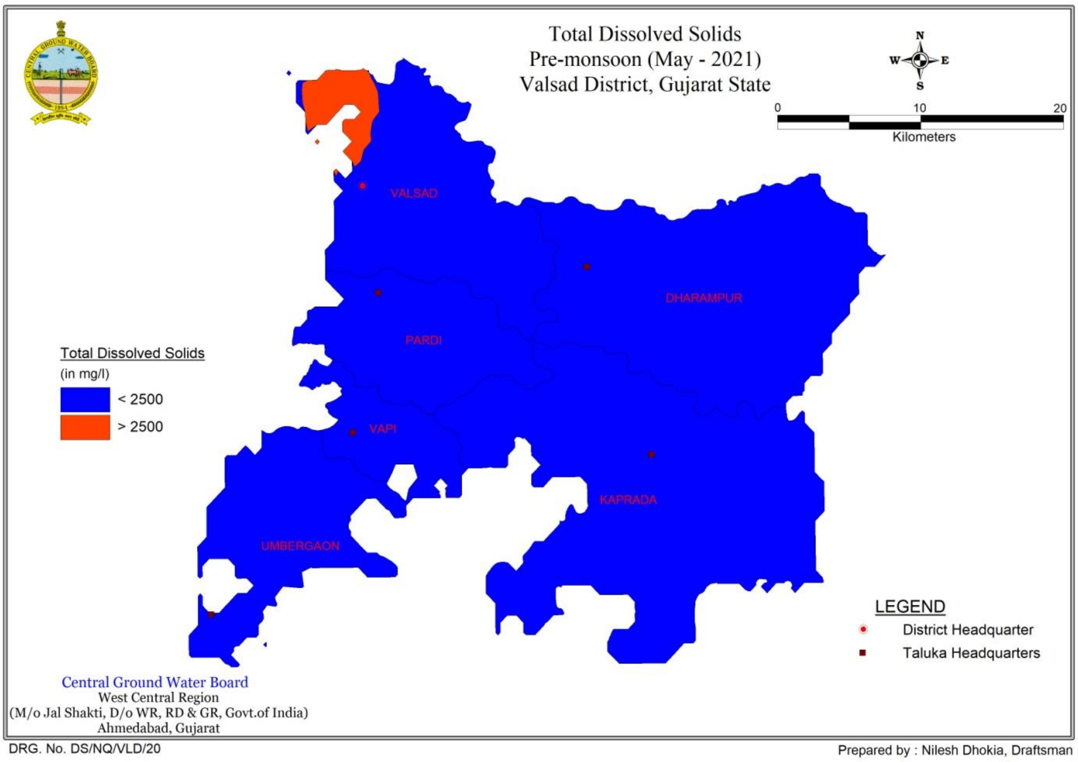


***Figure 36* Distribution of Total dissolved solids in groundwater in year May 2021.**

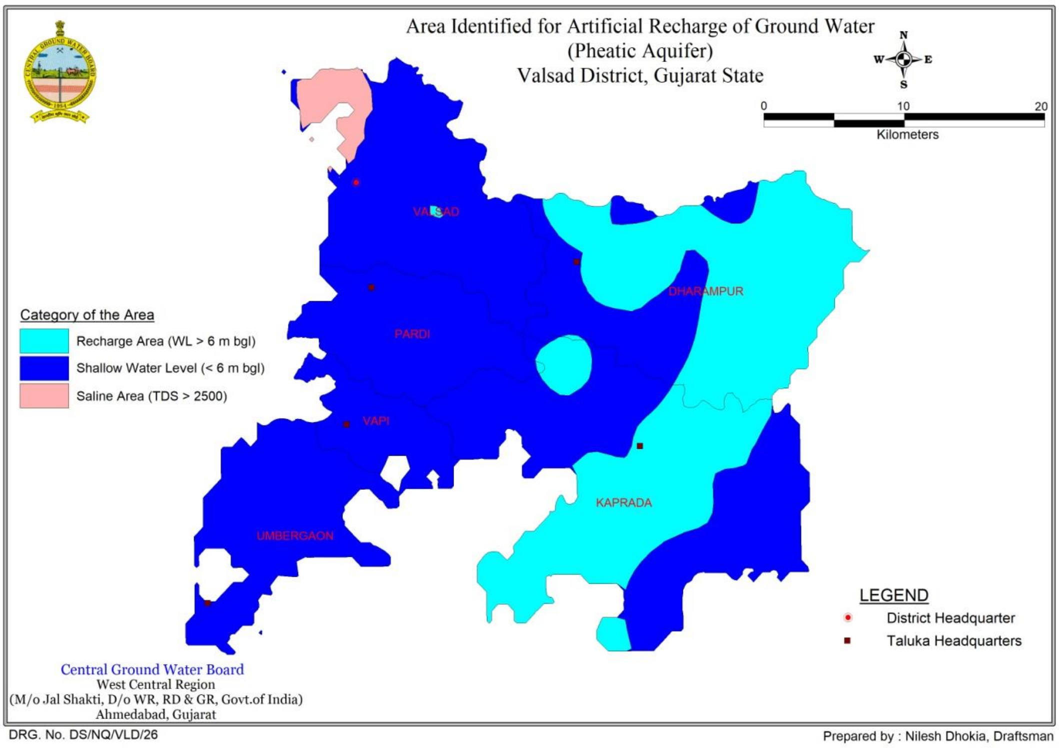


***Figure 37* Area suitable for recharge**

Table 14 Computation of feasible zones for Artificial recharge in Basaltic formation.

Taluka	WL Range	Average thickness m	Area of Vadose zone in sq. km in Basalt	Volume of vadose zone MCM in Basalt
DHARAMPUR	6 to 8	1	126.25	126.25
DHARAMPUR	8 to 10	2	139.46	278.92
DHARAMPUR	10 to 12	3	156.34	469.02
DHARAMPUR	12 to 15	4.5	38.26	172.19
DHARAMPUR	15 to 20	7	14.83	103.8
DHARAMPUR	20 to 25	9.5	11.79	112.05
DHARAMPUR	25 to 30	12	9.46	113.49
Total			496.4	1375.72
KAPRADA	6 to 8	1	202.7	202.7
KAPRADA	8 to 10	2	89.13	178.27
KAPRADA	10 to 12	3	64.13	192.39
KAPRADA	12 to 15	4.5	30.31	136.39
KAPRADA	15 to 20	7	23.22	162.53
			409.49	872.28
PARDI	6 to 8	1	0.92	0.92
PARDI	8 to 10	2	0.04	0.07
			0.96	1
VALSAD	6 to 8	1	1.52	1.52
Grand Total			908.37	2250.51

Table 15 Area with declining trends- feasible for recharge in basalt

Taluka	WL trends cm/year	Average thickness of desaturation in m	Area in sq. km	Volume of vadose zone in (MCM)
DHARAMPUR	0 to 100	0.5	366.25	183.13
KAPRADA	0 to 100	0.5	302.71	151.36
PARDI	0 to 100	0.5	49.13	24.57
VALSAD	0 to 100	0.5	108.61	54.3

Table 16Groundwater storage potential in de-saturated zone to be used for storage upto 6 meter below ground level in Basaltic formation

Sr. No	Description	DHARAMPUR	KAPRADA	PARDI	VALSAD	Total
1	Volume of the vadose zone (mcm)	1375.72	872.28	1.00	1.52	2249.00
2	Clay Content (%)	-	-	-	-	-
3	Volume of Clay in the vadose zone (mcm)	-	-	-	-	0.00
4	Net Volume of formation in de-saturated zone (mcm)	1375.72	872.28	1.00	1.52	2249.00
5	Average Sp. Yield of the formations	0.01	0.01	0.01	0.01	-
6	Average co-efficient of Replenishment of the formations	0.012	0.012	0.012	0.012	-
7	Volume of water required for recharge in de-saturated zone (mcm) (4 x 6)	16.51	10.47	0.01	0.02	26.99
	Ground water storage potential in the annually declining zone					
1	Volume of annually declining zone (mcm)	183.13	151.36	24.57	54.30	25.21
2	Clay Content (%)	-	-	-	-	-
3	Volume of Clay in the annually declining zone (mcm)	-	-	-	-	-
4	Net Volume of formation to arrest declining trend (mcm)	183.13	151.36	24.57	54.30	359.06

5	Average Sp. Yield of the formations	0.01	0.01	0.01	0.01	-
6	Average co-efficient of Replenishment of the formations	0.012	0.012	0.01 2	0.012	-
7	Volume of water required for recharge to control annual Depletion (mcm) (4 x 6)	2.20	1.82	0.29	0.65	4.31
	Total Volume of water required for recharge (mcm)	18.71	12.28	10.7 6	0.67	31.30

Dharampur and Kaprada talukas are identified for artificial recharge because all other talukas show water level below 6 mbgl. Ground water recharge of 132 hams is expected for the district as show in table 9.

Only Dharampur and Kaprada talukas shows water level below 6 meters from ground level, therefore artificial recharge plan is proposed for these two talukas only.

Table 17 Proposed Artificial Recharge and WUE Interventions in** Valsad **District

Table-: Proposed Artificial Recharge and WUE Interventions in Valsad District		
Block	Recharge through Check dams and Percolation tanks Ham	On farm activities (proposed in 30 % of total groundwater irrigated area) (in ha)
Dharmpur	648.08	671
Kaprada	677.08	657
Pardi	0	1798
Umargam	0	1132
Valsad	0	3434
Vapi	0	778
Valsad District	1325.16515	8470

8.3.1.3 Ground water Development Plan

As per GWRE 2020 all 06 blocks of Valsad district fall under safe category. Ground water stage of development ranges from 17.45 % (Kaprada) to 52.67 % (Valsad). To elevate the stage of ground water development in all blocks, 1125 no Dug wells (20 m depth) and 775 no Bore wells in Hard rock are proposed as feasible extraction structures.

8.3.1.4 Additional irrigation potential creation with safe groundwater development

The extraction structures will result in additional ground water draft of 1355 hams which will create 2710 Ha additional irrigation potential for the district. (Table 17 and 18)

Table 18- Feasible Extraction Structures to Elevate the Stage of GW Development (Hard Rock)

Talukas	Feasible Extraction structures to elevate the Stage of GW development (Hard Rock)			G.W Draft from Extraction structures (ham)	Additional Irrigation Potential Created (Ha)
	TW	DW	Total		
Dharmpur	0	0	0	0.00	0
Kaprada	0	0	0	0.00	0
Pardi	325	425	750	460.00	920
Umargam	275	375	650	530.00	1060
Valsad	175	325	500	365.00	730
Vapi	0	0	0	0.00	0
Valsad District	775	1125	1900	1355.00	2710

8.3.2 Demand Side Measures

Total 8470 hac area is proposed for on farm activities (Laser levelling/Bench terracing/Contour banding). Ground water recharge of 559 ham (through on farm activities and GW return flow) is expected for the district

8.3.3 Regulatory Measures

Unlike several countries, India does not have any separate and exclusive water law dealing with all water resources and covering all aspects. Instead, the water related legal provisions are dispersed across various irrigation acts, central and state laws, orders/decrees of the courts, customary laws and various penal and criminal procedure codes. As a result, understanding of the exact legal position with respect to ground water becomes rather cumbersome. Moreover, India does not have any explicit legal framework specifying water rights.

The Supreme Court of India has, however, reinterpreted Article 21 of the Constitution of India to include the right to water as a fundamental right to life. The Easement Act of 1882 made all rivers and lakes the absolute right of the state. But as per the provisions of the Easement Act 1882 as usually understood and the Transfer of the Property Act of 1882, a land owner is supposed to have a right to ground water beneath his land as it is considered as an easement of the land. So, the land owners own the ground water on their lands.

The Water (Prevention and Control of Pollution) Act, 1974 was passed by the Parliament in 1974 for prevention of pollution of water due to discharge of liquid effluents from industries. Subsequently, another Act Namely Water (Prevention and Control of Pollution) Cess Act 1977 was enacted for enabling the effective implementation of the earlier Act. All the states adopted the Act by 1990 and State Pollution Control Boards of the respective, states were inter alia set up under the Act.

The Environment (Protection) Act (EPA), 1986 was passed by the Union Parliament in 1986 and was notified by the Union Ministry of Environment and Forests. This Act covers different areas of "environment" including water as well as items interrelated to water.

8.3.4 Institutional Measures

Central Ground Water Authority was set up on 14th January, 1997 by the Ministry of Environment and Forests, Government of India in pursuance of an order of the Hon'ble Supreme Court of India dated 10th December, 1996 on a PIL. Authority has been established under sub-section (3) of Section 3 of the Environment (Protection) Act, 1986. Currently Central Ground Water Authority is run by Ministry of Jal Shakti Government of India. The Authority has been empowered to exercise the powers and perform the following functions: - (i) Exercise powers under Section 5 of the Environment (Protection) Act, 1986. The Authority can issue directions in writing to any person, officer or any Authority and such persons, officer or Authority shall be bound to comply with such directions. For example – The Authority has power to direct the closure, prohibition or regulation of any industry or process and also the stoppage or regulation of the supply of electricity or water or any other service. (ii) To resort to the penal provisions contained in Section 15 to 21 of the Environment (Protection) Act, 1986. In Sections from 15 to 21 of the Act, it has been summarized that penalty should be levied in avoidance of the rules, orders and directions of the Act. Also, if this offence is done by companies or Government Departments, every person, who at the time the offence was committed, was responsible and also the company or Govt. Department should be punished accordingly. Also, the Central Govt. may ask from time to time, to the concerned officer, State Government or the authority to furnish the required information, report etc. All the members, officers and employees of such authority working under this Act shall be deemed to be public servants. (iii) To regulate indiscriminate boring and withdrawal of ground water in the country and to issue necessary directions with a view to preserve and protect the ground water.

Areas of Activities of CGWA to achieve the mandate, the Authority have divided its functions into following mentioned four sub-heads. These are detailed as follows.

(a) Regulation of ground water:

(i) Extraction of ground water development

(ii) Construction of wells

(iii) Registration of ground water abstraction structures

(iv) Performance of business of drilling wells

(v) Sale of ground water

(b) Conservation of ground Water Conservation and artificial recharge of ground water including roof-top run-off harvesting storm water recharge and by other means etc.

(c) Protection of ground water:

(i) Protection of ground water quality deterioration from disposal of urban and industrial wastes.

(ii) Management of ground water in coastal aquifers.

(iii) Clearance of solid & liquid waste disposals sites.

(iv) Clearance for setting up of ground water-based industries.

(d) Mass Awareness: Promotion of education & Mass Awareness Programmes.

Detailed literature, in local language, should be published on ground water conditions. Mass contact functions should be organized involving the administration, political persons, schools and the users in the affected area. Operational Modalities the Authority has taken a decision that instead of adopting a policy strategy, it should adopt a pro-active approach and sensitize persons and users at the different levels with regard to need for judicious use and scientific management of ground water.

The Authority has, therefore, decided to adopt the following plan of action.

1. Organize mass awareness programmes involving the users and NGOs to explain the objectives of the notification of any area.

The effort shall involve:

(i) Preparation and issue of literature in local languages,
(ii) Establish one to one contact by involving voluntary agencies, and
(iii) Education through schools, etc.

2. Issue of messages through news, media for seeking cooperation of the people in the effort.

3. Organize activities like registration of wells, grant of permission for the replacement of the existing or the construction of new wells, organizing roof-top rain water harvesting without causing any inconvenience to the people.

4. Issue insertions through electronic display boards,

5. Production of films, etc.

6. Issue of notices to offenders giving them sufficient time to explain their position and take corrective actions.

7. Personal hearing before imposition of penalties.

To regulate indiscriminate boring and withdrawal of ground water in the country and to issue necessary regulatory directions with a view to preserve and protect the ground water.

8.4 SUMMARY OF INTERVENTIONS AND EXPECTED BENEFITS AND COST ESTIMATES FOR VALSAD DISTRICT

Total 1125 no's of Dug wells and 775 nos of bore wells are proposed to be constructed. In addition to those 205 nos of Check dams and 195 Percolation tanks and in 8470 hac area on-form activities to be completed. Ultimately it will provide 2710 ham additional irrigation potential for entire district and stage of groundwater extraction also to be under safe category. Over view of this is presented in below given table no 19 & 20.

Table 19 Summary of Interventions and Expected Benefits and Cost Estimates for Valsad District

Summary of Interventions and Expected Benefits	
Interventions Recommended	
Check Dams	205 Nos.
Percolation Tanks	195 Nos
On-farm activities	8470 hac
Groundwater Development (Feasible Extraction Structures to elevate the stage of GW Development)	
Dug wells	1125
Tube wells	775
Expected Benefits	
Expected Annual Recharge (ham)	2039.37
Total Recharge/ Saving (ham)	2039.37
Additional Irrigation Potential Created (Ha)	2710

Table 20-Projected Status of Groundwater Resource After Implementation of GW Management Plan, Valsad District (Gujarat)

Talukas	Net G.W. Availability (Ham)	Additional Recharge from Recharge interventions (ham)	Additional Recharge from RTRWH (ham)	Additional Recharge from Return flow of GW Irrigation	Total Net G.W. Availability after intervention (Ham)	Existing G.W Draft for all purpose (ham)	Conservation of Ground water through Supplemental irrigation (ham)	Conservation of Ground water through WUE, on farm activity & Sprinkler/Drip Irrigation (ham)	G.W Draft from Extraction structures (ham)	Net GW draft after interventions (ham)	Present stage of G.W. Development (%)	Projected stage of G.W. Development after construction of extraction structures (%)	Projected stage of GW development after construction of extraction structures & implementation of conservation measures(in %)	Additional Irrigation Potential Created (Ha)
Dharmpur	12337.15	648.08	0.00	0.00	12985.23	3762.55	137.70	33.55	0.00	3591.30	30.50	30.50	28.71723596	0
Kaprada	13842.60	677.08	0.00	0.00	14519.68	2416.05	144.59	32.85	0.00	2238.62	17.45	17.45	16.41	0.00
Pardi	12474.67	179.80	0.00	46.00	12700.47	3062.64	0.00	89.90	460.00	3432.74	24.55	28.13	27.03	920.00
Umargam	7011.97	113.20	0.00	53.00	7178.17	1990.48	0.00	56.60	530.00	2463.88	28.39	35.68	34.32	1060.00
Valsad	12127.49	343.40	0.00	36.50	12507.39	6386.97	0.00	171.70	365.00	6580.27	52.67	55.51	52.94	730.00
Vapi	3007.69	77.80	0.00	0.00	3085.49	1000.41	0.00	38.90	0.00	961.51	33.26	33.26	31.16	0.00
Valsad District	60801.57	2039.36	0.00	135.50	62976.44	18619.10	282.29	423.50	1355.00	19268.32	30.62	33.42	31.76	2710

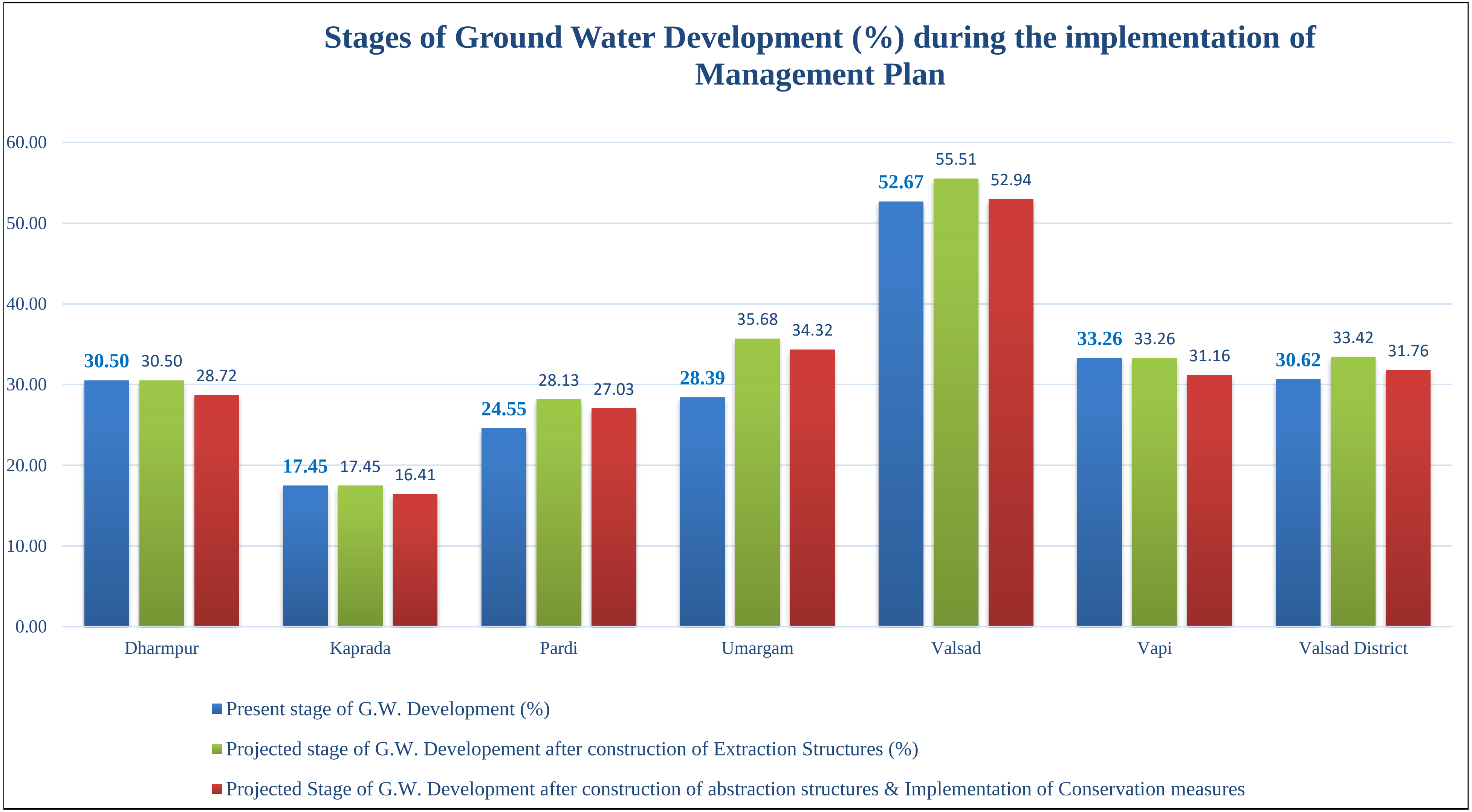


Figure 38 Graph representing stages of G.W. Development (%) for different seps of implementation of Management Plan

CHAPTER IX
CONCLUSION AND RECOMMENDATIONS

1. Average rainfall (2002-2021for entire district is 2325 mm.
2. Geologically Valsad district is a northern extension of Deccan Plateau of Central India, belonging to late Cretaceous – early Eocene age and here, it is followed by Quaternary sediments.
3. Two major aquifer systems exist in Valsad district up to 200-meter depth. Major aquifer bearing formation is weathered and fractured/fissures basalt.
4. Unconfined aquifer {comprised of Weathered basalt (0-21 meter below ground level) and shallow fracture zone (2 & 90 meter below ground level)} ranges from 0 to 90 m bgl.
5. Semi confined/Deeper aquifer lies in Fractured Basalt ranges in between 90 & 200 mbgl.
6. The depth to water level in the district ranges from 0 to 45.56 mbgl during the pre-monsoon period and some patches shows that water level in deep in Dharampur and Kaprada talukas
7. During the post monsoon period the depth to water level ranged from 0 mbgl at many places including Bhimpor k.falia village to 29.86 mbgl at Sidhumbar.
8. Quality of water is potable with minimum and maximum EC values are 225 to 3950 microS/cm respectively.
9. Artificial recharge structures like Check dams and on farm activities (Sprinkler and Drip irrigation) are proposed in the district to encounter needed surface runoff.
10. As per the Master plan 2020 for Artificial Recharge (AR) to Ground Water in Gujarat state, 497.87 MCM of surplus surface water is provisioned for artificial recharge through various recharge structures in Valsad district. For These 205 Check dams and 195 Percolation tanks are proposed which will recharge a total of 1325.16 ham of groundwater.
11. To elevate the stage of ground water development in all blocks, 1125 no Dug wells (20 m depth) and 775 no Tube well/Bore well in Hard rock are proposed as feasible extraction structures.
12. To prevent Over Exploitation water conservation activities such as on farm activities (Laser levelling/Bench terracing/Contour banding) in 8470 hac area is proposed.
13. Ground water return flow of135.50 ham is expected from irrigation of fields in the district.
14. 423.50 ham conservation of ground water through on farm activities is expected for the district.
15. Projected stage of Ground water development after creating additional extraction structures is 33.42 % for 06 no blocks in Valsad district. Projected stage of Ground Water development after Artificial Recharge and additional conservation activities is 31.76 % for 06 no blocks in Valsad district.
16. As a conservation measure, farmers should be encouraged and educated to adopt modern irrigation techniques like drip, sprinkler irrigation etc. to effect minimum withdrawal and maximum utilization of groundwater.
17. The water quality in general is good. In areas where ground water has higher concentration of Nitrate is observed, necessary sanitation measures should be adopted.
18. The ‘Mass Awareness Programme’ and 'Water Management Training Programme' should be organized in regular basis in the district for awareness on the depletion of groundwater resources and quality problems.
19. These interventions also need to be supported by regulation, so that the ground water resources are protected for future generation and also serve as ground water sanctuary in times of distress/drought. IEC activities and capacity building activities needs to be aggressively propagated to establish the institutional framework for participatory ground water

management.

20. Farmers should be encouraged and educated to adopt modern irrigation techniques to effect minimum withdrawal and maximum utilisation of groundwater.
21. The water quality in general is good. The ground water in major part of the district is suitable for domestic, irrigation and industrial purpose. But in area of saline aquifer, RTRWH should be adopt vigorously.
22. In demand side management Bore Blasting Technology (BBT) to be implemented to open up some new fractures as well as expand existing fractures to increase the bore well yield in Hard rock area.
23. Testing of existing defunct wells should be carried out to draw inference about the connectivity with the aquifer targeted to be recharged so that its efficacy can be established before going for the actual recharge.
24. Metering of ground water abstraction should be carried out in areas where MIS is practiced /proposed for effective monitoring of actual reduction in draft.
25. Conjunctive use of surface and ground water should be encouraged. Wherever surface water availability is there, it should be given precedence over ground water so as to preserve the precious resource for emergency utilization.
26. Roof Top Rain Water Harvesting technique to be implemented in urban area to enhance ground water storage through recharge.
27. Uniformity in pumping pattern is required.
28. People need to be aware of the aquifer system existing in the area.
29. Demand Vis-a vis supply management.
30. Awareness among local people regarding water conservation measures required

REFERENCES

1. *Hydrogeology of Gujarat State*
2. *Groundwater Brochure of Jamnagar District*
3. *Agriculture Contingency Plan for District VALSAD.*
4. *District Statistical Report.*
5. *Census of India*
6. *Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) District Irrigation Plan (2016-2020) Valsad District, Gujarat*
7. *Worldweatheronline.com (*https://www.worldweatheronline.com/valsad-weather-averages/gujarat/in.aspx*)*
8. *Report on Hydrogeology of Gujarat*
9. *Institutional Framework for Regulating Use of Ground Water in India*
10. *Master Plan for Artificial Recharge to Groundwater in India – 2020*
11. *Other Technical report*