केन्द्रीय भूमि जल बोर्ड

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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

Devbhumi Dwarka District
Gujarat

पश्चिम मध्य क्षेत्र, अहमदाबाद

West Central Region, Ahmedabad

AQUIFER MAP AND MANAGEMENT PLAN
DEVBHUMIDWARKA DISTRICT
GUJARAT STATE

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AQUIFER MAP AND GROUNDWATER MANAGEMENT PLAN, DEVBHUMI DWARKA DISTRICT, GUJARAT STATE

1. INTRODUCTION

Devbhumi Dwarka is a district in India located extreme western on southern coast of gulf of Kachchh in the state of Gujarat. District was carved out from Jamnagar district on August 15, 2013.There are four talukas in the district listed listed below

1. Okhamandal(Dwarka)
2. Khambhaliya
3. Kalyanpur
4. Bhanvad

Khambalia city itself is a district headquarter. District has its own pilgrimage importance where famous Dwarikadhish Temple and residing place of Lord Krishna existed. The name of the district is also derived from this famous temple name of Dwarika city. District is bounded by Arabian sea on three directions viz. North, West and South and from east by Jamnagar and Porbandar district.
Fig. 1(a) and 1(b) showing the index map and administrative division of Devbhumi Dwarka District respectively.

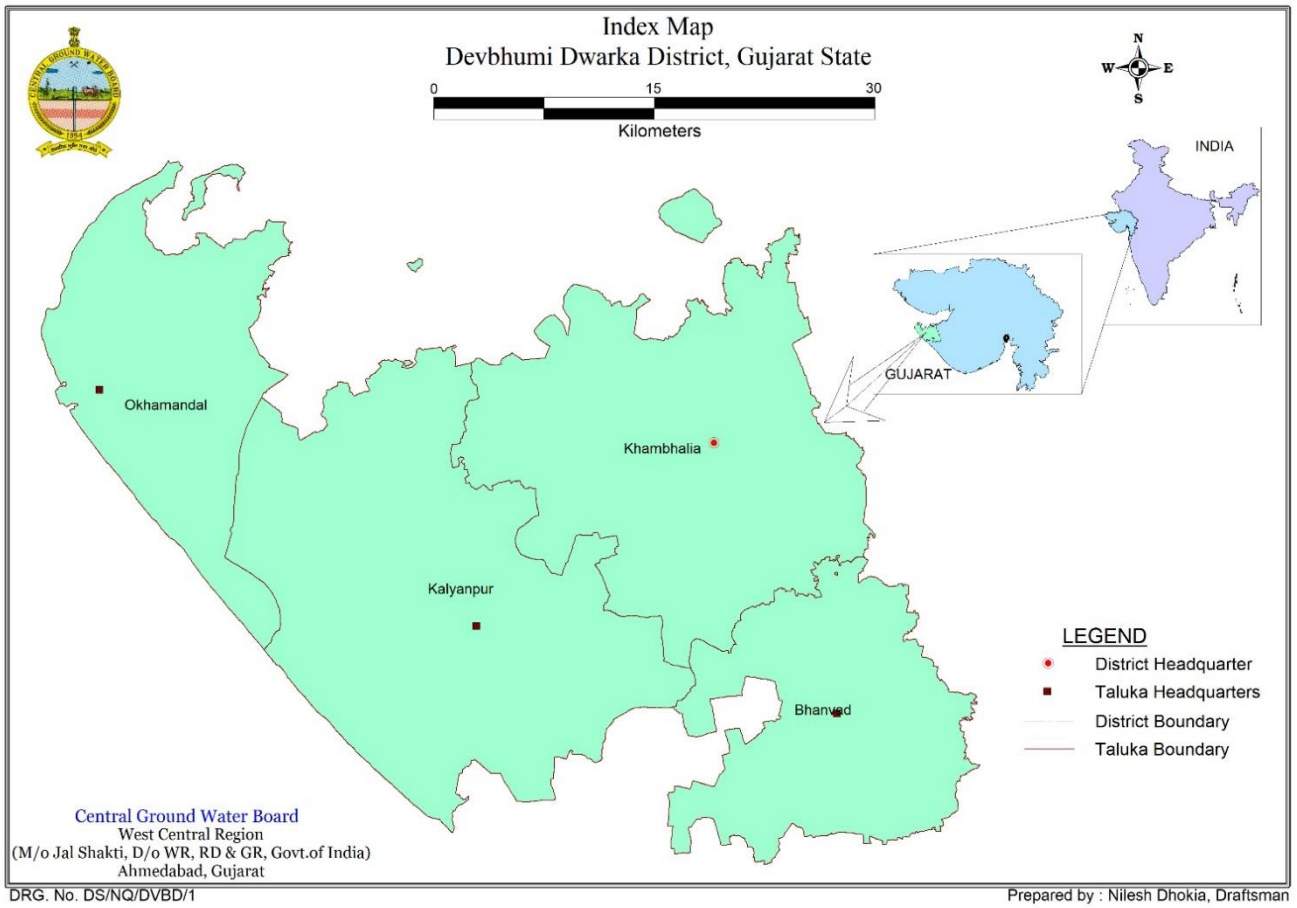


Figure 1(a). Index map showing the Devbhumi Dwarka district, Gujarat, India.

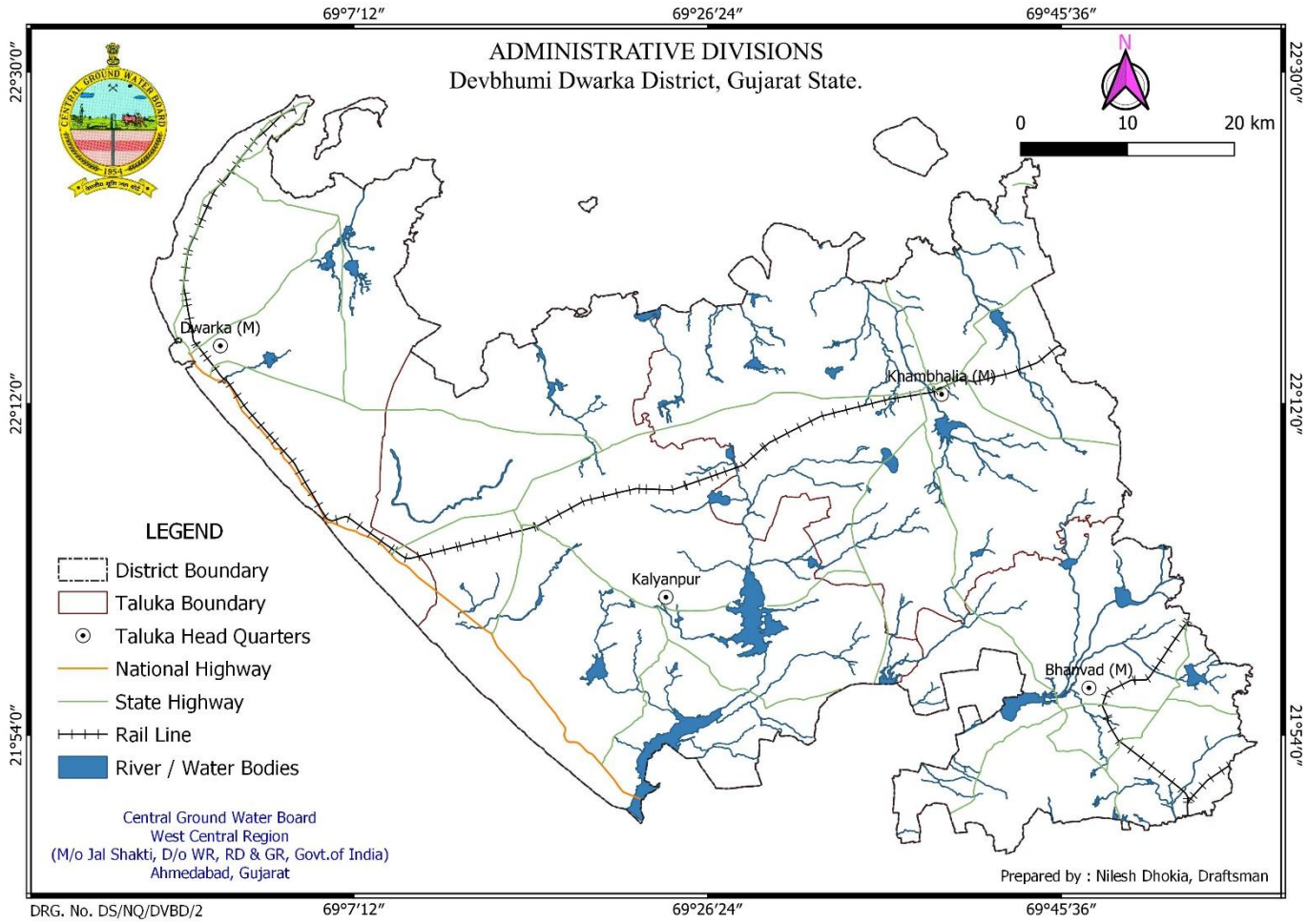


Figure 1(b). Map of Administrative division of the Devbhumi Dwarka district, Gujarat

1.1 Objective:

The primary objective of the Aquifer Mapping Exercise can be summed up as "Know your Aquifer, Manage your Aquifer". Demystification of Science and thereby involvement of stake holders is the essence of the entire project. 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. Greater the harmony between the two, greater will be 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 ground water availability with ground water accessibility and quality aspects.

1.2 Methodology:

Methodology involves creation of database for each of the principal aquifer. Delineation of aquifer extent (vertical and lateral). Standard output for effective presentation of scientific integration of Hydrogeological, geophysical, geological, hydro chemical data facts and on GIS platform, identification of issues, manifestation of issues and formulation of strategies to address the issues by possible interventions at local and regional level.

The activities of the Aquifer Mapping can be grouped as follows.

1.2.1 Data Compilation & Data Gap Analysis:

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

1.2.2 Data Generation

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

1.2.3 Aquifer Map Preparation:

On the basis of integration of data generated from various studies of hydrogeology & 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 as Aquifer maps providing spatial variation (lateral & vertical) in reference to aquifer extremities (i.e. quality & quantity).

1.2.4 Aquifer Management Plan Formulation:

Aquifer response Model has been utilized to identify a suitable strategy for sustainable development of the aquifer in the area.

All the above activities under the ground National Aquifer Mapping programme is depicted/elaborated and presented in figure 2.

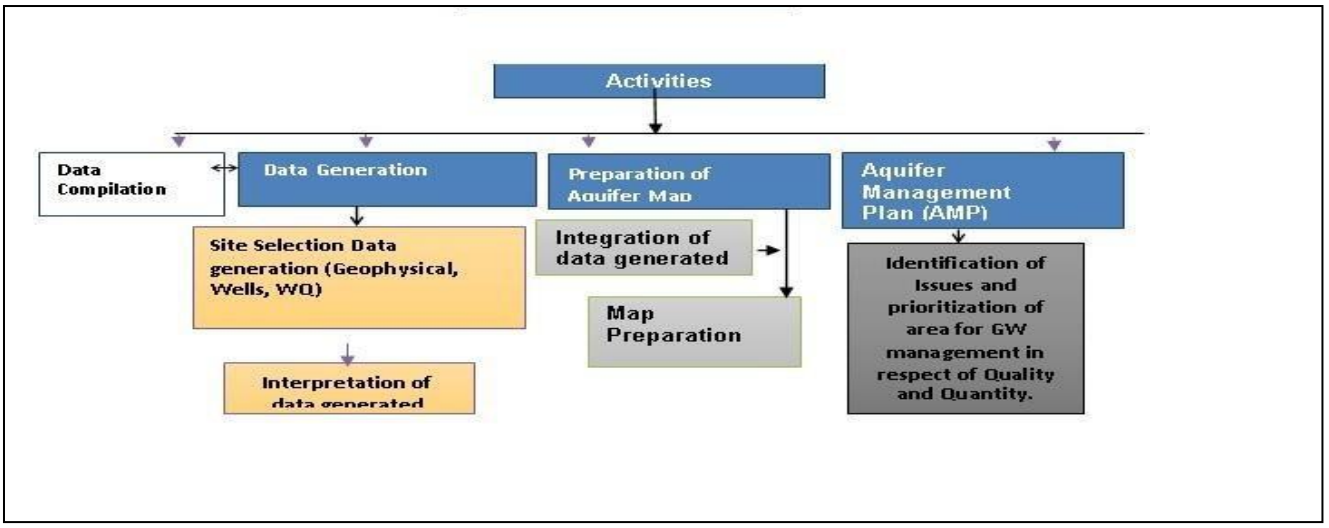


Figure 2. Activities under National Aquifer Mapping Programme

1.3 Demography

The total population of the district is 7,52,484 of which male population constitutes about 3,86,566 (51.37%) and female population is 3,65,918 (48.63 %) (Census, 2011) while its area is 4,051 km². Khambhaliya taluka comprises maximum population 2,68,062 of the district whereas Bhanvad taluka has minimum population 1,25,561 in the district. The district consists of 281 villages and 06 Muicipalities.

Table 1. Demographic details of the Devbhumi Dwarka district. (source- Census,2011)

Sr. No	Taluka	Male	Female	Total	Sex Ratio
1	Kalyanpur	99,575	96,458	1,96,033	970
2	Bhanvad	63,980	61,581	1,25,561	960
3	Okhamandal	84,074	78,754	1,62,828	936
4	Khambhaliya	1,38,937	1,29,125	2,68,062	928
	Total	3,86,566	3,65,918	7,52,484	938

1.4 Studies / Activity by CGWB

Central Ground Water Board has carried out number of studies in the district. The first systematic Hydrogeological investigation was carried out by K. K. Prasad during 1958-59 & 1959-60 (GSI). M.M. Oza, 1968-69 (GSI), continued systematic hydrogeological studies in the district. Central Ground Water Board from time to time covering different talukas of the district. Dr. M.N. Khan (1985-86) and Sh. A. Kannan (2003-04) Central Ground Water Board have carried out Reappraisal survey in different talukas of the district. Sh.R.C.Jain (1988-89) carried out non-conventional survey in the Jamnagar district. Sh. P. N. Phadtare (1981), CGWB, compiled "hydrogeology of Gujarat State" and discussed groundwater resource potential of the district based on earlier studies. Groundwater exploration by test drilling in the district commenced in fifties and is continued till 2010-11. Apart from the exploratory wells, Piezometer have also been constructed in the district. Representative dug wells and piezometers are monitored periodically for the ground water level and quality changes in the district and is continued till date. Above discussed work has been done when the Devbhumi Dwarka was the part of Jamnagar district.

1.5 Hydrometorology

Devbhumi Dwarka district is located in West of Gujarat, comes under normal rainfall areas in Gujarat, having Semi-arid climate with moderately low 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.

Climate and Raifall

Climate condition of an area is resultant of various component like temperature variation, mean average rainfall and number of rainy days. The temperature ranges from around 41°C in May to 6.3° C in the month of December. As can be seen from table below, the average rainfall for the last thirty-five years is 669 mm. The more rainfall received in the months of July and August and thereafter rainfall declined in the months of September and October. However, scanty and uneven rainfall pattern is common. The Taluka wise average rainfall is shown table below.

Table 2. Rainfall of Devbhumi Dwarka district (in mm) from 1987-2021

Years	Taluka			
	Bhanvad	**Okhamandal**	**Kalyanpur**	**Khambhaliya**
1987	6	15	15	44
1988	721	461	446	815
1989	612	326	572	432
1990	215	107	238	618
1991	347	88	397	270
1992	447	558	538	507
1993	196	108	235	168
1994	653	325	551	670
1995	494	141	441	233
1996	415	199	341	394
1997	487	426	668	600
1998	915	731	1274	950
1999	315	216	634	161
2000	423	484	516	496
2001	764	341	1196	726
2002	257	136	371	210
2003	549	508	998	610
2004	518	322	663	350
2005	500	413	353	642
2006	959	642	1524	681
2007	1177	903	1426	997
2008	730	557	835	501
2009	1156	816	1203	825
2010	1442	1246	1950	2585
2011	680	896	1359	1117
2012	319	470	380	545
2013	1062	414	987	1865
2014	712	891	570	507
2015	459	452	308	423
2016	706	335	436	993
2017	714	400	788	853
2018	282	144	166	579
2019	1035	634	1152	1354
2020	2279	1296	2248	2486
2021	915	809	1221	1115
Minimum	6	15	15	44
Maximum	2279	1296	2248	2585
Average	670	480	771	752
District Average	**669**			

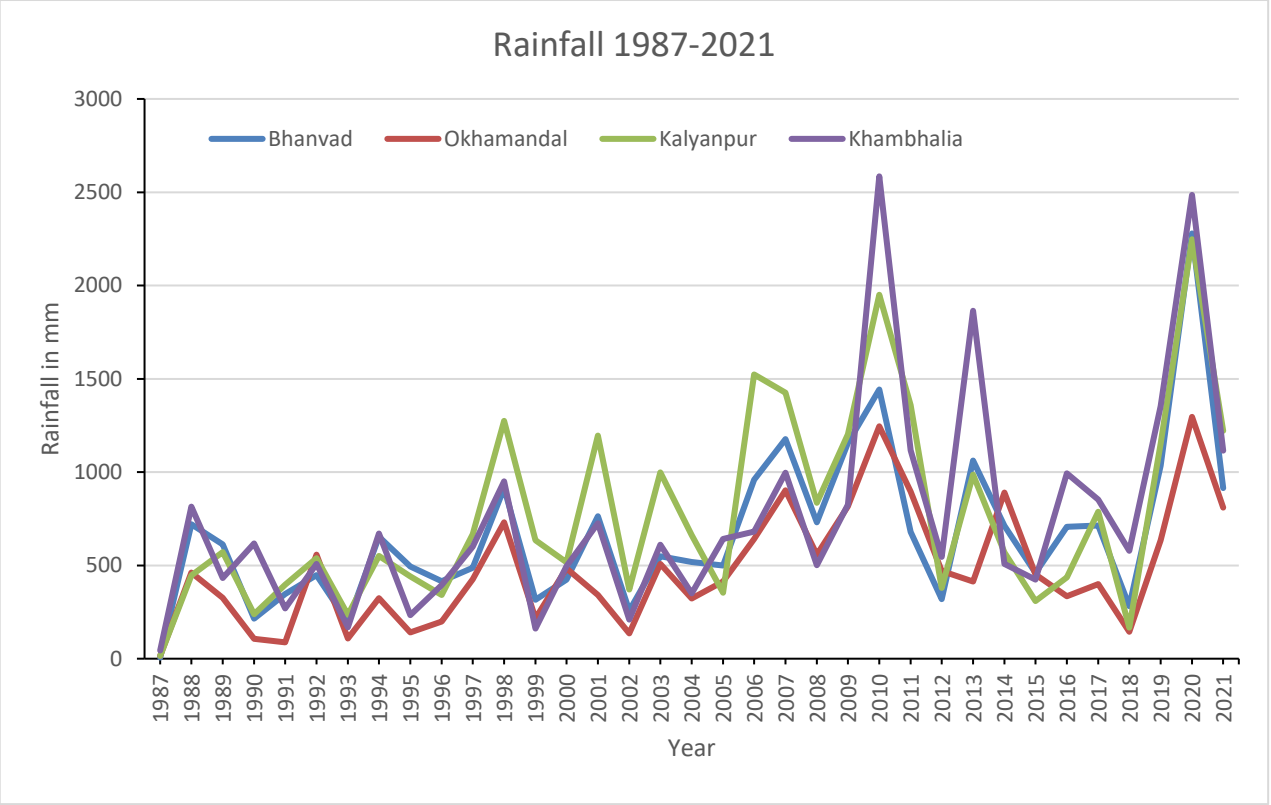


Figure 3. Rainfall variation of Devbhumi Dwarka district (1987-2021)

The graphical presentation of rainfall of the district is shown in the figure 3. In this figure it observed that the district has received minimum rainfall in 1987. The Khambhaliya taluka has received maximum rainfall (2585 mm) in 2010. The overall trend of the district showing rising trend from 1987 to 2021.

1.6 Geomorphology

Physiographically the district can be divided into the following units: Hilly areas and Coastal & alluvial Plains. Khambaliya and Kalyanpur talukas are characterised by plain topography, whereas Bhanwad taluka is characterised by hilly terrains. Cliffs are found in the Dwarka taluka with height upto 30m. Barda, Alech, Gop etc are famous hill ranges in the district. Okha Rann is a low-lying marshy area. Low coastal dunes and sand banks run along the north and west coasts.

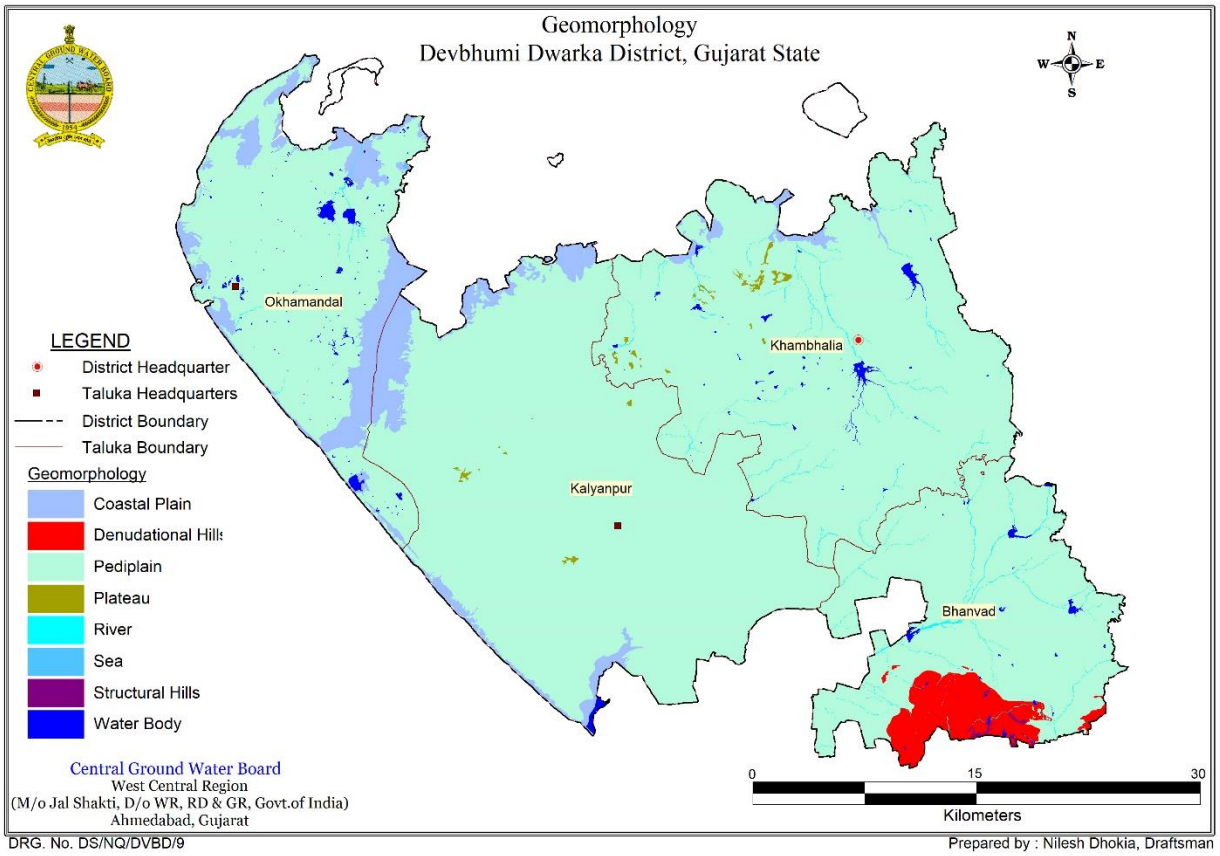


Figure 4. Geomorphological map of Devbhumi Dwarka district, Gujarat state

1.7 Surface Water Availability

Devbhumi Dwarka district is blessed with plenty of rivers like Sorthi, Vartu, Sani, Ghee, Sonmati, Sindhani, Bhadhari etc. On these rivers 9 dams are constructed and water is utilized for irrigation purpose through main canal of 70 Km and distributary canal of 67 km. Irrigation potential of these dams is 9067 Ha.

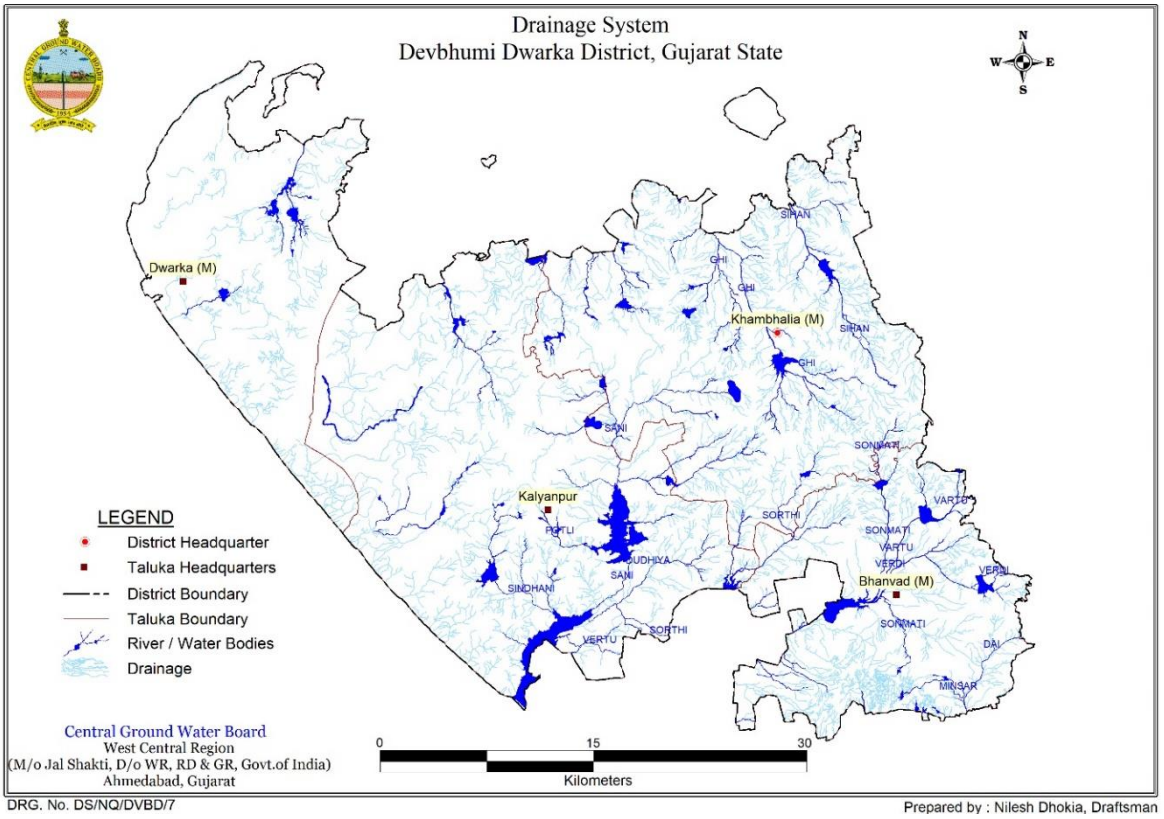


Figure 5. Drainage map of Devbhumi Dwarka district, Gujarat state

1.8 Soil type

Soils of the district may be broadly classified as Goradu sandy loam, Coastal alluvial (saline), Coarse soil from Granite, shallow black and hilly. Goradu sandy loam are the main soil type of the district, while the coastal and hilly soils are the sub-soils. The black soil is rich in mineral and organic matter and is more fertile. The medium black soils are found in Khambaliya, and kalyanpur talukas. These soils are generally 25 to 50 cm deep. Shallow black soils are found in Bhanwad, and Okhamandal talukas, which is about 25cm deep. The coastal alluvial soils are found in Kalyanpur and Khambaliya talukas. These soils are mostly saline and alkaline in nature. Hilly soils are found in southern parts of the district, particularly in Bhanwad taluka.

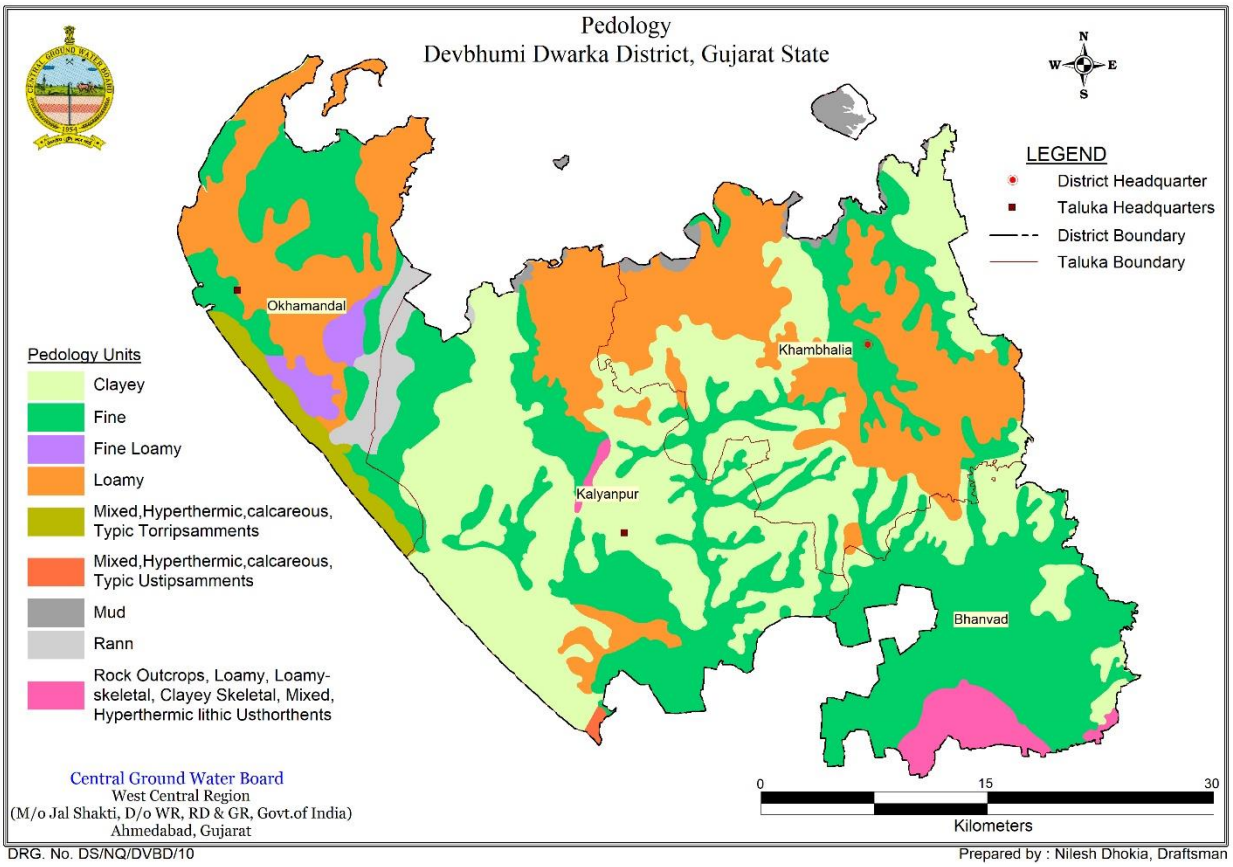


Figure 6. Map showing the soil texture in Devbhumi Dwarka district of Gujarat district

1.9 Land Use Pattern

The total geographical area of the district is 407509 Ha out of which nearly 238370 Ha (58.49%) is under agriculture. As per the district irrigation plan 2016-2020, the land under non agriculture use is 65600 Ha which is 16.10% of the total geographical area of the district. Out of the land under nonagricultural use Kalyanpur block has the highest (28909 Ha) followed by Khambhaiya (25876 Ha) and Bhanvad (8087 Ha). The forest area covers 4.26% of the total geographical area i.e 407509 Ha. The land use pattern in Devbhumi Dwarka district is shown in the map below:

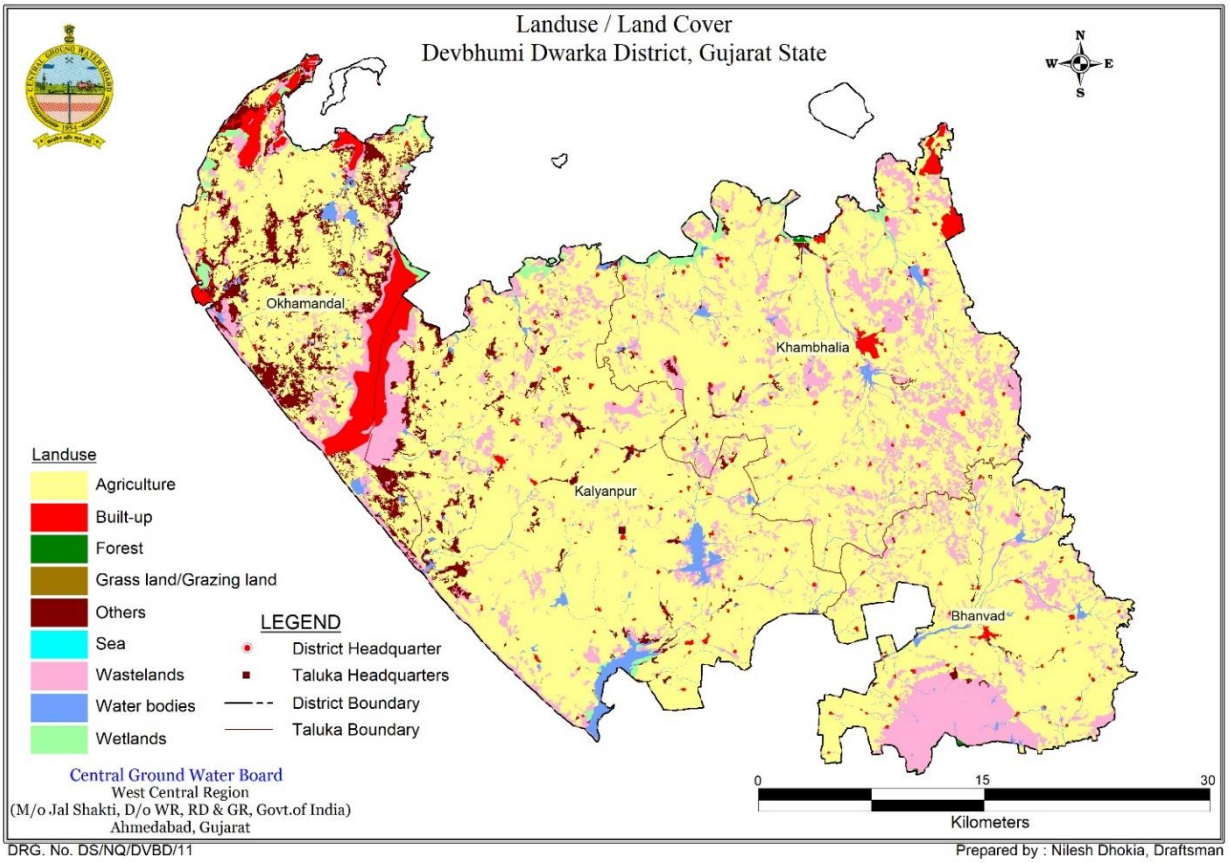


Figure 7. Map showing the landuse landcover in Devbhumi Dwarka district of Gujarat district

1.10 Agrcultural Activity

The total geographical area of the district is 407509 Ha out of which nearly 238370 Ha (58.49%) is under agriculture. The land under non agriculture use is 65600 Ha which is 16.10% of the total geographical area of the district. Out of the land under non agri use Kalyanpur block has the highest (28909 Ha) followed by Khambhaiya (25876 Ha) and Bhanvad (8087 Ha). The forest area covers 4.26% of the total geographical area i.e 407509 Ha. The average cropping intensity of the district is 107.21%. The taluka wise land utilization status is presented in the below table.

Table 3. Area Under Agriculture (in Ha)

Block		TGA	Area Under Agriculture		
			GCA	NSA	Croping Intensity (%)
Bhanvad		73195	55311	44915	123.15
Kalyanpur		141222	83662	81600	102.53
Dwarka		71667	36855	36355	101.38
Khambhaiya		121425	76850	75500	101.79
Total		407509	252678	238370	107.21

Source: District Irrigation Plan, Devbhumi Dwarka, Gujarat , Comprehensive district agriculture plan Jamnagar, Government of Gujarat. TGA- Total Geographical Area, GCA- Gross Cropped Area, NSA- Net Sown Area

Irrigation Based Classification

The Gross Irrigated Area of Devbhumi Dwarka district is 149813.80 ha which is 42.02% of the Gross cultivated area (356532.00 ha) of the district. The percentage of Gross Irrigated Land to gross cultivated area of the district is maximum in Khambhaiya block (15.54%) followed by Kalyanpur (14.73%) and Bhanvad (9.36%). The percentage of Gross Irrigated Land to gross cultivated area is minimum in Dwarka (Okhamandal) block (2.39%). Kalyanpur block highest rainfed area (83487 ha) which is 23.42% of the gross cultivated area (356532.00 ha) of the district followed by Khambhaiya (15.87%) & Bhanvad (9.45%). The block wise irrigation based classification can be seen from the table below:

Table 4. Block wise Irrigation based Classification

Taluka	Gross Irrigated Area (ha)	Gross Unirrigated Area (ha)	Gross Cultivated Area (ha)
Bhanvad	33358.4	33682.6	67041
Khambhaiya	55413.2	56581.8	111995
Kalyanpur	52528	83487	136015
Dwarka (Okhamandal)	8514.2	32966.8	41481
Total	**149813.8**	**206718.2**	**356532**

Source: District Irrigation Plan, Devbhumi Dwarka, Gujarat, Agriculture Department, Govt. of Gujarat

Agriculture and horticulture plays an important role in rural economy of Devbhumi Dwarka. The district comes under North Saurashtra Agro climatic Zone VI and falls under semi-arid tropic agro climatic region. It has three distinguished seasons i.e kharif (June to September), winter (October to January) and summer (February to May). The major agricultural crops grown in the district are Bajra, groundnut, mung, etc. The major vegetables and spices crops grown are onion, garlic, brinjal, cabbage, cauliflower, tomato, chilly, reddish, spinach, and fenugreek. The district is the major producer of the groundnut.

Area Wise, Crop Wise Irrigation Status

The total area under cultivation in the district except horticultural crops is 344830 Ha. The total irrigated area is 138235 Ha which is 40% of the total land leaving 60% for it in rainfed cultivation. Bajra is the only major cereal crop cultivated in Kharif season along with other crops like mung, udid and ground nut. However, in Rabi season wheat & gram is cultivated in abundance. Crop wise area under irrigated and rainfed situation is highlighted in the following table.

Table 5. Area wise crop wise irrigation status of various blocks (ha)

Crop Type	Kharif (Area in Ha)			Rabi (Area in Ha)			Summer (Area in Ha)			Total (Area in Ha)		
	Irr.	RF	Tot.	Irr.	RF	Tot.	Irr.	RF	Tot.	Irr.	RF	Tot.
Cereals	0	1073	1073	18448	0	18448	201	0	201	18649	1073	19722
Pulses	0	4851	4851	13455	50	13505	1304	0	1304	14759	4901	19660
Oil Seeds	4200	183542	187742	246	0	246	9713	0	9713	14159	183542	197701
Fibre	23803	0	23803	0	0	0	0	0	0	23803	0	23803
Any other crops	597	17022	17619	62910	57	62967	3358	0	3358	66865	17079	83944
Total	**28600**	**206488**	**235088**	**95059**	**107**	**95166**	**14576**	**0**	**14576**	**138235**	**206595**	**344830**

Source: District Irrigation Plan, Devbhumi Dwarka, Gujarat Irr- Irrigated, RF- Rainfed, Tot- Total

The district was having a total area of 11702 ha under horticulture crops during 2014-15. Out of the total area under horticulture crops fruits, vegetables, flowers and spices have area share of 10.53 per cent, 45.47 per cent, 43.27 per cent and 0.73 per cent respectively.

Production and Productivity of Major Crops

Cereals, Pulses, Oil seeds, and Fibres are the major crops cultivated in the district. Major crops include ground nut, cotton & wheat etc. These crops have an area share of 187312 Ha which is 88.37% of gross agriculture area (211962 Ha) of the district. The district produce a total of 6823793 qtl/yr of groundnut, 278668 qtl/yr of cotton and 1552149 qtl/yr of wheat during 2013-14.

2. GEOLOGY

Since district was carved out from Jamnagar district that's why hydrogeological and geological condition of the Devbhumi Dwarka district taken from Jamnagar district. Stratigraphy of Devbhumi Dwarka District, Gujarat is given in table 6. Area can be broadly grouped under hard rocks comprising "Deccan traps" and soft rocks comprising "Tertiaries and Alluvium". District is mostly underlain by Deccan Traps, and the rest by Alluvium and tertiaries. Hydrogeological conditions in various litho-units are described below:

2.1 Deccan Traps (Hard rock)

These are essentially basaltic flows having general horizontal to near horizontal disposition over large area. The basaltic flows do not have any primary porosity in the lower massive portion, but the top vesicular portion has some porosity because of the vesicles formed due to escaping gases. Both massive and vesicular portions have no primary permeability, as the vesicles are seldom interconnected. The secondary porosity and permeability developed due to fracturing and jointing provides passage for infiltration, storage and movement of groundwater.

2.2 Gaj Beds

Groundwater in these series occurs both under confined and water table conditions. The upper granular bed of the series consisting of limestone and grits forms a good aquifer for shallow groundwater. Dug wells and dug-cum bore wells within the depth range of 20-25 mbgl are constructed.

2.3 Dwarka Beds

Groundwater mainly occurs under water table condition; because of the clayey nature of the formations and the narrow stretch of sandy limestone exposed to recharge the rocks of this formation are poor aquifers.

2.4 Milliolite Series

Groundwater occurs under phreatic conditions. These milliolite limestone acts as a good reservoir for shallow groundwater. The depth of water level in milliolite limestones is generally about 5m bgl.

2.5 Alluvium

Groundwater occurs under unconfined conditions. The thickness of the alluvium is not more than 20m. Because of its clayey nature, percolation of rainwater is very poor resulting in poor yields.

Table 6. Stratigraphy of Devbhumi Dwarka District, Gujarat.

Table 2- Stratigraphy of Devbhumi Dwarka District, Gujarat.			
Geological Age (Era)	**Epoch**	**Formation**	**Lithology**
Quaternary	Holocene	Alluvium	Soil, sand complex and fluviomarine deposits
	Pliestocene	Miliolite Limestone	Sandy limestone With Shell of milonite
Tertiary	Pliocene	Dwarka beds	
	Miocene	Gaj beds	Limestone, Marl and Gypseous Clay
	Eocene	Leteritic rocks	
Tertiary-Mesozoic	Lower Eocene to Upper Cretaceous	Deccan Traps	Basalt as stratified lava flows comprising amygdalolidal basalt, fine grained porphyritic basalt and basaltic/doleritic dykes.

3. DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

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-).

Table 7. Brief activities showing data compilation and generations

S.No.	Activity	Sub-activity	Task
1	Compilation of existing data/ Identification	Compilation of Existing data on groundwater	Preparation of base map and various thematic layers, compilation of information on Hydrology, Geology, Geophysics, Hydrogeology, Geochemical etc. Creation of data base of Exploration Wells, delineation of Principal aquifers (vertical and lateral) and compilation of Aquifer wise water level and draft data etc.
		Identification of Data Gap	Data gap in thematic layers, sub-surface information and aquifer parameters, information on hydrology, geology, geophysics, hydrogeology, geochemical, in aquifer delineation (vertical and lateral) and gap in aquifer wise water level and draft data etc.
2	Generation of Data	Generation of geological layers (1:50,000)	Preparation of sub-surface geology, geomorphologic analysis, analysis of land use pattern.
		Surface and sub-surface geo-electrical and gravity data generation	Vertical Electrical Sounding (VES), bore-hole logging, 2-D imaging etc.
		Hydrological Parameters on groundwater recharge	Soil infiltration studies, rainfall data analysis, canal flow and recharge structures.
		Preparation of Hydrogeological map (1:50, 000 scale)	Water level monitoring, exploratory drilling, pumping tests, preparation of sub-surface hydrogeological sections.
		Generation of additional water quality parameters	Analysis of groundwater for general parameters Including fluoride.
3	Aquifer Map Preparation (1:50,000 scale)	Analysis of data and preparation of GIS layers and preparation of aquifer maps	Integration of Hydrogeological, Geophysical, Geological and Hydro-chemical data.
4	Aquifer Management Plan	Preparation of aquifer management plan	Information on aquifer through training to Administrators, NGO's, progressive farmers and stakeholders etc. and putting in public domain.

3.1 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 Exploratory wells studies carried out and used in prepare a hydro geological cross section, Fence diagram and 3D Model. The data has been analyzed using Rockworks 16 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 Aquifer Groups and Aquitard up to 200 m. The stratigraphic sections depicting unconfined aquifer, semi confined Aquifer for alluvium and weathered aquifer & fractured aquifer for Basaltic rock are placed at Figs (9 to 12). 3D Solid Model and Fence Diagram and of district is depicted in Fig. 13 and 14, respectively. Data integration in respect to Devbhumi Dwarka district is represented in table 8.

Table 8. Data integration in respect to Devbhumi Dwarka district

Type of Data & source	**No of Wells**
Aquifer Disposition	
CGWB	**14**
Long term Fluctuation	
CGWB+GWRDC	**20** **+39**
Decadal Analysis water Level	
CGWB+GWRDC	**20+39**
Analysis of water Quality	
CGWB	**62**

3.2 Conceptualization of Aquifer system in 2D

A total of 14 exploratory wells and piezometers lithologs are utilized to decipher the subsurface geometry of the aquifer by using Rockworks 16 software prepared hydro geological cross sections, Fence diagram and 3D Model up to the depth of 200 mbgl. And four 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 9 (A-A') to figure 15 (D-D').

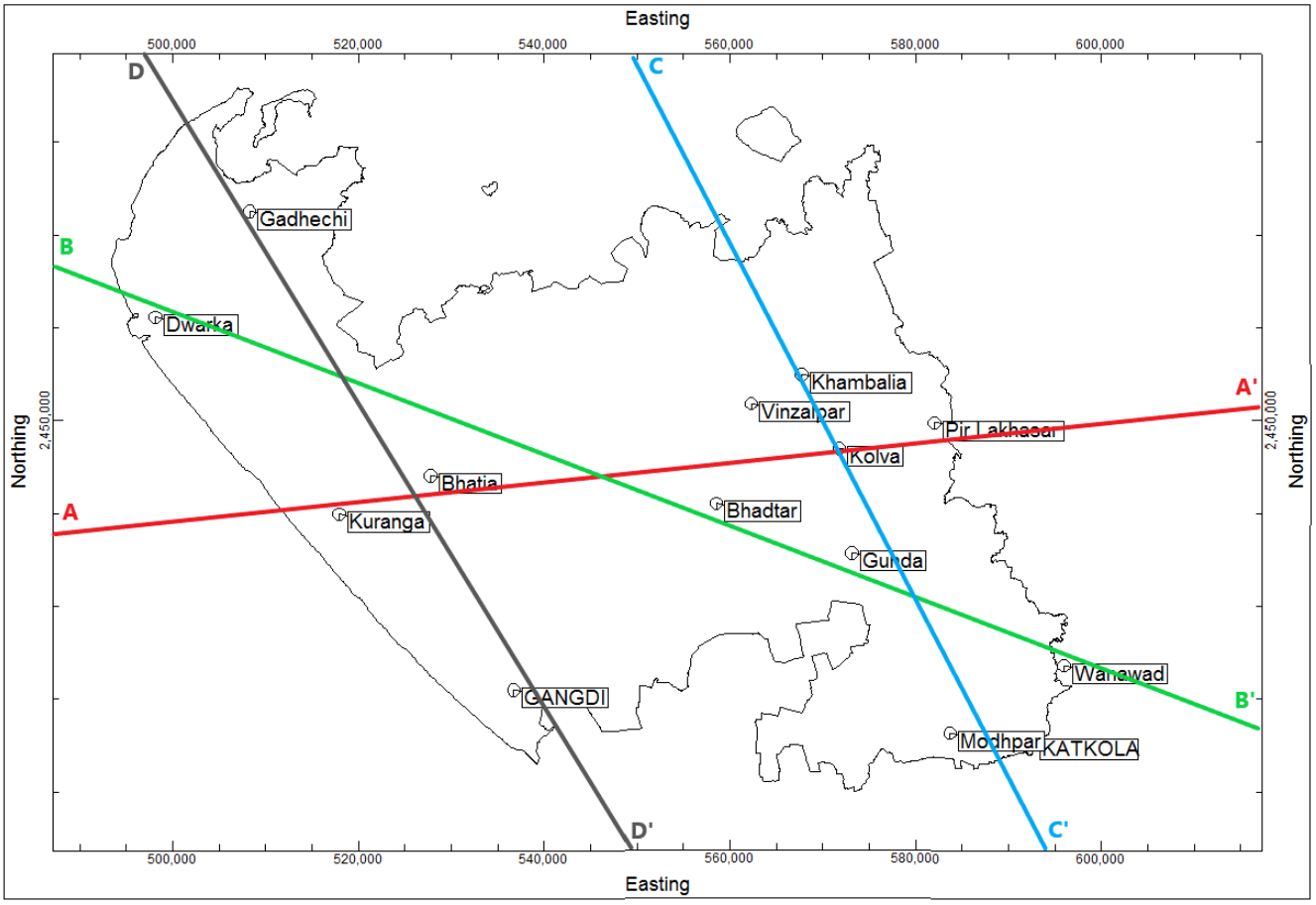


Figure 8. Map showing drawn section lines

.

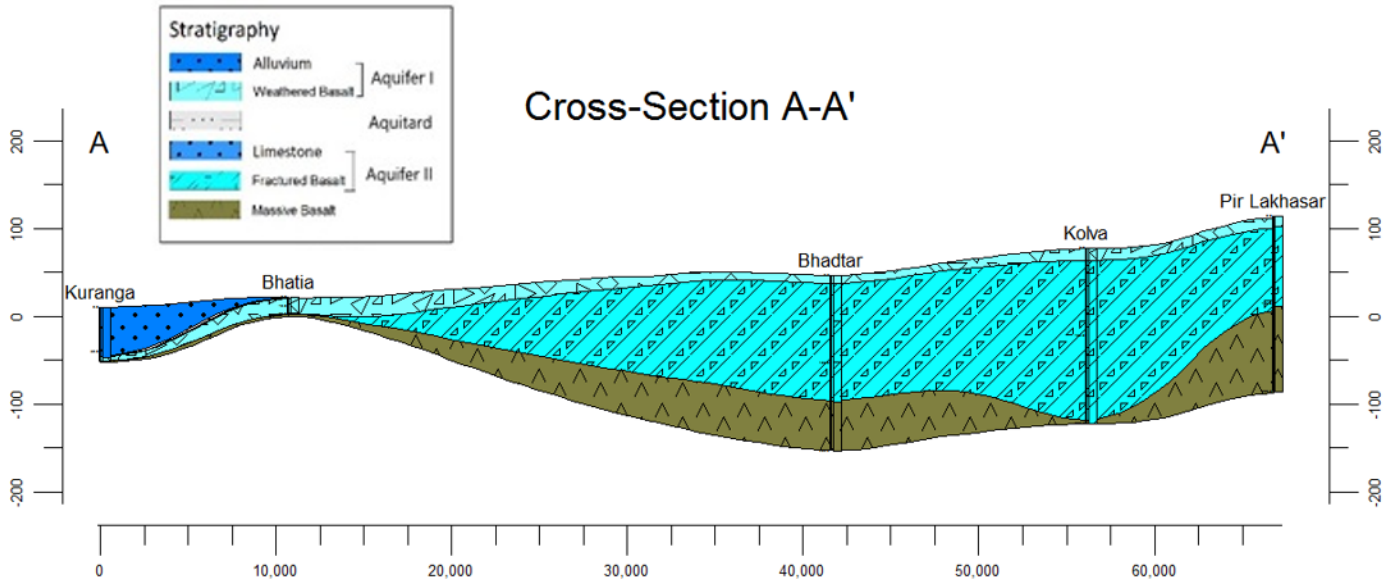
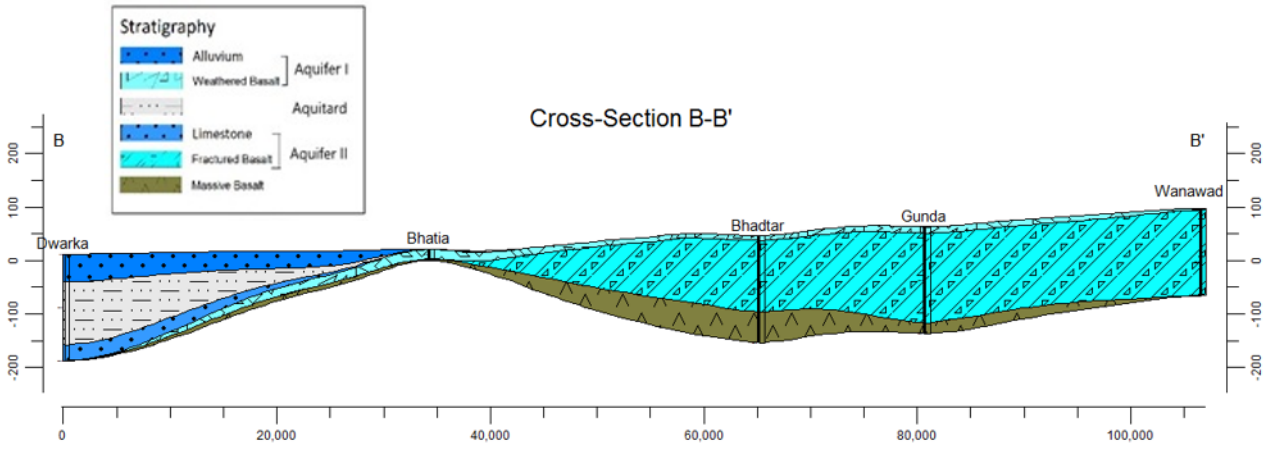


Figure 9. Hydogeological cross section between Kuranga and Pir Lakhasar (A-A')

Section A-A' (Fig. 9)- Section is drawn roughly E-W direction in between Kuranga and Pirlakhasar, passing through Bhatia, and Kolva Stratigraphicaly from Section, it is deciphered that Hard rock formation (weathered basalt & fractured basalt) forms the major aquifer system in the district and rested on Massive basalt along drawn section line.



Section B-B' (Fig. 10)- Section is drawn roughly NW-SE direction and in between Dwarka and Wanawad passing through Bhatia, Bhadtar, and Gunda. Section is represented Stratigraphicaly, from section it is deciphered that Hard rock formation (weathered & Fractured) along with alluvium forms the major aquifer system in the district and rested on Massive rock along drawn section line.

Figure 10. Hydogeological cross section between Dwarka and Wanawad (B-B')

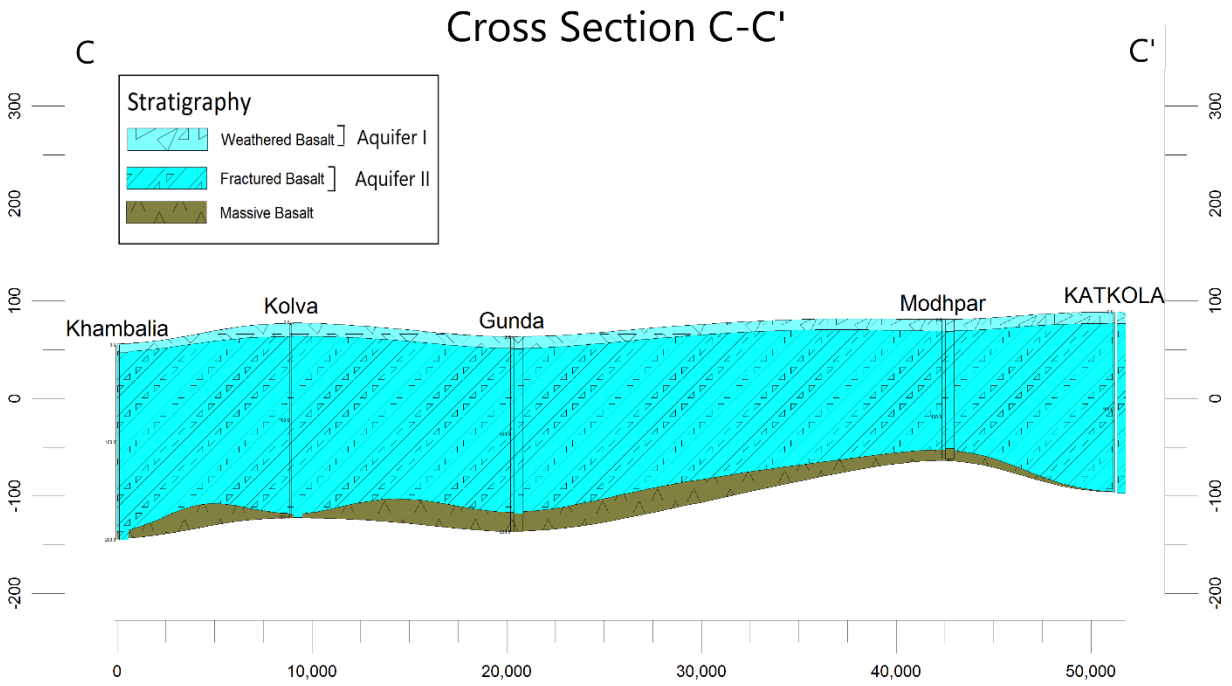


Figure 11. Hydogeological cross section between Khambhaliya and Katkola (C-C')

Section C-C' (Fig. 11)- Section is drawn roughly NNW-SSE direction and in between Khambhaliya and Katkola, passing through Kolva, Gunda and Modhpar. Section is represented Stratigraphicaly, from section it is deciphered that that Hard rock formation (weathered basalt & Fractured basalt) forms the major aquifer system in the district and rested on Massive rock along drawn section line.

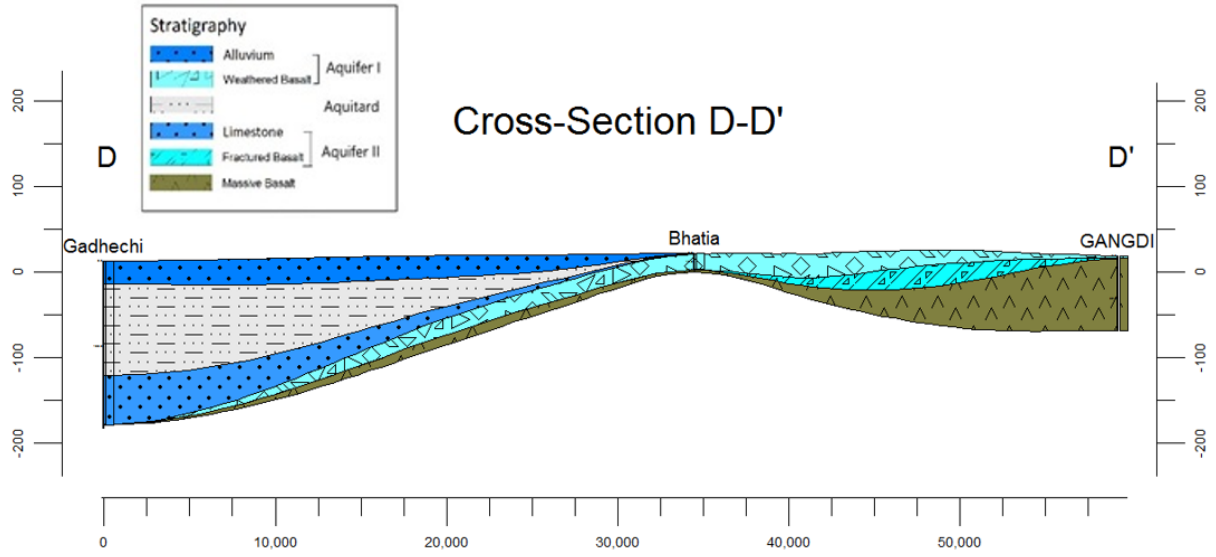


Figure 12. Hydogeological cross section between Gadhechi and Gangdi (D-D')

Section D-D' (Fig. 12)- Section is drawn roughly NNW-SSE direction and in between Godhechi and Gangdi, passing through Bhatia. Section is represented Stratigraphicaly, from section it is deciphered that that Alluvium and Hard rock formation (weathered basalt & Fractured basalt) forms the major aquifer system in the district and rested on Massive rock along drawn section line.

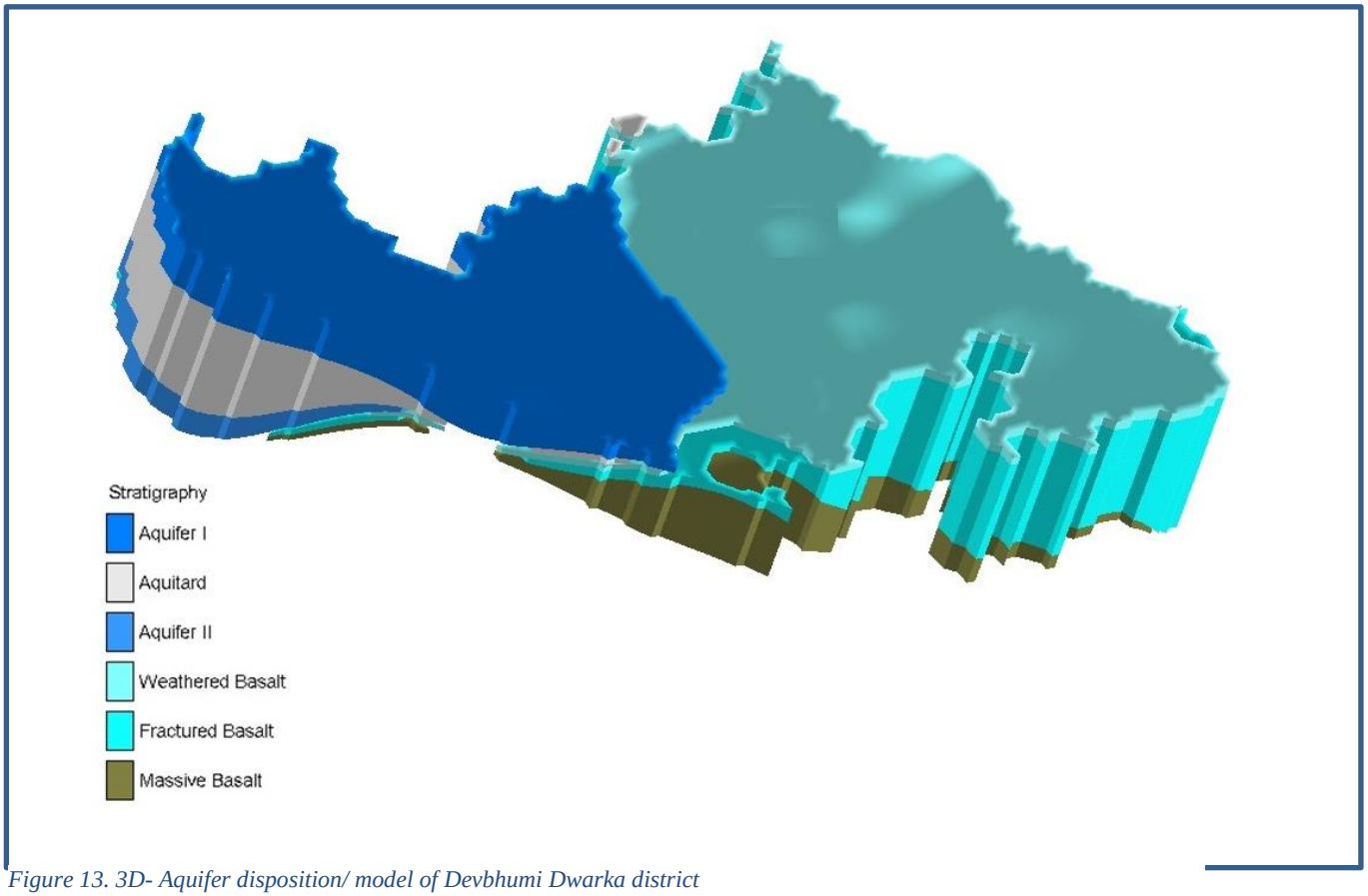


Figure 13. 3D- Aquifer disposition/ model of Devbhumi Dwarka district

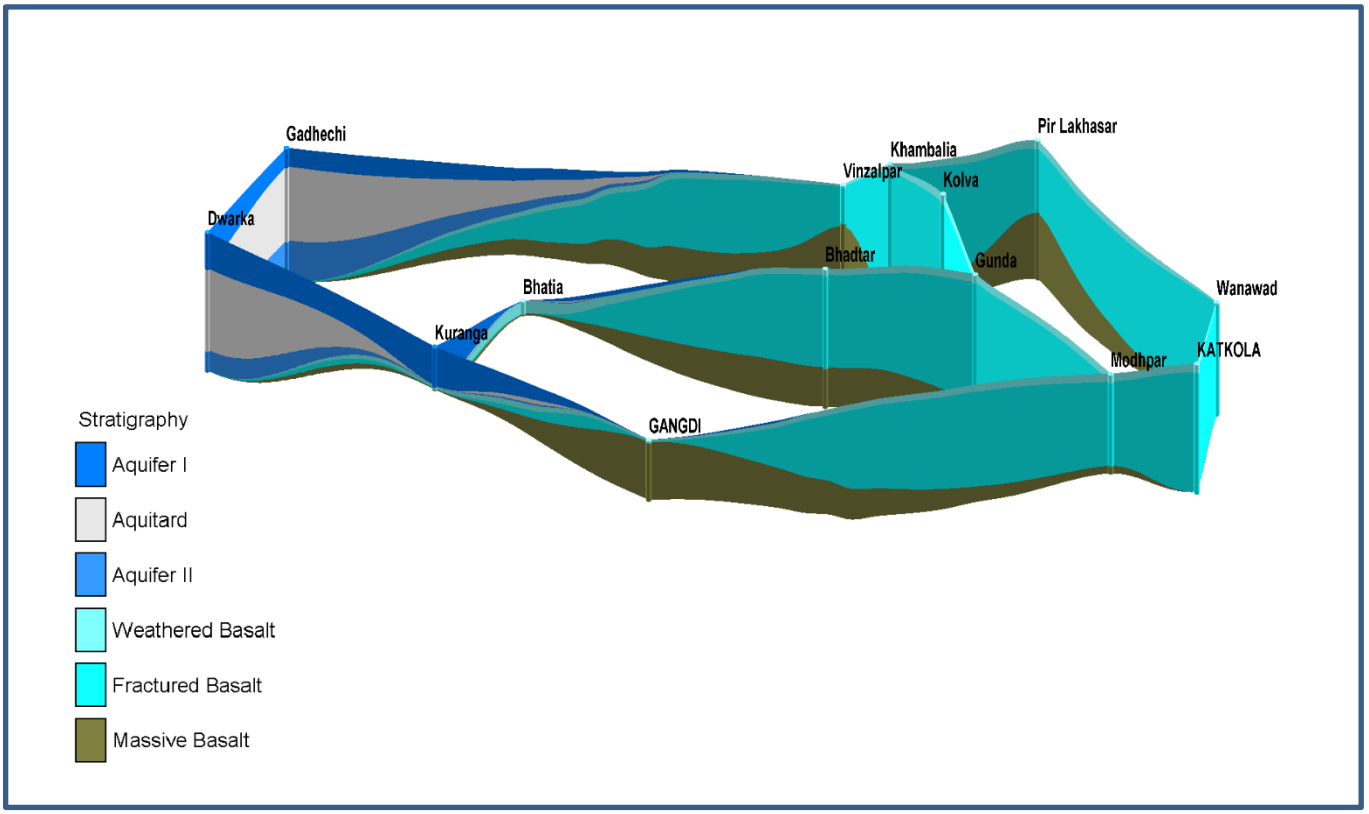


Figure 14. Fence diagram of Devbhumi Dwarka district

Table 9. Aquifer characterization and disposition of Devbhumi Dwarka district.

Aquifer Characterization and Disposition (Dwarka)										
Stratigraphy	**Aquifer Nomenclature**	**Lithological Characteristics**	**Depth of occurrence**	**Thickness**	**Water Level (mbgl)**	**Quality (EC)**	**Discharge**	**Transmissivity**	**Nature of Aquifer**	**Remarks**
			Aquifer (mbgl)	**Range (m)**	**Range (mbgl)**	**Range µS/cm**	**Range lps**	**Range m2/day**		
Quaternary	**Aquifer I**	Alluvium - Sand, and Kankar	0 to 57	0 to 57	2 to 20	1100 to 8000			Phreatic	Fresh to Brackish
Tertiary	**Aquitard**	Sandy Limestone, with shell of Milonite, Marl and Gypseous Clay	27 to 170	0 to 118						Fresh to Brackish
	Aquifer II	Limestone of Dwarka beds and Gaj beds	134 to 200	0 to 58		4000-18000			Semi confined to Confined	Slightly brackish to Saline
Mesozoic	**Weathered Basalt**	Basalt	0 to 18	0 to 18	2 to 40	500-2500			Phreatic	Fresh to Slightly brackish
	Fractured Basalt	Basalt	3 to 200	0 to 192	31.24 to 74.51	600-2000	1 to 10	1.27 to 159.77	Semi confined	Fresh to Slightly brackish

4.GROUND WATER SCENARIO

Groundwater occurs in alluvium hard rock and soft rocks. Though ground water occurs in all types of formation, but the most productive aquifer is Quarternary sediments (Alluvium) and fractured formation, figure 16. Hydrogeological conditions in various litho units are described below:

Deccan Traps (Hard rock)

These are essentially basaltic flows having general horizontal to near horizontal disposition over large area. The basaltic flows do not have any primary porosity in the lower massive portion, but the top vesicular portion has some porosity because of the vesicles formed due to escaping gases. Both massive and vesicular portions have no primary permeability, as the vesicles are seldom interconnected. The secondary porosity and permeability developed due to fracturing and jointing provides passage for infiltration, storage and movement of groundwater. The weathered zone extends to about 20 m bgl in the surface flows. Weathered flow contacts extend to greater depths. The permeability of these zones are further intensified by fracturing and jointing. These interflow zones and fractured and jointed zones have given rise to stratified aquifer system, which is responsible for occurrence of water even at greater depths. Weathering of basalts, which extends down to 20 m and the fractured basalts beneath the weathered mantle have given rise to water table aquifers down to 40 m bgl.

Gaj Beds

Groundwater in these series occurs both under confined and water table conditions. The upper granular bed of the series consisting of limestone and grits forms a good aquifer for shallow groundwater. Dug wells and dug-cum bore wells within the depth range of 20-25 mbgl are constructed. The depth of water level in the Gaj aquifer ranges from 5 to 15 m bgl during pre-monsoon period. The yield of the wells varies from 4 to 312 m^3/day and an average yield of 66m^3/day.

Dwarka Beds

Groundwater mainly occurs under water table condition; because of the clayey nature of the formations and the narrow stretch of sandy limestone exposed to recharge the rocks of this formation are poor aquifers. The depth of the water level in the Dwarka beds ranges from 2 to 10 m bgl during pre-monsoon period. Dug wells and dug-cum bore wells within the depth range of 20-35 mbgl are constructed. The yield of the wells varies from 8 to 270 m3/day and an average yield of 80m^3/day.

Milliolite Series

Groundwater occurs under phreatic conditions. These milliolite limestone acts as a good reservoir for shallow groundwater. The depth of water level in milliolite limestones is generally about 5m bgl. Open wells are about 10m in depth. The yield of these wells ranges from 100-200m^3/day.

Alluvium

Groundwater occurs under unconfined conditions. The thickness of the alluvium is not more than 20m. Because of its clayey nature, percolation of rainwater is very poor resulting in poor yields. The depth of water level ranges from 2 to 10m bgl (Premonsoon). Fine to medium grained, unconsolidated sand comprises the aquifer materials in the blown sand and it occurs as water bearing formation in the southern part of the district

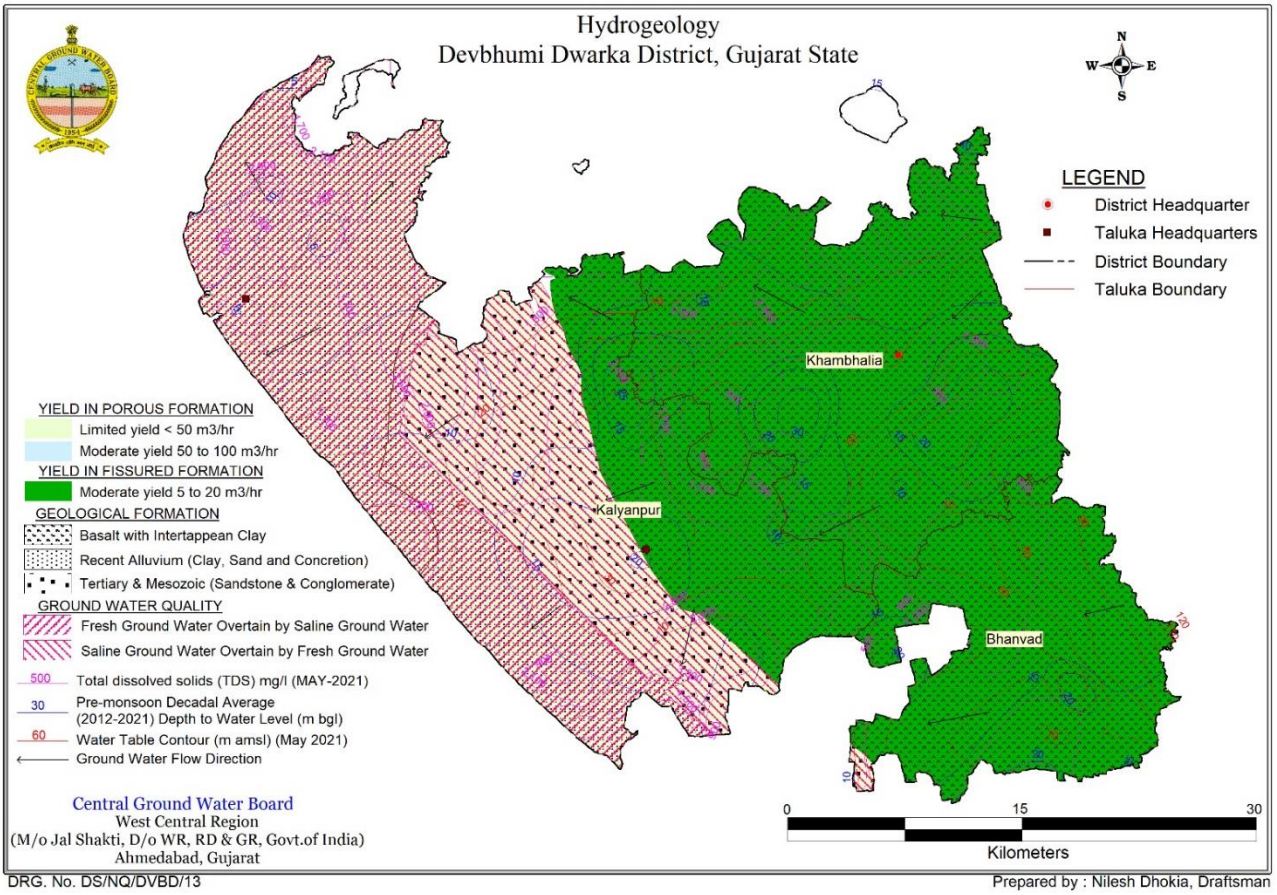


Figure 15. Map showing the Hydrogeological setup of Devbhumi Dwarka District

4.1 Behaviour of Water Levels

The behaviour of water levels was studied based on the water level data collected from the National Network of Hydrograph Stations (NNHS). The water level data of May 2021 and November 2021 was used for preparing the depth to water level maps. The seasonal fluctuation in water levels was calculated between May and November 2021. Total 59 nos. of monitoring stations including 39 nos. monitoring station of Gujarat Water Resources Development Corporation (GWRDC) were taken during preparation of maps.

4.2 Depth to water level (Pre monsoon)

Pre monsoon depth to water levels of Devbhumi Dwarka district are shown in the (Fig. 16), which depict that water levels in most part of the district ranges in between 5.0 m bgl to 10 m bgl. Small area in Kalyanpur, Khambhaliya and Bhanwad taluka, shows deeper water level of more than 20 m bgl. Shallow water level are observed in patches in all talukas of the district.

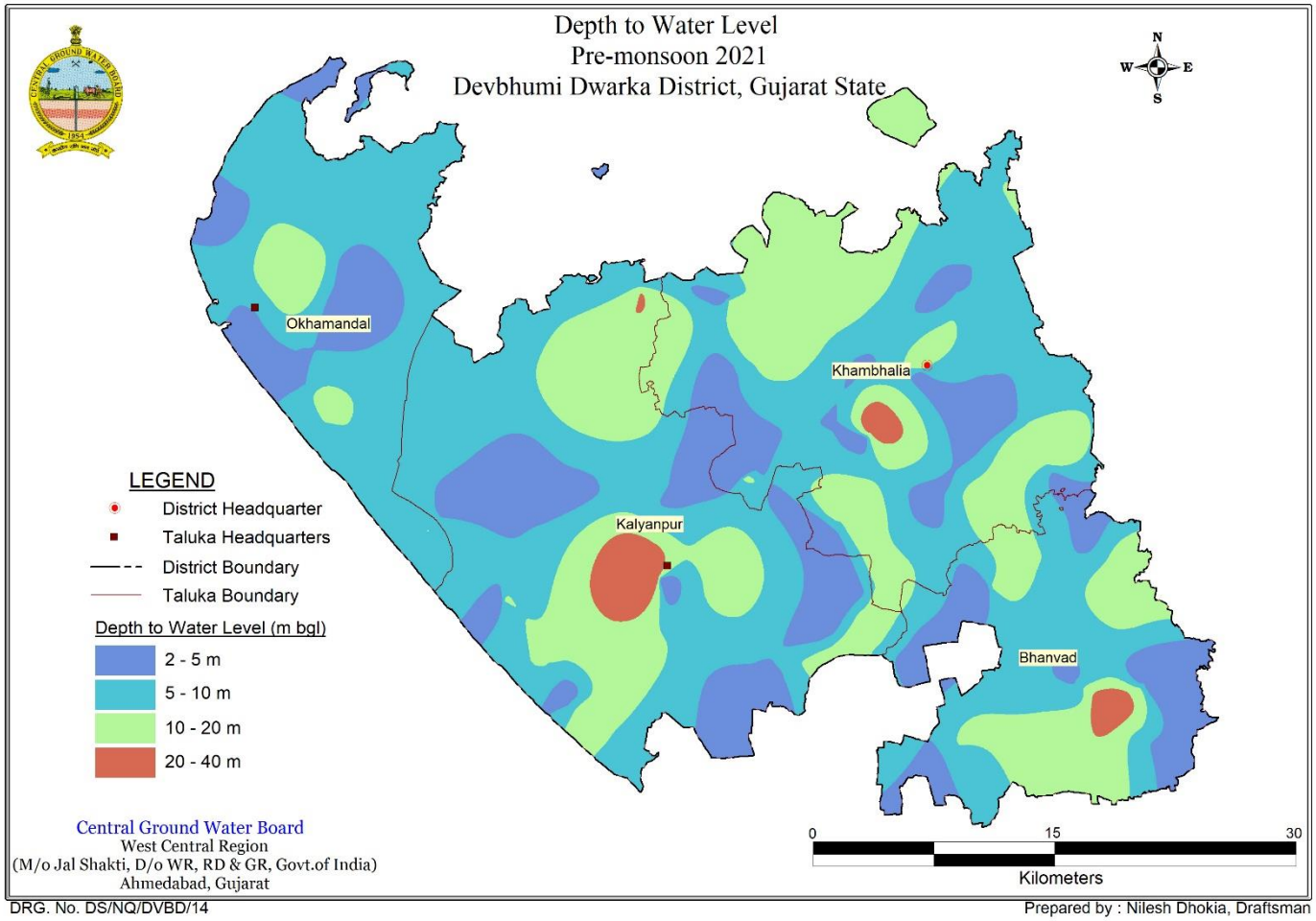


Figure 16. Pre-monsoon (May 2021) depth to water level of Devbhumi Dwarka District

4.3 Depth to water level (Post monsoon)

Post-monsoon water level as shown below in map for the period of November, 2021 (Fig. 17) shows that shallow water level upto 5.0 m bgl are observed in most part of the district which reflect good recharge were taken place due to rainfall. Deeper water level are concentrated only in few part of the district.

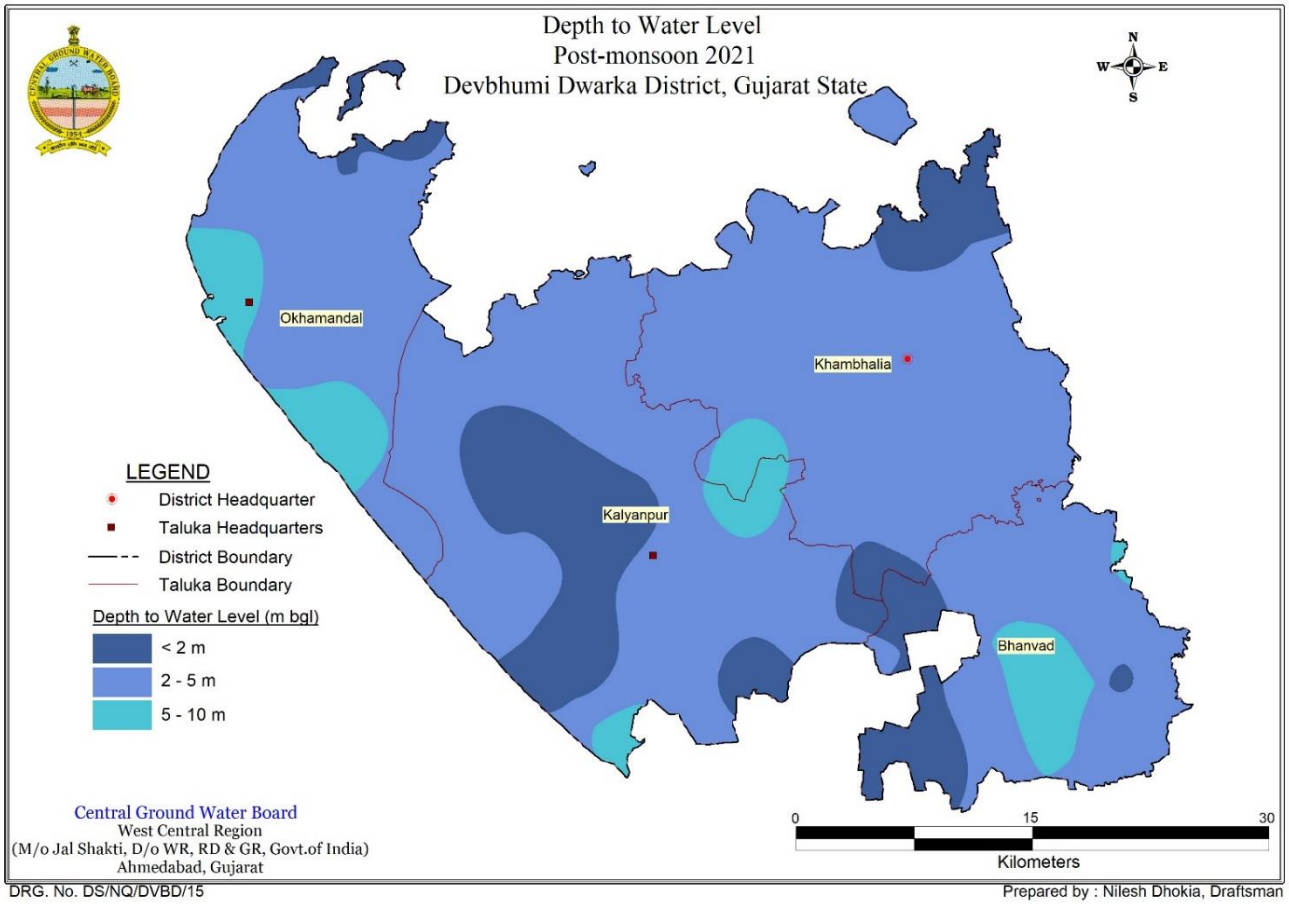


Figure 17. Post-monsoon (Nov-2021) depth to water level of Devbhumi Dwarka District

4.4 Water table and groundwater movement

The elevation of water table in Pre monsoon 2021 is observed higher along SE adjoining district boundary with Jamnagar district where water table contour ranges in between 55 m amsl to 90 m amsl which flowing towards West and SW direction. In Khambhaliya taluka the movement of groundwater is observed toward NE direction (Figure 18).

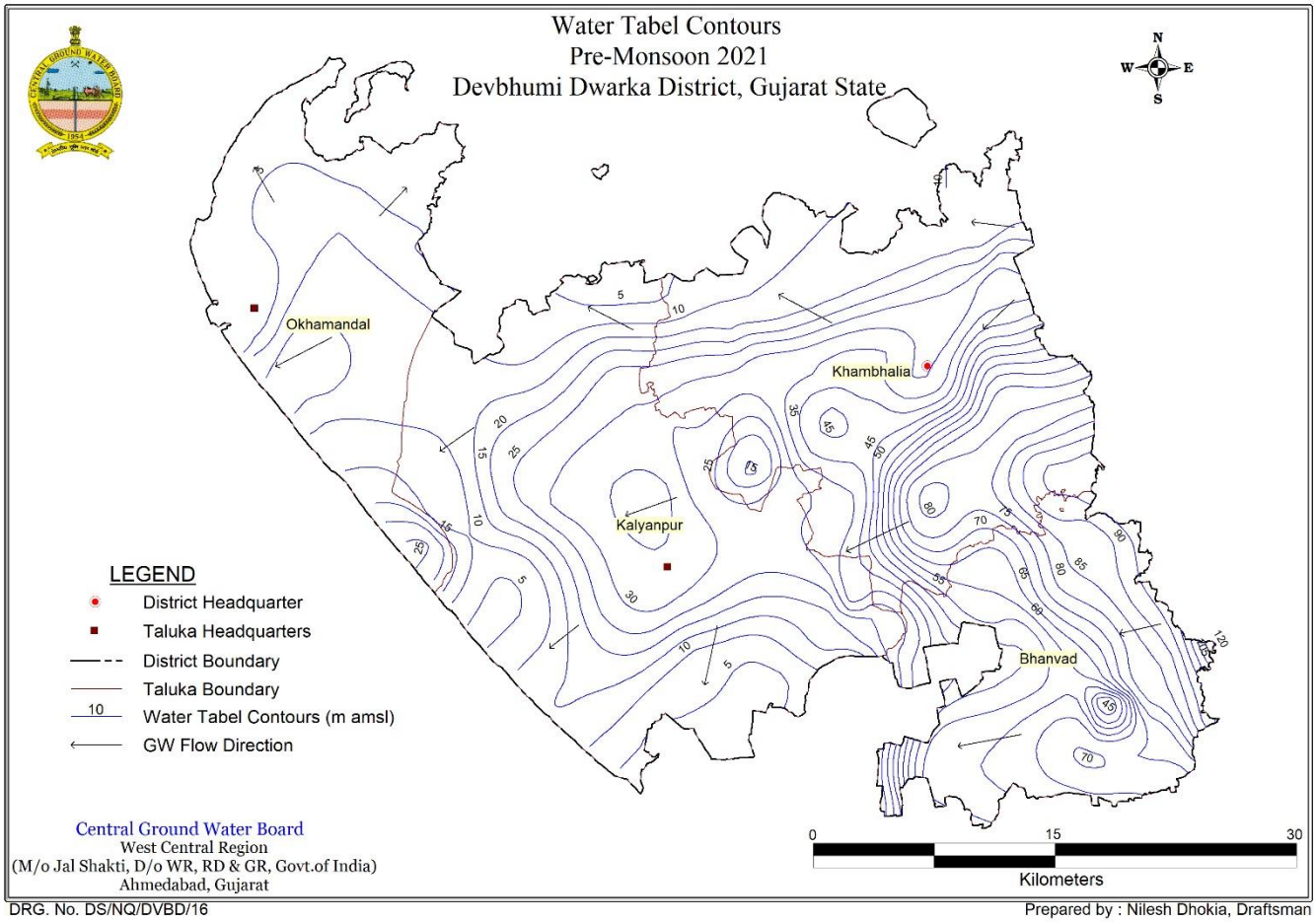


Figure 18. Water level contour map (Post-Monsoon_2019) of Devbhumi Dwarka district

4.5 Ground water fluctuation of Pre to Post-Monsoon (2021)

The whole district is showing the rising trend of groundwater level from pre to post monsoon. From map its depicted that whole part of the district shows rising trend of more than 4 meters. Most of the part of Okhamandal taluka showing less than 2 to 4 meter rise but in the southern and south eastern part of the taluka is showing more than 4 meter rise in water level. In Bhanvad taluka the northern part showing less than 2 meter rise and rest of the area in the taluka showing more than 4 meter rise in the water level. Figure 19 showing groundwater fluctuation of pre to post monsoon season 2021.

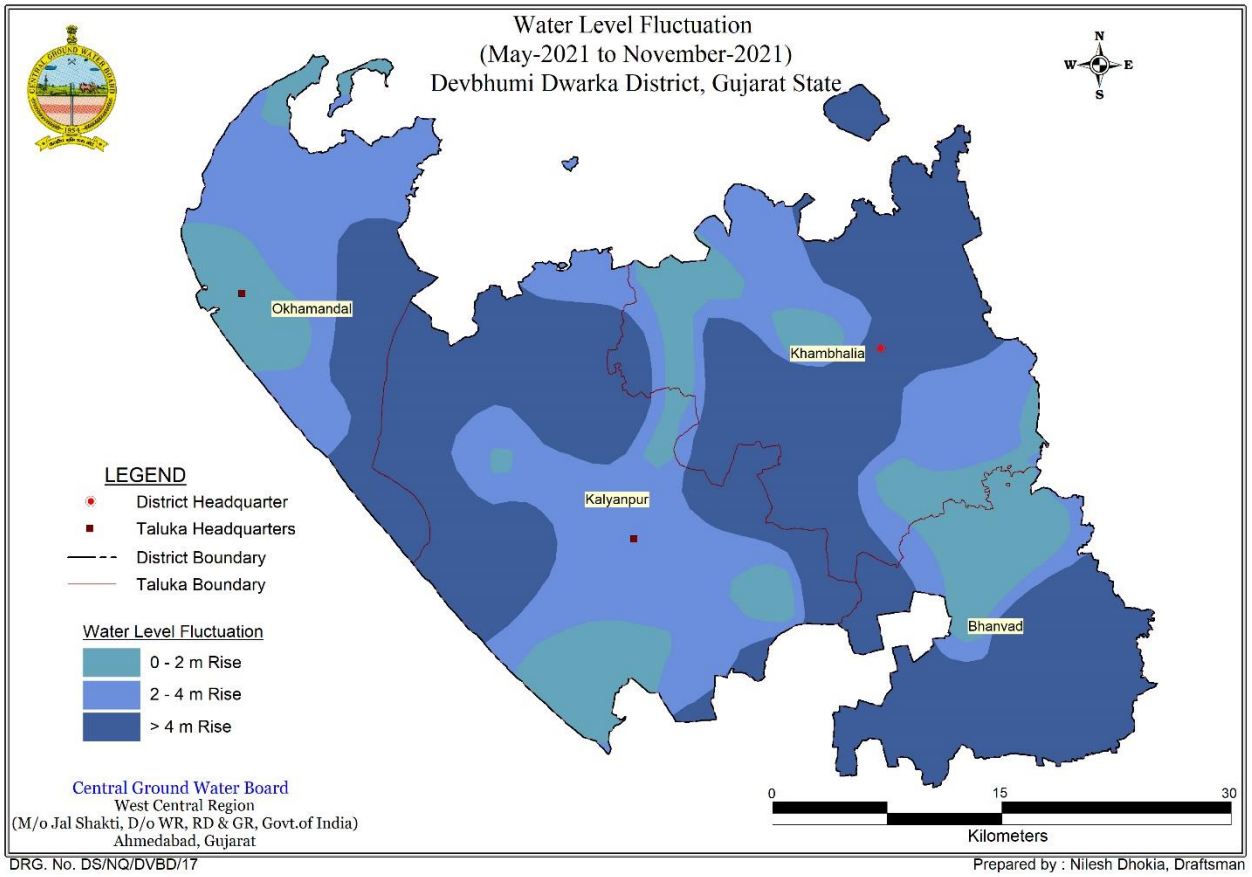


Figure 19. Map showing groundwater fluctuation of pre to post monsoon season 2021

4.6 Ground water decadal average depth to water level (2012-2021) Map

The decadal (2012-2021) average water level map has been prepared and shown in figure 20. In the pre monsoon, decadal average water level goes up to 40 meters below ground level. Most of the deeper water level is noticed in the Khambhaliya taluka and at the few patches are also present in Kalyanpur taluka (Figure 20a). However, in the post monsoon season, decadal average water level goes up to 20 meter below ground level in the district which is shown in figure 20b.

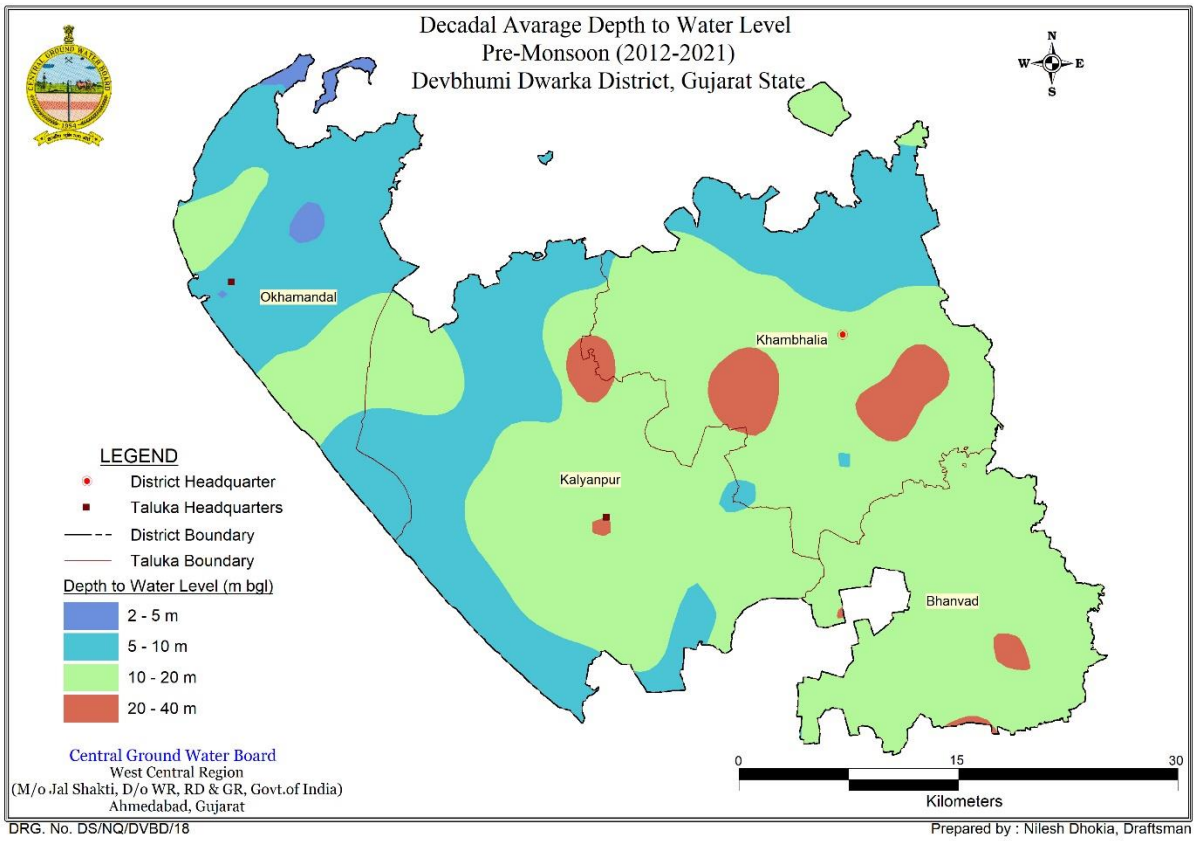


Figure 20a. Ground water decadal trend Pre-Monsoon (2012-2021)

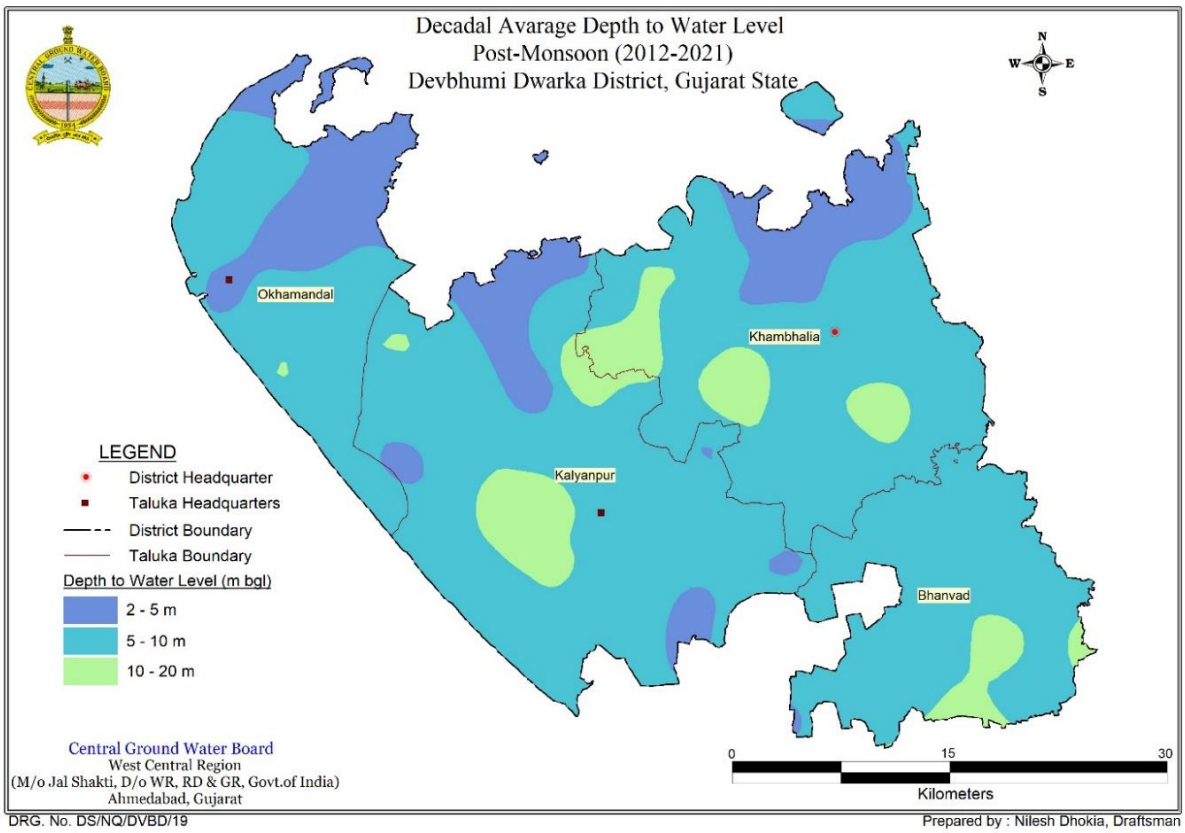


Figure 20b. Ground water decadal trend Post-Monsoon (2012-2021)

4.7 Hydrograph and water level trend (2012-2021)

From the analysis of water level trend of the Devbhumi district from 2012 to 2021, it is observed that during pre monsoon season, the water level has a rise of 0.1234 m/year (Ambardi) to 1.3428 m/year (Kuvadia) and also has fall of 0.0134 m/year (Dwarka) to 0.9300 m/year (Vinjhalpur) Similarly from the analysis of the post monsoon data of 2012 to 2021 the rise shown by the water level of 0.0687 m/year (Dwarka) to 1.0768 m/year (Kuvadia) and no fall is noticed. Pre monsoon and Post monsoon long term rising and decline trend of water level of various hydrograph stations established by CGWB are also studied in graphic form. The hydrographs are showing falling and rising trend in the pre monsoon season. However, in post monsoon only rising trend in hydrographs is observed.

Table 10. Long Term Trend of Water Level from 2012 to 2021

S. No.	Location	Taluka	District	Pre Monsoon			Post Monsoon		
				Data Point	Rise (m/y)	Fall (m/y)	Data Point	Rise (m/y)	Fall
1	Ambardi	Bhanawad	Devbhumi Dwarka	10	0.1234		10	0.0736	
2	Mota Kalvad	Bhanawad	Devbhumi Dwarka	10		0.2643	10	0.8379	
3	Dwarka	Okhamandal	Devbhumi Dwarka	9		0.0134	9	0.0687	
4	Mojap	Okhamandal	Devbhumi Dwarka	10		0.1086	10	0.2944	
5	Raval	Kalyanpur	Devbhumi Dwarka	9	0.3862		9	0.3237	
6	Kalyanpur	Kalyanpur	Devbhumi Dwarka	10	1.3149		10	1.0767	
7	Kuvadia	Khambhaliya	Devbhumi Dwarka	9	1.3428		9	1.0768	
8	Vinjhalpur	Khambhaliya	Devbhumi Dwarka	8		0.9300	8	0.2048	

Historical data of water level were used for preparing the hydrographs as well as for computing long term trend. Few of the hydrographs (Figure 21-28) representing the falling trends of water level of Devbhumi Dwarka district are presented below.

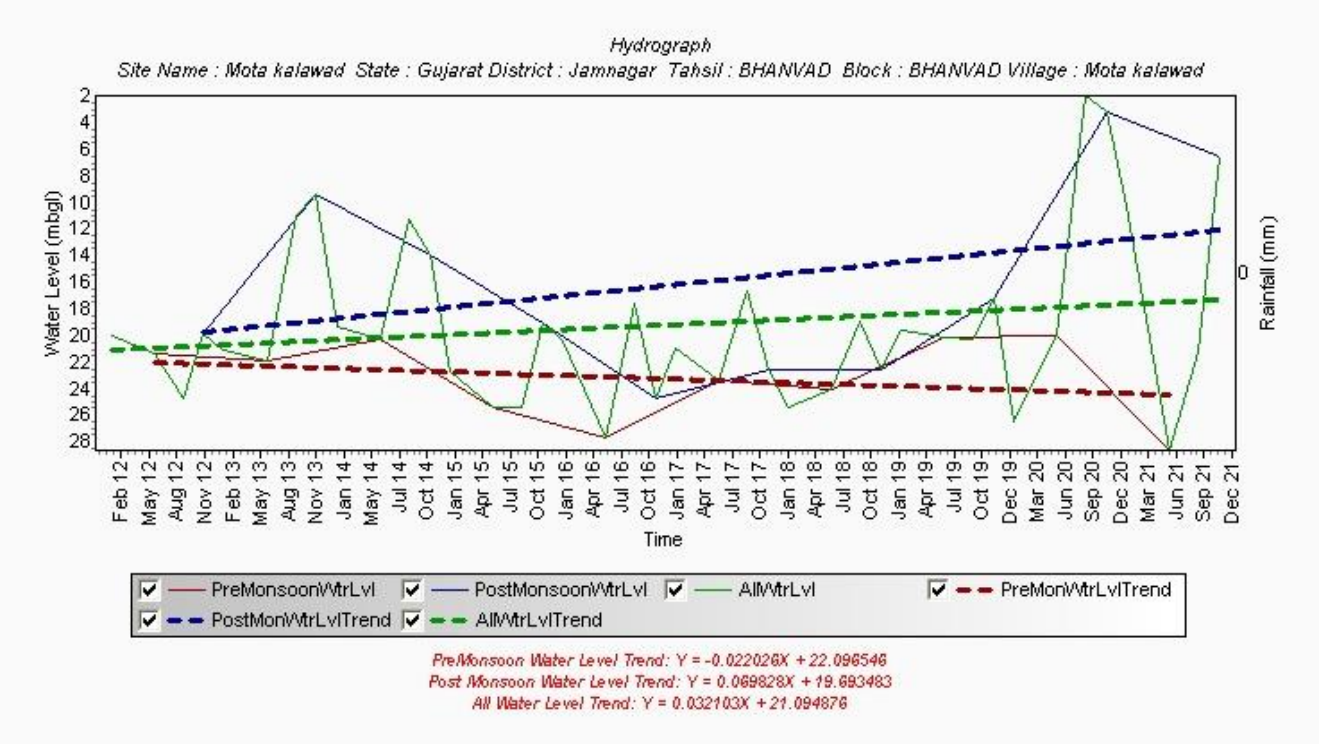


Figure 21. Hydrograph and water level trend at Mota Kalwad site of Devbhumi Dwarka.

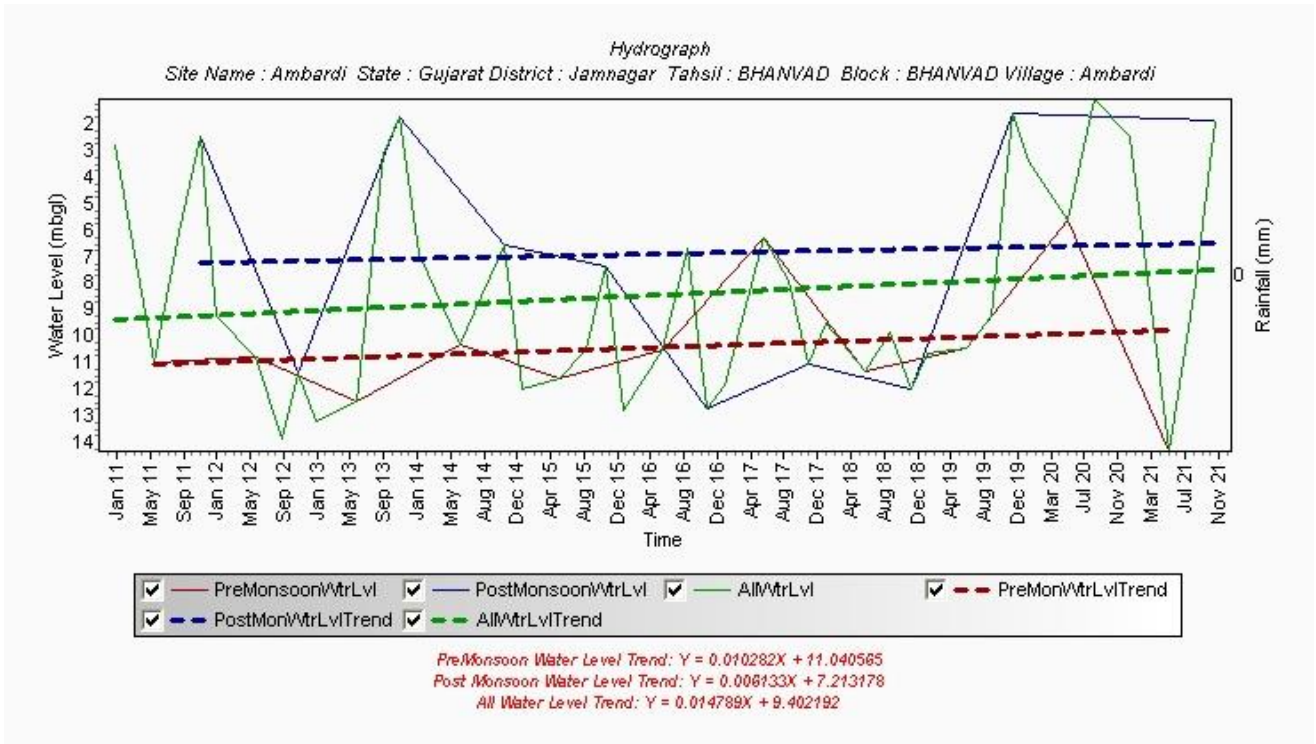


Figure 22. Hydrograph and water level trend at Ambardi site of Devbhumi Dwarka.

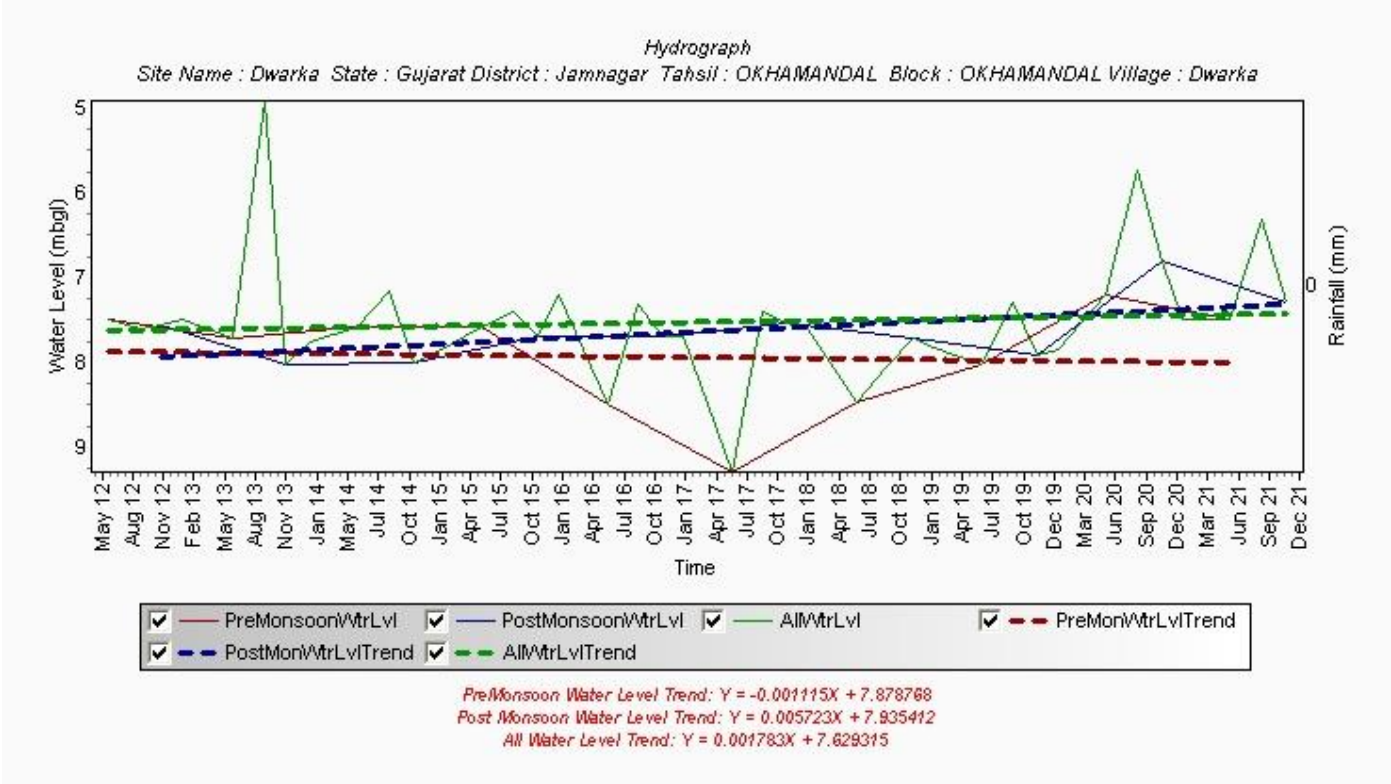


Figure 23. Hydrograph and water level trend at Dwarka site of Devbhumi Dwarka.

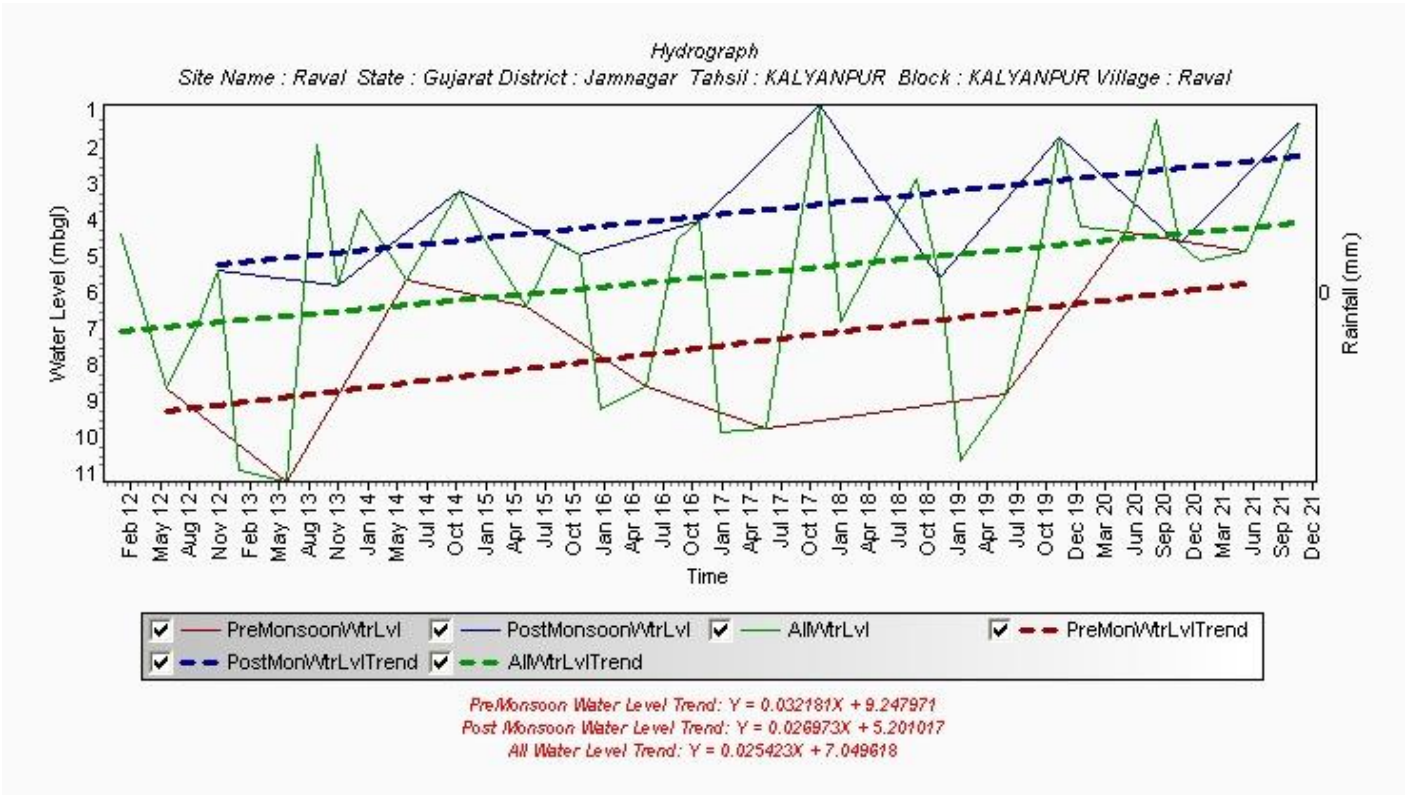


Figure 24. Hydrograph and water level trend at Raval site of Devbhumi Dwarka.

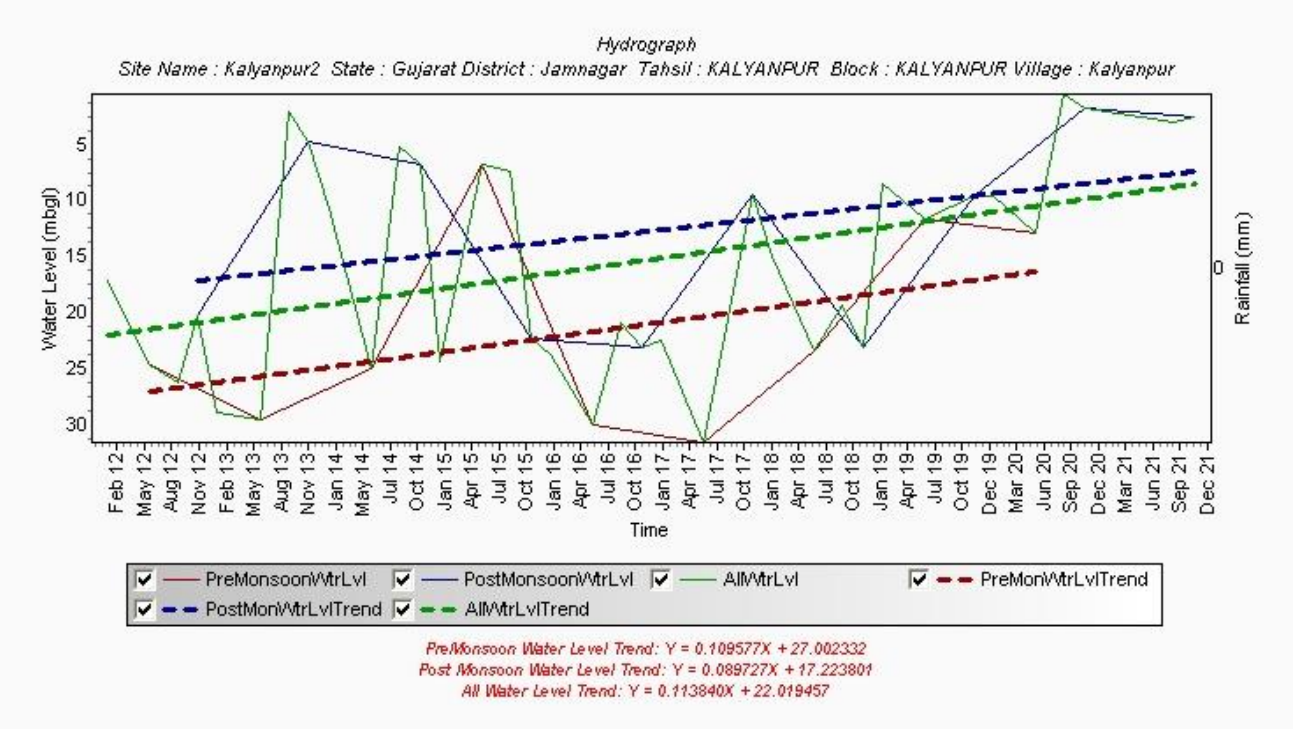


Figure 25. Hydrograph and water level trend at Kalyanpur site of Devbhumi Dwarka.

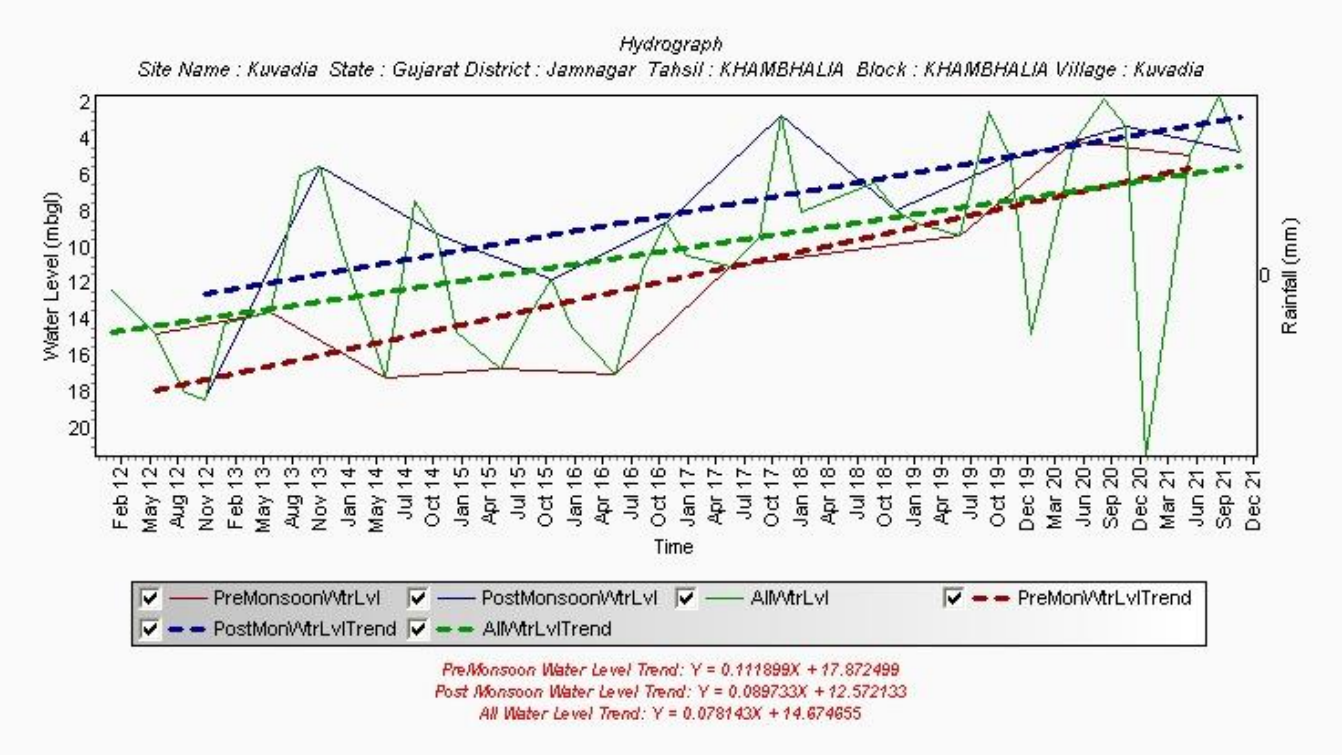


Figure 26. Hydrograph and water level trend at Kuvadia site of Devbhumi Dwarka.

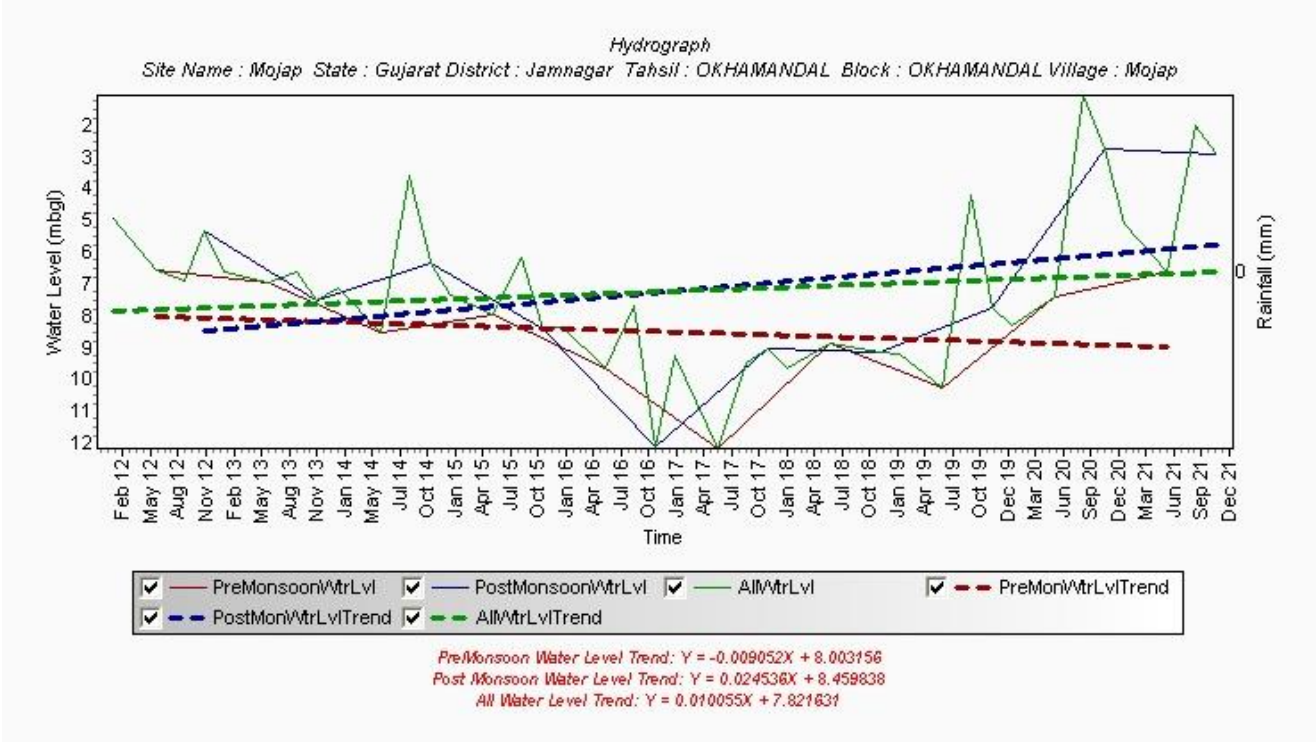


Figure 27. Hydrograph and water level trend at Mojap site of Devbhumi Dwarka.

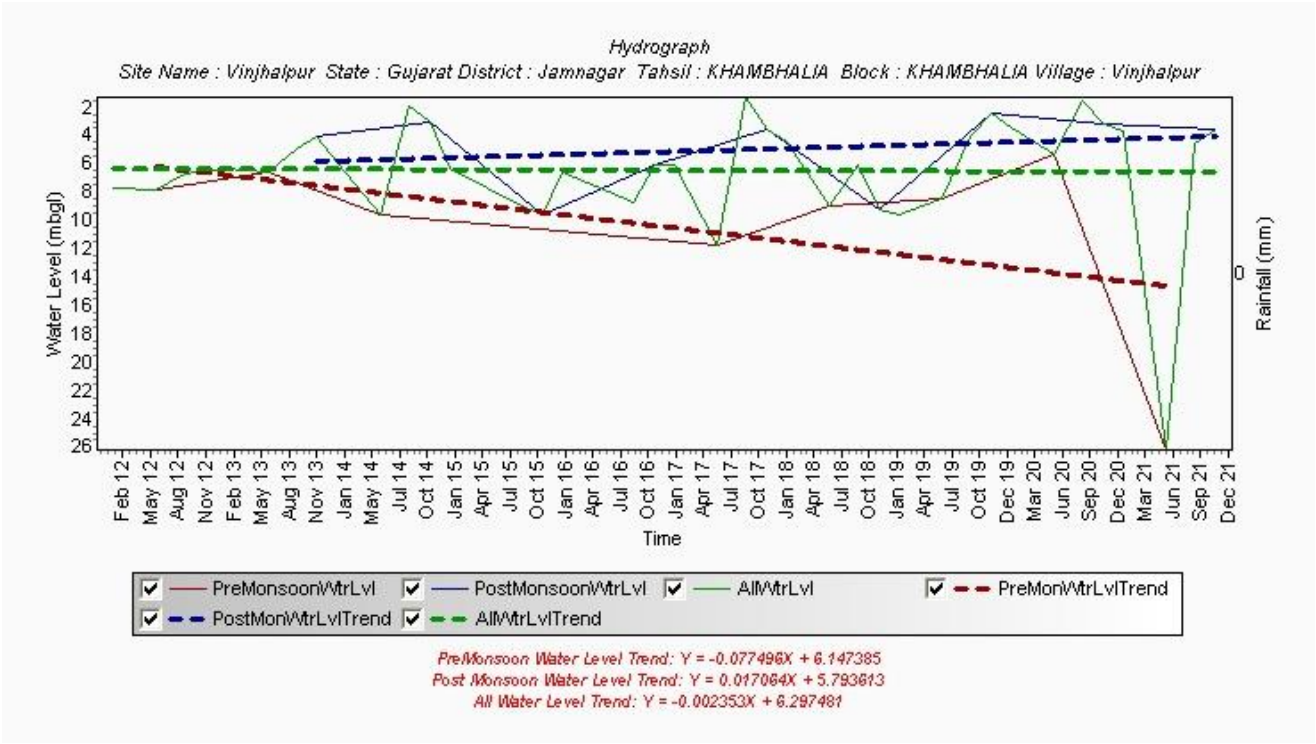


Figure 28. Hydrograph and water level trend at Vinjhalpur site of Devbhumi Dwarka.

5. 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-2020). These resources were computed after reorganization of the districts, talukas of the district are considered as Assessment Unit (AU) and total area of 3219.67 sq km are taken as area of assessment of the district including 04 talukas. Computed resource are presented in tabulated (table-11) and graphically represented as below.

Table 11. 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)

Taluka	ANNUAL REPLENISHABLE GROUND WATER RESOURCE (mcm)					Natural Discharge during non-monsoon season (mcm)	Net Annual Ground Water Availability (mcm)	ANNUAL GROUND WATER DRAFT (mcm)			Projected Demand for Domestic and Industrial uses upto 2025 (mcm)	Ground Water Availability for future irrigation (mcm)	Stage of Ground Water Development (%) (12/9) * 100	Category
	Monsoon		Non Monsoon		Total Annual Ground Water Recharge			Irrigation	Domestic And Industrial uses	Total				
	Recharge from rainfall	Recharge from other sources	Recharge from rainfall	Recharge from other sources										
BHANVAD	101.92	8.92	**0.00**	15.99	126.84	6.34	120.50	68.72	0.83	69.54	0.89	50.89	57.71	**Safe**
KALYANPUR	140.21	8.24	**0.00**	12.58	161.03	8.05	152.98	85.26	4.55	89.81	4.98	62.80	58.71	**Safe**
KHAMBHALIYA	118.89	9.28	**0.00**	16.15	144.31	7.22	137.09	89.72	6.22	95.94	6.81	40.65	69.98	**Safe**
OKHAMANDAL	13.86	0.83	**0.00**	0.71	15.41	0.77	14.64	1.14	1.97	3.11	2.81	11.37	21.22	**Safe**
DISTRICT	374.88	27.27	**0.00**	45.43	447.59	22.38	425.21	244.84	13.56	258.40	15.49	165.72	**60.77**	**Safe**

5.1 Ground Water Recharge

Total Annual Ground Water Recharge from Rainfall and other sources for both monsoon and non monsoon season for the district is 447.59 mcm. And ground water recharge in talukas varies from 15.41 mcm (Okhamandal taluka) to 161.03 mcm (Kalyanpur taluka).

5.2 Net Ground Water Availability

Annual Extractable Ground Water Resource/ Net Ground Water Availability of the district is 425.21 mcm which computed after deducting total natural discharge of 22.38 mcm from total annual ground water recharge.

5.3 Annual Ground Water Draft

The gross ground water draft for all uses (i.e. Irrigation, Domestic and Industrial uses) in the district is 258.40 mcm. The existing gross ground water extraction for all uses varies from 3.11 mcm (Okhamandal taluka) to 95.94 mcm (Khambhaliya taluka). Approximately 95 % of ground water extraction are used for Irrigational purposes, remaining 5% are being extracted mainly for Domestic and Industrial purposes (very less).

5.4 Projected demand for Domestic and Industrial use upto 2025

The total Projected demand of ground water for Domestic and Industrial uses in the district is 15.49 mcm. Projected demand for domestic uses varies from 0.89 mcm (Bhanwad taluka) to 6.81 mcm (Khambhaliya taluka).

5.5 Ground water Availability for future Irrigation

Net ground water availibilty for future use in the district is 165.72 mcm. Taluka wise it varies from 11.37 mcm (Okhamandal taluka) to 62.80 mcm (Kalyanpur taluka).

5.6 Stage of Ground Water Extraction

As per the Ground Water Resource Estimation (GWRE-2020), the stage of Ground Water extraction of the district is 60.77 % which categorized as Safe. Whereas in taluka it varies varies from 21.22 % (Okhamandal Taluka) to 69.98 % (Khambhaliya Taluka) and all the 04 talukas of the district are categorized as SAFE.

6. HYDROCHEMISTRY

Groundwater in the district is in general potable and fresh, both in phreatic and confined aquifers within 200 m depth.

The chemical quality of groundwater in shallow aquifer of the district has been analyzed based on the water samples collected during National Hydrographs Monitoring Stations (NHS) in May 2021 form CGWB and their hydrochemistry is presented in Table-12. The ground water is in general alkaline in nature.

Table 12. Statistical Analysis of Chemical Constituents of Ground Water in Devbhumi Dwarka District, May 2021.

Parameters	Minimum	Maximum	Average
pH	7.41	8.93	8.00
EC (uS/cm)	416.00	20290.00	2593.23
TDS (mg/L)	278.72	13594.00	1737.46
CO_3^- (mg/L)	36.00	72.00	4.13
HCO_3^- (mg/L)	85.00	586.00	275.02
Cl^- (mg/L)	49.63	5183.00	615.86
SO_4^{2-} (mg/L)	14.00	1500.00	158.80
NO_3^- (mg/L)	0.99	2212.00	84.87
F^- (mg/L)	0.02	6.60	0.63
Alkalinity (mg/L)	70.00	560.00	232.31
Ca^{2+} (mg/L)	16.00	408.00	117.74
Mg^{2+} (mg/L)	7.30	360.00	74.12
TH (mg/L)	160.13	2500.00	598.98
Na^+ (mg/L)	28.00	3350.00	334.98
K^+ (mg/L)	0.10	1050.00	24.31
SiO_2 (mg/L)	7.30	80.00	35.93
SAR (mg/L)	0.96	29.00	5.37

6.1 Hydrogen Ion Concentration (pH)

The technical definition of pH is that it is a measure of the activity of the hydrogen ion (H^+) and is reported as the reciprocal of the logarithm of the hydrogen ion activity. In general, a water with a pH < 7 is considered acidic and with a pH > 7 is considered basic. The normal range for pH in surface water systems is 6.5 to 8.5 and for groundwater systems 6 to 8.5. Alkalinity is a measure of the capacity of the water to resist a change in pH that would tend to make the water more acidic. The pH is an indicator of acidity of the water. The value of pH ranges between 7.41 & 8.93 in the district. The result shows that the groundwater water of the district is slightly alkaline in nature.

6.2 Electrical Conductivity:

Electrical conductivity is a measure of water capacity to convey electric current. The most desirable limit of EC in drinking water is prescribed as 1,500 µS/cm (WHO 2004) In devbhumi Dwarka district the EC Ranges from 416 µS/cm to 20290 µS/cm with average value of 2593.23 µS/cm

6.3 Total Dissolved Solid (TDS)

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. Total Dissolved Solid is an overall parameter indicating salinity of ground water Total dissolved solids (TDS) is usually low for freshwater sources, at less than 500 ppm. Seawater and brackish (mixed fresh and sweater) water contain 500–30,000 and 30–40,000 ppm TDS, respectively. The Total Dissolved Solid of ground water varies from 279 mg/l to about 13594 mg/l. Figure 29 shows the distribution of TDS in Devbhumi Dwarka district.

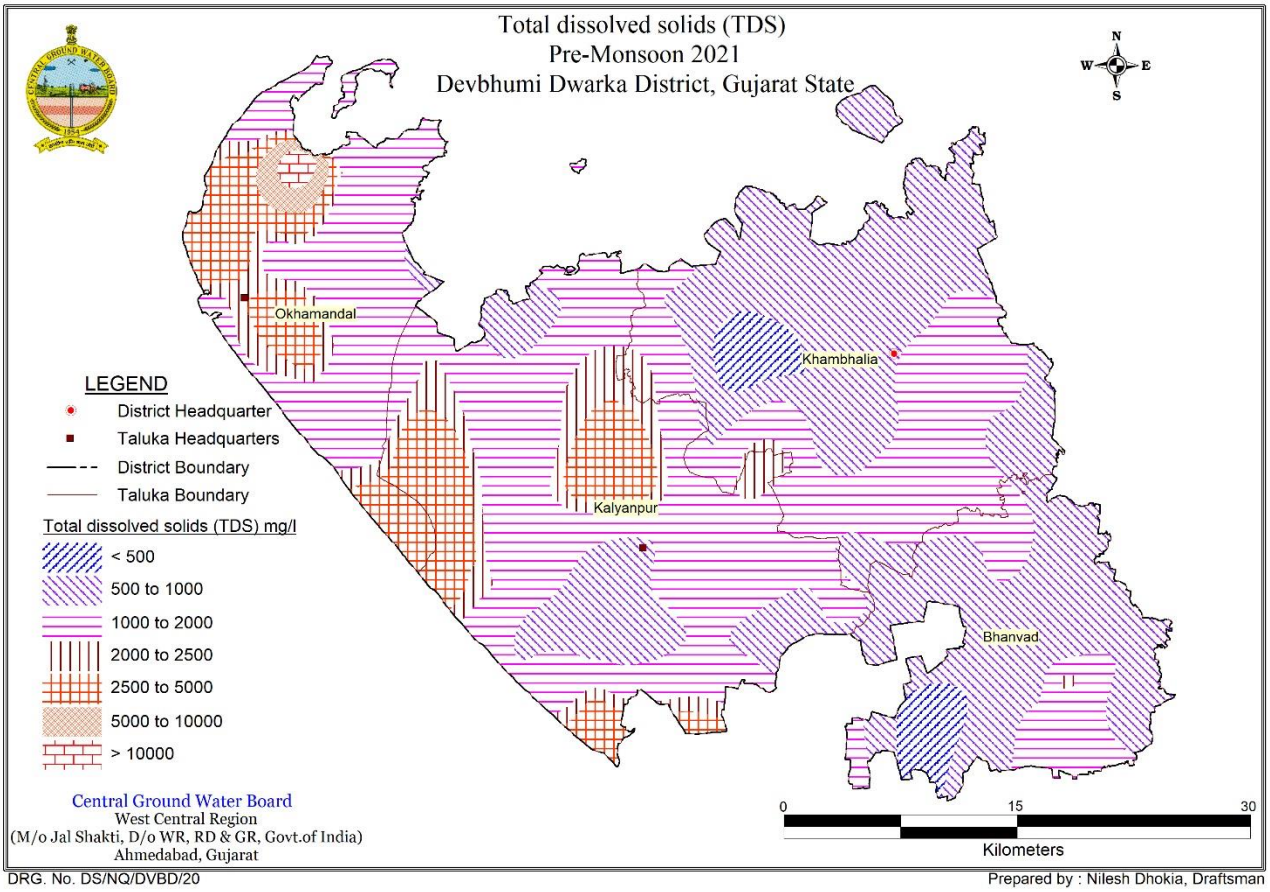


Figure 29. Map showing Taluka wise Total Dissolved Solids (TDS) values of Devbhumi Dwarka District.

6.4 Carbonate (CO_3^-) and Bicarbonate (HCO_3^-)

The shallow groundwater in Devbhumi Dwarka district does not contain any Carbonate except at five locations namely Mulvasar, Drasan Vel, Asota mota, Beh and Meripur. The Bicarbonate concentration in district are varies in between 36 mg/l at Drasan Vel to 72 mg/l at Asota Mota.

6.5 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 30, Two Talukas namely Okhamandal and Kalyanpur shows Cl concentration more than permissible limit.

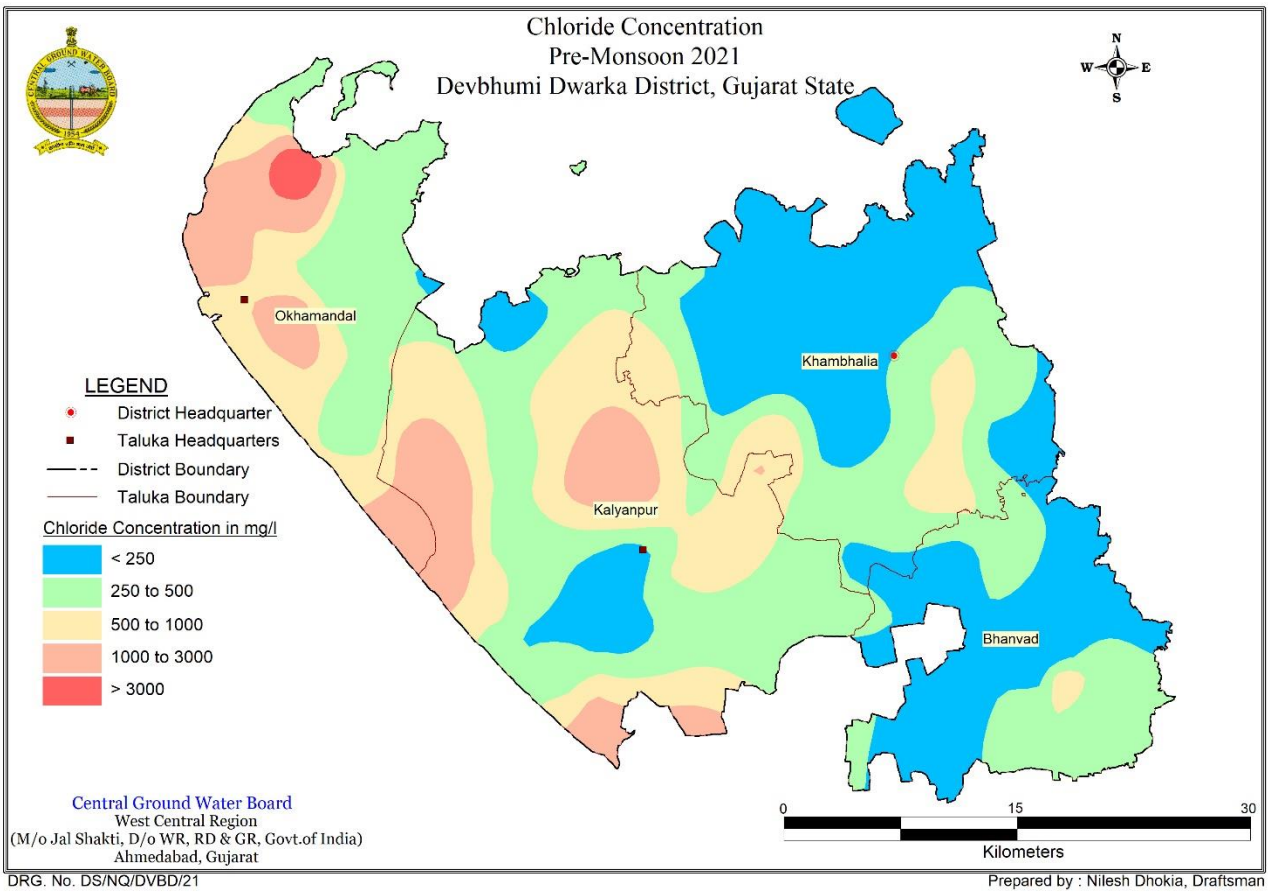


Figure 30. Map showing Taluka wise Chloride (Cl) concentration in Devbhumi Dwarka District.

6.6 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 between 0.99 mg/l and 2212 mg/l. There are 23 isolated monitoring stations where these values are more than the limits as per BIS drinking water standards (45 mg/l) as shown in figure 31.

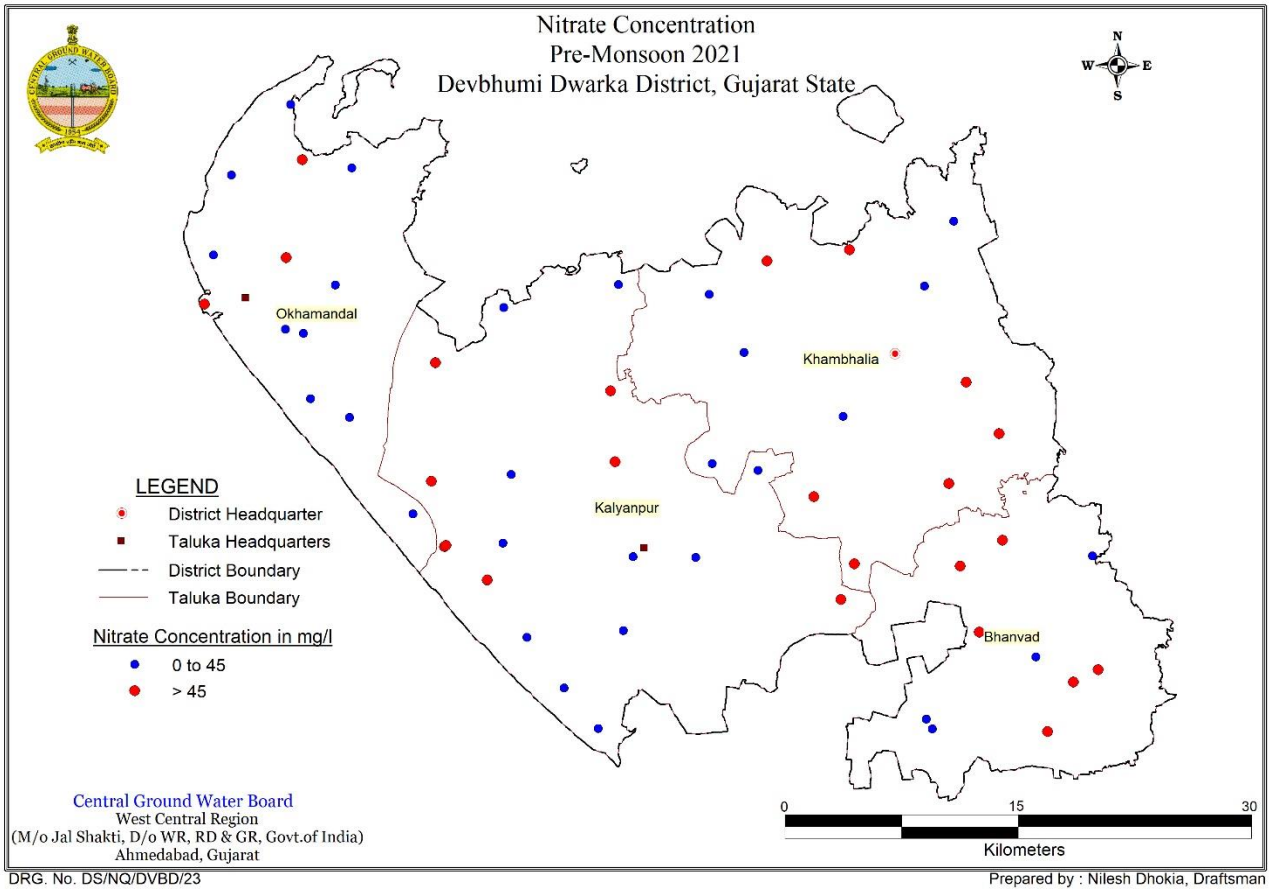


Figure 31. Map showing Taluka wise Nitrate (NO3) concentration in Devbhumi Dwarka District.

6.7 Sulphate (SO_4^{2-})

As water moves through soil and rock formations that contain sulphate minerals, some of the sulphate dissolves into the groundwater. Minerals that contain sulfate include magnesium sulphate (Epsom salt), sodium sulphate (Glauber's salt), and calcium sulphate (gypsum). In the district, Sulphate concentration varies from 14 mg/l to 1500 mg/l.

6.8 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 is released to the soil and groundwater by the process of weathering of primary rock or leaching of landfill contaminants. When fluoride is released into the soil and groundwater, the concentration may increase until saturation is reached. Fluoride concentration in Devbhumi Dwarka district are varies in between 0.02 mg/l and 6.60 mg/l. There are 5 isolated locations where Fluoride concentration is more than permissible limit as presented in figure 32.

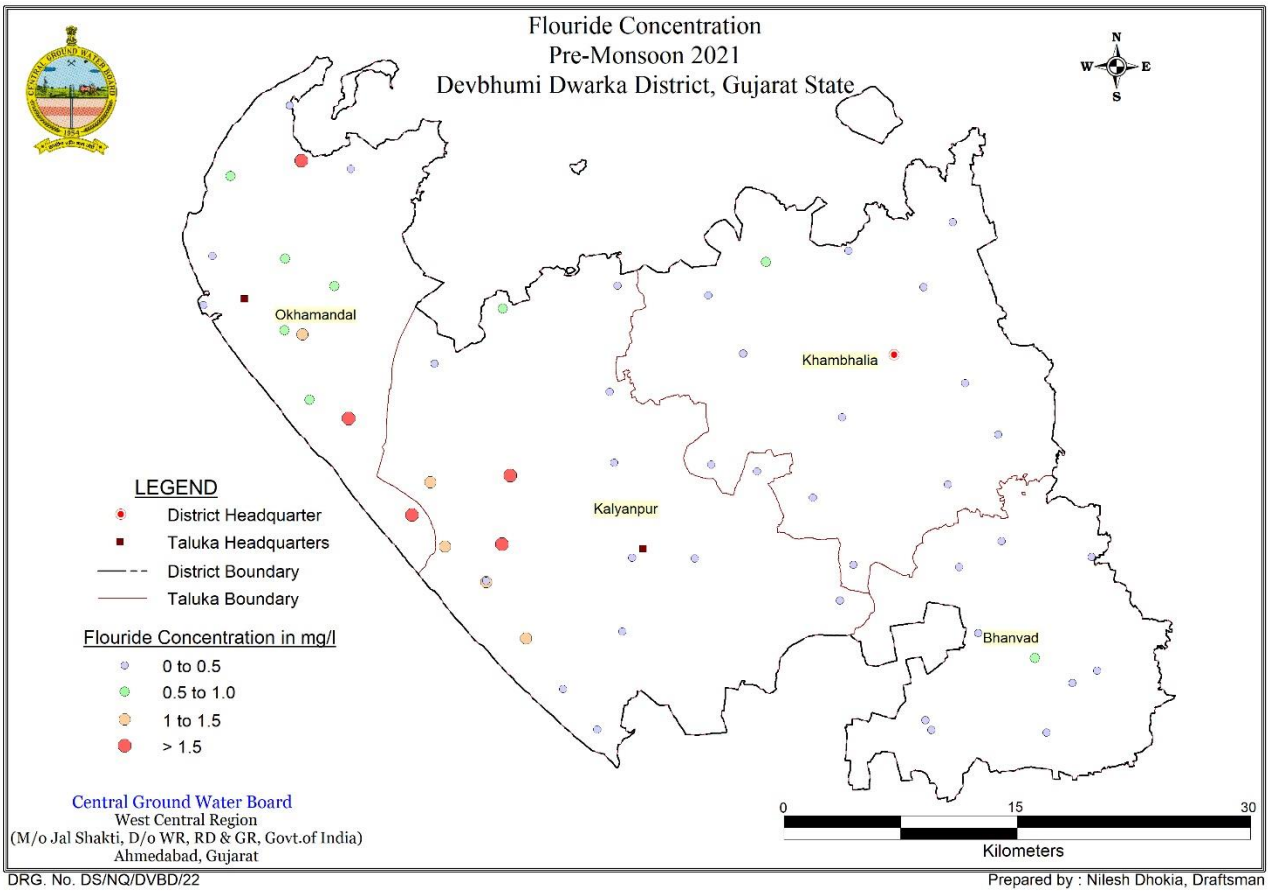


Figure 32. Map showing Taluka wise Flouride (F) concentration in Devbhumi Dwarka District.

6.9 Calcium (Ca^{2+})

Calcium concentration in Devbhumi Dwarka district varies between 16 mg/l and 408 mg/l. The concentration of calcium is found within permissible limits in the district (permissible limit as per BIS norms is 200 mg/l) except 12 locations in the district.

6.10 Magnesium (Mg^{2+})

The Concentration of Magnesium in areas ranges from 7.3 mg/l to 360 mg/l. In 12 isolate villages the concentration of Magnesium is more than maximum permissible limits of 100 mg/l (as per BIS norms).

6.11 Sodium (Na^{+})

Potassium is important ions in ground water and are used to assess quality control for samples and laboratory analysis. Sodium is often naturally found in groundwater. In water, sodium has no smell but it can be tasted by most people at concentrations of 200 milligrams per litre (mg/L) or more. Sodium concentration in the district varies between 28 mg/l at Vadtara and 3350 mg/l. at Hamusa in the district.

6.12 Potassium (K^{+})

Potassium is important ions in ground water and are used to assess quality control for samples and laboratory analysis. The principal potassium minerals of silicate rocks are the feldspars orthoclase and microcline (KAlSi3O8), the micas, and the feldspathoid leucite ($KAlSi_2O_6$). The potassium feldspars are resistant to attack by water. Presumably they are altered to silica, clay, and potassium ions by the same process as other feldspars, only more slowly. In sediments, the potassium commonly is present in unaltered feldspar or mica particles or in illite or other clay minerals. The concentration of Potassium in shallow ground water ranges from 0.01 mg/l Kajuda to 1050 mg/l Hamusa in the district.

7. SUSTAINABLE GROUNDWATER DEVELOPMENT AND MANAGEMENT

7.1 Groundwater related issue:

7.1.1 Low Ground water development

As per GWRE 2020 the total ground water resources of the district are in order of 447.59 mcm/year and utilizable resources are 425.21 mcm/year. The net annual drafts of 258.40 MCM/year leaves a balance of 165.72 mcm/year of ground water available for future development.

Low Ground Water Development: Stage of Ground water development of the district is 60.77 %, however talukas wise it ranges from 21.22% (Okhamandal taluka) to 69.98% (Khambhaliya taluka).

7.1.2 Pollution (Geogenic and Anthropogenic)

Groundwater quality of Devbhumi Dwarka has a special significance and needs greater attention of all concerned since it is the only major source for domestic, consumption. Occurrence of Fluoride beyond acceptable limit (As per the BIS standards [IS 10500: 2012] for drinking water) in Shallow aquifers identified in localized isolated villages of Okhamandal and Kalyanpur. Fluoride problem in the district is basically geogenic. The nitrate problem is also very common in almost all talukas of the district. The elevated nitrate concentration in groundwater of the district may be due to Anthropogenic activity basically from fertilizers.

7.1.3 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 (<2 m^3/hr) to 90 m^3/hr. 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 diameter of well for maximum storage.

7.1.4 Reasons for Issues

Sustainability: Inherent salinity in the district is observed. Absence of primary porosity and very low development of secondary porosity, de-saturation of weathered zone and permeability.

7.2 Management Strategies

As per the estimate of ground water resources and irrigation potential, there exists a scope for further development of ground water resources in major parts of the district. As per GWRE 2017 all the four (04) talukas of the district are under **safe** category. Stage of Ground water development

of the district is 60.77%, however taluka wise it ranges from 21.22% (Okhamandal taluka) to 69.98% (Khambhaliya taluka). Thus, further ground water development could be augmented in a judicious way.

7.3 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.

- Ground water development Plan
- Supply side measures
- Demand side measures
- Regulatory measures
- Institutional measures

7.3.1 Ground water Development Plan

To elevate the stage of ground water development to 60.98% in all Talukas, 200 nos. of Dug wells (15m depth) and 5 nos. of Tube well (150m depth) are proposed as feasible extraction structures table 13. The extraction structures will result as expected annual ground water draft of 107.5 ham which will create 238.89 Ha additional irrigation potential in the district.

Table 13. Feasible Extraction structures to elevate the Stage of GW development to 60.98%

Extraction / Talukas	Feasible Extraction structures to elevate the Stage of GW development to 60.98% (Hard Rock)			G.W Draft from Extraction structures (ham)	Additional Irrigation Potential Created (Ha)
	TW	DW	Total		
Banvad	0	0	0	0.00	0.00
Kalyanpur	0	0	0	0.00	0.00
Khmbaliya	0	0	0	0.00	0.00
Okhamandal	5	200	205	107.50	238.89
District	5	200	205	107.5	238.89

7.3.2 Supply side interventions

As per Master Plan 2019, surplus surface water of 15.24 mcm non committed is allocated to suggest artificial recharge in district of Devbhumi Dwarka. To harvest the surface water, the different artificial recharge structures are proposed as check dam and Percolation tank to recharge the aquifer which is presented in table 14.

Table 14. Proposed Artificial Recharge and WUE Interventions in Devbhumi Dwarka District

Recharge / Talukas	Artificial Recharge through Check Dam	Artificial Recharge through Percolation Tank	Additional Recharge from Recharge interventions (ham)
Bhanvad	56	10	636.87
Kalyanpur	140	25	841.18
Khambaliya	5	1	367.70
Okhamandal	4	1	12.62
District	205	37	1858.36515

❖ **IDENTIFICATION OF RECHARGE AREA**

There are two major water hydrogeological units bearing geological formations occurring in the District have been categorized broadly in two hydrogeological units, namely, alluvial deposits and consolidated rock units of Cretaceous Basalt. The thickness of available unsaturated zone (below 6 m bgl) is computed on basis of Post monsoon (2012-2021) decadal average depth to water level map and Similarly, Post monsoon (2012-2021) decadal water level trend map. On basis of these two maps, area suitable for artificial recharge in Gujarat State is identified taking into consideration of following four categories.

- Area showing declining trend > 0.10 m/year and water level between 6-9 m bgl.
- Area showing declining trend 0 to 0.10 m/year and water level between 6 -9 m bgl.
- Area showing declining trend > 0.10 m/year and water level between > 9 m bgl.
- Area showing declining trend 0 to 0.10 m/year and water level between >9 m bgl.

7.3.3 Demand side intervention

Feasible extraction structures are proposed to elevate the stage of ground water development to 60.77 %, to avoid further exploitation demand side management is also recommended to restrict the stage of ground water development to 57.85 %. An area of 9792 Ha is proposed for on farm activities (Laser leveling/Bench terracing/Contour banding), area and 425 no of farm ponds are recommended which will serve dual purpose of irrigation and recharge to ground water. And expected conservation of ground water through efficiency enhancement measures is 572.32 ham is expected for the district.

❖ **Farm Ponds**

A farm pond is a large hole dug out in the earth, usually square or rectangular in shape (Fig. 33), which harvests rainwater and stores it for future use. It has an inlet to regulate inflow and an outlet to discharge excess water. The pond is surrounded by a small bund, which prevents erosion on the banks of the pond. The size and depth depend on the amount of land available, the type of soil, the farmer's water requirements, the cost of excavation, and the possible uses of the excavated earth. Water from the farm pond is conveyed to the fields manually, by pumping, or by both methods.

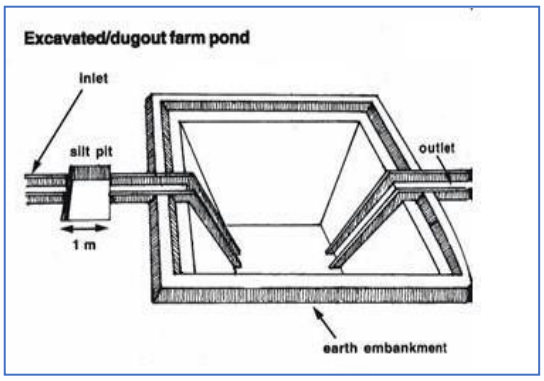


Figure 33. Schematic diagram of Farm pond

Advantages of Farm Ponds

- They provide water to start growing crops, without waiting for rain to fall.
- They provide irrigation water during dry spells between rainfalls. This increases the yield, the number of crops in one year, and the diversity of crops that can be grown.
- Bunds can be used to raise vegetables and fruit trees, thus supplying the farm household with an additional source of income and of nutritious food.
- Farmers are able to apply adequate farm inputs and perform farming operations at the appropriate time, thus increasing their productivity and their confidence in farming.
- They check soil erosion and minimize siltation of waterways and reservoirs.
- They supply water for domestic purposes and livestock
- They promote fish rearing.
- They recharge the ground water.
- The excavated earth has a very high value and can be used to enrich soil in the fields, leveling land, and constructing farm ponds.

Table 15. Projected Status of Groundwater Resource after implementation of GW Management Plan, Devbhumi Dwarka District (Gujarat)

Projected Status of Groundwater Resource after implementation of GW Management plan, Devbhumi Dwarka District (Gujarat)												
Talukas	**Net G.W. Availability (Ham)**	**Additional Recharge from Recharge interventions (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 WUE, on farm activity & farm ponds (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 & Recharge measures (in %)**	**Additional Irrigation Potential Created (Ha)**
Bhanvad	12050.09	366.87	0.00	12416.96	6954.28	157.74	0.00	6796.54	57.71	57.71	54.57	0.00
Kalyanpur	15297.70	571.18	0.00	15868.88	8980.83	187.53	0.00	8793.30	58.71	58.71	55.41	0.00
Khmbaliya	13709.28	367.70	0.00	14076.98	9594.08	194.04	0.00	9400.04	69.98	69.98	66.78	0.00
Okhamandal	1463.75	12.62	27.95	1504.32	310.57	33.01	107.50	385.06	21.22	28.03	25.60	238.89
District	42520.82	1858.37	27.95	44407.14	25839.76	572.32	107.5	25374.94	60.77	60.98	57.85	238.89

8. CONCLUSION AND RECOMMENDATIONS

- Artificial recharge structures like percolation tank and through defunct tubewell are proposed in the district to encounter needed surface runoff.
- To elevate the stage of ground water development to 60.98 % in all Talukas, 200 nos. of Dug wells (15m depth) and 5 nos. of Tube well (150m depth) are proposed as feasible extraction structures.
- To prevent Over Exploitation, water conservation activities like On farm activities , farm ponds are recommended.
- 9792 Ha area is proposed for on farm activities (Laser leveling/Bench terracing/Contour banding) and 1000 no of farm ponds are recommended which will serve dual purpose of irrigation and recharge to ground water.
- Ground water return flow of 27.95 ham is expected from irrigation of fields in the district.
- 572.32 ham conservation of ground water through WUE measures, on farm activities & farm ponds is expected for the district.
- 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 utilisation of groundwater.
- The water quality in general is fresh and brackish in nature. However higher EC, Nitrate and fluoride concentration is observed in isolated pockets. Ground water in such areas may be used after blending with surface water. In areas where ground water has higher concentration of Nitrate is observed, necessary sanitation measures should be adopted.
- Taking into consideration of tribal domination and drought prone area, 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.
- Present supply side interventions are suggested based on availability 16 MCM non committed source of water is referred by State Government (Reference Master Plan of Artificial recharge 2020). Proposed enhancements of present Groundwater development stage is subjected to implementation of recharge interventions, availability of cultivable land and yield of Groundwater structures.
- 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.

Annexure

Annexure I. Pre monsoon 2021 Depth to water level data of Devbhumi Dwarka District.

Agency	District	Taluka	Site Name	Local Geology	DEPTH	Pre Monsoon WL
CGWB	DEVBHUMI DWARKA	BHANVAD	Ambardi	Compact Sandstone	19.22	14.34
CGWB	DEVBHUMI DWARKA	OHKAMANDAL	Aramda	Alluvium	18	5.10
CGWB	DEVBHUMI DWARKA	KHAMBHALIYA	Bhadthar	Basalt	15.75	15.10
CGWB	DEVBHUMI DWARKA	BHANVAD	Bhanvad	Basalt	16.4	4.70
CGWB	DEVBHUMI DWARKA	KALYANPUR	Bhatia	Basalt	20.5	3.91
CGWB	DEVBHUMI DWARKA	KALYANPUR	Bhatiya	Clay	30.5	2.15
CGWB	DEVBHUMI DWARKA	KALYANPUR	Bhogat1	Not Available	11.75	10.45
CGWB	DEVBHUMI DWARKA	OHKAMANDAL	Dwarka	Alluvium	10	7.50
CGWB	DEVBHUMI DWARKA	KALYANPUR	Juvanpur	Basalt	50.01	14.00
CGWB	DEVBHUMI DWARKA	KHAMBHALIYA	Kajuda	Basalt	50.01	9.20
CGWB	DEVBHUMI DWARKA	KALYANPUR	Kalyanpur2	Basalt	32	0.00
CGWB	DEVBHUMI DWARKA	KHAMBHALIYA	Khambhaliya	Basalt	30.5	13.55
CGWB	DEVBHUMI DWARKA	KALYANPUR	Khirsara	Basalt	19.5	13.09
CGWB	DEVBHUMI DWARKA	KHAMBHALIYA	Kuvadia	Basalt	50.01	4.85
CGWB	DEVBHUMI DWARKA	BHANVAD	Modpar	Basalt	18	16.40
CGWB	DEVBHUMI DWARKA	OHKAMANDAL	Mojap	Alluvium	13.64	6.64
CGWB	DEVBHUMI DWARKA	BHANVAD	Mota kalawad	Basalt	27	28.65
CGWB	DEVBHUMI DWARKA	KALYANPUR	Pindara1	Alluvium	13.55	8.50
CGWB	DEVBHUMI DWARKA	KALYANPUR	Raval	Basalt	12	4.85
CGWB	DEVBHUMI DWARKA	KHAMBHALIYA	Salaya	Basalt	13	0.00
CGWB	DEVBHUMI DWARKA	OHKAMANDAL	Samrasar1	Basalt	8.53	7.80

CGWB	DEVBHUMI DWARKA	KHAMBHALIYA	Vadtara	Basalt	14.85	12.00
CGWB	DEVBHUMI DWARKA	OHKAMANDAL	Varwada	Alluvium	50.01	0.00
CGWB	DEVBHUMI DWARKA	KHAMBHALIYA	Vinjhalpur	Basalt	30	26.20
CGWB	Devbhoomi Dwarka	Okhamandal	Mulvasar	Limstone	15.5	2.85
CGWB	Devbhoomi Dwarka	Okhamandal	Drasan Vel	Limstone	25	17.15
CGWB	Devbhoomi Dwarka	Okhamandal	Korada	Limstone	12.4	6.65
CGWB	Devbhoomi Dwarka	Okhamandal	Gorinja	Limstone	19.5	15.6
CGWB	Devbhoomi Dwarka	Okhamandal	Meripur	Limstone	15	8.5
CGWB	Devbhoomi Dwarka	Khambhaliya	Bajana	Basalt	25	19.7
CGWB	Devbhoomi Dwarka	Khambhaliya	Bhadthar	Basalt	18.33	16.5
CGWB	Devbhoomi Dwarka	Khambhaliya	Bhandaria	Basalt	20	13.8
CGWB	Devbhoomi Dwarka	Kalyanpur	Kanakpar	Basalt	17.6	8.5
CGWB	Devbhoomi Dwarka	Khambhaliya	Sidhpur	Basalt	10.5	3.65
CGWB	Devbhoomi Dwarka	Kalyanpur	Khakharda	Basalt	14.35	7.2
CGWB	Devbhoomi Dwarka	Okhamandal	Kurunga vadivistar	Limstone	18	10.05
CGWB	Devbhoomi Dwarka	Kalyanpur	Gojines	Basalt	15	8.95
CGWB	Devbhoomi Dwarka	Kalyanpur	Bhogat	Basalt	10	5.7
CGWB	Devbhoomi Dwarka	Kalyanpur	Kalyanpur	Basalt	40.45	33
CGWB	Devbhoomi Dwarka	Kalyanpur	Haripar	Basalt	17.6	12.2
CGWB	Devbhoomi Dwarka	Kalyanpur	Asota mota	Basalt	28.26	20.1
CGWB	Devbhoomi Dwarka	Khambhaliya	Beh	Basalt	25	19
CGWB	Devbhoomi Dwarka	Khambhaliya	Charbara	Basalt	22	17
CGWB	Devbhoomi Dwarka	Khambhaliya	Danta	Basalt	15.16	8.8
CGWB	Devbhoomi Dwarka	Kalyanpur	Gurgadh	Limstone	14.66	5.65
CGWB	Devbhoomi Dwarka	Khambhaliya	Lalparda	Basalt	17.5	11.9
CGWB	Devbhoomi Dwarka	Bhanvad	Mota gunda	Basalt	18	11.35
CGWB	Devbhoomi Dwarka	Bhanvad	Jampar	Basalt	15	10.1
CGWB	Devbhoomi Dwarka	Bhanvad	Fotdi	Basalt	20	16.2
CGWB	Devbhoomi Dwarka	Bhanvad	Rupamora	Basalt	16.8	9.6

CGWB	Devbhoomi Dwarka	Kalyanpur	Gandhvi	Basalt	15	9.05
CGWB	Devbhoomi Dwarka	Kalyanpur	Lamba	Basalt	20	12.3
CGWB	Devbhoomi Dwarka	Kalyanpur	Navadra	Basalt	14.52	10.3
CGWB	Devbhoomi Dwarka	Kalyanpur	Devaliya	Basalt	15.44	12.9
CGWB	Devbhoomi Dwarka	Kalyanpur	Nagadiya	Basalt	14.8	13.6
CGWB	Devbhoomi Dwarka	Bhanvad	Pachhatar	Basalt	15.6	10.1

Annexure II. Post Monsoon 2021 Depth to water level data of Devbhumi Dwarka District.

Agency	District	Taluka	Site Name	Local Geology	DEPTH	Post Monsoon WL
CGWB	DEVBHUMI DWARKA	BHANVAD	Ambardi	Compact Sandstone	19.22	1.86
CGWB	DEVBHUMI DWARKA	OHKAMANDAL	Aramda	Alluvium	18	3.35
CGWB	DEVBHUMI DWARKA	KHAMBHALIYA	Bhadthar	Basalt	15.75	2.65
CGWB	DEVBHUMI DWARKA	BHANVAD	Bhanvad	Basalt	16.4	0.00
CGWB	DEVBHUMI DWARKA	KALYANPUR	Bhatia	Basalt	20.5	1.06
CGWB	DEVBHUMI DWARKA	KALYANPUR	Bhatiya	Clay	30.5	0.50
CGWB	DEVBHUMI DWARKA	KALYANPUR	Bhogat1	Not Available	11.75	3.05
CGWB	DEVBHUMI DWARKA	OHKAMANDAL	Dwarka	Alluvium	10	7.30
CGWB	DEVBHUMI DWARKA	KALYANPUR	Juvanpur	Basalt	50.01	3.00
CGWB	DEVBHUMI DWARKA	KHAMBHALIYA	Kajuda	Basalt	50.01	1.60
CGWB	DEVBHUMI DWARKA	KALYANPUR	Kalyanpur2	Basalt	32	2.50
CGWB	DEVBHUMI DWARKA	KHAMBHALIYA	Khambhaliya	Basalt	30.5	3.55
CGWB	DEVBHUMI DWARKA	KALYANPUR	Khirsara	Basalt	19.5	1.39
CGWB	DEVBHUMI DWARKA	KHAMBHALIYA	Kuvadia	Basalt	50.01	4.65

CGWB	DEVBHUMI DWARKA	BHANVAD	Modpar	Basalt	18	5.40
CGWB	DEVBHUMI DWARKA	OHKAMANDAL	Mojap	Alluvium	13.64	2.89
CGWB	DEVBHUMI DWARKA	BHANVAD	Mota kalawad	Basalt	27	6.50
CGWB	DEVBHUMI DWARKA	KALYANPUR	Pindara1	Alluvium	13.55	3.87
CGWB	DEVBHUMI DWARKA	KALYANPUR	Raval	Basalt	12	1.30
CGWB	DEVBHUMI DWARKA	KHAMBHALIYA	Salaya	Basalt	13	2.24
CGWB	DEVBHUMI DWARKA	OHKAMANDAL	Samrasar1	Basalt	8.53	1.78
CGWB	DEVBHUMI DWARKA	KHAMBHALIYA	Vadtara	Basalt	14.85	3.90
CGWB	DEVBHUMI DWARKA	OHKAMANDAL	Varwada	Alluvium	50.01	2.20
CGWB	DEVBHUMI DWARKA	KHAMBHALIYA	Vinjhalpur	Basalt	30	3.60
CGWB	Devbhoomi Dwarka	Okhamandal	Mulvasar	Limstone	15.5	2.08
CGWB	Devbhoomi Dwarka	Okhamandal	Drasan Vel	Limstone	25	3
CGWB	Devbhoomi Dwarka	Okhamandal	Korada	Limstone	12.4	4.2
CGWB	Devbhoomi Dwarka	Okhamandal	Gorinja	Limstone	19.5	4.25
CGWB	Devbhoomi Dwarka	Okhamandal	Meripur	Limstone	15	4.35
CGWB	Devbhoomi Dwarka	Khambhaliya	Bajana	Basalt	25	14.5
CGWB	Devbhoomi Dwarka	Khambhaliya	Bhadthar	Basalt	18.33	NA
CGWB	Devbhoomi Dwarka	Khambhaliya	Bhandaria	Basalt	20	6.05
CGWB	Devbhoomi Dwarka	Kalyanpur	Kanakpar	Basalt	17.6	7.75
CGWB	Devbhoomi Dwarka	Khambhaliya	Sidhpur	Basalt	10.5	1.7
CGWB	Devbhoomi Dwarka	Kalyanpur	Khakharda	Basalt	14.35	5.5
CGWB	Devbhoomi Dwarka	Okhamandal	Kurunga vadivistar	Limstone	18	8.52
CGWB	Devbhoomi Dwarka	Kalyanpur	Gojines	Basalt	15	3.1
CGWB	Devbhoomi Dwarka	Kalyanpur	Bhogat	Basalt	10	2.18
CGWB	Devbhoomi Dwarka	Kalyanpur	Kalyanpur	Basalt	40.45	2.9
CGWB	Devbhoomi Dwarka	Kalyanpur	Haripar	Basalt	17.6	NA
CGWB	Devbhoomi Dwarka	Kalyanpur	Asota mota	Basalt	28.26	3
CGWB	Devbhoomi Dwarka	Khambhaliya	Beh	Basalt	25	3.6

CGWB	Devbhoomi Dwarka	Khambhaliya	Charbara	Basalt	22	3.8
CGWB	Devbhoomi Dwarka	Khambhaliya	Danta	Basalt	15.16	3.4
CGWB	Devbhoomi Dwarka	Kalyanpur	Gurgadh	Limstone	14.66	2.7
CGWB	Devbhoomi Dwarka	Khambhaliya	Lalparda	Basalt	17.5	5.3
CGWB	Devbhoomi Dwarka	Bhanvad	Mota gunda	Basalt	18	5.17
CGWB	Devbhoomi Dwarka	Bhanvad	Jampar	Basalt	15	7.5
CGWB	Devbhoomi Dwarka	Bhanvad	Fotdi	Basalt	20	9.26
CGWB	Devbhoomi Dwarka	Bhanvad	Rupamora	Basalt	16.8	3.4
CGWB	Devbhoomi Dwarka	Kalyanpur	Gandhvi	Basalt	15	2.8
CGWB	Devbhoomi Dwarka	Kalyanpur	Lamba	Basalt	20	4.2
CGWB	Devbhoomi Dwarka	Kalyanpur	Navadra	Basalt	14.52	1.5
CGWB	Devbhoomi Dwarka	Kalyanpur	Devaliya	Basalt	15.44	3.6
CGWB	Devbhoomi Dwarka	Kalyanpur	Nagadiya	Basalt	14.8	3.2
CGWB	Devbhoomi Dwarka	Bhanvad	Pachhatar	Basalt	15.6	4.5

Annexure III. Hydrochemistry of Devbhumi Dwarka District in Pre monsoon season 2021

District	Taluka	Location	Source	pH	EC	TDS	CO3	HCO3	Cl	NO3	SO4	F	Alk	Ca	Mg	TH	Na	K	SiO2	SAR
Devbhumi Dwarka	Bhanvad	Ambardi	DW	8.00	1540	1032	0	134	284	180	104	0.22	110	128	71	610	86	1.10	56	1.51
Devbhumi Dwarka	Okhamandal	Aramda	DW	7.90	1737	1164	0	403	376	62	3.30	0.38	330	84	85	560	180	5.70	25	3.31
Devbhumi Dwarka	Bhanvad	Bhanvad	DW	8.20	906	607	0	366	99	41	7.10	0.56	300	48	32	250	106	3.30	40	2.91
Devbhumi Dwarka	Kalyanpur	Bhogat1	DW	7.80	3361	2252	0	244	787	293	16	1.04	200	108	90	641	425	11	18	7.30
Devbhumi Dwarka	Okhamandal	Dwarka	DW	7.92	2590	1735	0	366	518	200	72	0.11	300	56	56	370	378	34	18	8.54
Devbhumi Dwarka	Kalyanpur	Juvanpur	DW	8.16	3612	2420	0	268	922	205	73	0.11	220	96	161	901	450	8.90	45	6.52
Devbhumi Dwarka	Khambhaliya	Kajuda	DW	8.18	886	594	0	354	92	50	9	0.22	290	44	44	290	92	0.10	58	2.35
Devbhumi Dwarka	Kalyanpur	Kalyanpur	DW	7.90	965	647	0	281	142	53	19	0.17	230	44	34	250	118	0.80	44	3.24
Devbhumi Dwarka	Kalyanpur	Khirsara	DW	7.92	1677	1124	0	256	347	102	63	0.14	210	168	61	671	102	1.50	40	1.71
Devbhumi Dwarka	Khambhaliya	Kuvadia	DW	8.23	796	533	0	268	113	34	32	0.24	220	72	22	270	78	0.70	33	2.06
Devbhumi Dwarka	Bhanvad	Modpar	DW	7.89	1618	1084	0	195	383	72	54	0.45	160	88	24	320	242	3.30	80	5.88
Devbhumi Dwarka	Okhamandal	Mojap	DW	7.99	4362	2923	0	366	1149	210	24	0.69	300	92	117	711	706	4.90	21	11.52
Devbhumi Dwarka	Kalyanpur	Pindara1	DW	7.95	860	576	0	195	142	91	1.90	0.57	160	76	19	270	90	8.90	9	2.38
Devbhumi Dwarka	Kalyanpur	Raval	DW	7.69	2928	1962	0	85	879	102	85	0.33	70	337	39	1001	199	1.50	27	2.74
Devbhumi Dwarka	Khambhaliya	Salaya	DW	8.00	1156	775	0	232	191	51	152	0.26	190	76	51	400	109	1.10	65	2.37
Devbhumi Dwarka	Okhamandal	Samrasar1	DW	8.00	1829	1225	0	244	390	129	25	0.50	200	80	58	440	228	3.00	7	4.73
Devbhumi Dwarka	Khambhaliya	Vadtara	DW	8.29	416	279	0	146	50	22	2.71	0.29	120	36	17	160	28	2.21	20	0.96
Devbhumi Dwarka	Okhamandal	Varwada	DW	7.97	5892	3948	0	195	1900	257	19	0.38	160	289	151	1341	870	7.36	17	10.33
Devbhumi Dwarka	Khambhaliya	Vinjhalpur	DW	8.28	838	561	0	317	99	45	21	0.20	260	32	49	280	84	1.24	44	2.18
Devbhumi Dwarka	Okhamandal	Hambusar	DW	8.14	1140	764	0	476	113	54	0.99	0.23	390	44	27	220	175	23	29	5.13
Devbhumi Dwarka	Kalyanpur	Vamansa	DW	7.80	6028	4039	0	146	1758	384	113	1.48	120	124	236	1281	811	6.33	28	9.86
Devbhumi Dwarka	Kalyanpur	Bhatia	DW	8.24	1863	1248	0	256	362	244	7.49	1.98	210	116	34	430	243	48	22	5.10
Devbhumi Dwarka	Khabhalia	Hanzdapur	DW	8.19	2416	1619	0	207	567	123	107	0.40	170	128	63	580	290	1.95	190	5.24
Devbhumi Dwarka	Dwarka	Hamusa	BW	7.96	20290	13594	0	537	5183	1500	2212	6.6	440	408	360	2500	3350	1050	26	29

Devbhumi Dwarka	Okhamandal	Mulvasar	DW	8.41	1844	1235	48	586	263	85	10.1	0.81	560	72	58	420	245	52	24	5.2
Devbhumi Dwarka	Dwarka	Drasan Vel	DW	8.5	2412	1616	36	146	525	120	80	0.56	180	36	85	440	325	26	32	6.74
Devbhumi Dwarka	Okhamandal	Korada	DW	7.61	3015	2020	0	281	710	166	34	0.9	230	100	71	540	432	6.5	26	8.08
Devbhumi Dwarka	Okhamandal	Korada Vadivistar	BW	7.78	8145	5457	0	464	2414	487	26	1.2	380	156	187	1160	1412	22	27	18
Devbhumi Dwarka	Okhamandal	Gorinja	DW	8.14	2643	1771	0	390	611	116	13	0.6	320	76	83	530	390	6.04	24	7.37
Devbhumi Dwarka	Dwarka	Meripur	DW	8.31	1483	994	60	305	256	73	5.71	2.85	350	32	51	290	230	17	20	5.87
Devbhumi Dwarka	Khambhaliya	Bajana	DW	8.23	1324	887	0	268	206	79	122	0.3	220	88	44	400	150	0.89	46	3.26
Devbhumi Dwarka	Khambhaliya	Bhadthar	BW	8.03	1696	1136	0	195	355	94	101	0.17	160	92	46	420	223	0.82	50	4.73
Devbhumi Dwarka	Khambhaliya	Bhandaria	DW	7.82	2388	1600	0	122	582	127	90	0	100	248	92	1000	95	0.7	33	1.31
Devbhumi Dwarka	Kalyanpur	Kanakpar	DW	7.68	3593	2407	0	220	1022	85	40	0.17	180	316	124	1300	250	1.83	51	3.01
Devbhumi Dwarka	Khambhaliya	Sidhpur	DW	7.98	1500	1005	0	268	334	65	31	0.22	220	88	61	470	155	0.55	35	3.11
Devbhumi Dwarka	Kalyanpur	Khakharda	DW	7.85	5732	3840	0	256	1704	365	78	0.14	210	248	238	1600	634	6.41	45	6.89
Devbhumi Dwarka	Dwarka	Kurunga vadivistar	DW	7.97	5165	3461	0	378	1207	612	NA	2.1	310	136	170	1040	802	11.7	21	11
Devbhumi Dwarka	Kalyanpur	Gojines	DW	7.84	6042	4048	0	354	1775	316	52	1.45	290	208	161	1180	870	11.6	18	11
Devbhumi Dwarka	Kalyanpur	Gojines	BW	7.85	4741	3176	0	293	1278	203	71	0.41	240	204	141	1090	607	5.93	23	7.99
Devbhumi Dwarka	Kalyanpur	Bhogat	DW	8.2	2332	1562	0	342	391	258	42	3.5	280	64	44	340	400	3.01	17	9.43
Devbhumi Dwarka	Kalyanpur	Haripar	DW	8.06	2477	1660	0	317	596	81	45	0.32	260	92	117	710	260	0.61	53	4.24
Devbhumi Dwarka	Kalyanpur	Asota mota	DW	8.93	2031	1361	72	305	462	63	2.62	0.27	370	16	36	190	430	3.53	24	14
Devbhumi Dwarka	Khambhaliya	Beh	DW	8.38	1031	691	36	207	185	37	30	0.25	230	76	49	390	80	1.19	41	1.76
Devbhumi Dwarka	Khambhaliya	Charbara	DW	7.83	1160	777	0	403	163	24	57	0.99	330	100	34	390	111	9.86	61	2.44
Devbhumi Dwarka	Khambhaliya	Danta	DW	8.11	1092	732	0	293	156	111	28	0.08	240	100	49	450	72	1.89	45	1.48
Devbhumi Dwarka	Kalyanpur	Gurgadh	DW	7.56	2831	1897	0	220	568	250	145	0.27	180	228	54	790	282	16.9	35	4.36
Devbhumi Dwarka	Kalyanpur	Gurgadh	BW	7.41	3194	2140	0	183	632	225	250	0.24	150	292	61	980	250	22	41	3.47
Devbhumi Dwarka	Khambhaliya	Lalparda	DW	7.83	1367	916	0	281	220	123	47	0.34	230	76	46	380	154	2	45	3.42
Devbhumi Dwarka	Bhanvad	Mota gunda	DW	8.09	1020	683	0	281	121	76	80	0.09	230	80	46	390	80	1.25	54	1.76
Devbhumi Dwarka	Bhanvad	Jampar	DW	7.84	1801	1207	0	220	412	101	60	0.13	180	96	34	380	263	0.55	53	5.85
Devbhumi Dwarka	Bhanvad	Fotdi	DW	8.09	781	523	0	354	64	33	30	0.05	290	44	32	240	88	0.53	53	2.46
Devbhumi Dwarka	Bhanvad	Fotdi	BW	8.31	705	472	0	281	64	33	30	0.19	230	32	27	190	89	0.56	56	2.8

Devbhumi Dwarka	Bhanvad	Rupamora	DW	7.86	1288	863	0	207	241	84	64	0.17	170	108	51	480	88	0.27	54	1.75
Devbhumi Dwarka	Kalyanpur	Gandhvi	DW	7.73	4742	3177	0	122	1456	211	45	0.18	100	372	27	1040	610	6.27	38	8.22
Devbhumi Dwarka	Kalyanpur	Lamba	DW	8.14	2280	1528	0	439	462	131	33	0.48	360	96	66	510	310	1.32	35	5.97
Devbhumi Dwarka	Kalyanpur	Navadra	DW	7.92	1369	917	0	317	241	87	39	1.22	260	48	41	290	187	3.68	27	4.77
Devbhumi Dwarka	Kalyanpur	Devaliya	DW	7.99	983	659	0	171	185	57	20	0.02	140	76	34	330	73	2.37	28	1.75
Devbhumi Dwarka	Kalyanpur	Nagadiya	DW	7.95	1127	755	0	110	263	69	23	0	90	68	49	370	89	0.23	16	2.01
Devbhumi Dwarka	Bhanvad	Pachhatar	DW	8.02	543	364	0	232	57	17	6.57	0.34	190	64	7.3	190	49	3.79	31	1.53
Devbhumi Dwarka	Bhanvad	Pachhatar	BW	7.91	456	306	0	171	57	14	19	0.21	140	24	27	170	37	1.07	31	1.25
Devbhumi Dwarka	Bhanvad	Motakalvad	BW	7.6	3498	2344	0	195	880	168	97	0.13	160	240	97	1000	350	1.17	58	4.81
Devbhumi Dwarka	Kalyanpur	Kalyanpur	BW	8.04	1066	714	0	268	170	60	29	0.23	220	44	44	290	112	1.22	49	2.85

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