केन्द्रीय भूमि जल बोर्ड

जल संसाधन, नदी विकास और गंगा संरक्षण

विभाग, जल शक्ति मंत्रालय

भारत सरकार

Central Ground Water Board

Department of Water Resources, River Development and Ganga Rejuvenation,

Ministry of Jal Shakti

Government of India

AQUIFER MAPPING AND MANAGEMENT OF GROUND WATER RESOURCES

Narmada District
Gujarat

पश्चिम मध्य क्षेत्र, अहमदाबाद

West Central Region, Ahmedabad

Government of India
Ministry of Jal Shakti
Department of WR, RD and GR.

Report
on

NATIONAL AQUIFER MAPPING AND MANAGEMENT PLAN (NAQUIM), NARMADA DISTRICT, GUJARAT STATE

Central Ground Water Board
West Central Region
Ahmedabad

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AQUIFER MAP AND MANAGEMENT PLAN
NARMADA DISTRICT
GUJARAT STATE

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NARMADA DISTRICT AT A GLANCE

SL No	Items	Statistics
1	**General Information (As per Census, 2011)**	
	i) Geographical Area (Sq Km)	2755.36
	ii) Administrative Divisions • Number ofTaluka • Number of towns • Number ofVillages	 5 5 609
	iii) Populations Rural Urban	590,297 Male-301,086 Female-289,211 528,425 61,872
	iv) Taluka wiseAverage Annual Rainfall (2007-16) a. Sagbara b. Dediapada c. Tilakwada d. Nandod	(mm) 1111 1065 904 980
2.	**GEOMORPHOLOGY**	
	Major Physiographic Units	High relief area, Piedmont zone
	Major Drainages	Narmada river and Tapi river
3.	**LAND USE (Source: Directorate of Agriculture, Seasons and Crops, Gandhinagar for 2014-15)(Area '00 ha)**	
	a) Forest area b) Fallow land c) Net area sown d) Area sown more than once e) Gross Cropped Area f) Other uncultivated land excluding fallow	1157 38 1054 237 1290 169
4.	**MAJOR SOIL TYPES**	
	Medium black and shallow black soil.	
5.	**AREA UNDER PRINCIPAL CROPS in (Area '00 ha)** **(Source: Directorate of Agriculture, Seasons and Crops, Gandhinagar for 2014-15)**	
	Total cereals: 332(Jowar:18, Bajra:02, Wheat:20, Maize:54, Paddy-228, Other Cereals-8) Total Pulses: 435, Total food Grains: 767, Total Oil seeds:63, Sugar Cane: 1, Cotton: 373.	
6.	**IRRIGATION BY DIFFERENT SOURCES** **(Source: Directorate of Agriculture, Seasons and Crops, Gandhinagar for 2014-15)**	Area ('00ha)

	Net Area Irrigated by Tank	0
	Net Area Irrigated by Canals	124
	Net Area Irrigated byTubewells	16
	Net Area Irrigated by Other Wells	139
	NetAreaIrrigated by Other sources	20
	GrossareaIrrigated byCanals	141
	GrossareaIrrigated by tank	0
	Gross area Irrigated by Tubewells	32
	Grossarea Irrigated by others wells	174
	Grossarea Irrigated by others sources	32

7.	**NUMBERS OF GROUND WATER MONITORING WELLS OF CGWB (As on 31-03-2019)**	**31**
	No of Dug Wells	20
	No of Piezometers	11

8. PREDOMINANT GEOLOGICAL FORMATIONS

Predominant geological formation is Deccan traps. Others are Gaj Beds, Miliolitic, Limestone, Alluvium.

9. HYDROGEOLOGY

Major Water Bearing Formation: Weathered, jointed & Fractured Basalts (80% area) of Deccan Traps, Gaj beds, Miliolitic Limestone and Alluvium.

Depth to water Level during 2019

Period	**Phreatic Aquifer (DTW)**		**Semi-confined Aquifer (PZ head)**	
	Min	**Max**	**Min**	**Max**
Pre Monsoon	2.26 (Ringani)	32.01 (Sunderpura_Pz)	NA	NA
Post Monsoon	0.4 (Khaidipada)	24.95 (Rajpipla)	NA	NA

Long Term (10 Years) Water Level Trend 2009-2018)

Trend	**Post- Monsoon**
Rise (m/Yr)	0.5495 (Selamba) to 0.0235 (Khota amba)
Fall (m/Yr)	-0.6937 (Rasela) to -0.0139 (Kanbi pitha)

10. GROUND WATER EXPLORATION BY CGWB (As on 31 -03 -2019)

No of wells drilled (EW, OW, Pz, SH, Total)
EW: 20, OW: 09, Pz: 06, SH: 00, **Total: 35**

Depth Range(m)	19 to 381
Discharge (Litres per second)	0.17 to 65.23
Drawdown	0.26 to 26.96 m
Transmissivity (m^2 / day) (Theis's Method)	1.67 to 22933

11 GROUND WATER QUALITY(As per chem. Analysis of samples collected during May 2019 NHS monitoring)

	Presence of chemical constituents more than permissible limit EC >3000µs/Cm F > 1.5 mg/l NO3 > 50mg/l	 1 village (Rasela) No villages 07 villages
	Type of water	Potable
12.	**DYNAMIC GROUND WATER RESOURCES (As on 2017) in HAM**	
	Total Ground Water Recharge	**7131.91**
	Net Annual Ground Water Availability for future use	**19020.22**
	Current Annual Ground Water Extraction	**4631.77**
	Annual GW Allocation for Domestic Use as on 2025	**1092.00**
	Stage of Ground Water Extraction (%)	19.37
13	**AWARENESS AND TRAINING ACTIVITY**	
	Public Interaction Programme	01
	Tier III training Programme	01
	Water management training Programme (WMTP)	01
14	**EFFORTS OF ARTIFICIAL RECHARGE & RAINWATER HARVESTING**	
	Projects completed by CGWB (No & Amount spent)	None
	Projects under technical guidance of CGWB (Numbers)	None
15	**GROUND WATER CONTROL AND REGULATION (2020)**	
	Number of OE Blocks	Nil
	Number of Critical Blocks	Nil
	Number of Semi Critical Blocks	Nil
	Number of Safe Blocks	05
	Number of Saline Blocks	Nil
	No. Of Blocks Notified by CGWA	Nil
16	**MAJOR GROUND WATER PROBLEMS AND ISSUES**	
	• The farmers don't have control over power supply;therefore, they irrigate the crops by groundwater when power supply is available rather than waiting for the wilting to start. • Flood irrigation technique which is practiced in the area is also the major cause of wastage of ground water as there is no control on the watering depth. • The Narmada is indeed shifting its course and causing erosion of the land over the past years. The phenomenon is more pronounced since 1994 flood of Narmada river. • Lack of awareness among the people regarding rainwater harvesting and artificial recharge.	

AQUIFER MAP AND MANAGEMENT PLAN, NARMADA DISTRICT, GUJARAT STATE

1. Introduction

Aquifer mapping is a process wherein a combination of geologic, geophysical, hydrologic and chemical field and laboratory analyses are applied to characterize the quantity, quality and sustainability of ground water in aquifers. There has been a paradigm shift from "groundwater development" to "groundwater management". An accurate and comprehensive micro-level picture of groundwater in India through aquifer mapping in different hydrogeological settings will enable robust groundwater management plans at the appropriate scale to be devised and implemented for this common-pool resource. This will help achieving drinking water security, improved irrigation facility and sustainability in water resources development in large parts of rural India, and many parts of urban India as well. The aquifer mapping program is important for planning suitable adaptation strategies to meet climate change also. Thus the crux of NAQUIM is not merely mapping, but reaching the goal – that of ground water management through community participation.

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 in Annexure –I and presented in figure 1.

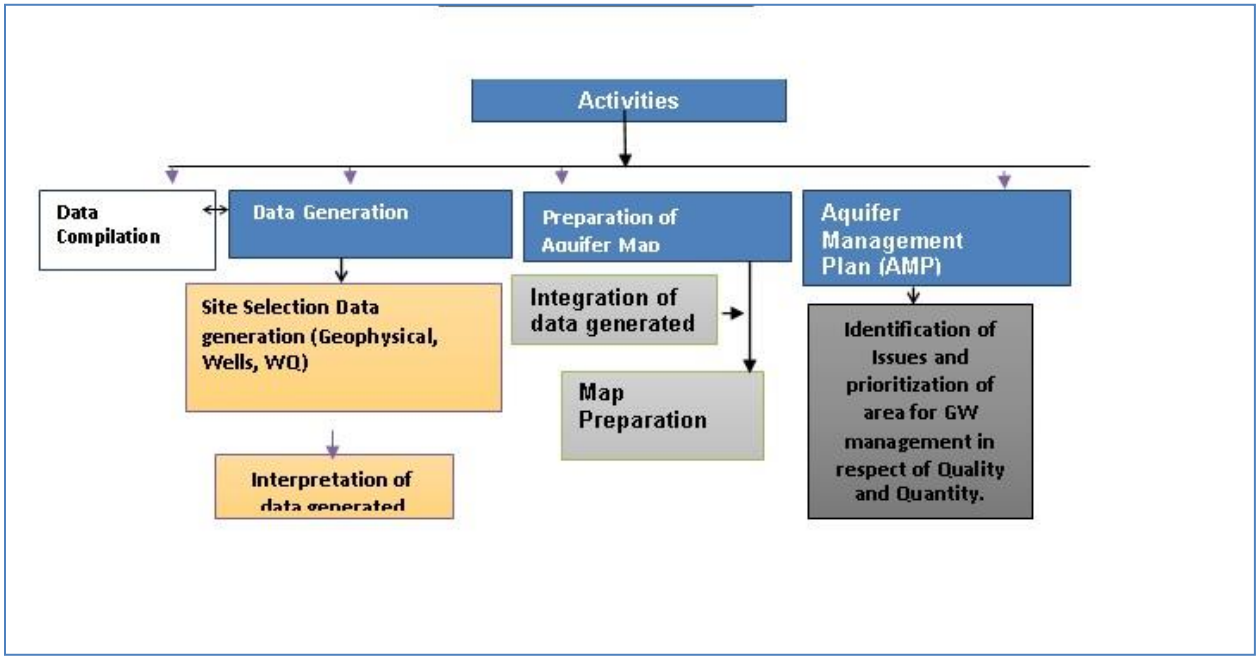


Figure 1- Activities under National Aquifer Mapping Programme

1.3 Locations, Extent and Accessibility

Narmada district was carved out on October 2, 1997 and situated in the southern part of Gujarat State. The district lies between north latitudes 21°23' and 22°05' and east longitudes 73°17' and 73°59'. The newly formed district consists of Tilakwada taluka of erstwhile Vadodara district and 3 talukas viz., Nandod, Dediapada and Sagbara of erstwhile Bharuch district. Therefore, most of the previous work done in the Bharuch district and Varodara district is now covered in Narmada district. The geographical area of the district is 2817 sq.km. Narmada district is bounded in the North by Vadodara district, in the south by Surat district, in the west by Bharuch district and in east by Maharashtra State (Figure-2).

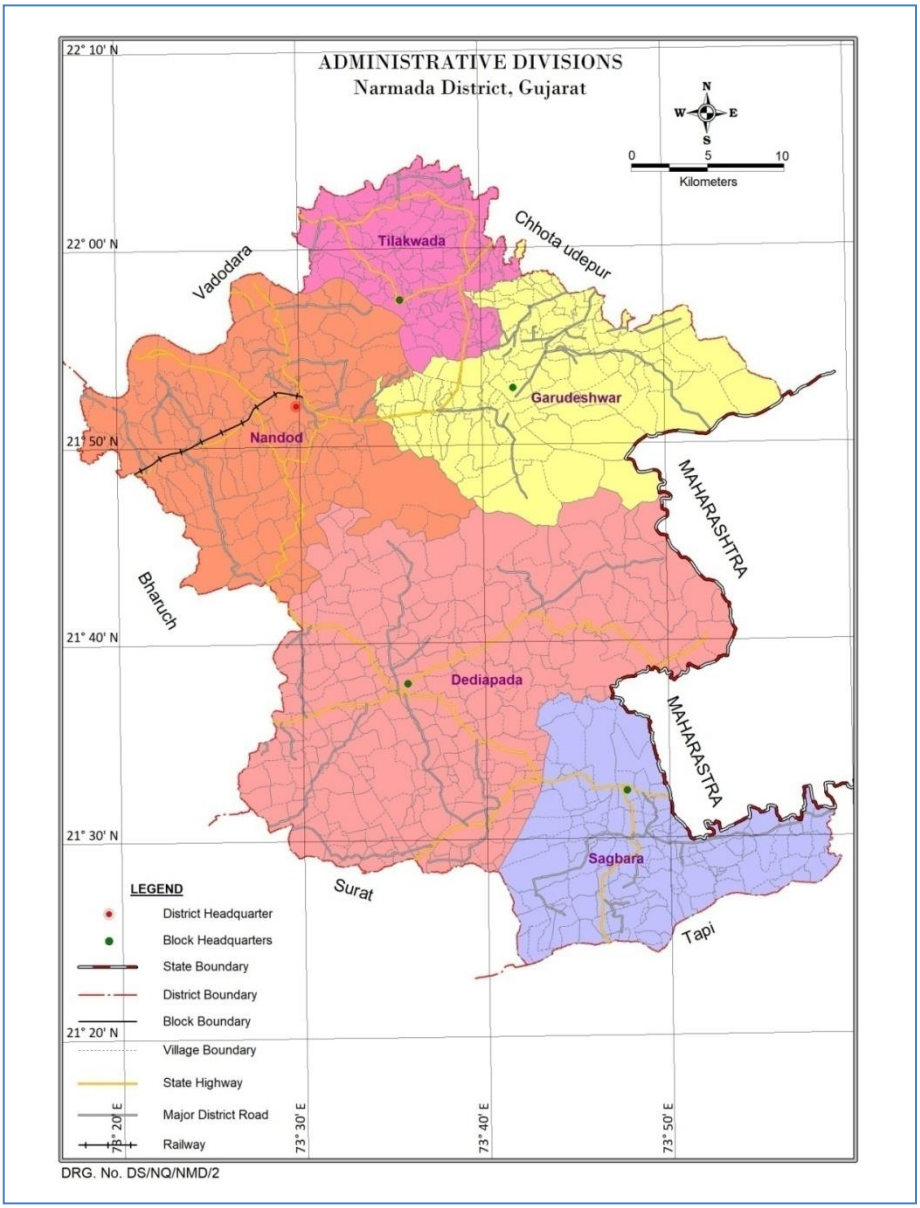


Figure 2: Administrative map of Narmada district.

1.4 Demography

Narmada covers 1.44% of total area of Gujarat State. Density (Population per sq. km) of the district is 6th lowest & is 210. Narmada district is the 3rd lowest populated district in the State.

The total population of the district is 590297 of which male population constitutes about 301086 (51.01%) and female population is 289211 (48.99 %). Nandod taluka comprises maximum population 241053 (40.84 %) of the district whereas Tilakwada taluka has minimum population 63871 (10.82 %) in the district. The district consists of 609 villages and 05 towns

Table 1- Demographic details of the Narmada district. (source- census 2011)

Blocks	Male	Female	Total	Male (%)	Female (%)	Total (%)
Nandod	124560	116493	241053	51.67	48.33	40.84
Dediyapada	88235	86214	174449	50.58	49.42	29.55
Sagbara	55094	55830	110924	49.67	50.33	18.79
Tilakwada	33197	30674	63871	51.98	48.02	10.82
Total	301086	289211	590297	51.01	48.99	

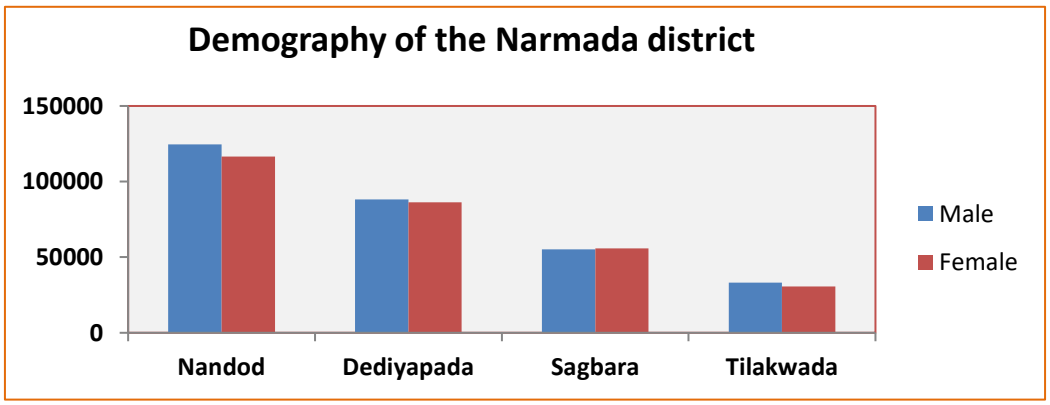


Figure 3- Histographical represenation of demography of Narmada district.

1.5 Previous work

Central Ground Water Board (1977-78) carried out detailed hydrogeological investigation in parts of Bharuch district. Sporadic hydrogeological survey work in connection with drilling and construction of tube wells in parts of Bharuch district was carried out by J. S. Auden (1951), Murthy (1967-68), Channabasappa (1962) of Geological Survey of India. Detailed exploratory work has been carried out under Narmada River Basin Project by the Central Ground Water Board between the years 1971 and 1978. Systematic hydrogeological survey carried out by Saleem Romani (1970-73) in parts of Narmada Basin, Naswadi, Tilakwada area of Vadodara district.

Groundwater exploration by test drilling in the district commenced in fifties and is continuing till 2008. A. K. Jain (1986-87) carried out groundwater exploration in Tilakwada Taluka. Apart from the exploratory well's piezometers have also been constructed in the district under the Hydrology project. Representative dug wells and piezometers are monitored periodically for the ground water regime studies and quality changes in the district and is continued till date.

1.6 Hydrometerology

The district has semi-arid climate. Medium temperatures, erratic rainfall and high evaporation are the characteristic features (Fig. 4). The average annual normal rainfall is 1081mm for the 50 years (1967-2007). Bharuch IMD station is falling close to the newly formed Narmada district Therefore, climatological data of Bharuch IMD station (1951-1980) is utilized for this district and is given in Table 2.

Table 2- Climatological data of Bharuch IMD station

Month	Max Temp (Deg.C)	Mini Temp (Deg.C)	Humidity (%)	Wind Spd. Kmpd	Sunshine (Hours)	Solar Rad. (MJ/m2/d)	Eto (mm/d)	Rainfall (mm)
January	31.3	11.9	51.5	105.9	9.0	17.3	3.7	1.2
February	33.8	14.4	45.0	111.3	9.2	19.6	4.5	1.0
March	37.6	19.0	44.0	125.7	9.8	22.7	5.8	0.8
April	40.0	23.3	45.0	158.0	10.4	25.2	7.2	1.0
May	39.6	26.2	55.5	222.6	10.8	26.2	8.0	12.5
June	35.6	26.5	69.5	263.9	7.6	21.3	6.3	121.0
July	32.0	25.5	81.0	237.0	4.4	16.5	4.3	307.6
August	31.2	25.0	83.5	206.4	4.2	15.9	3.9	243.1
September	32.6	24.4	76.0	154.4	6.3	18.1	4.4	197.6
October	35.9	22.0	59.5	102.3	7.9	18.5	4.5	35.2
November	34.8	16.9	52.5	84.4	8.0	16.5	3.7	3.7
December	32.2	13.2	53.5	93.3	8.9	16.5	3.4	0.1
Total	-	-	-	-	-	-	-	**924.8**
Average	**34.7**	**20.7**	**59.7**	**155.4**	**8.0**	**19.5**	**5.0**	-

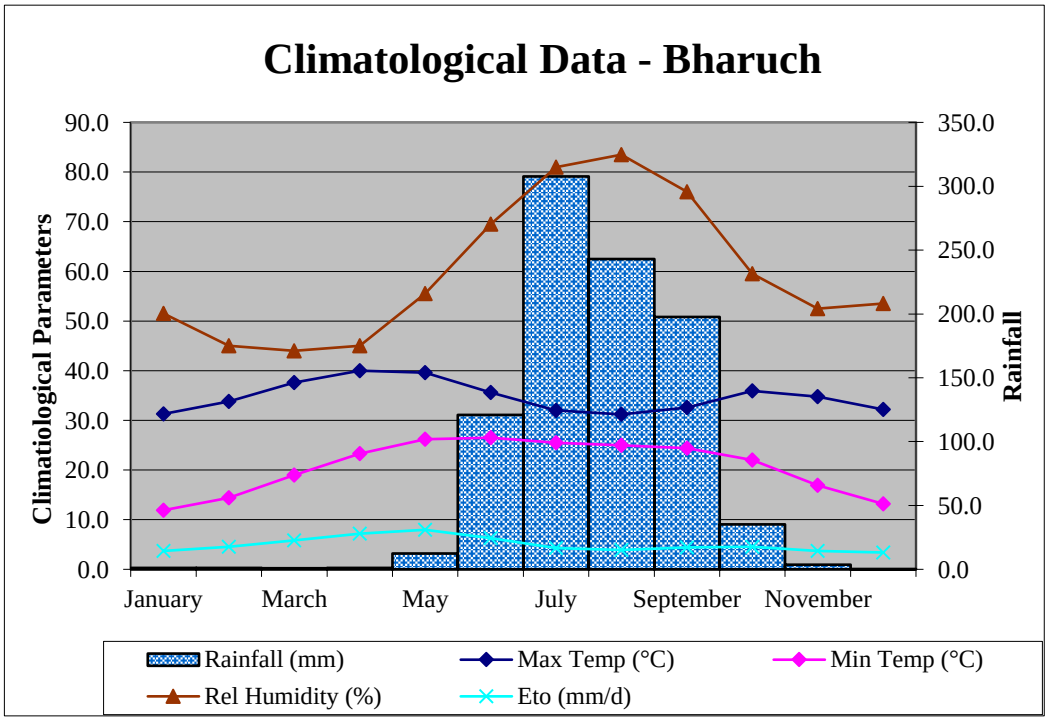


Figure 4- Statistical representation of Climatological data.

1.7 Geomorphology And Soil Type

1.7.1 Physiography

Narmada district has a varied landscape and may be divided into four topographic units:

The hilly area with high relief: Area is known as Rajpipla hills marks the emerging of Satpura and Shyadri ranges. It has got a prominent ridge and valley topography oriented in almost East -West direction.

Piedmont zone: Periphery of hilly area is characterized by an outward sloping accumulation of loose, coarse material which has been deeply dissected.

Alluvial plain: The alluvial plain, which is nearly flat, constitutes a huge pile of alluvium, deposited during the Holocene and Pleistocene times. Narmada flood plain has conspicuous recent disposition of its own. Narmada has got an entrenched meandering course which has cut terraces and deposited flood load on both sides.

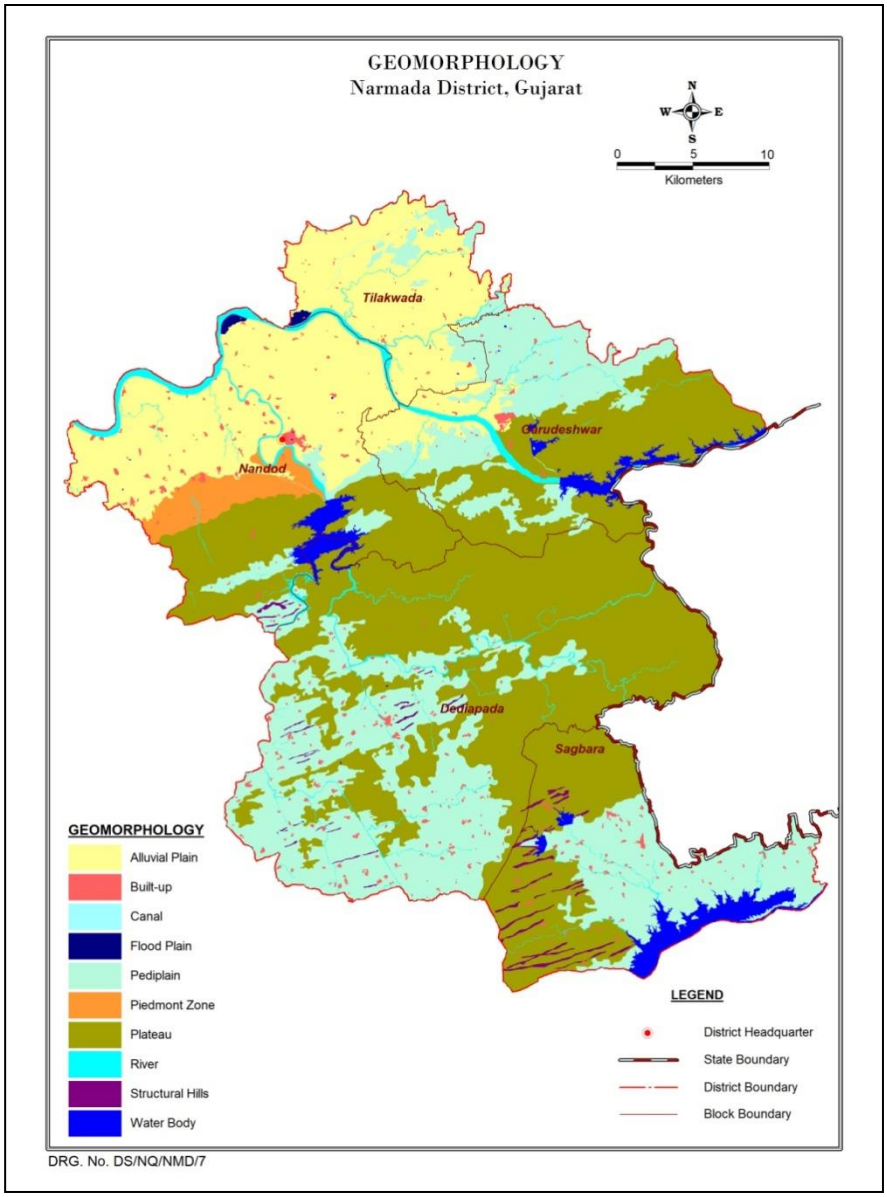


Figure 5- Geomorphological map of Narmada distict, Gujarat state.

1.7.2 Drainage

District is drained from east to west mainly by three rivers namely the Narmada, the Kim and the Tapi. The river Narmada after entering the low level of Gujarat plains near Markai, flows westward to the Gulf of Khambat in Bharuch district. Narmada moves through a basaltic terrain, between high rough banks of hard clay and sand deposits located mostly in Garudeshwar and Tilakwada talukas. In its course through the district, the Narmada receives important tributaries namely the Karjan, the Orsang, the Heran, the Aswan, and the Men. Rising in the Rajpipla hills, the Kim, for the first part of its course passes through the Nandod taluka and Valia Mahal territory. The south eastern extreme Baktura and Bhadod village of the district touches the Tapi, the second important river of south Gujarat.

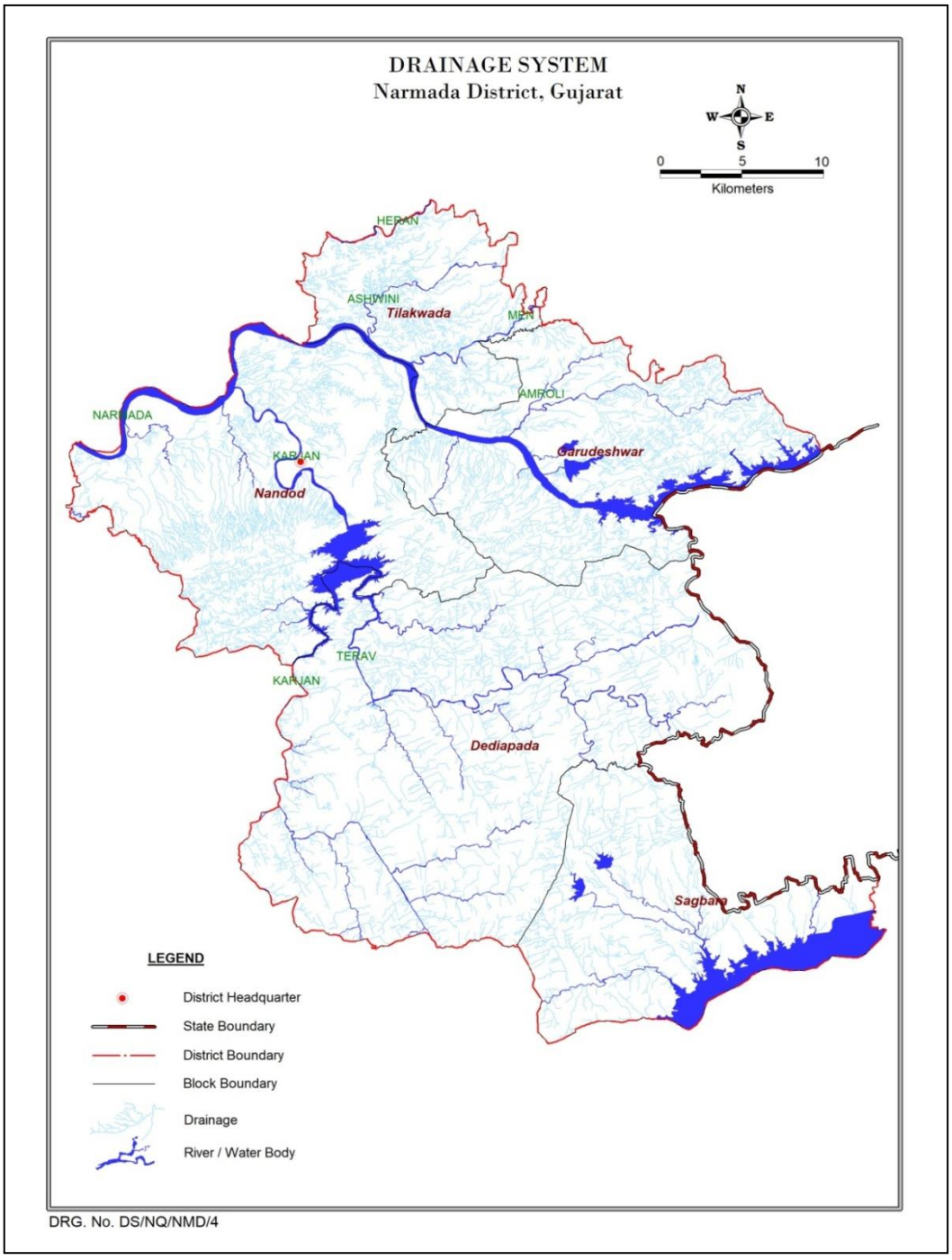


Figure 6- Map showing the drainage system of Narmda district of Gujarat district.

1.7.3 Soils Type

The soils found in Narmada district are as follows.

Black cotton soil: These soils have their origin in trap. They are varies from 60 cm to as high as a few meters. Black soils formed due to decomposition of trap parent material transported through flow of rivers. The soils are dark brown to very dark grayish brown in colour which contain 40-70% clay are poor in drainage and neutral to alkaline reaction.

Gorat soil: It is a sandy alluvial type of soil which contain 40% clay and more sand particle that's why it do not retain moisture.

Bhatha soil: It is lateritic type of soil containing lot of pebbles and having very low waterobservation capacity.

Stony soil : The stony soil, covers only forest areas and no cultivation is done on these soils.
The soil all over the district contain low Nitrogen ,Phosparus (medium in Tilakwada taluka) and high Potash.

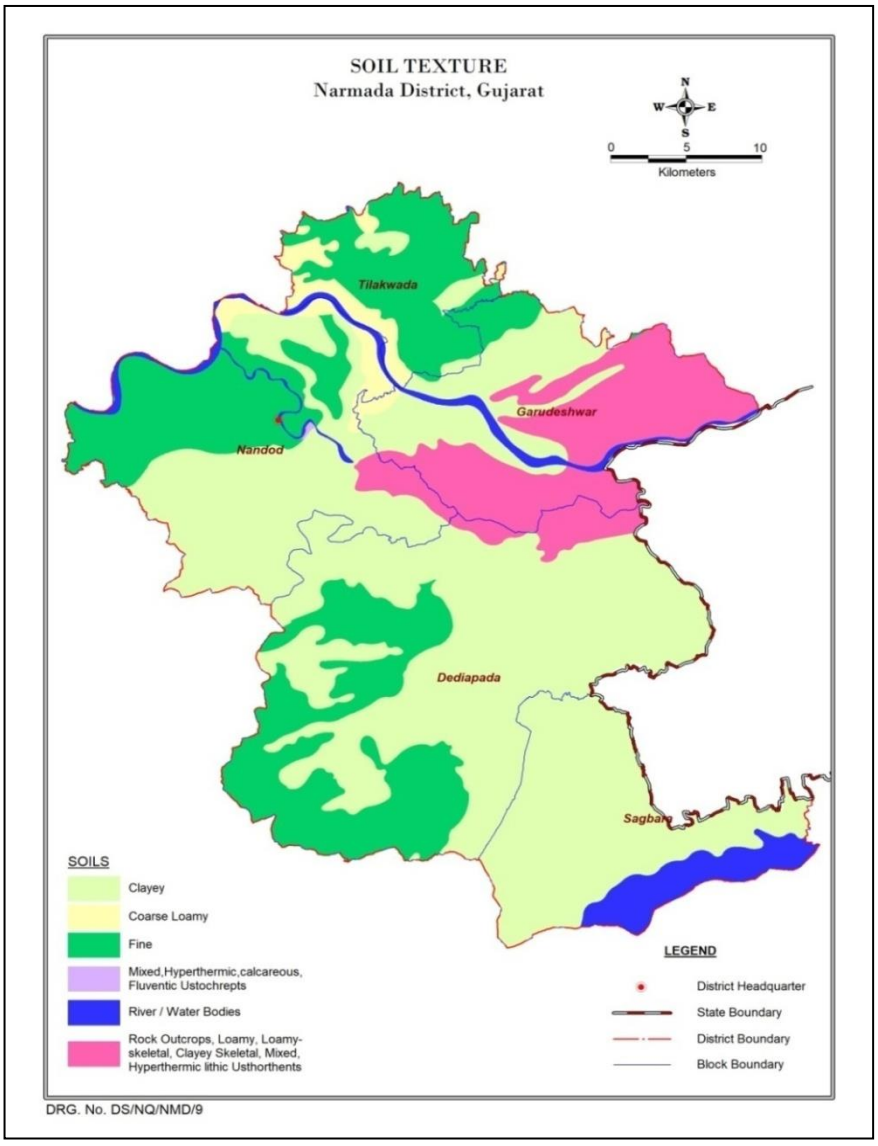


Figure 7- Map showing the soil texture in Narmda district of Gujarat district.

1.8 Land Utilization:

The total geographical area of the district is 275536 ha. Out of which Net area sown constitute is 105400 ha. having 23700 ha. of area sown more than once whereas Gross cropped area is 129000 ha. Total areaunder non cultivable constitute Forest land and Fallow land covering an area of 115700 ha. and 3800 ha. respectively which statistical representation are area shown in figure- 8. (Source: Directorate of Agriculture, Seasons and Crops, Gandhinagar for 2014-15). Land use and land cover map is presented in figure (8).

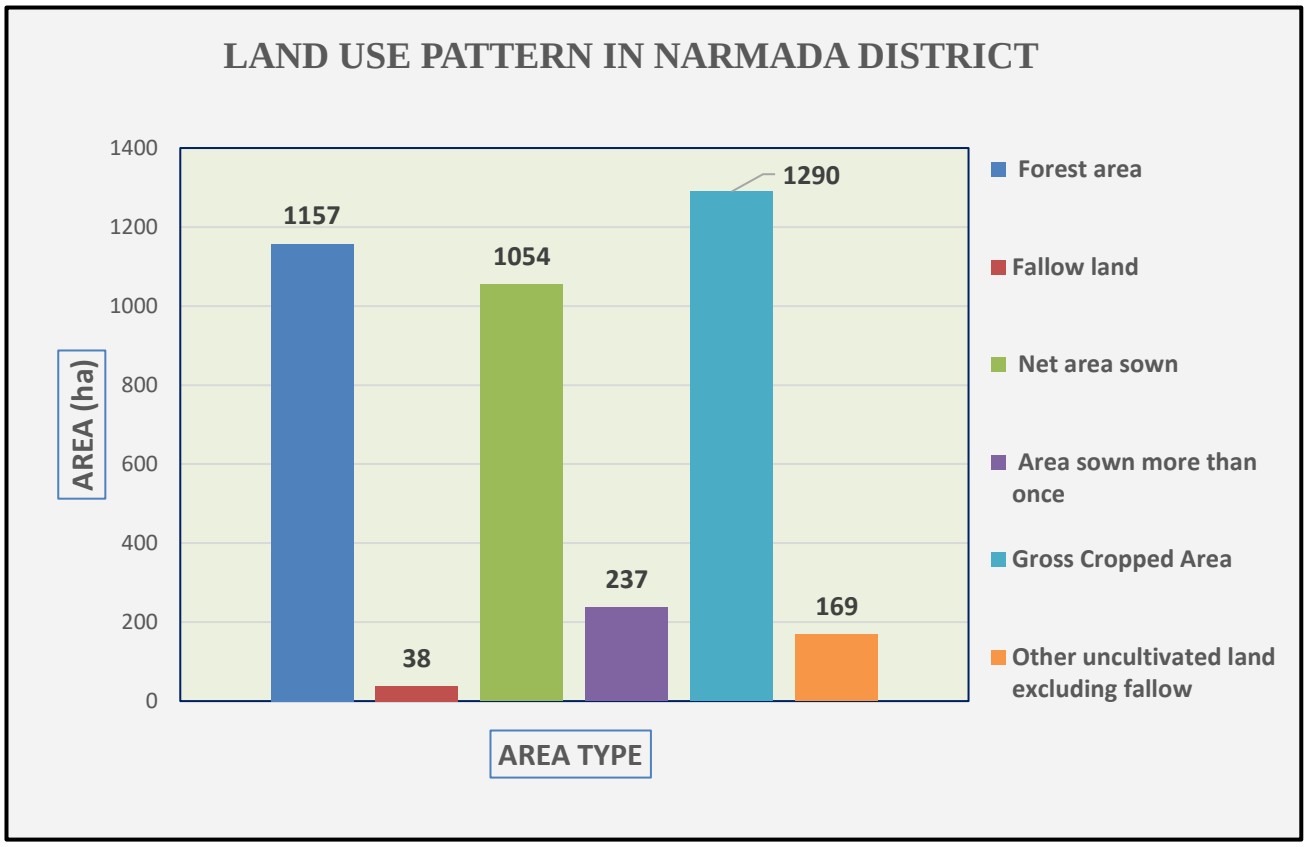


Figure 8- Land Utilization pattern in Narmada district.

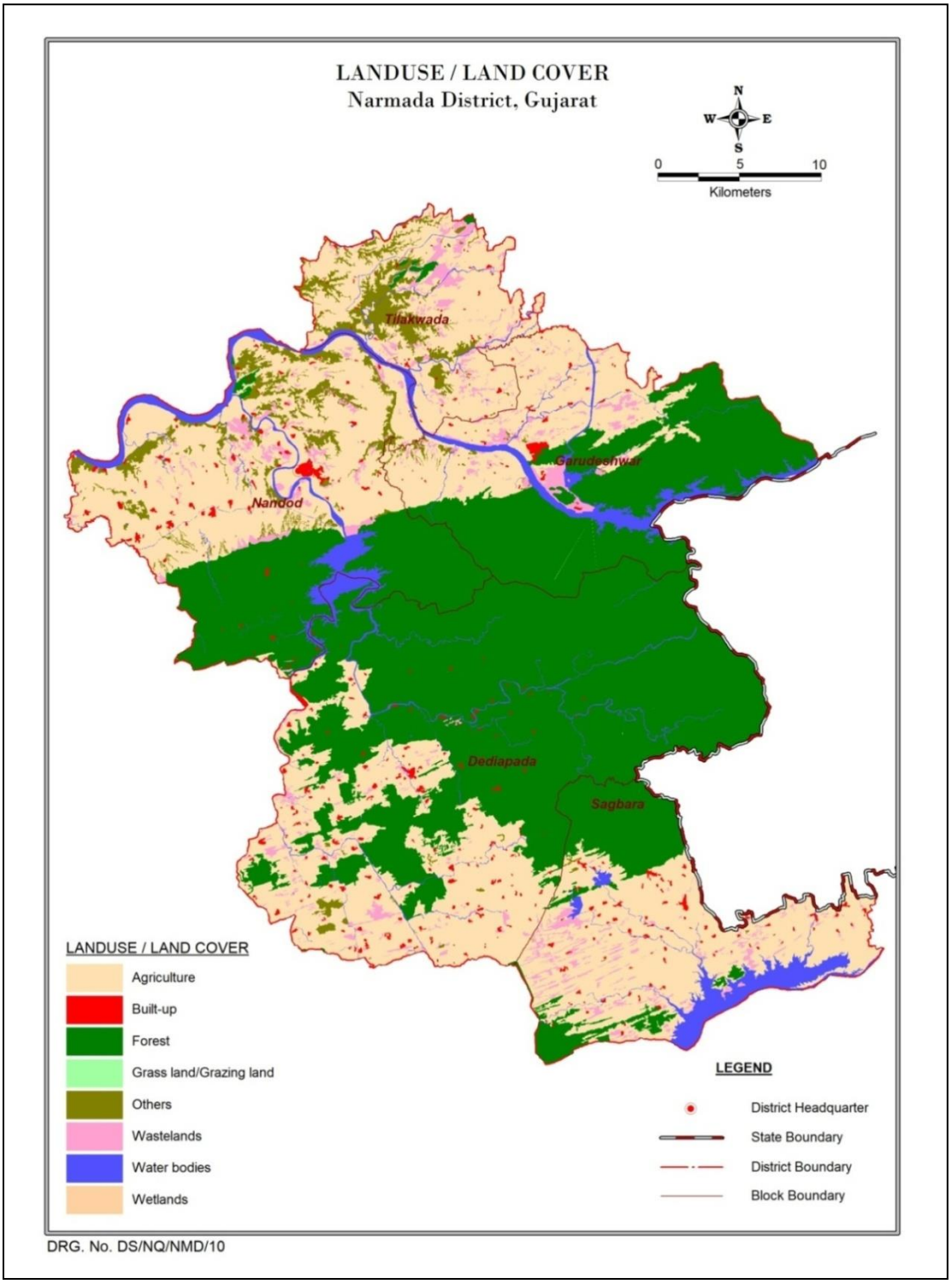


Figure 9- Map showing the land use and land cover in Narmda district of Gujarat district.

1.9 Cropping Pattern:

The majority of the farmers in the district are engaged in traditional cultivation of food grains having total 76700 ha. area of total geographical area. Followed by this district have Cotton, Pulse and Cereals (mostly Wheat, Paddy, Jowar and Maize) production which cultivated in area of 37300 ha., 43500 ha., and 33000ha respectively. Nandod taluka has become more developed comparatively others because of cultivation of banana, sugarcane and cotton .Statistical representation of cropping pattern for the district is shown in figure-10.

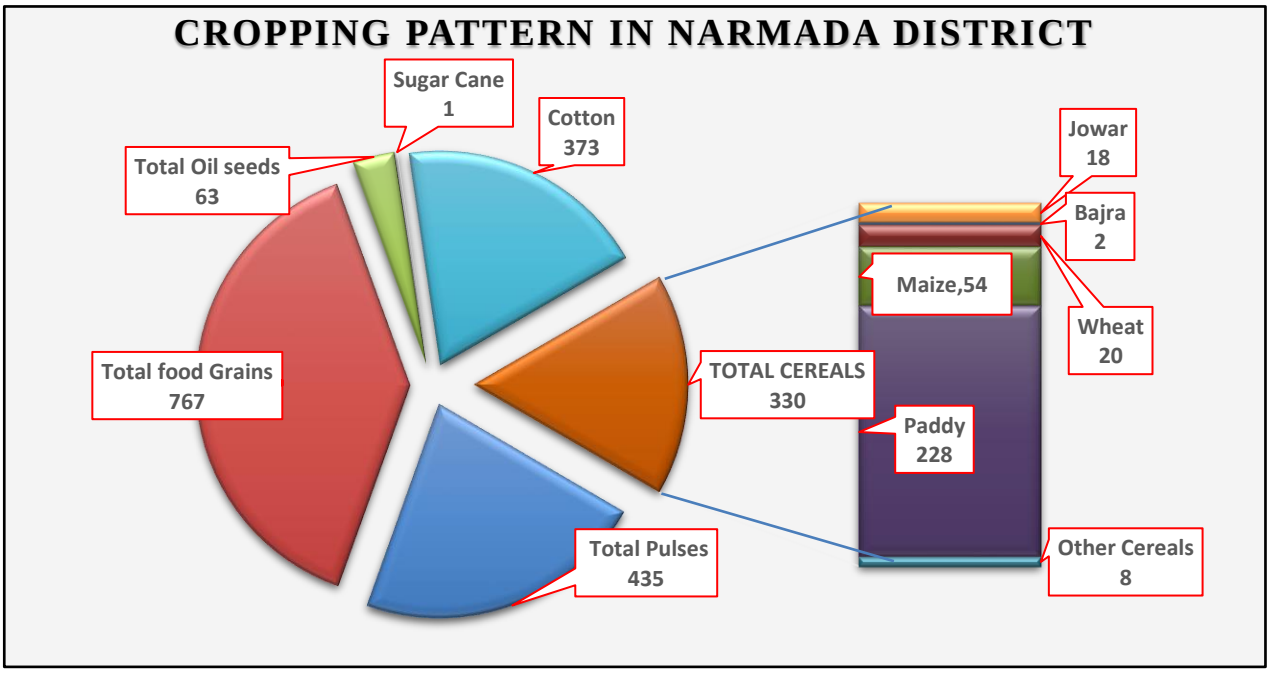


Figure 10- Cropping pattern in Narmada district of Gujarat state.

1.10 Irrigation Pattern:

In Narmada district, about 51 percent of the area lies under rainfed cultivation while only 49 percent of the total gross cropped area has irrigation facilities.The Tilakwada andNandod blocks have good irrigation facilities and mostly irrigation is done by canal water from Sardar Sarovar and Karajan projects which constitute 14100 ha. of gross area (figure-11).Whereas Dediapada and Sagbara talukas having very limited irrigation facilities viz. wells. Due to characteristic of hard rock formation in most part of the district shows Groundwater occurred under unconfined condition and its movement is controlled by Weathered, Joints, Fracture of Secondary Porosity. As per MI census 2013-14, district have 3507 no. of Dugwells and 1594 no. of Tubewells.

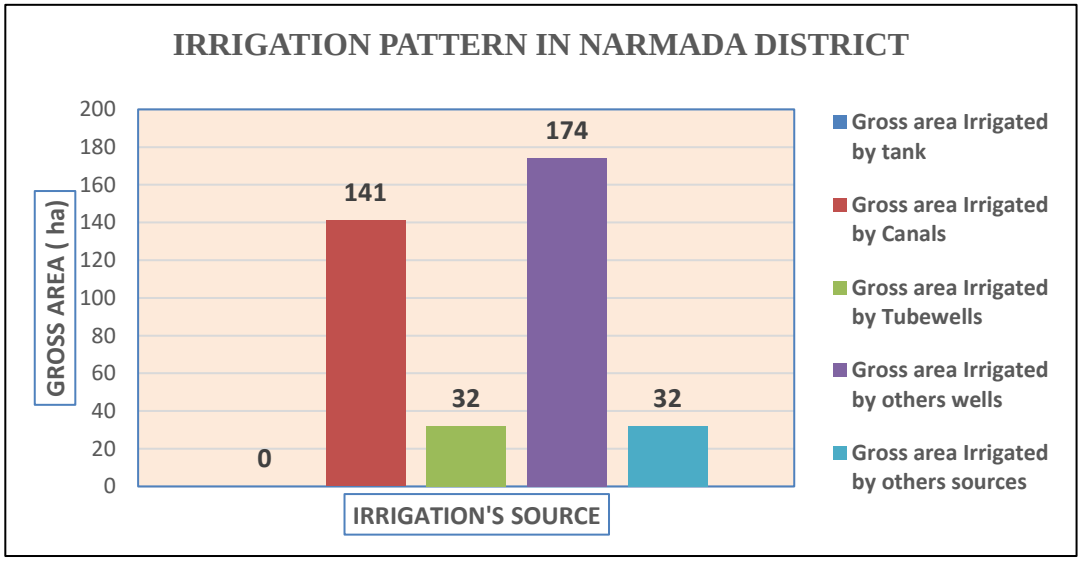


Figure 11- Irrigation pattern in Narmada district.

2. GEOLOGY

2.1 Semi-consolidated Lower Cretaceous formation

2.1.1 The Bagh beds

Groundwater occurs under unconfined conditions in the limestone and sandstone aquifers. Occurrences and movement of groundwater is restricted mainly to the fractures and joints in the limestones and sandstones. Due to the cherty nature of limestone aquifers and calcareous nature of the sandstones, the primary porosity as well as development of solution cavities is very poor. The Basal conglomerate beds are poorly permeable on account of calcareous cement. However, these conglomerates when exposed to surface, give rise to good aquifers which support shallow wells. The discharge in dug wells varies from 30 to 50 m3/day. In highly weathered conglomerates and sandstones, the yield of wells ranges up to 700 lpm for drawdown of 1 to 2 m and recuperation is fast.

The Bagh beds overlain by Deccan Trap are likely to yield groundwater under confined condition.

2.2 Consolidated upper Cretaceous

2.2.1 Deccan traps

The Deccan Traps, being the extrusive volcanic, where individualsflow laid down at specific time intervals, have given rise to multi layered stratified aquifers. Each individual flow comprises of two distinct units, namely the upper vesicular basalt and the lower massive basalt. The massive basalt is hard and compact with no primary porosity but the vesicular basalts exhibit porosity. Movement of groundwater is controlled by secondary porosity developed by the presence of fractures and joints.

The vesicular basalt forms a good aquifer where the fractures and joints interconnect the vesicles, thereby rendering the rock more porous. Similarly, the paleo-weathering which is invariably observed at depth near the top of every flow, has formed good aquifers at depth. This paleo-weathering is responsible for the occurrence of groundwater under confined conditions in the Deccan Trap and has given rise to multi-aquifer system down to the depth of several hundred meters.

The yields of dug wells in Deccan Traps, which range in depth from 5 to 25m below ground level, sustain pumping from half an hour to ten hours with discharge varying from 200 to 1200 lpm for drawdowns of 4 to 7 meters. Bore wells tapping deeper zones down to explored depths of 200 m, have yielded 100 to 1500 lpm for drawdown of 12 to 16m.

The dolerite and trachyte dykes intruding the Deccan Traps do not support good yield of well. These dykes, on the contrary, restrict the movement of groundwater and thus gives rise to storage of groundwater on one side of the dyke and dry aquifers on the other side.

2.3 Un-consolidated Quaternary formations Alluvium

Area close to either side of the Narmada river constitute highly potential belt. However, a large amount of water percolating through the loose alluvium is drained into the nullahs through seepages, thereby deepening the water levels.

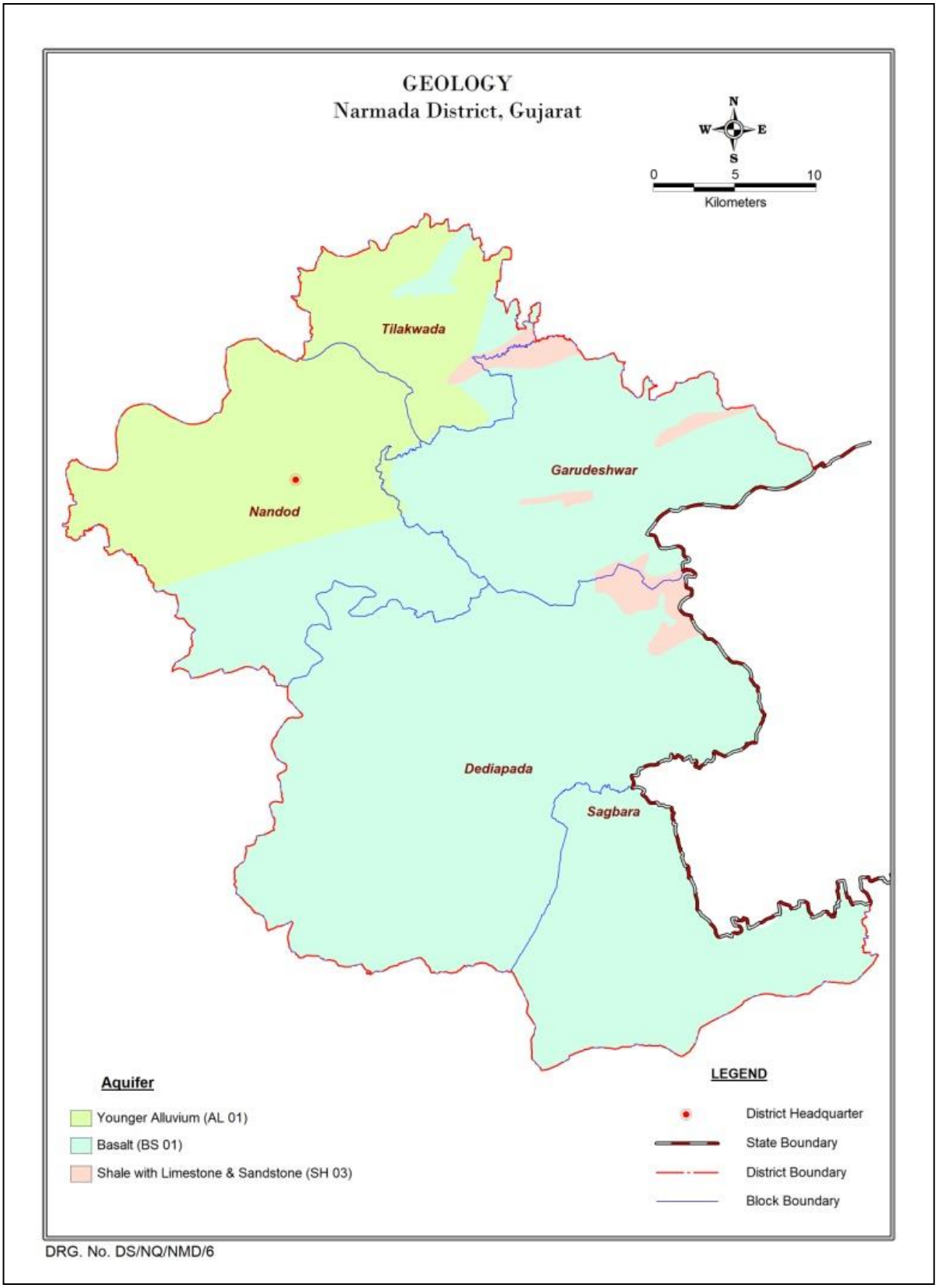


Figure 12- Geological map of Narmada district.

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 3- Brief activities showing data compilation and generations

S. No.	Activity	Sub-activity	Task
1	Compilation of existing data/ Identification of Principal Aquifer Units and Data Gap	Compilation of Existing data on groundwater	Preparation of base map and various thematic layers, compilation of information on Hydrology, Geology, Geophysics, Hydrogeology, Geochemical etc. Creation of data base of Exploration Wells, delineation of Principal aquifers (vertical and lateral) and compilation of Aquifer wise water level and draft data etc.
		Identification of Data Gap	Data gap in thematic layers, sub-surface information and aquifer parameters, information on 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, Confined Aquifer for alluvium and weathered aquifer & fractured aquifer for Basaltic rock are placed at Figs (14 to 18). Fence Diagram and 3D Solid Model of district is depicted in Fig. 19 and 20, respectively.

A total of 17 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.

Table 4-Data integration in respect to Narmada district.

Type of Data & source	**No Of Wells**
Aquifer Disposition	
CGWB	**17**
Long term Fluctuation	
CGWB+GWRDC	**21+44=65**
Decadal Analysis water Level	
CGWB+GWRDC	**21+44=81**
Analysis of water Quality	
CGWB+GWRDC	**18**

3.2 Conceptualization of Aquifer system in 2D

Five hydrogeological cross sections are drawn in different direction to cover entire area as per the availability of data point in the district and represented in figure 14 (A-A') to figure 18 (E-E').

During premonsoon (May) period the depth to water level ranged from 1.24 mbgl to 34.72 mbgl, whereas during postmonsoon period (November) the depth to water level ranged from 0.40 mbgl to 36.10 mbgl. Blockwise ranges of depth to water level are given in table 10.

Table 5- Pre monsoon and Post monsoon-2019 depth to water level details (CGWB & GWRDC) of Narmada district.

Taluka	Max of May WL in bgl	Min of May_2019 WL in bgl	Min of November WL in bgl	Max of November WL in bgl
Nandod	37.9	2.26	0.86	34.0
Tilakwada	22.22	2.05	0.67	24.11
Dediapada	43.60	3.61	0.14	11.30
Sagbara	28.85	7.40	1.03	11.30
Garudeshwar	14.40	5.10	2.10	8.30

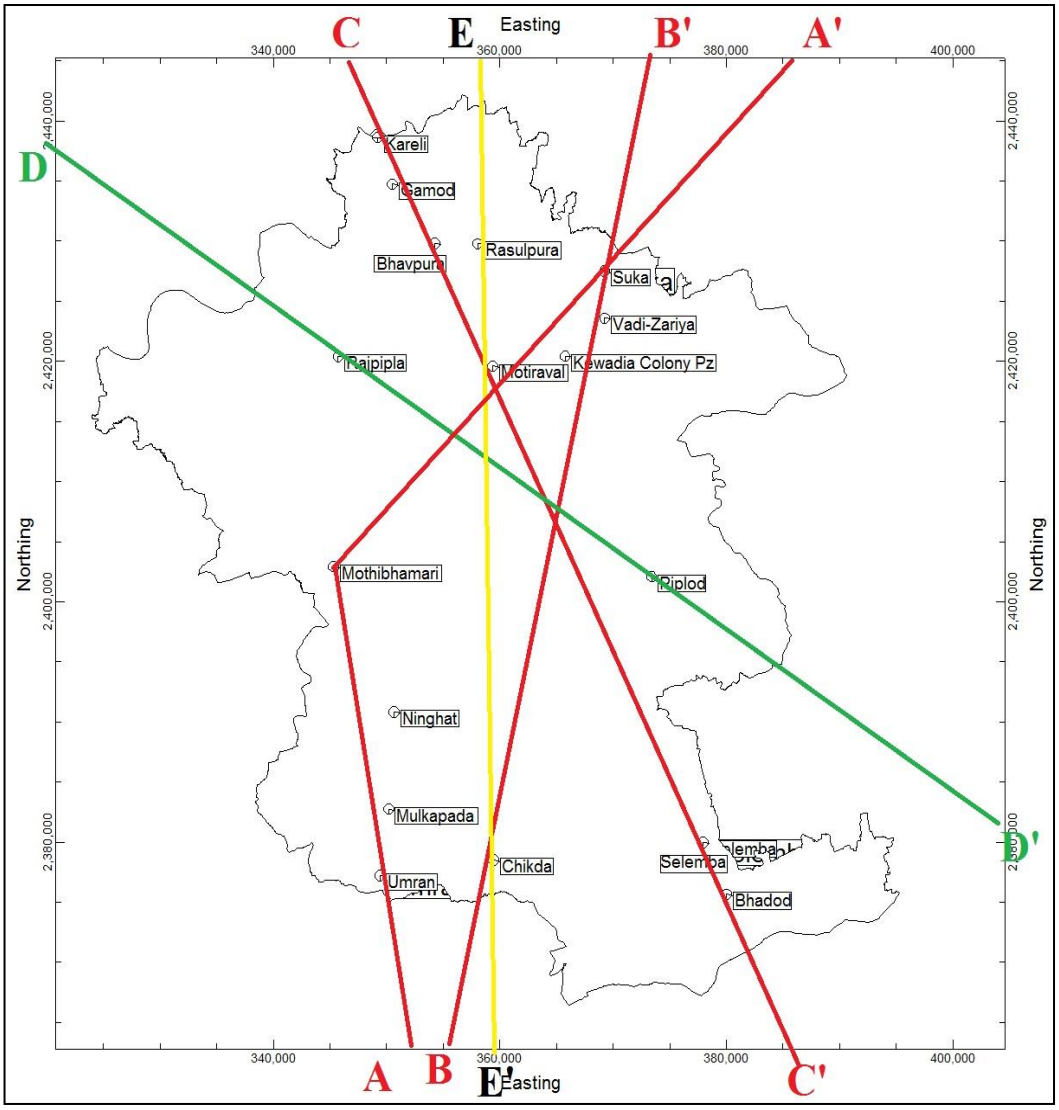


Figure 13- Map showing drawn section lines.

1. Section A-A' (Fig. 14)- Section is drawn roughly N-S direction and in between Umran and Suka, passing through Mulkapada, Motibhamari, Motiraval. Section is represented geologically, from section it is deciphered that basalt (weathered & Fractured Basalt) forms the major aquifer system in the district along drawn section line.

2. Section B-B' (Fig. 15)- Section is drawn roughly N-S direction and in between Chikda and Kareli, passing through Kewadia colony (Pz) and Wadi- Zariya. Section is represented geologically, from section it is deciphered that basalt (weathered & Fractured Basalt) forms the major aquifer system in the district along drawn section line

3. Section C-C' (Fig. 16)- Section is drawn roughly NNW-SSE direction and in between Kareli and Bhadod, passing through Gamod, Bhavpura and Motiraval. Section is represented geologically, at site Kareli, alluvium formation encountered and separated by Aquitard layers and these succession are overlain by massive granite forming the basemen in NW site of the district, Gamod and Bhavpura site multilayered alluvium deposits forms the aquifer system whereas from cross section of Motiraval and Badod its deciphered that basalt (weathered & Fractured Basalt) forms the major aquifer system.

4. Section D-D' (Fig. 17) North- West to South-East direction in between site of Rajpipla and Piplod, from section it is deciphered that multi layered alluvium deposits rested over massive basalts whereas in Piplod site basalt (weathered & Fractured Basalt) forms the major aquifer system in the district

5. Section E-E' (Fig. 18) North- South direction in between site of Rasulpura and Chikda, through Motiraval , from section it is deciphered that multi layered alluvium deposits are formed at Rasulpura site whereas in Motiraval and Chikda site basalt (weathered & Fractured Basalt) forms the major aquifer system in the district.

The study of these 2D sections, Fence and 3D solid model reveals that there is a basaltic formation with weathered rocks followed by fracture basalts and lower most formation is Massive basalts in all the taluka except some section in Tilawada and Nandod taluka shows intercalation of Bagh and Lameta beds, alluvial formation with boulders .The weathered basalts varies in thickness from 4.2 to 27m. And the fractured/ jointed basalts thickness is varies in between 6m to 139m. The Quaternery alluvium formation is confined only to Tilakwada and Nandod taluka.

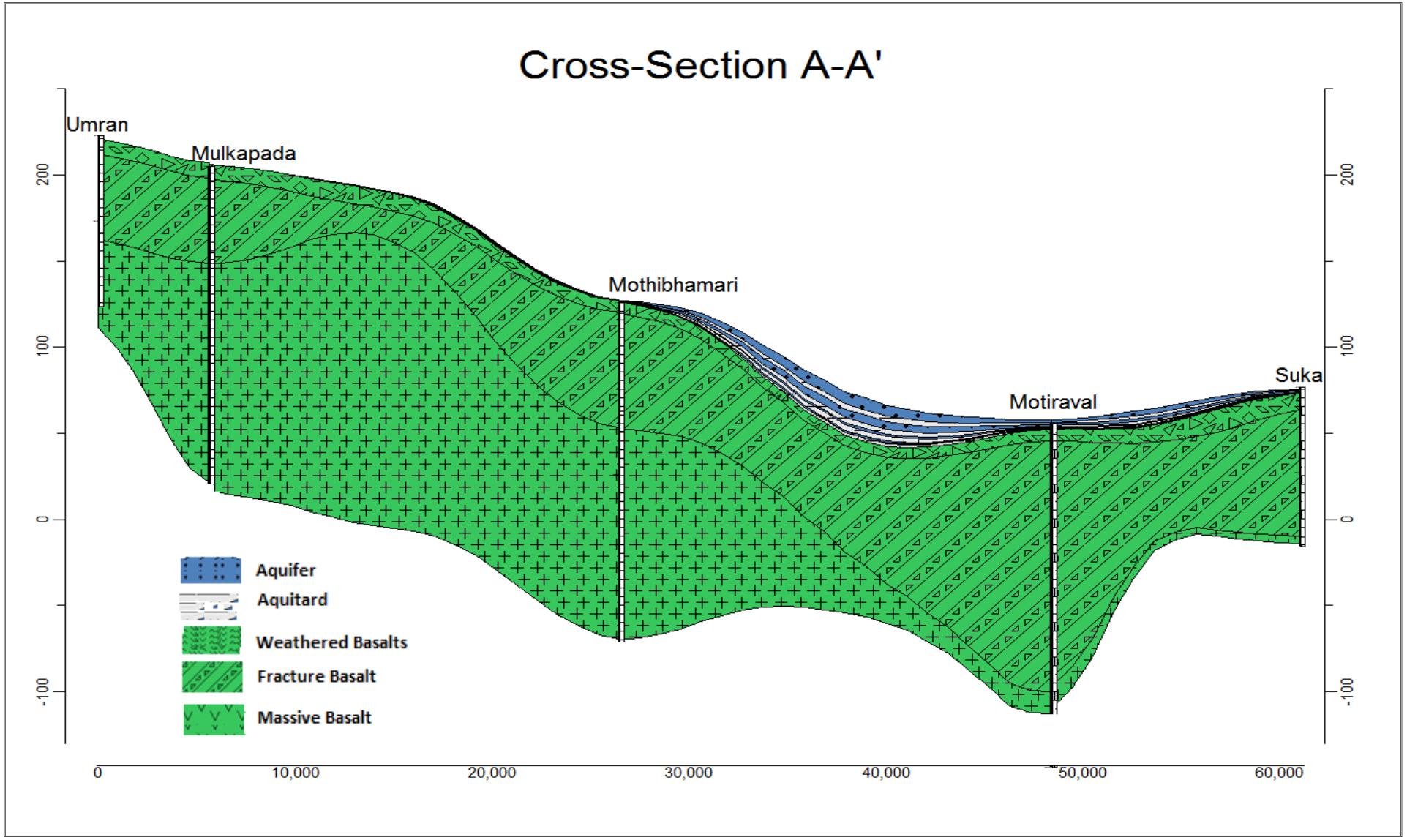


Figure 14- Hydogeological cross section between Umran and Suka (A-A')

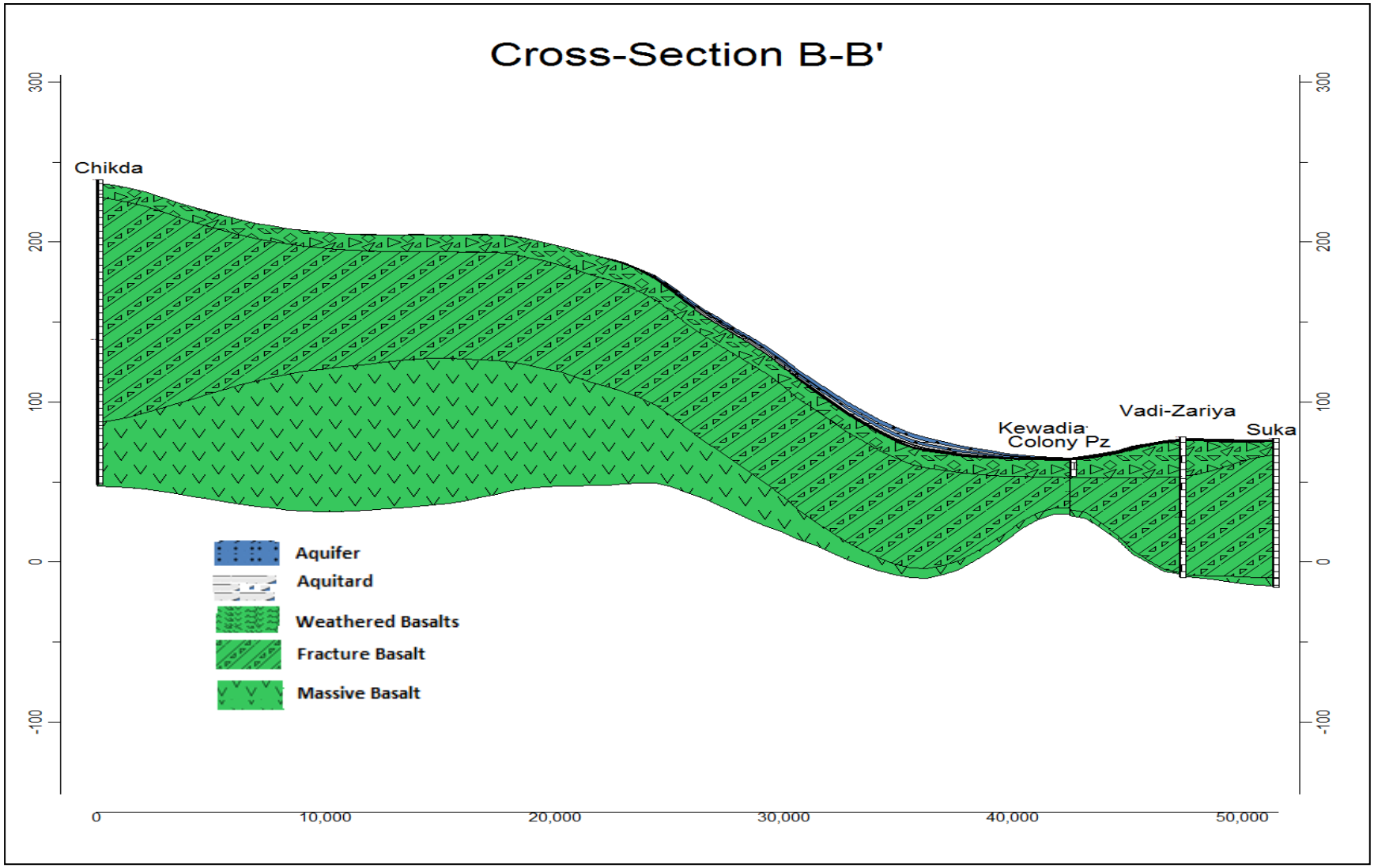


Figure 15-Hydogeological cross section between Chilka and Kareli (B-B'')

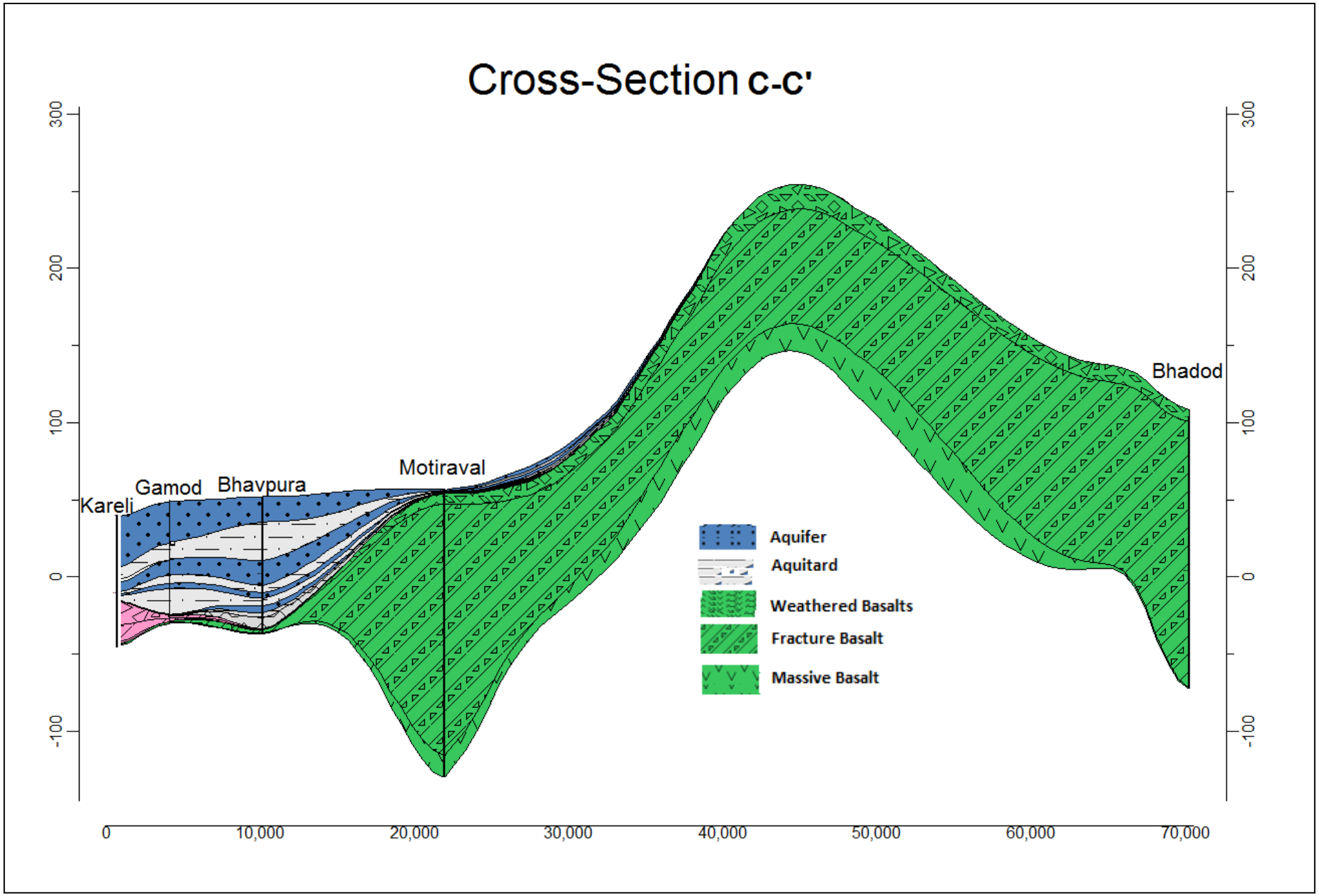


Figure 16- Hydogeological cross section between Kareli and Bhadod (C-C')

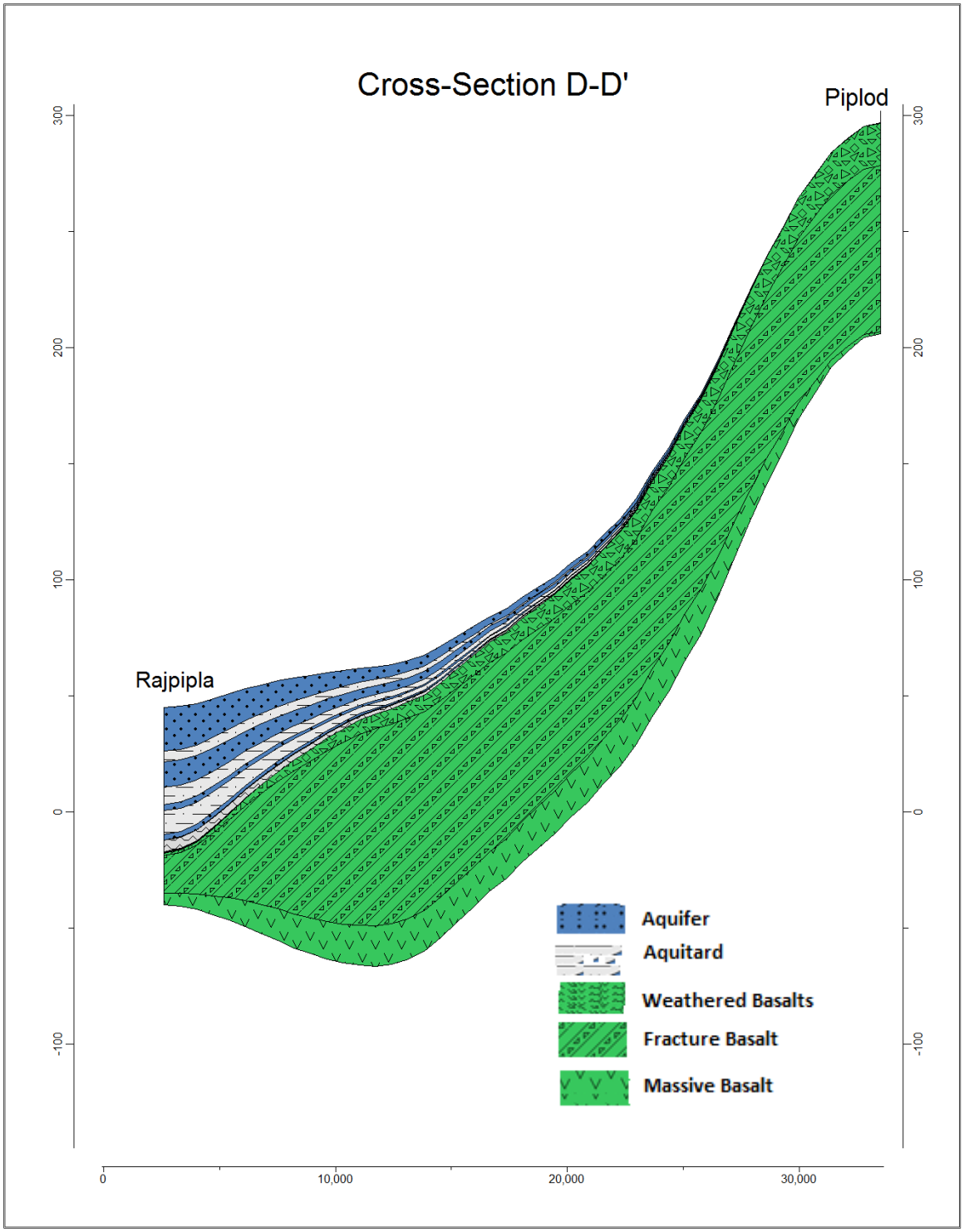


Figure 17- Hydogeological cross section between Rajpipla and Piplod (D-D')

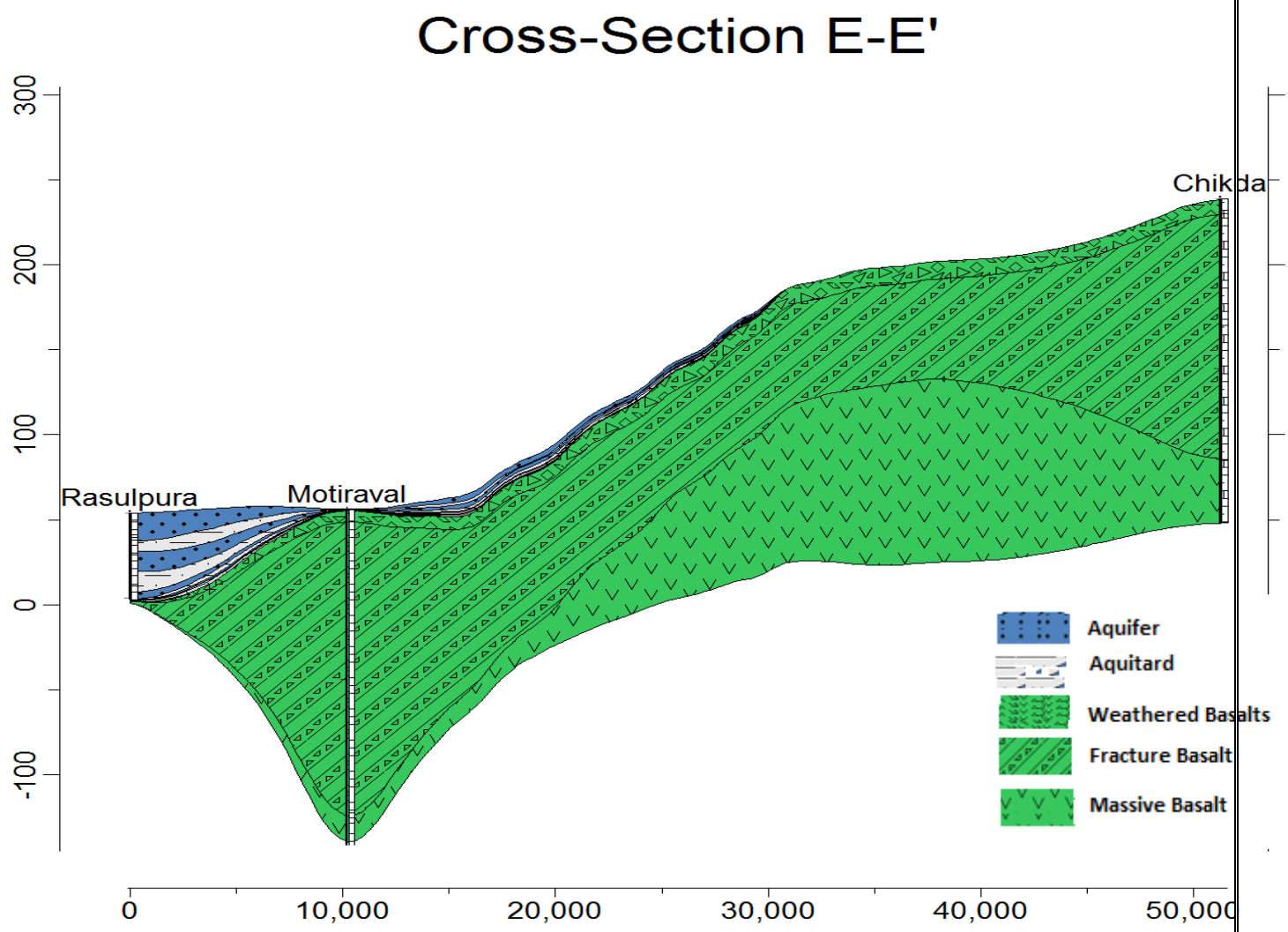


Figure 18- Hydogeological cross section between Rasulpura and Chikda (E-E')

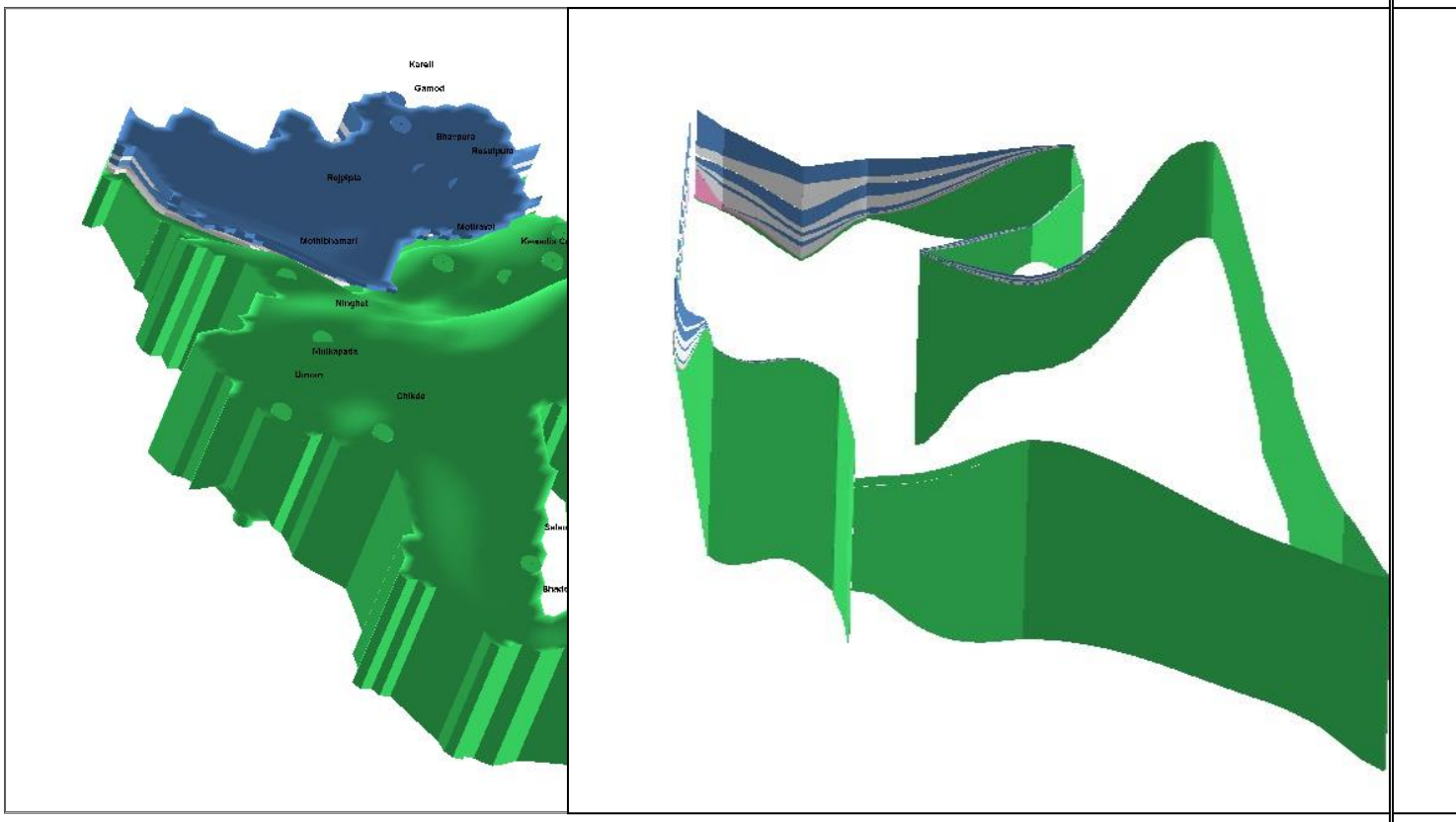


Figure 19- 3D- disposition/ model of Narmada district

ırmada district

Table 6- Aquifer characterization and disposition of Narmada district.

Aquifer Characterization and Disposition										
Stratigraphy	Aquifer Nomenclature	Lithological Characteristics	Depth of occurrence Aquifer (mbgl)	Thickness Range (m)	Water Level (mbgl) Range (mbgl)	Quality (TDS) Range Mg/l	Discharge Range lps	Transmissivity Range m2/day	Nature of Aquifer	Remarks
Quatenary	Alluvium [AL]	Younger Alluvium with sand, silt, clay, cobble and Pebble dominated [AL03]	0 to 24	12 to 24	5 to 10	500 to 600			Phreatic	Good Quality
			40 to 54		2 to 16	300 to 2000	1 to 4	35.83 to 1000	Confined	Good Quality
Mesozoic to Cenozoic	Basalts[BS]	Amygdular, Fractured, Weathered and Massive basalts [BS01]	0 to 24	16 to 24	5 to 13	400 to 1500			Phreatic	Good Quality
			55 to 75		3 to 18	250 to 1200	0.5 to 26	3.36 to 87.98	Confined	Good Quality
Upper Palaeozoic to Cenozoic	Shale [SH]	Shale with Limestone and Sandstone of Bagh Formation [SH03]	0 to 20	15 to 20	5 to 14	400 to 1500			Phreatic	Good Quality

4. GROUND WATER SCENARIO

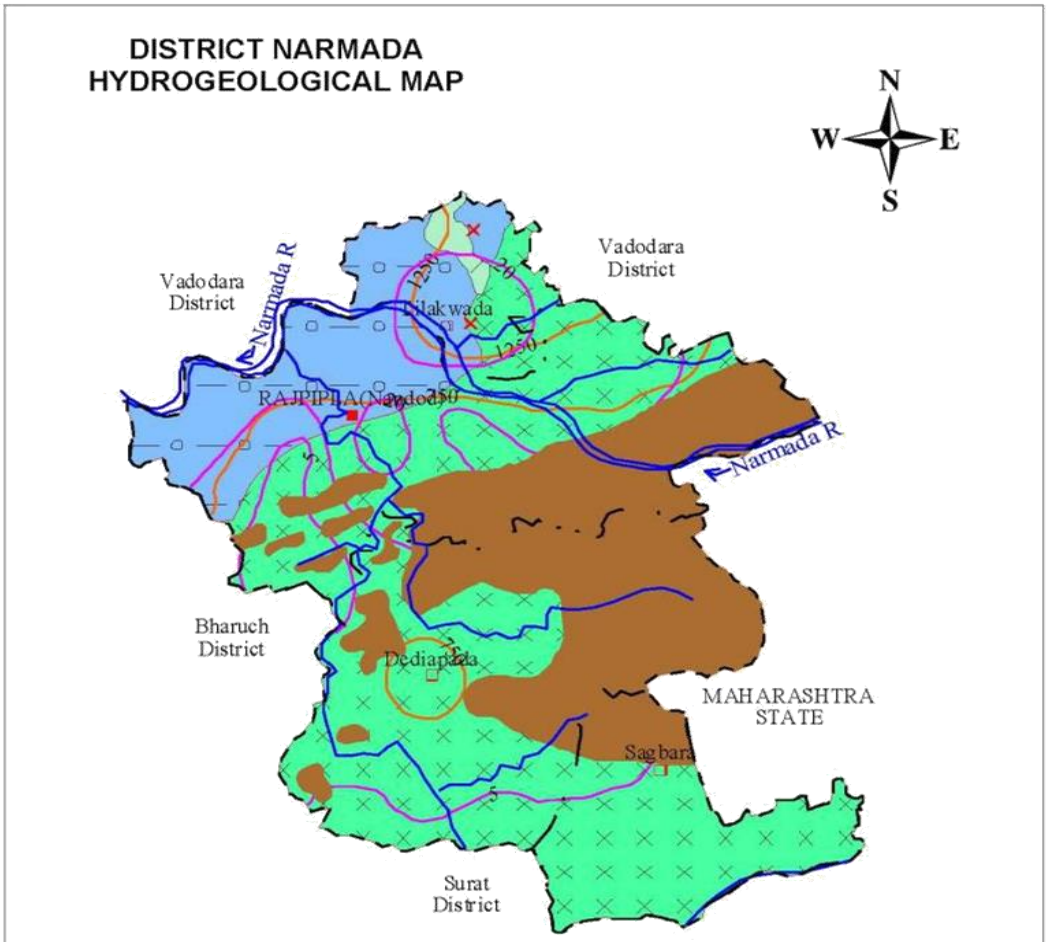
4.1 Hydrogeology

The river Narmada, which flows in almost East –West direction through northern part of the district which is predominantly underlain by unconsolidated alluvial sand, gravel and boulders. Most part of the district is covered by basaltic rocks of the Cretaceous age. The Mesozoic formations are exposed under a small area mostly in Tilakwada taluka.

Groundwater occurs under unconfined conditions in all the rock formations in most of the area of the district. Weathered zone below water table acts as good repository for storage of groundwater in Deccan Trap areas. In the Infratrapean rocks (Bagh beds- sandstone, marls and limestone), apart from occurrence of water in the pore spaces between sand grains, the principal joints, fissures and other planes of structural weakness play an important role in the movement of groundwater. In the alluvium, groundwater occupies the open spaces between particles of sand, gravel and boulder.Hydrogeological conditions in the different geological formations are presented in the Fig. 7 and are described below.

4.2 Aquifer Parameters

In Basaltic areas the exploratory wells were constructed upto depth of 200 m bgl. and discharge of the wells are ranges from 0.83 lps (Ninghat EW) and 26.01 lps (Bhadod EW). Transmissivity from 0.75 to 127.17 m2/day. Whereas in alluvium areas discharge in the wells are ranges in between 2 lps (Rasulpura) to 49.5 lps (Gamod).



	Formation	Wells Feasible	Depth of Well (m)	Discharge (lpm)
	Soft Rock Aquifer	Dug Well Tubewell	15-30 50-150	200-300 300-800
	Hard Rock Aquifer	Dug Well Borewell	10-25 50-100	60-100 60-150
	Hard Rock Aquifer	Dug Well Borewell	10-25 100-200	80-150 100-300
	Hilly Areas	Not Suitable		
20	Pre-monsoon Decadal mean (1993-2000) Depth to Water Level (mbgl)		2000	Electrical Conductivity (µS/cm at 25° C)
×	Fluoride > Maximum Permissible Limit (1.5 mg/l)			
	Drainage		■/□	District/Taluka HQ

Figure 21- Map showing the Hydrogeological setup of Narmada District.

4.3 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). There are a total number of 21 monitoring stations in the district which include 18 open wells and 03 piezometers. Gujarat Water Resources Development Corporation (GWRDC) has established 44 Observation Wells. The water level data of May 2019 and November 2019 was used for preparing the depth to water level maps. The seasonal fluctuation in water levels was calculated between May and November 2019.

4.3.1 Depth to water level (Pre monsoon)

Pre monsoon depth to water levels as shown in the map May 2019 (Fig. 22), depict that in most part of the district water levels ranges in between 2m bgl to 30m bgl. Small stretches in adjoin boundary region Nandod and Dediapada taluka, and small patch in boundary region of Tilakwada and Nandod shows deeper water level ranges in between 30 m bgl to more than 40m bgl.

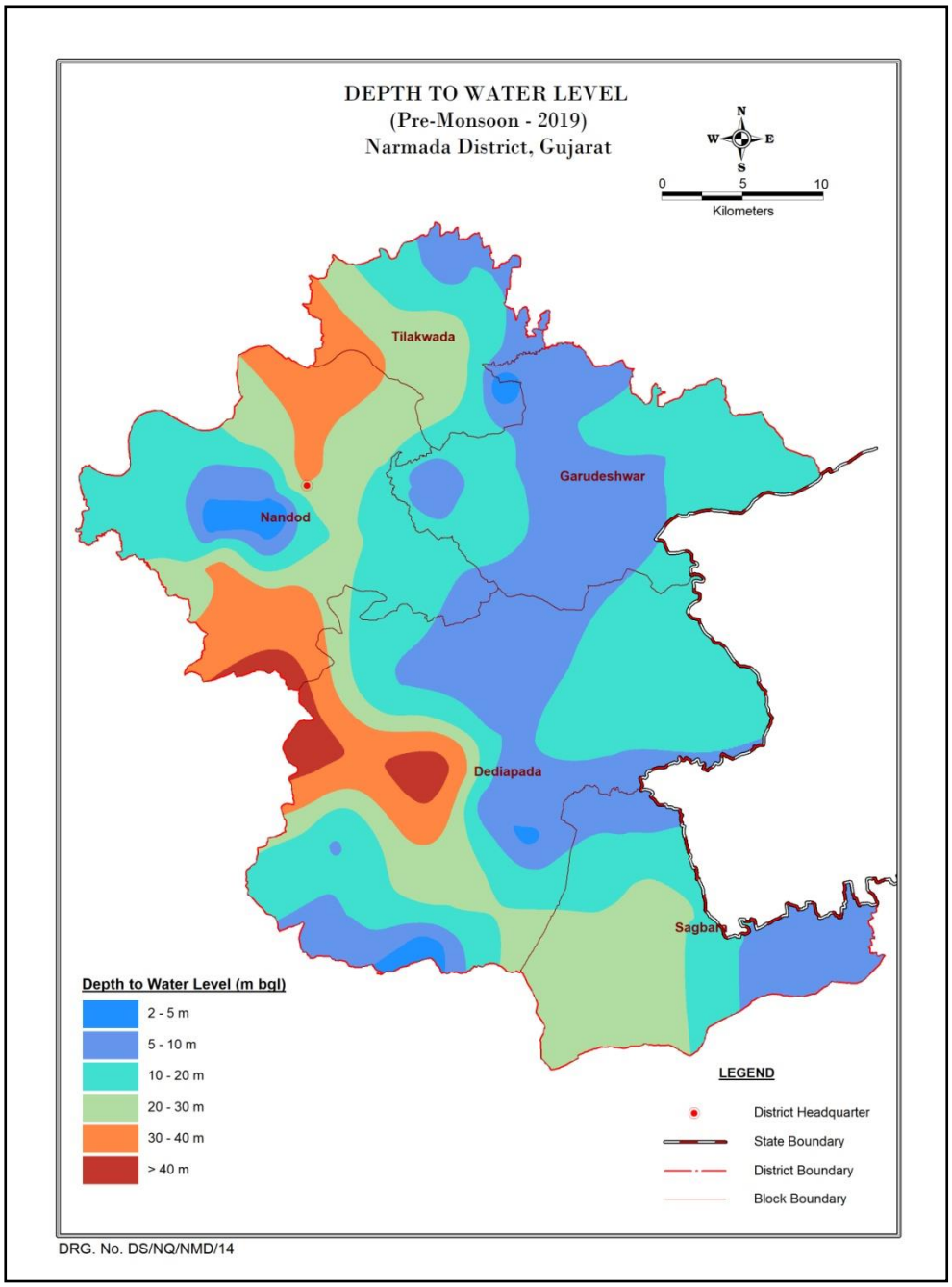


Figure 22-Pre-monsoon (May 2019) depth to water level of Narmada District.

4.3.2 Depth to water level (Post monsoon)

Post-monsoon water level as shown inmap for the period of November, 2019 (Fig. 23) depict that Dediapada, Sagbara and Garudeshwar taluka shows depth to water level ranges from less than 2 m bgl to 20 m bgl and small region of adjoining boundary of Tilakwada and Nandod taluka's shows that water level ranges from 20m bgl to more than 30m bgl.

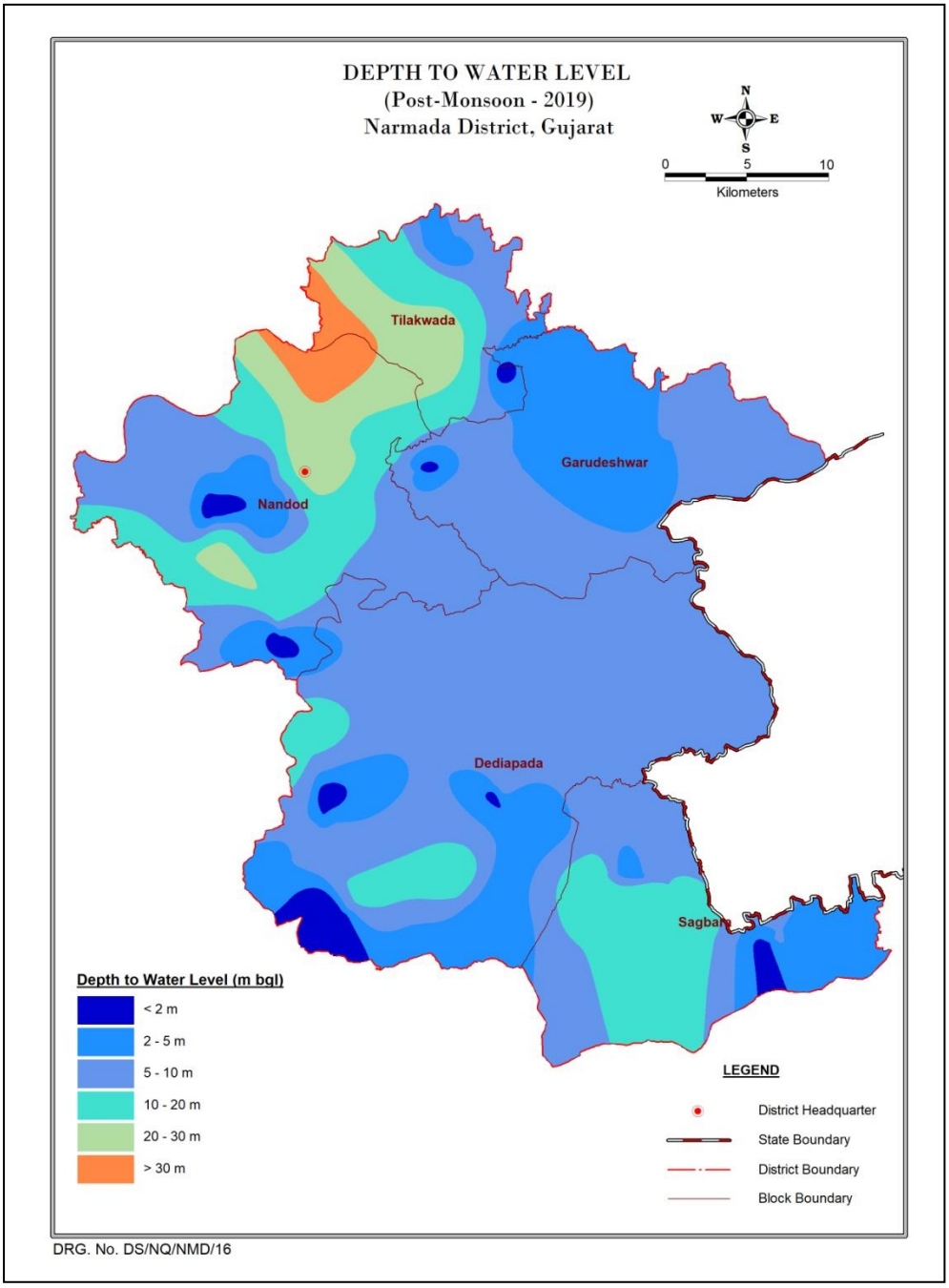


Figure 23- Pre-monsoon (Nov_ 2019) depth to water level of Narmada District.

4.3.3 Water table and groundwater movement

The elevation of water table ranges in between 30m amsl to 210m amsl (Fig 25) during May 2015 and 30 m amsl to 250m amsl during November 2019 (Fig. 26). Which shows that the ground water flow direction is towards Narmada river in upper (Northern part) of the district whereas in Lower (Southern part) of the district it is toward Tapi river basin.

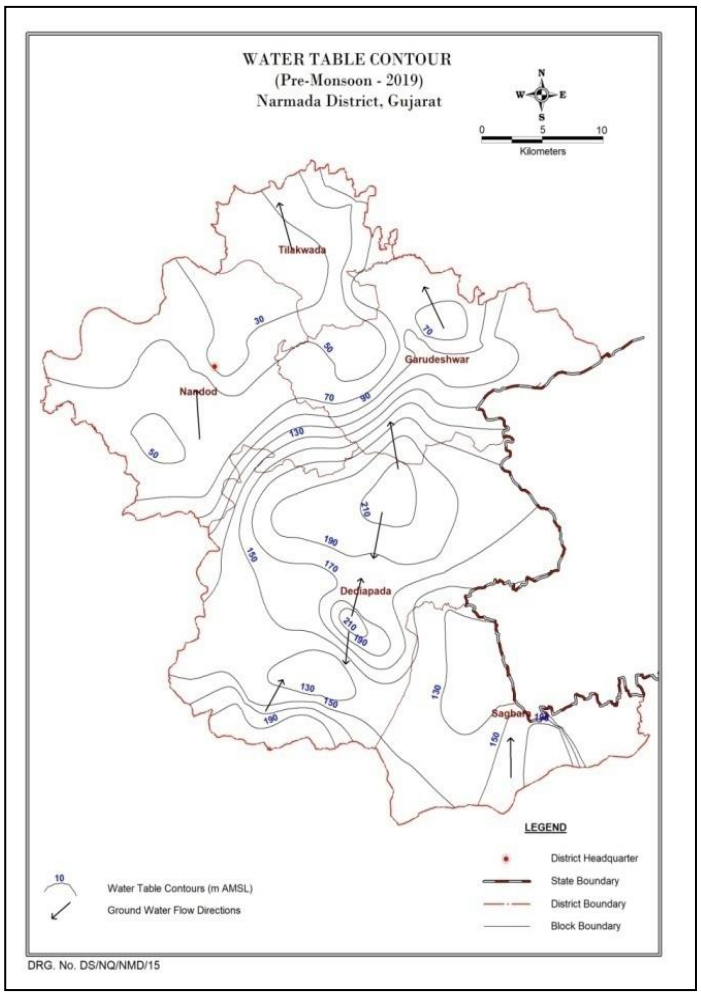


Figure 24- Water level contour map (Pre-Monsoon_2019) of Narmada district.

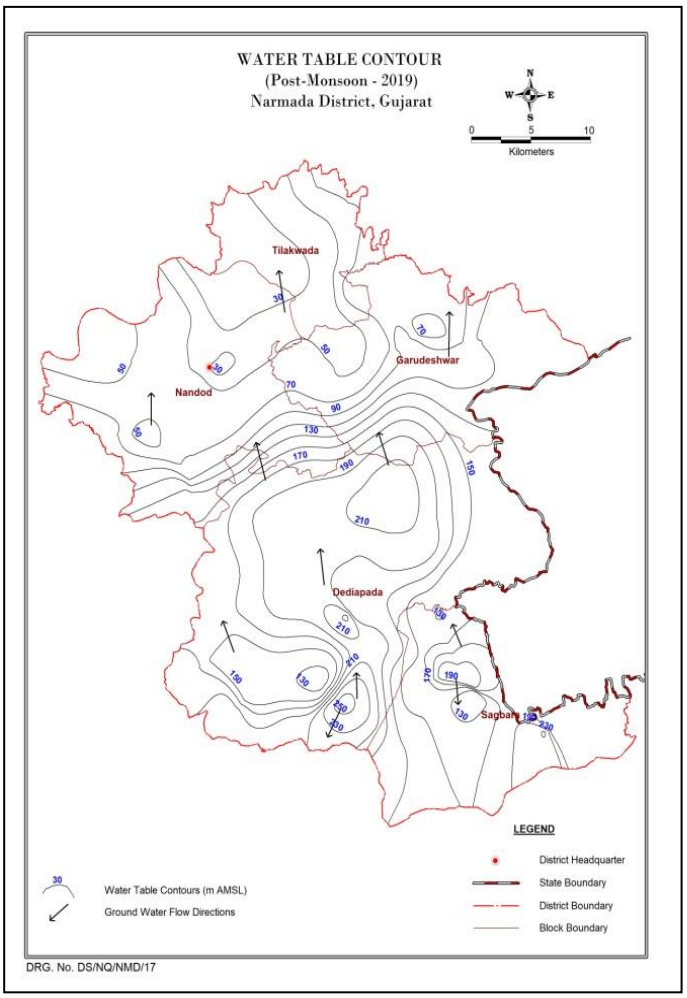


Figure 25- Water level contour map (Post-Monsoon_2019) of Narmada district.

4.3.4 Pre vs Post Monsoon Fluctuation Map.

Map showing Pre vs Post Monsoon Fluctuation water level map of May 2019 with November 2019 (Fig.26**)** shows rise in water level in the district from 2 mbgl to more than 8m bgl.

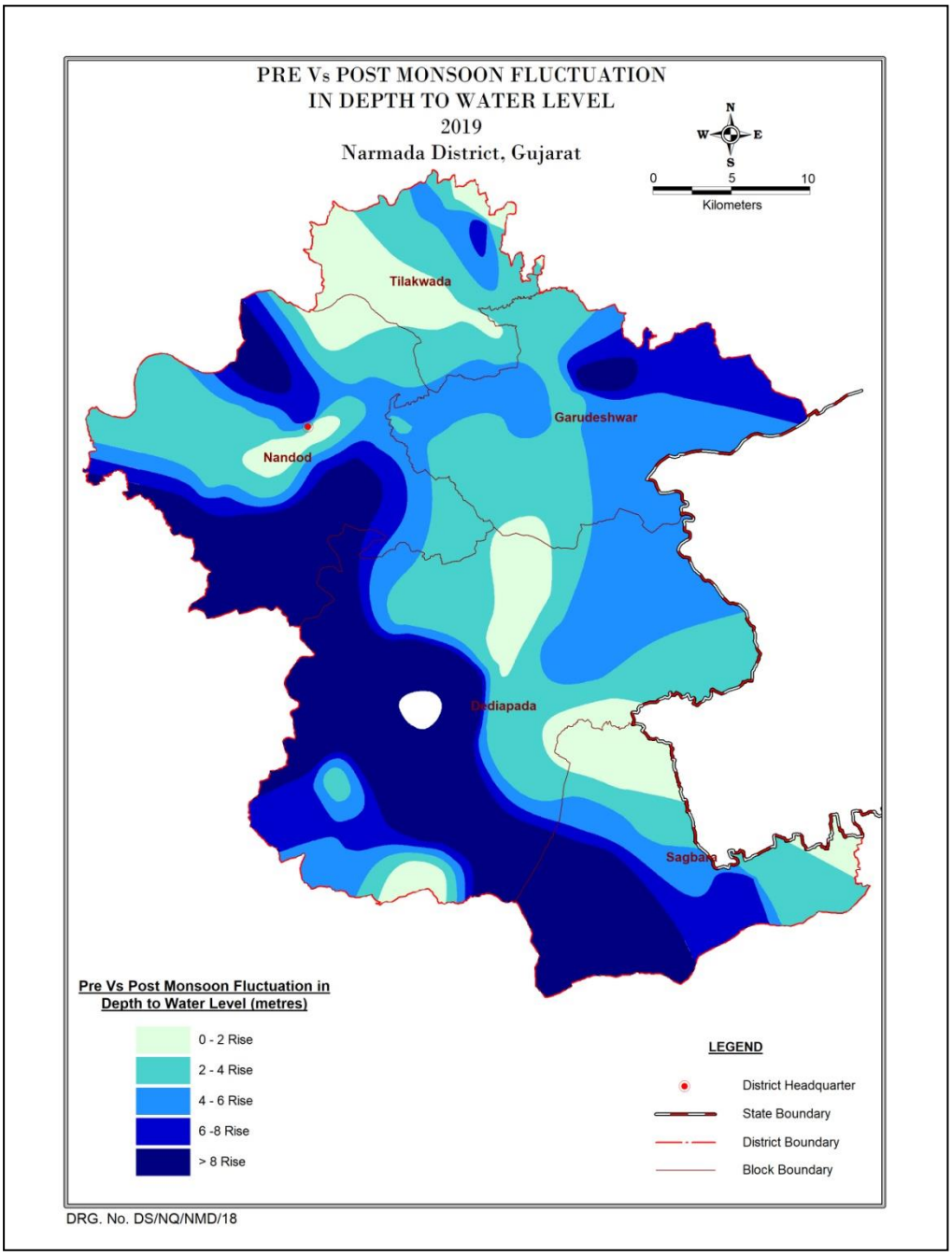


Figure 26-Pre vs Post monsoon fluctuation in depth to water level map of Narmada District.

4.3.5 Ground water decadal trend Post-Monsoon (2009-2018)

Map:

Decadal trend of ground water level for the period of 2009 to 2018 has been prepared and presented in figure-27. From map its depicted that most part of the district shows falling trend which ranges more than 0.10 m/ year to 0.10 m/year. Only eastern part of district shows rising trend of more than 0.10 m/ year.

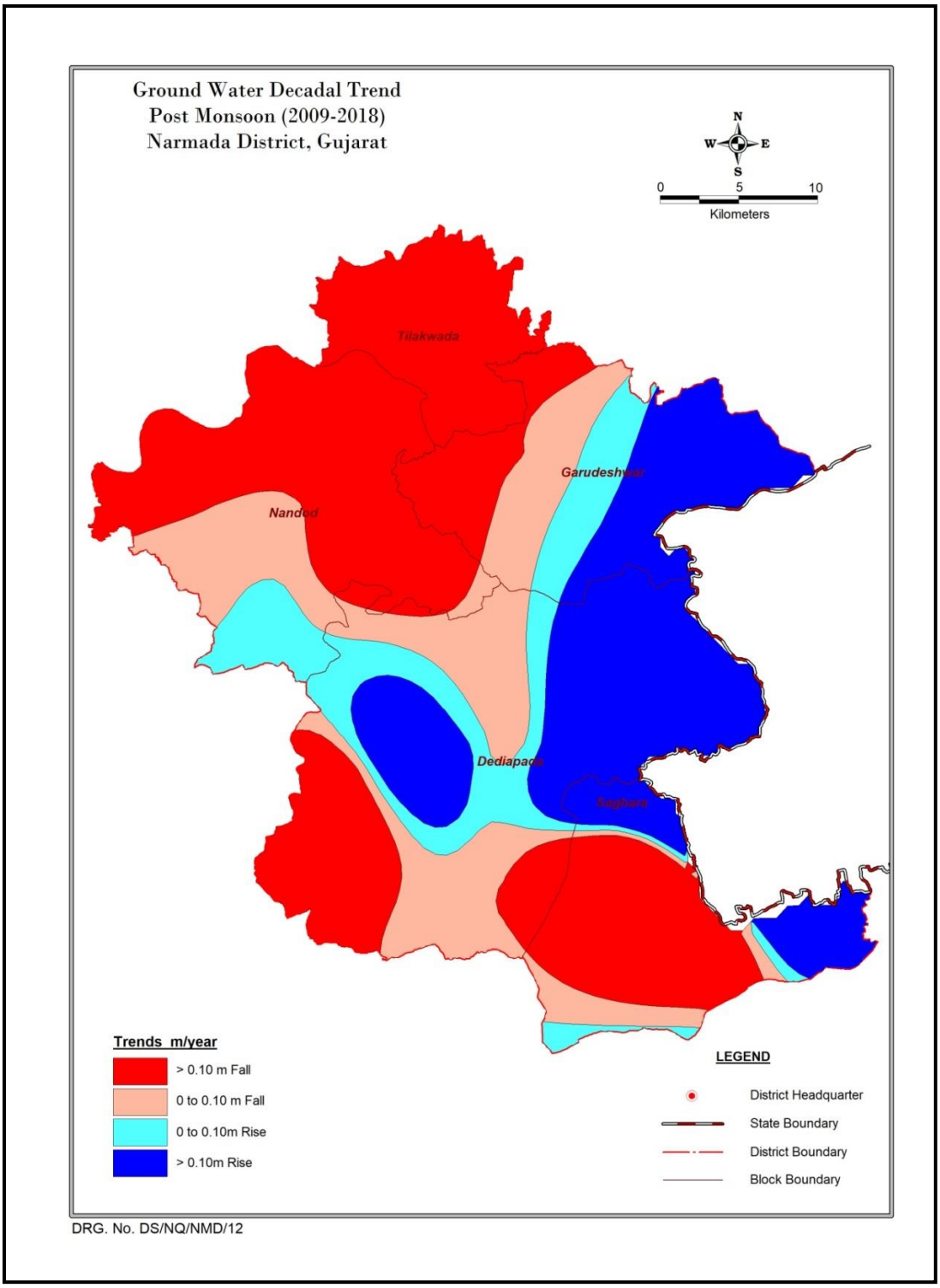


Figure 27-Ground water Level trend..(2009-18).

5. GROUND WATER RESOURCE POTENTIAL

5.1 Ground Water Resources

The ground water resources of the district were calculated as on March 2017 in collaboration with the Government of Gujarat using the methodology suggested by Ground Water Resource Estimation Committee (GEC-15). These resources were computed after reorganisation of the districts.

5.2 Ground Water Recharge

The Annual Ground Water Recharge varies from 26.62 mcm (Tilakwada taluka) to 89.39 mcm (Nandod Taluka). The Gross Annual Ground Water Recharge in the district is 251.76 mcm.

5.3 Ground Water Draft

The ground water draft for irrigation, Domestic and Industrial uses is presented in Table: 14. The Existing Gross Ground Water Draft for all uses varies from 3.98 mcm (Tilakwada taluka) to 22.29 mcm (Nandod Taluka). The Gross Ground Water Draft for All uses in the district is 46.31 mcm.

5.4 Projected demand for Domestic and Industrial use upto 2025

Projected demand for domestic and industrial uses varies from 1.18 mcm (Tilakwada taluka) to 3.23 mcm (Dediapada taluka). The total Projected demand for domestic and industrial uses in the district is 10.92 mcm.

5.5 Ground water Availability for future irrigation

Ground water availibilty for future irrigation is varies from 21.18 mcm(Tilakwada taluka) to 62.32 mcm (Nandod taluka) and total 192.74 mcm ground water is available for future irrigation.

5.6 Stage of Ground Water Development

As per the Ground Water Resource Estimation (GWRE-2017), the stage of Ground Water Development varies from 13.01 % (Dediapada Taluka) to 26.25 % (Nandod Taluka). The overall ground water development in the district is 19.36 %. All the five talukas of the district are categorized as SAFE.

Table 7-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 (2017)															
District : Narmada															
Sr. No.	Taluka	ANNUAL REPLENISHABLE GROUND WATER RESOURCE (mcm)					Natural Discharge during non-monsoon season (mcm) (5 % of 7)	Net Annual Ground Water Availability (mcm) (7- 8)	ANNUAL GROUND WATER DRAFT (mcm)			Projected Demand for Domestic and Industrial uses upto 2025 (mcm)	Ground Water Availability for future irrigation (mcm) {(9)-(10+13)}	Stage of Ground Water Development (%) (12/9) * 100	Category
		Monsoon		Non Monsoon		Total Annual Ground Water Recharge (3+4+5+6)			Irrigation	Domestic And Industrial uses	Total (10 + 11)				
		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
1	Nandod	38.70	22.57	0.00	28.12	89.39	4.47	84.92	19.82	2.47	22.29	2.78	62.32	26.25	Safe
2	Dediapada	33.00	14.64	0.00	2.03	49.68	2.48	47.19	3.27	2.87	6.14	3.23	40.70	13.01	Safe
3	Garudeshvaar	1.68	11.92	0.00	25.31	38.91	1.95	36.96	5.90	1.49	7.39	1.68	30.47	19.99	Safe
4	Sagbara	26.76	10.92	0.00	9.49	47.17	2.36	44.81	4.69	1.83	6.51	2.05	38.07	14.54	Safe
5	Tilakwada	14.89	5.36	0.00	6.36	26.62	1.33	25.29	2.93	1.05	3.98	1.18	21.18	15.73	Safe
District Total		**115.03**	**65.41**	**0.00**	**71.32**	**251.76**	**12.59**	**239.18**	**36.60**	**9.72**	**46.31**	**10.92**	**192.74**	**19.36**	**Safe**

Major basin in the district is Narmada River which having interconnected canal channel upto the most of the village. And number of different Ground Water Abstraction structure of the district is tabulated below in table-3 (A, B, and C). As most part of the district having Basaltic formation and maximum utilization of Ground water based on the Dug Wells and Shallow tube wells which can also be observed in below table (data source: MI census 2013-14)

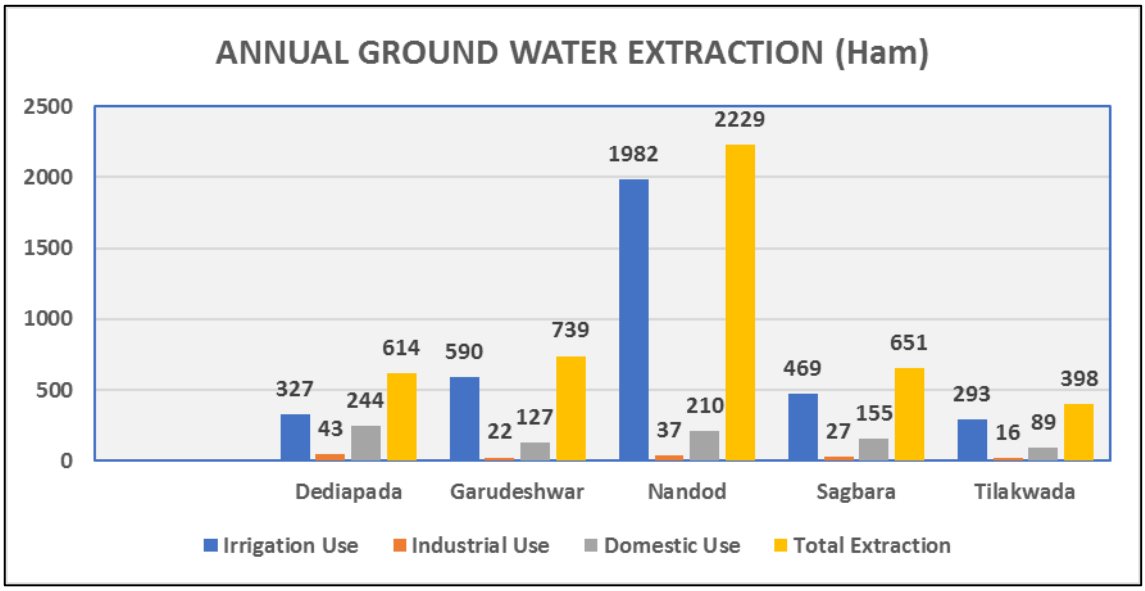


Figure 28- Histogram representation of Annual Ground Water Extraction (Ham) in Narmada district as per GWE 2017.

Table 10- Number of Groundwater Abstraction Structure (Deep tube well) in the District (Source: MI Census 2013-14).

Deep Tube Well	0-20m	20-40m	40-60m	60-70m	70-90m	90-110m	110-130m	130-150m	>150m
No.	0	0	0	0	0	0	0	0	3

Table 9- Number of Groundwater Abstraction (shallow tube well) Structure in the District (Source: MI Census 2013-14).

Shallow Tube Well	0-20m	20-35m	35-40m	40-60m	60-70m	>70m
No.	77	1517	0	0	0	0

Table 8- Number of Groundwater Abstraction Structure (Dug Well) in the District (Source: MI Census 2013-14)

Dug Well	Pucca	Kutcha	Dug-cum-Bore
No.	3438	69	0

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 duringNational Hydrographs Monitoring Stations (NHS) in May 2019, and presented in Table-11. The ground water is in general alkaline in nature. Distribution of Electrical Conductivity and Chloride concentration has been shown in figure (29) and (30) respectively.

Constituents	Minimum	Maximum	Average
pH	6.94	7.66	7.30
EC (uS/cm)	468	3600	958
TDS (mg/l)	314	2412	641.8
CO_3 (mg/l)	0	0	0
HCO_3 (mg/l)	171	1037	321.89
Cl (mg/l)	14	539	92.6
NO_3 (mg/l)	10	141	46.89
SO_4 (mg/l)	10	155	44.33
F (mg/l)	0.12	0.75	0.35
Alkalinity (mg/l)	140.3	850.5	264.01
Ca (mg/l)	40	124	66.33
Mg (mg/l)	12	185	48.11
TH (mg/l)	205	910	363.61
Na (mg/l)	14	410	52.44
K (mg/l)	0.1	3.1	0.66

Table 11- Statistical Analysis of Chemical Constituents of Ground Water in Narmada District, May 2019.

6.1 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 6.94 & 7.66 in the district.

6.2 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.

Iso conductivity Map of the district shown below in (Fig.29), Due to Basaltic Nature of the district has EC value within Permissible limit i.e. almost all talukas except extreme north region of Nandod taluka show EC value more than acceptable limit.

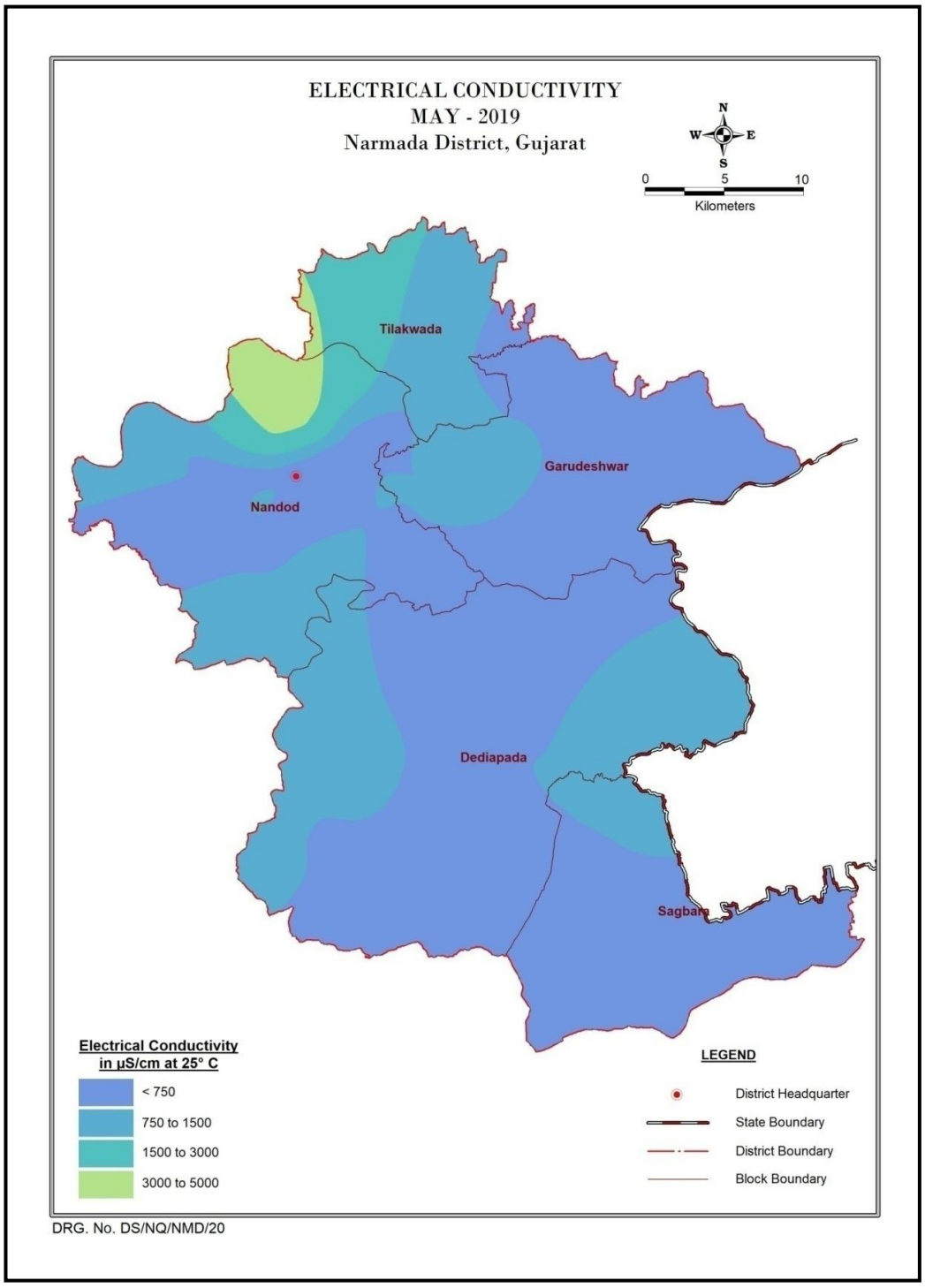


Figure 29-Map showing Taluka wise Electrical Conductivity (EC) values of Narmada District.

6.3 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 314 mg/l to about 2412 mg/l.

6.4 Carbonate (CO3) and Bicarbonate (HCO3)

The shallow ground water in Narmada district does not contain any Carbonate. The Bicarbonate concentration in district varied between 171 mg/l to 1037 mg/l.

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, taluka of Sagbara, Dediapada, Garudeshwar and more than 80% region of Nandod lies below acceptable limits. Whereas rest region of the Taluka lies within Permissible limits. A small patch in extreme northern boundary of Nandod taluka shows Cl value more than acceptable limit.

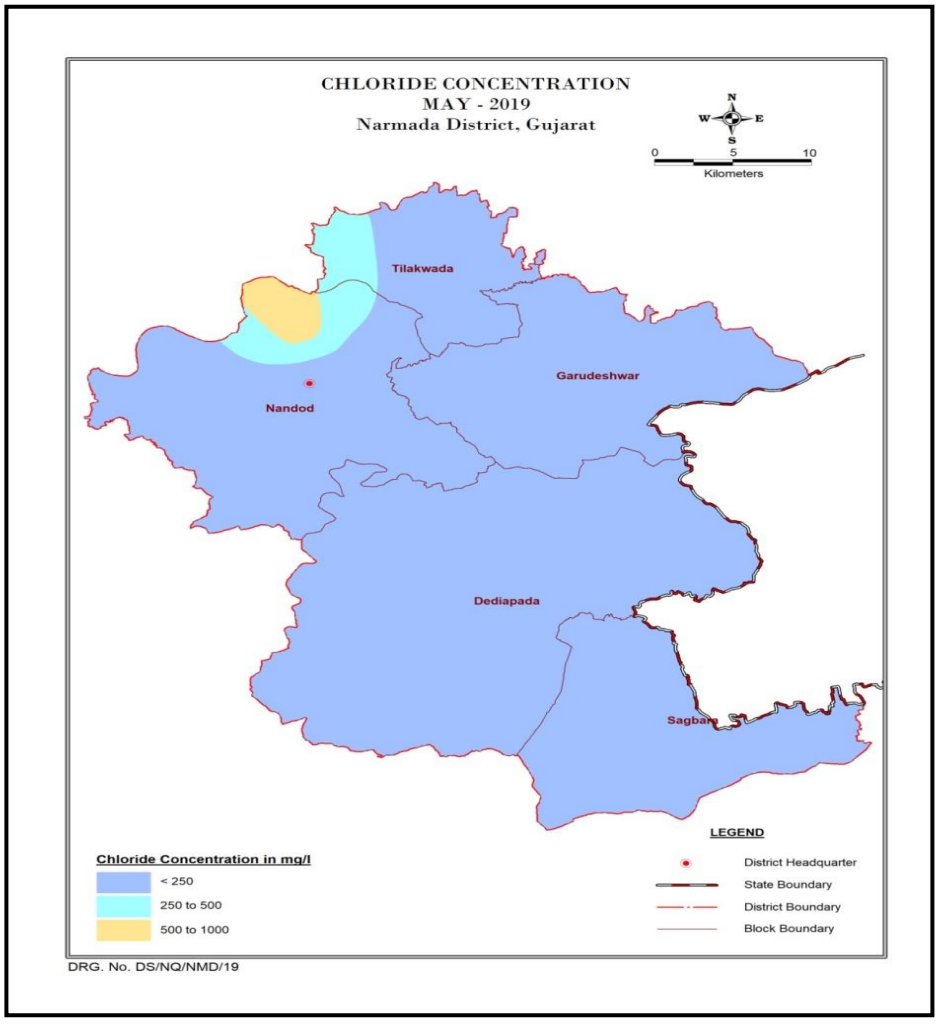


Figure 30-Map showing Taluka wise Chloride (Cl) concentration of Narmada District.

6.6 Nitrate (NO3)

Nitrate concentration in the ground water in district varies between 10 mg/l (Ralda) and 141 mg/l (Chuli). There are seven stations where these values are more than the limits as per BIS drinking water standards (45 mg/l).

6.7 Sulphate (SO4)

In the district area, the sulphate concentration varies from 10 mg/l (Khaidipada) to 155 mg/l (Rasela).

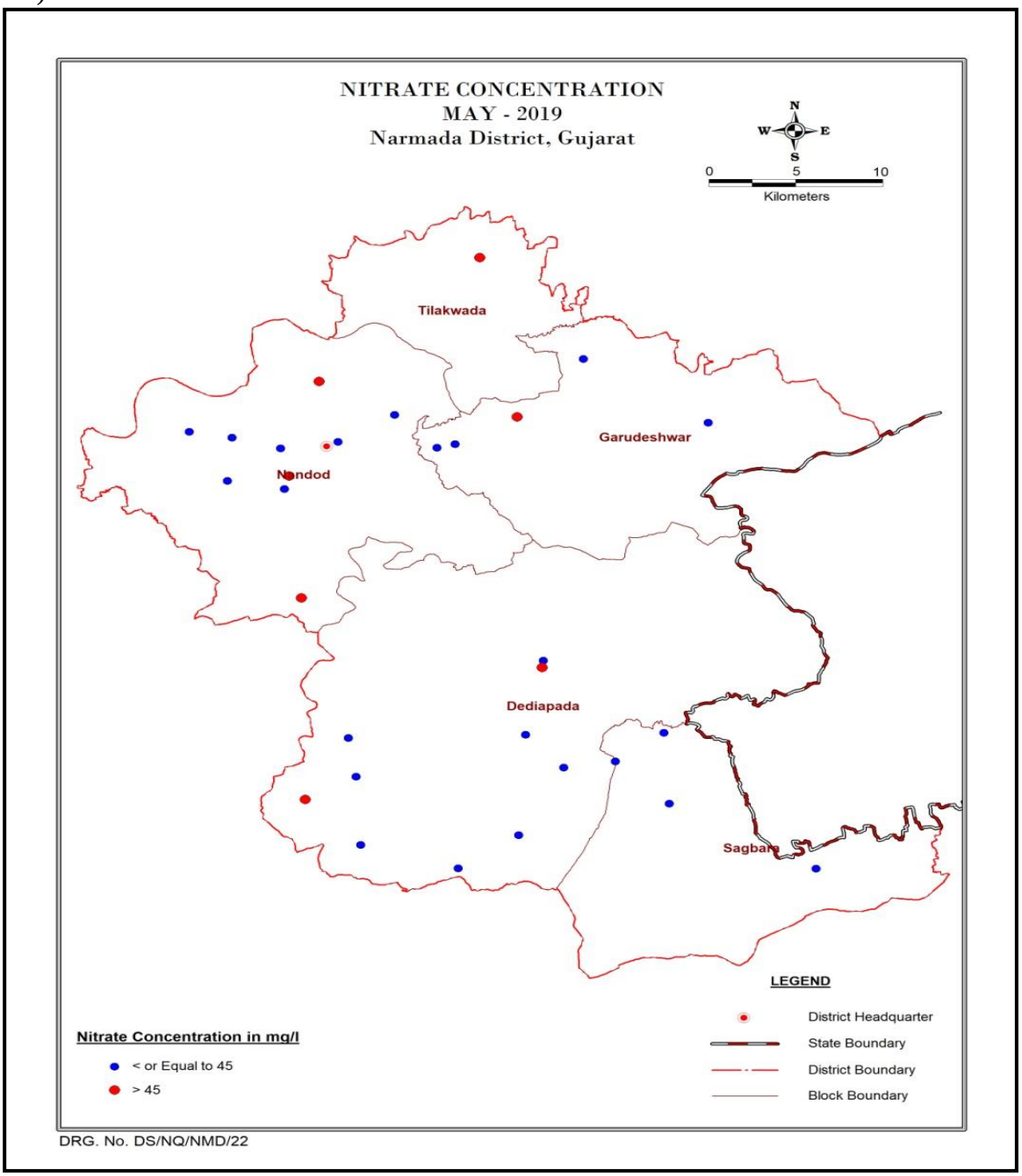


Figure 31- Concentration of Nitrate in Narmada district.

6.8 Fluoride (F)

Fluoride concentration in ground water varies between almost 0.12 mg/l (Chuli) and 0.75 mg/l (Namaria).

6.9 Calcium (Ca)

Calcium concentration in district varies between 40 mg/l (Ralda) and 124 mg/l (Chuli). The concentration of calcium is found within permissible limits in the district (permissible limit as per BIS norms is 200 mg/l).

6.10 Magnesium (Mg)

The Concentration of Magnesium in areas ranges from 12 mg/l (Salemba) to 185 mg/l (Rasela). The concentration of magnesium is more than maximum permissible limits of 100 mg/l (as per BIS norms) is recorded at Namaria (107 mg/l.) and Rasela (216 mg/l).

6.11 Sodium (Na)

Sodium concentration in area varies between 14 mg/l (Amyar, Ralda and Jhank) and 410 mg/l (Rasela).

6.12 Potassium (K)

The concentration of Potassium in shallow ground water ranges from 0.1 mg/l (Kanbi pitha) to 3.1 mg/l (Rasela).

6.13 Total Hardness as CaCO3 (TH)

Total Hardness in ground water in alluvial areas range between 205 mg/l (Ralda) and 910 mg/l (Rsela).

7. SUSTAINABLE GROUNDWATER DEVELOPMENT AND MANAGEMENT

7.1 Groundwater related issue:

7.1.1 Low Ground water development

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 five (05) blocks of district are under safe category. Ground water stage of development ranges from 13.01 % (Dediapada) to 26.25 % (Nandod). Thus, management of ground water resources could be developed/augmentated in a judicious way.

7.1.2 Pollution (Geogenic and Anthropogenic)

Ground water in both shallow and deeper Aquifers is Potable and fit for domestic, drinking, irrigation and other industrial purposes and Nitrate concentrate is observed in shallow aquifer at localized pockets.

7.1.3 Sustainability

Most part of the district has weathered & Fractured Basalt which forms the major aquifer. Yield in baslatic aquifer varies very low yield (<2 lps) to 26 lps.. The yield from bore wells have reduced in a lean period, recoupment time in some phreatic aquifer is very low thats the reason people residing there constructed large daimeter of well for maximum storage.

7.1.4 Reasons for Issues

Sustainability: 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 five (05) talukas of the district are under **safe** category. Ground water stage of development ranges from 13.01 % (Dediapada) to 26.25 % (Nandod). Thus, further ground water development could be augmented in a judicious way.

In the entire Narmada district, there is a scope exists for further ground water development.

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 50% in all taluka, 6675 nos. Dug wells (15 m depth) and 2896 nos of Tubewell (100m depth) in Hard rock are proposed as feasible extraction structures table 12. And further the extraction structures will result in expected annual ground water draft of 7681.5 ham which will create 15363 Ha of additional irrigation potential in the district.

Table 12- Feasible Extraction structures to elevate the Stage of GW development to 50% (Hard Rock)

Block	Feasible Extraction structures to elevate the Stage of GW development to 50% (Hard Rock)		
	TW	DW	Total
Garudeshwar	700	240	940
Nandod	1290	300	1590
Tilakwada	580	90	670
Dediapada	215	3045	3260
Sagbara	111	3000	3111
District	2896	6675	9571

7.3.2 Supply side interventions

As per Master Plan 2020, surplus surface water of 459.04 mcm is already available for artificial recharge in district of narmada. To harvest the required surface water different structures are proposed like check dam, Percolation tank and existing defunct tube and presented in table 13.
Expected annual Groundwater recharge is 1105.9 ham from recommended total 317 nos of check dam of 5.1 ham capacity/each, total 156 nos. of Percolation tank of 13.5 ham/each and 42 nos. of already existed defunct tubewell are reccommended for harvesting the part of available runoff and to recharge the Groundwater

Table 13- Proposed Artificial Recharge and WUE Interventions in Narmada District

Block	Check Dams of 17000 cum Capacity (Nos)	Percolation Tank (~ 90000 m3 capacity)	Recharge through defunct Tubewell(Capacity @ 3 ham)	On farm Activities (Area in ha)	Farm Pond (Per Farm Pond Storage 0.576 m3 considered as per DIP.)
Garudeshwar	75	25	5	Not proposed	Not proposed
Nandod	100	80	12	Not proposed	Not proposed
Tilakwada	52	16	4	Not proposed	Not proposed
Dediapada	90	35	15	Not proposed	Not proposed
Sagbara	Not proposed	Not proposed	6	187	380
District	317	156	42	187	380

7.3.3 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 Deccan trap basalt/intrusives. The thickness of available unsaturated zone (below 6 m bgl) is computed on basis of Post monsoon (2009-18) decadal average depth to water level map and Similarly, Post monsoon (2009-18) decadal water level trend map of Gujarat State is presented in figure 27. On basis of these two maps, area suitable for artificial recharge in Gujarat State is identified taking into consideration of following four categories, and presented as figure 32.

- 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.

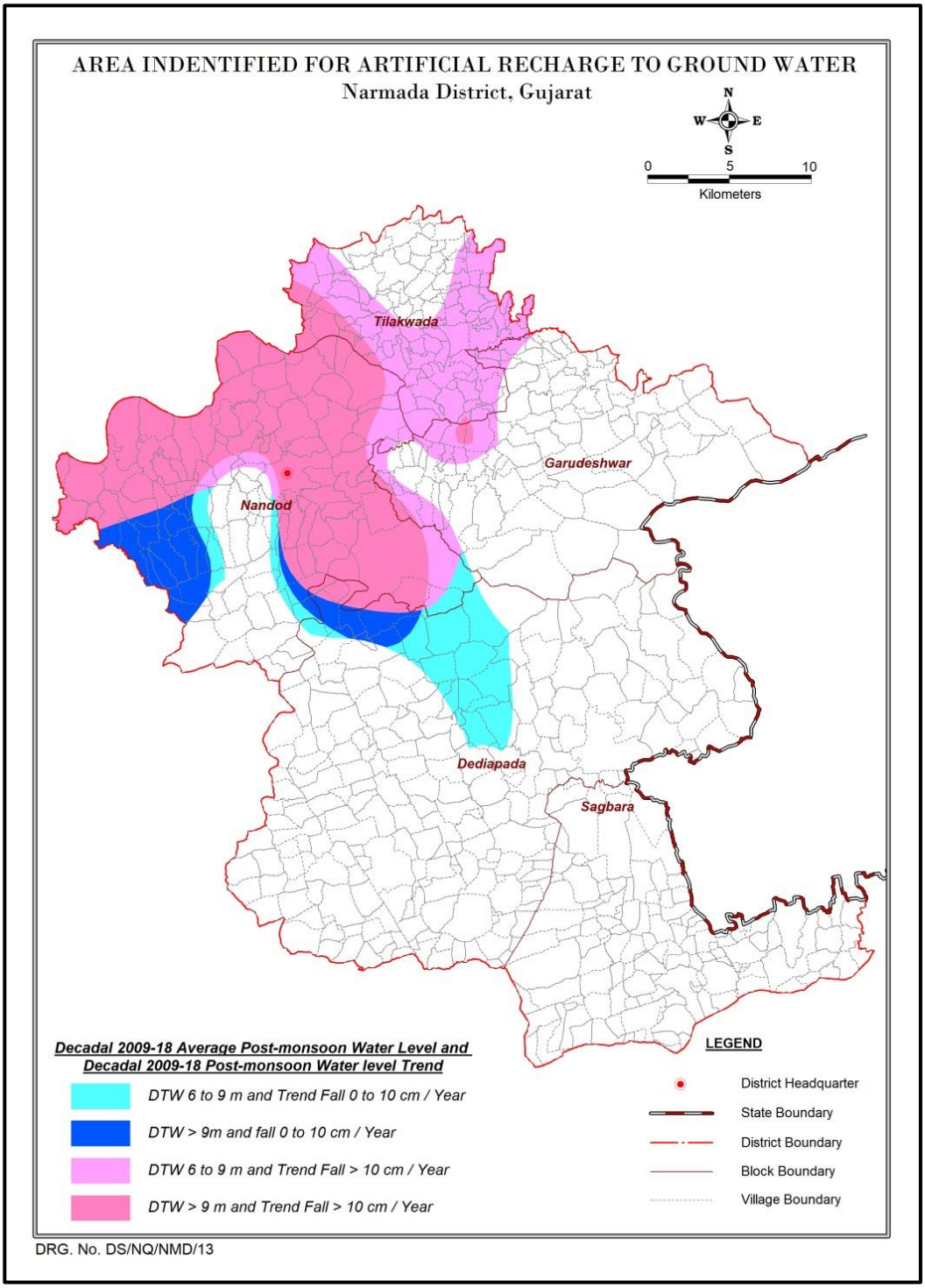


Figure 32- Suitable area identified for artificial recharge in Narmada district.

7.3.4 Demand side intervention

- Feasible extraction structures are proposed to elevate the stage of ground water development to 50%, to avoid further exploitation demand side management is also recommended to restrict the stage of ground water development to 45%.
- 187 Ha area is proposed for on farm activities (Laser levelling/Bench terracing/Contour banding) and 380 no of farm ponds are recommended which will serve dual purpose of irrigation and recharge to ground water.
- Expected Annual Ground water recharge of 237.58 ham (through on farm activities and GW return flow) is expected for the district.
- 195.40 ham saving of ground water through on farm & farm ponds activities is expected for the district.

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- **Farm Ponds**

A farm pond is a large hole dug out in the earth, usually square or rectangular in shape (Fig. 7.5), 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.

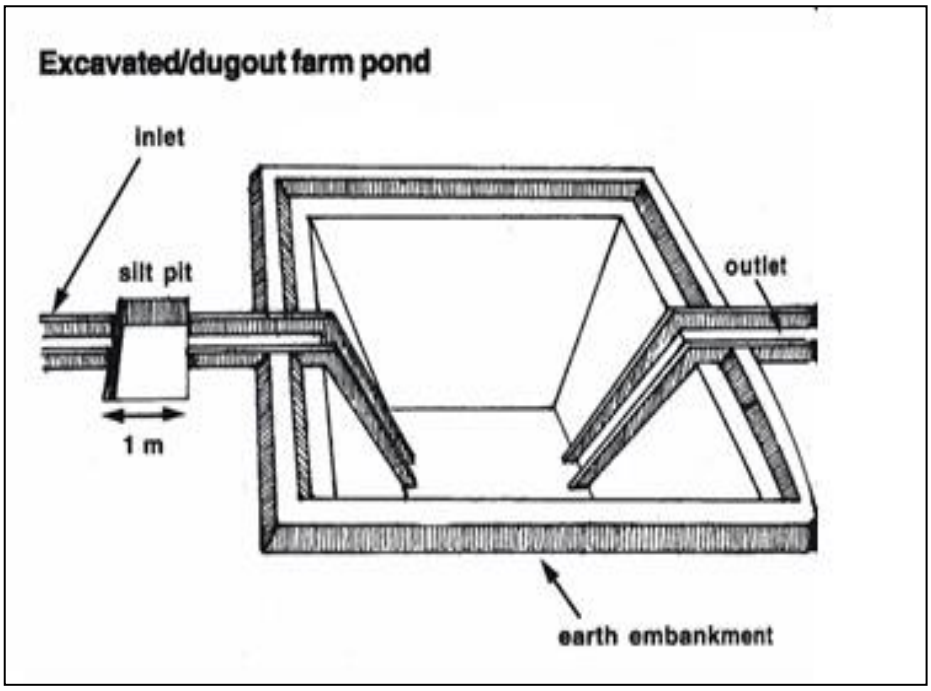


Figure 33- Thematic diagram of Farm pond.

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 supplies water for domestic purposes and livestock
- They promote fish rearing.
- They recharge the ground water.
- They improve drainage.
- The excavated earth has a very high value and can be used to enrich soil in the fields, leveling land, and constructing farm roads

Table 14- Projected Status of Groundwater Resource after implementation of GW Management Plan, Narmada District (Gujarat)

Projected Status of Groundwater Resource after implementation of GW Management Plan, Narmada 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 Supplemental irrigation (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 measures & Recharge measures (in %)	Projected stage of GW development after construction of extraction structures & implementation of conservation & Recharge measures (in %)	Additional Irrigation Potential Created (Ha)
Sagbara	4480.92	21.10	166.65	4668.67	651.43	4.86	195.40	1666.50	2117.67	14.54	50	46	45	3333
Dediapada	4719.26	256.18	184.50	5159.95	613.82	136.08	0.00	1845.00	2322.74	13.01	50	50	45	3690
Tilakwada	2528.72	123.35	91.50	2743.57	397.66	74.84	0.00	915.00	1237.82	15.73	50	50	45	1830
Nandod	8492.21	535.98	208.50	9236.69	2229.39	147.42	0.00	2085.00	4166.97	26.25	50	50	45	4170
Garudeshwar	3696.40	187.99	117.00	4001.39	739.09	107.33	0.00	1170.00	1801.76	19.99	50	50	45	2340
Narmada district	23917.51	1267.26	768.15	25952.92	4631.39	470.53	195.40	7681.50	11646.96	19.36	50	49	45	15363

8. CONCLUSION AND RECOMMENDATIONS

- Artificial recharge structures like Check dam (317), Percolation tank (156) Defunct Tube wells (42 no) are suggested as 459.05 mcm surplus surface water is available in the district as per the Master plan-2020.

- To elevate the stage of ground water development to 50% in district 6675 no Dug wells (20 m depth) in Hard rock and 2896 no Tube wells (100m depth) in proposed as feasible extraction structures.

- 27913 Hectare land may additionally irrigated on 70% of groundwater development and observing all intervention proposed.

- To prevent Over Exploitation, water conservation activities like On farm activities , farm ponds and Micro irrigation system (Sprinkler/drip) are recommended.

- 187 Ha area is proposed for on farm activities (Laser levelling/Bench terracing/Contour banding) and 380 no of farm ponds are recommended which will serve dual purpose of irrigation and recharge to ground water.

- Ground water recharge of 768.5 ham (through on farm activities and GW return flow) is expected for the district.

- 195.40 ham saving of ground water through WUE measures & farm ponds activities 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 good. However higher EC values 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.

AQUIFER MAPPING AND MANAGEMENT PLAN OF ALL THE BLOCKS, OF NARMADA DISTRICT, GUJARAT

1. Aquifer Mapping and Management Plan of Dediapada Taluka, Narmada District, Gujarat

1.1 Salient Information of Dediapada taluka

Salient information about the Dediapada taluka are given in following table

Table 15- Salient information about Dediapada Taluka.

SALIENT FEATURES OF DEDIAPADA TALUKA		
1.	**GEOGRAPHICAL AREA (Sq km)**	1023.87
2.	**NO. OF VILLAGES**	213
3.	**NO. OF MUNICIPALITY**	
4.	**POPULATION (as per census 2011)**	174449
4.1	**Male**	88235
4.2	**Female**	86214
5.	**Average Rainfall (mm) (2007-16)**	1067
6.	**Major and Minor Bansin**	Narmada river , Terav and Karjan river
7.	**CROPPING PATTERN:**	
7.1	NET SOWN AREA (Ha)	18812
7.2	GROSS CROPPED AREA (Ha)	20700
7.3	CROPPING INTENSITY	110.04
7.4	AREA SOWN MORE THAN ONCE (Ha)	1888.44
8.	**IRRIGATION PATTERN :**	
8.1	NET IRRIGATED AREA (Ha)	544
8.2	GROSS IRRIGATED AREA (Ha)	11393.1
9.	**MAJOR CROPS:**	Paddy, Wheat, Jowar, bajra, Maize, Mung, Udid, Tur, Groundnut, Cotton, Castor, Sesamum and Soyabean

1.2 Location

Dediyapada is a taluka in Narmada district Gujarat India. This taluka is bounded by , Sagbara taluka from south, Surat and Baruch district from South and West direction respectively, and from North side it is bounded by Nandod taluka and Garudeshwar taluka and from West side by Maharashtra state Figure (34). Dediapada is well connected with Ankleshwar, Rajpipla, Sagbara by highway.

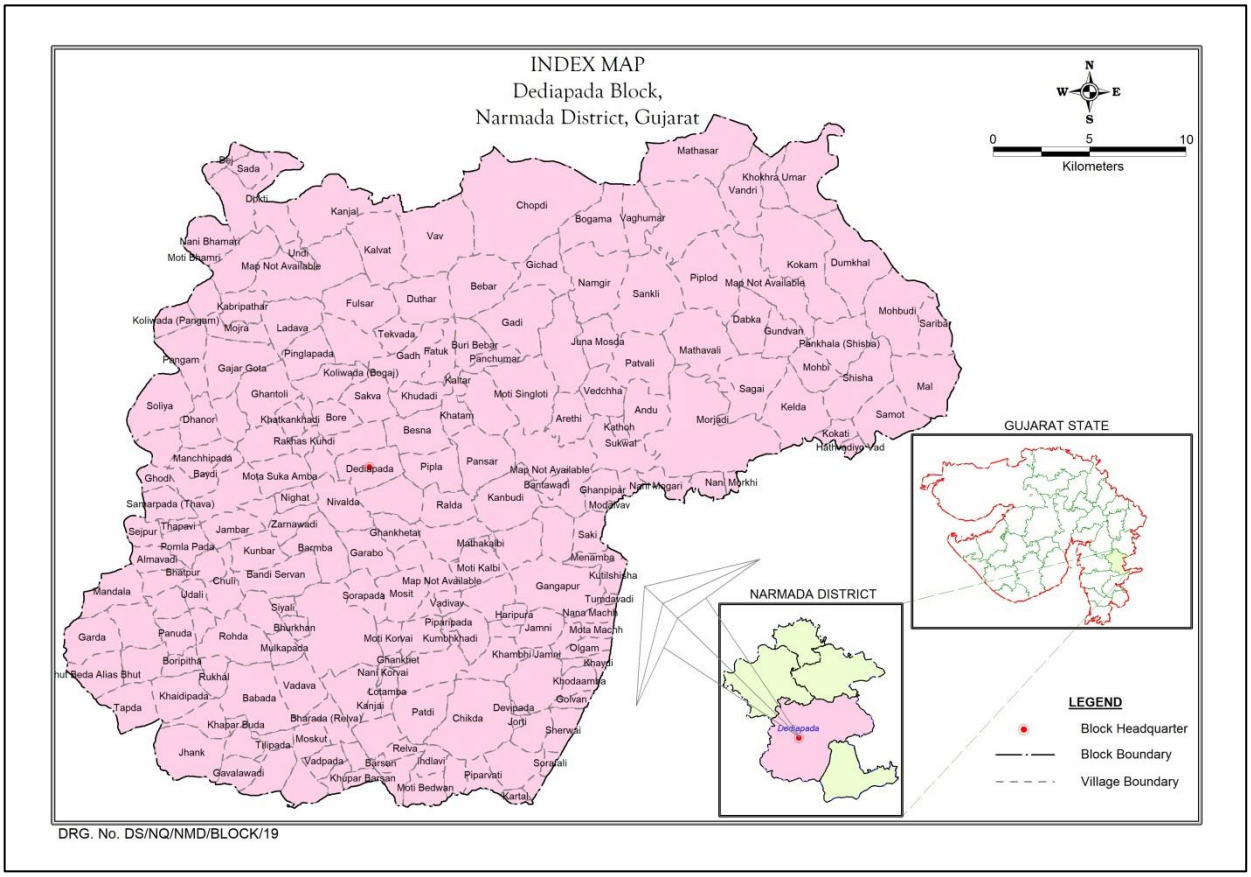


Figure 34- Administrative map of Dediapada taluka.

1.3 Water Level Behaviour

Depth to water level map for pre and post-monsson -2019 of Dediapada taluka are presented in fig (35.) and (36) respectively. For pre monsoon period it is observed that depth to water level ranges from 2 m bgl to more than 40m bgl. fig (35). Whereas in post monsoon period it is varies in between 0 m bgl to 20 m bgl. fig.(36).

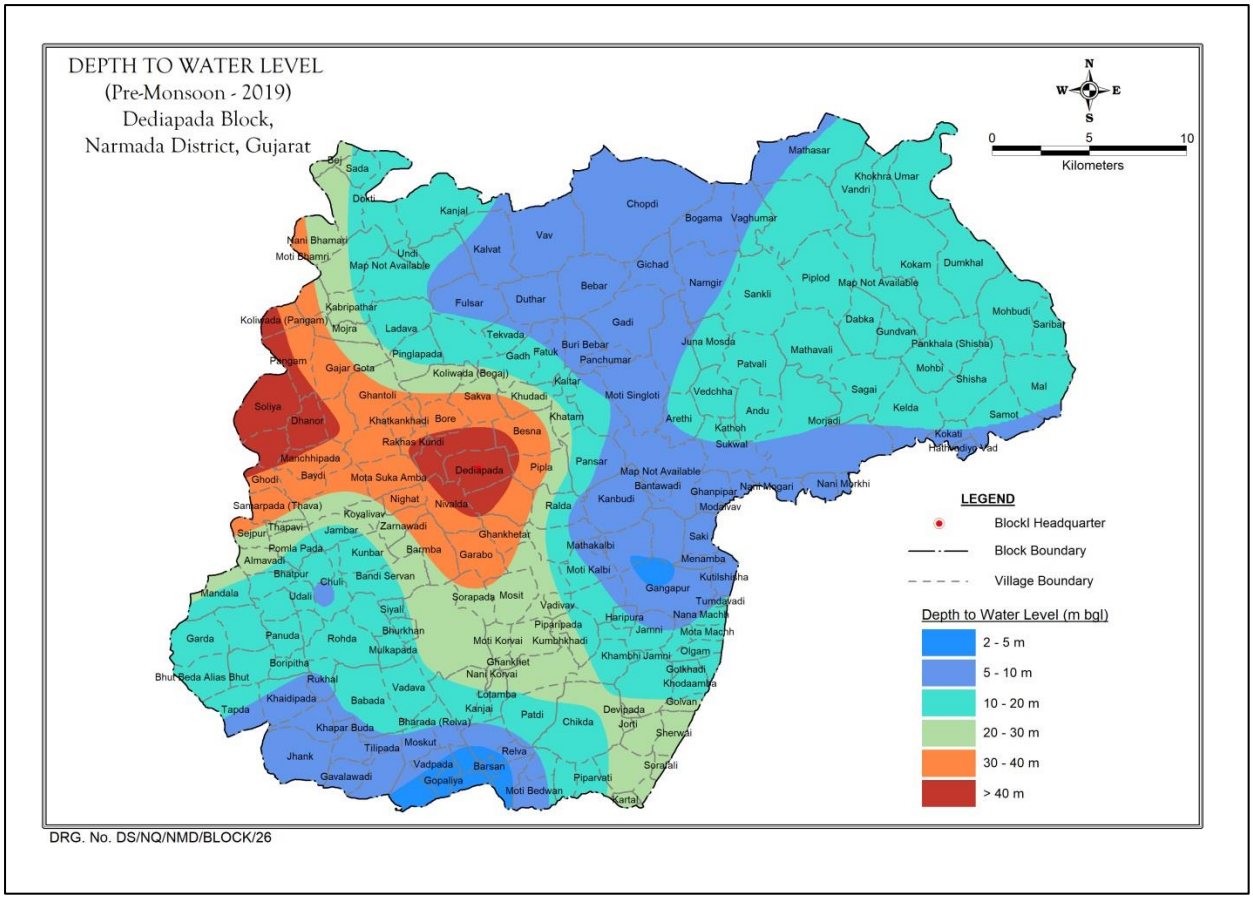


Figure 35- Pre monsoon depth to water level map.

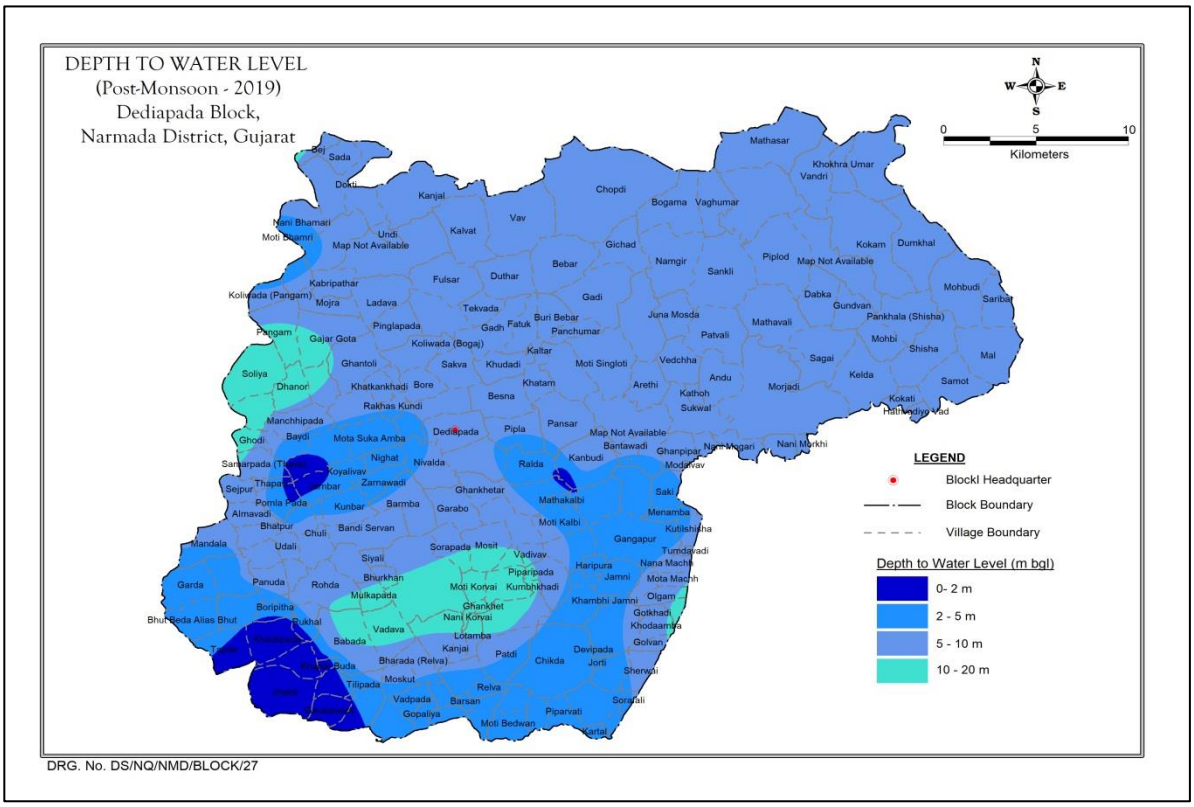


Figure 36- Post monsoon depth to water level map

1.4 Aquifer Dispositon

Most part of the taluka is covered by basaltic rocks of the Cretaceous age. Groundwater occurs under unconfined to semiconfined conditions. Phreatic zone form the thickness of 4.2 m to 27 m. and Semi confined aquifer thickness varies from 6 m to 139m.and discharge varies from 0.15 lps to 26 lps., apart from occurrence of water in the pore spaces between sand grains, the principal joints, fissures and other planes of structural weakness play an important role in the movement of groundwater.

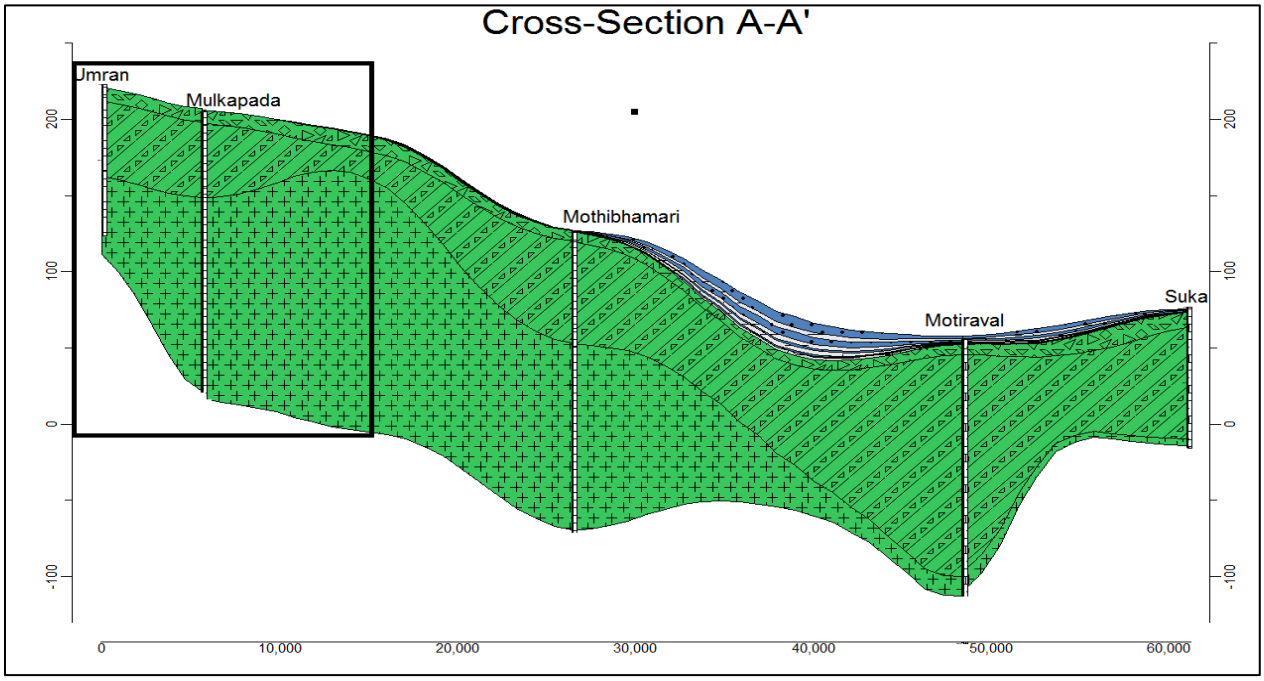


Figure 37- Cross section A-A' of site Umran and Mulkapada fall in Dediapda taluka.

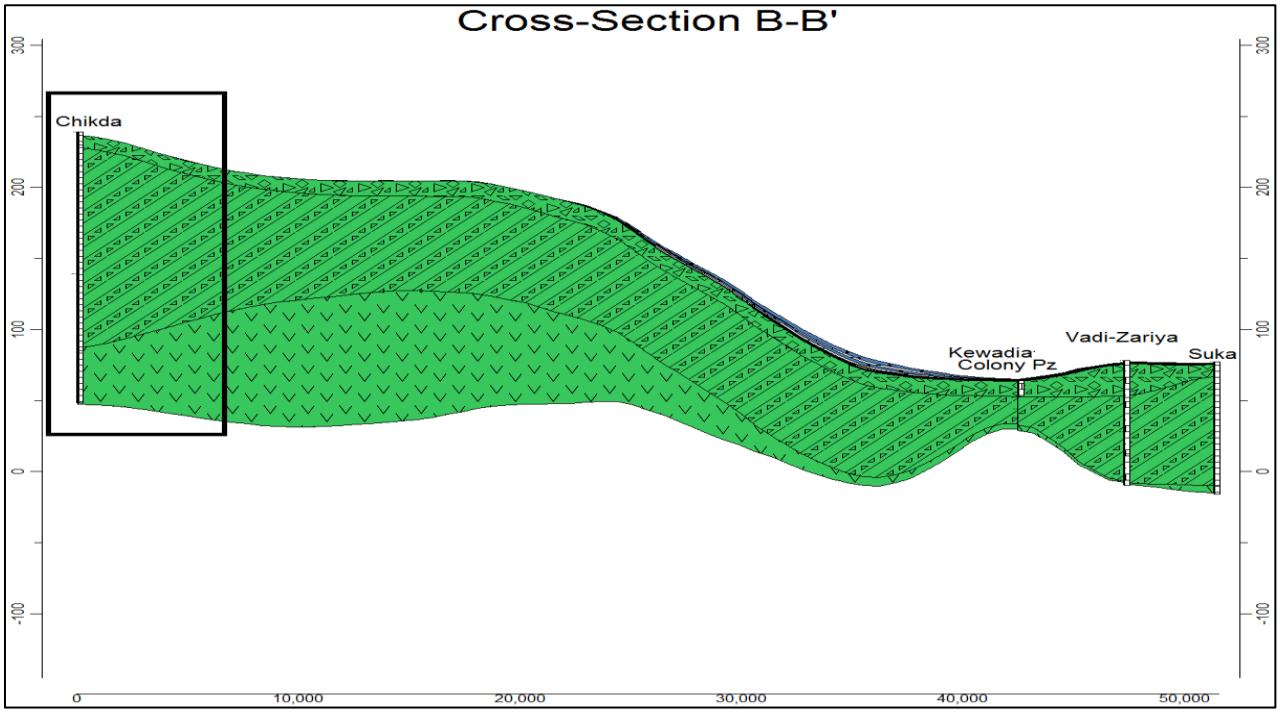


Figure 38- Cross section B-B' of site Chikda fall in Dediapda taluka

1.5 Ground water resource

As per GWRE 2017, Stage of ground water development of taluka is 13.01 % and fall is safe category. Total Resources Dynamic and instorage (Fresh) is 479149.28 ham. Tabulated form of ground water resources, availability, utilization and stage of ground water development is presented in table16.

Table 16- ground water resources, availability, utilization and stage of ground water development of Dediapada taluka

ANNUAL REPLENISHABLE GROUND WATER RESOURCE (mcm)					Natural Discharge during non-monsoon season (mcm) (5 % of 7)	Net Annual Ground Water Availability (mcm) (7- 8)	ANNUAL GROUND WATER DRAFT (mcm)			Projected Demand for Domestic and Industrial uses upto 2025 (mcm)	Ground Water Availability for future irrigation (mcm) {(9)-(10+13)}	Stage of Ground Water Development (%) (12/9) * 100	Category
Monsoon		Non Monsoon		Total Annual Ground Water Recharge (3+4+5+6)			Irrigation	Domestic And Industrial uses	Total (10 + 11)				
Recharge from rainfall	Recharge from other sources	Recharge from rainfall	Recharge from other sources										
3	4	5	6	7	8	9	10	11	12	13	14	15	16
33.00	14.64	0.00	2.03	49.68	2.48	47.19	3.27	2.87	6.14	3.23	40.70	13.01	Safe

1.6 Hydrochemistry

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 2019, and presented in Table-4. The ground water is in general alkaline in nature. Distribution of Electrical Conductivity and Chloride concentration has been shown in figure (7) and (8) respectively

Table 17- Chemical quality details

Constituents	Minimum	Maximum	Average
pH	7.12	7.66	7.31
EC (uS/cm)	468	1034	717.8
TDS (mg/l)	314	2412	641.8
CO_3 (mg/l)	0	0	0
HCO_3 (mg/l)	171	281	233.3
Cl (mg/l)	14	121	62
NO_3 (mg/l)	10	141	54.87
SO_4 (mg/l)	10	108	33.5
F (mg/l)	0.12	0.53	0.323
Alkalinity (mg/l)	140.3	230.5	191.41
Ca (mg/l)	40	124	71.5
Mg (mg/l)	19	58	31.5
TH (mg/l)	205	450	308.12
Na (mg/l)	14	46	22.62
K (mg/l)	0.1	0.8	0.35

1.7 Ground Water Management

1.7.1 Groundwater Management Issues

- Dediapda taluka of the district comes under "SAFE" category as per GWRE-2017.
- Low Ground water Development: The Stage of Groundwater Development of the taluka is 13.01 %. Groundwater quality is fresh in the shallow as well as deeper aquifers.
- The water quality in general is good. However Nitrate concentration is observed in isolated pockets

1.7.2 Groundwater Management Strategies

- The Stage of Groundwater Development of the taluka is 13.01 %. lowest in the district.
- Groundwater management plan is prepared with an aim to enhance the groundwater usage for creation of additional irrigation potential for the district for uplifting the economic condition of the farmers.
- To elevate the stage of ground water development to 50% in the taluka, 3045 nos. Dug wells (15 m depth) and 215 no's of Tube well (100m depth) in Hard rock are proposed as feasible extraction structures.

1.7.3 Groundwater Management Plan

1.7.3.1 Supply Side Management

- As per Master Plan 2020, surplus surface water of 459.04 mcm is already available in the district for artificial recharge check dam, Percolation tank and existing defunct tube wells which can be used as injection well in Narmada district.

- Expected annual Groundwater recharge is 256.18 ham from recommended total 90 nos of check dam of 5.1 ham capacity/each, total 35 nos. of Percolation tank of 13.5 ham/each and 15 nos. of already existed defunct tubewell are reccommended for harvesting the part of available runoff and to recharge the Groundwater.

Table 18- Details of artificial recharge and conservation structure in Dediapada taluka.

Block	Check Dams of 17000 cum Capacity (Nos)	Percolation Tank (~ 90000 m3 capacity)	Recharge through defunct Tubewell(Capacity @ 3 ham)	On farm Acti-vities (Area in ha)	Farm Pond (Per Farm Pond Storage 0.576 m3 considered as per DIP.) Nos.	Feasible Extraction structures to elevate the Stage of GW development to 50% (Hard Rock)		
						TW	DW	Total
Dediapada	90	35	15	0		215	3045	3260

1.7.3.2 Demand Side Management

- Feasible extraction structures are proposed to elevate the stage of ground water development to 50%, to avoid further exploitation demand side management is also recommended.

Table 19- Pojected stage of ground water developmnet after intervention.

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 Supplemental irrigation (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 measures & Recharge measures (in %)	Projected stage of GW development after construction of extraction structures & implementation of conservation & Recharge measures (in %)	Additional Irrigation Potential Created (Ha)
Dediapada	4719.26	256.18	184.50	5159.95	613.82	136.08	0.00	1845.00	2322.74	13.01	50	50	45	3690

2. Aquifer Mapping and Management Plan of Tilakwada Taluka, Narmada District, Gujarat

2.1 Salient Information

Salient information about the Tilakwada taluka are given in below table 19.

Table 20- Salient information about Tilakwada Taluka.

SALIENT FEATURES OF TILAKWADA TALUKA		
1.	**GEOGRAPHICAL AREA (Sq km)**	244.41
2.	**NO. OF VILLAGES**	97
3.	**NO. OF MUNICIPALITY**	
4.	**POPULATION (as per census 2011)**	63871
4.1	**Male**	33197
4.2	**Female**	30674
5.	**AVERAGE RAINFALL (mm) (2007-16)**	895
6.	**MAJOR AND MINOR BANSIN**	Major: Narmada river , Minor: Heran, Ashwini and Men river
7.	**CROPPING PATTERN:**	
7.1	NET SOWN AREA (Ha)	28614
7.2	GROSS CROPPED AREA (Ha)	31486
7.3	CROPPING INTENSITY	110.04
7.4	AREA SOWN MORE THAN ONCE (Ha)	2872.43
8.	**IRRIGATION PATTERN :**	
8.1	NET IRRIGATED AREA (Ha)	13984
8.2	GROSS IRRIGATED AREA (Ha)	20163.8
9.	**MAJOR CROPS:**	Paddy, Wheat, Jowar, bajra, Maize, Mung, Udid, Tur, Groundnut, Cotton, Castor, Sesamum and Soyabean

2.2 Location

Tilakwada is a taluka in Narmada district, Gujarat, India. This taluka is bounded by , Chhota Udaipur district from North east direction, by Vadodara district from north west, by Nandod taluka from SW and by Garudeshwar taluka from SE (fig 39). Taluka is well connected with state and NH highway.

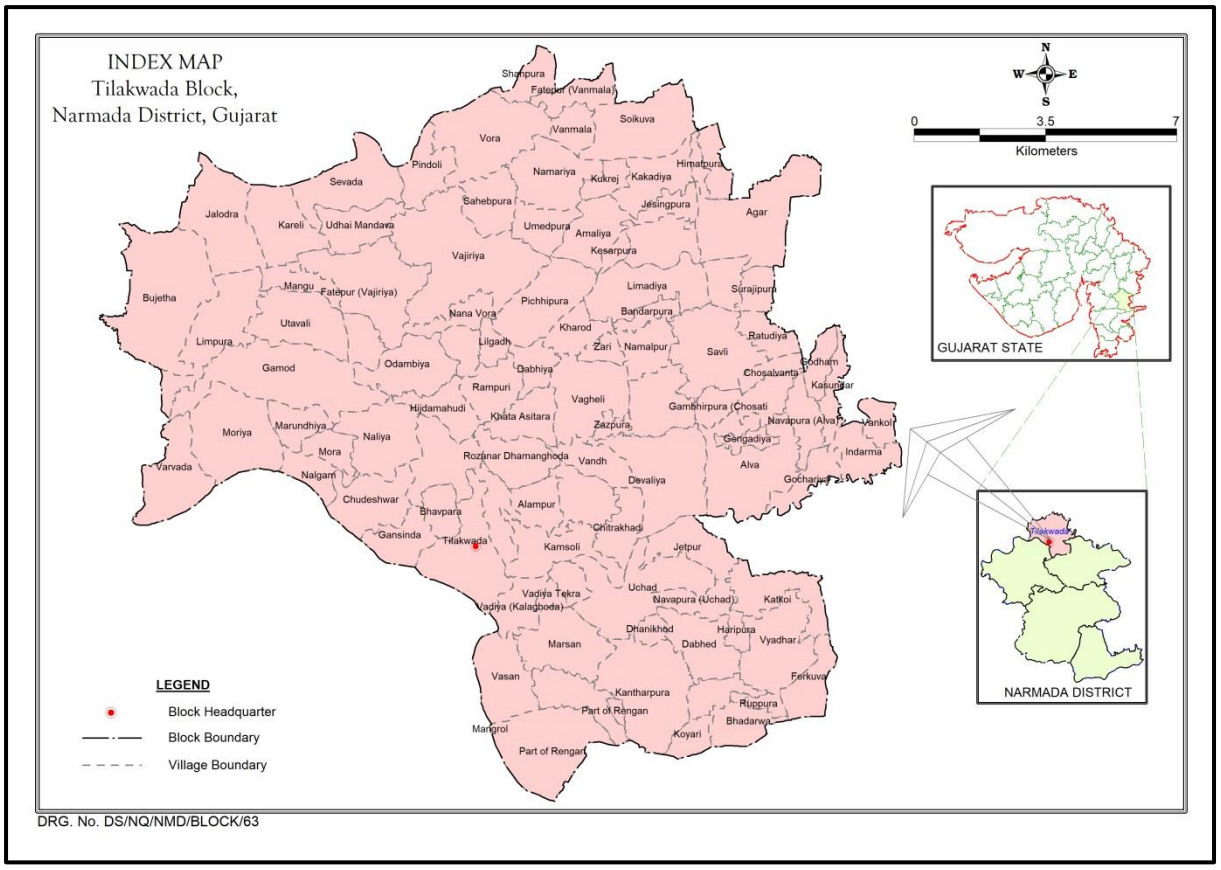


Figure 39- Administrative map of Tilakwada taluka.

2.3 Water Level Behaviour

Depth to water level map for pre and post-monsson -2019 of Tilakwada taluka are presented in fig (40.) and (41) respectively. For pre monsoon period it is observed that depth to water level ranges from 2 m bgl to more than 40m bgl. fig (40). Whereas in post monsoon period it is varies in between 0 m bgl to more than 20 m bgl. fig.(41).

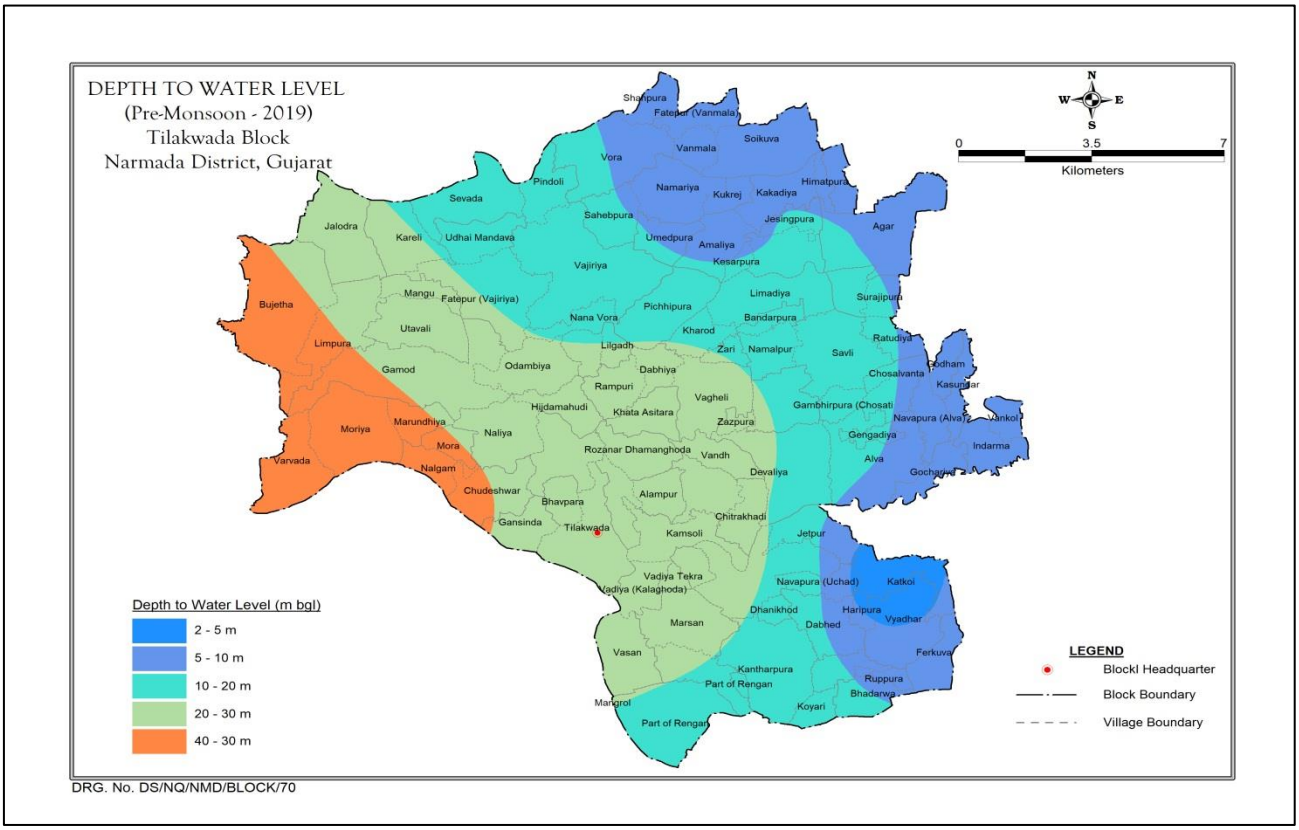


Figure 40- Pre monsoon depth to water level map

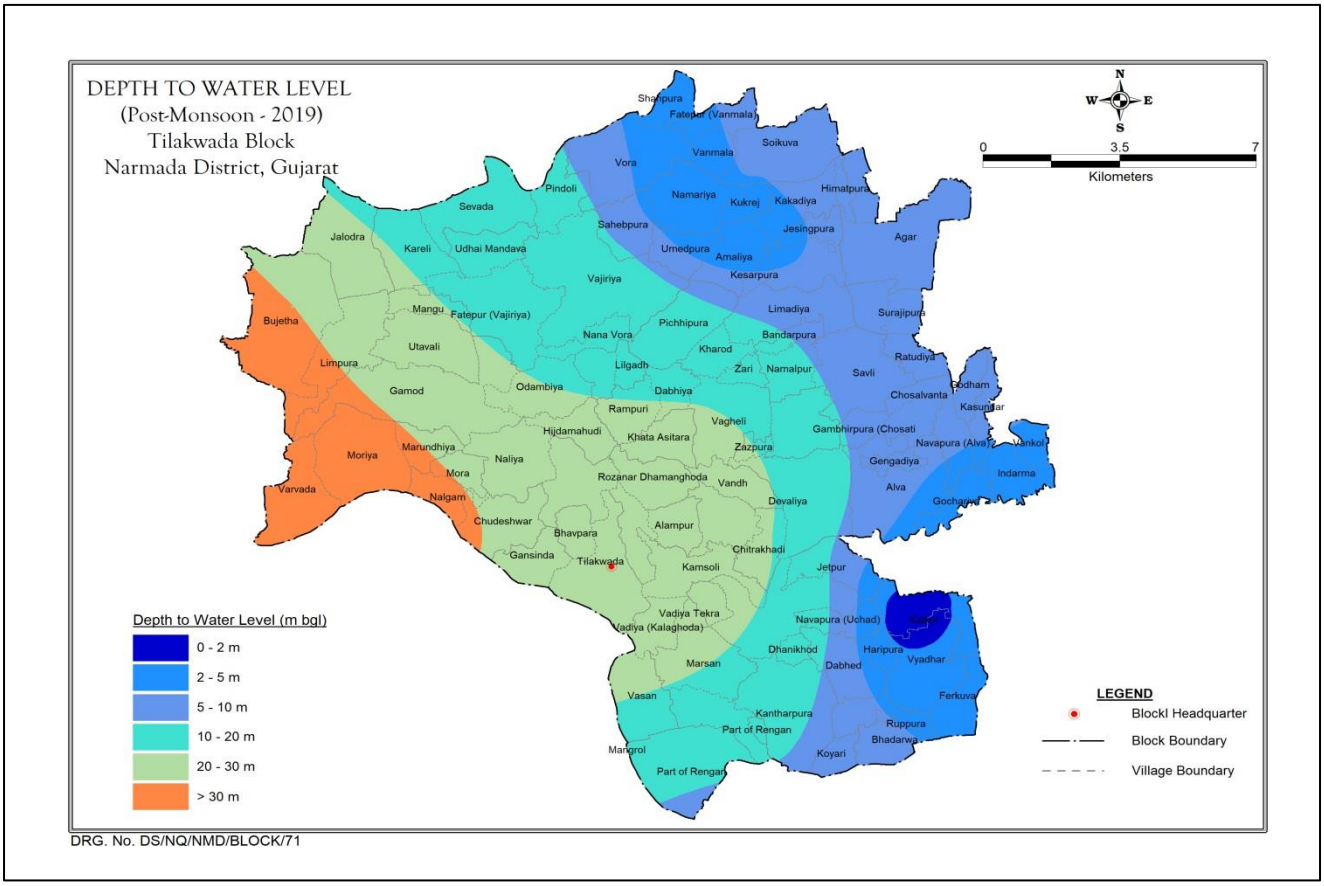


Figure 41- Post monsoon depth to water level map

2.4 Aquifer Dispositon

Most part of the taluka is covered by Quaternary alluvium comprising Alluvium with sand, silt, clay, cobble and Pebble dominated and localized shale of upper Paleozoic to Cenozoic age encountered. Groundwater occurs under unconfined to confined conditions. Phreatic zone form the thickness of 12m to 24m in quaternary alluvium, aquifer characteristics are presented in table -21.

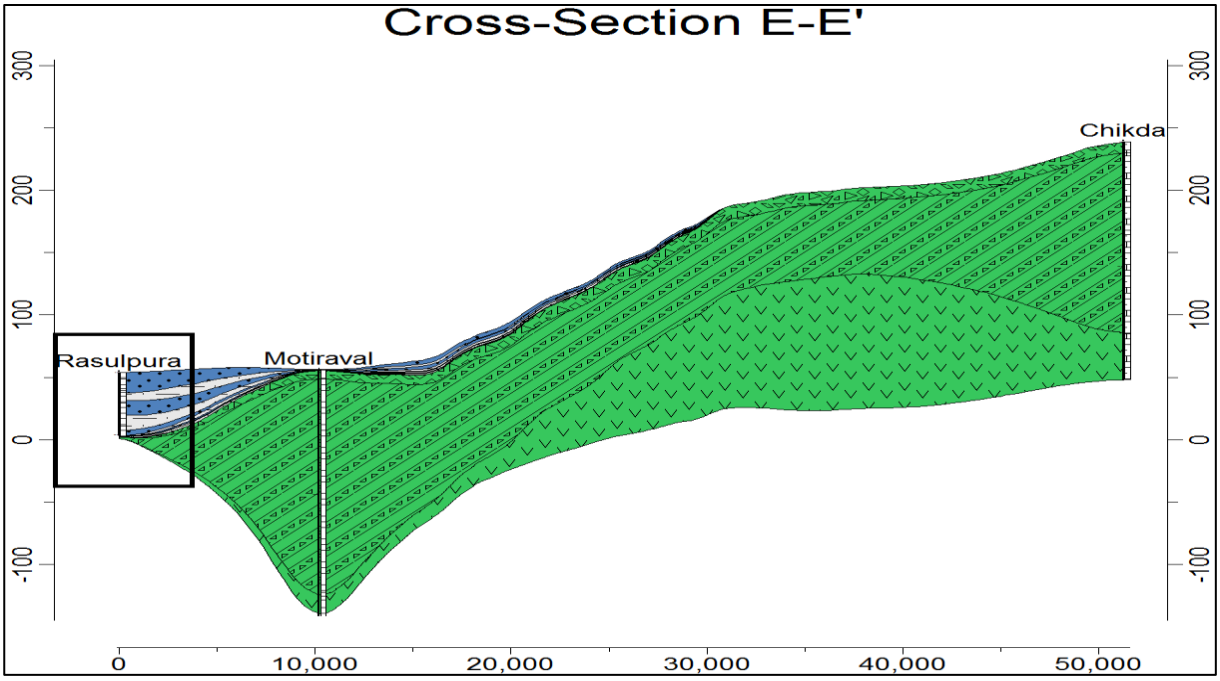


Figure 43- Cross section E-E' of site Rasulpura fall in Tilakwada taluka.

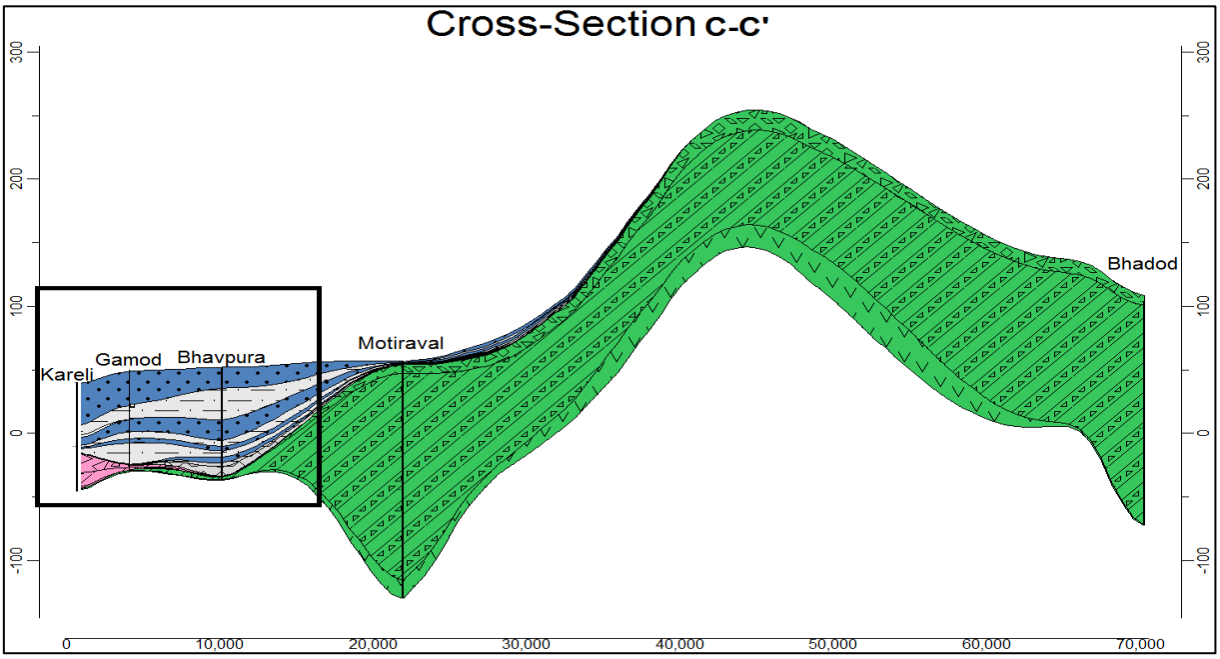


Figure 42- Cross section C-C' of site Kareli, Gamod, Bhavpura fall inTilakwada taluka

Table 21- Aquifer Characteristic details

Stratigraphy	Aquifer Nomenclature	Lithological Characteristics	Depth of occurrence Aquifer (mbgl)	Thickness Range (m)	Water Level (mbgl) Range (mbgl)	Quality (TDS) Range Mg/l	Discharge Range lps	Transmissivity Range m2/day	Nature of Aquifer	Remarks
Quatenary	Alluvium [AL]	Younger Alluvium with sand, silt, clay, cobble and Pebble dominated [AL03]	0 to 24	12 to 24	5 to 10	500 to 600			Phreatic	Good Quality
			40 to 54		2 to 16	300 to 2000	1 to 4	35.83 to 1000	Confined	Good Quality
Upper Palaeozoic to Cenozoic	Shale [SH]	Shale with Limestone and Sandstone of Bagh Formation [SH03]	0 to 20	15 to 20	5 to 14	400 to 1500			Phreatic	Good Quality

2.5 Ground water resource

As per GWRE 2017, Stage of ground water development of taluka is 15.73 % and fall is safe category. Total Resources Dynamic and instorage (Fresh**) is** 25397.60 ham. Tabulated form of ground water resources, availability, utilization and stage of ground water development is presented in table 22.

Table 22- ground water resources, availability, utilization and stage of ground water development of Tilakwada taluka

ANNUAL REPLENISHABLE GROUND WATER RESOURCE (mcm)					Natural Discharge during non-monsoon season (mcm) (5 % of 7)	Net Annual Ground Water Availability (mcm) (7- 8)	ANNUAL GROUND WATER DRAFT (mcm)			Projected Demand for Domestic and Industrial uses upto 2025 (mcm)	Ground Water Availability for future irrigation (mcm) {(9)-(10+13)}	Stage of Ground Water Development (%) (12/9) * 100	Category
Monsoon		Non Monsoon		Total Annual Ground Water Recharge (3+4+5+6)			Irrigation	Domestic And Industrial uses	Total (10 + 11)				
Recharge from rainfall	Recharge from other sources	Recharge from rainfall	Recharge from other sources										
3	4	5	6	7	8	9	10	11	12	13	14	15	16
14.89	5.36	0.00	6.36	26.62	1.33	25.29	2.93	1.05	3.98	1.18	21.18	15.73	Safe

2.6 Hydrochemistry

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 2019, and presented in Table 23.

Table 23- Chemical quality in details

Constituents	Minimum
pH	7.35
EC (uS/cm)	1349
TDS (mg/l)	904
CO_3 (mg/l)	0
HCO_3 (mg/l)	415
Cl (mg/l)	121
NO_3 (mg/l)	58
SO_4 (mg/l)	112
F (mg/l)	0.75
Alkalinity (mg/l)	340.4
Ca (mg/l)	48
Mg (mg/l)	107
TH (mg/l)	560
Na (mg/l)	51
K (mg/l)	1.0

2.7 Ground Water Management

2.7.1 Groundwater Management Issues

- Tilakwada taluka of the district comes under "SAFE" category as per GWRE-2017.
- Low Ground water Development: The Stage of Groundwater Development of the district is 15.73 %. Groundwater quality is fresh in the shallow as well as deeper aquifers.
- The water quality in general is good. However Nitrate concentration is observed in isolated pockets

2.7.2 Groundwater Management Strategies

- Groundwater management plan is prepared with an aim to enhance the groundwater usage for creation of additional irrigation potential for the district for uplifting the economic condition of the farmers.
- To elevate the stage of ground water development to 50% in the taluka, 90 nos. Dug wells (15 m depth) and 580 nos of Tubewell (100m depth) in Hard rock are proposed as feasible extraction structures.
- The extraction structures will result in expected annual ground water draft of 915 ham which will create 1830 Ha of additional irrigation potential in the district.

2.7.3 Groundwater Management Plan

2.7.3.1 Supply Side Management

- As per Master Plan 2020, surplus surface water of 459.04 mcm is already available in the district for artificial recharge check dam, Percolation tank and existing defunct tube wells which can be used as injection well in Narmada district.

- Expected annual Groundwater recharge is 123.35 ham from recommended total 52 nos of check dam of 5.1 ham capacity/each, total 16 nos. of Percolation tank of 13.5 ham/each and 04 nos. of already existed defunct tubewell are recommended for harvesting the part of available runoff and to recharge the Groundwater.

Table 24- Details of artificial recharge and conservation structure in Tilakwada taluka.

Block	Check Dams of 17000 cum Capacity (Nos)	Percolation Tank (~ 90000 m3 capacity)	Recharge through defunct Tubewell(Capacity @ 3 ham)	On farm Acti-vities (Area in ha)	Farm Pond (Per Farm Pond Storage 0.576 m3 considered as per DIP.) Nos.	Feasible Extraction structures to elevate the Stage of GW development to 50% (Hard Rock)			Project Cost (Crore)
						TW	DW	Total	
Tilakwada	52	16	4	0		580	90	670	16.72

2.7.3.2 Demand Side Management

- Feasible extraction structures are proposed to elevate the stage of ground water development to 50%, to avoid further exploitation demand side management is also recommended.

Table 25- Pojected stage of ground water development after intervention.

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 Supplemental irrigation (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 measures & Recharge measures (in %)	Projected stage of GW development after construction of extraction structures & implementation of conservation & Recharge measures (in %)	Additional Irrigation Potential Created (Ha)
Tilakwada	2528.72	123.35	91.50	2743.57	397.66	74.84	0.00	915.00	1237.82	15.73	50	50	45	1830

3. Aquifer Mapping and Management Plan of Garudeshwar Taluka, Narmada District, Gujarat

3.1 Salient Information

Salient information about the Garudeshwar taluka are given in below table 26 .

Table 26- Salient information about Garudeshwar Taluka.

SALIENT FEATURES OF GARUDESHWAR TALUKA		
1.	GEOGRAPHICAL AREA (Sq km)	244.41
2.	NO. OF VILLAGES	97
3.	NO. OF MUNICIPALITY	
6.	MAJOR AND MINOR BANSIN	Major: Narmada river , Minor: Amroli river

3.2 Location

Garudeshwar is a taluka in Narmada district, Gujarat, India. This taluka is bounded by Chhota Udaipur district from Norht and east side, by Dediapada, Nandod and Tilakwada taluka from south, west and NNW side respectively (fig 44). Taluka is well connected with state and NH highway.

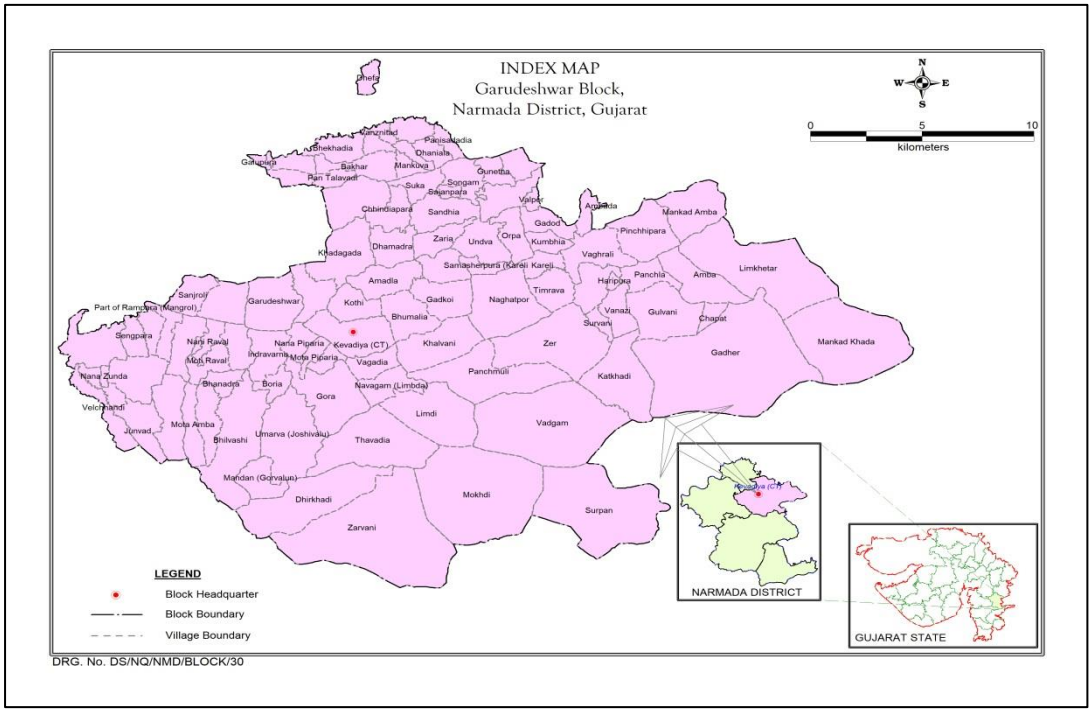


Figure 44- Administrative map of Garudeshwar taluka.

3.3 Water Level Behaviour

Depth to water level map for pre and post-monsson -2019 of Garudeshwar taluka are presented in fig (45.) and (46) respectively. In most part of the taluka depth to water level ranges from 5m bgl to 10m bgl and 10mbgl to 20m bgl. Whereas in post monsoon period most part of the taluka depth to water level is varies in between 2m bgl to5m bgl and 5m bgl to 10m bgl.

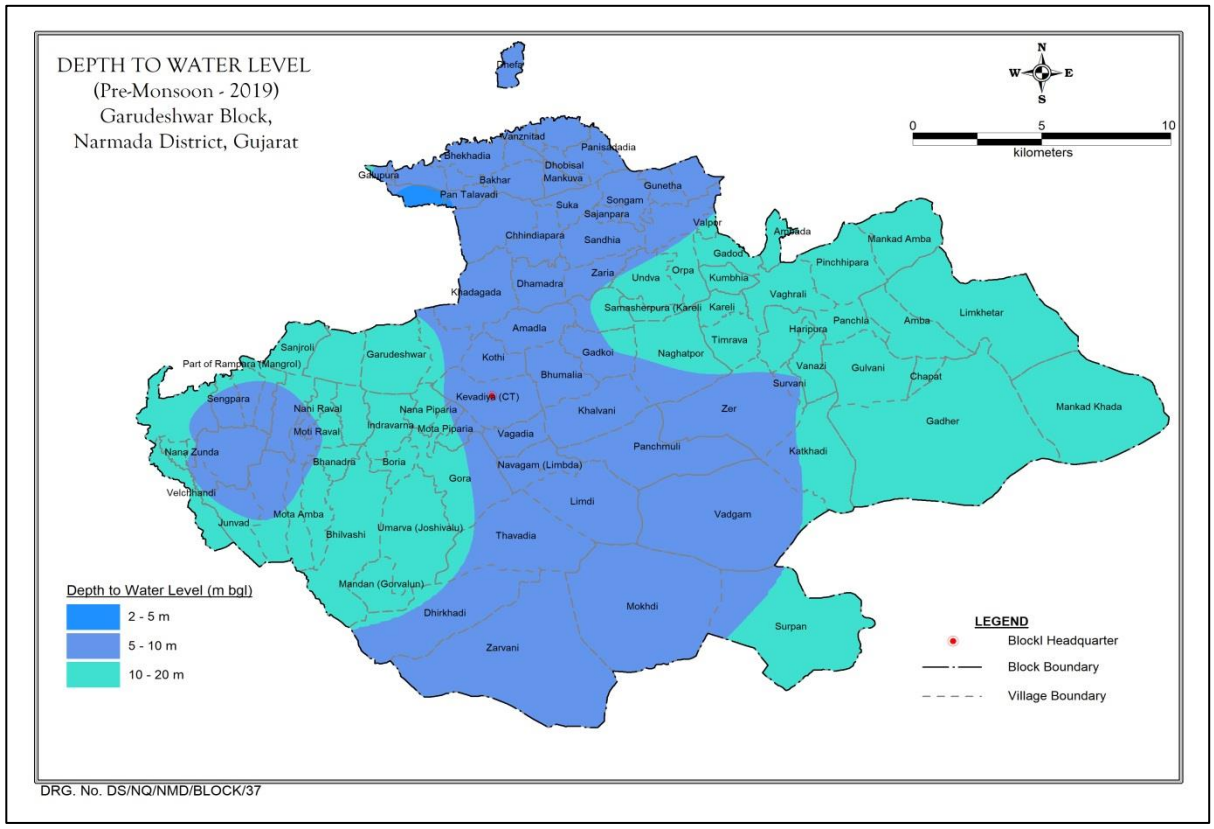


Figure 45- Pre monsoon depth to water level map

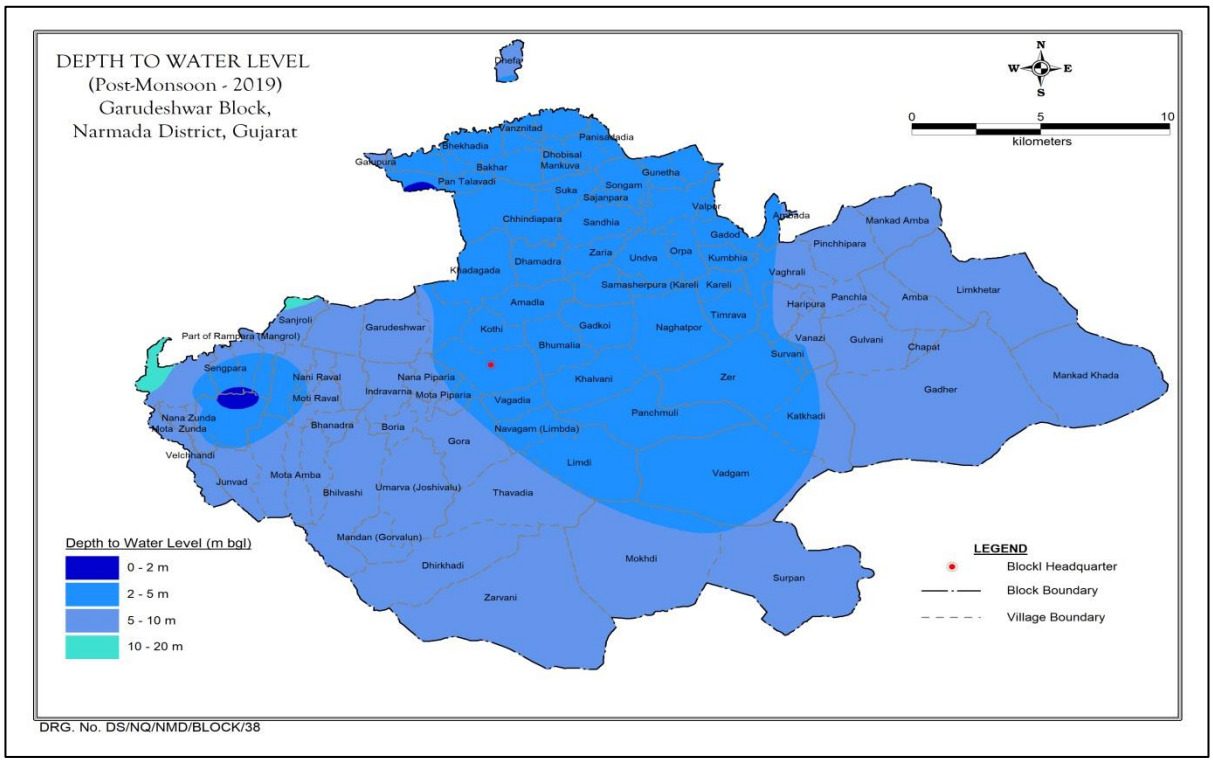


Figure 46- Post monsoon depth to water level map

3.4 Aquifer Dispositon

Most part of the taluka is covered by basaltic rocks of the Cretaceous age. Groundwater occurs under unconfined to semi confined conditions. Phreatic zone form the thickness of 0 m to 18 m. and un confined aquifer thickness varies from 3 m to 33m.and discharge varies from 9.5 lps to 23.91 lps, apart from occurrence of water in the pore spaces between sand grains, the principal joints, fissures and other planes of structural weakness play an important role in the movement of groundwater.

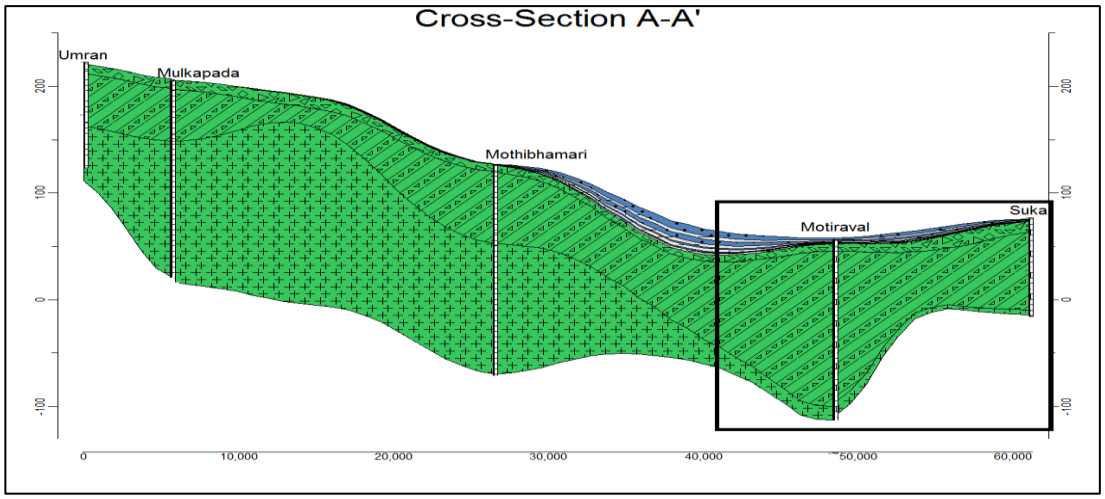


Figure 47- Cross section C-C' of site Kareli, Gamod, Bhavpura fall in Garudeshwar taluka

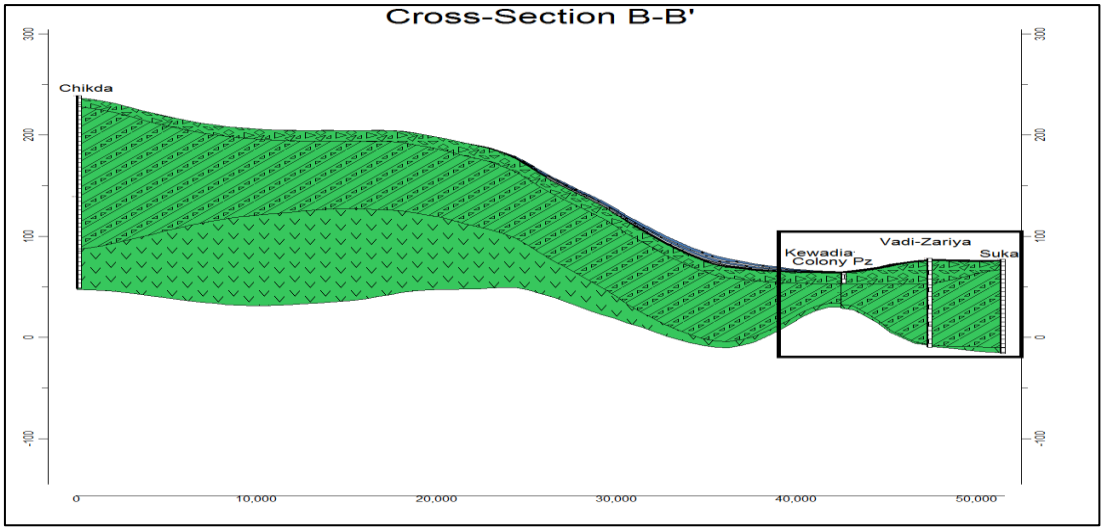


Figure 48- Cross section C-C' of site Kareli, Gamod, Bhavpura fall in Garudeshwar taluka

3.5 Ground water resource

As per GWRE 2017, Stage of ground water development of taluka is 19.99 % and fall is safe category. Tabulated form of ground water resources, availability, utilization and stage of ground water development is presented in table 27.

Table 27- ground water resources, availability, utilization and stage of ground water development of Tilakwada taluka

Sr. No.	Taluka	ANNUAL REPLENISHABLE GROUND WATER RESOURCE (mcm)					Natural Discharge during non-monsoon season (mcm) (5 % of 7)	Net Annual Ground Water Availability (mcm) (7- 8)	ANNUAL GROUND WATER DRAFT (mcm)			Projected Demand for Domestic and Industrial uses upto 2025 (mcm)	Ground Water Availability for future irrigation (mcm) {(9)-(10+13)}	Stage of Ground Water Development (%) (12/9) * 100	Category
		Monsoon		Non Monsoon		Total Annual Ground Water Recharge (3+4+5+6			Irrigation	Domestic And Industrial uses	Total (10 + 11)				
		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
3	Garudes	1.68	11.92	0.00	25.31	38.91	1.95	36.96	5.90	1.49	7.39	1.68	30.47	19.99	Safe

3.6 Hydrochemistry

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 2019, and presented in Table-27.

Table 28- Chemical quality in details

Constituents	Minimum	Maximum	Average
pH	7.23	7.55	7.39
EC (uS/cm)	750	1030	890
TDS (mg/l)	503	690	596.5
CO_3 (mg/l)	0	0	0
HCO_3 (mg/l)	305	378	341.5
Cl (mg/l)	50	71	60.5
NO_3 (mg/l)	52	70	61
SO_4 (mg/l)	12	48	30
F (mg/l)	0.36	0.68	0.52
Alkalinity (mg/l)	250.2	310	280.1
Ca (mg/l)	56	60	58
Mg (mg/l)	36	61	48.5
TH (mg/l)	290	400	345
Na (mg/l)	38	52	45
K (mg/l)	1.1	2.3	1.7

3.7 Ground Water Management

3.7.1 Groundwater Management Issues

- Garudeshwar taluka of the district comes under "SAFE" category as per GWRE-2017.
- Low Ground water Development: The Stage of Groundwater Development of the district is 19.99 %. Groundwater quality is fresh in the shallow as well as deeper aquifers.
- The water quality in general is good. However Nitrate concentration is observed in isolated pockets

3.7.2 Groundwater Management Strategies

- Groundwater management plan is prepared with an aim to enhance the groundwater usage for creation of additional irrigation potential for the district for uplifting the economic condition of the farmers.
- To elevate the stage of ground water development to 50% in all taluka, 240 nos. Dug wells (15 m depth) and 700 nos of Tubewell (100m depth) in Hard rock are proposed as feasible extraction structures.
- The extraction structures will result in expected annual ground water draft of 1170 ham which will create 2340 Ha of additional irrigation potential in the district.

3.7.3 Groundwater Management Plan

3.7.3.1 Supply Side Management

- As per Master Plan 2020, surplus surface water of 459.04 mcm is already available in the district for artificial recharge check dam, Percolation tank and existing defunct tube wells which can be used as injection well in Narmada district.

- Expected annual Groundwater recharge is 1105.9 ham from recommended total 75 nos of check dam of 5.1 ham capacity/each, total 25 nos. of Percolation tank of 13.5 ham/each and 05 nos. of already existed defunct tubewell are reccommended for harvesting the part of available runoff and to recharge the Groundwater.

Table 29- Details of artificial recharge and conservation structure in Garudeshwar taluka.

Block	Check Dams of 17000 cum Capacity (Nos)	Percolation Tank (~ 90000 m3 capacity)	Recharge through defunct Tubewell(Capacity @ 3 ham)	On farm Acti-vities (Area in ha)	Farm Pond (Per Farm Pond Storage 0.576 m3 considered as per DIP.)	Feasible Extraction structures to elevate the Stage of GW development to 50% (Hard Rock)			Project Cost (Crore)
					Nos.	TW	DW	Total	
Garudeshwar	75	25	5	0		700	240	940	25.6

3.7.3.2 Demand Side Management

Feasible extraction structures are proposed to elevate the stage of ground water development to 50%, to avoid further exploitation demand side management is also recommended.

Table 30- Pojected stage of ground water development after intervention.

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 Supplemental irrigation (ham)	Conservation of Ground water through WUE, on farm activity & farm ponds	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 & Recharge measures (in %)	Projected stage of GW development after construction of extraction structures & implementation of conservation & Recharge measures (in %)	Additional Irrigation Potential Created (Ha)
Garudeshwar	3696.40	187.99	117.00	4001.39	739.09	107.33	0.00	1170.00	1801.76	19.99	50	50	45	2340

4. Aquifer Mapping and Management Plan of Nandod Taluka, Narmada District, Gujarat

4.1 Salient Information

Salient information about the Nandod taluka are given in below table 31.

Table 31- Salient information about Nandod Taluka.

SALIENT FEATURES OF NANDOD TALUKA		
1.	**GEOGRAPHICAL AREA (Sq km)**	778.97
2.	**NO. OF VILLAGES**	203
3.	**NO. OF MUNICIPALITY**	1
4.	**POPULATION (as per census 2011)**	150258
4.1	**Male**	124560
4.2	**Female**	116493
5.	**AVERAGE RAINFALL (mm) (2007-16)**	971
6.	**MAJOR AND MINOR BANSIN**	Major: Narmada river , Minor: Karjan river
7.	**CROPPING PATTERN:**	
7.1	NET SOWN AREA (Ha)	46490
7.2	GROSS CROPPED AREA (Ha)	51157
7.3	CROPPING INTENSITY	110.04
7.4	AREA SOWN MORE THAN ONCE (Ha)	4667
8.	**IRRIGATION PATTERN :**	
8.1	NET IRRIGATED AREA (Ha)	22428
8.2	GROSS IRRIGATED AREA (Ha)	41719.6
9.	**MAJOR CROPS:**	Paddy, Wheat, Jowar, bajra, Maize, Mung, Udid, Tur, Groundnut, Cotton, Castor, Sesamum and Soyabean

4.2 Location

Nandod is a taluka in Narmada district, Gujarat, India. This taluka is bounded by Vadodara district from Norbt west direction, by Bharuch district from south west, by Tilakwada taluka from NE and by Garudeshwar taluka from Eastern and from south by Dediapada taluka (fig 49). Taluka is well connected with state and NH highway.

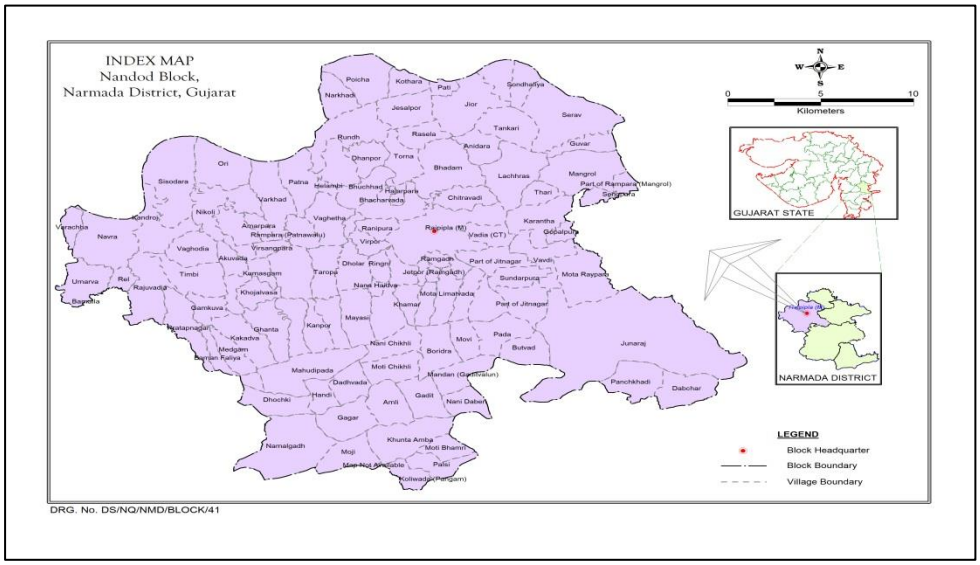


Figure 49- Administrative map of Nandod taluka.

4.3 Water Level Behaviour

Depth to water level map for pre and post-monsson -2019 of Tilakwada taluka are presented in fig (50.) and (51) respectively. For pre monsoon period it is observed that depth to water level ranges from 2 m bgl to more than 40m bgl. fig (50). Whereas in post monsoon period it is varies in between 0 m bgl to more than 20 m bgl. fig.(51).

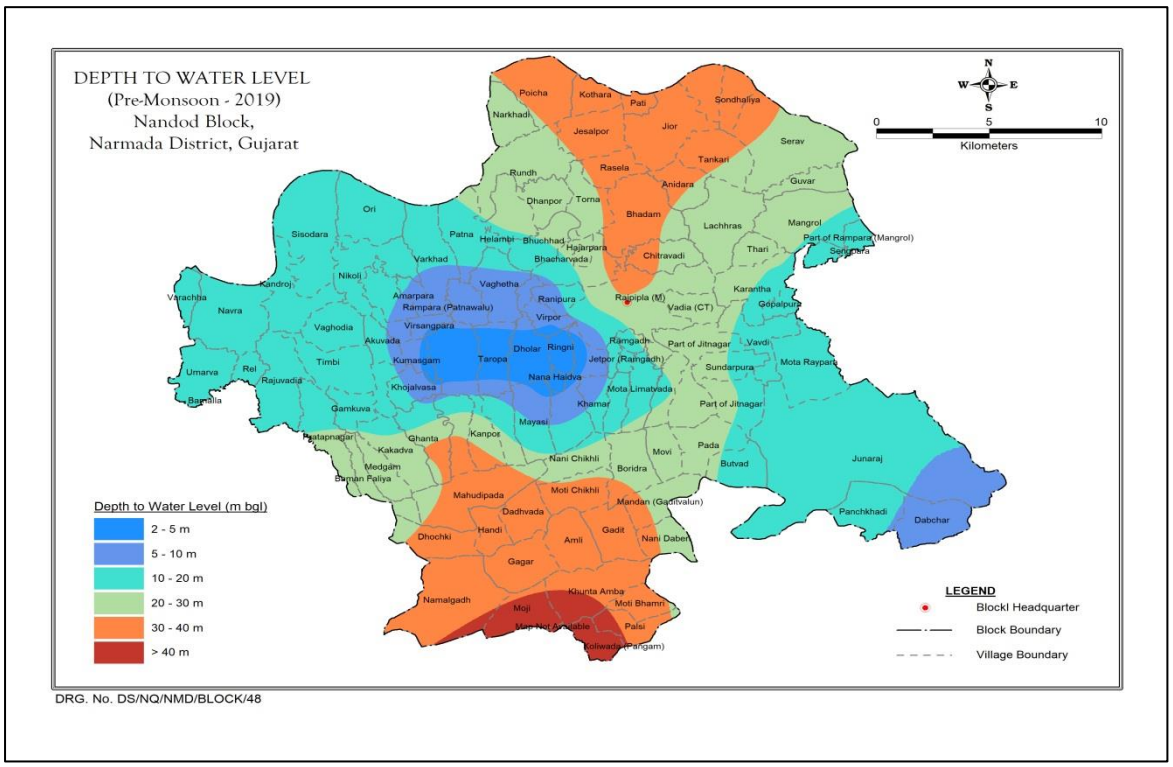


Figure 50- Pre monsoon depth to water level map

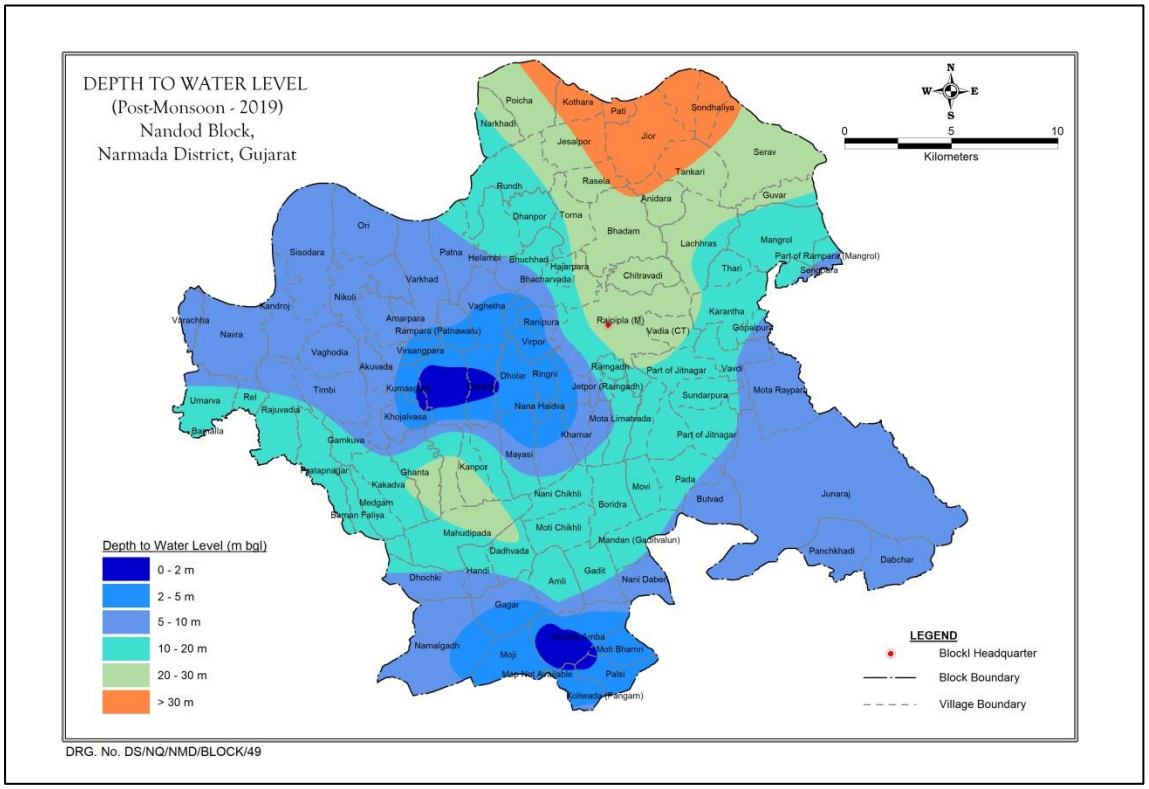


Figure 51- Post monsoon depth to water level map

4.4 Aquifer Dispositon

Most part of the taluka is covered by basaltic rocks of the Cretaceous age. Groundwater occurs under unconfined to semi confined conditions. Phreatic zone form the thickness of 4.2 m to 27 m. and Semi confined aquifer thickness varies from 6 m to 139m.and discharge varies from 0.15 lps to 26 lps., apart from occurrence of water in the pore spaces between sand grains, the principal joints, fissures and other planes of structural weakness play an important role in the movement of groundwater.

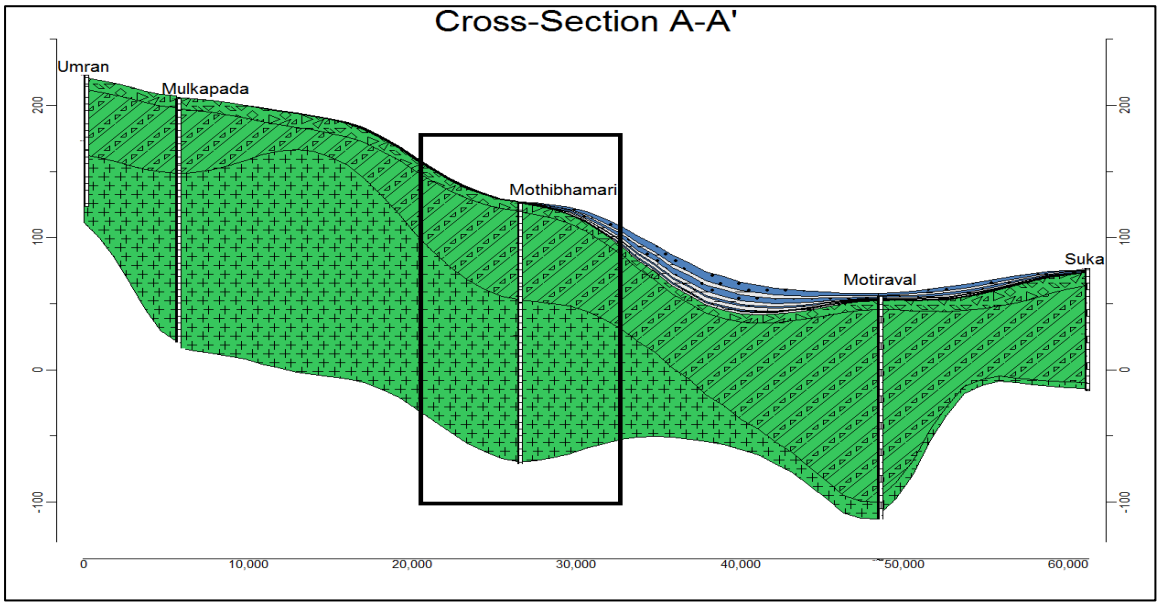


Figure 53- Cross section E-E' of site Rasulpura fall in Tilakwada taluka.

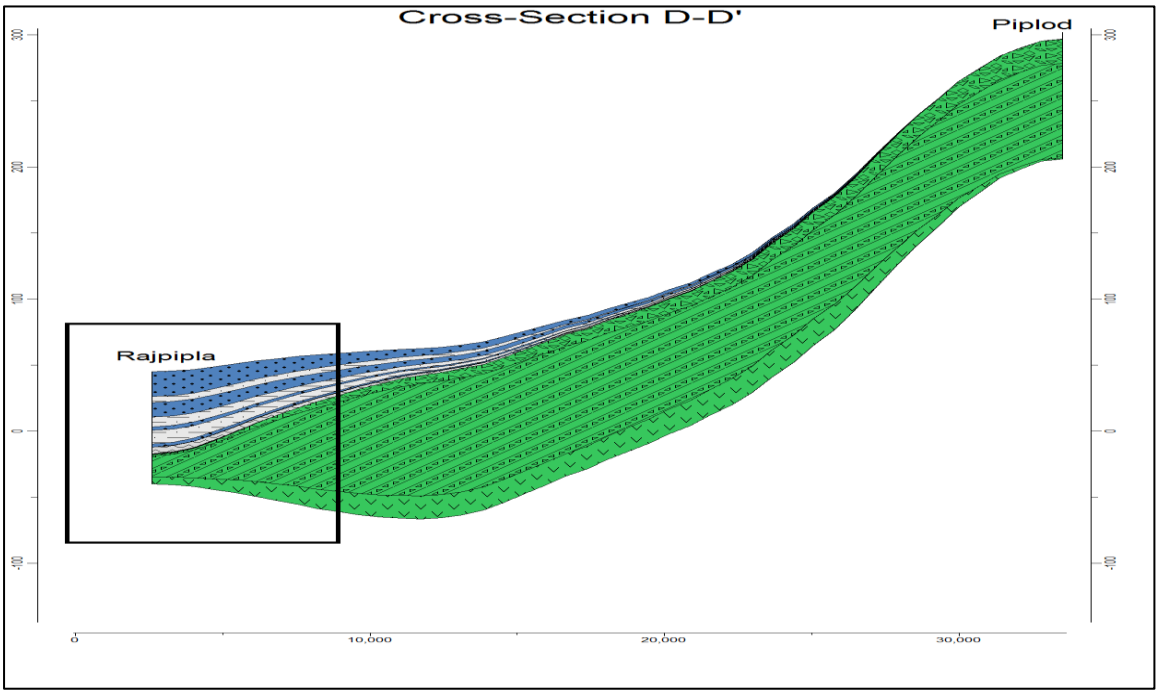


Figure 52- Cross section C-C' of site Kareli, Gamod, Bhavpura fall inTilakwada taluka

4.5 Ground water resource

As per GWRE 2017, Stage of ground water development of taluka is 26.25 % and fall is safe category. Total Resources Dynamic and instorage (Fresh**) is** 779.97 ham. Tabulated form of ground water resources, availability, utilization and stage of ground water development is presented in table 32.

Table 32- ground water resources, availability, utilization and stage of ground water development of Nandod taluka

ANNUAL REPLENISHABLE GROUND WATER RESOURCE (mcm)					**Natural Discharge during non-monsoon season (mcm) (5 % of 7)**	**Net Annual Ground Water Availability (mcm) (7- 8)**	**ANNUAL GROUND WATER DRAFT (mcm)**			**Projected Demand for Domestic and Industrial uses upto 2025 (mcm)**	**Ground Water Availability for future irrigation (mcm) {(9)-(10+13)}**	**Stage of Ground Water Development (%) (12/9) * 100**	**Category**
Monsoon		**Non Monsoon**		**Total Annual Ground Water Recharge (3+4+5+6)**			**Irrigation**	**Domestic And Industrial uses**	**Total (10+11)**				
Recharge from rainfall	**Recharge from other sources**	**Recharge from rainfall**	**Recharge from other sources**										
3	4	5	6	7	8	9	10	11	12	13	14	15	16
38.70	22.57	0.00	28.12	89.39	4.47	84.92	19.82	2.47	22.29	2.78	62.32	26.25	Safe

4.6 Hydrochemistry

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 2019, and presented in Table-33.

Table 33- Chemical quality details.

Constituents	Minimum	Maximum	Average
pH	6.94	7.66	7.36
EC (uS/cm)	468	3600	1320.17
TDS (mg/l)	314	2412	884.67
CO_3 (mg/l)	0	0	0.00
HCO_3 (mg/l)	171	1037	437.17
Cl (mg/l)	35	539	136.00
NO_3 (mg/l)	10	58	29.17
SO_4 (mg/l)	15	155	83.33
F (mg/l)	0.16	0.75	0.45
Alkalinity (mg/l)	140.3	850.5	358.57
Ca (mg/l)	40	76	54.33
Mg (mg/l)	26	185	78.00
TH (mg/l)	205	910	455.83
Na (mg/l)	14	410	93.83
K (mg/l)	0.1	3.1	0.87

4.7 Ground Water Management

4.7.1 Groundwater Management Issues

- Nandod talukas of the district comes under "SAFE" category as per GWRE-2017.
- Low Ground water Development: The Stage of Groundwater Development of the taluka is 26.32 % however, Groundwater quality is fresh in the shallow as well as deeper aquifers..
- The water quality in general is good. However Nitrate concentration is observed in isolated pockets

4.7.2 Groundwater Management Strategies

- The Stage of Groundwater Development of the district is 26.32 % .Groundwater management plan is prepared with an aim to enhance the groundwater usage for creation of additional irrigation potential for the district for uplifting the economic condition of the farmers
- To elevate the stage of ground water development to 50% in the taluka, 300 nos. Dug wells (15 m depth) and 1290 no's of Tubewell (100m depth) in Hard rock are proposed as feasible extraction structures.
- The extraction structures will result in expected annual ground water draft of 2085 ham which will create 4170 Ha of additional irrigation potential in the district.

4.7.3 Groundwater Management Plan

4.7.3.1 Supply Side Management

- As per Master Plan 2020, surplus surface water of 459.04 mcm is already available in the district for artificial recharge check dam, Percolation tank and existing defunct tube wells which can be used as injection well in the taluka.

- Expected annual Groundwater recharge is 535.98 ham from recommended total 100 nos of check dam of 5.1 ham capacity/each, total 80 nos. of Percolation tank of 13.5 ham/each and

12 nos. of already existed defunct tubewell are reccommended for harvesting the part of available runoff and to recharge the Groundwater

Table 34- Details of artificial recharge and conservation structure in Nandod taluka.

Block	Check Dams of 17000 cum Capacity (Nos)	Percolation Tank (~ 90000 m3 capacity)	Recharge through defunct Tubewell(Capacity @ 3 ham)	On farm Acti-vities (Area in ha)	Farm Pond (Per Farm Pond Storage 0.576 m3 considered as per DIP.) Nos.	Feasible Extraction structures to elevate the Stage of GW development to 50% (Hard Rock)		
						TW	DW	Total
Nandod	100	80	12	0		1290	300	1590

4.7.3.2 Demand Side Management

- Feasible extraction structures are proposed to elevate the stage of ground water development to 50%, to avoid further exploitation demand side management is also recommended.

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 Supplemental irrigation (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 measures & Recharge measures (in %)	Projected stage of GW development after construction of extraction structures & implementation of conservation & Recharge measures (in %)	Additional Irrigation Potential Created (Ha)
Nandod	8492.21	535.98	208.50	9236.69	2229.39	147.42	0.00	2085.00	4166.97	26.25	50	50	45	4170

5. Aquifer Mapping and Management Plan of Sagbara Taluka, Narmada District, Gujarat

5.1 Salient Information

Salient information about the Sagbara taluka are given in below table 35.

Table 35- Salient information about Sagbara Taluka.

SALIENT FEATURES OF SAGBARA TALUKA		
1.	**GEOGRAPHICAL AREA (Sq km)**	367.4
2.	**NO. OF VILLAGES**	96
3.	**NO. OF MUNICIPALITY**	
4.	**POPULATION (as per census 2011)**	110924
4.1	**Male**	55094
4.2	**Female**	55830
5.	**AVERAGE RAINFALL (mm) (2007-16)**	1125
6.	**MAJOR AND MINOR BANSIN**	Major: Tapi river, Minor: Narmada river
7.	**CROPPING PATTERN:**	
7.1	NET SOWN AREA (Ha)	17185
7.2	GROSS CROPPED AREA (Ha)	18910
7.3	CROPPING INTENSITY	110.04
7.4	AREA SOWN MORE THAN ONCE (Ha)	1725.14
8.	**IRRIGATION PATTERN :**	
8.1	NET IRRIGATED AREA (Ha)	2148
8.2	GROSS IRRIGATED AREA (Ha)	12879.5
9.	**MAJOR CROPS:**	Paddy, Wheat, Jowar, bajra, Maize, Mung, Udid, Tur, Groundnut, Cotton, Castor, Sesamum and Soyabean

5.2 Location

Sagbara is a taluka in Narmada district, Gujarat, India. This taluka is bounded by Surat district from north east direction, by Tapi district from southeast, by Dediapada taluka from north direction and by Maharastra state from west and north east direction (fig 54). Taluka is well connected with state and NH highway.

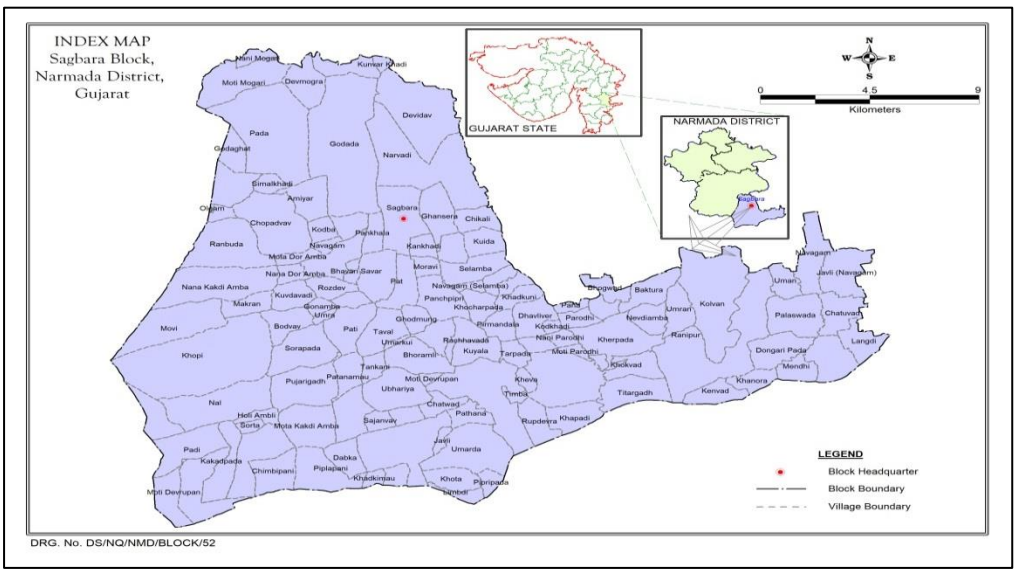


Figure 54- Administrative map of Tilakwada taluka.

5.3 Water Level Behaviour

Depth to water level map for pre and post-monsson -2019 of Sagbara taluka are presented in fig (55) and (56) respectively. For pre monsoon period it is observed that depth to water level ranges from 5 m bgl to 30m bgl. fig (55). Whereas in post monsoon period it is varies in between 0 m bgl to more than 20 m bgl. fig.(56).

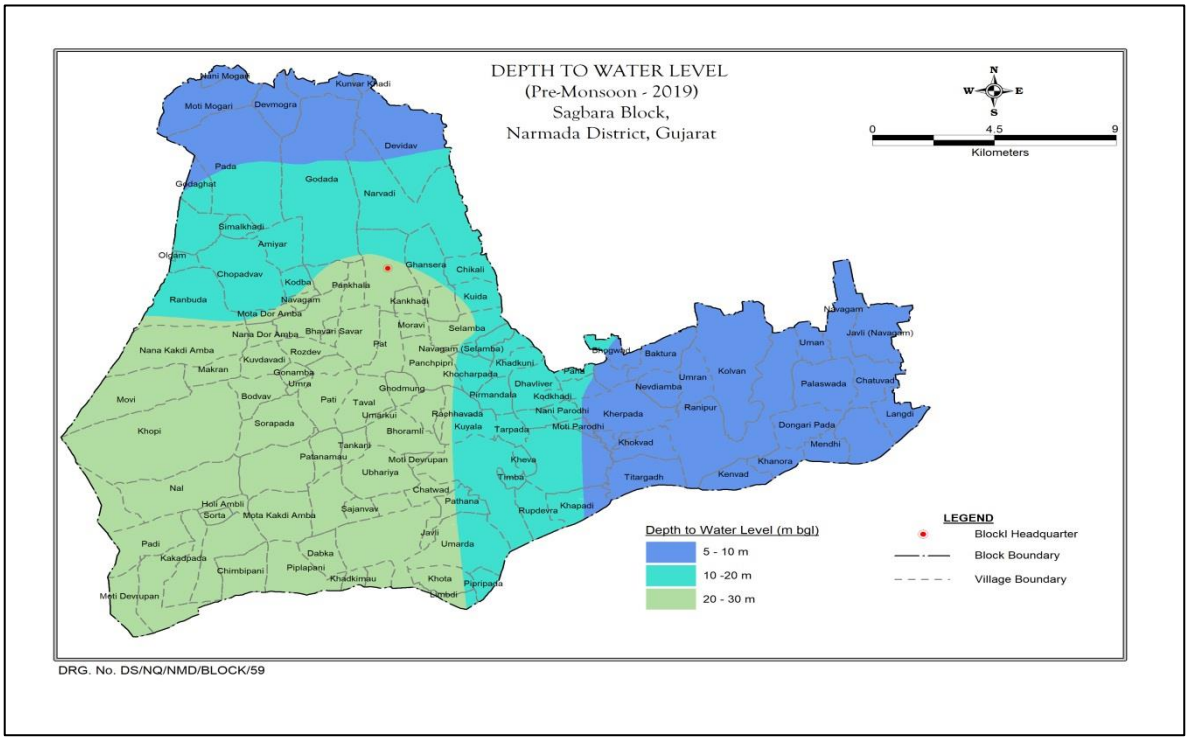


Figure 55- Pre monsoon depth to water level map

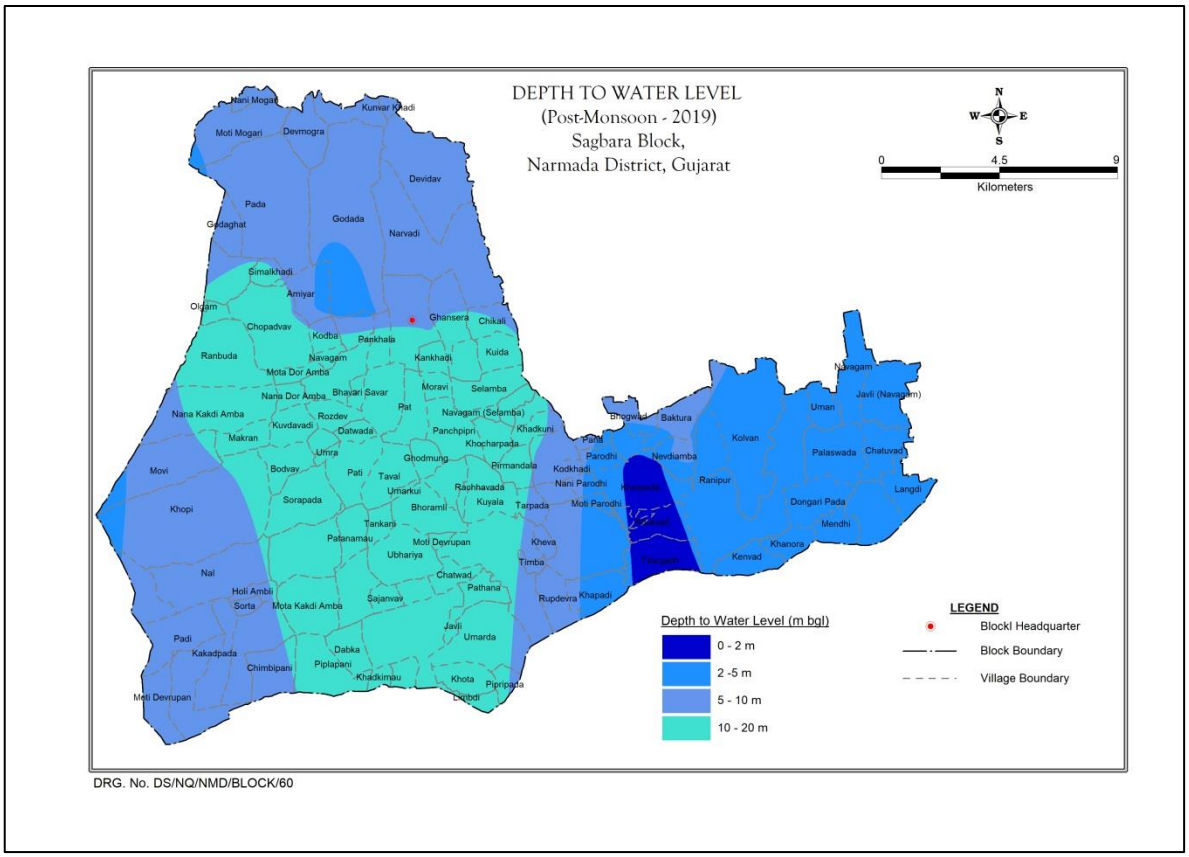


Figure 56- Post monsoon depth to water level map

5.4 Aquifer Dispositon

Most part of the taluka is covered by basaltic rocks of the Cretaceous age. Groundwater occurs under unconfined to semi confined conditions. Phreatic zone form the thickness of 0 m to 15.4m. and Semi confined aquifer thickness varies from 6 m to 139m.and discharge varies from 0.15 lps to 26 lps., occurrence of groundwater r in the pore spaces between sand grains, the principal joints, fissures and other planes of structural weakness play an important role in the movement of groundwater.

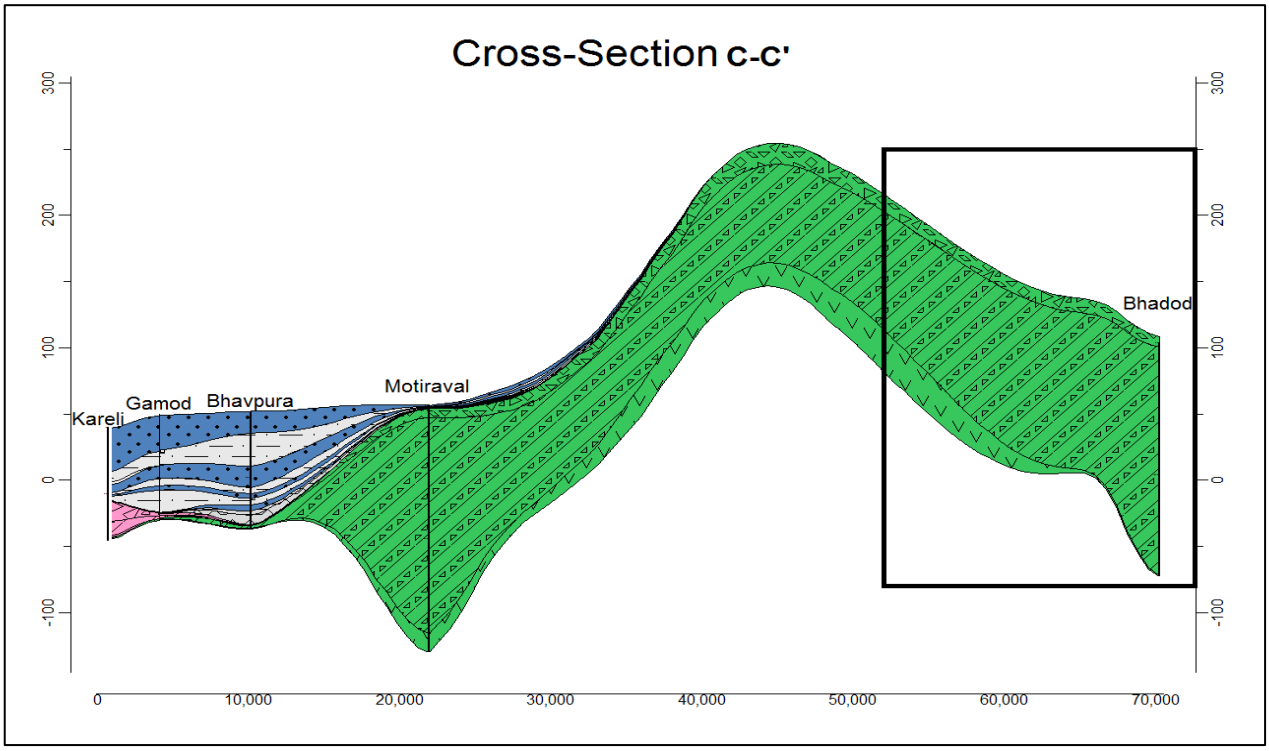


Figure 57- Cross section E-E' of site Rasulpura fall in Tilakwada taluka.

5.5 Ground water resource

As per GWRE 2017, Stage of ground water development of taluka is 14.54 % and fall is safe category. Total Resources Dynamic and instorage (Fresh**)** is 11841.57 ham. Tabulated form of ground water resources, availability, utilization and stage of ground water development is presented in table 36.

Table 36- ground water resources, availability, utilization and stage of ground water development of Tilakwada taluka

ANNUAL REPLENISHABLE GROUND WATER RESOURCE (mcm)					Natural Discharge during non-monsoon season (mcm) (5 % of 7)	Net Annual Ground Water Availability (mcm) (7- 8)	ANNUAL GROUND WATER DRAFT (mcm)			Projected Demand for Domestic and Industrial uses upto 2025 (mcm)	Ground Water Availability for future irrigation (mcm) {(9)-(10+13)}	Stage of Ground Water Development (%) (12/9) * 100	Category
Monsoon		Non Monsoon		Total Annual Ground Water Recharge (3+4+5+6			Irrigation	Domestic And Industrial uses	Total (10 + 11)				
Recharge from rainfall	Recharge from other sources	Recharge from rainfall	Recharge from other sources										
3	4	5	6	7	8	9	10	11	12	13	14	15	16
26.76	10.92	0.00	9.49	47.17	2.36	44.81	4.69	1.83	6.51	2.05	38.07	14.54	Safe

5.6 Hydrochemistry

The chemical quality of groundwater in shallow aquifer of the taluka has been analyzed based on the water samples collected during National Hydrographs Monitoring Stations (NHS) in May 2019, and presented in Table-37.

Table 37- Chemical quality details

Constituents	Minimum	Maximum	Average
pH	6.98	7.53	7.31
EC (uS/cm)	560	1011	735.50
TDS (mg/l)	375	677	492.75
CO_3 (mg/l)	0	0	0.00
HCO_3 (mg/l)	207	329	246.75
Cl (mg/l)	28	199	78.00
NO_3 (mg/l)	15	60	36.50
SO_4 (mg/l)	20	28	23.25
F (mg/l)	0.21	0.37	0.27
Alkalinity (mg/l)	169.8	269.8	202.38
Ca (mg/l)	56	104	74.00
Mg (mg/l)	12	34	25.50
TH (mg/l)	240	320	290.00
Na (mg/l)	14	87	35.00
K (mg/l)	0.1	0.5	0.25

5.7 Ground Water Management

5.7.1 Groundwater Management Issues

- Sagbara taluka of the district comes under "SAFE" category as per GWRE-2017.
- Low Ground water Development: The Stage of Groundwater Development of the Sagbara taluka is 14.54 %.. Groundwater quality is fresh in the shallow as well as deeper aquifers..
- The water quality in general is good

5.7.2 Groundwater Management Strategies

- Groundwater management plan is prepared with an aim to enhance the groundwater usage for creation of additional irrigation potential for the district for uplifting the economic condition of the farmers.
- To elevate the stage of ground water development to 50% in Sagbara taluka, 3000 nos. Dug wells (15 m depth) and 111 no's of Tubewell (100m depth) in Hard rock are proposed as feasible extraction structures.
- The extraction structures will result in expected annual ground water draft of 1666.50 ham which will create 3333 Ha of additional irrigation potential in the taluka.

5.7.3 Groundwater Management Plan

5.7.3.1 Supply Side Management

- As per Master Plan 2020, surplus surface water of 459.04 mcm is already available in the district for artificial recharge check dam, Percolation tank and existing defunct tube wells which can be used as injection well in Narmada district.

Table 38- Details of artificial recharge and conservation structure in Sagbara taluka.

Block	Check Dams of 17000 cum Capacity (Nos)	Percolation Tank (~ 90000 m3 capacity)	Recharge through defunct Tubewell(Capacity @ 3	On farm Acti-vities (Area in ha)	Farm Pond (Per Farm Pond Storage 0.576 m3 considered Nos.	Feasible Extraction structures to elevate the Stage of GW development to 50% (Hard Rock)			Project Cost (Crore)
						TW	DW	Total	
Sagbara	0	0	6	187	380	111	3000	3111	95.5

5.7.3.2 Demand Side Management

- Feasible extraction structures are proposed to elevate the stage of ground water development to 50%, to avoid further exploitation demand side management is also recommended.
- 187 Ha area is proposed for on farm activities (Laser levelling/Bench terracing/Contour banding) and 380 no of farm ponds are recommended which will serve dual purpose of irrigation and recharge to ground water.

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 Supplemental irrigation (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 measures & Recharge measures (in %)	Projected stage of GW development after construction of extraction structures & implementation of conservation & Recharge measures (in %)	Additional Irrigation Potential Created (Ha)
Sagbara	4480.92	21.10	166.65	4668.67	651.43	4.86	195.40	1666.50	2117.67	14.54	50	46	45	3333

List of Annexures

Annexure I- Chemical quality data of NHS 2019.

Location	Taluka	pH	EC	TDS	HCO3	Cl	NO3	S04	F	Alkalinity	Ca	Mg	TH	Na	K
Almavadi	Dediapada	7.26	1034	693	268	121	127	22	0.22	219.8	84	58	450	29	0.60
Amayar	Sagbara	7.41	646	433	244	35	60	23	0.21	200.1	60	34	290	14	0.30
Chikada	Dediapada	7.26	841	563	244	106	66	16	0.22	200.1	64	39	320	46	0.80
Chuli	Dediapada	7.12	990	663	220	99	141	58	0.12	180.4	124	32	440	24	0.40
Dev Mogra	Sagbara	6.98	725	486	329	28	34	22	0.22	269.8	76	32	320	19	0.10
Garudeshwar	Nandod	7.23	1030	690	378	71	70	48	0.36	310	60	61	400	52	2.3
Hirapura	Nandod	7.55	750	503	305	50	52	12	0.68	250.2	56	36	290	38	1.1
Jankh	Dediapada	7.41	605	405	256	35	24	21	0.46	210	72	22	270	14	0.3
Kanbi Pitha	Dediapada	7.14	587	393	281	14	27	18	0.28	230.5	56	29	260	15	0.1
Khaidi Pada	Dediapada	7.18	544	364	232	43	16	10	0.31	190.3	56	19	220	23	0.2
Khota Amba	Nandod	6.94	925	620	415	35	21	55	0.36	340.4	58	62	400	30	0.3
Namaria	Tilakwada	7.35	1349	904	415	121	58	112	0.75	340.4	48	107	560	51	1.0
Nani Singlot	Dediapada	7.51	674	452	171	43	28	108	0.45	140.3	76	27	300	16	0.3
Ralda	Dediapada	7.66	468	314	195	35	10	15	0.53	159.9	40	26	205	14	0.1
Rasela	Nandod	7.42	3600	2412	1037	539	41	155	0.16	850.5	60	185	910	410	3.1
Ringani	Nandod	7.29	905	606	390	43	17	55	0.46	319.9	44	61	360	42	0.4
Salemba 1	Sagbara	7.31	1011	677	207	199	37	20	0.37	169.8	104	12	310	87	0.5
Umaran	Sagbara	7.53	560	375	207	50	15	28	0.27	169.8	56	24	240	20	0.1

Annexure II- Ground Water quality of well inventory' established well in Narmada district.

S.No	Location	Taluka	Source of sample	pH	EC	TDS	HCO3	Cl	NO3	S04	F	Alkalinity	Ca	Mg	TH	Na	K
1	Vadia	Nandod	DW	7.61	906	607	427	57	34	14	0.31	350	52	36.48	280	88.22	1.14
2	Nani Chikhli	Nandod	DW	6.93	654	438	122	21	168	48	0.5	100	68	24.32	270	23.5	5.08
3	Gajargota	Dediapada	TW	7.66	556	373	171	43	48	26	0.41	140	64	19.456	240	18.99	0.09
4	Mota Suka Amba	Dediapada	DW	7.6	515	345	195	43	18	28	0.29	160	60	19.456	230	20	0.45
5	Chuli	Dediapada	DW	7.7	688	461	293	64	8.9	32	0.37	240	88	21.888	310	23.93	1.25
6	Khaidipada	Dediapada	DW	8.3	615	412	183	50	8.9	40	0.17	190	76	21.888	280	20	1.39
7	Kundi Amba	Dediapada	DW	7.89	590	395	220	64	24	23	0.12	180	60	29.184	270	17.53	0.35
8	Olgam	Sagbhara	DW	7.88	596	399	293	43	1.8	14	0.39	240	76	19.456	270	22.12	0.66
9	Mediasag	Sagbhara	DW	7.92	468	314	281	21	0.8	7.5	0.22	230	60	19.456	230	17.3	0.39
10	Ukravar	Sagbhara	DW	7.66	327	219	159	14	4.5	23	0.16	130	40	12.16	150	8.85	1.12
11	Zarwani	Garudeshwar	DW	7.57	491	329	305	21	8.1	12	0.36	250	68	19.456	250	16.5	2.17
12	Bhumaliya	Garudeshwar	DW	7.59	484	324	329	21	1.1	7.7	0.75	270	64	21.888	250	23.46	0.9
13	Suka	Garudeshwar	DW	7.77	529	354	329	28	2.7	10	0.73	270	68	21.888	260	26.83	1.19
14	Dhavadi	Garudeshwar	DW	7.77	492	330	329	28	8.9	6.7	0.62	270	80	12.16	250	22.64	0.92
15	Jetpor	Tilakwada	TW	8.19	1390	931	915	21	23	22	1.39	750	36	48.64	290	262.75	0.78
16	Fatepur	Tilakwada	DW	7.75	1951	1307	903	312	7.7	26	0.38	740	40	75.392	410	273.75	0.99
17	Gavar		DW	7.78	817	547	451	57	31	16	0.14	370	56	41.344	310	81.46	1.37
18	Bhadam	Nandod	DW	8	648	434	366	43	12	13	0.21	300	60	41.344	320	41.61	0.52
19	Pratapnagar	Nandod	DW	7.9	633	424	390	36	6.5	19	0.34	320	44	51.072	320	41.91	2.07
20	Akuvada	Nandod	DW	7.7	897	601	427	71	41	37	0.36	350	64	60.8	410	55.11	0.24
21	Borda	Dediapada	DW	7.72	2089	1400	793	327	11	84	0.42	650	240	126.464	1120	61	8.45
22	Patalamau	Sagbara	DW	7.91	465	312	244	85	11	10	0.49	200	60	17.024	220	21.83	0.27
23	Nal	Sagbara	DW	7.35	691	463	171	71	75	45	0.28	140	88	17.024	290	28.77	30
24	Navagam	Sagbara	DW	7.7	1101	738	317	156	79	26	0.43	260	96	55.936	470	54.17	0.71
26	Nikoli	Nandod	DW	8.03	978	655	549	78	3.7	21	0.38	450	92	46.208	420	70.16	5.28
27	Bal	Dediapada	DW	7.95	382	256	207	21	20	6.7	0.32	170	56	9.728	180	11.74	1.12

28	Piplod	Dediapada	DW	7.88	578	387	329	50	13	25	0.46	270	76	19.456	270	34.52	1.62
30	Kanji	Dediapada	DW	7.95	499	334	256	36	20	15	0.21	210	76	17.024	260	14.19	7.42
31	Kokati	Dediapada	DW	7.91	355	238	207	14	11	8.1	0.16	170	56	19.456	220	13.07	1.18
32	Sagai	Dediapada	DW	8.01	534	358	232	36	38	8.2	0.32	190	60	43.776	330	19.35	0.91
33	Gadh	Dediapada	DW	8.05	466	312	293	21	5.8	15	0.27	240	56	31.616	270	18.04	0.82
34	Boridra	Nandod	DW	7.94	609	408	366	28	10	15	0.41	300	68	41.344	340	26.11	1.42
35	Poicha	Nandod	DW	7.96	820	549	586	36	19	11	0.42	480	72	46.208	370	90.82	7.97
36	Umran	Dediapada	DW	7.86	391	262	146	28	3.8	25	0.21	120	44	19.456	190	22.82	0.17

Annexure III- NHS well monitoring data (Post Monsoon) 2019.

District	Govt. Agency	Site Name	LAT	LONG	Water Level	RL (m amsl)	Water Table
Narmada	CGWB	Agar(Rep)_Pz	22.031	73.657	6.35	63	56.65
Narmada	CGWB	Almadi	21.609	73.511	0.78	167	166.22
Narmada	CGWB	Amayar	21.547	73.767	2.3	205	202.7
Narmada	CGWB	Baman Phalia_Pz	21.798	73.379	11.18	87	75.82
Narmada	CGWB	Chikada	21.521	73.646	1.45	223	221.55
Narmada	CGWB	Chuli	21.555	73.476	2.76	181	178.24
Narmada	CGWB	Garudeshwar	21.892	73.65	8.18	45	36.82
Narmada	CGWB	Hirapura	21.868	73.6	1.5	70	68.5
Narmada	CGWB	Jankh	21.492	73.597	3.3	210	206.7
Narmada	CGWB	Kanbi pitha	21.521	73.646	3.71	292	288.29
Narmada	CGWB	Kewadia_Pz	21.883	73.701	2.53	61	58.47
Narmada	CGWB	Khaidipada	21.514	73.519	0.14	198	197.86
Narmada	CGWB	Khota amba	21.733	73.475	1.09	140	138.91
Narmada	CGWB	Namaria	22.044	73.622	2.05	60	57.95
Narmada	CGWB	Nani singlot	21.669	73.667	7.65	194	186.35
Narmada	CGWB	Rajpipla	21.875	73.5	24.95	59	34.05
Narmada	CGWB	Ralda	21.61	73.653	1.79	233	231.21
Narmada	CGWB	Rasulpura_Pz	21.967	73.625	22.22	53	30.78
Narmada	CGWB	Ringani	21.842	73.467	2.22	72	69.78
Narmada	CGWB	Selemba 1	21.61	73.763	7.5	137	129.5
Narmada	CGWB	Umran	21.488	73.883	1.03	232	230.97
Narmada	SGWD-Gujarat	Dumkhal	21.7325	73.8406	6.7	144	137.26
Narmada	SGWD-Gujarat	Namgir	21.7272	73.7033	7	230	223
Narmada	SGWD-Gujarat	Kanbudi	21.6192	73.6583	5.8	180	174.2

Narmada	SGWD-Gujarat	Gangpur	21.5803	73.6828	2.1	203.1	201.03
Narmada	SGWD-Gujarat	Chuli	21.5744	73.5164	6.8	143.1	136.31
Narmada	SGWD-Gujarat	Motisingloti	21.6753	73.6678	5.75	202.6	196.87
Narmada	SGWD-Gujarat	Fulsar	21.71	73.58	6.3	205	198.7
Narmada	SGWD-Gujarat	Patvali	21.6825	73.7361	6.67	212	205.29
Narmada	SGWD-Gujarat	Kharchipada	21.5667	73.4903	9.6	160	150.4
Narmada	SGWD-Gujarat	Babda	21.5294	73.5383	11.2	150	138.8
Narmada	SGWD-Gujarat	Kundi Amba	21.5425	73.6236	11.7	136	124.3
Narmada	SGWD-Gujarat	Solia	21.66	73.49	13.3	170	156.7
Narmada	SGWD-Gujarat	Dediapada	21.635	73.5967	5.3	204.8	199.52
Narmada	SGWD-Gujarat	Nana zunda	21.8653	73.5853	6.6	68.7	62.09
Narmada	SGWD-Gujarat	Chhindiapura	21.9422	73.7039	4.2	91.3	87.09
Narmada	SGWD-Gujarat	Bhumalia	21.8894	73.7228	3.1	105.3	102.2
Narmada	SGWD-Gujarat	Vaviala	21.9419	73.6878	2.4	85	82.6
Narmada	SGWD-Gujarat	Navapara	21.8817	73.3872	7.6	51.5	43.91
Narmada	SGWD-Gujarat	Indravarna	21.8622	73.6528	9.1	57.5	48.42
Narmada	SGWD-Gujarat	Survani	21.8844	73.8031	4.3	99.1	94.84
Narmada	SGWD-Gujarat	Gulvani	21.8961	73.8275	7.9	131.2	123.27
Narmada	SGWD-Gujarat	Naghatpor	21.9	73.75	2.5	65	62.5
Narmada	SGWD-Gujarat	Nana haidwa	21.83	73.4628	2.55	68.2	65.6
Narmada	SGWD-Gujarat	Amletha	21.8378	73.4172	1.16	67.6	66.43
Narmada	SGWD-Gujarat	Jiyor	21.9594	73.5142	35.7	47	11.27
Narmada	SGWD-Gujarat	Pratapnagar	21.8761	73.4214	5.7	61.7	55.96
Narmada	SGWD-Gujarat	Virpur	21.8661	73.46	3.02	59	56.02
Narmada	SGWD-Gujarat	Rajpipla	21.8714	73.5061	27.7	51.1	23.43
Narmada	SGWD-Gujarat	Thari	21.8947	73.5519	18.28	54.1	35.84

Narmada	SGWD-Gujarat	Dhanpur	21.92	73.46	16.8	72.2	55.4
Narmada	SGWD-Gujarat	Navapura	21.8817	73.3872	10.4	51.5	41.11
Narmada	SGWD-Gujarat	Jitgadh	21.8244	73.5314	11.4	75	63.6
Narmada	SGWD-Gujarat	Ghanta	21.7994	73.4181	24.97	68.2	43.19
Narmada	SGWD-Gujarat	Amli	21.7622	73.4697	17.9	90	72.1
Narmada	SGWD-Gujarat	Sagbara	21.5386	73.7983	9.4	213.4	203.95
Narmada	SGWD-Gujarat	Nevdi Amba	21.4917	73.8933	5.1	110.3	105.2
Narmada	SGWD-Gujarat	Chopadvav	21.54	73.74	12.9	150.6	137.7
Narmada	SGWD-Gujarat	Kankhadi	21.5283	73.8033	18.3	140.3	122
Narmada	SGWD-Gujarat	Nal	21.4531	73.7111	7.05	179.6	172.57
Narmada	SGWD-Gujarat	Agar	22.0378	73.6617	7.3	80.3	73
Narmada	SGWD-Gujarat	Soikuva	22.0569	73.6353	5.8	85.3	79.5
Narmada	SGWD-Gujarat	Katkoi	21.9444	73.6661	1.47	80.6	79.13
Narmada	SGWD-Gujarat	Namaria	22.0453	73.6119	2.9	58.3	55.41
Narmada	SGWD-Gujarat	Vajeria	22.0319	73.5814	14.4	49.2	34.78

Annexure IV- Decadal water level trend (2009-18)

SITE_NAME	DISTRICT_NAME	SITE_TYPE	DEPTH	LOCAL_GEOLOGY	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Trends	MAX	MIN	Count	Average 2009_18
Chikada	Narmada	Dug Well	6.45	Basalt	2	3.28	4.03	1.48	3.34	3.85	5.42	3.05	2.85	4.67	-0.17242	5.42	1.48	10	3.40
Kanbi pitha	Narmada	Dug Well	6.2	Basalt	1.13	1.16	2.81	1.45	1.4	1.24	2.44	1.39		1.47	-0.01394	2.81	1.13	9	1.61
Amayar	Narmada	Dug Well	10	Basalt	2.91	2.93	3.41	1.61	3.12	3.21	9.25	9.25		3.25	-0.47211	9.25	1.61	9	4.33
Selemba	Narmada	Dug Well	13	Basalt	8.86		10.6	4.51		6.34	6.44				0.549561	10.6	4.51	5	7.35
Dediapada	Narmada	Dug Well	8.68	Basalt	5.41	5.58	7.98	7.98	8.68				2.66		0.33475	8.68	2.66	6	6.38
Nani singlot	Narmada	Dug Well	10.4	Basalt	7.6	7.12	8.3	6.44	4.61	4.18	7.83	7.8	7.72	8.05	-0.05752	8.3	4.18	10	6.97
Khota amba	Narmada	Dug Well	4.52	Basalt	1.05	1.11	2.46	0.99	1.17	1.04	1.07	1.34	1.12	1.22	0.023576	2.46	0.99	10	1.26
Baman Phalia_Pz	Narmada	Bore Well	43	Basalt	17.85	16	14.69	19.32	12.56	15.4	19.4	19.32	15.9	15.41	-0.02164	19.4	12.56	10	16.59
Sunderpura_Pz	Narmada	Bore Well	50	Basalt	27.44	27.22	26.3	27.84	27.6	27.77				30.21	-0.33574	30.21	26.3	7	27.77
Ringani	Narmada	Dug Well	14.55	Basalt	2.19	1.71	1.7	1.55	2.15	1.51	1.6	1.6	1.6	2.87	-0.02642	2.87	1.51	10	1.85
Hirapura	Narmada	Dug Well	14.25	Alluvium	5.35	3.16	2.04	6.46	1.74	3.42	4.46	7.35	3.04	6.94	-0.21636	7.35	1.74	10	4.40
Kewadia_Pz	Narmada	Bore Well	19.8	Basalt	4.45	3.19	2.69	4.02	2.27	2.5	4.26	3.55	2.95	4.4	-0.01891	4.45	2.27	10	3.43
Garudeshwar	Narmada	Dug Well	18.71	Basalt	10.38	4.17	9.31	9.31	9.08	9.72	10.95	10.46	9.65	10.96	-0.33267	10.96	4.17	10	9.40
Rasela	Narmada	Dug Well	19.3	Alluvium	8.91	12.3		17.5	19.3	10	17.5	17.5		16.32	-0.69372	19.3	8.91	8	14.92
Agar(Rep)_Pz	Narmada	Bore Well	44.2	Sandstone	10.95	10.11	2.98	3.27	7.1	0.81	11.22	11.32	10.85	12.24	-0.46091	12.24	0.81	10	8.09
Namaria	Narmada	Dug Well	19.55	Alluvium	3.72	3.06	2.06	2.04	4.01	1.41	4.13	4.56	3	4.21	-0.12218	4.56	1.41	10	3.22

Annexure V- Exploratory details in Narmada district.

S.No.	*VILLAGE*	*TALUKA*	*DISTRICT*	*XLONG*	*YLAT*	WELL_TYPE	*YEAR_CONS*	*GEOLOGY*	*DEPTH_DR*	*DEPTH_CONS*	*PYT_Disch(lps)*	*PYT_SWL(mbgl)*	*PYT_RDD*	*PYT_T*
1	Rasela	Nandod	Narmada	73.49167	21.9208333	EW	1972-1976	Alluvium	92.05	75.6	330	5.5		148.8
2	Nawa Rajuwadia	Nandod	Narmada	73.34583	21.8416667	EW	1972-1976	Alluvium	381.61	227.5	578	9.633		50.88
3	Bhavpura	Tilakwada	Narmada	73.58833	21.9666667	EW	1985-1986	Alluvium	93.43	83.5	1020	17		
4	Bhavpura	Tilakwada	Narmada	73.58833	21.9636111	OW-1	1985-1986	Alluvium	81.1	80.07	0	0		
5	Bhavpura	Tilakwada	Narmada	73.58833	21.9636111	OW-2	1985-1986	Alluvium	80.43	80	0	0		
6	Kareli	Tilakwada	Narmada	73.54833	22.0422222	EW	1985-1986	Alluvium	86.24	84	1779	29.65		586
7	Gamod	Tilakwada	Narmada	73.55139	22.0422222	EW	1986-1987	Alluvium	70.83	64	2994	49.9		219.4
8	Gamod	Tilakwada	Narmada	73.55139	22.0422222	OW	1986-1987	Alluvium	70	65	0	0		
9	Rasulpura (I & II)	Tilakwada	Narmada	73.625	21.9666667	EW	1986-1987	Alluvium	90	90	120	2		1.67
10	Agar	Tilakwada	Narmada	73.5875	22.0319444	EW	1986-1987	Alluvium	89	0	300	5		11.63
13	Ninghat	Dediapada	Narmada	73.55722	21.6141667	EW	2006 -00	Basalt	202.70	202.70	0.83	7.62	66.61	
14	Selemba	Sagbara	Narmada	73.82139	21.5183333	EW	2006 -00	Basalt	126.40	126.40	15	10.09	9.31	
15	Chikda	Dediapada	Narmada	70.89694	21.5075	EW	2006 -00	Basalt	152.30	152.30	12.32	7.87	5.83	
16	Moti Singloti	Dediapada	Narmada	73.68139	21.67	EW	2006 -00	Basalt	202.70	202.70	0.3	9.01	_	
17	Gagar	Nandod	Narmada	73.44778	21.7452778	EW	2006 -00	Basalt	105.10	105.10	15	15.01	10.35	
18	Sunderpura	Nandod	Narmada	73.53472	21.8388889	EW	2006 -00	Alluvium/Basalt	45.1	45.1	9	28.83	0.16	
19	Selemba	Sagbara	Narmada	73.82139	21.5183333	OW	2006 -00	Basalt	126.40	126.40	13	11.54	22.16	

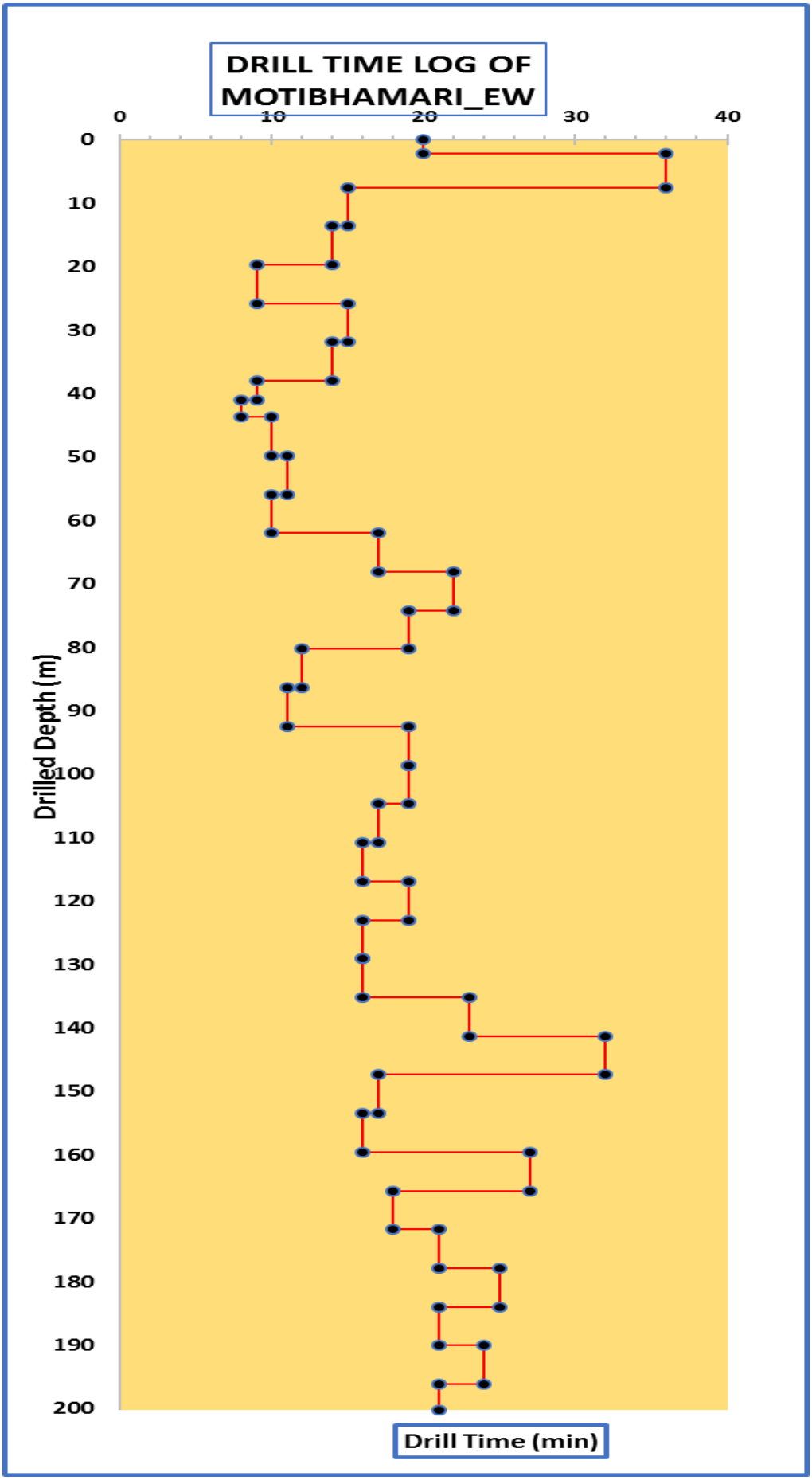
20	Chikda	Dediapada	Narmada	70.89694	21.5075	OW	2006 -00	Basalt	190.50	190.50	4	7.84	49.4	
21	Gagar	Nandod	Narmada	73.44778	21.7452778	OW	2006 -00	Basalt	105.1	105.1	17.54	15.11	12.15	
22	Wadi	Nandod	Narmada	73.73417	#VALUE!	EW	2007-2008	Fractured Basalt	87.8	87.8	22.20	12.50	11.63 (1st min)	
23	Bamanphalia	Nandod	Narmada	73.37917	21.7983333	Pz	2007-2008	Weathered Basalt	43	43	2.24	18.15	0.15 (1st min of recovery)	
24	Kewadia Colony	Nandod	Narmada	73.70056	21.8827778	Pz	2007-2008	Weathered/ Fractured Basalt	19.8	19.8	9.5	2.32	0.69 (2nd min of recovery)	
25	Sunderpura	Nandod	Narmada	73.53472	21.8388889	Pz	2007-2008	Boulders	50	50	2.23	29.64	0.29 (1.30th min of recovery)	
26	Agar	Tilakwada	Narmada	73.65667	22.0311111	Pz	2007-2008	Sandstone	44.2	32	0.17	9.9	7.17 (3rd min of recovery)	
27	Motiraval	Garudeshwar	Narmada	21.8749	73.638873	EW	2018-19	Basalt	200	200	2.05	14.45	31.6(30th mn)	26.06
28	Umran	Dediapada	Narmada	21.49138	73.5461797	EW	2018-19	Basalt	99.3	99.3	17.14	10.42	2.33(3rd min)	62.74
29	Umran	Dediapada	Narmada	21.49138	73.5461797	OW	2018-19	Basalt	99.3	99.3	17.34	10.34	0.21cm(1st min)	57.23
30	Mulkapada	Dediapada	Narmada	21.54132	73.553279	EW	2018-19	Basalt	200	200	9.2	22.28	17.97 (14th min)	6.83
31	Mulkapada	Dediapada	Narmada	21.54151	73.5532703	OW	2018-19	Basalt	141.5	141.5	11.3	21.51	21.32(2nd min)	10.89
32	Sauka	Garudeshwar	Narmada	21.479566	73.841704	EW	2019-20	Basalt	92.9	92.9	7.01	17.6	12.26 (Ist min)	49.08
32	Suka	Garudeshwar	Narmada	21.479566	73.841704	OW	2019-20	Basalt	92.9	92.9	5.51	23.91	11.16 (Ist Min)	67.76

33	Bhadod	Sagbara	Narmada	21.47957	73.841704	EW	2018-19	Basalt	188	188	26.01	23.83	12.39(4th min)	46.26
34	Bhadod	Sagbara	Narmada	21.47957	73.841704	OW	2018-19	Basalt	189.8	189.8	25.25	27.22	9.1(3RD MIN)	44.16
35	Moti Bhamari	Nandod	Narmada	21.723034	73.504274	EW	2019-20	Basalt	200.2	200.2	54	1.73	22.96 (5th Min)	3.36

Annexure VI- Lithological details of Motibhamari EW, Nandod tal, Narmada dist.

Lithology of Motibhamari EW, Taluka- Nandod, District- Narmada					
Depth of Drilling					
From	To	Thickness	Index	Lithology	Remarks
0.00	3.00	3.00	Top soil	Light brown color, very fine to fine sand mixed with clay and powdery form.	
3.00	6.00	3.00	weathered basalts	light grey color, chips size, uneven to subangular shape mixed in powder.	
6.00	27.00	21.00	Massive Basalt	light grey color, chips size, uneven to rounded shape mostly in powdery form.	
27.00	45.00	18.00	Massive Basalt	Grey color, predominately chips of larger size mixed in poweder.	
45.00	60.00	15.00	Massive Basalt	Dark grey color, predominately chips of larger size mixed in poweder.	
60.00	63.00	3.00	Massive Basalt	light grey color to whittish color, minor amount of chips of reddish in color, larger size mixed in poweder.	
63.00	75.00	12.00	Massive Basalt	Light pinkish color, medium to large size chips.	
75.00	81.00	6.00	Massive Basalt	Metalic black, fine to medium, moderately hard mixed with powdery crushed.	
81.00	90.00	9.00	Massive Basalt	light pinkish color, fine to large size, subrounded to angular chips.	
90.00	129.00	39.00	Amygdular Basalt	Black color, fine to medium size chips, some of having secondary deposits as calcites making whittish appearance	
129.00	156.00	27.00	Massive Basalt	Black color,fine to large chips Angular chips Cutting, Hard and compact	
156.00	165.00	9.00	Amygdular Basalt	Whitish patches on brownish balck cuttings, subangular to subrounded shape, moderately hard	
165.00	200.20	35.20	Massive Basalt	Metalic black, fine to medium, moderately hard mixed with powdery crushed.	

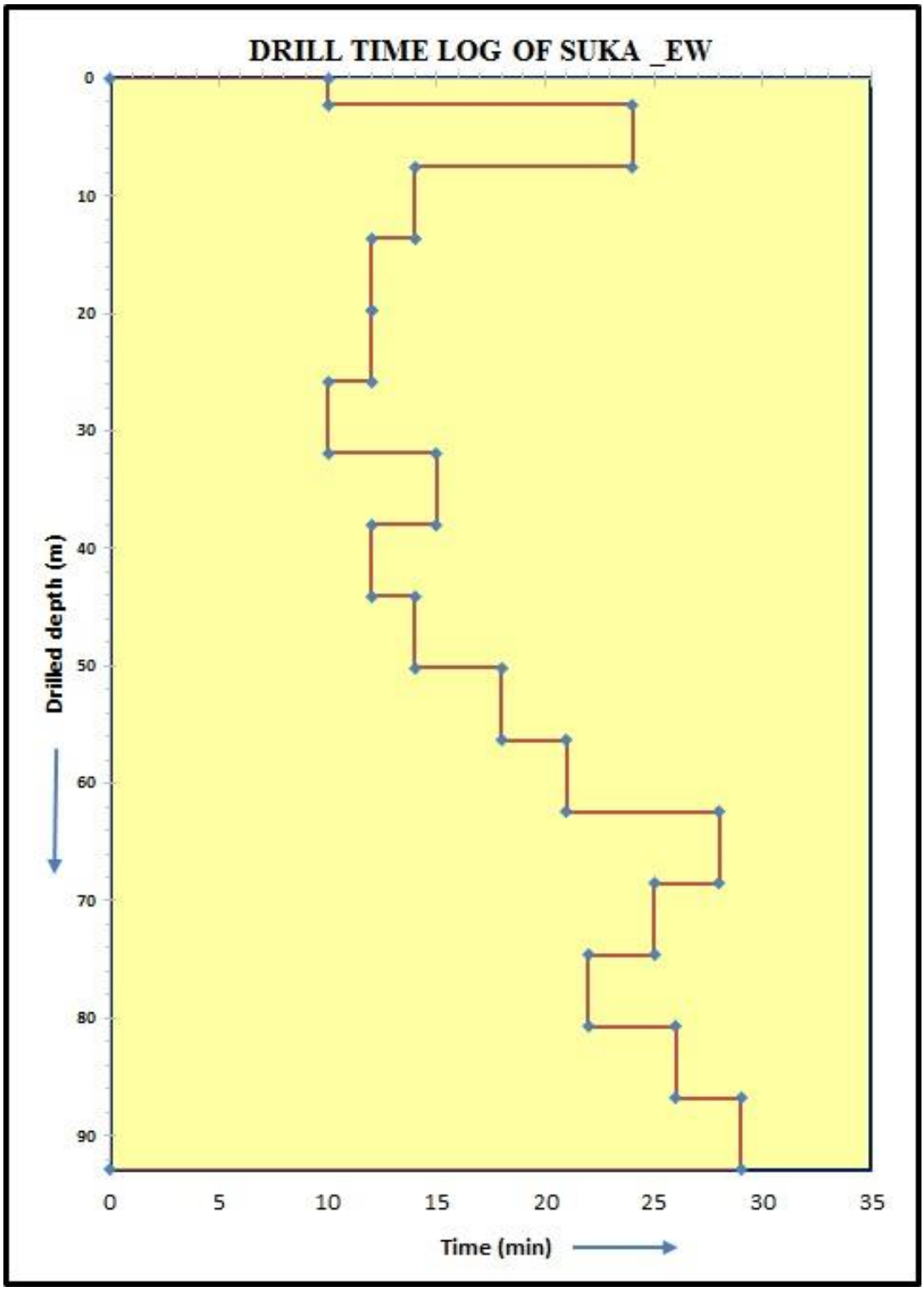
Plate 1- Drill time log of Motibhamari EW.



Annexure VII- Lithology of Suka EW, Taluka- Gaeudeshwar, District- Narmada

Lithology of Suka EW, Taluka- Gaeudeshwar, District- Narmada					
Depth of Drilling					
From	**To**	**Thickness**	**Index**	**Lithology**	**Remarks**
0.00	3.00	3.00	Top soil	Brownish color with weathered basalts fragments little friable.	
3.00	6.00	3.00	Weathered basalts	Brownish Black color, chips cuttings, moderately Hard of Gravel size.	
6.00	21.00	15.00	Vesicular Basalt	Brownish Black color, sub angular to subrounded cuttings, fine to medium grain size formed small vesicle.	
21.00	27.00	6.00	Weathered basalts	Brownish color, sub angular to subrounded chips cuttings, fine to medium grain size.	water zone
27.00	51.00	24.00	Massive Basalt	Pitch Black color, Angular chips Cutting, Hard and compact	
51.00	60.00	9.00	Vesicular Basalt	Reddish black color, fine to medium grain size cutting with few angular shape chips.	water zone
60.00	63.00	3.00	Fractured basalts	Blackish brown color, Bouldery cuttings.	
63.00	69.00	6.00	Massive Basalt	Greyish black color, angular shape, fine chips size and hard in nature.	
69.00	78.00	9.00	Fractured basalts	Brownish black color, Bouldery cuttings.	
78.00	87.00	9.00	Amygdular basalts	Blackish color, angular chips with secondary mineral zeolites deposit, hard and compact in nature.	
87.00	92.90	5.90	Massive Basalt	Greyish black color, angular shape, fine chips size and hard in nature.	

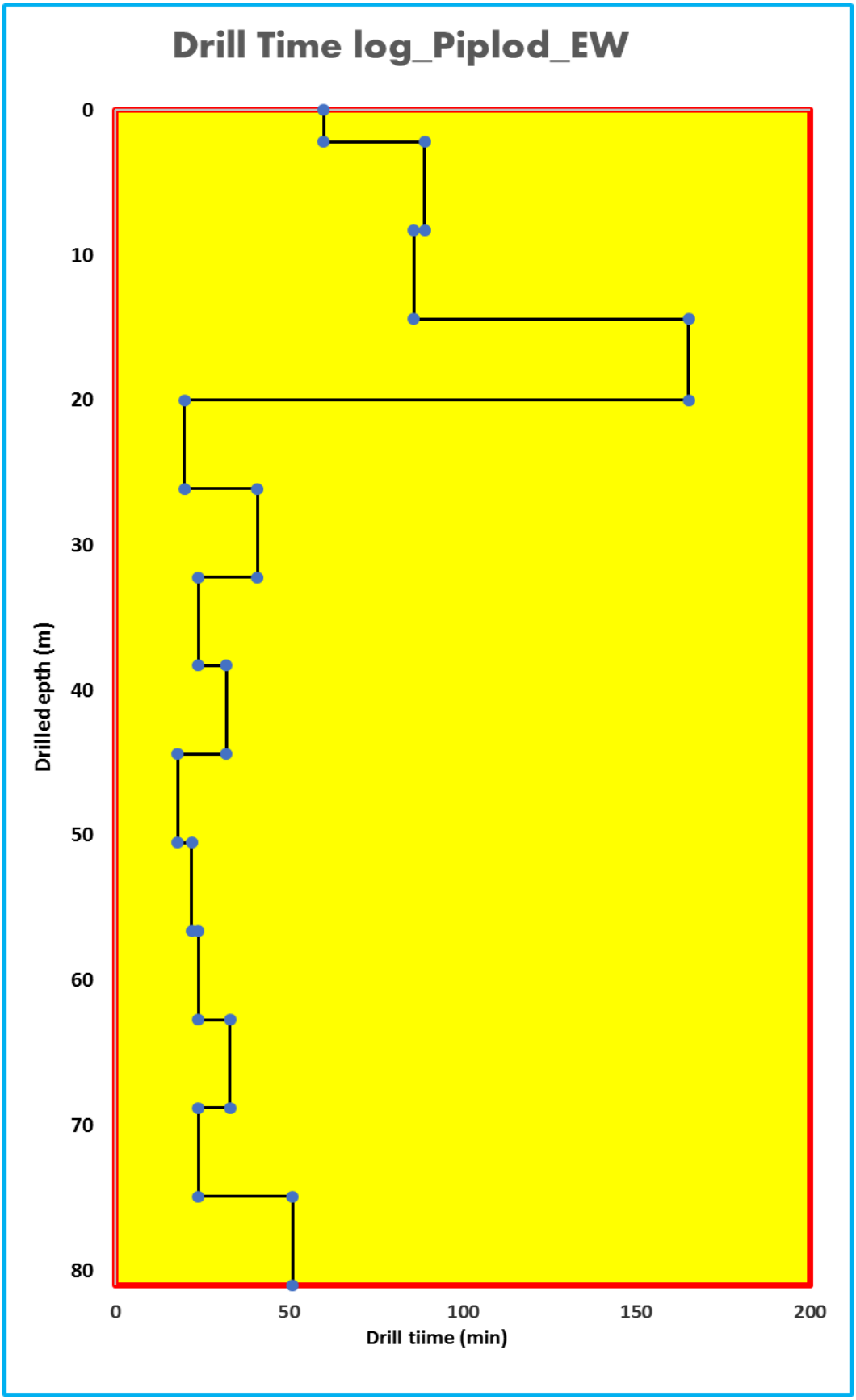
Plate 2- Drill time log of Suka EW.



Annexure VIII- Lithology of Piplod EW, Dediapada taluka, District- Narmada

Lithology of Piplod EW, Dediapada taluka, District- Narmada					
Depth of Drilling					
From	To	Thickness	Index	Lithology	Remarks
0.00	3.00	3.00	Top Soil	Reddish color, mixed with clay and small size kanar	
3.00	6.00	3.00	Kankar and Soil	Predominately with Kankar of boulder size fragments mixed with reddish clay	
6.00	12.00	6.00	Kankar and weathered basalts	Predominately of Kankar of bouldery size mixed with light reddish colorchips of basaltic fragments.	Moisture
12.00	15.00	3.00	Weathered basalts	Grey color, small size particles, uneven chips shape mixed with kankar and soil.	
15.00	18.00	3.00	Amygdoidal Basalt	Mediumm to fine size, uneven shape of amygadular basalts having amygdule of calcite in very minor amount.	
18.00	21.00	3.00	Bole bed	Light reddish color, angular to subangular shape, large to medium size.	
21.00	30.00	9.00	Amygdular basalts	Greyish color, medium to fine sized of uneven shaped having secondary mineral deposits of calcite.	
30.00	33.00	3.00	Amygdular/ Fractured basalts	Brownish grey Color, Fine to medium size chips cuttings having 40-60% of boulder size fragments of amygdular basalts.	water zones
33.00	36.00	3.00	Bole bed	Black color, large to medium of uneven shape mixed in clay type powedery form of bole.	
36.00	39.00	3.00	Fratured basalts	Reddish brown color of larger boulder size fragments contributing in major amounts and had oxidised and deposited secondary mineral as calcite.	water zones
39.00	42.00	3.00	Fratured basalts	Reddish brown color, uneven shape of boulder fragments along with grey color chips cutting.	water zones
42.00	48.00	6.00	Amygdular basalts	Brown to reddish color, medium to fine sized fragments mixed with larger size of brown color cuttings, having whittish appearance giving evidences of secondary deposits.	
48.00	51.00	3.00	Fratured basalts	Larger boulder size of vesicular and amygdular basalts of reddish color having calcite deposits over some chips.	water zones
51.00	54.00	3.00	Amygdular basalts	Light grey color, fine size cuttting, having blueish appearance over soe fragments making evidence of secondary deposits.	
54.00	57.00	3.00	Fratured basalts	Light Yellowish color, dominately of boulder size, having medium size chips cuttings.	water zones
57.00	69.00	12.00	Amygdular basalts	Dominately yellowish color of cuttings mixed with medium size grey paticels of uneven shape having whittish appearance of secondary mineral calcites deposits in well developed form.	
69.00	72.00	3.00	Fratured basalts	Brownish color, Boulder size fragments, of uneven and irregular shapes of predominately along with minor amounts of black chips cutting.	water zones
72.00	81.00	9.00	Fratured basalts	Dark black color, boulder size, dominately having some chips of uneven shapes shows secondary mineral deposits of calcites.	Major water bearing zone

Plate 3- Drill time log of Piplod EW.



Annexure IX- Lithology of Mulkapada, Dediapada Taluka, Narmada dist.

Depth (in m)		Thickness (in m)	Index	Lithology	Remarks
From	**To**				
2.2	8.3	6.1	Weathered Basalt	Greyish red colour, medium size chips, uneven shape, non-sticky powdery form.	
8.3	38.3	30	Amygdaloidal Basalt	Dark black colour, very fine to medium size chips, moderately hard, non-sticky powder form.	
38.3	50.5	12.2	Massive Basalt	Black colour, large to medium size chips, rough appearance, hard.	
50.5	56.6	6.1	Fracture Basalt	Blackish appearnce, medium size bolder, angular to sub rounded, along with chips.	Main zone of water
56.6	68.8	12.2	Amygdaloidal Basalt	Dark Pitchy colour, medium to fine size, some finer size feldspathic grains.	
68.8	74.9	6.1	Amygdaloidal Basalt	Black colour, medium size chips fo uneven size along with some calcic finer grains	
74.9	87.1	12.2	Amygdaloidal Basalt	Metalic black colour, fine to medium sized chips with few amount of crushed particles and very fine grains of seconday mineral	
87.1	93.2	6.1	Massive Basalt	Dark colour, fine size chips, hard and rough in nature, subangular shape	
93.2	123.7	30.5	Amygdaloidal Basalt	Dark grey colour, medium to fine size chips and fragments, hard and compact.	
123.7	135.9	12.2	Amygdaloidal Basalt	Dark colour, fine size chips and fragments of subangular to angular, rough and hard.	
135.9	148.1	12.2	Massive Basalt	Metalic black colour, medium size chips of uneven size, rough and smoothy appearance.	
148.1	166.4	18.3	Massive Basalt	Pitchy colour, major amount of larger size chips with few medium to fine size, uneven shape, hard.	
166.4	181.6	15.2	Massive Basalt	Pitchy colour, medium size particles is more copared to above, uneven shape, hard.	
181.6	184.7	3.1	Massive Basalt	Very dark colour, medium size chips of uneven shape,hard and rough apperance.	
184.7	190.8	6.1	Amygdaloidal Basalt	Black colour, medium to fine sized chips with some powdery form of seconadry particles, moderately hard.	
190.8	193.8	3	Massive Basalt	Metalic black colour, medium size chips of subangular to angular in shape, hard in nature.	
193.8	200	6.2	Massive Basalt	Metalic black colour, medium to fine size chips of subangular to angular in shape with few amounts of crushed, hard in nature.	

Annexure X- Litholog of Umran EW, Dediapada, Narmada dist.

Depth (in m)		Thickness (in m)	Index	Lithology	Remarks
From	To				
0	2.2	2.2	Top Soil	Brownish grey colour, non-sticky, along with kanker	
2.2	8.3	6.1	Weathered basalt	Brownish colour, angular to subangular chips, moderately hard	
8.3	13.9	5.6	Massive basalt	Pitch black, angular chips, hard and compact	
13.9	29.1	15.2	Red bole	Brownish grey colour, powedery sample with few chips, little sticky	
29.1	32.2	3.1	Fracture basalt	Whitish brown colour, subrounded, small bolder, moderately friable	Water Zone-10-12 discharge
32.2	35.2	3	Vesicular basalt	Reddish grey colour, powedery sample with 60-70% subrounded to angular chips	
35.2	47.4	12.2	Amygdaloidal basalt	Brownish white, fined grain sample, secondary mineral 60-70%.	
47.4	50.5	3.1	Fracture basalt	Whitish colour, bolder size, calcic limestone as secondary.	
50.5	56.6	6.1	Vesicular basalt	Brownish black colour, angular chips with vesicular structure.	
56.6	68.8	12.2	Amygdaloidal basalt	Greyish colour with whitish packet, angular to subrounded chips, hard and compact.	
68.8	93.2	24.4	Massive basalt	Pitch black, angular chips, fine grained, hard and compact	
93.2	99.3	6.1	Vesicular and Amygdaloidal basalt	Brownish colour with equal amount of vesicles filled with secondary mineral zeolite deposits.	

Annexure- XI- - Litholog of Motirwal EW, Garudeshwar, Narmada dist.

Depth (in m)		Thickness (in m)	Index	Lithology	Remarks
From	To				
0.00	2.20	2.20	Top Soil	Light brown colour, some yellowish colour soil fragment along with small amount of chips size of basaltic fragment.	
2.20	6.10	3.90	Exposed weatherd Basalt	Grey colour , chips size, hard and compact of basaltic fragment.	
6.10	44.10	38.00	Massive basalt	Very dark colour, bigger chips size, hard and compact	
44.10	68.50	24.40	Amygdaloidal basalt	Dark grey and brownish colour, larger chips size of Basaltic fragment. Along with minor amount of grey colour calcic limestone.	
68.50	92.90	24.40	Massive basalt	black colour, medium chips size , massive and compact	
92.90	111.20	18.30	Massive basalt	Brownish colour, Medium size chips, hard and compact	
111.20	135.60	24.40	Massive basalt	Very dark/ mettalic black colour, larger chips size, very hard and massive	
135.60	141.70	6.10	Massive basalt + Sandstone	Brownish colour, Medium size chips, massive and compact along with very small amount of medium to fine grained of sst of reddish colour.	
141.70	160.00	18.30	Massive basalt	Dark black colour, massive, and compact medium size chips	

160.00	178.30	18.30	Massive basalt	light black colour, medium chips size and massive, minor amount of greenish colour of basaltic fragments also, very small amount of grey colour limestone	
178.30	184.40	6.10	Fractured basalt	Light black and grey colour, boulder size of uneven basaltic fragments, hard, compact and massive.	Fracture zone, 2-3 lps-discharge
184.40	200.00	15.60	Massive basalt	light grey and black colour, medium to larger size chips, hard and compact.	

References

- Census of India 2011, District Census Handbook, Narmada District.
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