Government of India
Ministry of Water Resources

GROUNDWATER BROCHURE

NARMADA DISTRICT

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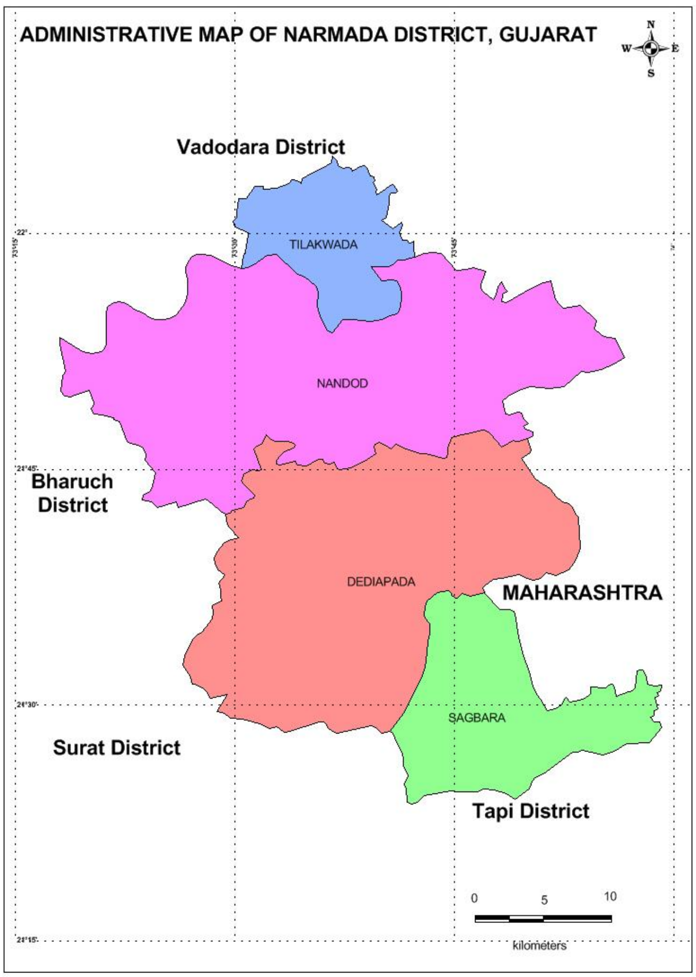
DISTRICT GROUND WATER BROCHURE
NARMADA DISTRICT, GUJARAT

INTRODUCTION

Narmada district is 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 geographical area of the district is 2755 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 (**Fig.1**). This district was carved out on October 2, 1997. The newly formed district consist of Tilakwada taluka of erstwhile Vadodara district and 3 talukas viz., Nandod, Dediyapada and Sagbara of erstwhile Bharuch district. and consists of 609 villages. Total population of the district as per 2011 census is 5,90,379.

Fig-1



STUDIES/ACTIVITIES BY CGWB

This district was carved out on October 2, 1997. The newly formed district consist of Tilakwada taluka of erstwhile Vadodara district and 3 talukas viz., Nandod, Dediyapada 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.

A. R. Pandey of Central Ground Water Board (1977-78) carried out detailed hydrogeological investigation in parts of Bharuch distrlict. 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.

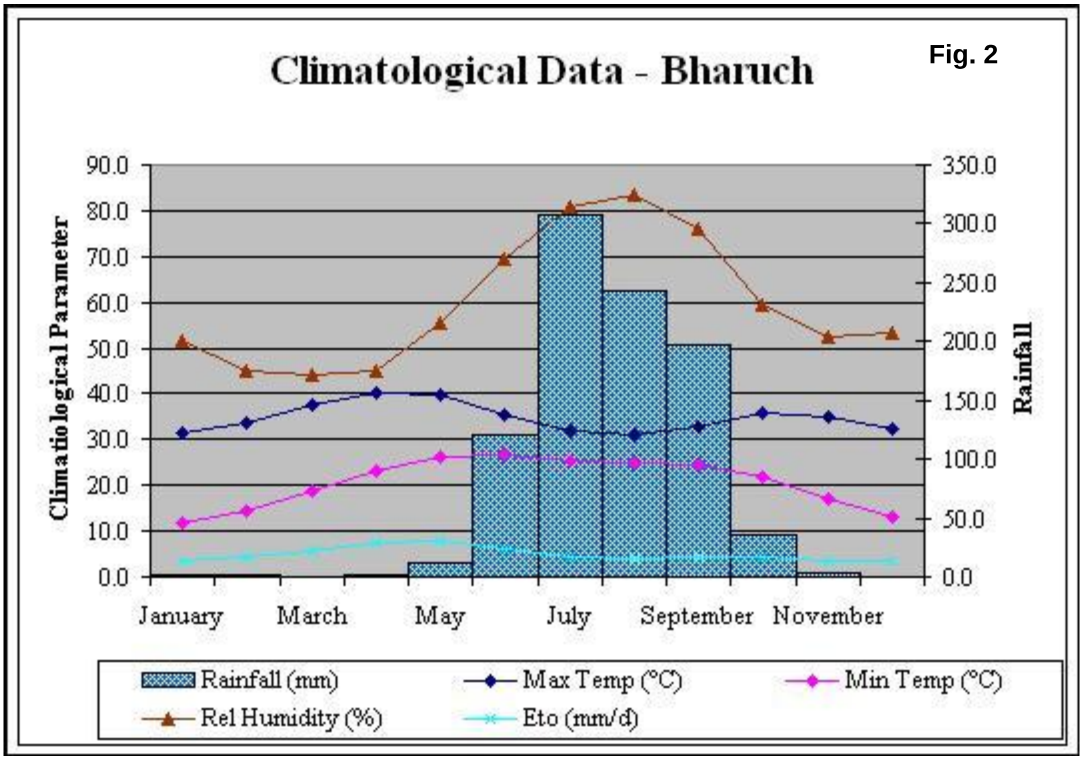
Groundwater exploration by test drilling in the district commenced in fifties and is continuing till 2008. A. K. Jain (1986-87) carried out groundwater exploration in Tilakwada Taluka. Apart from the exploratory wells Piezometers have also been constructed in the district under the Hydrology project. 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.

RAINFALL AND CLIMATE

The district has semi arid climate. Extreme temperatures, erratic rainfall and high evaporation are the characteristic features (Fig. 2). The average annual normal rainfall is 924.8 mm for the 30 years. Bharuch IMD station is falling close to the newly formed Narmada district Therefore, climatological data of Bharuch IMD station (1951-1980) is ustilised for this district and is given in Table 1.

Table 1: 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)	Wind Spd. Kmph
January	31.3	11.9	51.5	105.9	9.0	17.3	3.7	1.2	5.9
February	33.8	14.4	45.0	111.3	9.2	19.6	4.5	1.0	6.2
March	37.6	19.0	44.0	125.7	9.8	22.7	5.8	0.8	7
April	40.0	23.3	45.0	158.0	10.4	25.2	7.2	1.0	8.8
May	39.6	26.2	55.5	222.6	10.8	26.2	8.0	12.5	12.4
June	35.6	26.5	69.5	263.9	7.6	21.3	6.3	121.0	14.7
July	32.0	25.5	81.0	237.0	4.4	16.5	4.3	307.6	13.2
August	31.2	25.0	83.5	206.4	4.2	15.9	3.9	243.1	11.5
September	32.6	24.4	76.0	154.4	6.3	18.1	4.4	197.6	8.6
October	35.9	22.0	59.5	102.3	7.9	18.5	4.5	35.2	5.7
November	34.8	16.9	52.5	84.4	8.0	16.5	3.7	3.7	4.7
December	32.2	13.2	53.5	93.3	8.9	16.5	3.4	0.1	5.2
Total	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**924.8**	
Average	**34.7**	**20.7**	**59.7**	**155.4**	**8.0**	**19.5**	**5.0**	**-**	



GEOMORPHOLOGY AND SOIL TYPE

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 merging 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.

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 rich flat plain, between high rough banks of hard clay and sand deposits located mostly in Tilakwada taluka. 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 extremity of the district touches the Tapi, the second important river of south Gujarat.

SOILS

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, containing 40-70% clay , are poor in drainage and neutral to alkaline reaction.

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

Bhatha soil : It is lateritic type of soil, containing lot of pebbles with water observation capacity is low.

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.

GROUND WATER SCENARIO

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. 3** and are described below.

Semi-consolidated Lower Cretaceous formation

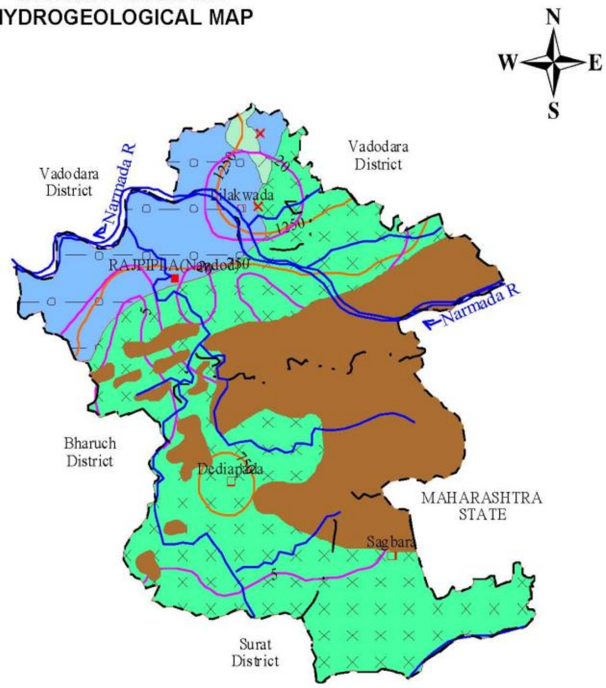
The Bagh beds

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 m^3/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.

Fig. 3

DISTRICT NARMADA
HYDROGEOLOGICAL MAP



	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

Consolidated upper Cretaceous formation

The Deccan traps

The Deccan Traps, being the extrusive volcanics, where individuals flows were 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 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.

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.

Depth to water level

Pre monsoon water levels as shown in the map for the period May. 2012 (**Fig. 5**) ranges mostly 5 to 10 m bgl in the largest part of the district. Shallow water levels are mostly experienced in Dendiapada taluka. Water level more than 20 m bgl is observed in Nandod taluka.

A perusal of the map for the period of Nov 2012 (**Fig.4**) reveal that in the major part of the district, the depth to water level ranges from 2 to 5 m bgl and most of the area falls in Dendiapada and Sagbara talukas. The area is covered by the water level between 5 and 10 m bgl in central part of the district. Deep water levels range from 10 to 40 mbgl are observed mostly in Nandod taluka

Fig - 4

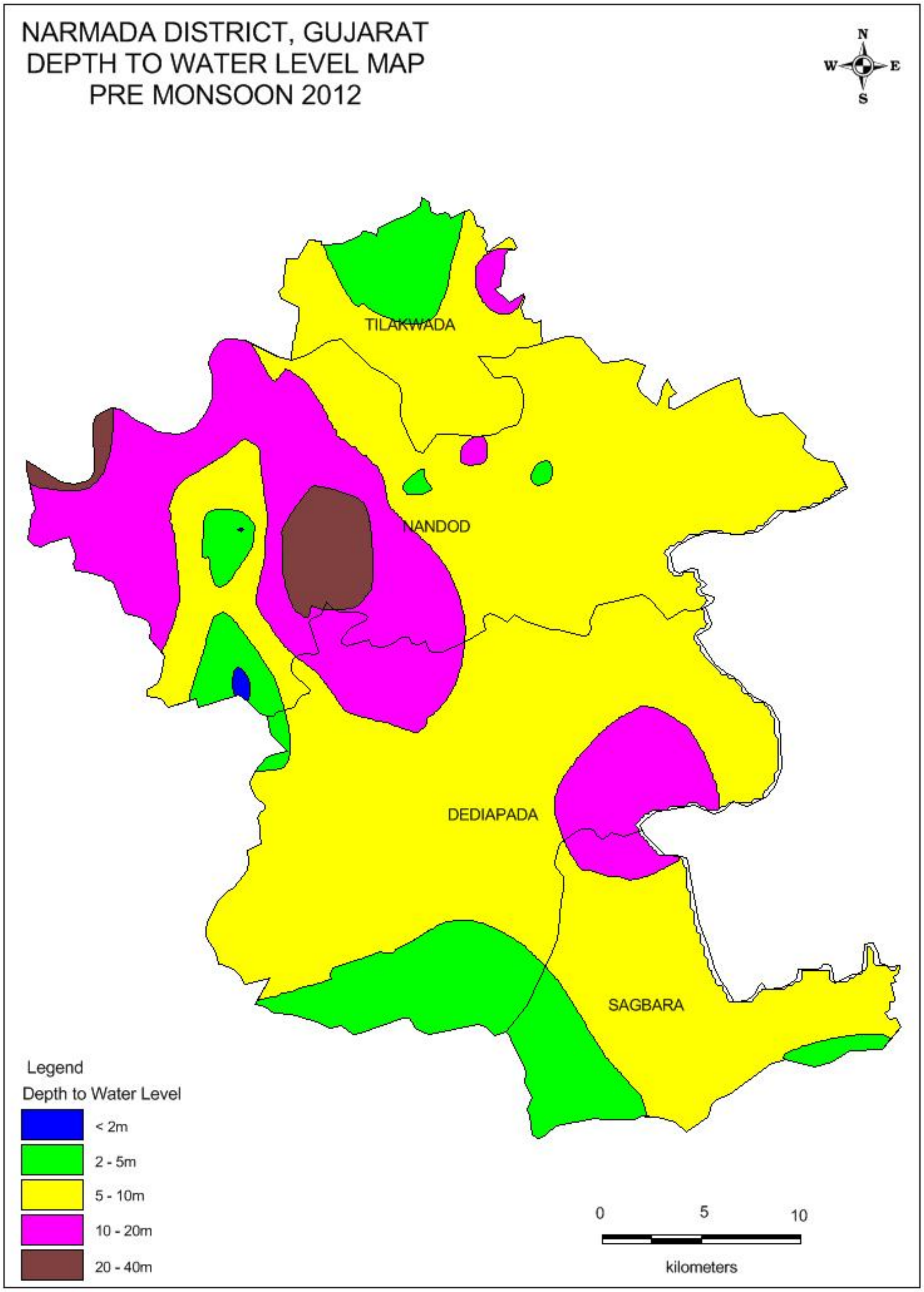
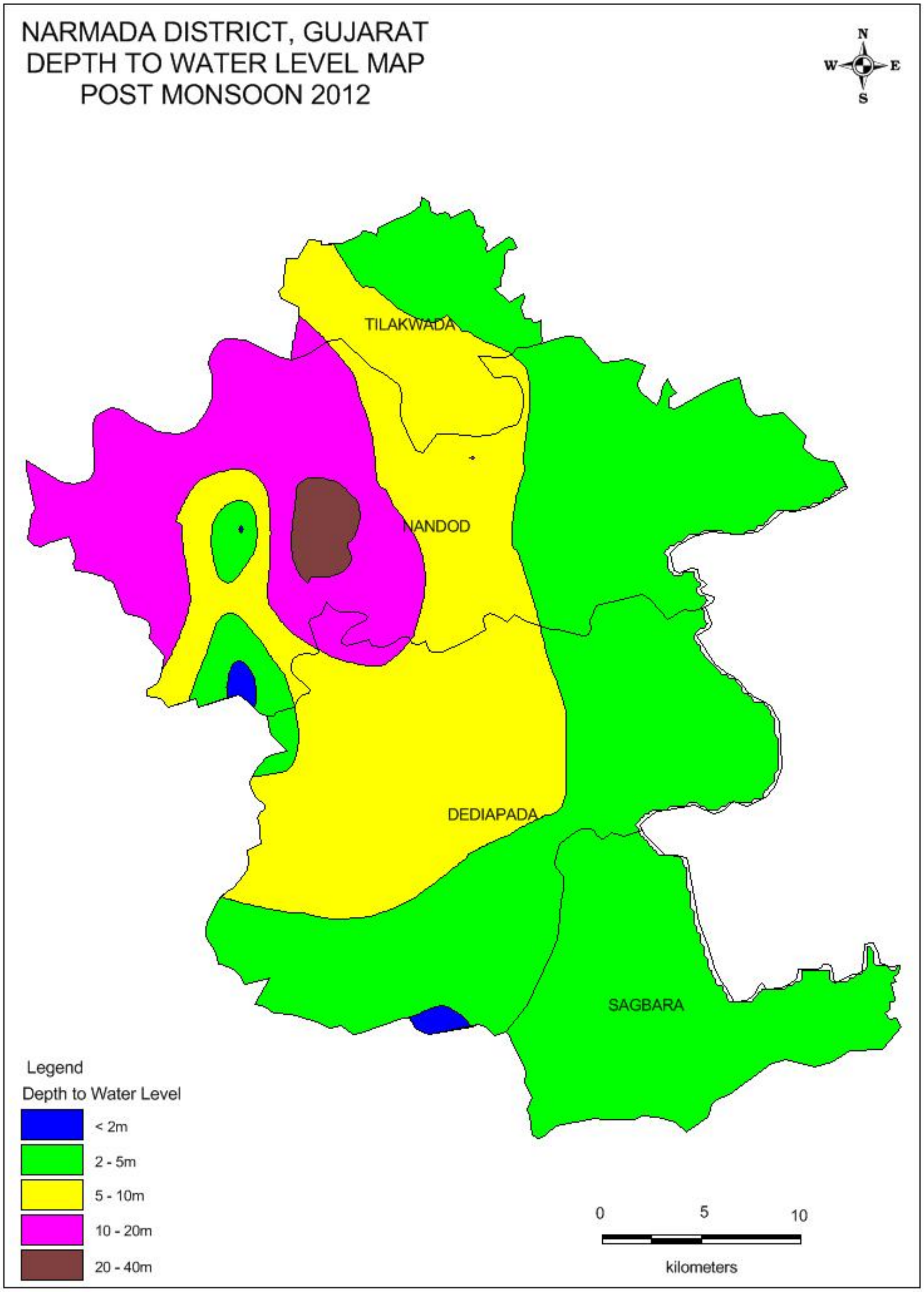

NARMADA DISTRICT, GUJARAT
DEPTH TO WATER LEVEL MAP
PRE MONSOON 2012
N
W
E
S
TILAKWADA
NANDOD
DEDIAPADA
SAGBARA
Legend
Depth to Water Level
< 2m
2 - 5m
5 - 10m
10 - 20m
20 - 40m
0
5
10
kilometers

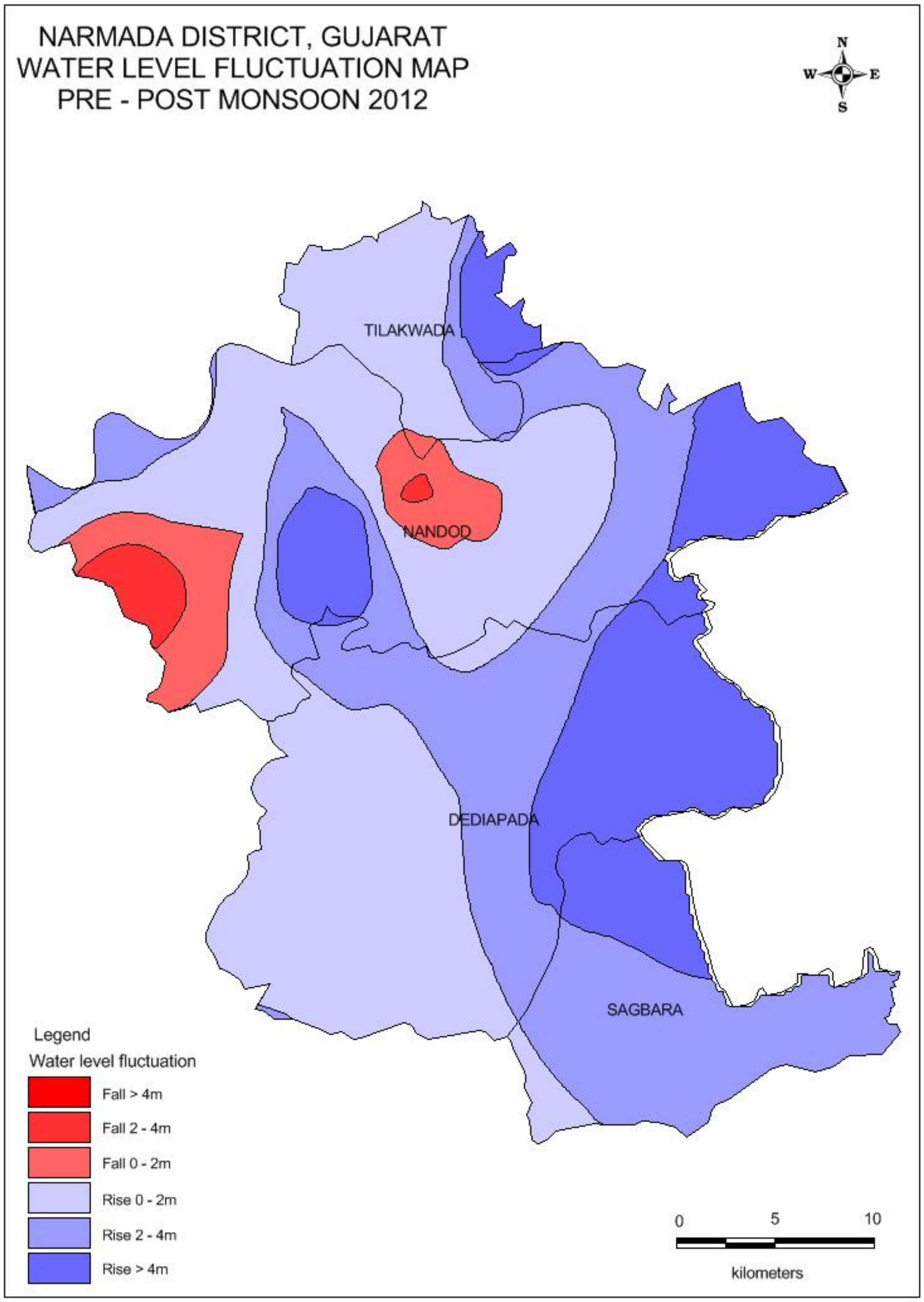
Fig - 5


NARMADA DISTRICT, GUJARAT
DEPTH TO WATER LEVEL MAP
POST MONSOON 2012
N
W
E
S
TILAKWADA
NANDOD
DEDIAPADA
SAGBARA
Legend
Depth to Water Level
< 2m
2 - 5m
5 - 10m
10 - 20m
20 - 40m
0
5
10
kilometers

Annual fluctuation of water levels

Map showing water level fluctuation between May 2012 and November 2012 (**Fig. 6**) shows mostly rise in water level in the district. About 50% of the area covered in rise of 2 to 4 m. Fall in the water levels are mostly confined to Nandod taluka in the range of 0 to 2 m and 2 to 4m in patches.

Fig - 6



Groundwater Quality:

The chemical quality of groundwater in shallow aquifer has been studied based on the water samples collected from 10 monitoring stations (NHS) during the year May 2011. The ground water is in general alkaline in nature. A perusal of map shows the electrical conductivity (EC) and chloride concentration increasing towards northwest direction. Groundwater quality in Basaltic formation is generally fresh and electrical conductivity is mostly less than 1000 µS/cm and chloride concentration is less than 250 mg/l. Quality in alluvium and Bagh beds are poor as compared to basaltic rocks and EC is observed to be in the range of 2000 to 5000 µS/cm in northwest portion of the district.

GROUND WATER DEVELOPMENT POTENTIAL OF NARMADA DISTRICT (2011)

Ground Water Resources

The ground water resources of the district as per GWRE 2011 are presented in Table 2. All the talukas in Narmada district are categorised as safe.

TABLE 2- Groundwater development potential of Narmada district (2011)

Sr. No.	Assessment Unit/ Taluka	Net Available Ground Water Recharge (Hac.m/Yr)	Ground Water Draft for irrigation (Hac.m/Yr)	Existing Gross Ground Water Draft for domestic and industrial water supply (in ha m)	Existing Gross Ground Water Draft for All uses (4+5) (in ha m)	Allocation for domestic and industrial requirement supply upto next 25 years (in ha m)	Net Ground Water Availability for future irrigation development (3-4-7) (in ha m)	Stage of Ground Water Development {(6/3)*100} (%) (in ha m)
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1	**Nandod**	**10407.06**	**3523.40**	**699.00**	**4222.40**	**938.00**	**5945.66**	**40.57**
2	**Dendiapada**	**3085.34**	**321.00**	**433.00**	**754.00**	**581.00**	**2183.34**	**24.44**
3	**Sagbara**	**5011.17**	**438.80**	**253.00**	**691.80**	**339.00**	**4233.37**	**13.81**
4	**Tilakwada**	**2990.50**	**542.60**	**169.00**	**711.60**	**227.00**	**2220.90**	**23.80**
TOTAL		**21494.07**	**4825.80**	**1554.00**	**6503.80**	**2085.00**	**14583.27**	**29.68**

Status of Ground Water Development (Taluka wise)

The alluvial aquifers in the district are exploited with the help of dug wells, dug-cum-bored wells and tube wells for irrigation. The yield of wells in alluvial formation vary from 400 to 700 litre per minute (lpm) for drawdowns varying from a few meters to as much as 21 m. There are 2872 wells of all types in the district are in use as per the MI Census 2000-2001 and the total annual draft is computed to of the order of 6503 ha. m (GEC 2011). Groundwater development in Nandod taluka is highest (40.57%). The wells in hard rocks generally have low to moderate recuperation. The development of groundwater in Dendiapada taluka is low (16.61%) as the taluka is entirely occupied by hard rocks which have low to medium potentialities. The Taluka - wise groundwater structures are furnished in **Table3**. The wells in hard rocks generally have low to moderate recuperation.

Table: 3- Taluka wise groundwater structure in use.

Sl. No.	Name of taluka	Dug well	Tube well	Total
1	Dendiapada	656	11	667
2	Nandod	896	317	1213
3	Segwara	567	5	572
4	Tilakwada	291	129	420
	Total	2410	462	2872

NA -Data not available

Irrigation scenario from ground water sources

Dugwells

As per MI census 2000-01 there are 2772 dugwells out of which 2410 are in use. Irrigation potential created through these dugwells is 5417 ha. m and potential utilized is 5407 ha. m area.

Tubewells:

As per MI census 2000-01 there are 560 deep tubewells in the district out of which 461 are in use. The irrigation potential created is 2646 ha.m are and potential utilized is 1643 ha.m.

The Taluka-wise details of irrigation potential for ground water sources presented in Table-4.

Table: 4- Potential created by groundwater abstraction structures

Taluka	Dugwells		Tubewells	
	Potential created	Potential utilized	Potential created	Potential utilized
Dendiapada	1450	1449	112	11
Nandod	1971	1970	1750	944
Segwara	1388	1384	73	0
Tilakwada	608	604	715	693
Total	5417	5407	2650	1648

(NA- Data not available, Source: M I Census 2000-01, area in ha.)

Ground Water Management Strategy

All talukas in the district are categorised as safe in the GEC 2011 report and district as a whole has 29.68% of development. Hence, there is further scope for development of the ground water resources in the district. The irrigated area in the district forms is 406 Sq. Km cultivable area (**Table 5**). The area irrigated by wells form about 97% of the total irrigated area. This indicates that irrigation in the district depends on groundwater to very great extent. The district is quite rich in surface water resources. The available surface water in Narmada should be properly utilized after the completion of canal networks. None of the talulkas has been notified either by Central Ground Water Authority (CGWA) or State Water Authority (SGWA).

The suitable recharge structures feasible in the district are Percolation tanks/ponds, Recharge wells, Recharge shaft, Check dams, nalla bunds and gully plugs etc depending on the terrain conditions.

In the desaturated phreatic aquifers with deep water levels, spreading channels, recharge pits, recharge ponds etc wherever suitable to utilize surplus runoff and tail end releases from the canals.

Various rainwater harvesting schemes depending on the suitable hydrogeological conditions have been constructed in the district viz. Check dams, Recharge tube wells , deepening the of the village ponds etc and have shown good impact on the groundwater scenario.

Table: 5 Agricultural land and source irrigation

Sl. No.	Name of taluka	Geographical area	Cultvable area	Net area sown	Net area irrigated through			
					Major/medium scheme	Groundwater	Surface water	Total
1	Dendiapada	93981	8270	8003	0	1999	0	1999
2	Nandod	69508	39122	37569	0	3073	0	3073
3	Segwara	35223	10833	9613	205	1572	0	1777
4	Tilakwada	21645	10938	10572	0	1197	0	1197
5	Total	220357	69163	65757	205	7841	0	8046

Ground Water Related Issues and Problems

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 practised 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.

Recommendations

- There is an urgent need for management of resources for sustainable development.
- Suitable ground water legislation may be enforced and all future ground water exploitation by deep tube wells can be restricted.
- Creating awareness among the farmers regarding water conservation through judicious use of water and adoption of efficient irrigation techniques like drip/sprinkler irrigation.
- The land holding of the group of farmers under public tubewell irrigation should be brought under the provision of the change in crops, irrigation practices and installation of drip/sprinkler irrigation technique.
- Soft term institutional finances to the farmers and liberal subsidies in equipments are suggested.
- Resorting to artificial recharge practices by diverting surplus run-off during monsoon into ponds, percolation tanks,. Spreading basins, abandoned dugwells etc.
- Taking up artificial recharge on large scale through appropriate techniques on a regional scale with active community participation.
- Institutional finance and appropriate technology should be freely made available to any individual or cooperative group of farmers that undertake resource augmentation and management measures.
- The level of groundwater development is low in all talukas and there is good scope of groundwater development.
- The area in the vicinity of Narmada river may be developed by constructing groundwater structures to utilise the subsurface groundwater flow to river.