For official use

Technical Report Series

GROUNDWATER BROCHURE

BHARUCH DISTRICT

Government of India

Ministry of Water Resources

Central Ground Water Board

West Central Region

Ahmedabad

March 2014

BHARUCH DISTRICT AT A GLANCE

SL No.	Items	Statistics	
1	General Information		
	i) Geographical Area (Sq. Km)	6527	
	ii) Administrative Divisions (As on 31/3/2012) **Number of Taluka** **Number of Villages**	 8 663	
	iii) Populations (As per 2011 census)	15,51,000 souls	
	iv) Average Annual Rainfall (mm)	707	
2.	GEOMORPHOLOGY		
	Major Physiographic Units	Alluvial plain , Hillocks	
	Major Drainages	Narmada	
3.	LAND USE (Sq. Km)		
	a) Forest area **b) Net area sown** **c) Total Cropped area**	245 Sq.Km 3308 Sq.Km 3388 Sq.Km	
4.	MAJOR SOIL TYPES	Sandy soil & Saline and Alkali soil	
5.	AREA UNDER PRINCIPALFOODGRAIN CROPS	sq. km.	
6.	IRRIGATION BY DIFFERENT SOURCES (Areas and numbers of structures) (MI Census 2000-01)	No.	Area (ha.)
	Dugwells	4963	12201
	Tube wells/Borewells	3727	23486
	Tanks/Ponds/Water conservation structures (ha)	-	78
	Canals (ha)	-	157
	Net Irrigated area(ha)	29847	
7.	NUMBERS OF GROUND WATER MONITORING WELLS **OF CGWB (As on November 2012)** **No of Dug Wells** **No of Piezometers**	 36 30 6	
8.	PREDOMINANT GEOLOGICAL FORMATIONS		
	Deccan Trap, Sandstone, Alluvium		
9.	HYDROGEOLOGY		
	➢ **Major Water Bearing Formation: Quaternary alluvium** **Depth to water level during 2012**		

	Phreatic aquifer (DTW)		**Semiconfined and Confined aquifer (Pz head)**	
	Min.	**Max.**	**Min.**	**Max.**

	Pre-monsoon	**1.37 (Sajod)**	**12.56 (Sarod)**	**8.82 (Bharuch I)**	**5.08 (Kadodara)**
	Post-monsoon	**0.15 (Mahegam)**	**9.37 (RojaTankaria)**	**9.64 (Bharuch II)**	**16.56 (Bharuch)**

Long term water level trend in 10 yrs (2003-2012)

May2003-May2012 (Pre-Monsoon)
Phreatic aquifer : Stabilised

Rising - Min: 0.01 m/yrMax: 0.74 m /yr
Declining - Min: 0.01 m/yrMax: 0.39 m /yr

Nov.2003-Nov.2012 (Post Monsoon)
Phreatic aquifer : Stabilised
Rising - Min: 0.002 m/yrMax:1.33 m /yr
Declining - Min: 0.007 m/yr Max: 0.37 m /yr

10.	GROUND WATER EXPLORATION BY CGWB (As on 31 -03 -2012)	
	No of wellsdrilled (EW, OW, Pz, SH, Total)	

EW	**OW**	**Pz**	**SH**	**Total**
35	**14**	**05**	**None 05**	**59**

	Depth Range(m)	30-611
	Discharge (Litres per minut)	330-3367
11	GROUND WATER QUALITY	
	Presence of chemical constituents more than permissible limit)	Fluoride:0 to 1.6ppm Salinity : .07 to 4.75ppm EC: 351 to 5300µs/cm
	Type of water	Predominant bicarbonate-Chloride type
12.	DYNAMIC GROUND WATER RESOURCES (2011)-in ham	
	Annual Replanishable Ground Water Resources	40915.71
	Net Annual Ground Water Draft	38869.93
	Projected Demand for Domestic and industrial Uses upto 2025	2978.00
	Stage of Ground Water Development	47.36
13	AWARENESS AND TRAINING ACTIVITY	
	Mass Awareness Programmes organized	01
	Water Management Training Programmes organized **No of Participants**	01
14	EFFORTS OF ARTIFICIAL RECHARGE &RAINWATER HARVESTING	
	Projects completed by CGWB (No & Amount spent)	None
	Projects under technical guidance of CGWB	None

	(Numbers)	
15	GROUND WATER CONTROL AND REGULATION	
	Number of OE Blocks	nil
	Number of Critical Blocks	nil
	Number of blocks notified/No. of Saline Blocks	none
16	MAJOR GROUND WATER PROBLEMS AND ISSUES	
	i) Increasing depth of tubewells **ii) Pollution due to Industries** **iii) Inherent salinity of the aquifers in the western part of the district** **iv) Increasing instances of high fluoride** **v) Groundwater contamination due to unplanned construction and poor technical design of tube wells** **vi) Awareness amongst villagers on water conservation techniques** **vii) Demand supply management**	

DISTRICT GROUND WATER BROCHURE
BHARUCH DISTRICT, GUJARAT

1. Basic Information about Bharuch District

Bharuch District is situated on the Bank of Narmada river, the lifeline of Gujarat. The district is well known for its well developed Industrial area industrial estates of Bharuch are unique among those of Gujarat and India. Arabian sea braces its west side. The District looks beautiful with forests and river banks covered by greeneries. Since the ancient age the history of district has shown remarkable peculiarities. Ancient scriptures depict about Pandavas living in forest of Zagadia and Valia during their secret forest-dwelling.

Geographical condition of District :

Location	:	: 21° 24' – 22° 17' N Latitude
		: 72° 22' – 73° 31' E Longitude
Total Area		:6527 Sq. Km.
Total Villages	: 663	

Population: 2011 census

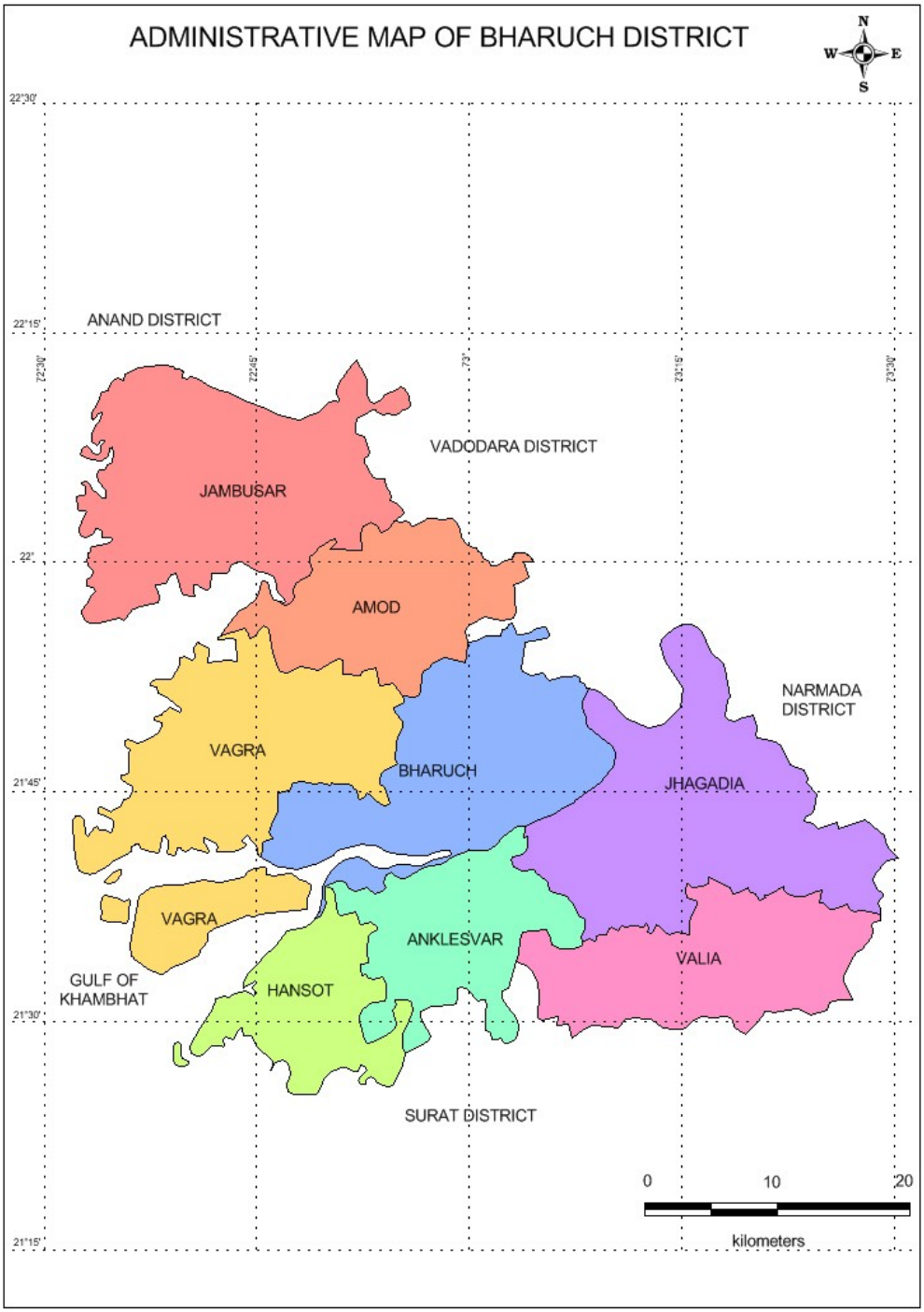
Male	**:**7,13,475
Female	**:**6,56,629
TOTAL	**:** 13,70,104

Population density in the district is 239 souls per sq km. The district has observed a high decadal growth rate of 13.14. The literacy rate for the district is 74.41% as per 2011 census data.

Administrative boundaries:

The Bharuch district is bound in the north by Vadodara, Narmada and Kheda districts, in the south by Surat district, in the west by Gulf of Khambat and in east by Maharashtra State (fig. 1). Recently the old Bharuch district was subdivided in to Narmada and Bharuch districts. Bharuch city is the headquater for the district. There are 21 towns in the district and 663 villages. The district is further divided into seven Takukas, these are (1) Bharuch (2) Jambusar (3) Amod (4) Vagra (5) Jhagadia (6) Ankleshvar& (7) Hansot. There are 543 village panchayats in the district. The district is tribal dominated and 1326.5 sq km is covered by tribal area.

Fig. 1


ADMINISTRATIVE MAP OF BHARUCH DISTRICT
N
W
E
S
22°30'
22°15'
72°30'
72°45'
73°
73°15'
73°30'
ANAND DISTRICT
VADODARA DISTRICT
JAMBUSAR
AMOD
22°
VAGRA
BHARUCH
NARMADA
DISTRICT
JHAGADIA
21°45'
VAGRA
ANKLESVAR
VALIA
GULF OF
KHAMBHAT
HANSOT
21°30'
SURAT DISTRICT
0
10
20
kilometers
21°15'

Agriculture

Major Crop: Paddy, Bajri, Cotton, Wheat, Jowar, Tur, Arando, & Raydo

Soil: Black cotton, Gorat, Bhata, Dyari, and stony soil.

Rivers: Main rivers are Mahi, Dhadhar, Narmada and Kim.

2. Studies/Activities by CGWB

A. R. Pandey of Cenral 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 in parts of Bharuch district under Narmada River Basin Project by the Central Ground Water Board between the years 1971 and 1978.

Groundwater exploration by test drilling in the district commenced in fifties and is continuing till date (AAP 2007-08). 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 level and quality changes in the district and is continued till date.

3. Rainfall and climate

Atmosphere: Average min. temperature – 20.7°C
Average max.temperature – 34.7°C

The district has semi arid climate. Extreme temperatures, erratic rainfall and high evaporation are the characteristic features of this type of climate (fig. 2). The average annual normal rainfall is 924.8 mm for the 30 years. Climatological data of Bharuch IMD station (1951-1980) is given in the table 1.

Fig. 2

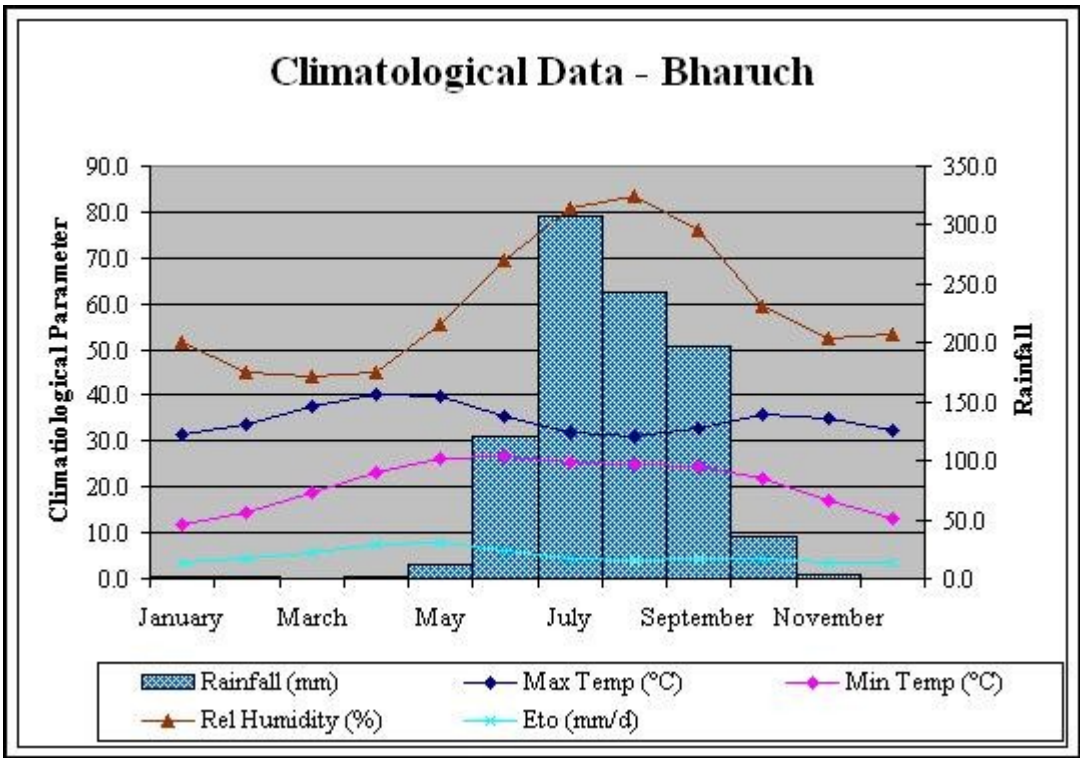


Table 1 Climatological data of Bharuch IMD station (1951-1980)

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**	-	

The average rain fall during the last decade (2003 to 2012) is 707 mm.

4. Physiography:

Bharuch district has got a varied landscape. The whole area may divided into four topographic units.

- The hilly area with high relief
- Piedomont zone
- Alluvial plain
- Coastal area

5. Ground Water Scenario:

Occurrence of Groundwater:

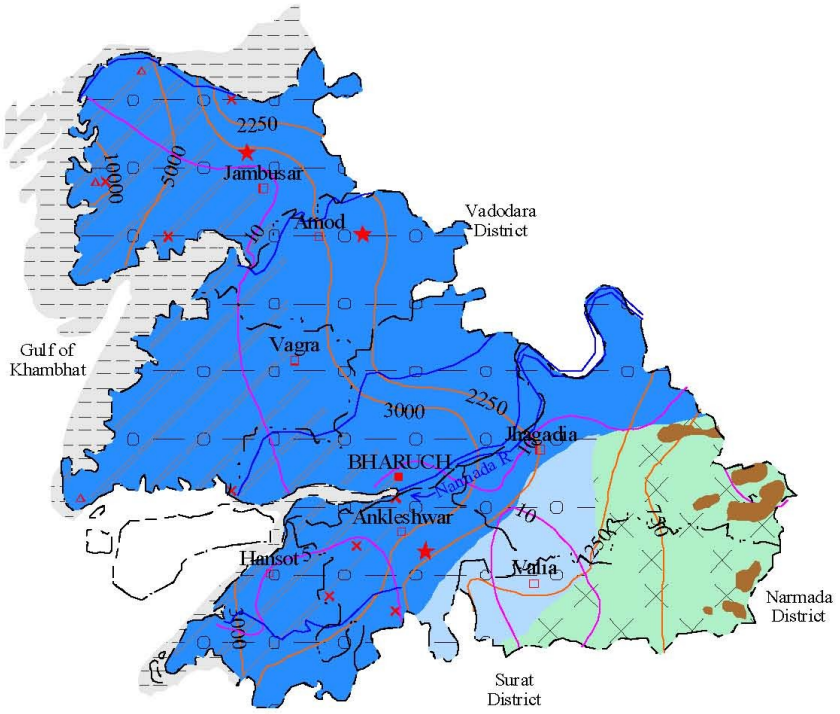
The geology of the district with vast area affected by inherent/coastal salinity, presents a complex hydrogeological pattern. Hydrogeological map is shown in fig.3 The hard rocks, the semi-consolidated Cretaceous, and Tertiary formations and unconsolidated alluvial deposits, all comprise multi – aquifer systems thereby presenting unconfined as well as confined groundwater conditions in the entire district. Tertiary formations, are inherently saline and contain poor quality of groundwater. Groundwater occurs under unconfined conditions in the limestone and sandstone aquifers of Bagh beds. Occurrence and movement of groundwater is restricted mainly to the fractures and joints in the limestones and sandstones. The discharge in dug wells varies from 30 to 50 m^3/day. The bagh beds, where overlain by Deccan Trap are likely to yield groundwater under confined conditions.

The Deccan Trap have given rise to multi-layered stratified aquifers. Each individual flow comprises two distinct units, namely the upper vesicular basalt and the lower massive basalt. The massive basalt is hard and compact with primary porosity but the vesicular basalts exhibit porosity. The movement of groundwater is therefore controlled by the secondary porosity developed by the presence of fractures and joints. The paleoweathering which is invariably observed at depth near the top of every flow, has given rise to good aquifers at depth. The yield of the dug wells in Deccan traps, which range in depth from 5 to 25m bgl, sustain pumping from 1/2 hour to 10 hour with discharge varying from 200 to 1200 litre per minute (LPM) for drawdown of 4 to 7 m. Bore well tapping deeper zones down to 150m below ground level(bgl), have yielded 100 to 600 LPM for a drawdown of 6 to 15m.

The sandstone are the main aquifers in the Tertiary formations but the limestone also yield significant quantities of groundwater wherever karstic development have taken place. Deep tube well tapping the Tertiary formations are capable of yielding 300 to 3000 LPM of water for meager drawdown of 1 to 7m. The alluvium formations in the western most part of the area do not constitute potential aquifers on account of inferior quality of water.

Fig. 3

DISTRICT BHARUCH
HYDROGEOLOGICAL MAP

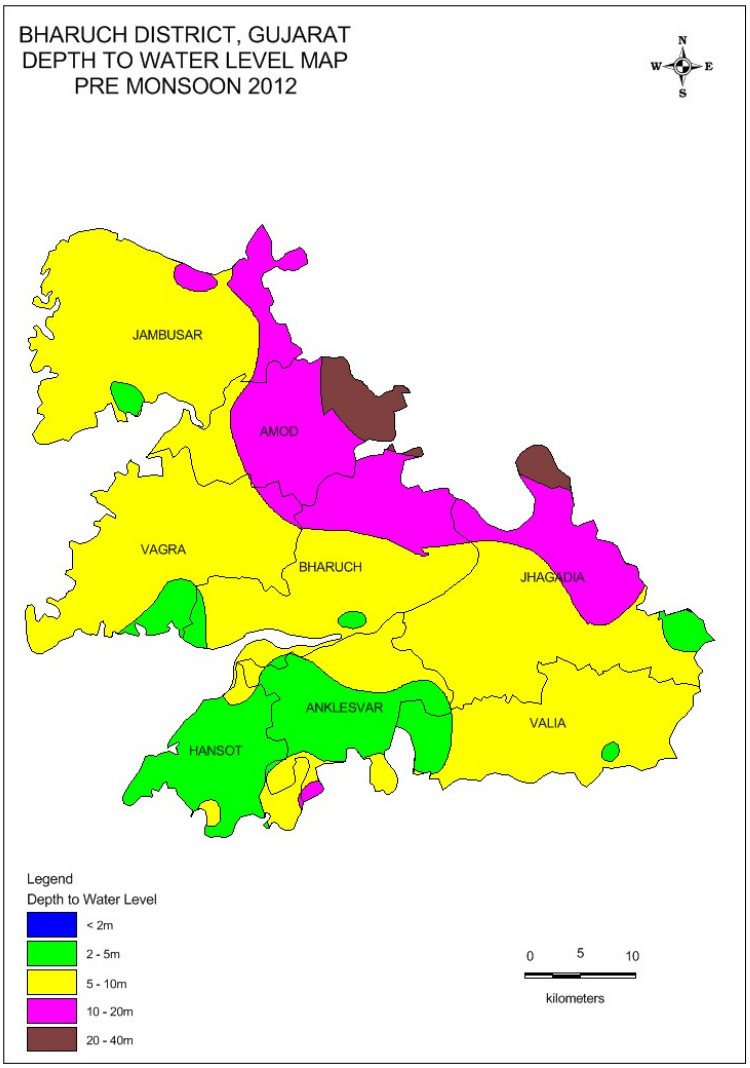


	Formation	Wells Feasible	Depth of Well (m)	Discharge (lpm)
	Soft Rock Aquifer	Dug Well Tubewell	10-25 50-100	200-300 400-60
	Soft Rock Aquifer	Dug Well Tubewell	15- 30 100-200	200-300 600-1200
	Hard Rock Aquifer	Dug Well Borewell	10-25 100-200	60-150 100-300
	Hilly Areas	Not Suitable		
	Saline Area	Not Suitable except localised fresh water pockets		
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)		△	Nitrate > Maximum Permissible Limit (100 mg/l)
★	Over Exploited Taluka			
	Drainage		■/□	District/Taluka HQ

Depth to water level:

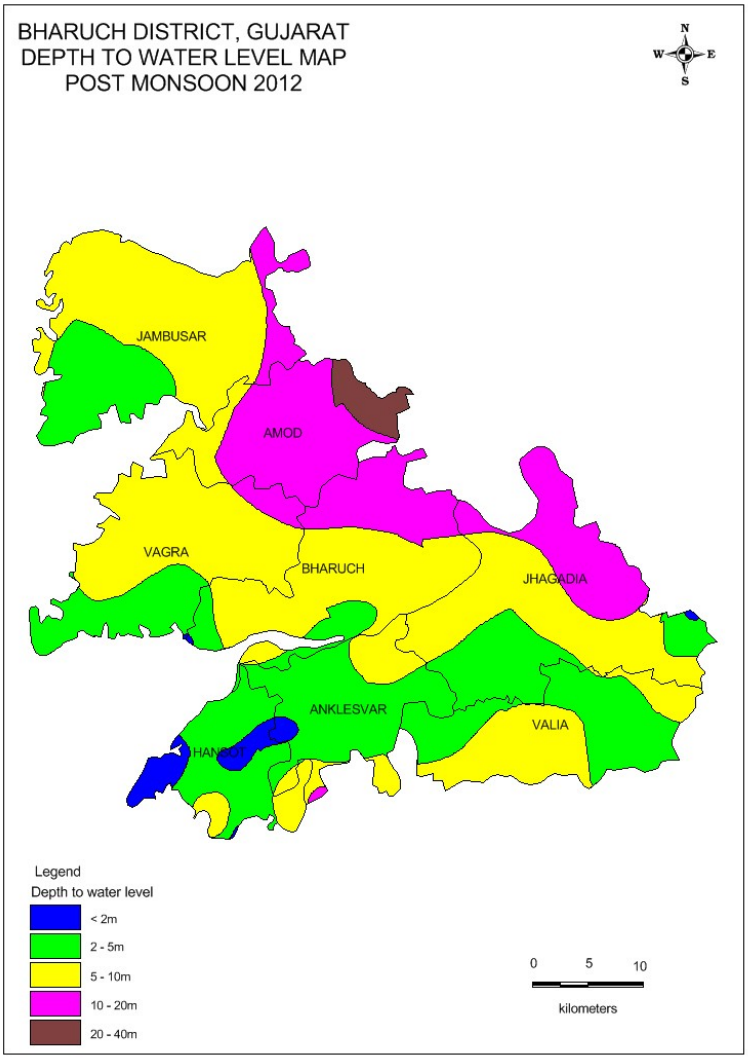
A perusal of the map for the period of May 2012 (fig. 4) reveal that in the major part of the district the depth to water level ranges 5 to 20 m bgl. Shallow water level i.e. less than 5 m bgl is observed mainly in the western and south western part of the district in the most part of the Hansot and parts of Anklesvar, Jabbusar, Vagra taluka. In the eastern part the district particularly in the Jhgadia taluka, water level less than 5 mbgl is observed as shown in the map. Deep water level more than 20 m is observed in the Amod, Bharuch and Jhagadia talukas in the eastern part of the district.

Fig 4



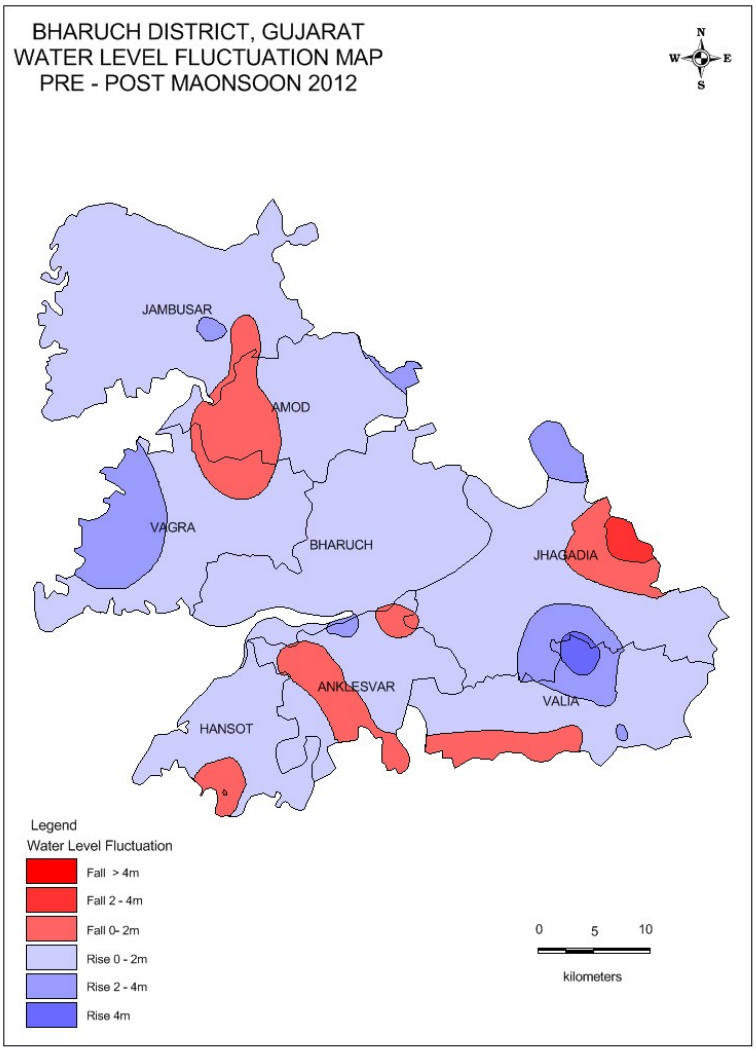
Post monsoon water level as shown in the map for the period Nov. 2012 (fig. 5) reveals that water levels in general area shallower as compared to premonsoon, which shows the effect of monsoon recharge.

Fig. 5.



During the year 2012 a over all rise in water levels was observed due to recharge from monsoon rainfall of 707 mm during the year (Fig. 6). An average rise of about 2 m was observed over the premonsoon water levels in large part of the district. Rise to the tune of more than 2 m is observed in pockets in eastern as well as western parts and southern part of the district. Fall in water is also observed in certain pockets.

Fig.. 6



6. Ground water resources:

The taluka-wise dynamic ground water resources of the district have been estimated for the year 2011. These ground water estimates for the phreatic aquifer in the district are presented in the table no 2.

Table 2 Taluka wise groundwater availability, utilization and stage of development (2011).

(in ham)

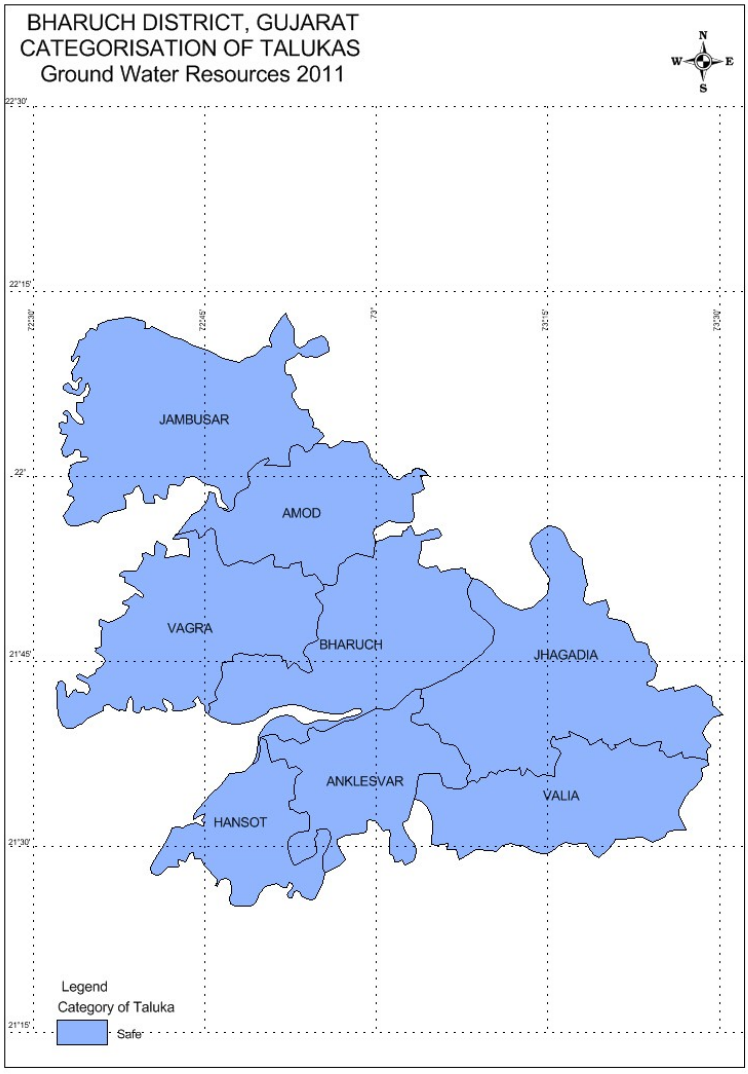
Sr no.	Taluka	Net annual ground water availability	Annual Groun water Draft	Projected demand for domestic and industrial use up to 2025	Ground water availability for the future irrigation	Stage of development in %	Category of Ground Water Development
1	Amod	4260.26	2727.50	236.00	1478.76	64.02	Safe
2	Ankleswar	6762.84	1711.80	666.00	4899.04	25.31	Safe
3	Bharuch	5379.29	2901.00	389.00	2372.29	53.93	Safe
4	Jhagdia	8031.60	5218.20	699.00	2630.40	64.97	Safe
5	Jambusar	1071.38	398.00	179.00	618.38	37.15	Safe
6	Hansot	4459.37	530.00	70.00	3907.37	11.89	Safe
7	Valia	7642.66	4638.40	530.00	2882.16	60.69	Safe
8	Vagra	1262.53	285.00	209.00	921.53	22.57	Safe
	Total	**38869.93**	**18409.90**	**2978.00**	**19709.93**	**47.36**	**Safe**

Table: 3- Taluka wise groundwater structure in use.

Sl. No.	Name of taluka	Dug well	Shallow Tube well	Deep Tube well	Total
1	Amod	**1113**	**-**	**43**	**1156**
2	Ankleswar	**41**	**143**	**2**	**186**
3	Bharuch	**944**	**145**	**7**	**1096**
4	Jhagdia	**946**	**1353**	**148**	**2447**
5	Jambusar	**200**	**17**	**4**	**221**
6	Hansot	**169**	**-**	**-**	**169**
7	Valia	**1469**	**1862**	**3**	**3334**
8	Vagra	**81**	**-**	**-**	**81**
	Total	**4963**	**3520**	**207**	**8690**

NA -Data not available **(Source: M I Census 2000-01)**

Fig. 7



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. Groundwater development in Jhagadia taluka is highest (64.97%). The wells in hard rocks generally have low to moderate recuperation. The development of groundwater in Hansot taluka is low (11.89%) as the taluka is inherently saline in large part. The Taluka - wise groundwater structures are furnished in **Table3**.

Irrigation scenario from ground water sources

Dugwells: As per MI census 2000-01 there are 4963 dugwells Irrigation potential created through these dugwells is 19186 ha and potential utilized is 12201 ha. area.

Shallow tubewells: As per MI Census 2000-01 there are 3520 shallow tubewells. The irrigation potential created and utilized is 15240 ha and potential utilized is 12724 ha.

***Deep Tubewells*:** As per MI census 2000-01 there are 207 deep tubewells in the district. The irrigation potential created is 8246 ha.m and potential utilized is 5054 ha.

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		Shallow tubewells		Deep tubewells	
	Potential created	Potential utilized	Potential created	Potential utilized	Potential created	Potential utilized
Amod	**4639**	**270**			**4155**	**2077**
Ankleswar	**120**	**83**	**472**	**326**	**8**	**6**
Bharuch	**3939**	**1842**	**827**	**367**	**356**	**217**
Jhagdia	3701	**447**	**7983**	**6632**	**3513**	**2693**
Jambusar	**848**	**598**	**40**	**30**	**113**	**0**
Hansot	**638**	**2069**	**-**	**-**	**-**	
Valia	**5003**	**4032**	**5918**	**5369**	**101**	**61**
Vagra	**298**	**226**	**-**	**-**	**-**	**-**
Total	**19186**	**12201**	**15240**	**12724**	**8246**	**5054**

(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 47.36% of development. Hence, there is further scope for development of the ground water resources in the district. The irrigated area in the district forms about 8% of the total cultivable area (Table 5). The area irrigated by wells form about 99% 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.

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.

None of the talulkas has been notified either by Central Ground Water Authority (CGWA) or State Water Authority (SGWA)

Table: 5 Agricultural land and source irrigation

Sl. No.	Name of taluka	Geographical area	Cultivable area	Net area sown	Net area irrigated through			
					Major/medium scheme	Groundwater	Surface water	Total
1	Amod	45250	37809	33457	0	9130	0	9130
2	Ankleswar	43842	35340	32547	0	533	0	533
3	Bharuch	63257	50237	45895	0	2414	0	2414
4	Jhagdia	81795	48905	38333	0	7367	150	7519
5	Jambusar	111820	67605	64908	0	0	0	0
6	Hansot	39296	23704	22323	78	436	0	514
7	Valia	50160	40037	39560	0	9447	5	9452
8	Vagra	89184	50569	43513	0	285	0	285
	Total	524604	354206	320492	78	29612	157	29847

7. Agencies involved in resolving the issues:

Gujarat Water Resources Development Corporation, Gandhinagar, (GWRDC) Gujarat Water Supply & Sewerage Board, Gandhinagar (GWSSB), Rural Development Department, Gandhinagar are the agencies involved in resolving water related issues.

8. Available data base :

Data on water levels, water quality rainfall, landuse pattern, village wise source of water supply is available.

9. Information on Public Domain **(District information centre/ Website):**

Information on ground water resources, rainfall data , flood, disaster management, etc is available on web sites of
Narmada Water Resources Department http://guj-nwrws.gujarat.gov.in/**,**
Gujarat Water Resources Development Corporation (GWRDC)http://www.gwrdc.gujarat.gov.in/**,**

Gujarat Water Supply &Sewerage Board (GWSSB)http://www.gwssb.org/,
Gujarat Watershed Management Agency (www.ruraldev.**gujarat**.gov.in/wds.html)
and Gujarat State Disaster Management Authority(GSDMA) http://www.gsdma.org/

10. Technical issues identified in construction of wells:

The alluvial aquifers in the district are exploited with the help of dug well, dug-cum-bore well or shallow tube wells for irrigation. The yield of the alluvial wells vary from 400 to 700 lpm for drawdown varying from a few meter to as much as 21 m. However , a lot of the area in the western talukas particularly in the region adjoining the Gulf of Khambat is underlain by saline aquifers and hence not found suitable for ground water exploitation. The well in the hard rocks generally have low to moderate recuperation.

11. Areas notified under water law: Nil

12. Conclusion:

Large part of the alluvium area in the western part are not suitable for the ground water development due to high salinity. The gross annual ground water draft is of the order of 184.09 MCM/yr. The total ground water resources available in the district in the order of 388.69 MCM / yr. from the phreatic aquifer. From the point of view the ground water development in the all the talukas comes under the safe category except Amod and Jhagadia talukas falls in the semi-critical category.

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 river 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.

13. 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.**