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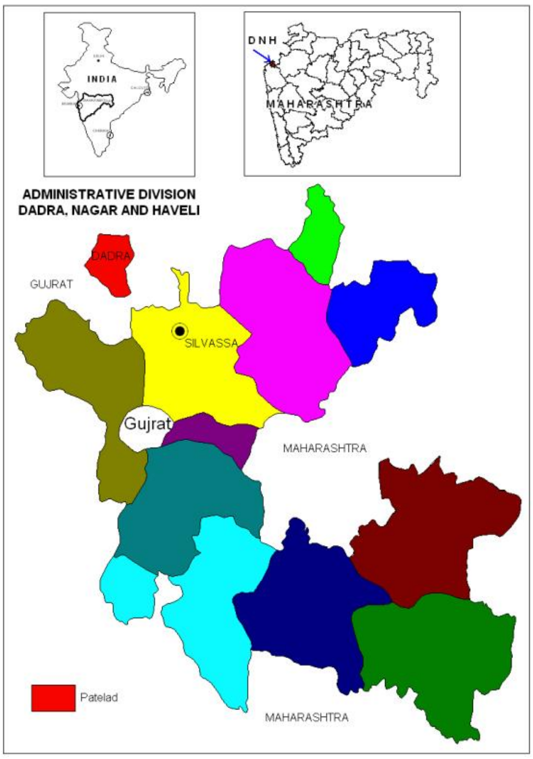
भारत सरकार
जल संसाधन मंत्रालय
केंद्रीय भूजल बोर्ड

GOVT OF INDIA
MINISTRY OF WATER RESOURCES
CENTRAL GROUND WATER BOARD

संघ राज्य क्षेत्र दादरा एवं नगर हवेली की भूजल विज्ञान जानकारी

GROUND WATER INFORMATION
UNION TERRITORY OF DADRA & NAGAR HAVELI



By

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Scientist-D

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मध्य क्षेत्र, नागपुर

CENTRAL REGION
NAGPUR
2013

UNION TERRITORY OF DADRA & NAGAR HAVELI AT A GLANCE

1. GENERAL INFORMATION		
Geographical Area		491 sq. km
Administrative Divisions (As on 31/03/2011)	:	Single Taluka with 11 Patelads; Amboli, Dadra, Dapada, Dudhani, Khanvel, Kilavani, Mandoni, Naroli, Randha, Silvassa-I and Silvassa-II
Villages	:	72
Population (2011)	:	3,42,853
Normal Annual Rainfall	:	2050 to 2500 mm
2. GEOMORPHOLOGY		
Major Physiographic unit	:	3; Residual Plateaus Denudational Slopes and Valley Plains
Major Drainage	:	3; Damanganga, Kolak and Kalunadi
3. LAND USE (2011)		
Forest Area	:	203.00 sq. km.
Area under Agriculture	:	210.15 sq. km.
4. SOIL TYPE		
Three types of soils, Lateritic Soil, Shallow Black cotton soil and Deep Black cotton soil		
5. PRINCIPAL CROPS (2011)		
Cereals	:	123 sq. km.
Pulses	:	37 sq. km.
Vegetables & Fruits	:	33 sq. km.
6. IRRIGATION BY DIFFERENT SOURCES (2011)**- Nos./Potential Created (ha)**		
Dugwells	:	388 / 649.09
Borewells	:	3 / 14.34
Surface Lift Sources	:	25 / 1149.06
Net Irrigated Area	:	1812.49
7. GROUND WATER MONITORING WELLS (As on 31/05/2012)		
Dugwells	:	8
Piezometers	:	Nil
8. GEOLOGY		
Upper Cretaceous-Lower Eocene	:	Deccan Trap Basalt
9. HYDROGEOLOGY		
Water Bearing Formation	:	Hard Rock: Deccan Traps-Weathered/Fractured/Jointed massive or vesicular Basalt
Premonsoon Depth to Water Level (May 2012)	:	3.80 to 10.61 m bgl
Postmonsoon Depth to Water Level (Nov. 2012)	:	1.75 to 7.96 m bgl
Annual Water Level Trend (2003-2012)	:	Rise: 0.04 to 0.31 m/year Fall: 0.01 to 0.45 m/year

10. GROUND WATER EXPLORATION (As on 31/03/11)

Wells Drilled	:	EW-09, OW-Nil
Depth Range	:	60 to 84 m bgl
Discharge	:	0.52 to 10.28 lps
Transmissivity	:	Deccan Trap Basalt-0.40 to 804 m^2/day

11. GROUND WATER QUALITY

Slightly Alkaline, Good and suitable for drinking and irrigation purpose.

12. DYNAMIC GROUND WATER RESOURCES- (As on 2008-09)

Net Annual Ground Water Availability	:	56.40 MCM
Annual Ground Water Draft (Irrigation+Domestic)	:	8.60 MCM
Allocation for Domestic and Industrial requirement up to next 25 years	:	8.66 MCM
Stage of Ground Water Development	:	15.26%

13. AWARENESS AND TRAINING ACTIVITY

Mass Awareness Programme	**:**	**Two**
a. Date	:	19/01/2006 & 14/03/2012
b. Place	:	Khanvel & Dudhani
c. Participants	:	350 & 175
Water Management Training Programme	**:**	**One**
a. Date	:	17 to 18/01/2006
b. Place	:	Silvassa
c. Participants	:	40
Projects under Technical Guidance	**:**	**Nil**

15. GROUND WATER CONTROL & REGULATION

Over Exploited Taluka	:	None
Critical Taluka	:	None
Notified Taluka	:	None

16. MAJOR GROUND WATER PROBLEMS AND ISSUES

The local people are not aware of the benefits of ground water development, modern agricultural/irrigation technology, the issues needs to be addressed by educating and creating awareness amongst the people to take up ground water development and practicing modern irrigation practices as it will help in increasing their agricultural produce, reduce their dependence on rain water for rain fed irrigation and improve their socio-economic conditions. The major parts of the UT are showing rise in long term water level trends however, some parts of the UT of DNH around Modpada, Shelti, Samarvarni and Dapada are showing falling ground water level trends. In the UT the ground water quality is good and potable for all kind of use, except area around Samarvarni village.

Ground Water Information
Union Territory of Dadra & Nagar Haveli

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Union Territory of Dadra & Nagar Haveli

1.0 Introduction

The Dadra and Nagar Haveli was born on 17th December 1779 as a result of a treaty between Portuguese and Marathas. It remained under the Portuguese Colonial Rule from 1783 to 1954.The Union Territory of Dadra and Nagar Haveli (UT of D&NH) was liberated from Portuguese occupation on 2nd August 1954 by the local nationalist workers. During the period 1954 to 1961 the selected Village Panchayat members ran the Administration of the territory. On 11th August 1961, it was declared as Union Territory under the Dadra and Nagar Haveli Act, 1961 (No. 35 of 1961) and was integrated with the Indian Union. The Union Territory of Dadra and Nagar Haveli is situated on the western coast of India between states of Gujarat and Maharashtra. It lies between north latitudes 20° 02’ and 20° 22’ and east longitudes 72° 54’ and 73° 14’ and falls in Survey of India Toposheet no. 46 D/15, 16, 46H/3 and H/4. The Territory is surrounded on the west, north and east by Valsad district of Gujarat State and in the south and southeast by Thane and Nashik districts of Maharashtra State.

The UT of D&NH is spread over an area of 491 sq. km. and comprises 72 villages and forms a single district and single taluka Union Territory. For revenue purpose all the villages have been divided in to 11 Patelads namely Amboli, Dadra, Dapada, Dudhani, Khanvel, Kilavani, Mandoni, Naroli, Randha, Silvassa-I and Silvassa-II. The headquarters of UT of D&NH is located at Silvassa.

The UT of D&NH is not linked with railway. The nearest railway station is Vapi in Valsad district (Gujarat State), which is almost 18 km from Silvassa. The UT is linked with NH-8 (Ahmedabad- Mumbai). The total population of the Union Territory is 3,42,853 as per 2011 census. Out of which 1,83,024 (53.38%) souls constitute rural population and 1,59,829 (46.62%) constitute urban population. The urban population in the last 10 years has increased by 68%. Forest and agriculture are the prominent land use in Dadra and Nagar Haveli and forms 41.46% and 44.62% of total area respectively followed by the industrial and built-up structures.

Central Ground Water Board has taken up several studies in the UT of D&NH. A list of studies conducted in the UT of DNH till March 2011 is presented below**.**

1. Systematic hydrogeological survey in 1976-77 covering the entire Territory.
2. Hydrogeological investigations for pin pointing the site for deep, large diameter community irrigation water supply wells in 1984.
3. Hydrogeological investigations for pin pointing the site for community irrigation dug wells in 23 hamlets in year 1984.

4. Hydrogeological surveys for pinpointing the sites for dug wells and bore wells in 22 villages/ hamlets facing acute water supply scarcity In the year 1987
5. Hydrogeological investigations in 21 villages/ hamlets in non-command areas for the construction of community irrigation wells, wherein construction of irrigation wells at 19 points was recommended in year 1990.
6. Hydrogeological investigations in 21 villages/ hamlets for the construction of large diameter dug wells in 1991.
7. Hydrogeological investigations in 21 villages/ hamlets for community irrigation wells 21 sites were selected in 1992.
8. Hydrogeological investigations for rural water supply in 34 villages for meeting the water supply in 1993.
9. Ground water resource estimation 2004, 2008-09 and 2011.

Ground water exploration in the UT of Dadra & Nagar Haveli has been taken up and a total of 9 exploratory wells have been drilled. Pumping test to determine aquifer parameters were also conducted. The main objectives of the Ground Water Exploration were to decipher the sub surface geology of the UT of Dadra & Nagar Haveli , identify various water bearing horizons, their depth range, yield and aerial extent, to compute hydraulic characteristics such as transmissivity, storage coefficient and specific capacity of the aquifer encountered and to evaluate chemical quality of ground water through samples collected from different aquifer. The salient features of ground water exploration are given in **Table-1**.

Table-1: Salient Features of Ground Water Exploration.

S. No.	Location	Depth	SWL	Discharge	Draw-down	Transmissivity	Specific Capacity	Zones Tapped
		(m)	(m bgl)	(lps)	(m)	(m^2/day)	(l/s/m.dd)	(m bgl)
1	Samarvarni 20°15’30” 73°0’30 46H/3	78.39	5.84	0.52	15.47	10.85	0.034	WB
2	Silvassa (Agri. Farm) 20°16’30” 72°59’30” 46 D/15	74.00	6.74	0.83	30.00	0.70	0.027	WVB: 7.17 – 17.00
3	Galonda 20°17’ 73°3’, 46 H/3	76.39	4.56	2.33	14.86	67.00	0.160	Jointed porphyritic basalt 17.11 – 18.11; VB- 21.59 – 22.59; JVB- 27.07 – 28.07
4	Naroli 20°16’30” 72°57’ 46 D/15	61.35	6.34	10.28	6.38	98.50	1.610	FVB- 15.00 - 16.11, 18.00 – 18.60, 24.20 – 25.00; Highly JMB- 54.70 – 55.40, 60.00 – 60.90

S. No.	Location	Depth	SWL	Discharge	Draw-down	Transmissivity	Specific Capacity	Zones Tapped
		(m)	(m bgl)	(lps)	(m)	(m^2/day)	(l/s/m.dd)	(m bgl)
5	Vagdhara 20°19'/72°58' 46 D/15	60.20	6.76	9.46	7.65	97.20	1.240	Highly JVB- 14.70 – 17.00; JVB- 59.00 – 60.20
6	Anboli 20°8' 73°1' 46 H/4	70.91	7.57	1.87	10.17	59.00	0.184	WVB- 17.11 – 18.11; VB- 21.59 – 22.59; JVB- 27.07 – 28.07; FVB- 36.03 – 38.03
7	Kherdi 20°7' 73°1' 46 H/4	72.51	4.73	3.16	17.50	41.20	0.180	FVB- 4.69 – 15.70
8	Rudhana 20°5' 73°5'30" 46H/4	84.35	5.66	0.60	30.00	0.40	0.020	FB- 7.30
9	Korchond 20°9' 30" 73°9'30"	71.50	5.25	10.16	1.89	804.00	5.370	VB- 18.00 – 20.65

Here, B- Basalt, W- Weathered, V- Vesicular, J- Jointed, F- Fractured, M- Massive.

The ground water exploration was carried out and 9 EW were constructed. The perusal of above table indicates that the depth of EW ranges from 60.20 to 84.35 metres below ground level (m bgl) and the yield ranges from 0.52 to 10.28 litre per second (lps). The transmissivity of the aquifer varies between 0.40 to 804 m^2/day whereas the Specific Capacity ranges between 0.020 and 5.370 lps/ m of dd.

A map of the UT of DNH showing the Patelad Boundaries, UT headquarters, physical features is presented as **Figure-1**, whereas the location of exploratory and monitoring wells is presented in **Figure-2**.

2.0 Climate and Rainfall

The climate of the Union Territory of Dadra and Nagar Haveli is characterised by an oppressive summer, dampness in the atmosphere nearly throughout the year, heavy southwest monsoon rainfall and a mild winter. The year can be divided in to four seasons. The cold season from December to February is followed by the summer season from March to May. The southwest monsoon season from June to September and the post monsoon season constitute the month of October and November. The average maximum temperature is recorded as 30.9°C whereas average minimum temperature is recorded as 19.6°C. The average wind speed recorded is 7.4 km/h. The rainfall in this area varies from 2050 mm to about 2500 mm and increases from east to west. It is minimum in the eastern parts around 2050 mm and about 2500 mm in the north western part. The distribution of average annual rainfall in the UT of D&NH is presented in **Figure-3**.

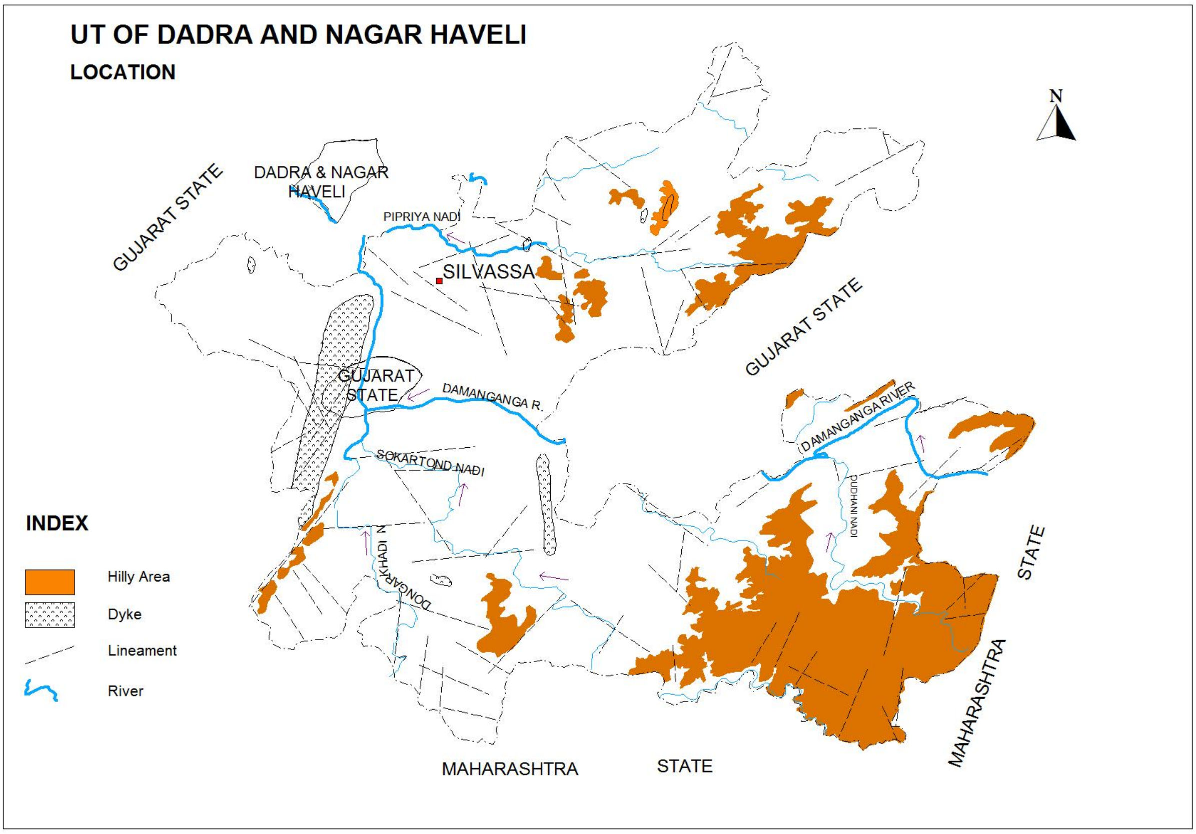


Figure 1: Location

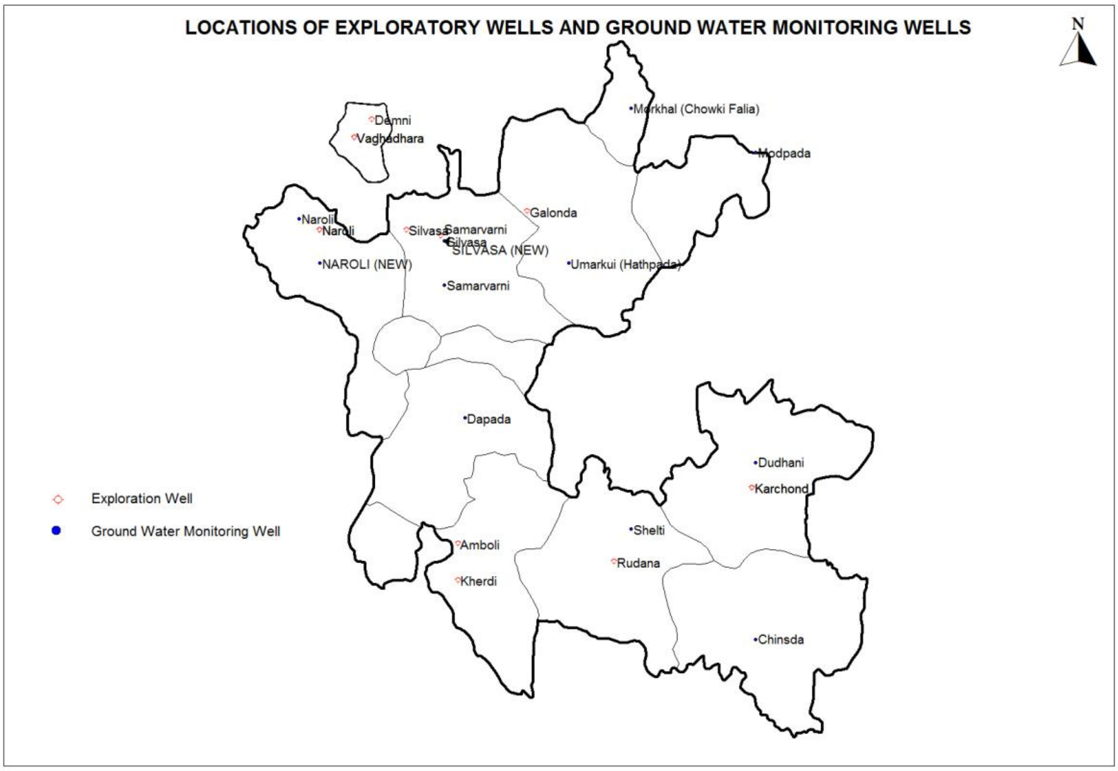


Figure 2: Location of Exploratory Wells and Ground Water Monitoring Wells

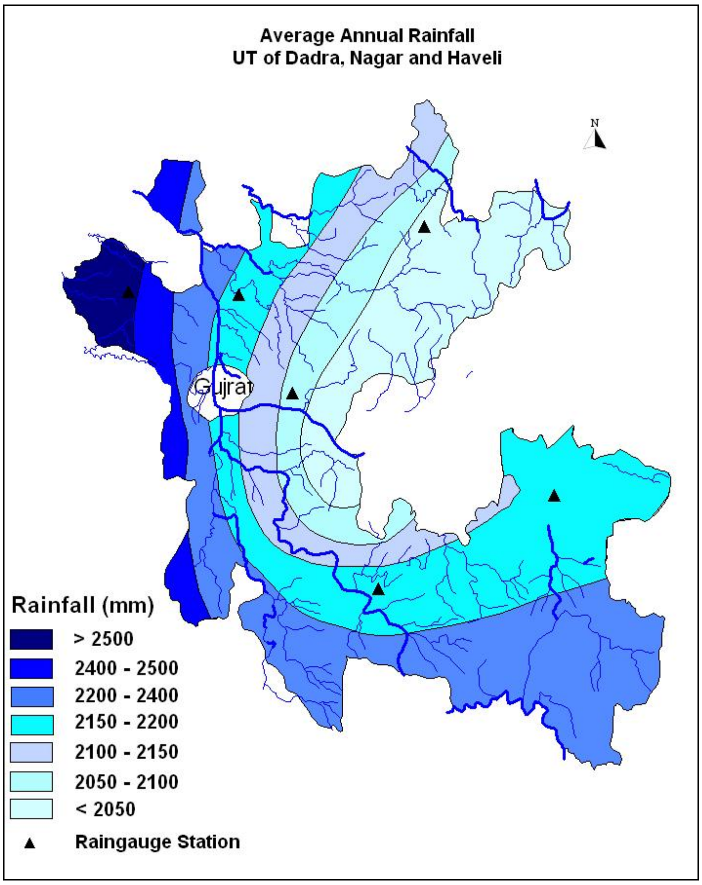


Figure 3: Distribution of Average Annual Rainfall

The annual rainfall data for the period 2002 to 2011 is presented in **Table-2**. The perusal of data indicates that the minimum rainfall of 1760.80 mm was received in the year 2002, whereas maximum rainfall of 2725.66 mm was received in the year 2005. The average annual rainfall for the decade was found to be 2387.01 mm.

The probability of occurrence of normal annual rainfall over the UT has been studied. It is observed that the chances of receiving normal annual rainfall are around 42%. The coefficient of variation of annual rainfall from normal is around 28%. The percentage probability of receiving excess rainfall (i.e. 25% or more in excess of the normal) is around 15% i.e. once in 6 to 7 years. A study of the negative departures of the annual rainfall from the normal reveals, that the probability of occurrence of moderate drought is around 14%, i.e. one drought in every 7 years.

Table 2: Annual Rainfall Data (2002-2011).

S. No.	Year	Rainfall (mm)
1	2002	1760.80
2	2003	2124.75
3	2004	2399.50

S. No.	Year	Rainfall (mm)
4	2005	2725.66
5	2006	2626.30
6	2007	2612.60
7	2008	2385.00
8	2009	2006.00
9	2010	2547.10
10	2011	2682.40
	Average	**2387.01**

(Source: Socio Economic Development of Dadra & Nagar Haveli, 2011-12)

3.0 Geomorphology and Soil Types

Physiographically the UT forms part of Deccan Plateau. The UT of D&NH is divided into three physiographic units i.e. Residual Plateaus, Denudational Slopes and Valley Plains and their description is as follows.

1) Residual Plateau's, these are flat-topped crests surrounded by steep scarps. These residual plateaus occur in the western fringe, the south-eastern part of and in the isolated patches in the northeastern part of the Territory. The elevation in this category ranges between 100-300 m amsl the elevation more than 200 m amsl is seen in north eastern and south-eastern part of the Territory.

2) Denudational Slopes, these form the scarp zone between plateaus and plains and comprises of moderate to steep slopes. The major area under this category lies almost in the eastern part in north south alignment in dissected form ranging roughly between 50 and 100 m above MSL.

3) Valley Plains, the valley plains form the flat topography with gentle slope of SE-NW forming the Damanganga River and its tributaries and it ranges in elevation below 50 m above m amsl. It comprises of weathered rock fragments and soils. The rock fragments are various sizes and mixed with soils.

The Union Territory of D & NH is mainly drained by Damanganga River and its tributaries (382.32 kms). The northern part (69.32 km) is drained by Kolak River and its tributaries. A small portion (37.26 km) of the Territory in the west is drained by the Kalunadi and its tributaries.

The soils occurring on the Deccan plateau are generally black cotton soils. Within this broad categorisation, there are significant variations depending upon topography. Three major type of soil occurs in the UT i.e., lateritic soils, shallow black cotton soils deep black soils and their description is as follows:

1) Lateritic Soil, these soils are well stabilised and have good porosity leading to good permeability and aeration and are non-calcareous soils and have low pH. **2) Shallow Black Cotton Soil**, are medium textured soils with gravels and pebbles and hard rock is met early below the soil restricting free movement of water and air. Though the soils are permeable enough, but have low moisture holding capacity and thus call for specific moisture management for sustainable land use under cultivation.

3) Deep Black Soil, are very deep soils having very high fertility and are capable of supporting a variable number of crops.

4.0 Ground Water Scenario

4.1 Hydrogeology

The major water bearing formation in the UT of DNH is Deccan Trap Basalt. A map depicting the hydrogeological features is shown in **Figure-4**.

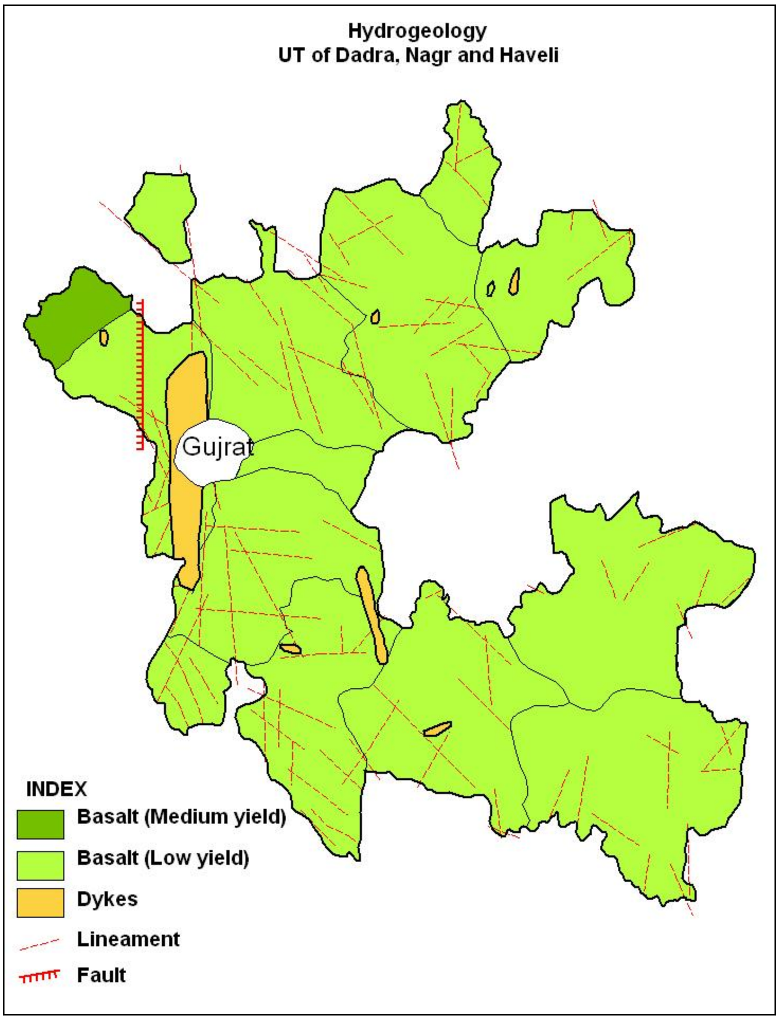


Figure 4: Hydrogeology

4.1.1 Hard Rock Formations

4.1.1.1 Deccan Trap Basalt

The basaltic lava flows are massive and fine grained with negligible primary porosity and transmissivity. The area occurs in the vicinity of western coast, which have witnessed many tectonic disturbances. These have caused development of joints and fractures in the basaltic strata. Also weathered zones of about 10-20 m thickness have developed in plains and depressions. Thus the weathered, jointed and fractured zones of vesicular and massive units of a flow constitute the main water bearing horizons. However, these zones are not continuous and uniformly developed laterally or vertically and this factor plays an important role in the success and failure of wells in the area.

On the basis of hydrogeological data collected from dugwells and results of pumping tests on wells it is revealed that ground water occurs under both water table and semi-confined to confined conditions in the various lava flows consisting of vesicular and massive units. The occurrence of ground water under confined conditions is observed in the western part of the area around Naroli and Dadra. The potential confined aquifers occur at an attitude of 20 m below the mean sea level and with compact, amygdular and massive basalt of about 25 m thickness acting as a confining layer. The thick confining layer also inhibits vertical leakage to the confined aquifers. The confined aquifers also show lateral variation in hydraulic characteristic within short distances.

4.2 Water Level Scenario

Central Ground Water Board periodically monitors 8 National Hydrograph Network Stations (NHNS) stations in the UT of DNH, four times a year i.e. in January, May (Premonsoon), August and November (Postmonsoon). The water level data for the year 2011-12 is given below in **Table- 3**.

Table 2: Water Level Data (2012-2013).

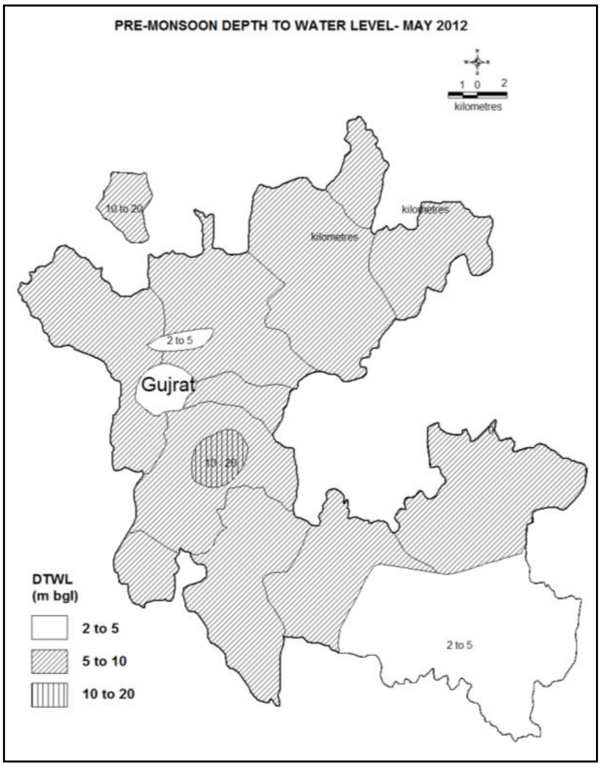
S. No.	Location/Villages	May-12	Aug-12	Nov-12	Jan-13	Fluctuation
1.	Chinsda	3.8	0.95	1.75	1.86	2.05
2.	Dapada	10.61	7.8	7.96	9.03	2.65
3.	Dudhani		5.6	3.1	5.84	-
4.	Samarvarni	4.63	2.8	2.83	3.82	1.8
5.	Shelti	5.05		2.05	2.81	3
6.	Umarkui (Hathpada)	9.55	0.8	2.63	5.2	6.92

4.2.1 Depth to Water Level – Premonsoon (May-2012)

The depth to water levels in the UT of DNH during premonsoon ranges between 3.80 (Chinsda) and 10.61 (Dapada) m bgl. Depth to water level during premonsoon has been depicted in **Figure-5**. Very shallow water levels in the range of 2 to 5 m bgl are seen in south eastern part of UT of DNH. In major part of the UT of DNH water levels are observed between 5 and10 m bgl, whereas moderately deep water levels ranging between 10 and 20 m bgl are observed in small central part of the UT of DNH.

4.2.2 Depth to Water Level – Postmonsoon (Nov.-2012)

The depth to water levels during postmonsoon ranges between 1.75 m bgl (Chinsda) and 7.96 m bgl (Dapada). Spatial variation in postmonsoon depth to water levels is shown in **Figure-6**. Very shallow water levels in the below 2 m bgl are seen in south eastern part of UT of DNH. In major part of the UT of DNH water levels are observed between 2 and 5 m bgl, whereas moderate water levels ranging between 5 and 10 m bgl are observed in central part of the UT of DNH.



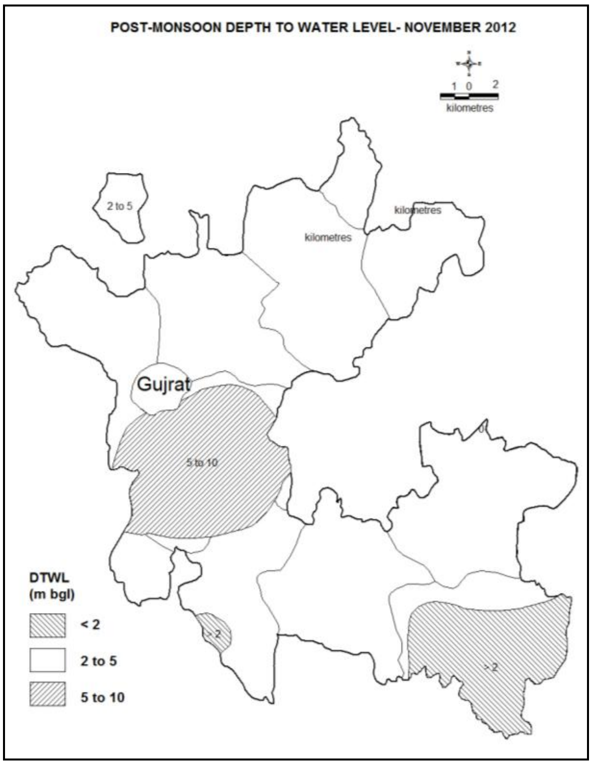


Figure 5 & 6: Premonsoon (May 2012) & Postmonsoon (Nov. 2012) Depth to Water Level

4.2.3 Seasonal Water Level Fluctuation– (May-Nov. 2012)

The seasonal fluctuations in water levels have been observed in the range of 1.80 m (Samarvarni) to 6.92 m (Umarkui (Hathpada)). Rise in water levels in the range of 2 to 4 m is observed in major parts, whereas rise of more than 4 m is mainly observed in north parts of the UT of DNH.

4.2.4 Water Level Trend (2003-2012)

Annual water level trends for last ten years (2003-2012) have been computed for 10 NHNS. Analysis of trend indicates that rise in water levels has been recorded at 6 stations and it ranges between 0.04 (Umarkui) and 0.31 m/year (Morkhal). Fall in water levels has been observed at 4 stations and ranges between 0.01 (Dapada) and 0.45 m/year (Modpada). In majority of NHNS, rising trend of water levels has been observed.

Table 2: Water Level Trend Data (2003-2012).

S No.	Location	Annual trend (m/year)	
		Rise	**Fall**
1	Silvasa (New)	0.25	
2	Modpada		0.45
3	Morkhal (Chowki Falia)	0.31	
4	Chinsda	0.13	
5	Shelti		0.06
6	Dudhani	0.17	
7	Dapada		0.01
8	Samarvarni		0.10
9	Naroli (New)	0.05	
10	Umarkui (Hathpada)	0.04	

4.3 Aquifer Parameters

Pumping tests on 24 open wells have been conducted during various surveys of CGWB to determine the aquifer parameters such as specific capacity, transmissivity etc. The specific capacity of the wells was determined by using the Slichter's formula.

The analysis of pumping test data reveals that the specific capacity value ranges between 3.00 and 300 lpm/m of drawdown in the wells tapping basaltic formations whereas in alluvium the specific capacity is 740 lpm/ m of drawdown. The variation is specific capacity in the basalt is due to the wide differences in the hydraulic characteristics of the aquifer. The transmissivity of shallow aquifers has been determined using Jacobs method and it ranges between 5.5 and 305 m^2/day. The optimum yield of shallow aquifer in the area ranges from 9 m^3 /day to 1800 m3/day.

The pumping test data of exploratory wells has been analysed using Jacob's method and the transmissivity was found to be varying from 0.40 to 804 m^2/day. The specific capacity of deeper aquifer ranges from 0.02 - 5.37 lps/m of drawdown.

4.4 Ground Water Resources

The estimation of ground water resources of UT of Dadra & Nagar Haveli has been done by Central Ground Water Board, Central Region, Nagpur as per the recommendations of GEC 1997 Methodology. Ground Water Resources estimation was carried out for 416.00 sq. km. area out of which 42.35 sq. km. is under command and 373.65 sq. km. is non-command.

As per the estimation the total annual ground water recharge is 59.37 MCM with the natural discharge of 2.96 MCM, thus the net annual ground water availability comes to be 56.40 MCM. The annual ground water draft for all uses is estimated at 8.60 MCM with domestic sector being the major consumer having a draft of 7.49 MCM, whereas draft for irrigation purpose is only 1.11 MCM. The allocation for domestic and industrial requirement up to next 25 years is 8.66 MCM. The net ground water availability for future irrigation is estimated at 46.62 MCM. The UT of DNH being considered as a single taluka/unit for assessment purpose its stage of development was assessed as 15.25% and has been categorised as “Safe’. The details of ground water assessment are presented in Table 5.

Table-5: Ground Water Resources (2008-09) (figures in ham)

Area Type	Net Annual Ground Water Availability	Existing Gross Ground Water Draft for irrigation	Existing Gross Ground Water Draft for domestic and industrial water supply	Existing Gross Ground Water Draft for All uses	Provision for domestic and industrial requirement supply to 2025	Net Ground Water Availability for future irrigation development	Stage of Ground Water Development
Command	1180.68	32.97	337.95	370.92	511.5	636.21	31.41
Non Command	4459.89	78.50	411.30	489.80	354.97	4026.42	10.98
Total	**5640.57**	**111.47**	**749.25**	**860.72**	**866.47**	**4662.63**	**15.25**

4.5 Ground Water Quality

CGWB is monitoring the ground water quality of the UT of DNH since the last three decades through its established monitoring wells. The objectives behind the monitoring are to develop an overall picture of the ground water quality of the UT. During the year 2012, the Board has carried out the ground water quality monitoring of 4 monitoring wells. These wells consists of the dugwells representing the shallow aquifer. The sampling of ground water from these wells was carried out in the month of May 2012 (pre-monsoon period). The water samples after collection were immediately subjected for the analysis of various parameters in the Regional Chemical Laboratory of the Board at Nagpur. The parameters analyzed, include pH, Electrical Conductivity (EC), Total hardness (TH), Calcium (Ca), Magnesium (Mg), Sodium (Na), Potassium (K), Carbonate (CO_3), Bicarbonate (HCO_3), Chloride (Cl), Sulphate (SO_4), Nitrate (NO_3) and Fluoride (F). The sample collection, preservation, storage, transportation and analysis were carried out as per the standard methods given in the manual of American Public Health Association for the Examination of Water and Wastewater (APHA, 1998). The ground water quality data thus generated was first checked for completeness and then the validation of data was carried out using standard checks. Subsequently, the interpretation of data was carried out to develop the overall picture of ground water quality in the UT for the year 2012.

Table-6: Results of Ground Water Analysis.

Location	pH	EC µS/cm	TH as $CaCO_3$	Ca	Mg	Na	K	CO3	HCO_3	Cl	SO_4	NO_3	F	RSC
			mg/L											
Dapada	7.45	619	250	60	24	24	1.93	0	317	28	1.7	0.04	0.48	1.0
Samar-varni	7.5	1105	295	44	45	126	1.93	0	458	124	19	0.4	0.82	3.0
Umarkhui	7.55	453	185	54	12	12	2.18	0	226	21	2.4	0.1	0.25	0.4
Chinsda	6.97	262	120	18	18	9	0.48	0	140	14	6.1	0.1	0.09	0.5

4.5.1 Suitability of Ground Water for Drinking Purpose

The suitability of ground water for drinking purpose is determined keeping in view the effects of various chemical constituents in water on the biological system of human being. Though many ions are very essential for the growth of human, but when present in excess, have an adverse effect on human body. The standards proposed by the Bureau of Indian Standards (BIS) for drinking water (IS-10500-91, Revised 2003) were used to decide the suitability of ground water. The classification of ground water samples was carried out based on the desirable and maximum permissible limits for the parameters viz., viz., TH, Ca, Mg, Cl, SO4 and NO_3 prescribed in the standards and is given in **Table-7**.

Table-7: Classification of Ground Water Samples for Drinking based on BIS Drinking Water Standards (IS-10500-91, Revised 2003)

Parameters	DL	MPL	Samples with conc. < DL	Samples with conc. in DL-MPL	Samples with conc. >MPL
TH (mg/L)	300	600	4	Nil	Nil
Ca (mg/L)	75	200	4	Nil	Nil
Mg (mg/L)	30	100	3	1	Nil
Cl (mg/L)	250	1000	4	Nil	Nil
SO_4 (mg/L)	200	400	4	Nil	Nil
NO_3 (mg/L)	45	No relaxation	4	--	Nil
F (mg/L)	1.0	1.5	4	Nil	Nil

(Here, DL- Desirable Limit, MPL- Maximum Permissible Limit)

The perusal of **Table-7** shows that the concentrations of all the parameters in almost all the samples are below the maximum permissible limit of the BIS standards. Only one sample is having the concentration of Total Magnesium (Mg) more than the desirable limits but within the maximum permissible limit. Overall, it can be concluded that the ground water quality in the wells monitored in the UT is suitable for drinking.

4.5.2 Suitability of Ground Water for Irrigation Purpose

The water used for irrigation is an important factor in productivity of crop, its yield and quality of irrigated crops. The quality of irrigation water depends primarily on the presence of dissolved salts and their concentrations.

Electrical Conductivity (EC) and Residual Sodium Carbonate (RSC) are the most important quality criteria, which influence the water quality and its suitability for irrigation.

4.5.2.1 Electrical Conductivity (EC)

The amount of dissolved ions in the water is best represented by the parameter electrical conductivity. The classification of water for irrigation based on the EC values is as follows.

Low Salinity Water (EC: 100-250 µS/cm): This water can be used for irrigation with most crops on most soils with little likelihood that salinity will develop.

Medium Salinity Water (EC: 250 – 750 µS/cm): This water can be used if moderate amount of leaching occurs. Plants with moderate salt tolerance can be grown in most cases without special practices for salinity control.

High Salinity Water (EC: 750 – 2250 µS/cm): This water cannot be used on soils with restricted drainage. Even with adequate drainage, special management for salinity control may be required and plants with good salt tolerance should be selected.

Very High Salinity Water (EC: >2250 µS/cm): This water is not suitable for irrigation under ordinary condition. The soils must be permeable, drainage must be adequate, irrigation water must be applied in excess to provide considerable leaching and very salt tolerant crops should be selected.

The classification of ground water samples collected from monitoring wells for irrigation purpose was carried out and given below in **Table-8**.

It is clear from the **Table-8** that maximum number of samples (73%) falls under the category of high salinity water while nearly 75% of samples fall in low salinity water category. This shows that the ground water in the pre-monsoon season from shallow aquifer in the UT of DNH is suitable for irrigation.

Table-8: Classification of Ground Water for Irrigation based on EC.

Type	**EC (µS/cm)**	**No. of Samples**	**% of Samples**
Low Salinity Water	<250	3	75
Medium Salinity Water	250-750	1	25
High Salinity Water	750-2250	Nil	Nil
Very High Salinity Water	>2250	Nil	Nil
Total		**4**	**100.0**

4.5.2.2 Residual Sodium Carbonate (RSC)

Residual Sodium Carbonate (RSC) is considered to be superior to EC as a measure of sodicity particularly at low salinity levels. The classification of ground water samples based on RSC values for its suitability for irrigation purpose is shown below in **Table-9**.

Table-9: Classification of Ground Water for Irrigation based on RSC.

Type	RSC	No. of Samples	% of Samples
Good	<1.25	3	75
Doubtful	1.25-2.50	1	25
Unsuitable	>2.50	Nil	Nil
Total		**4**	**100**

The perusal of **Table-9** shows that the RSC values of ground water samples collected from the wells is less than 1.25 in about 75% of wells, which reflects that the overall quality of ground water in the monitoring wells is good for irrigation purpose.

The high values of RSC (>2.50) and EC (250 – 750 µS/cm) was found in only 1 sample located at Samarvarni and thus it falls in doubtful category.

4.6 Status of Ground Water Development

Ground water development depends on many factors viz., availability, crop water requirement, socio-economic fabric and on the yield of the aquifers existing in that area.

Ground water is predominantly used for domestic, as it is the major ground water utilising sector. As per the data (2008-09) provided by the administration of UT of DNH, there are 264 dugwells and 1401 borewells are utilised to meet the domestic water requirements.

The Socio-Economic Development Booklet of UT of DNH (2011-12) indicates that area irrigated by ground water is 6.50 sq. km., whereas the surface water accounts for about 11.50 sq.km. and the net irrigated area is about 18.12 sq.km., thus ground water account for 35 %, of net irrigated area. There are about 388 irrigation dugwells and 3 irrigation tubewells in the UT which, create an irrigation potential of 6.50 sq.km.

5.0 Ground Water Management Strategy

Ground water has special significance for sustaining the drinking water requirements and agricultural development in the UT of DNH. Although ground water development is low in the UT of DNH, but in some parts declining ground water levels have been observed. Thus there is a need to adopt an integrated approach of development of ground water resources dovetailed with ground water augmentation to provide sustainability to ground water development.

5.1 Ground Water Development

Ground Water Development of the area has been done through both dug wells, and bore wells for irrigational as well as for domestic supply. Ground water development scenario of the UT of DNH is favorable for further ground water development in years to come as the stage of ground water development for the UT is merely 15% and ground water available for future irrigation is about 46.62 MCM. The development of this resource will increase the irrigation potential of the UT of DNH manifold and it will be less expensive in time and cost as compared to surface water. The poor development of ground water is due to the following socio-economic reasons:

- Villagers have got very small land holdings and they do not consider agriculture as an economical prospect.
- The cultivators are illiterate, tribal and are ignorant of improved agricultural practices.
- Due to the command area of the Damanganga project, there is less demand on ground water for irrigation.

The dugwells are found to be the most reliable source of ground water extraction. In order to develop the available ground water resource for future irrigation, dugwells down to the depth of 12 to 15 m with 4 to 5 m diameter are found to be feasible in Deccan Trap. It is observed that 3-4 hours of well pumping can give a sustainable yield of about 30 m^3/day. The borewells, if taken, needs to be taken up after proper hydrogeological survey of the area.

5.2 Water Conservation and Artificial Recharge

Ground water plays vital role for meeting the domestic and irrigation requirements in the UT of DNH. At present, the water levels are also shallow and trend is also rising at many places, however, declining water level trend has also been observed. There is a need to increase to conserve water flowing out from area through rivers and nalas at various places by constructing different types of water conservation structures. These structures will not only prevent outgoing surface run-off from the small watersheds, but also will act as artificial recharge structures and arrest soil erosion.

In Basaltic area, the artificial recharge structures feasible are check dams, gully plugs, percolation tanks, nala bunds, etc. Existing dugwells can also be used for artificial recharge, however, the source water should be properly filtered before being put in the wells.

6.0 Ground Water Related Issues and Problems

As such, there is no ground water related issue or problem, the rainfall is high, water levels are shallow and are showing rising trend in most part of the UT of DNH. The ground water quality was also found potable for drinking purpose and suitable for irrigation. However, the issue of low ground water development needs to be addressed by educating and creating awareness amongst the people to take up ground water development for irrigation purposes as it will help in increasing their agricultural produce, reduce their dependence on rain water for rain fed irrigation and improve their socio-economic conditions.

7.0 Mass Awareness and Training Activities

7.1 M.A.P. and W.M.T.P.

Till March 2012, two MAP had been organised at Khanvel and Dudhani, whereas one WMTP has been organised at Silvassa. The details are given in **Table-8**.

Table-8: Status of MAP & WMTP.

S. No.	Item	AAP	Venue	Date	Participants
1	WMTP	2005-06	Silvassa	17 to 18/01/2006	40
2	MAP	2005-06	Khanvel	19/01/2006	350
3	MAP	2011-12	Dudhani	14/03/2012	175

7.2 Participation in Exhibition, Mela, Fair etc.

During the MAP at Silvassa and Khanvel, an exhibition depicting rainwater harvesting model, various ground water related posters, leaflets, literature and technical reports were displayed along with maps of UT of DNH. The models, maps, posters were explained to the visitors in details.

8.0 Areas Notified by CGWA/SGWA

As per ground water resource estimation the UT of DNH falls under “Safe” category, hence till March 2012 the area has not been notified either by CGWA or SGWA.

9.0 Recommendations

1. The dugwells are most suitable structures for ground water development in the UT of DNH. The sites for borewell wherever feasible, need to be selected only after proper scientific investigation.
2. Ground water development scenario of the UT of DNH is favourable for further ground water development in years to come as the stage of ground water development for the UT is merely 15% and ground water available for future irrigation is 46.62 MCM.
3. The development is to be carried out in a planned manner using suitable ground water abstractions structures depending on the terrain, aquifer potential, quality aspects etc.
4. Dugwells down to the depth of 12 to 15 m with 4 to 5 m diameter are found to be feasible in Deccan Trap. It is observed that 3-4 hours of well pumping can give a sustainable yield of about 30 m3/day.

5. Some parts of the UT of DNH around Modpada, Shelti, Samarvarni and Dapada are showing falling ground water level trends, hence the water conservation and artificial recharge structures needs to be taken up in areas.
6. The scope exists for construction of suitable artificial recharge structures in the UT. In Basaltic area, the artificial recharge structures feasible are check dams, gully plugs, percolation tanks, nalla bunds, etc. Existing dugwells can also be used for artificial recharge, however, the source water should be properly filtered before being put in the wells.
7. The existing village ponds need to be rejuvenated to act both as water conservation and artificial recharge structures.
8. As the local people are not aware of the benefits of ground water development, modern agricultural/irrigation technology, the issues needs to be addressed by educating and creating awareness amongst the people to take up ground water development and practicing modern irrigation practices as it will help in increasing their agricultural produce, reduce their dependence on rain water for rain fed irrigation and improve their socio-economic conditions.
9. Hence ground water development, augmentation and management perspective issues are to be taken up together. However, scientific and multi-sectoral approaches are needed. Hence all the aspects related to development and augmentation, involvement of NGOs and adapting modern irrigation practices etc will play an important role in conserving and developing the precious water resources.