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Technical Report Series

GROUNDWATER BROCHURE
DIU
UT of DAMAN & DIU

Compiled
By

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STA (GP)

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Ministry of Water Resources
CENTRAL GROUND WATER BOARD
West Central Region
Ahmedabad
April 2014

UT of DIU AT A GLANCE

SL No.	Items	Statistics	
1	General Information		
	i) Geographical Area (Sq Km)	40	
	ii) Administrative Divisions (As on 31/3/2009) Number of Taluka Number of Villages	1 1 4	
	iii) Populations (As per 2011 census)	52,056	
	iv) Average Annual Rainfall (mm)	864	
2.	Major Physiographic Units	Gently rolling topography with central highland	
	Major Drainages	Nil	
3.	LAND USE (Sq Km)		
	a) Forest area b) Net area sown c) Cultivable area	5.16 5.41 5.43	
4.	MAJOR SOIL TYPES	Calcareous soil and blown sand	
5.	AREA UNDER PRINCIPALFOODGRAIN CROPS	4.30	
6.	IRRIGATION BY DIFFERENT SOURCES (Areas and numbers of structures) (Source :Statistical abstract Gujarat 2006)	No.	Area (Sq Km)
	Dug wells	-	
	Tube wells/Bore wells	-	
	Canals		8.34
	Other Sources	-	-
	Net Irrigated area (Sq Km)	1.40	
	Gross Irrigated area (Sq Km)	1.51	
8.	PREDOMINANT GEOLOGICAL FORMATIONS		
	a) Milliolite limestone b) Coastal Alluvium.		
9.	HYDROGEOLOGY		
10.	GROUND WATER EXPLORATION BY CGWB (As on 31 -03 -2009)		
	No of wells drilled (EW, OW, Pz, SH, Total)		

EW	OW	Pz	SH	Total
2	2	4	None	8

	Depth Range(m)	18-50
11	GROUND WATER QUALITY	
	Presence of chemical constituents more than permissible limit (e.g. EC,F,As,Fe)	Drinking – No Irrigation- Iron toxicity, Alkalinity Hazard. Sodium-81.35
	Type of water	Freshwater float above

		saline water in upland areas, Brine in the deeper aquifers
12.	DYNAMIC GROUND WATER RESOURCES (2011)- in MCM	
	Annual Replenisible Ground Water Resources	5.50
	Net Annual Ground Water Draft	4.95
	Projected Demand for Domestic and industrial Uses up to 2025	0.80
	Stage of Ground Water Development	116.58%
13	AWARENESS AND TRAINING ACTIVITY	
	Mass Awareness Programmes organized Date Place No of Participants	One Water Resources day was organised on 28/3/1999 Diu > 200
	Water Management Training Programmes organized Date Place No of Participants	One 08th March 2003 Diu 50
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	
	Number of OE Blocks	1
	Number of Critical Blocks	1
	Number of blocks notified	1
16	MAJOR GROUND WATER PROBLEMS AND ISSUES	
	i) Salinity in Ground water not only by normal coastal salinity ingress but also by inherent salinity. ii) The cavernous nature of the Milliolite limestone with the conduits extending right into the sea, makes it highly vulnerable to sea water ingression. iii) Occurrence of limited fresh water floating above the saline water. iv) Even on the central high land heavy pumping may cause upcoming of saline water. v) Frequent Draught vi) Over exploitation of available fresh water along the coastal strip. (upto 1 km from the coast) Because of the location and geographical set up and non availability of potable water the district has not found any industrial growth.	

DISTRICT GROUND WATER BROCHURE
UT OF DIU

INTRODUCTION

Diu is a completely isolated island from mainland Gujarat by a east-west extending marshy low land which remains covered by the tidal waters of the Arabian sea. It is a Union Territory under UT of Daman and Diu. Diu is situated between north latitudes 20°44'39" & 20°42'00" and east longitudes 70°52'26"& 71°00'24" and falls in Survey of India toposheet No. 41 L/14. It covers an area of 40 sq. km with 19.2 km length and width varying from 1 to 2.5 km. Out of the total area 22.24 Sq. Km is Rural area and 17.76 Sq.km is urban area. The UT is bounded on the northwest by Junagadh district, whereas to the east it is the Amreli district. The Arabian sea, with its partly rocky and partly sandy shore forms the southern boundary. Central Ground Water Authority (CGWA) has notified the UT of Diu since 1999 on the basis of limited fresh water resources.

Administrative Divisions

There are 10 hamlets (4 villages) and the town of Diu, all situated on the main island where as the 5th village Goghla is situated on a small projection of the main land which is separated from the Diu island by a small channel.

Demography

The total population of the district as per 2001 census is 44,215, which include 20878 male and 23337 female. The sex ratio is about 1110 Women per 1000 men. The rural population is 22637 and urban population is 21578.

Previous Work

The Central Ground Water Board carried out two short-term investigations in connection with domestic water supply (Saleem Romani, 1971 and A. Ahmed, 1980). Saleem Romani surveyed only the area around Bucherwada whereas A. Ahmed surveyed the entire Diu island. Later ground water exploration was carried out by CGWB and four exploratory wells (2 EW and & OW) were constructed. The maximum explored depth is 200m bgl. 4 more Piezometers were constructed during the years 2008 and 09.

RAINFALL AND CLIMATE

Diu being an island enjoys a maritime climate, with the constant sea breezes affecting its temperature. With a plain topography, the weather remains dry, though pleasant throughout the year. During summers, the climate in Diu ranges between a maximum of 36°C and a minimum of 20°C. However, during winters, it comes down to a maximum of 26°C and the minimum temperature remains about 20°C.

Small hillocks of sand dunes, with a maximum height of not more than 30 metres form the central high land. The soil is barren and dry, and receives an average annual rainfall of about 598.60 mm. The monsoon season lasts from the month of June to September. The maximum rainfall during the monsoons is about 635 mm. With an abundant of palm and coconut trees shooting throughout the place, Diu enjoys a lush and varicoloured

vegetation. Some of the major plants found in Diu are Casuarinas, Furiflora, Acacia, and Hoka etc.

Rain fall

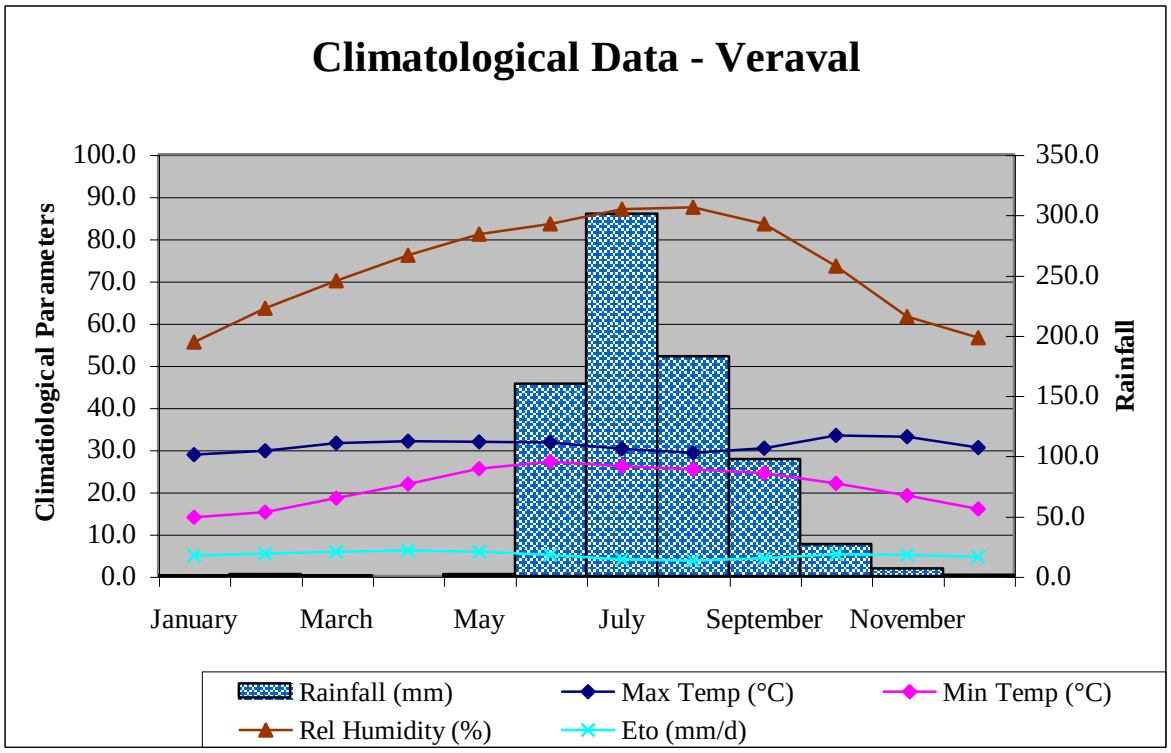
The rainfall occurs during the southwest monsoon, starting from June and extending up to October. The rainfall is inconsistent, with average annual rainfall 598.60mm in 34 rainy days. The long term average annual rainfall is 664.04 mm. Rainfall analysis revealed that the co-efficient of variation is 37.99%. This suggests the wide variability of the annual rainfall. Long term monthly means of annual rainfall distribution shows that over 90 % of the rainfall occur between mid-June to mid-September due to southwest monsoon and associated intense low-pressure system. The cumulative departure pattern infers erratic rainfall. The rainfall characteristics have a strong impact on the groundwater level and quality of UT of Diu, which is discussed in the detail under groundwater scenario.

The relative humidity in the near by Veraval as per IMD varies between 55.5% January and 87.5% during August. The wind velocity in the Veraval varies from about 205 km/d during November to about 561 km/d during July.

The potential Evapo-transpiration, calculated using Penman's Method varies between 3.7 mm/d during August and 6.0 mm/d during April. The nearest station is situated in Veraval district Junagadh (20°54' N: 70 22' E- Altitude 8.0 m amsl.) and its detail is given table-1

Table- 1 Climatological data for IMD station Veraval

Month	Max Temp (°C)	Mini Temp (°C)	Humidity (%)	Wind Spd. Kmpd	Sunshine (Hours)	Solar Rad. (MJ/m2/d)	Evapotrans –piration (Eto) (mm/d)	Rain fall (mm)
January	28.8	14.0	55.5	242.4	9.70	18.5	4.8	0.6
February	29.7	15.1	63.5	258.3	10.30	21.3	5.2	1.7
March	31.5	18.5	70.0	291.9	9.90	23.0	5.8	0.4
April	32.0	21.8	76.0	318.4	10.50	25.4	6.0	0.0
May	31.8	25.5	81.0	337.9	10.30	25.5	5.8	1.5
June	31.6	27.1	83.5	447.6	7.40	21.0	5.1	159.5
July	30.1	26.1	87.0	560.8	4.00	15.8	3.9	300.5
August	29.2	25.3	87.5	465.2	4.30	16.0	3.7	182.6
September	30.3	24.4	83.5	311.3	6.20	18.0	4.2	97.0
October	33.3	22.0	73.5	226.4	9.40	20.8	5.2	26.6
November	33.1	19.1	61.5	205.2	9.70	18.9	5.0	6.1
December	30.4	15.9	56.5	217.6	9.50	17.5	4.6	1.0
Total	-	-	-	-	-	-	-	777.5
Average	31.0	21.2	73.3	323.6	8.4	20.1	4.9	119.6



GEOMORPHOLOGY AND SOIL TYPE

There is a central high land made up of sand dune and sloping in all the direction and the reduced level comes to around 2 m agl along the coast.

Soil

Up to almost a kilometre from the coast, the soils are saline and alkaline with higher percentage of silt. These are formed due to degeneration of coastal soils by salinity ingress. These soils slowly grade into yellowish brown calcareous soils which contain admixture of medium to coarse grained material comprising Miliolite shell pieces. They range in thickness from 0.3 to 1 m. in low lying areas, accumulation of organic material coupled with intense weathering, have given rise to black cotton soil covers varying from few cm to nearly a metre in thickness. The blown sand deposits, on the central high land, are essentially weathered products of the friable Miliolite limestone and are thus highly calcareous.

GROUND WATER SCENARIO

Geology

The area comprises Miliolite limestone of Pleistocene to Recent age and of about 50 m thick. It is a highly porous limestone which is friable except for the one or two layers near the ground surface, where the calcification of the limestone due to calcium carbonate solution has given rise to hard and compact crust. The Miliolite limestone is of high grade with very little contents of magnesium and insoluble. Solution activity has resulted in formation of caverns of varying dimensions. This karstic activity is more predominant in the zone of water level fluctuation and near the lower contact with the underlying clay

formations. The limestones exhibits strike which is roughly parallel to sea and the dips are undulating like typical sand-dune deposits.

Miliolite limestones are underlain by Gaj formations of Miocene age. The Gaj formations comprise upper yellowish white clays underlain by interbedded marls, calcareous sandstones and grits, impure limestones and clays. The Gaj formation is found to be extending down to the explored depths of 200m. The base of Gaj Formation rests over the Deccan Trap Basalt.

The generalized geological succession in the area is as follows

Age	Formation	Lithology	Max. thickness/ Remarks
Recent to Pleistocene	Coastal Alluvium & Miliolite limestone	Sand, clays, Miliolite-limestone	40-50 m
Miocene (Tertiary)	Gaj beds	Clay, Marl, calc. sandstone, lime stone etc.	+ 200 m Not exposed
Upper Cretaceous to Eocene	Deccan Trap	Basaltic lava	Not exposed

Hydrogeology

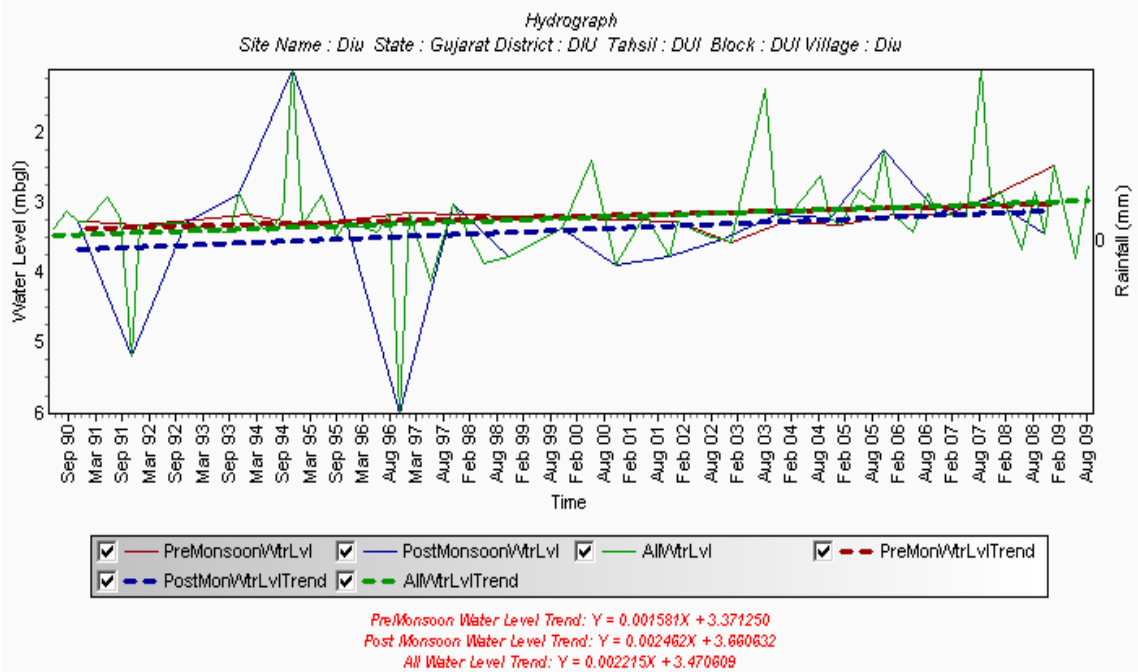
Ground water occurs under water table condition in the Miliolite limestone. The depth to water table varies from 12 m bgl in the central high land to 3 m bgl in the area up to 1 kilometre inland from the high tide water line. Close to salt pans or sea the water levels are almost same as high water line levels. This suggests that the central high land is the main ground water recharge area and sub-surface flow of ground water is from the central high land to the coastal area. The seasonal fluctuation in the water table level is 2 to 5 m in the central high land but along the coastal strip, the seasonal water level fluctuations are insignificant. The yields of well are very high (50 m^3 to 240 m^3/ day) for drawdown ranging from 0.5 to 1.25 m.

The ground water occurs in the inter bedded calcareous sandstones, grits and arenaceous limestones of the deeper Gaj formation. Ground water is in confined condition in this formation with piezometric levels varying from 1.5 m to 3.0 m bgl. The quality of the water is saline in the upper Gaj formations, which is inherent as the deposition of Gaj formation was in marine condition. The intercalated marls and clay formations, which restrict the circulation of ground water, cause further deterioration in quality.

Pumping tests in two Dugwells (Large Diameter wells) were carried out by A.Ahmed (1980). The results of the short duration pumping test conducted at Sarwari, near airfield and Phophrona village revealed the specific capacities of the dugwells were (as

determined by Slitcher's formula) 566.39 lpm/m and 31 lpm/m respectively. The rates of infiltration were 322.8 lpm and 40.92 lpm respectively (After Ahmed, 1980).

The hydrograph of observation well (National Hydrograph Station) for the past decade indicates that the coastal plains in the immediate vicinity of the high grounds are still not affected by the salinity ingress as the subsurface inflows from the unutilised ground water reservoirs in the highlands maintain constant supply to these areas. In the area where the hydrograph station is situated, there is no exploitation on account of lack of cultivation and is reflected in the lack of seasonal water level fluctuation.



Ground Water Resources

As per the GWRE 2009 the net availability of ground water in the UT of Diu is 495 ha m. The over all gross ground water draft is 577 ha m which includes 509 ha m for irrigation and 68 ha m for domestic purposes. About 80 ha m is allocated for the future development of industries and domestic needs for the next 25 years. The over all ground water stage of development of UT of Diu is 116.58%. So the UT of Diu comes under Over Exploited category. The UT of Diu is notified for further ground water development by CGWA.

The ground water resources potential as on March 2009 of Union Territory of Diu and stage of development are presented in the following table-2.

Table- 2 Ground Water Resources Potential

Sr. No	Assessment Unit/ Taluka	Net Annual Ground Water Availability (In ha m)	Existing Gross G.W. Draft for irrigation. (in ha m)	Existing Gross G. W. Draft for Dom. water supply (In ha m)	Existing Gross G. W. Draft for All uses (4+5) (In ha m)	Allocation for dom. and ind. upto next 25 years (In ha m)	Net G.W Availability for future irrigation Development (3-4-7) (In ha m)	Stage of G. W. Development {(6/3)*100} (%)	Category
1	2	3	4	5	6	7	8	9	10
1	Diu	495	509	68	577	80	Nil	116.58	OE

Ground Water Quality

The quality of ground water in the central high lands is good with electrical conductivity values of 500 μmhos/cm. The water is alkaline with low contents of sodium and chloride. However, the salinity of ground water shows gradual increase from the central high land to the coastal area. The EC values in the uncontaminated (by sea water ingression) ground water near the coast are as high as 4000 μmhos/cm with high chloride, sulphate and sodium contents. This is mainly due to contribution from the salts precipitated on the surface from the atmosphere charged with sea water vapour. Theses salts get infiltrated along with rain water into the sub-soil water. The quality of ground water shows further deterioration in isolated areas along the coast, wherever there is high extraction of ground water for domestic or irrigation purposes. The EC values in ground water in such pockets vary from 4000 to 10,000 μmhos/cm with proportions increase in sodium, chloride, and sulphate.

In addition to the nearness to coast, the depth factor was also found equally responsible for the increase in salinity of ground water. Wells more than 8 metres in depth, i.e. in which the bottom of the well reached almost the sea level, the quality of ground water is always inferior. The exploratory drilling indicated that the salinity is extremely high (60,000 μmhos/cm) in the deeper cavernous zones of Milliolite limestone between 18 and 50 m depth. The chemical quality of the lone observation well (NHS) is given in the table-3.

Table- 3 Chemical Constituents of Groundwater

Chemical Constituents	National Hydrograph Stations		Piezometers	
	Jolawadi	Gomtimata	Vanakbara Pz	Chakratirth Pz
pH	8.12	7.90	7.71	7.94
Ca (ppm)	44	80	280	240
Mg (ppm)	62	96	316	195
Na (ppm)	169	310	1252	760
K (ppm)	26	5.3	15.3	27
Cl (ppm)	156	433	2946	1669
No3(ppm)	80	95	53	38
So4 (ppm)	15	15	201	197
HCO3 (ppm)	561	683	317	464
TH (ppm)	370	600	2000	1350
EC (μS/cm)	1500	2490	8920	6000
Fluoride (ppm)	0.80	0.10	0.65	0.55
Alkalinity(ppm)	460	560	260	380
SAR	3.8	5.5	12.2	9.0
Fe(ppm)	0.16	0.43		

GROUND WATER MANAGEMENT STRATEGY

Ground Water Development

Groundwater in UT of Diu is developed mainly by dug wells and dug-cum-tube wells. The dugwells are generally round or square with the diameter varying between 2.5 to 4 m. Very large diameter wells having diameter in the range of 6 to 9 m do exists. Most of the dugwells are used for domestic and irrigation purposes, however very few dugwells that are located in the elevated regions are used for public drinking water supply. There are about 540 dugwells/dugcum bore wells. Of 743 dugwells that existed in 1985 about 203 dugwells have become dry in 2002. Field investigation revealed that, the dug wells mostly existing in the central part have become dry. This includes 10 % of the wells that has become abandoned, either due to well collapse or in some cases due to quality deterioration. The depth of the dugwells/dugcum-borewells ranged between 3.10 m and 19.00 m bgl.

The water level in the dugwells varied between 1.30 mbgl near the coast and 10.48 mbgl in the elevated region. The topography of the UT of Diu is mostly undulating and it is observed that the water level parallels the topography. The water table configuration shows that, the freshwater mounds do exist in sand dunal area near Vanakbara, Dagachi and near Diu town where the reduced ground level is about 14 magl. Comparison of the water level from 1979 to 09, revealed that as such the water level has neither declined

nor increased, but the quality has deteriorated, except for the dugwell that exists in Bucharwada, Kevadi village. It is reported that, the deterioration in the quality, started before between the years 1980 to 85. Whatever exploitation taking place is concentrated in the 8 sq.kms zone i.e. in the half a kilometre wide strip along the coast.

Water Conservation and Artificial Recharge

Drinking water status

The total drinking water requirement for UT of DIU is about 4.5 MLD. The source of water supply is only through pipeline from Raval Dam, (15 Kms away from DIU) situated in Una of Junagadh District. As per the status of 2002 the daily receipt of water from Raval Dam in only 2.5 MLD (Average). Hence, every alternate day water supply was made to the public. The water from Raval Dam is treated at the treatment plant situated at Ghoghla village before distribution.

The UT of Diu in near future has plan to avail water from the Sardar Sarovar Narmada Dam Canal based project, wherein it is proposed to avail 22 MLD water from the future off-take point at Una by considering the demand of drinking water requirement upto the year 2030.

Steps taken for Improving Groundwater resources

The local administration has taken up several measures to improve groundwater situation, by constructing earthen check dam, Tidal Bund, Percolation pond since 1995 under several schemes, and the same is presented below.

Site 1: Earthen Check Dam, Bucharwada Village

The Earthen Check Dam was constructed under the Honourable M.P special assistance scheme during 1998. This was constructed to arrest the surface runoff and also to prevent the tidal water (saline) entry towards inland. Impact analysis has to be made in the near by so as to ascertain, whether it has any impact in the near by dugwells. EC of the surface water is 7500 μmhos/cm

Site 2: Tidal Bund, Near PWD sump house, Bucharwada Village

The tidal bund was constructed to prevent the tidal water mixing with the stored water collected during monsoon period. EC of the surface water is 6000 μmhos/cm

Site 3: Tidal Bund, 400 m away from site 2, Bucharwada village

This site is located 400 meters away form site 3 and is almost similar as that of sites 2.

Site 4: Pond, Dhagasi village, Bucharwada Panchayat

This pond constructed in the Dhagasi village under Jawahar Vidhayala scheme stores the surface runoff.

Measures to improve groundwater scenario in UT of Diu

Due to high porous nature of the Miliolite limestone as well as the sand dunes, the rainfall recharge into the aquifer is high. But, with sloping topographic nature towards the sea, the seepage to the sea is also high. As a result, the rainwater that gets recharged into the aquifer system through vertical percolation, does not reside within the aquifer for a long time, instead it dissipates into the sea. As a result, dilution by rainfall recharge is very less and becomes insufficient. Hence, it is necessary to ensure that the recharged

water stores in the aquifer system for a longer period, which in turn would dilute and improve the groundwater quality in due course of time. Artificial recharge structures that prevent unwanted runoff into the sea is required at favourable location.

The sand dunes existing within the forest premises with the thickness ranging between 8 – 12 m forms the main recharging zones. Hence, artificial recharge in the elevated sand dunal areas would be fruitful. Over pumping at several places by farmers for irrigation should be avoided to eliminate the chances of disturbances in the fresh water – saline water interface.

The storm runoff in UT of Diu is very insignificant on account of scanty rainfall and infiltration of most of the rainwater into highly permeable rock unit and sands. There are hardly half a dozen ponds, which retains water only for a short period after the monsoon. However, the pond that exists in Daghaci village (referred as Tungana mode) retains fresh water, of EC of 2200 μmhos/cm, for a long period even till the month of February after monsoon. The excess water from the talav floods into the sea. A rainwater harvesting structure to arrest the run off into the sea would pave way for unwanted loss of freshwater getting mixed into the sea. This will induce groundwater recharge and agricultural activities under well irrigation. The dugwells, near by the talav has water level ranging between 2 – 3 m bgl and has a depth ranging between 4 – 6.50 m bgl. The dugwells (nearby the talav) do not yield for more than 1or 2 hours for an average yield of 60 lpm at a drawdown of 1.5 to 2 m.

Field investigations revealed that,

No noticeable increase or decline in water level for the past two decades.

Quality deterioration in the dugwells started during 1980 – 1985.

Tubewells of shallow depth were constructed after 1980.

After post monsoon, the water level in the dugwells raises by 2 to 3 m and the quality of the nearby dugwells slightly improves by dilution.

The central high land is identical for implementation of artificial recharge. There is a scope for harnessing about 1.5 mcm of rainwater from 4 Sq.Km in central highlands.

Ground Water Related Issues and Problems

Salinity in Ground water does not increase only by normal coastal salinity ingress but also by inherent salinity.

The cavernous nature of the Miliolite limestone with the conduits extending right into the sea, makes it highly vulnerable to sea water ingression.

Occurrence of limited fresh water floating above the saline water.

Even on the central high land heavy pumping may cause upcoming of saline water.

Frequent Drought.

Over exploitation of available fresh water along the coastal strip. (up to 1 km from the coast)

Awareness and Training Activity

Till now no mass awareness programme has been conducted in the island

One Water management training programme was conducted in Diu on 8 March Jan 2003 by CGWB. About 50 trainees got benefited by the training.

One Water Resources day was organised by CGWB in 1999. About 200 participants participated the event.

Areas Notified by CGWA/SGWA

The entire Diu is notified by CGWA

Recommendations

There is an urgent need for management of the limited resources available.

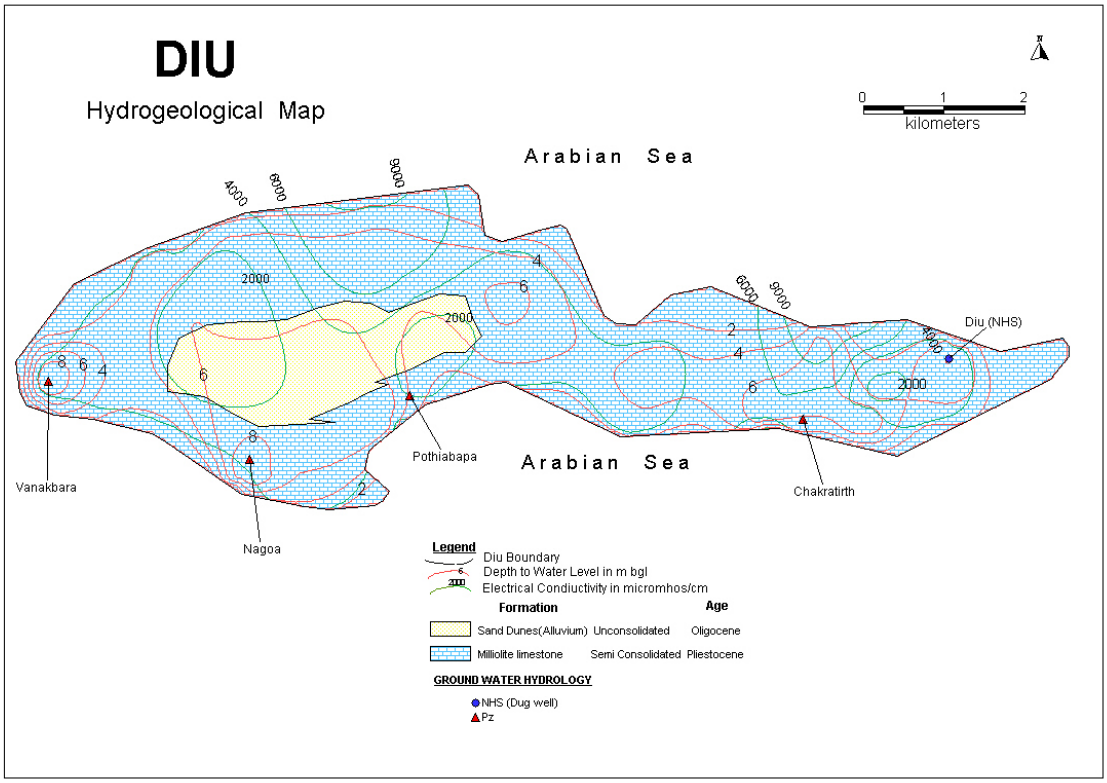
In order to prevent further deterioration in ground water quality along the coastal strip, efforts should be made to reduce the present exploitation. On availability of the water from Rawal Dam on the main land, the pumping from existing wells being used for domestic water supply may be discontinued.

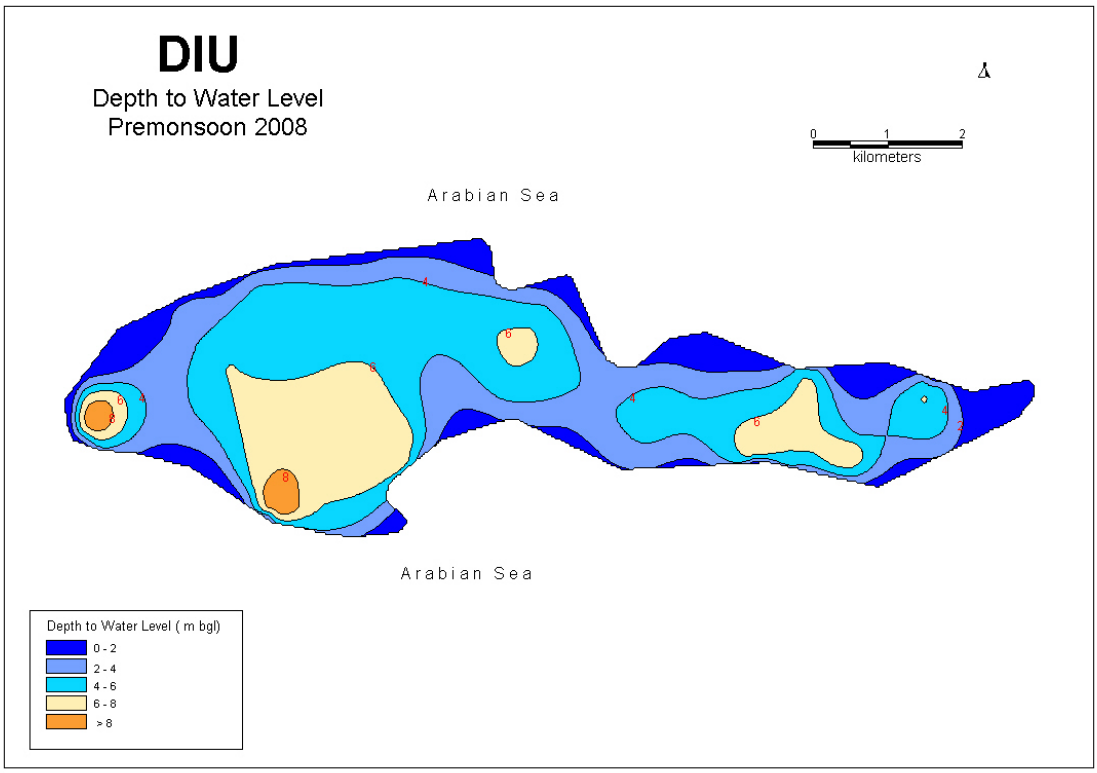
Creating awareness among the farmers regarding water conservation through judicious use of water and adoption of efficient irrigation techniques like drip/sprinkler irrigation.

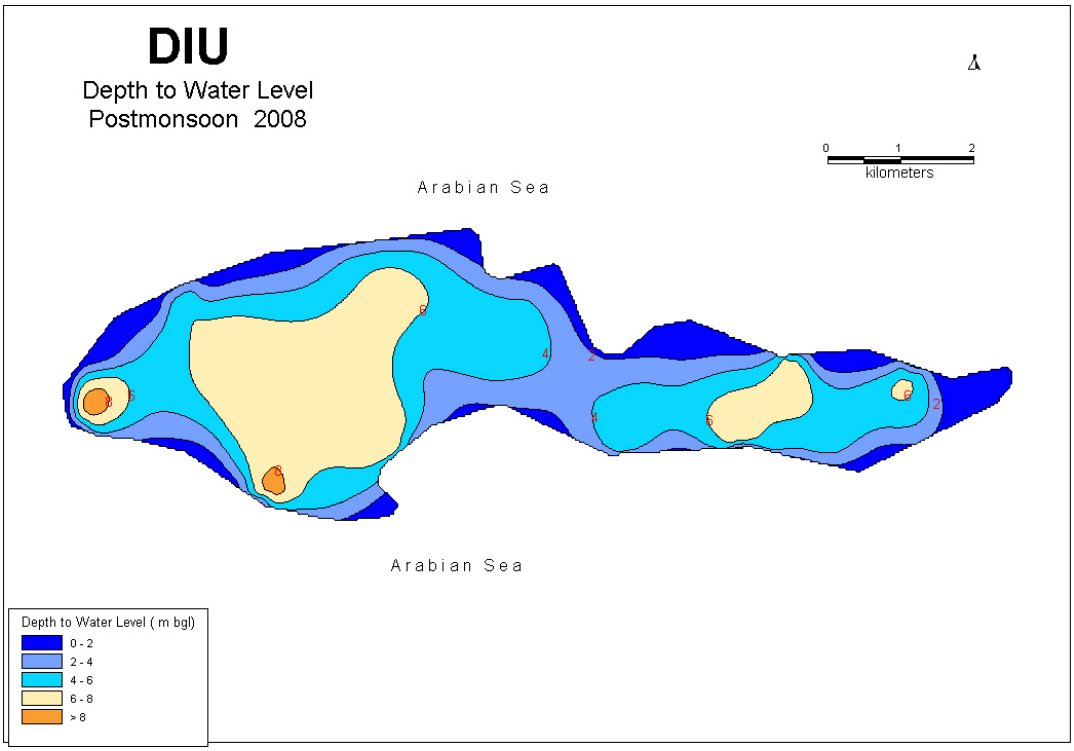
Taking up artificial recharge on large scale through appropriate techniques on a local scale with active community participation.

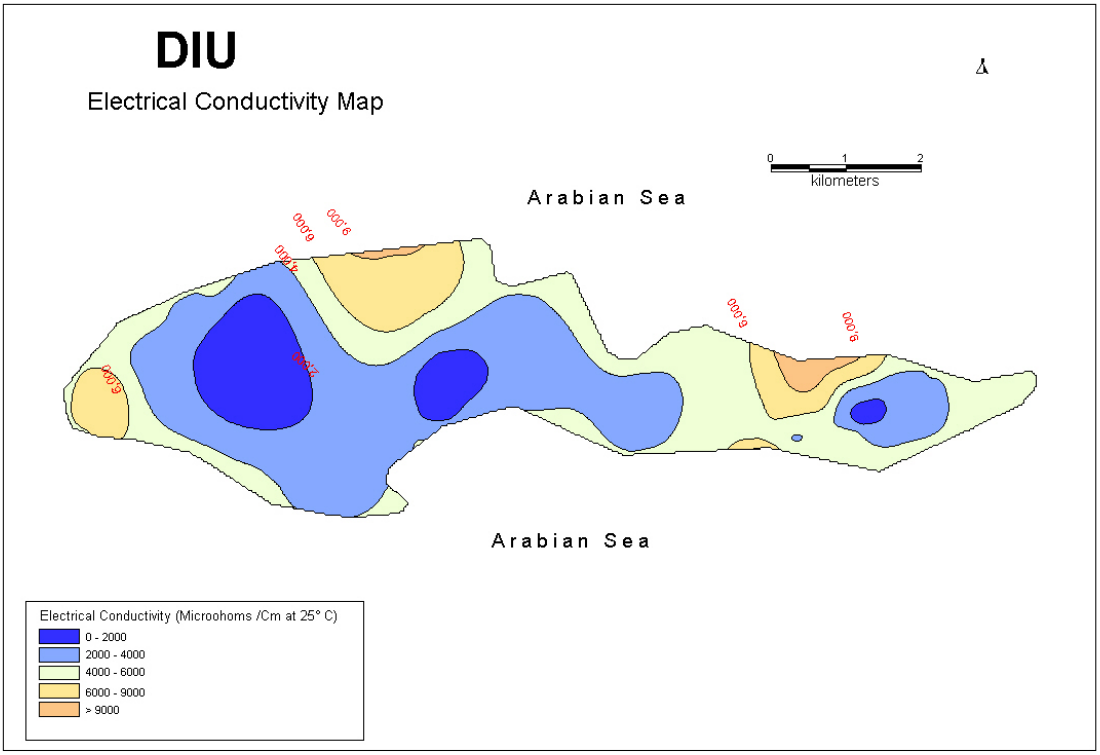
Institutional finance and appropriate technology should be freely made available to any individual or cooperative group of farmers that undertake resource augmentation and management measures.

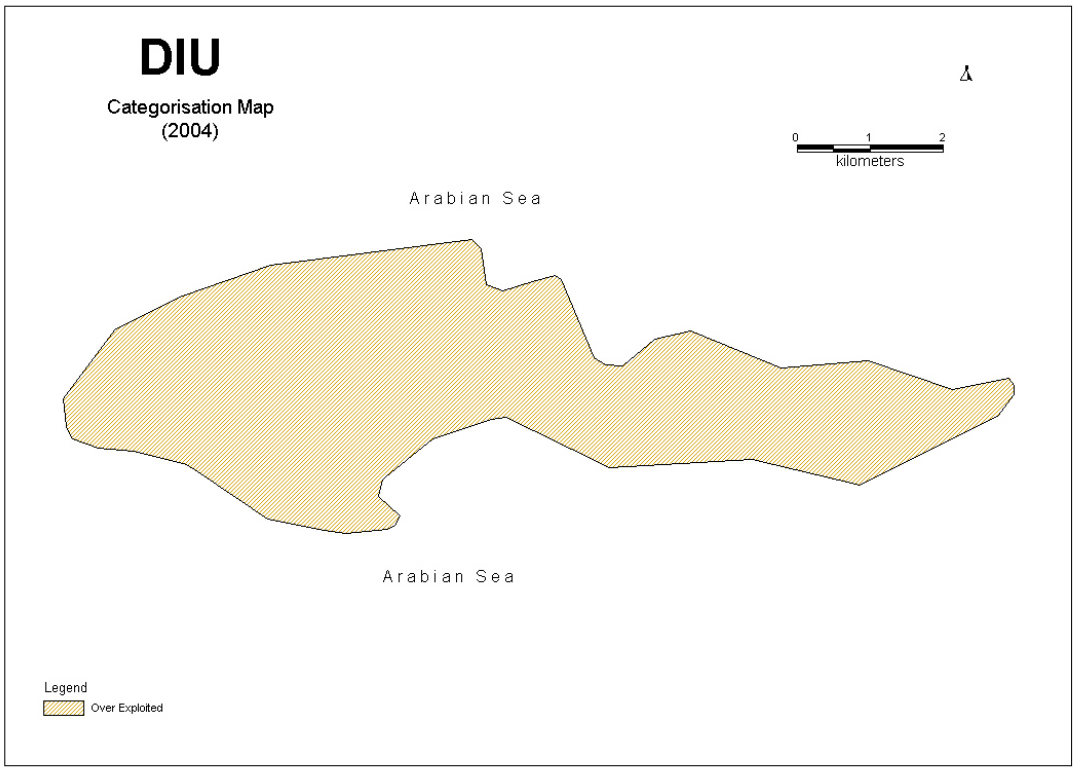
Intervention in terms of improving agricultural practises introducing new variants of crops, which can sustain in high TDS level.

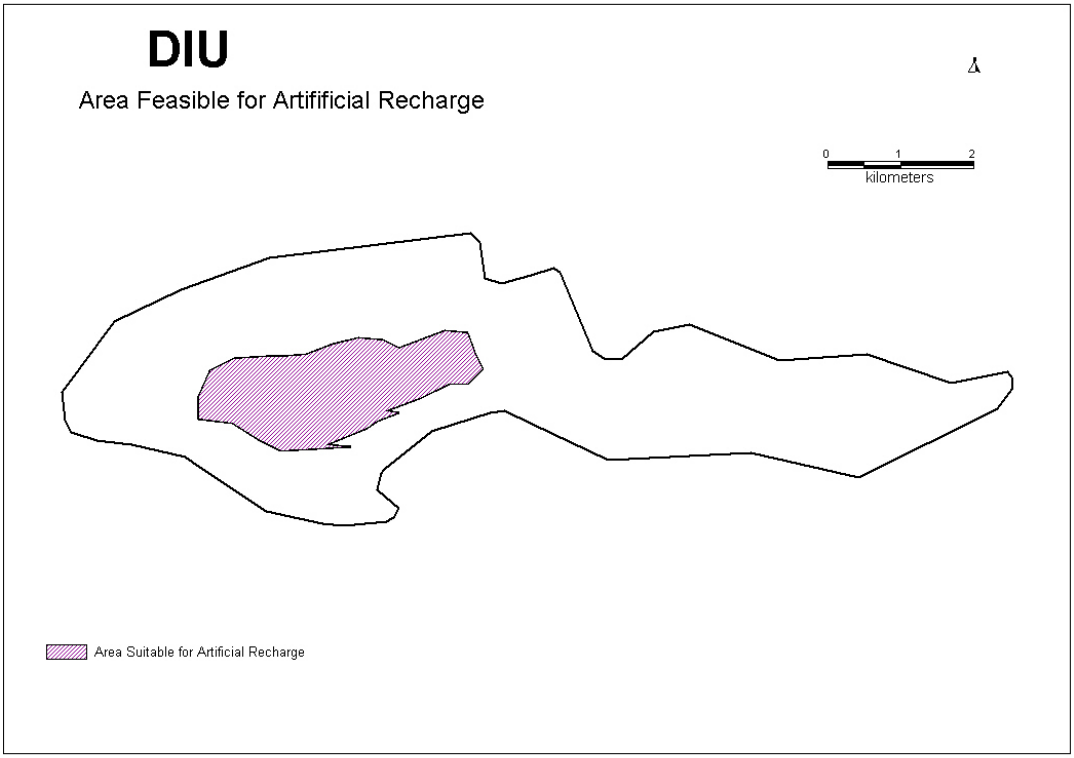

DIU
Hydrogeological Map
0 1 2
kilometers
Arabian Sea
4000
8000
9000
2000
6000
9000
4000
Diu (NHS)
Pothiabapa
Vanakbara
Nagoa
Chakratirth
Arabian Sea
Legend
Diu Boundary
Depth to Water Level in m bgl
Electrical Condiuctivity in micromhos/cm
Formation
Age
Sand Dunes(Alluvium) Unconsolidated Oligocene
Miliolite limestone Semi Consolidated Pliestocene
GROUND WATER HYDROLOGY
NHS (Dug well)
Pz


DIU
Depth to Water Level
Premonsoon 2008
0 1 2
kilometers
Arabian Sea
Arabian Sea
Depth to Water Level (m bgl)
0 - 2
2 - 4
4 - 6
6 - 8
> 8


DIU
Depth to Water Level
Postmonsoon 2008
0 1 2
kilometers
Arabian Sea
Arabian Sea
Depth to Water Level (m bgl)
0 - 2
2 - 4
4 - 6
6 - 8
> 8


DIU
Electrical Conductivity Map
0 1 2
kilometers
Arabian Sea
Arabian Sea
Electrical Conductivity (Microohms /Cm at 25° C)
0 - 2000
2000 - 4000
4000 - 6000
6000 - 9000
> 9000


DIU
Categorisation Map
(2004)
0 1 2
kilometers
Arabian Sea
Arabian Sea
Legend
Over Exploited


DIU
Area Feasible for Artifificial Recharge
0 1 2
kilometers
Area Suitable for Artificial Recharge