Draft Report

केंद्रीय भूमि जल बोर्ड

जल संसाधन, नदी विकास और गंगा संरक्षण मंत्रालय

भारत सरकार

Central Ground Water Board

Ministry of Water Resources, River Development and Ganga Rejuvenation

Government of India

Report on

AQUIFER MAPS AND MANAGEMENT PLAN

Kodinar, Junagarh District, Gujarat

पश्चिमी मध्य क्षेत्र, अहमदाबाद

West Central Region, Ahmedabad

भारत सरकार
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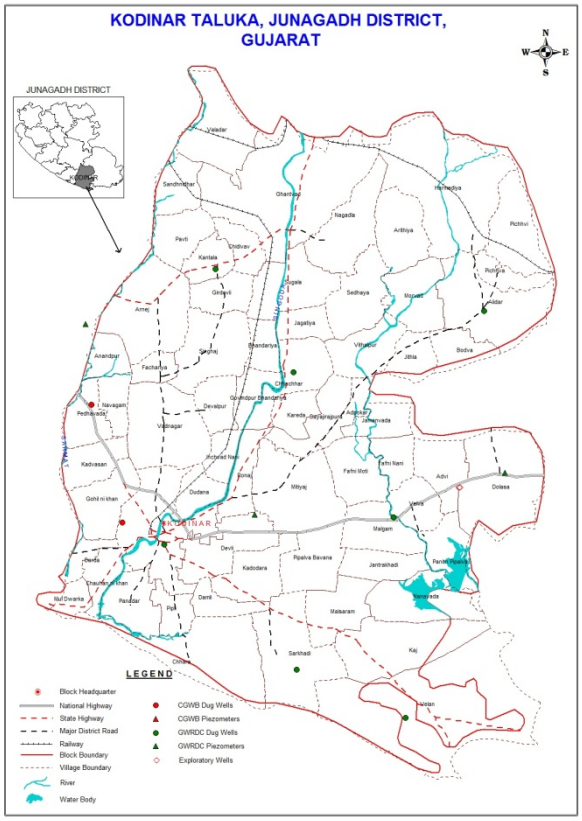
GOVERNMENT OF INDIA
MINISTRY OF WATER RESOURCES, RIVER DEVELOPMENT AND GANGA REJUVENATION



REPORT ON

AQUIFER MAPS & MANAGEMENT PLANS
KODINAR TALUKA, JUNAGADH DISTRICT, GUJARAT STATE

CENTRAL GROUND WATER BOARD
WEST CENTRAL REGION

AHMEDABAD

REPORT ON
AQUIFER MAPS & MANAGEMENT PLANS
KODINARTALUKA, JUNAGADH DISTRICT, GUJARAT STATE

1. SALIENT FEATURES

<table>
<tr><td>1</td><td>Name of the TALUKA& Area, Location(Fig-1)</td><td colspan="4">Kodinar - 520.23 Km^2
20°41’30” to 20°59’45” N
70°38’39” to 70°53’00” E</td></tr>
<tr><td>2</td><td>No. of Town, villages</td><td colspan="4"></td></tr>
<tr><td>3</td><td>District/State</td><td colspan="4">Junagadh/Gujarat</td></tr>
<tr><td>4</td><td>Population (2011 Census)</td><td colspan="4">Male- 94573, Female- 92744, Total- 187,317</td></tr>
<tr><td>5</td><td>Normal Rainfall (mm)</td><td colspan="4">842.41 mm- Monsoon Rainfall (IMD) (in mm) (Long Term) 50
1150.90 mm -Average Monsoon Rainfall (in mm) (2003-12)</td></tr>
<tr><td>6</td><td>Agriculture (20015-16)</td><td colspan="4">
<table>
<tr><td colspan="2">Kharif Crops</td><td colspan="2">Rabi Crops</td></tr>
<tr><td>Crop</td><td>Area in Hact</td><td>Crop</td><td>Area in Hact</td></tr>
<tr><td>Groundnut</td><td>18227</td><td>Wheat</td><td>5700</td></tr>
<tr><td>Tal</td><td>0</td><td>Juvar</td><td>0</td></tr>
<tr><td>Castor</td><td>0</td><td>Castor</td><td>0</td></tr>
<tr><td></td><td></td><td>Gram</td><td>20</td></tr>
<tr><td>Bajri</td><td>1600</td><td>Bajri</td><td>2800</td></tr>
<tr><td>Tuver</td><td>0</td><td>Tuver</td><td>0</td></tr>
<tr><td>Mug</td><td>250</td><td>Mug</td><td>0</td></tr>
<tr><td>Udad</td><td>150</td><td>Mustered</td><td>0</td></tr>
<tr><td>Cotton</td><td>3000</td><td>Isabgol</td><td>0</td></tr>
<tr><td>Sugarcane</td><td>5000</td><td>Sugarcane</td><td>2500</td></tr>
<tr><td>Vegetables</td><td>700</td><td>Vegetables</td><td>1400</td></tr>
<tr><td>Fodder</td><td>4000</td><td>Fodder</td><td>200</td></tr>
<tr><td>Gam Guvar</td><td>0</td><td>Jira</td><td>0</td></tr>
<tr><td>Soyabin</td><td>0</td><td>Onion</td><td>0</td></tr>
<tr><td></td><td></td><td>Coriander</td><td>150</td></tr>
<tr><td></td><td></td><td>Garlic</td><td>0</td></tr>
<tr><td></td><td></td><td>Methi</td><td>0</td></tr>
<tr><td>Total</td><td>32927</td><td>Total</td><td>14770</td></tr>
</table>
</td></tr>
<tr><td rowspan="3">7</td><td rowspan="3">Existing and future water demands (MCM)</td><td colspan="2">Sector</td><td>Existing (MCM)</td><td>Future (MCM) (Year 2025)</td></tr>
<tr><td colspan="2">Domestic and Industrial</td><td>6.00</td><td>8.04</td></tr>
<tr><td colspan="2">Irrigation</td><td>71.87</td><td>36.65</td></tr>
<tr><td>8</td><td>Water level behaviour (2015)(Fig-2 & 3)</td><td colspan="4">11.70-24.45 m (Pre-monsoon)</td></tr>
</table>

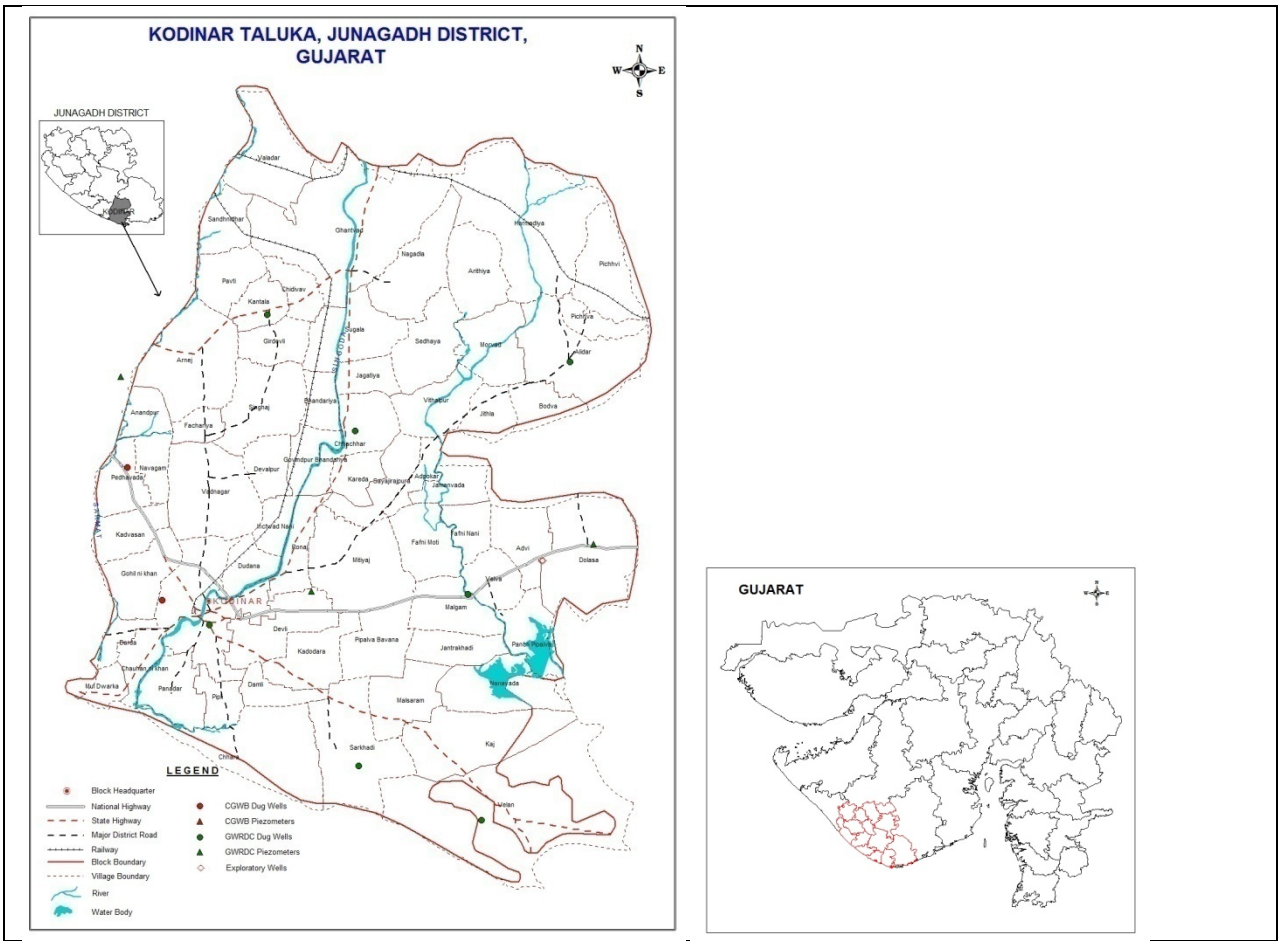


Fig-1: Location Map

1. Hydrogeology:

Mainly three formations form aquifers in the area (Fig.2) namely Basalt, Limestone and Alluvium. The limestone constitute both Miliolitic limestone and Gaj limestone, however the quality of water is saline in Gaj limestone at depths. Alluvium is surficial features and does not forms good aquifer though the quality of ground water is also saline at depth. Miliolite limestone occupies major parts of the taluka. It also occurs as small outliers in Gaj and Trap country. The limestone is karstified at places. It is made of remains of foraminifers Miliolite around which calcite grain have formed (Krishnan, 1968). In upstream area the basaltic aquifer is only aquifer where the ground water exists upto the depth of weathering and in the fracture zones wherever encountered in the depth. Two hydrogeological Cross sections are given in Fig. 3.

Subsurface Hydrogeology

As inferred from borehole data of the Kodinar Taluka, Miliolitic limestone and weathered and fractured Basalt forms the principal aquifer in the Taluka. Top portion of Gaj formation is ocherous limestone with pockets of yellow clay and is easily distinguishable from the overlying Miliolite limestone. It is horizontally bedded and dip at small angle towards the sea. The lower part of Gaj formation is of marine origin whereas part is estuarine (Krishnan, 1968). Groundwater in aquifers occurs under unconfined conditions and in the fractures encountered in the massive basaltic formation in the depth. The movement of groundwater is controlled by the extent of weathering, fracture and joints in the trap formation. Groundwater exploration has been done down to a max. depth of 100 mbgl and the average discharge ranges from 2 to 5 lps by compressor during drilling. The quality of water has Salinity problem particularly area close to vicinity of sea, Ghed area.

2. AQUIFER DISPOSITION

Name of aquifer	Aquifer material	Nature of aquifer	Aquifer depth and zone encountered (m)	Nature of porosity	Compressor discharge	Quality
Miliolitic Limestone	Limestone	Unconfined	0 to 21	Primary and secondary (Poreses, fractures and solution cavities)	-	-
Gaj limestone	Limestone	Unconfined & confined	6 to 57	Primary and Secondary (Pores, Fractures and solution cavities)	Average yield 201m^3/day	Good to bad
Deccan Trap	Basalt	Unconfined (Weathered and fractured)	44 to 58	Secondary (weathered & fracture)	1 to 2 lps	Fresh
		Deep Fracture (Massive & amygdolidal)	Explore up to the depth of 100 m	Secondary (fractures, joints, shears and flow contacts)	Compressor discharge 2 to 5 lps	Fresh

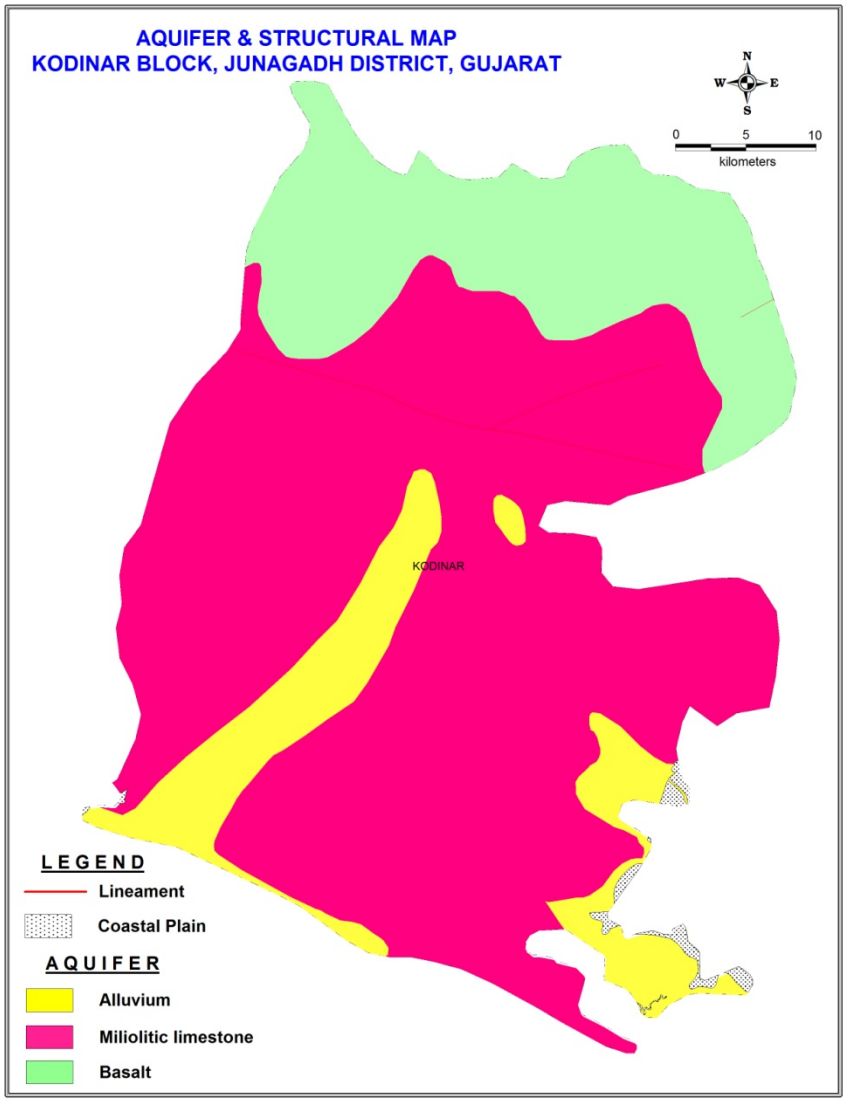
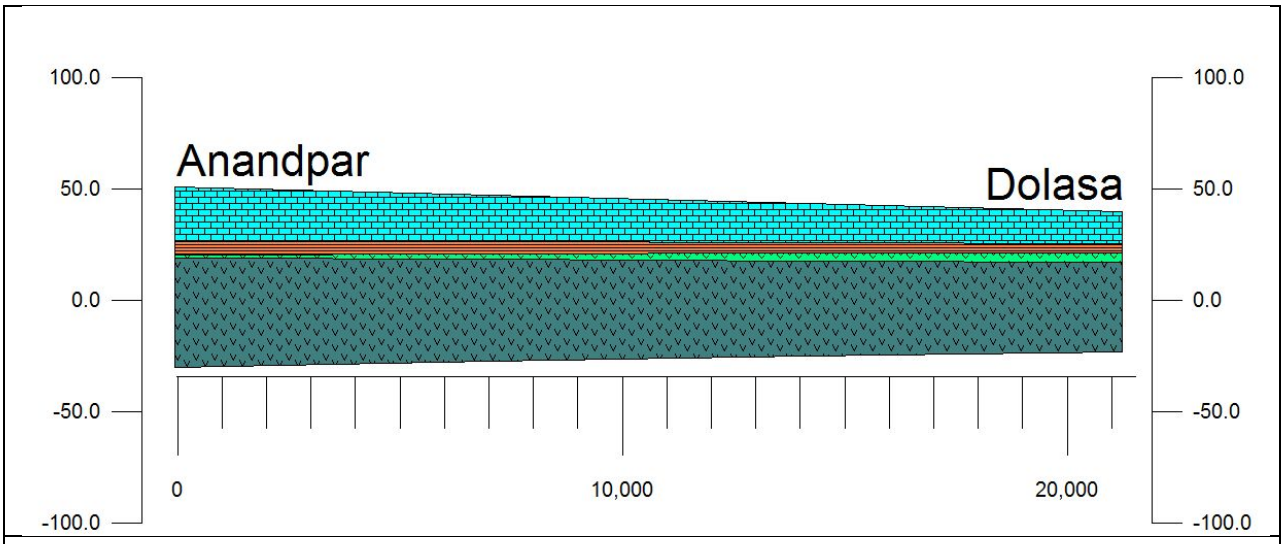
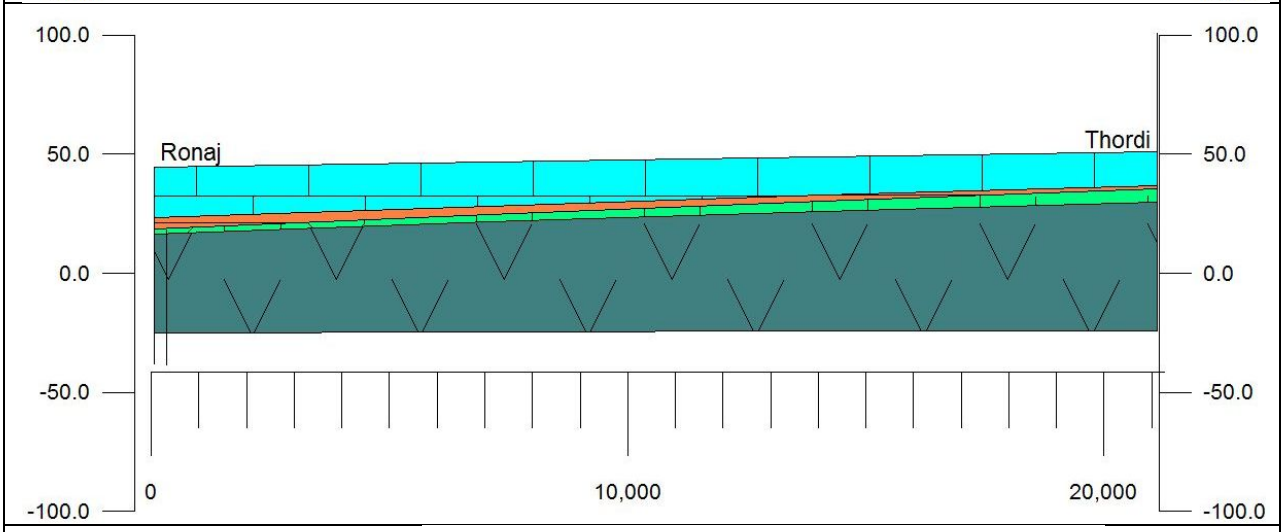
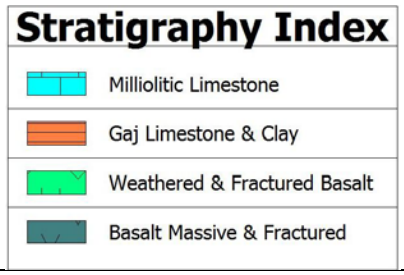


Fig 2: Aquifer disposition of the area







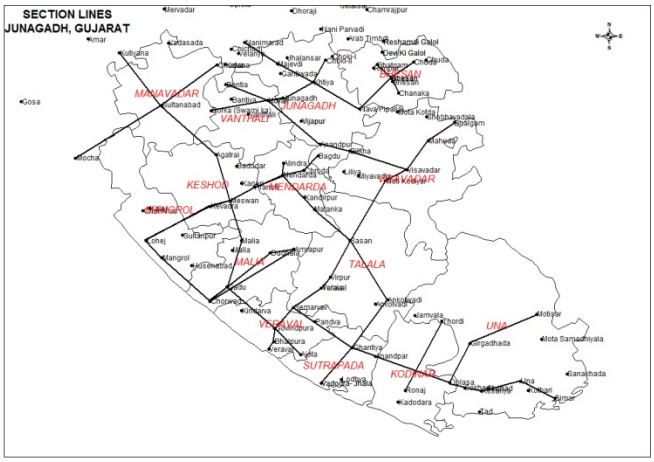


Fig-3: Stratigraphic Section

Depth to water level:

Major part of the taluka is having depth to water level mostly between 10 to 40 m bgl except isolsted patch in Nothern side exibit waterr level less than 10 m bgl. Decadal average water level mostly between the period of May 2006 and 2015 ranges from 10 to 20m bgl. (Fig 4). In coastal part decadal average depth to water level is less than 10 m bgl and isolated part of waterlevel less than 10 m and morethan 20 m bgl (Fig.5).

Long term groundwater fluctuation of water level for pre-monsoon and post- monsoon period are depicted in Fig. 6 & 7 for the period of 1987 to 2015. Ranges of the long-term fluctuation is given in Table below.

Pre-monsoon(1987-2015)				Post-monsoon(1987-2015)			
Rise		Fall		Rise		Fall	
Min	Max	Min	Max	Min	Max	Min	Max
0.25	1.60	2.80	11.80	0.05	7.90	Negligible	

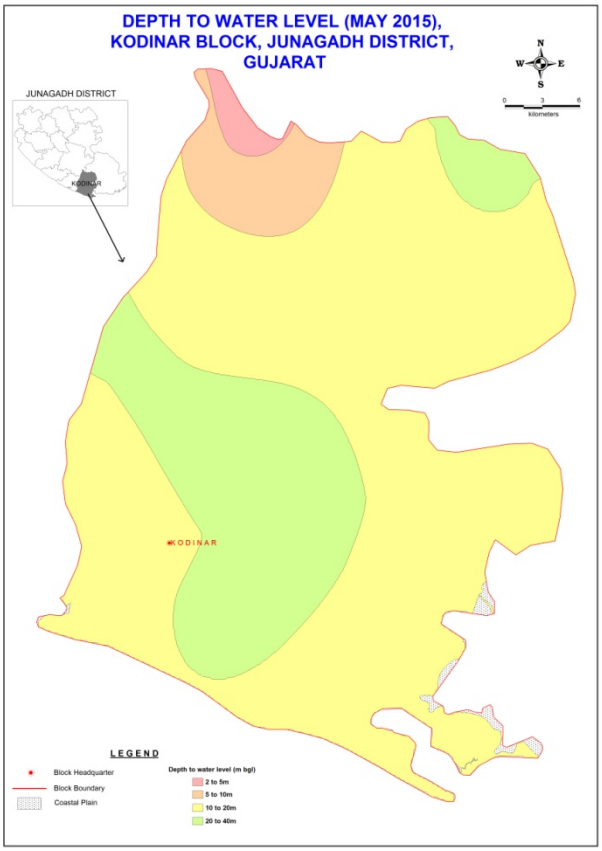


Fig 4: DTW Map (Pre monsoon)

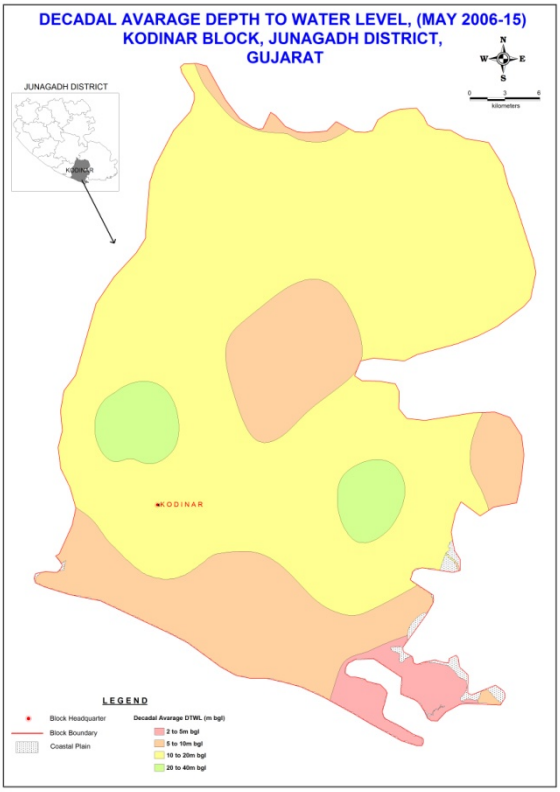


Fig 5: Decadal Average Depth to Water Level

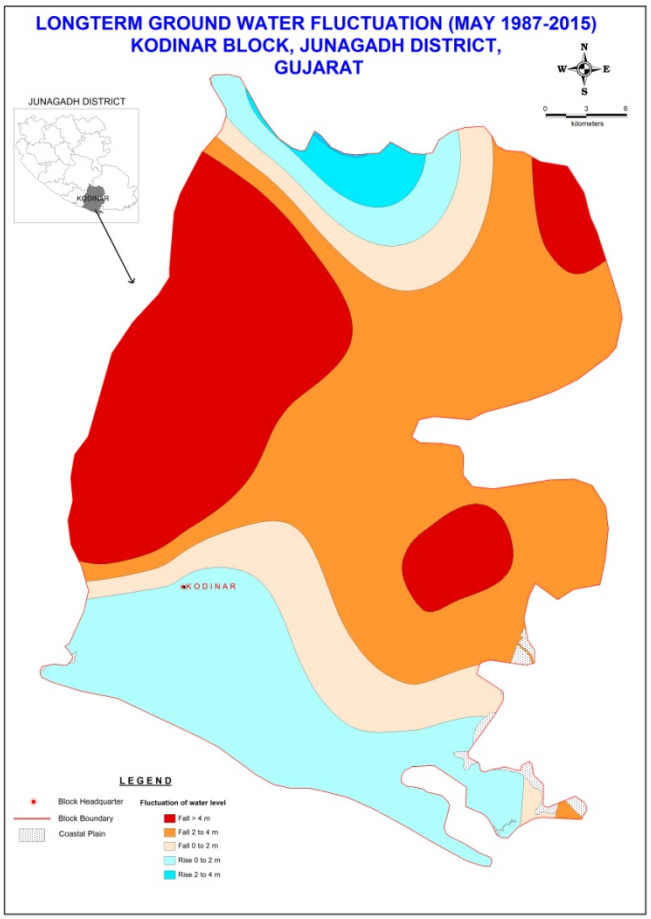


Fig.6 Absolute fluctuation Pre-monsoon

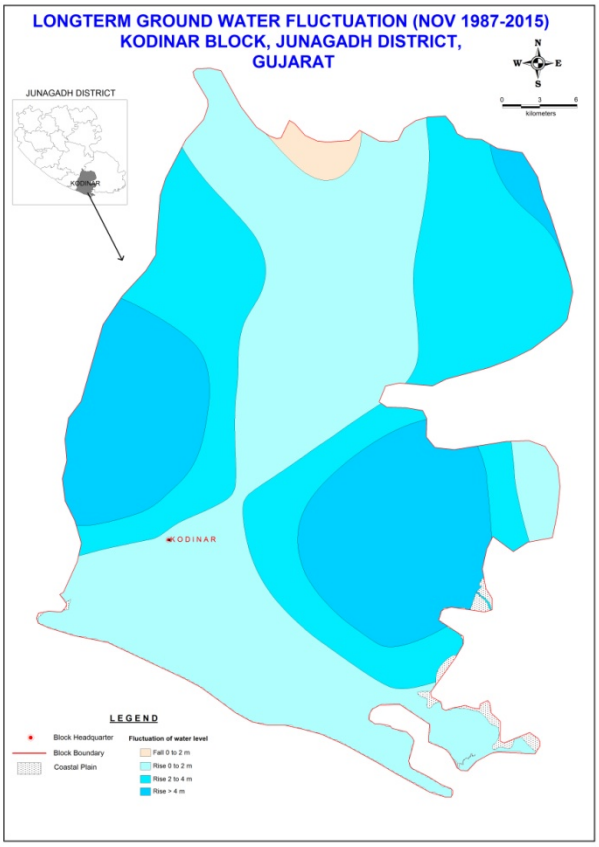


Fig. 7 Absolute fluctuation Post-monsoon

Water Table map (Fig 8) shows water table are ranges 7.45 m below msl to 120 m above msl and groundwater flow direction is from NNE to SSW with gradientof flow is steeper in the Notern side and becomes gentler when it approches to the coast.

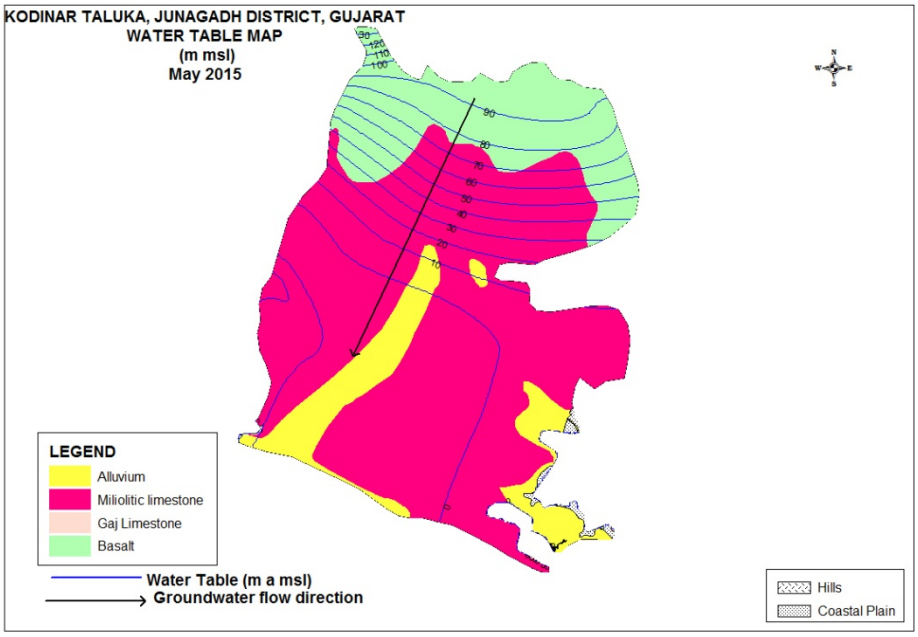


Fig 8: Water Table map with flow direction

3. Groundwater resource extraction, contamination.

Dynamic GW Resources in MCM

Total groundwater availability of the area is estimated in year 2013 is 116.56 MCM and total groundwater withdrawal for all purposes is 77.87 MCM. The stage of groundwater development is 66.81% and the taluka is categorized “Safe” (Table 2) in the fresh area. Resources in the saline area is shown in table 2.

Table: 2 Groundwater resources 2013

S No.	Item	Fresh	Saline
1	Area	474.87	61.93
2	Total GW Recharge (MCM)	122.69	9.39
3	Net GW Availability (MCM)	116.56	8.45
4	Gross Draft (MCM)	77.87	5.02
5	Net Availability for Future Irrigation (MCM)	36.65	3.43
6	Stage of GW Development %	66.81 (safe)	59.42(Safe)

In Storage GW Resources

Typr of Rock Formation	Total Unit Area (sq km)	Fresh Area (sq km)	Saline/Brackish Area (sq km)	Depth of Bedrock(Soft Rock Areas/Depth upto which the aquifer is commonly Developed (HR Areas) (m)	Average Pre monsoon Water Level in (m)	Total saturated Thickness m	Thickness of the Granular Zone-Fracture zone/Productive Zone below Premonsoon WL(M)	Average Specific Yield (Sy) Fraction	FRESH In storage GW Resources (MCM)	BRACKISH/SALINE In storage GW Resources (MCM)
Alluvium	58.83	52.74	5.32	9.85	9.83	0.02		0.1	0.11	0.01
Basalt Weathered	106.47	106.12	0.32	18.43	13.59	4.84		0.02	10.27	0.03
Basalt-Massive-Fractured zone		106.12	0.32				11.49	0.01	12.19	0.00
Milliolitic Limestone	349.90	271.56	77.95	21.79	14.96	6.83		0.1	185.48	53.24
	515.20	430.43	83.61						208.05	53.28

Chemical quality of groundwater

Groundwater quality in general is good. Salinity is expressed in terms of total dissolved solids (TDS). TDS in most of the area in the taluka is < 2000 mg/l except the coastal part in southern side of the area where TDS ranges 2000 to 5000 mg/l (Fig. 9). Min. &Max. ranges of some of the constituents is given in the following Table.

Taluka	Total dissolved solids		Cl		F		HCO3	
	Min	Max	Min	Max	Min	Max	Min	Max
Kodinar	549	4060	112	2440	0.06	1.48	134	512

Fig.9 Iso-TDS May 2015

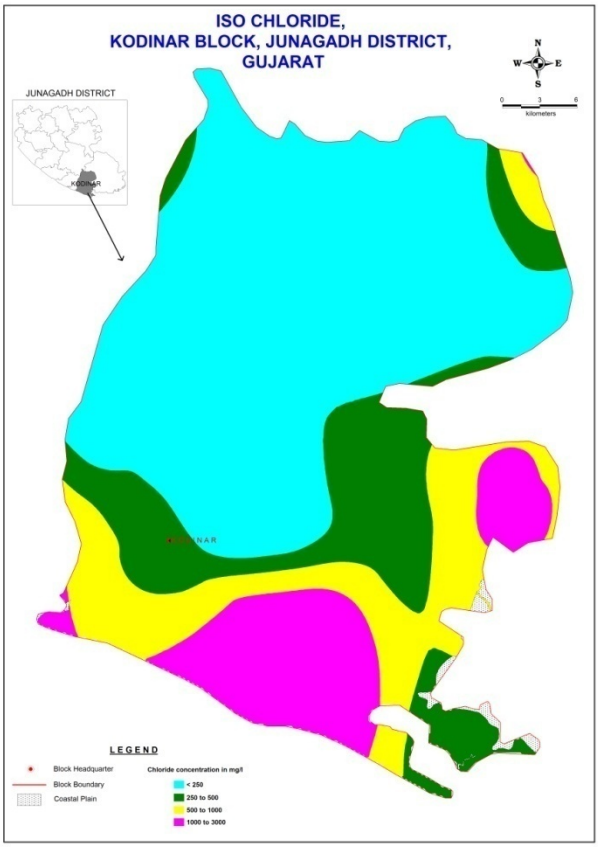


Fig. 10 Iso-Chloride May 2015

Ground Water Issues

- Salinity Ingress
- Inherent Salinity of Gaj Formation
- Sustainability of hard rock Aquifers
- Non Availability of sufficient Surface Water for Irrigation.
- Lack of awareness and involvement of stake holders in decision making.

4. **Groundwater resource enhancement.**

Table-3Computation of volume (MCM) of water required for recharge

Aquifer	Volume of unsaturated zone avilable for artificial recharge	Specific yield factor	Volume of water required for recharge MCM	Volume of rain water planned for Artificial recharge (MCM)
Alluvium	15.47	0.1	1.55	0.08
Basalt	3.00	0.02	0.06	0.02
Milliolitic Limestone	106.44	0.1	10.64	0.20
Total	124.91		12.25	0.30

Table: 4 Computation of Recharge structures.

Aquifer	Area feasible for artificial recharge Sq. Km	Volume of rain water planned for Artificial recharge (MCM)	Volume of water planned for conservation through Farm Pond	Volume of water planned for recharge through Check Dam	No of Farm Pond (Unit storage 0.05MCM)	No of Check Dam (Unit 0.05 MCM)
Alluvium	5.16	0.16	0.08	0.08	1	1
Basalt	1.00	0.03	0.02	0.02	0	0
Milliolitic Limestone	35.48	1.10	0.90	0.20	18	3
	41.64	1.29	1.00	0.29	19	4

Financial Outlay of the Plan

The total estimated cost of the Plan is 235.62 lakh, which includes Rs 32 lakh for ground water recharge activities, Rs 190 lakh (Farm ponds), 0.6 lakh for ground water monitoring (Piezometer construction) and Rs 11.22 lakh towards operation and maintenance charges. The tentative cost estimates of the various activities of the Plan are shown in Table 5.

Table: 5 Cost estimates of Recharge structures and monitoring well (Piezometers):

Feasible Artificial Recharge & Water Conservation structures/ activities	Tentative Design	Quantity (in nos. or area in sq. m)	Rainwater harvested (mcm)	Tentative unit cost (in Rs lakh)	Total tentative cost (in Rs lakh)	Expected Annual GW recharge/ conservation (mcm)
Recharge Structures/ Activities						
Check Dam		4	0.2	8	32	0.18
Sub total					32	0.18
Water Conservation Activities						
Farm Pond (3 fillings)	(30 m x 30m x 1.5 m) 900 sq.m or 0.1 ha	19	0.95	10	190	0.665
Impact assessment & Monitoring						
Piezometer	Up to 80 m bgl	4		0.6	2.4	
Impact assessment will be carried out by implemneting agency						
O & M - 5% of total cost of the scheme					11.22	
TOTAL					**235.62**	

Note: Type, number and cost of structure may vary according to site after ground verification

The tentative location of villages for construction of Check Dams and their cost estimates are shown in Fig. 8 and Table 6.

Table-6 : TENTATIVE LIST OF VILLAGES WHERE ARTIFICIAL RECHARGE STRUCTREUS CAN BE TAKEN UP

Sr. No.	Village Name
1	Dudana
2	Gohil ni khan
3	Malgam
4	Mitiyaj

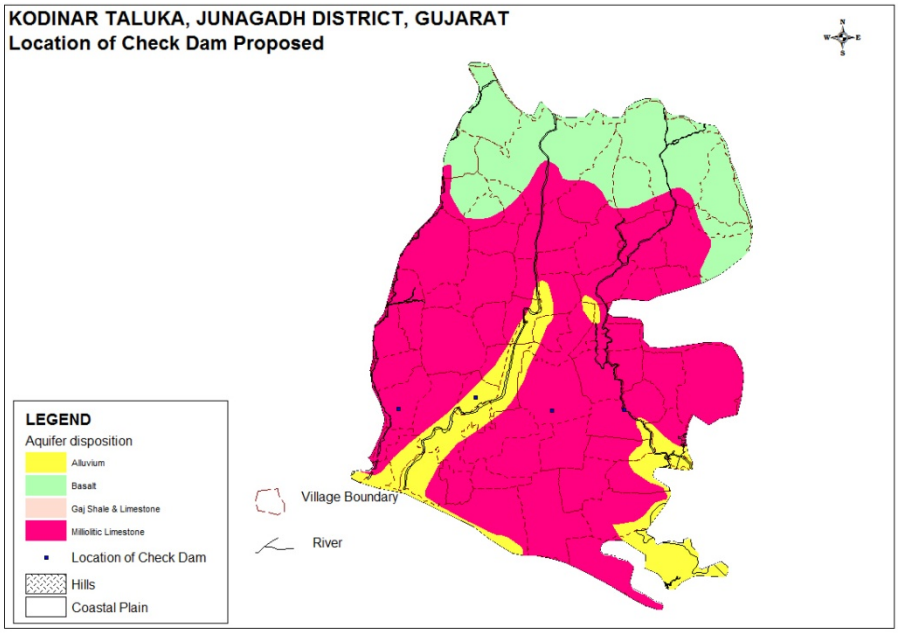


Fig. 11 tentative location of Check Dams

1. Demand Side Management:

As the surface water is not available to improve the supply of water, demand side management is essential.

Table: 7 Crop wise area in Hectares covered under micro irrigation methods (source Gujarat Green Revolution Company, Vadodara, Gujarat).

CROP	Area in Ha.	CROP	Area in Ha.
BAJRA	2.2	Mango	292.19
Banana	12.77	PULSES	1
BITTER GUARD	10.25	RIDGEGOURD	0.8
BOTTLE GUARD	168.25	Sapota	2.72
BRINJAL	14.73	SESAMUM	1.3
CASTOR	81.96	SPONGE GOURD	9.58
COCONUT	17.11	SUGARCANE	106.38
COTTON	556.17	TEAK	1.05
GRAM	5.8	WATERMELON	0.69
GREEN GRAM	44.54	WHEAT	54.46
GROUNDNUT	3703.15	Grand Total	5087.1

Water use efficiency by Drip Irrigation in Rabi crop season:

An area of 5087 hectare is covered by micro-irrigation scheme (MIS) under different crops grown in the district (Table 7). It is estimated the groundwater saving in the district by adopting the drip irrigation method to the main crop in Rabi season is about 14.76 MCM. It is estimated saving of groundwater through Drip irrigation separately to the Crop Cotton and Groundnut are 1.01 MCM and 9.08 MCM respectively (Table 8).

Table :8 Groundwater saving by Drip irrigation in MCM

Taluka	Rabi_Crops	Cotton crop		Grounnut crop		Total
		Summer	Kharif	Summer	Kharif	
Kodinar	14.76	0.10	0.91	6.88	2.20	24.86

Expected Benefits or outcome of the Plan

Ground water recharge and water conservation Plan of Kodinar Taluka, Junagadh district envisages gainful utilization of 0.29 MCM of volume of rain water planned for recharging of depleted aquifer system. Besides this, the proposed intervention would also lead to reduction of pre-existing ground water draft by 1.00 MCM annually through construction of farm ponds. By adopting the micro-irrigation area in the remaining area conserve the 24.86 MCM of groundwater draft in the district.

With the additional recharge and water conservation interventions as proposed in the Plan, it is anticipated that with enhanced recharge and reduction in ground water draft, the stage of ground water development will reduce to 45% from the existing 67%. The projected status of ground water resources and utilization scenario is presented in table 9.

Table :9 Projected Status of Groundwater Resource & Utilization on Recharge and Micro-Irrigation Interventions

Taluka	Net G.W. Availability (MCM)	Additional Recharge from RWH (mcm)	Total Net G.W. Availability after intervention (mcm)	Existing G.W Draft for all purpose (mcm)	Saving of Ground water through conservation (mcm)	Saving of Ground water through MIS (mcm)	Net GW draft after interventions (mcm)	Present stage of G.W. development (%)	Projected stage of G.W. Development (in %)
Kodinar	116.56	0.29	116.85	77.871	1.00	24.86	52.01	67	45

Projected irrigation potential:

It is estimated 1642 Ha additional irrigation potential may be created in the taluka on 70% of groundwater development Table 10.

Table: 10 Irrigation command area on 70% of development of groundwater

District	Development %	Net G.W. Availability (MCM)	Additional Recharge from RWH (mcm)	Total Net G.W. Availability after intervention (mcm)	Max GW avilable on 70% development MCM	Existing G.W Draft for all purpose (mcm)	Balanced GW avilable on 70% development and Existing Draft	Saving of Ground water through conservation (mcm)	**Net GW avilable for withdrawl after interventions (mcm)**	Average crop water requirement by Drip Irrigationm	Additional area to be Irrigate in sq. km	Area can be Irrigate in Ha
Kodinar	70	116.56	0.29	116.85	81.80	77.87	3.92	1.00	4.92	0.30	16.41	1641.48

CONCLUSION AND RECOMMENDATION:

1. It is recommended to increase the recharge of groundwater from external surface water sources. It is also important to properly maintain and timely operate the existing recharge and salinity control structures.
2. Recommended to construct the 4 check dam and 19 Farm ponds in the Taluka to recharge 029 MCM and conserve 1.00 MCM of rainfall runoff.
3. During the electrification of well/ bore wells, the micro-irrigation through drip/sprinkler irrigation should be made mendatory, so as to minimize use of groundwater.
4. 1436 Hectares area may brought under micro-irrigation to adopt Drip method to save about 14.76 MCM of water during the Rabi crop season.
5. 8714 Hectare Groundnut crop area during pre-Kharif season and last phase of Kharif season may brought under Drip irrigation to save 9.09 MCM of water.
6. 1500 Hectare Cotton crop area during pre-Kharif season and last phase of Kharif season may brought under Drip irrigation to save 1.01 MCM of water.

7. 1642 Hectare land may additionally irrigated on 70% of groundwater development and observing all intervention proposed.

- **The implementation of the project would result in additional recharge. The other tangible/ non-tangible benefits of the project are:**

- Recharging the ground water will help in arresting the rapid decline in ground water resources and will also ensure improvement in quality of ground water by way of dilution.
- Proposed structures and measures will also enhance the ground water potential and would ensure sustainability of ground water resources.
- Surface runoff water stored or harnessed can be used as supplemental irrigational resources and will reduce the stress on the ground water.
- Besides, it will also help in reducing the amount and spate of storm water being drained by river and controlling soil erosion.