7.0

OCCURRENCE OF SALINITY IN GUJARAT

7.0

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7.1 Dissolved Salt in Water

The great solvent capacity of water makes it a unique compound on the earth, giving a status of a "UNIVERSAL SOLVENT'. Because of this great solvent capacity, water has got some disadvantages as well. Major evidence of disadvantage is experienced when we need high purity or required quality of water. Water will pick up ions from the walls of the piping system or container and increase the conductivity of even the distilled water. Water dissolves many materials which may enter the solution in their solid, liquid or gaseous states. The resulting solutions may contain completely ionized solutes, such as sodium chloride or un-ionized solutes, such as oxygen in its molecular form.

Chemical materials dissolve in water to such an extent that it often becomes unsuitable for human consumption. Besides various chemicals, natural waters also contain pollutants from natural and human activities. As we know, the water we get from the nature through the "WATER CYCLE" is in distilled form. But during its travel and stay on the earth, many impurities are getting dissolved into water, sometimes rendering it unacceptable for the intended use. The raindrops absorb gases in the atmosphere, such as $C0_2$ even before they reach the ground. There is further accumulation of dissolved chemicals as the water comes into contact with soils, rocks, and minerals. The concentration of dissolved chemicals in water determines its quality. Many substances dissolve in water and their molecules become dispersed in a manner characteristics of each substance. Electrolytes, when dissolved in water, dissociate into positively and negatively charged particles. These charged particles are called **"ions"** and the dissociation process is called **"ionization"**. For example, NaCl ionizes into positively charged Na^+ ion and a negatively charged cl^- ion. Positive ions are called "cations" and negatively charged ions are known as "Anions". An electrolyte facilitates the flow of electric current. This current can be measured by conductivity meter, value of which will give presence of dissolved salts in water. Total Dissolved Salts (TDS) value of a water can be obtained by multiplying the conductivity value by **0.66** except in certain special cases e.g. mine waters. TDS could also be measured by evaporating filtered water sample in a drying oven and weighing the residue. Thus TDS of a solution is a rough measurement of its ionic strength.

National waters can be classified in broad terms according to their TDS value as follows

Sr.No	Type of water	TDS Value (mg/l)
1	Fresh Water	0-1000
2	Brackish water	1000-5000
3	Moderately saline	5000-10000
4	Highly saline	10000-30000
5	Sea water (Brine)	Above 35000

Thus saline water refers to water containing an appreciable amount of Total Dissolved Solids(TDS). The presence of such solids not only imports unpleasant(salty) taste to the drinking water but it interferes with many of its uses. It causes inflammation in the digestive track and is also hard. It causes scale in the boiler and is unacceptable for many industrial manufacturing processes. Quality of water required for some of the uses is as under :

Sr.No.	Intended use	Quality Required(TDS mg/l)
1	Boiler	10
2	Industrial	10-200
3	Drinking	500
4	Irrigation	1000

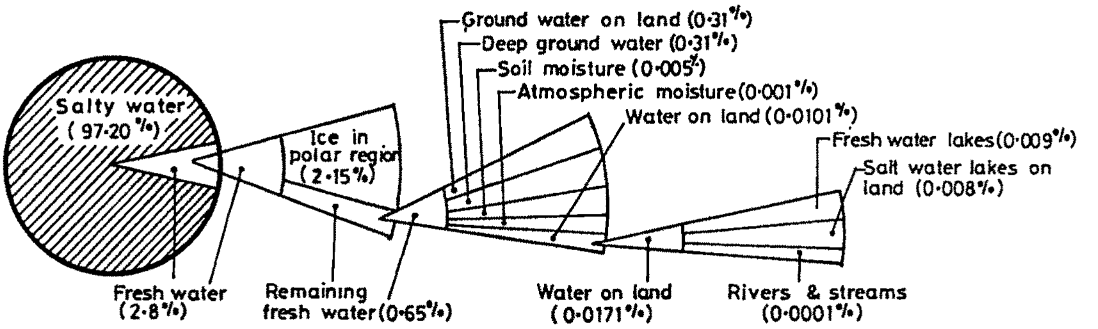
Most of the drinking water standards including WHO's guideline values stipulate that desirable value of TDS in drinking water should be 500 mg/l which can be tolerated upto 1500 mg/l beyond which the water should be rejected. Bureau of Indian Standards in its drinking water standards published under IS:10500 (1991) relaxes the value of TDS upto 2000 mg/l in the circumstances where no alternative source is available. Such situation arises in coastal and desert area where salinity is more.

7.2 Availability of fresh water on land.

Nature has blessed earth with large bodies of water. These account for approximately 75% of the earth's total surface area. Unfortunately, this water is not uniformly distributed. Ninety seven percent of the total water on earth is sea-water containing 3.5% of dissolved salts. This water having so high salinity cannot be used for drinking or agricultural as well as industrial uses. Ninety per cent of the remaining 3% (i.e. 2.7%) water is locked up in polar ice-caps and is therefore not available for ready use. The remaining 10% of the 3% (i.e. 0.3%) is available for ready use. This 0.3% of fresh water includes shallow ground water (0.31%), deep ground water (0.31%), moisture content of soil, atmospheric vapor and surface water in form of lakes and rivers. Thus the total water on the earth, at a glance could be summarised as under :

Sr. No.	Location	Percentage
1	Oceans	97%
2	Polar regions	2.7%
3	Fresh water	0.3%

If we further examine the actual fresh water easily available to us in the forms of lakes and rivers on the surface of land or explorable ground water it can be depicted as under:



The United Nation's World Water Conference document (1977) says that **"If all the world's water were represented by a gallon bottle, the quantity of fresh water would be about a teaspoonful. And two droplets would suffice to represent the surface flowing water the rest being ground water"**. Although the ocean water, which comprises a large fraction of the earth's water component is too salty for any direct use, it is the main source of natural fresh water apart from ground water. The process by which rain water is accomplished is called **"Natural Water Cycle"** through which we get precipitation. Part of this rain water, which occurs over land areas replenishes the water in rivers, lakes, streams and wells. The annual precipitation on the earth is adequate for the population, but its distribution is not even and uniform. it varies from place to place. The difference in precipitation appears logical when we consider the irregular geological distribution of mountains and other topographical features including the air circulation. This situation has created arid, semi-arid and desert areas at many places on the earth. In many such places (e.g. middle-east) rainfall is limited or almost nonexistent. Certain areas like north Chile and Cape Verde (Sal Island) at times get no rains at all for 10 years at a stretch. On the other hand, on some of the tropical forest there is constant rain through out the year. No wonder then that there is either drought or flood anywhere and at any time. The most serious problem today is that of water. There is as much water today as there ever was. The water cycle is continuous and endless. However water has become scarce. There are many factors which have also contributed to the growing water shortage. They can be summarised as under :

- Exploding population
- Rising living standards
- Growing urbanization

- Rapid Industrialisation
- Expansion of Agricultural irrigation
- Pollution of natural water reserves
- Cultural development
- Political awareness.

Water shortages are not confined to the arid lands which comprises more than 60% of the earth's total surface. Even in the countries where plenty of water is available, many supply and quality problems exist and some areas experience shortage. A Syrian delegate at UN Water Conference (1977) has rightly pointed out that "**A day is not far off when a drop of water will cost more than a drop of oil**". The renowned scientist of the century, Albert Einstein has also warned the world by saying that "**Greatest fear to the world is not of war but that of shortage of water**".

7.3 Water Problem

India occupying 3.3 million sq. km of land in the south east Asia has got of climatic variations. Average rainfall in the country is 1170 mm having minimum of 100 mm in Rajasthan and maximum of 11000 mm in Cherapunji(Meghalaya). It receives annually around 4000 km3 of rain water of which only 1/4th is retained as surface and ground water and the rest is lost as run off to the sea. The total water requirement in the country is expected to rise to 750 km3 by 2000 A.D. The water availability therefore generally appears adequate (Sadhukhan H.K.). However the rainfall is uneven and inadequate at many places creating shortage of water. About 3,25,000 km2 area of the country (9.7%) of total area) is arid characterised by a dry climate and lack of fresh water.

70% of the country's population lives in 5,75,000 villages out of which 2,27,000 were having problem of drinking water(Gomakale) of these problem villages, 29100 villages were found chemically contaminated and 17500 villages having brackishness problem. (Govt. of India - MRD document 1988). The main occupation of rural people in the country is agriculture needing more water for irrigation purpose to grow more food for the increasing population. Rapid industrialisation and consequent urbanization have resulted in fast increase in the water demand. The country has also got long coastline which causes ingress of salinity in coastal areas. Failure of monsoon further aggravates the water supply situation. A number of habitations situated in arid, semi-arid and coastal areas are known to face chronic water shortage. Sadhukhan of BARC, Bombay has quoted (1987) from a document of Government of India(Ministry of Rural Development) that fresh water availability and demand in some metropolitan cities of India are as under.

Sr.No.	City	Demand (MLD) at 140 LPCD rate	Availability (MLD)
1	Bombay	3385	2385
2	Delhi	2925	1800
3	Calcutta	1350	1035
4	Madras	450	247.5
5	Bangalore	1107	418.5
6	Hyderabad	720	405
7	Ahmedabad	675	495

(MLD= Million Liters per day, LPCD= Liters per capita per day)

These figures clearly indicate that there is a vast deficit of water in all major cities. Government of India in Ministry of Rural Development which takes care of drinking water supply to rural areas has constituted a Water Technology Mission since 1986 which is now known as "Rajiv Gandhi National Drinking Water Mission". Under this mission a sub-mission on control of salinity has been launched to address the specific problems of salinity in the country.

7.4 Shortage of water in Gujarat

The geohydrological profile of Gujarat has been elaborately explained in the chapter on "Profile of Gujarat State". We therefore without repeating it here, will only see the water situation pertaining in the State especially the shortage of water, prevalence of salinity and action taken to solve the problems, arising out of it. Availability and use of water in Gujarat is estimated (9) as under :

- Total water resources
  - Surface water - 31000 million m3
  - Ground water - 17000 million m3
  - Total water - 48000 million m3
- Available water
  - Surface water - 9300 million m3
  - Ground water - 6800 million m3
- Water demand
  - Domestic
    - Urban - 600 million m3
    - Rural - 400 million m3
    - Total - 1000 million m3
  - Industries(including thermal energy) - 2000 million m3
  - Irrigation - 9380 million m3
  - Total water demand - 12380 million m3

Apparently water availability and demand statistics appears satisfactory but the reality at many places is altogether different. Barring the south and the central part of Gujarat, rest of the areas particularly Kutch, Saurashtra and north Gujarat are facing perennial problem of water supply. Having wide variations in rainfall, these areas very often receive very scanty rainfall. Kutch in particular receives on average 400 mm of rainfall and at times no rain at all.

A news paper report of 5.11.1993 reveals following facts about water scarcity in Kutch.

- Since formation of separate Gujarat State, Kutch has witnessed 11 droughts so far.
- In the last three decades following years were drought years in Kutch 1955, 1960, 1969, 1972, 1974, 1982, 1985 to 87, 1990 and 1991.
- 600 villages are provided with drinking water through 106 group/regional water supply schemes importing water from far off places, which is a record in the State.
- 277 villages are supplied with the water through road tankers in the summer months.
- A master plan amounting to Rs.550 million is prepared to cater to the water supply needs of 450 villages.

The irrigation commission (1972) has classified the rainfall regions of Gujarat into four regions as shown in the table below.(14)

Region	Coefficient of variation	Degree of Reliability	Number of Districts	Percentage area
1	Above 60	Exceptionally low	3	16.5
2	40 to 60	Very low	10	44.6
3	30 to 40	Low	12	38.1
4	30	Satisfactory	1	0.8

The co-efficient of variability is the ratio of standard deviation of the annual rainfall to the mean annual rainfall over any given region expressed as percentage.

A high coefficient of variation is associated with a low degree of reliability of rainfall. It can be seen that areas with less than 30% coefficient of variation are practically non-existent and over 61 percent of the State has highly unreliable rainfall with over 17 percent of the area getting totally unreliable rainfall.

2300 sq.km area of Kutch region is under the effect of desert, where in addition to scanty rainfall, the ground waters are saline. The state of Gujarat is sharing the longest coastal line in the country i.e. 1600 kms, out of which 1125 kms is in this region only which has severely affected the ground waters by ingress of salinity. As per an estimate the ingress of salinity advances by 1 km in width every year and it has so far affected nearly 1.1 million hectares of land. About 83% of area in Kutch-Saurashtra region is rocky which contains meager underground water. The districts of north Gujarat particularly Banaskantha and Mehsana are receiving scanty rainfall and facing arid to semi-arid conditions. 42 talukas(Blocks) are drought prone in the State. Following adversities in the drought prone areas of Gujarat aggravate the water shortage and enhance the salinity problem.

- Because of the scanty rainfall their main dependence is on ground water but ground water is not constant everywhere.
- Drought situation is a recurring phenomenon in these regions. Drought pattern is Gujarat follows the following course.
    - Normal drought - once in 3 to 7 years.
    - Severe drought - once in 7 to 10 years.
    - Very severe drought - once in 14 to 20 years.

  In the current century, Gujarat has faced 33 droughts so far. Since the separate State of Gujarat came into existence in 1960 it has faced 12 droughts.
- There are no more perennial rivers in Gujarat except a few in south Gujarat. Out of total 185 rivers, 168 rivers are in drought prone areas alone and all of them are non-perennial, and account for less than 20 percent of ultimate surface water utilization.
- Rainfall is in a short spell of time(about 20 days) during June to Sept. and the length of rivers are so short and with steep slope that all water run away to sea, generating floods during monsoon.
- Due to scanty and erratic rainfall, surface water reservoirs do not get adequately replenished.
- Evaporation of water from open water bodies in a tropical region like this is also a major problem. Potential evaporation based on pan evaporation measurement for these regions is 300 cm/year (Vasoya).
- There is no substantial natural recharge due to erratic and scanty rainfall.
- The major dependence for water is on under ground sources which are neither sufficient in quantity nor acceptable in quality (due to salinity, nitrates, fluoride,etc.) at many places.
- Gujarat is potentially advanced in agricultural and industrial development resulting in ever increasing water demand.
- The water resources are severely polluted due to industrial effluents at many places.
- Water Tables are going down by 4 to 5 mts. every year due to over drawal resulting into deterioration of quality. Today(1994-95) the ground waters have gone beyond 350 mts.

- Exploitation of ground waters to meet with the increasing demand of exploding population is causing sea water intrusion increasing the salinity of mainland areas.

7.5 Prevalence of Salinity in Gujarat.

In Gujarat State, about 15 districts have got saline areas where local ground water development for supplying potable water is not possible. Such saline areas are about 3500 sq.km. and cover hard rock areas, alluvium areas, coastal areas and fringe areas of the little Rann(Desert) of Kutch. District wise details of saline areas given as under :

Sr.No.	District	Saline area (sq.km.)
1	Ahmedabad	2610.05
2	Baroda	274.34
3	Surat	859.64
4	Kheda	1554.28
5	Gandhinagar	-
6	Panchmahals	-
7	Mehsana	1795.00
8	Bharuch	2300.67
9	Sabarkantha	-
10	Banaskantha	2936.31
11	Valsad	219.01
12	Dangs	-
13	Surendranagar	4608.80
14	Amreli	877.35
15	Jamnagar	1897.51
16	Rajkot	1312.28
17	Junagadh	1308.16
18	Bhavnagar	1938.13
19	Kutch	10421.78
	Total	34962.32
		Say 35000 sq.km

In such areas either upper aquifers are saline or at some places salinity is observed at depth. The map of Gujarat showing TDS containts in Ground Water is given at **Annexure - 7.1** indicating saline areas in the State.

Part of Banaskantha, Kutch, Mehsana, Surendranagar and Jamnagar lying adjacent to the Rann(Desert) of Kutch are also highly affected by salinity. In these areas unconfined and confined aquifers have been highly affected and highly saline water is encountered from the sources. Such areas are as under.

District	Talukas affected
Kutch	Mundra, Anjar,Bhachau,Rapar
Banaskantha	Santalpur,Varahi
Mehsana	Sami
Surendranagar	Dasada,Dhangadhara, Halvad
Rajkot	Malia
Jamnagar	Jodia,Dhrol,Jamnagar,Khambhalia,Dwarka.

Due to vicinity of desert, there is intrusion of saline water in the above areas and sources developed in those areas show increasing trend in salinity.

In many areas of north Gujarat the ground water draft is more than ground water recharge. This has resulted in lowering water levels. This is known as **"ground water mining"**. Average fall in the water levels during the period of 1980 to 1990 was reported as under:

Sr.No.	District	Average Depletion (in m.)
1	Rajkot	3.51
2	Jamnagar	6.24
3	Junagadh	6.32
4	Amreli	5.48
5	Bhavnagar	5.35
6	Kutch	5.81
7	Mehsana	22.30
8	Banaskantha	

Based on pre-monsoon and post-monsoon water level measurements carried out by Gujarat Water Resources Development Corporation(GWRDC), decline in water levels in different districts is as follow.

Sr.No.	District	Average decline in mt./year.	
		Unconfined aquifer	Confined aquifer
1	Banaskantha	0.91	1.8
2	Mehsana	2.80	6.2
3	Ahmedabad	1.27	1.37
4	Sabarkantha	1.61	0.69

Due to decline in water levels following effects are observed:

- Open wells (shallow wells) have gone dry.
- Deep tube wells are required to be drilled at higher cost.
- Quality of ground water has deteriorated and problems of salinity,
- hardness, fluoride and nitrate have occurred.
- The natural gradient of water is changed and saline water has intruded in the inland area.

During the survey carried out under Rajiv Gandhi National Drinking Water Mission in 1992, in all 1072 villages were found having affected by salinity in water(TDS more than 2000 ppm.). Districtwise picture was found as under:

Sr.No.	District	Villages affected by salinity
1	Ahmedabad	107
2	Junagadh	49
3	Rajkot	50
4	Surendranagar	26
5	Amreli	8
6	Bhavnagar	25
7	Jamnagar	47
8	Gandhinagar	None
9	Sabarkantha	28
10	Banaskantha	78
11	Kutch	13
12	Mehsana	132
13	Vadodara	105
14	Kheda	205
15	Bharuch	116

16	Surat	34
17	Panchamahals	38
18	Valsad	11
19	Dangs	None

7.5.1 Ingress of Salinity in coastal areas

The State of Gujarat has the longest coast line i.e. 1/3 rd of the country (1600 km). Out of 1600 km, Saurashtra and Kutch cover about 1125 km. Every year on an average 0.5 to 1.0 km distance from the coastline is affected by salinity ingress. Thus about 5 to 7.5 km wide strip of the inland area has been rendered saline till now and water quality has deteriorated to more than 2000 ppm of TDS in an area of 100 km2.

Large number of water supply schemes have been completed in coastal areas but are affected by salinity ingress. Details are as under.

Sr.No	District	No.of taluka affected	No. of villages affected	No.of schemes completed but affected by salinity ingress	No.of schemes under progress
1	Amreli	3	75	59	8
2	Bhavnagar	4	123	71	22
3	Kutch	7	187	109	19
4	Jamnagar	5	117	88	1
5	Junagadh	4	98	65	10

As per an estimate about 627 villages of five districts of Saurashtra are highly affected by salinity ingress.

Details of villages affected by salinity ingress.

Sr.No.	Name of District	Taluka	No.of villages affected
1	Amreli	Rajula	25
		Jafarabad	27
		Kodinar	23
2	Bhavnagar	Bhavnagar	23
		Ghogha	19
		Talaja	46
		Mahuva	35

3	Kutch	Rapar	9
		Bhachau	19
		Anjar	18
		Mundra	38
		Mandvi	39
		Abdasa	36
		Lakhapat	28
4	Jamnagar	Jamnagar	17
		Khambhalia	15
		Jodia	29
		Kalyanpur	25
		Okha Mandal	31
5	Junagadh	Malia	12
		Veraval	31
		Una	22
		Porbandar	33
		Total	627

A press report of Times of India, Ahmedabad edition dated 27.10.1993 highlights the effect of salinity coupled with shortage which read that "Salinity ingress has spread its tentacles far and wide on the 1125 km long Kutch-Saurashtra coastal belt engulfing 779 villages with a population of 13.3 lacs making the life of the people miserable".

Water in 43,178 wells has become totally saline and nearly 10.65 lakhs(1.065 million) hectares of agricultural land has become pastures. The gravity of situation can also be gauged from the fact that number of "Ghost villages" on the coastal belt has been increasing for the last two decades with the large scale migration of people to the near by towns and cities. Successive droughts in the region have also rendered all preventive measures taken by the Government useless". A report published in popular Gujarat daily "Sandesh" dated 1.5.1994 says that **2.5 million acre land and 43000 wells in Saurashtra region have turned saline.**

The Government of Gujarat appointed a high power committee headed by the Chief Secretary of the State in 1976 to examine the problem of Salinity and suggest remedial measures to contain salinity ingress. Based on the outcome of the report of the committee, and knowing the gravity of problem, the State Government prepared a master plan costing Rs.3887 million in 1980 to combat salinity. The World Bank supported this project and implementation started through constructing check dams, recharge tanks, tidal regulators, static barriers and recharging of wells as well as afforestation. In the recent past a revised plan of Rs.90000 million is prepared and support from the Netherlands Government is sought.

7.5.2 No Source Villages

Providing safe potable water (acceptable quality) in water problem areas is the responsibility of the State Government. The problem villages are identified based on a criteria known as "No Source Criteria". One of the clauses of no source criteria is regarding unacceptable "chemical quality of water". The major quality problem in the State of Gujarat is that of salinity coupled with dissolved salts of fluoride and nitrates.

Out of total **18275** villages in the State as many as **14370** are facing problem of water and are declared as "No Source Villages". At the end of fifth five year plan., there were **3844** problem villages which have increased to **16357** in **1987-88.** In Saurashtra alone **4543** villages out of a total **4727** were having problem of water.

The status of No-source villages as on 1.3.1993 (master plan of GWSSB 1993-94) was as under :

• Total villages as per 1981 census	:	18114
• Villages identified as "No Source" prior to Fifth Five Year Plan	:	9038
• Additional villages identified as "No Source" during Sixth Five Year Plan	:	440
• Villages identified as "No Source" during Seventh Five Year Plan	:	835
• Total "No Source" villages	:	14273
• Villages covered with water supply facilities during Fifth Five Year Plan	:	3720
• Villages covered during Sixth Five Year Plan	:	4228
• Villages covered during Seventh Five Year Plan	:	5206
• Total villages covered at the end of Seventh Five Year Plan	:	13154
• Villages identified as "No Source" during 1992-97	:	230
• Villages remaining to be tackled during Eighth Five Year Plan	:	416

•	Total "No Source" villages during Eighth Five Year Plan	:	14503
•	Total village covered upto 1994	:	14407
•	Village remaining to be covered at the end of 1994	:	96

In addition to providing water supply to the No-Source villages on priority basis under the Minimum Needs Programme (MNP) of State Government supported by Accelerated Rural Water Supply Programme(ARWSP), huge sum of money is spent on providing relief to the scarcity hit villages. Money spent during the scarcity of 1985-87 will give an indication of funds required to tackle the drinking water supply problem on temporary basis.

Year	**Amount spent(Rs.in million)**
1985-86	660
1986-87	640
1987-88	780

The State Government had to spend Rs.47 million providing 3.15 million litres of water per day for sixty days through railway tankers to city of Rajkot in Saurashtra region during 1986-87. It was for the first time in the country for such a long time water was supplied through Railway tankers. The cost of water came to Rs.250 per m3. Inspite of spending huge funds the problem of water is not solved on permanent basis as the problem villages are reappearing again and again during subsequent scarcities.

The water supply authorities in the State have developed 290 comprehensive (Regional) schemes providing water to about 3000 problem villages in the State. For these villages the local sources are either inadequate or saline and hence water has to be imported through distant areas. The Government has to bear the entire cost of providing such schemes and to maintain them. Many of the regional schemes cover more than 100 villages under one scheme. Operation of such schemes become very difficult in view of long distance pipeline.

Problems with long distance pipe supply schemes -

- Heavy pumping at source and on line for boosting the pressure.
- Joint failures and leakages over a long distance in pipes.
- Huge amounts required for capital cost.
- Difficult to locate a safe source.
- Over a period of time, due to heavy drawal, the water in the safe source also turns saline.
- Protest from local groups increasing for drawing water to other areas.

- Growth of vegetation in the pipe line blocking the flow.
- Maintenance very cost and difficult to handle.
- On line water theft.
- Conventional treatment is surface source or chlorination if ground source is required.
- Tail end villages get less water or no water.

Only 13% area of the State is suitable for drilling tubewells for taping potable water which is shown in the map given in **Annexure - 7.2**

7.5.3 Water Supply by tankers

In rural areas where no possibility of supplying water through conventional means is availàble, water is supplied through tankers. This is more so during summer months when the spot sources get dried out or tail end villages in a piped water supply scheme are not getting water.

The State Government provide tanker water supply to such villages/habitations through its Gujarat Water Supply and Sewerage Board. The Board has got 364 motorised tankers. It has also got 1343 HDPE tanks of 5000 liters capacity which can be mounted on tractor or bullock cart.

Status of tanker supply to the villages during scarcity of 1993-94 was as under: (Ref. No.16)

Sr.No	District	No.of villages	No.of Tankers	Expenditure (Rs in million)
1	Jamnagar	408	248	22.9
2	Kutch	405	75	23.0
3	Junagadh	340	169	10.8
4	Rajkot	173	165	3.8
5	Bhavnagar	210	163	12.8
6	Amreli	76	52	1.3
7	Surendranagar	24	11	0.46
8	Ahmedabad	6	5	0.34
9	Mehsana	68	5	0.18
10	Banaskantha	26	7	0.02
11	Sabarkantha	17	4	0.10
12	Kheda	9	2	0.11
13	Panchmahals	41	9	0.14

Year wise status of Water tankers in Gujarat was as under

Year	No.of villages covered	Expenditure incurred (Rs. in lakh)
1985-86		
Plan	-	1083
Non Plan	-	393
1986-87		
Plan	-	-
Non Plan	1841	335
1987-88		
Plan	-	312
Non Plan	1200	-
1991-92		
Plan	1919	1147

Total number of tankers deployed was - 912.

7.6 Desalination

Desalination is a term used to describe process applied for reduction of excess salinity usually referred to as Total Dissolved Solids(TDS).

Desalination is considered as a last resort in a country like India looking to the cost involved and energy required. But when all other alternatives to supply water to the community fail then desalination has to be thought of at any cost.

Desalination can be considered in the following circumstances.

- As the conventional treatments do not have provision for removal of dissolved ingredients.
- As an alternative to long distance transportation of water.
- To mitigate the harmful health effects of TDS, Fluoride, Nitrate, Hardness, Sulphate, Alkalinity, etc.
- Local supplies for fresh water are becoming inadequate.
- High quality of water with low TDS(for industrial use) is required.
- To augment the public water supplies.
- When disputes arise about importing good quality water from other areas.
- Development of certain areas has been impeding by inadequate or unreliable water supply.

Although costwise comparatively it is high, it has got some advantages also. They could be enumerated as under :

7.6.1 Advantages

- When all other alternatives fail to supply water, it promises to supply water in the required quality and quantities.
- Need based small installations could be provided reducing the large capital investments at a time for big projects like dam reservoirs, surface water treatment and long distance pipelines.
- Can be installed in short duration as compared to other conventional projects.
- Product water will be free from other impurities, such as fluoride, nitrate, toxic chemicals and bacterial contamination which otherwise causes serious health hazards.
- Helps avoid ground water depletion through abstraction which otherwise provoke sea water intrusion and water shortage in future.
- Plant machinery could be shifted to any other place in future if required.
- Saves diversion of irrigation water for drinking purpose thereby increasing the crop production.
- Poses less organisational problems as compared to long distance pipelines.
- Raw water is ensured (Brackish/saline water) during water scarcity years.
- Feed water is available locally and no fear of opposition for bringing the water from other areas by people there.
- Operation and maintenance cost could be brought down by recovering salt as a bye-product.

7.6.2 Different Techniques

Several desalination methods have been commercially developed for the removal of excess TDS in waters. The selection of the right process requires careful evaluation of the process efficiency, plant capital and running costs. As a general guide, the most frequent application of various desalination processes has been in the following categories of TDS in water.

Sr.No.	TDS value (mg/l)	Process
1	500-1500	Ion-exchange
2	1500-5000	Electrodialysis OR Reverse Osmosis
3	5000-10000	Reverse Osmosis
4	Above 10000	Reverse Osmosis with high resistance membrane.
5	Above 30000	Distillation.

7.6.3 Classification of Desalination processes :

Desalination is carried out by various processes depending upon the suitability and viability of a process. Saliant processes could be classified as under.

7.6.3.1
- Processes in which desalination takes place without any phase change. e.g. Reverse Osmosis and Electrodialysis.
- Processes in which desalination takes place with phase change. e.g. Solar distillation and freezing.

7.6.3.2
- Processes using heat e.g. various distillation processes.
- Processes using mechanical energy, e.g. Reverse Osmosis and vapor compression.
- Processes using electricity. e.g. Electrodialysis.
- Processes using chemical energy. e.g. Ion-Exchange.

7.6.3.3
- Processes that departs water from the solution.

  e.g. Vapor compression
  Multistage flash.
  Reverse Osmosis.
  Crystallization.
  Freezing
  Solvent extraction.
- Processes that separate salt from the solution.

  e.g. Ion Exchange
  Electrodialysis
  Liquid extraction.

7.6.4 Comparison of main processes.

The main processes viz. Electrodialysis (ED), Reverse Osmosis (RO) and Multi-stage Flash(MSF) are in use. A comparative statement of these three methods highlighting salient features is given in the **Annexure -7.3** which will give an idea about the selection a process.

7.6.5 Desalination Programme in Gujarat.

As seen in the forgoing paras, Gujarat has got severe problem of salinity. A large number of villages are severely affected by salinity for which controlling as well as corrective measures are being taken by various ways. As mentioned earlier, when all other alternatives to supply safe potable water to the community fail, desalination has to be resorted too. There are certain pockets in Gujarat where no other alternative to overcome the problem of salinity is available, desalination is resorted to. Government of India in Ministry of Rural Development has launched a separate Sub-Mission on **"Control of Brackishness"** ,under which desalination plants are provided to various states. Gujarat has also received such plants under this project details of which are furnished below.

Gujarat was perhaps the first State in the country to take lead in installing desalination plants for brackish water conversion in rural areas. Way back in 1985-87, six plants were installed in the State on pilot basis, to experiment the technology at field level in rural conditions. Two of these plants were provided under R&D programme and the rest four under the scarcity relief programme. Eleven more such plants were installed during the scarcity period of **1986-89** under the **Technology Mission** Programme of Government of India. Twelve more plants were installed during **1989-91**. Most of these plants are installed in Kutch and Saurashtra region where the salinity and water problems are maximum. The capacity of such plants varied from $10m^3/d$ to $100m^{3/d}$. Except one Electrodialysis plant at Adalsar, all other plants are based on Reverse Osmosis technology for brackish water conversion. The details of all such plants are given in the **Table - 7.1**

7.6.6 Plant performance.

The performance of desalination plant is dependent on the following design parameters

Sr.No	Item	Reverse Osmosis	Electrodialysis
1	**Membrane**		
	• Material	Cellulose Polyamide	Cellulose
	• Type	Spiral	Ion Sellective
		Plate	Cation Exchange
		Tubular Hollow fine fi	Anion Exchange
	• Life Cellulose Pollamide	 2-3 years 3-5 years	 2-3 years
2	TDS range (ppm)	10000	5000
3	**Salt rejection**	90%	
4	**Working pressure**		
5	**Recovery**	50%	
6	**Energy requirement**	3 to 4 kwh/m3	1 kwh/m3
7	**Flux flow lts/min.**		
8	**Pre treatment**	Removal of SS pH adjustment Descaling	Softening pH adjustme Removal of org.

Analysis data of an RO plant installed at Malika in Surendranagar District(13) is as under

Parameter	Feedwater	Product water
pH	8.26	7.12
TDS (ppm)	3000	640
Total Alkalinity(ppm)	318.8	37.5
Total Hardness(ppm)	306	49.5
Calcium (ppm)	100	Nil
Magnesium(ppm)	56	Nil
Chloride (ppm)	1134.1	301.4
Sulphate(ppm)	115.63	Nil
Iron(ppb)	20	Nil

The desalination technology is considerably new for providing drinking water to rural areas. it needs skilled manpower, pre-treatment and energy. There are certain constraints in running such plants in remote rural areas. The State Government has appointed a committee of experts to suggest corrective measures to improve the performance of such plants.

7.6.7 Cost Economics:

The cost of a desalination plant will depend on many factors and will vary from area to area. The prominent constituents which decide the cost are

- Capacity of the plant
- Type of technique used (e.g. RO/ED/MSF)
- Quality of feed water (Brackish /Saline)
- Cost of energy
- Pre-treatment given
- Skilled operation.

Small sized desalination plants(Brackish water conversion) are experimented in the State and their costsare found to be as under:

Sr.No.	Item	Capacity (m3/d) 10	20	50	100
1	Capital Investment (Land,Source and Plant Machinery) Rs.in million	1.2	1.5	2.5	3.3
2	Water production cost (Rs. / m3)				
a)	Depreciation and interest	22	20	17	13
b)	Running cost				

	(Labour,Power,Chemicals and membrane replacement)	21	18	15	12
c)	Total cost (a+b)	43	38	32	25

Note : These costs are based on spiral wound R.O. technology which is largely used in Gujarat and prices of 1993-94

Obviously the technology of desalination is energy-intensive and is comparatively costly as compared to other modes of water supply. The cost of desalination stands as under in comparison with other methods of supply of drinking water (1993-94 prices).

Sr.No.	Mode of supply	Cost (Rs/m3)
1	By Road tankers	
	• within 50 kms	25
	• within 50-100 kms	50
	• within 100-150 kms	70
2	Railway tankers	60
3	R.O. Technology	
	• m3/d	43
	• m3/d	25
4	Piped water supply in rural areas	10
5	Bottled mineral water	10000

7.6.8 Conclusion :

Gujarat faces sever problem of brackishness and salinity. A large number of villages are identified affected by the menace of salinity. Thousands of hectares of land and wells are affected by ingress of salinity in coastal areas. The development of many area is impeded by this problem. The State Government is taking various actions to combat this menace. Desalination plants are being provided to supply fresh water to the hardcore villages. The technology is costly but needs to be adopted as a last resort. Measures are being taken to improve the performance of desalination plants.

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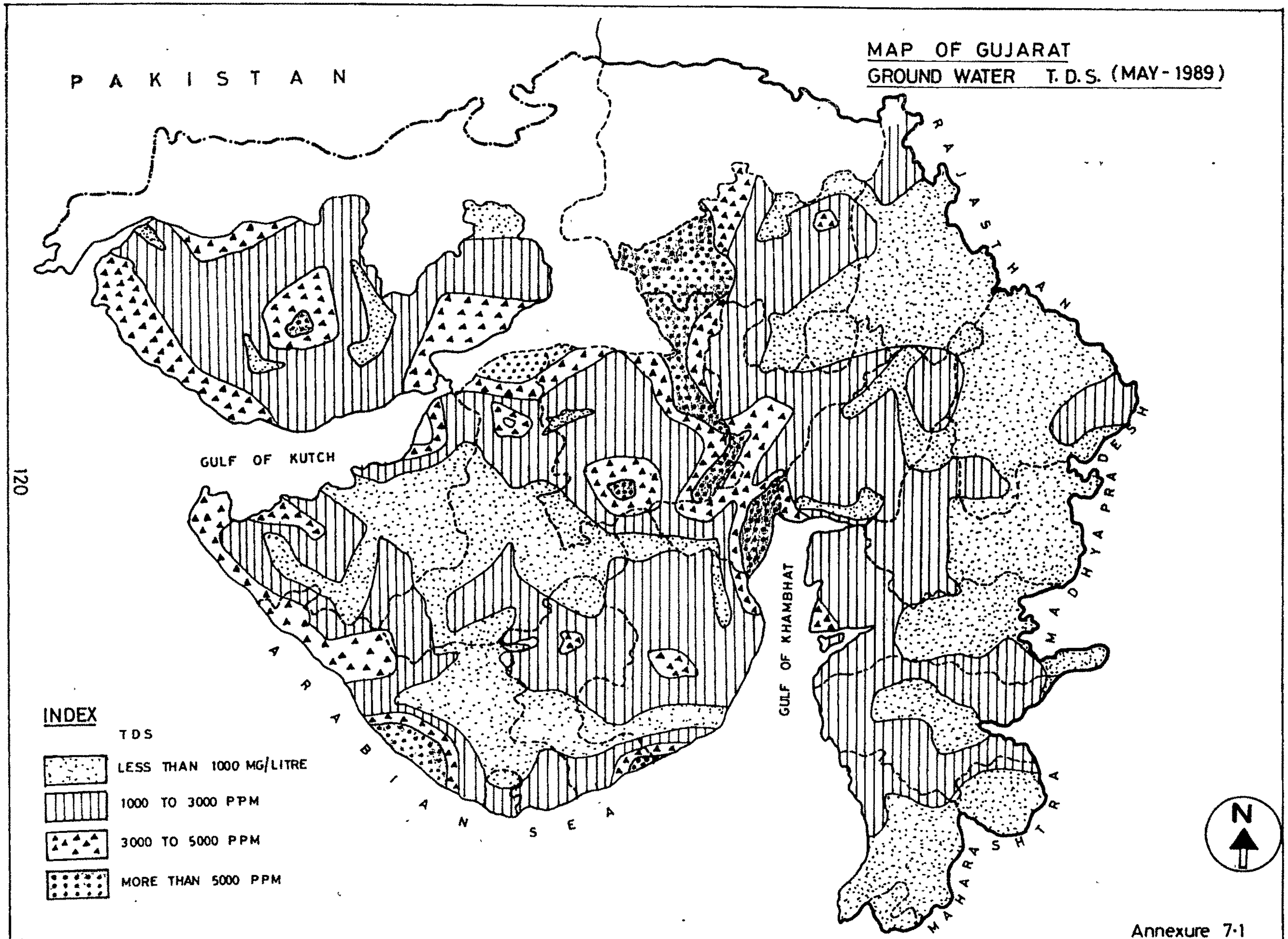
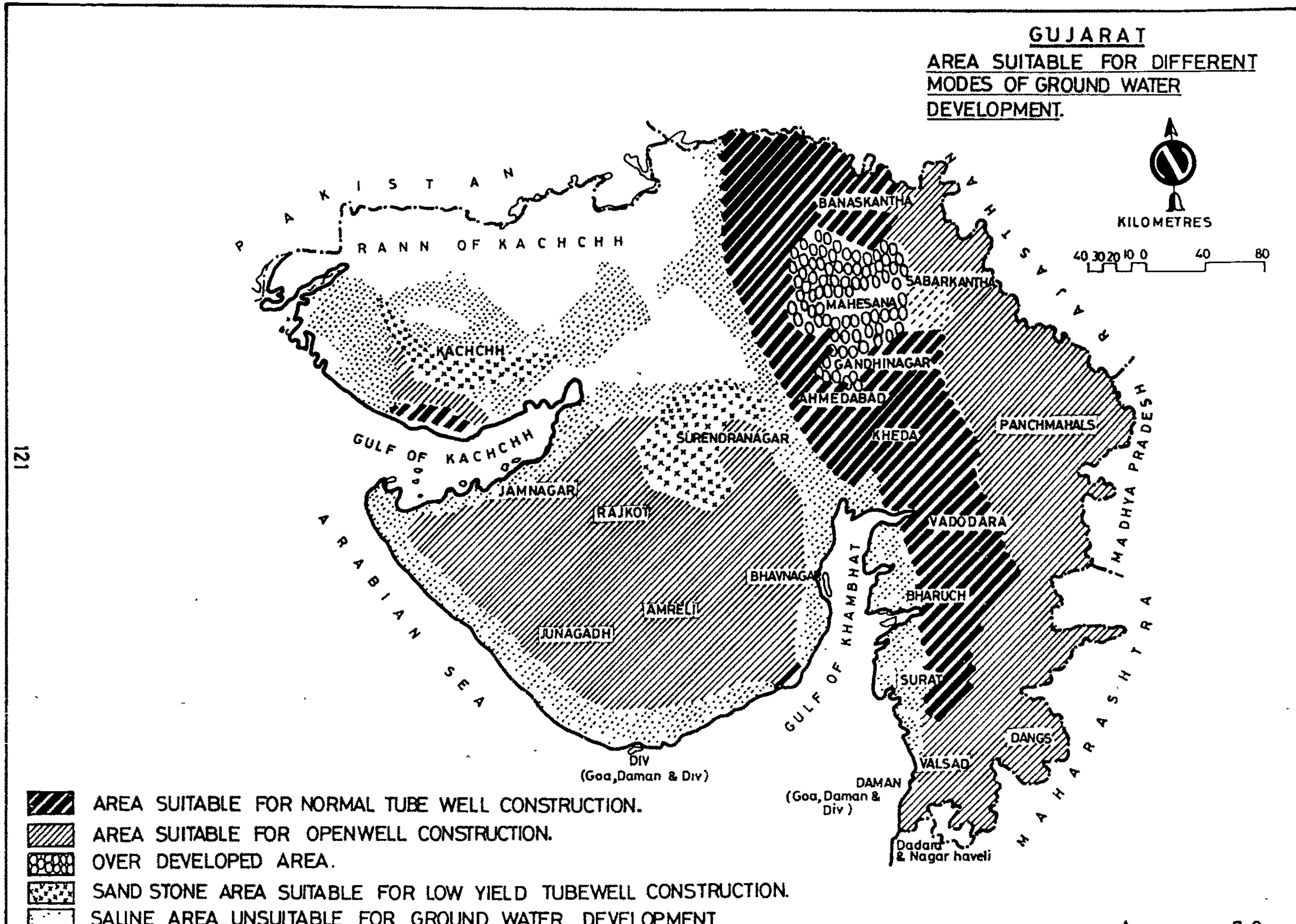

MAP OF GUJARAT
GROUND WATER T.D.S. (MAY-1989)
PAKISTAN
RAJASTHAN
MADHYA PRADESH
MAHARASHTRA
GULF OF KUTCH
GULF OF KHAMBHAT
ARABIAN SEA
N
INDEX
TDS
LESS THAN 1000 MG/LITRE
1000 TO 3000 PPM
3000 TO 5000 PPM
MORE THAN 5000 PPM
Annexure 7·1

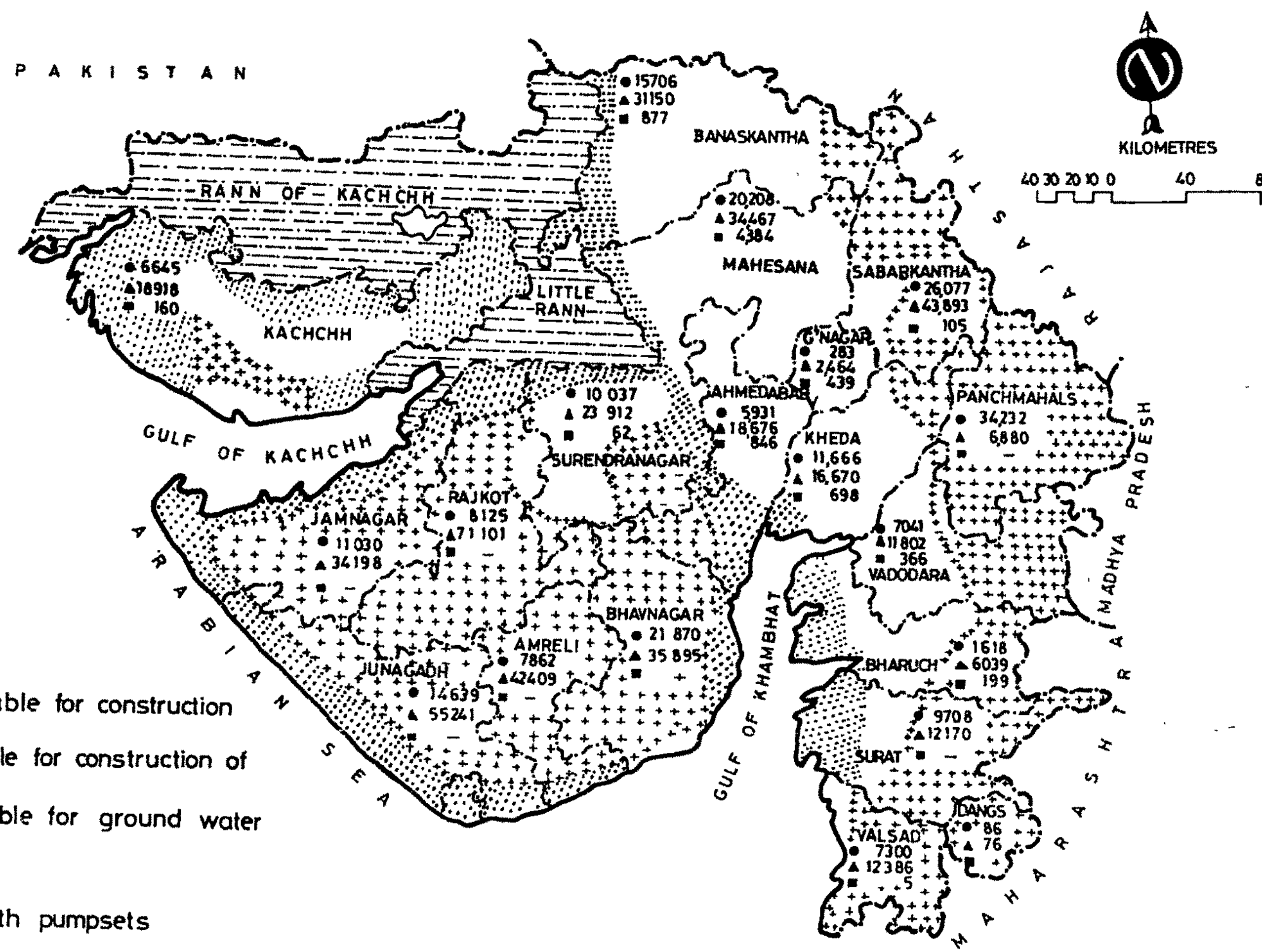

GUJARAT
AREA SUITABLE FOR DIFFERENT MODES OF GROUND WATER DEVELOPMENT.
KILOMETRES
40 30 20 10 0 40 80
PAKISTAN
RANN OF KACHCHH
RAJASTHAN
MADHYA PRADESH
MAHARASHTRA
BANASKANTHA
SABARKANTHA
MAHESANA
GANDHINAGAR
AHMEDABAD
KHEDA
PANCHMAHALS
VADODARA
BHARUCH
SURAT
DANGS
VALSAD
Dadara & Nagar haveli
DAMAN (Goa, Daman & Div)
KACHCHH
GULF OF KACHCHH
JAMNAGAR
RAJKOT
SURENDRANAGAR
BHAVNAGAR
AMRELI
JUNAGADH
DIV (Goa, Daman & Div)
GULF OF KHAMBHAT
ARABIAN SEA
AREA SUITABLE FOR NORMAL TUBE WELL CONSTRUCTION.
AREA SUITABLE FOR OPENWELL CONSTRUCTION.
OVER DEVELOPED AREA.
SAND STONE AREA SUITABLE FOR LOW YIELD TUBEWELL CONSTRUCTION.
SALINE AREA UNSUITABLE FOR GROUND WATER DEVELOPMENT.

Annexure 7·2

Annexure 7·2A

GUJARAT STATE

PLAN SHOWING DISTRICTWISE GROUND WATER STRUCTURES IN GUJARAT STATE



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- Alluvium area suitable for construction of tubewells.
- Saline area unsuitable for ground water development.
- ● Nos. of openwells
- ▲ Nos. of openwells with pumpsets
- ■ Nos. of tubewells

Table 7.1

Details of Desalination Plants installed in Gujarat State

Sr. No.	Name of village	Block (Taluka)	District	Population (1981)	Capacity (M/day)	Date of commissioning	Water Quality TDS (in mg/l) Raw	Product	Cost of plant US$	O&M Cost US$/m^3
1	Adalsar	Lakhatar	Surendranagar	1050	24	May 1985	4000	1200	11250	1.00
2	Malika	Lakhatar	Surendranagar	1000	24	April 1985	3814	1020	15200	1.00
3	Kotaiya	Mandvi	Kutch	346	30	Nov.1985	3408	634	4100	1.00
4	Hadmatiya	Kalyanpur	Jamnagar	995	30	July 1986	4000	1140	6600	1.00
5	Bamnasa	Kalyanpur	Jamnagar	987	24	July 1986	4470	602	5900	1.10
6	Kalyanpur	Vallabhipur	Bhavnagar	1184	24	July 1987	3530	720	5900	0.92
7	Shambhupura	Amreli	Amreli	541	48	Aug. 1986	2290	588	24750	0.95
8	Khardol	Vav	Banaskantha	630	24	May 1986	4560	750	15300	0.93
9	Velavadar	Vallabhipur	Bhavnagar	554	24	Nov. 1987	3120	990	5300	0.90
10	Daldevalia	Jamnagar	Jamnagar	3031	72	Aug. 1989	4570	1396	37500	NA
11	Kolithad	Gondal	Rajkot	NA	84	June 1987	2846	NA	33600	NA
12	Sidhsar	Jamjodhpur	Jamnagar	2608	50	May 1989	2780	530	41250	1.05
13	Ratiya	Bhuj	Kutch	453	30	April 1990	3980	480	12050	1.00
14	Kukadsar	Mundra	Kutch	398	24	Nov./1989	11400	1200	11950	1.05
15	Kanakpur	Kalyanpur	Jamnagar	1509	24	Jan. 1989	2050	824	26750	NA
16	Shiva	Bhanvad	Jamnagar	2088	48	Nov.1991	2550	640	26750	1.10
17	Shethi	Mangrol	Surat	NA	24	June 1990	2800	300	19250	1.15
18	Gajedi	Jodia	Jamnagar	1129	50	Sept.1990	3400	450	53600	1.20
19	Vibhapar	Jamnagar	Jamnagar	3026	50	June 1990	5510	404	82650	0:75
20	Tarsai	Jamjodhpur	Jamnagar	4065	100	June 1990	3160	260	101860	0.75
21	Gagwa	Jamnagar	Jamnagar	1006	20	May 1990	4730	560	46350	1.20
22	Chudeswar	Khambhalia	Jamnagar	2379	30	June 1990	13850	1190	48820	1.00
23	Saidevalia	Bhanvad	Jamnagar	1691	30	Aug.1990	3050	195	45900	1.00
24	Surajkaradi	Okhamandal	Jamnagar	5107	100	June 1990	9100	250	127270	0.70
25	Shiva	Bhanvad	Jamnagar	1691	20	Aug.1990	2300	980	9360	0.75
26	Arambhada	Okhamandal	Jamnagar	3364	50	June 1990	16000	225	84320	0.80
27	Beyd	Jamnagar	Jamnagar	4083	100	May 1990	9500	465	130500	0.70
28	Sachna	Jamnagar	Jamnagar	2614	50	June 1990	14000	250	83300	0.73

1. **NA : Not Available**
2. **Except Plant No. 1 (ED) all others are based on R.O. technology.**
3. **The costs are based on 1992 prices.**

Annexure No. 7.3

A comparative Statement of 3 Salient Desalination methods

Sr. No.	Characteristic	Desalination Techniques		
		Electrodialysis	Reverse osmosis	Multi Stage Flash Filtration
1.	Cost Break-up Capital Labour Chemicals/Spares Energy	 35 - 42% 7 - 9% 6 - 8% 40 - 50%	 16 - 42% 10 - 33% 21 - 35% 16 - 30%	 5 - 25% 10% 5% 60 - 80% (Steam)
2.	Cost competitiveness		ED cost competitive upto 10000 mg/l TDS	ED cost competitive upto 5000ppm TDS
3.	Raw water limitation	10000 mg/l	No limit	No limit
4.	Percentage coverage of World's total desalting capacity (1984)	4.7%	27.7% (20% land based + 7.7% sea based)	67.6%
5.	Motive power	Electrical Energy	Mechanical Energy	Steam
6.	Major Problems	1. Polarization 2. Membrane fouling 3. Scaling 4. Leaks 5. Electrode degradation	1. High pressure pump maintenance 2. Membrane fouling 3. Membrane import 4. Rigid pre-treatment	1. Skilled staff required 2. Product contamination due to tube leaks 3. Environment Impact 4. Slow start-up 5. Cannot operate below 60% of design capacity

7.	Major advantages	1. Suitable for brackish waters (5000 mg/l) 2. Economic choice if cheap electricity is available 3. Membrane locally available	1. Easy & simple operation 2. Rapid delivery and installation (6-9 months) 3. Fast start-up and shut down 4. Adaptable to varying production requirement for a greater range 5. Easy expansion due modular concept 6. Low energy consumption 7. Low Maintenance 8. Compact size-low area 9. Low corrosion due to ambient temperature cheaper construction materials can be used 10. Minimal environment impact 11. Modular concept permits by passing of a defective module	1. Large capacities (up to Mld) possible 2. Considerable operating experience available 3. Less susceptible to fouling as boiling does not take place on the tube surface 4. Low cost steam can be used 5. Less corrosion as well as scale prevention less hazardous 6. less affected by fouling due to lower heat transfer coefficients as compared to ME process