

# Chapter - 1



## Introduction



# 1 INTRODUCTION

## 1.1 GLOBAL WATER RESOURCES ENDOWMENT

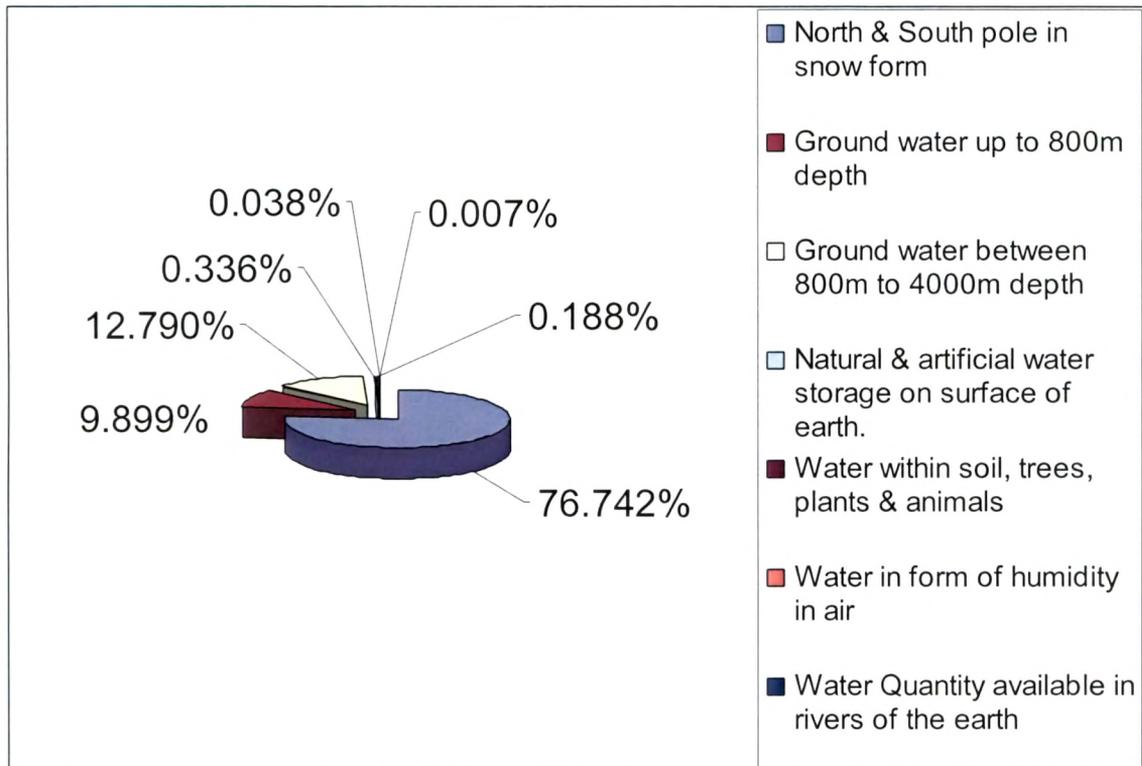
Water is a renewable natural resource having multiple roles as consumption good, production good and an environmental amenity. It contributes significantly to economic growth & overall human development. However, Water is a scarce resource to be planned, developed, conserved and managed on integrated and environmentally sound basis, keeping in view the socio-economic aspects and needs.

The total water resources on earth are estimated 1460 Million km<sup>3</sup>, of which, seawater is 1420.60 Million km<sup>3</sup> (97.3 %). Hence, only 39.40 Million km<sup>3</sup> (2.7%) is sweet water on earth (Table 1.1, Fig.1.1). the renewal of fresh water resources on the land mass is presented through annual water cycle in Table 1.2.

**Table 1.1 Details of distribution of sweet water available on earth**

Sr. No.	Zone wise details of water available	Quantity of water (Million km <sup>3</sup> )	Quantity of sweet water (%)
1	North & South poles in snow form	30.236	76.742
2	Ground water up to 800m depth	3.900	9.899
3	Ground water between 800m to 4000m depth	5.069	12.790
4	Natural & artificial water storage on surface of earth.	0.0132	0.336
5	Water within soil, trees, plants & animals	0.074	0.188
7	Water in form of humidity in air	0.014	0.038
8	Water quantity available in rivers of the earth	0.0016	0.007
	Total	39.400	100.00%

(Source : Central Water Commission, September-2003)



**Graph - 1.1 Distribution of sweet water available on earth**

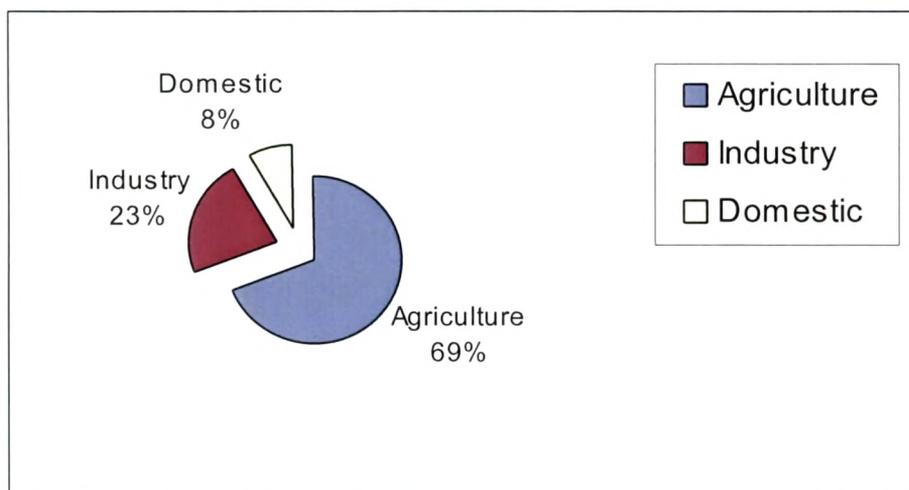
**Table 1.2 Annual water cycle**

Evaporation :	Sea/Oceans	3,40,000 km <sup>3</sup>
	Land Mass Water bodies	60,000 km <sup>3</sup>
	Total	4,00,000 km <sup>3</sup>
Precipitation in the form of rain splash :	Sea/Oceans	3,00,000 km <sup>3</sup>
	Land Mass	1,00,000 km <sup>3</sup>
	Total	4,00,000 km <sup>3</sup>

(Source : White paper on water in Gujarat, Government of Gujarat)

The utilization of fresh water resources at the global level is depicted in Graph 1.2. However, the world scenario as exiting and likely to be obtained (Table 1.3) in not comforting on considering by Falkenmark criteria. The most widely used criterion of water scarcity is propounded by M, Falkenmark. According to this criterion, if the level of annual renewable freshwater supplies falls below 1700 m<sup>3</sup> per capita, there will be local shortages of water. If it falls

below 1000 m<sup>3</sup>, water supply begins to hamper health, economy growth and human well being, and if it falls below 500 m<sup>3</sup> per annum, water availability becomes a primary constraint to life.



**Graph - 1.2 Global water use pattern**

**Table 1.3 World population v/s water availability**

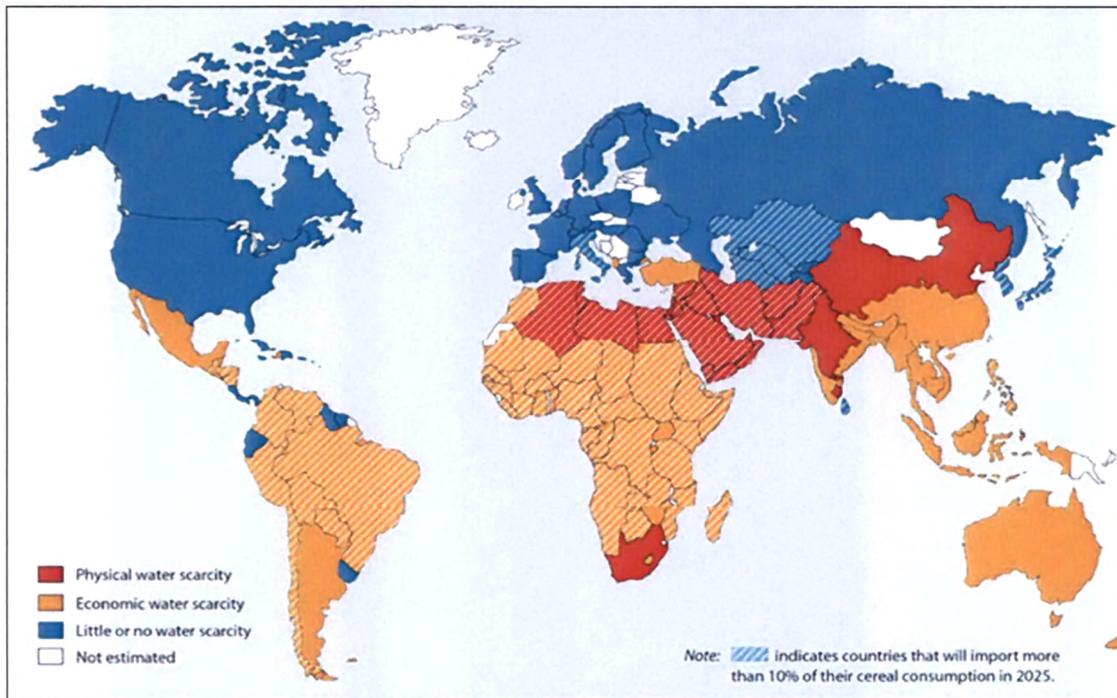
Name of the Nation	Population for the year 2007 (million)	Availability of water per capita for the year 2007 (m <sup>3</sup> )	Population up to 2025 (million)	Water to be available for the year 2025 (m <sup>3</sup> )
Algeria	33.9	531	47.7	378
Kenia	37.5	320	50.55	237
Egypt	75.5	782	97.6	605
Ethiopia	77.1	1260	112.0	867
Bafinaaso	11.5	2023	18.0	1293
Morraco	31.2	882	39.9	689
South Africa	48.5	835	57.5	705
Tunisia	10.3	598	13.5	328
Zimbave	13.4	1425	16.3	1172
Hyaty	9.6	1222	14.0	838
Pooru	27.9	1386	35.5	1090
Afghanistan	27.1	1435	35.20	1105
China	1318.8	2188	1569.6	1838
India	1169.0	1774	1384.6	1498
Israel	7.15	568	8.0	275
Iran	71.2	1032	77.0	955
Kuwait	2.9	121	4.1	57

Name of the Nation	Population for the year 2007 (million)	Availability of water per capita for the year 2007 (m <sup>3</sup> )	Population up to 2025 (million)	Water to be available for the year 2025 (m <sup>3</sup> )
Saudi Arabia	24.7	360	32.4	274
Yemen	22.4	678	33.0	460
Pakistan	163.6	4557	232.9	3201
<b>World Level</b>	<b>6594.0</b>	<b>10450</b>	<b>8036.0</b>	<b>8574</b>

(Source: [http://en.wikipedia.org/wiki/List\\_of\\_countries\\_by\\_population#List](http://en.wikipedia.org/wiki/List_of_countries_by_population#List))

## 1.2 WATER RESOURCES OF INDIA

India has 2.4 per cent of land, 16 percent of world's population, 15 percent of livestock and 4 per cent of water resources of the world (Fig. 1.1).



(Source: [www.mapsofworld.com](http://www.mapsofworld.com))

**Figure 1.1 World Map**

In India, three fourths of annual rainfall of 4000 billion cubic metres (BCM) occur during short span of monsoon (June to Sept) only in a period of about 100 hours duration. Annual average precipitation in western states (Gujarat and Rajasthan) is less than 500 mm, whereas annual average rainfall in

eastern states is, in general, more than 2500 mm. Temporal and spatial unevenness of rainfall causes floods in one part and drought in another part of the country.

There is a huge disparity spatially from basin to basin and region to region. The utilizable water resources availability in the country varies from 18,417 m<sup>3</sup> per capita per year in the Brahmaputra Basin to as low as 180 m<sup>3</sup> per capita per year in the Sabarmati Basin. Even within the Ganga Basin, water availability varies from 740 m<sup>3</sup> per capita per year in the Yamuna River to 3279 m<sup>3</sup> per capita per year in the Gandhak River. Major rivers of India are depicted in Fig.1.2.



(Source: Central Water Commission)

**Figure 1.2 Major rivers of India**

India has 12 major basins having combined catchment area of about 256 million hectare (m.ha) Besides, there are 46 medium basins of sizes varying between 2,000 to 20,000 km<sup>2</sup> coverings a total area of about 25 m.ha. Other

water bodies including tanks and ponds cover an area of about 7 m.ha. Average natural run-off of the country is 1869 BCM and it accounts for 4% of global supply.

Owing to hydrological, topographical and geological limitations, from 1896 BCM, only 690 BCM (37%) of surface water can be utilized by conventional storages and diversion structures. Ground water is another important source of water. On an average annual replenishable ground water has been assessed as about 432 BCM. Thus, the total utilizable water resources both from surface as well as ground water are about 1122 BCM.

Presently 605 BCM (54%) of water is being used for various beneficial purposes. The current levels of utilization of surface and groundwater resources are 70% and 30% only. Sector wise distribution is irrigation 83%, domestic 5%, industry 3% & others 6%.

The total live storage in 9300 dam reservoirs are 177 billion m<sup>3</sup> (BCM) at present. Implementation of various major, medium and minor irrigation and multipurpose projects has increased the irrigation potential of the country from 22.60 m.ha at the beginning of the plan period (1951) to 101.1 m.ha presently.

With development of irrigation, the annual average food grain production of the country has jumped to the level of more than 200 million tons against 51 million tons in 1951. Current utilization of water for generation of energy is about 20 BCM. Present use of water on domestic needs is about 30 BCM. Total navigable length of inland waterways in the country is 14,447 km. India has the distinction of being second largest producer of inland fish after China. Total inland fish production has now gone up to 2.50 million tons.

### **1.2.1 Water resources challenges in India**

The available utilizable water resources of the country may not be adequate to meet all future needs. All out efforts on the part of people from every walk of life need to be made to save every drop of water by adopting all possible means of water conservation and to increase efficiency of all water resources projects.

#### **(a) Floods and drought**

Floods are the most frequent natural calamities faced by India. On an average, floods are affecting about 33 million persons per year. Total flood prone area in the country is about 40 million ha. Out of which, about 14 million ha of flood prone area has been provided protection. One sixth area of the country is drought prone.

#### **(b) Water logging, salinity and alkalinity**

Inadequate drainage provision, improper water management, seepage from canals, obstructions to natural drainage on account of various developmental activities and inadequate system maintenance are main causes for water logging, salinity and alkalinity. An area of 8.51 million ha is affected by water logging, 5.50 million ha by salinity, 3.58 million ha by alkalinity and 4.50 million ha by acidity in irrigation commands in the country.

#### **(c) Over exploitation of ground water**

Punjab, Haryana, Tamil Nadu and Gujarat are the states where the water tables have declined steeply. Total 839 Talukas are overexploited and 226 Talukas are critical.

**(d) Other challenges**

Inadequate maintenance of irrigation systems, discharge of untreated industrial effluents to water bodies, water disputes among regions, chemical contamination of water, etc are other major challenges in the water sector.

**1.2.2 Solution to challenges****(a) Water management**

More than three fourths of current water utilization is through irrigation. As per tentative assessment, increase in irrigation efficiency alone may reduce the need for development of additional water supplies in 2025 by roughly one-half. Hence water management gains importance.

**(b) Interlinking of rivers**

The occurrence of floods and droughts has been a regular feature in India. Many river basins in the country have surplus water and on the other hand, other basins have serious shortage of water. Creation of storages and inter basin transfer of water from surplus to deficient basins may therefore be an option for equitable distribution and optimum development of water resources in the country.

**(c) Rainwater harvesting**

Under the situations of dwindling per capita availability of fresh water, over-exploitation of ground water coupled with depletion of ground water and deterioration of ground water quality, artificial recharging of depleted aquifers may prove to be a very useful proposition.

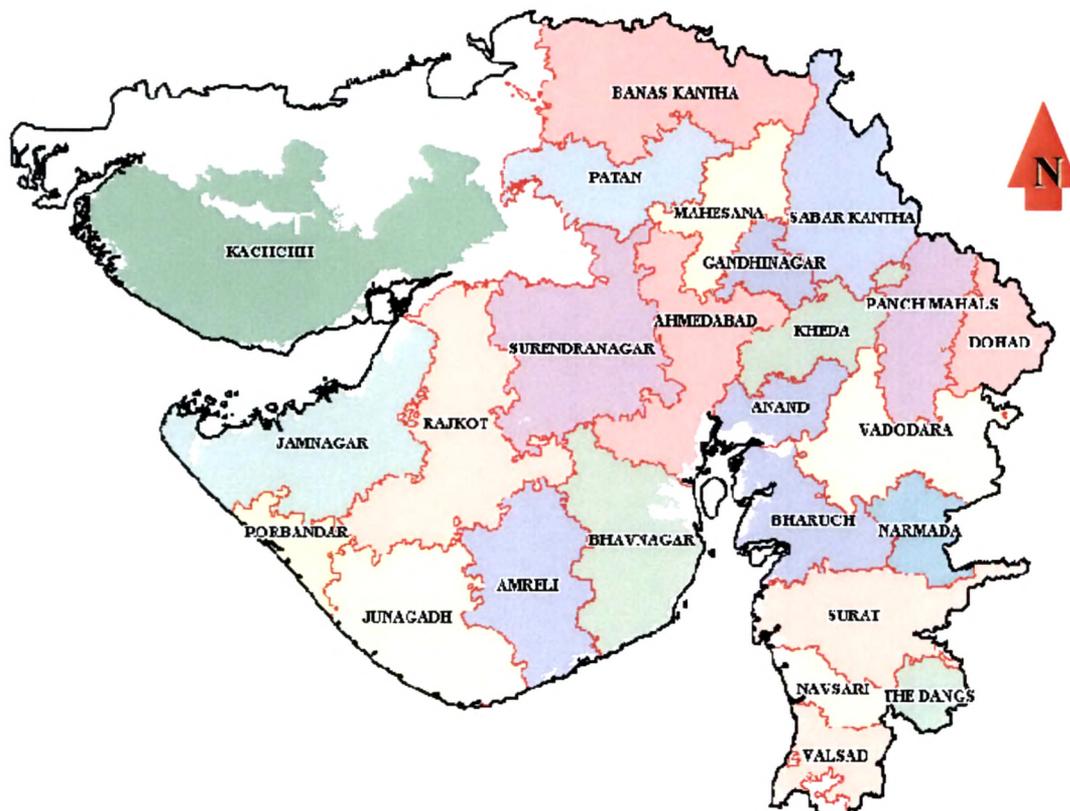
**(d) Reuse and conjunctive use**

Recycle and reuse, conjunctive use of surface and groundwater, may also need to be resorted to face day after day diminishing per capita availability of water in future.

## 1.3 GUJARAT STATE

### 1.3.1 Geographical details

Gujarat State occupies an area of 1,95,984 km<sup>2</sup>. in the western part of India and is situated between 20<sup>0</sup>6' north and 24<sup>0</sup> 42 north latitudes and 68<sup>0</sup> 10<sup>0</sup>, east and 74<sup>0</sup> 28' east longitudes. It has approximately 1600 km long coast on the western side extending from Lakhpat in Kachchh to Daman in South. Rajasthan, Madhya Pradesh and Maharashtra are the states along northern, eastern and southern borders respectively; there is common border with Pakistan in the northwest. The population as per 2001 census was 50.67 millions. Various districts are shown in Fig. 1.3.



**Figure 1.3 Districts of Gujarat**

Out of the total area of 1,95,984 km<sup>2</sup> nearly 1,09,314 km<sup>2</sup> is under hard rocks and 86,670 km<sup>2</sup> is alluvial area, in which 34,625 km<sup>2</sup> is saline area.

### 1.3.2 Physiography

The mountain ranges which are part of the north-south extending Sanhyadri Range (Western Ghat) occupied southeastern portion of the state, forming parts of Dangs, Valsad and Surat districts. The east-west trending Satpura range forming the divide between the Narmada and the Tapi basins in Madhya Pradesh culminates into the Sanhyadri in eastern part of Bharuch district, whereas the Vindhyan range enters the State of Gujarat in the eastern parts of Vadodara and Panchmahal districts to disappear into the plains of south Gujarat further west. The tentacles of the NNE-SS extending Aravalli range spread into the Sabarkantha and Banaskantha districts to disappear into the Mehsana alluvial plains in the west and to continue as broken low hill ranges which merge with the Vindhyan range in Panchmahals district. The rest of the State is a plain or undulating with few isolated hills of the Deccan basalts (Girnar, Pavagarh, Chotila, etc.) and the sandstone (Surendranagar and Kachchh district)

### 1.3.3 Topography

The State of Gujarat can be divided into five different parts based on the topographic features as follows :

- i) The eastern hilly tracts ranging in elevation from 300 m to 1400 m above Mean Sea Level (MSL) forming a divide from which majority of the west and southwest flowing rivers of the South Gujarat originate. The Narmada and Tapi are the only rivers which are cut across the hilly tract along the fault zones.
- ii) The vast alluvial plains, ranging in elevation from 25 m to 150 m, extend northward from the Tapi-Narmada delta regions to the Mehsana and western Banaskantha region and further westwards into the Little Rann of Kachchh and the Banni Plains of Kachchh.



occasional shallow grounds (sea level or less) have given rise to scattered saline lakes, the biggest of which is the Nal Sarovar in Ahmedabad district.

#### **1.3.4 Drainage**

The drainage of all the five areas has a distinct manifestation of the topographical features and physical characteristics of the rock formations. The flow directions of some of the major rivers are controlled by the major tectonic activities which occurred during geological times. Except the Narmada, the Tapi and the Mahi River, all other rivers in the eastern part of the state, originate on the western slopes of the eastern hills. They flow in the direction almost at right angle to the boundary towards southwest (the Sabarmati and the Mahi rivers) in the northeastern part, towards almost west (the Narmada, the Tapi, the Dhadhar) in the central region and towards northwest (the Kolak, the Par, the Ambica, etc.) in the southern part.

Most of the rivers in the alluvial plain are meandering with very wide courses, whereas those in rocky tracts have deep and narrow courses. The rivers in Saurashtra originate from the Central uplands and represent a radial drainage pattern.

#### **1.3.5 Geohydrology**

Except for the pre-Cambrian igneous and meta-sedimentary rocks, all other hard rocks (basalts) form multi-aquifer systems like the soft rocks. The semi-consolidated rocks (Mesozoic rocks) also support multi-aquifer system. The rocks are essentially impervious and compact but on weathering, the joints, fractures, shear zones, foliation, etc. become prominent, imparting the rock secondary porosity and permeability. These features are only down to depths of 30 m to 40 m. Only a few major shear zones maintain significant permeability at greater depths. The porosity and permeability are the two factors which control

the occurrence and movement of ground water. The alluvial formations and semi-consolidated formations have granular zones (sands, sandstones, grits, gravels etc.) which have good porosity and permeability but the degree of permeability varies with the degree of consolidation. In case of hard rocks, the primary porosity is lacking and only secondary porosity (fractures) plays important part. Ground water that occurs under water table is in phreatic, semi-confined and confined conditions. In hard rocks, the major fracture and shear zones connect the pyretic and shallow confined aquifers to give rise to semi-confined conditions. The water table aquifers show continuity as the weathered material allows passage of water from one rock unit to other in case of hard rocks, as far as particular basin is considered. Figure 1.5 depicts the geohydrology of Gujarat. Areal distribution of soils in Gujarat is presented in Table 1.4.

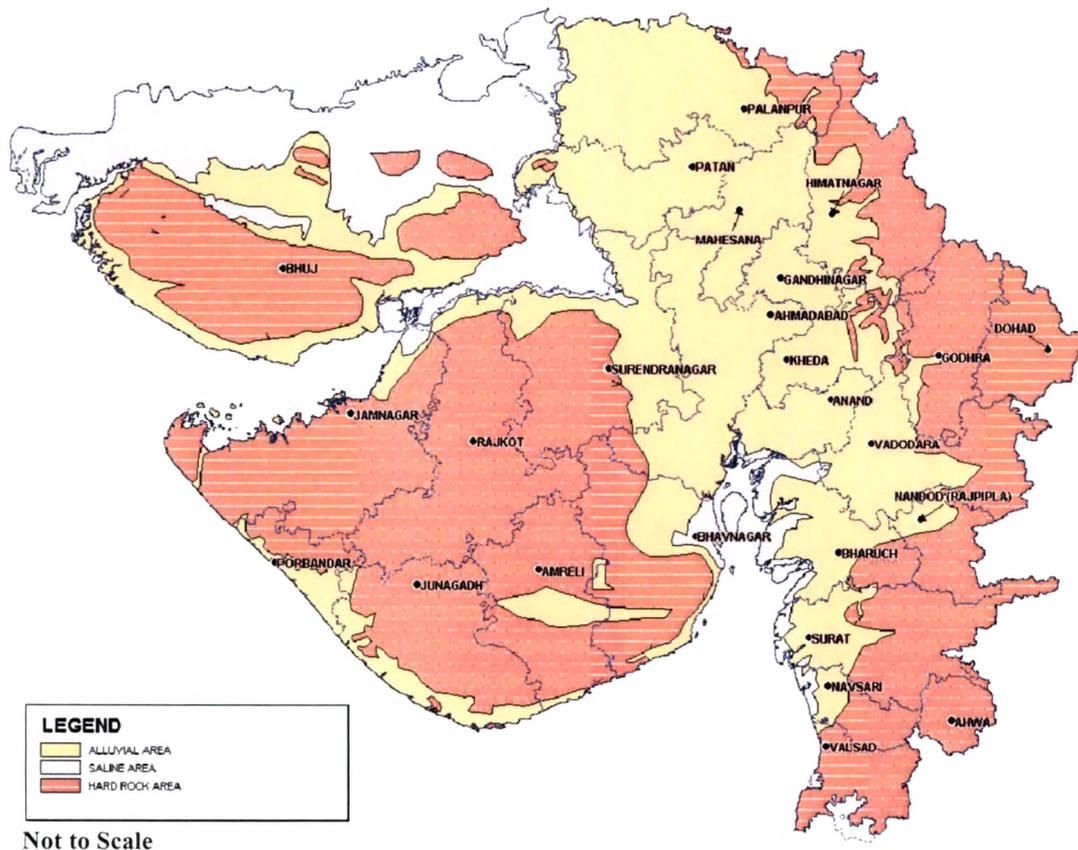


Figure 1.5 Geohydrology of Gujarat

**Table 1.4 Geological formation of Gujarat**

Area in km <sup>2</sup>		
Alluvial Area	71,180	(36.31%)
Rocky Area	94,350	(48.13%)
Saline Area	30,454	(15.56%)
Total Area	1,95,984	

### 1.3.6 Climate

The climate, in general, is characterized by three main seasons (summer, monsoon and winter). The monsoon period, June to October, forms part of summer season. The monsoon starts by middle of June, is at its peak in July and starts retreating by end of September.

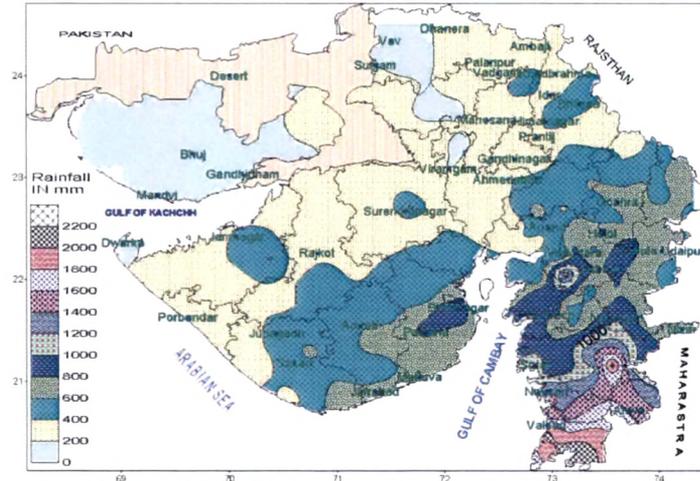
The relative humidity in all parts of the State, except the coastal strip, is low (being about 50% between October and May). Average annual relative humidity figures for different regions are as follows

South Gujarat	: 71%	North Gujarat	: 64%
Saurashtra Uplands	: 56% to 67%	Coastal Saurashtra	: 69% to 77%

Wind velocities are generally moderate except during the period prior to the onset of the monsoon and during the monsoon period. Winds blow from west or southwest during monsoon whereas they blow from north during winter.

### 1.3.7 Rainfall

The rainfall shows steep reduction from 2000 mm in the extreme south (Dangs, Valsad districts) to 650 mm in the northeast (Banaskantha district) and from the east, there is steady fall from 750 mm in Sabarkantha district to 300 mm in Kachchh. Fig. 1.6 depicts the rainfall pattern of Gujarat.

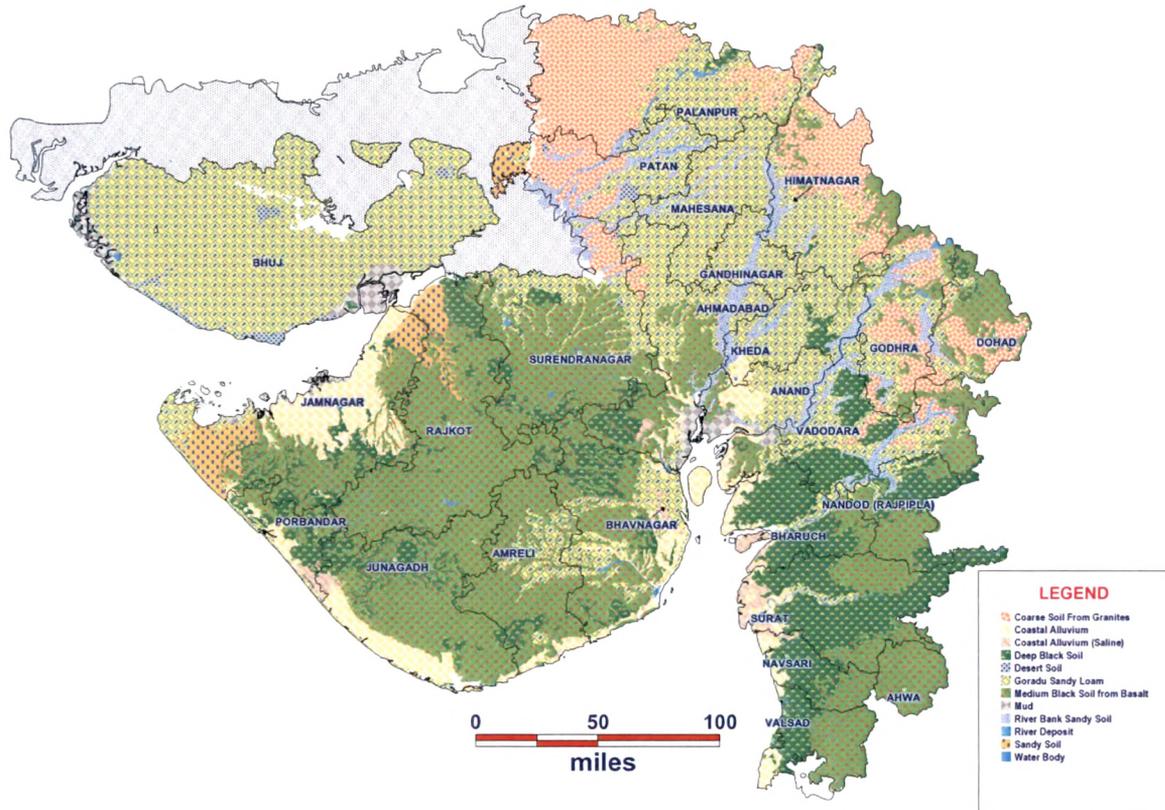


**Figure 1.6 Rainfall pattern in Gujarat**

**1.3.8 Soils**

All India Soil and Land Use Survey organization has classified the soils in Gujarat into seven groups:

- (i) Alluvial Soils, (ii) Black Soils, (iii) Saline-Alkaline Soils, (iv) Desert Soils, (v) Hilly Soils, (vi) Forest Soils and (vii) Lateritic Soils (Fig. 1.7).



**Figure 1.7 Soil pattern in Gujarat**

### 1.3.9 Water resources in Gujarat

The total geographical area of the State is 19.6 million hectares. Major rivers like Mahi, Sabarmati, Narmada and Tapi initiate from the neighboring States and enter through the eastern fringe of Gujarat State. About 45 percent of the surface water resources of Gujarat are available from inter State basins..

In the State of Gujarat, 17 rivers flow in the Gujarat region, 71 rivers in the Saurashtra region and 97 rivers in the Kachchh region. Hence, there are a total of 185 river basins in the State. Surface water potential of Gujarat state is assessed 20486 Mm<sup>3</sup> annually considering 75% dependability for Gujarat region, 60% for Saurashtra & 50% for Kachchh. Surplus water quantity 18047 Mm<sup>3</sup> is allocated from basins connected with Rajasthan, Madhya Pradesh & Maharashtra states. Regionwise and basinwise water resources in Gujarat are presented in Table 1.5.

**Table 1.5 Region wise and basin wise total water resources in Gujarat**

Sr No	River basin	Availability of water (Mm <sup>3</sup> )
<b>North Gujarat</b>		
1	Rel	49
2	Banas	854
3	Saraswati	404
4	Rupen	445
5	Sabarmati	3548
	<b>Sub Total</b>	<b>5300</b>
<b>Central and South Gujarat</b>		
6	Mahi	5650
7	Dhadhar	3600
8	Narmada	15150
9	Kim	435
10	Tapi	4900
11	Mindhola	340
12	Purna	580
13	Ambika	640
14	Auranga	380
15	Par	290

Sr	River basin	Availability
16	Kolak	180
17	Damanganga	680
18	Other Rivers	2875
	<b>SubTotal</b>	<b>35700</b>
<b>Saurashtra</b>		
19	Shetrunji	950
20	Bhadar	932
21	South Saurashtra	1794
22	North Western Saurashtra	1194
23	North & North Eastern Saurashtra	1860
24	Eastern Saurashtra	1170
	<b>TOTAL</b>	<b>7900</b>
<b>Kachchh</b>		
25	Kachchh	1100
	<b>TOTAL</b>	<b>1100</b>
	<b>Grand total of State</b>	<b>50000</b>

(Source : Water resources planning for the state of Gujarat- Tahal Consulting Engineers Ltd. 1997)

The regionwise available surface and ground water resources as well as design storage are presented in Tale 1.6 and Table 1.7 respectively.

**Table 1.6 Ground and surface water scenario**

	Surface water (Mm <sup>3</sup> )	Ground water (Mm <sup>3</sup> )	Total (Mm <sup>3</sup> )
South & Central Gujarat	31750	3950	35700 (71.40%)
Saurashtra	3600	4300	7900 (15.80%)
North Gujarat	2000	3300	5300 (10.60%)
Kachchh	650	450	1100 (2.20%)
<b>TOTAL</b>	<b>38000</b>	<b>12000</b>	<b>50000 (100%)</b>

(Source : Water resources planning for the state of Gujarat- Tahal Consulting engineers Ltd. 1997)

**Table 1.7 Design storage of water resources of Gujarat**

Region	Design storage (Mm <sup>3</sup> )		
	Gross	Live	Dead
North Gujarat Region	1944.11	1772.05	172.06
Central Gujarat Region	2533.07	2382.56	150.51
South Gujarat Region	8838.99	7836.14	1002.85
Kachchh	328.96	298.88	30.08
Saurashtra	2529.42	2378.92	150.50
<b>Total of Gujarat</b>	<b>16174.55</b>	<b>14668.55</b>	<b>1506.00</b>

(Source : State flood control cell, Government of Gujarat)

### 1.3.10 Availability of ground water resources

Utilizable ground water potential in Gujarat is 12000 Mm<sup>3</sup> While the available ground water resources are 3950 Mm<sup>3</sup> in the South and Central Gujarat regions, 4300 Mm<sup>3</sup> in Saurashtra region, 3300 Mm<sup>3</sup> in North Gujarat region and 450 Mm<sup>3</sup> in Kachchh region.

The ground water recharge rates per km<sup>2</sup> are 1,19,000 m<sup>3</sup> in the South and Central Gujarat region, 1,06,000 m<sup>3</sup> in North Gujarat region, 87,000 m<sup>3</sup> in Saurashtra region and 14,000 m<sup>3</sup> in Kachchh region.

### 1.3.11 Agriculture

The State is chronically dry and prone to drought. Most parts of the arid and semi arid regions are prone to drought / famine conditions in 3 to 5 year intervals.

There are a large number of crops (about 133) which are being cultivated, out of which paddy, wheat, bajra, jowar and maize are the principal cereal crops, tur and gram are important crops, pulse and the oilseeds include groundnut, mustard and seasamum, Cotton and sugarcane are cash crops. The cropwise distribution of cropped and irrigated area is given in Table 1.8. the overall land utilization pattern is presented in Table 1.9.

**Table 1.8 Total cropped area and irrigated area for year 2002-2003**  
(area in '00 ha)

Name of crop	Cropped area	Irrigated area
Rice	6287	3292
Wheat	4789	4030
Jowar	2122	87
Bajri	11294	1963
Barly	126	125
Maize	5044	317
Other cereals	530	27
Pulses	7494	693
Condiments and spices	2315	2306
Fruits	1531	1486
Vegetables	2001	1960
Cotton	16734	7377
Other fiber crops	56	0
Total oil seeds	28996	6446
Total drugs and narcotics	1814	1437
Fodder crops	12625	2290
Other non-food crops	28	13
<b>Total</b>	<b>103786</b>	<b>33849</b>

(Source : Director of economics and statistics, GOG)

**Table 1.9 Land utilisation pattern in Gujarat State for year 2002-03**  
(area in '00 ha)

Reporting area	188118
Forests	18535
Barren & unculturable land	26084
Land put to non agricultural uses	11446
Permanent pasture & other grazing land	8502
Land under misc. tree crops & groves not incl. in net area sown	40
Culturable waste	19848
Current fallows	9300
Other fallows	112
Net area sown	94814
Area sown more than once	11493
Gross area sown	106307
Percentage of net area sown to reporting area	50.40

(Source : Director of economics and statistics, GOG)

### 1.3.12 Water quality in Gujarat State

The quality of surface water resource is threatened by contamination and pollution by the domestic, industrial and agricultural users, while the quality of ground water gets deteriorated due to fast depleting water level caused by excessive pumping and resulting ingress of salinity. Out of 30,269 habitations of Gujarat State, 4341 habitations suffer from excess fluoride contents, 1336 habitations from excess nitrate contents and 2575 habitations from TDS contents. On an average, 6000 villages are provided with drinking water through tankers during scarcity period, which recurs almost once in every three years.

### 1.3.13 Reservoir sedimentation in Gujarat

The data presented in Table 1.10 indicate relatively larger percentage of serious category reservoirs in Saurashtra, than in other regions, however, the silt rate is relatively less.

**Table 1.10 Abstract of sedimentation survey**

Sr. No.	Reservoir as per trend of sedimentation	Region					Total
		Saurashtra	North Gujarat	Central	South	Kachchh	
A	Total no of reservoirs	55	10	10	8	8	91
1	Insignificant nos.	1	1	-	-	1	3
2	Significant nos.	15	3	3	3	4	28
3	Serious nos.	39	6	7	4	4	60
B	Annual % loss in capacity						
	Maximum	3.22	4.19	2.23	3.38	1.91	
	Minimum	0.06	0.09	0.16	0.02	0.23	
C	Silt rate ha.m/100 km <sup>2</sup> /year						
	Maximum	18.6	61.03	64.07	123.68	15.54	
	Minimum	1.43	0.02	1.90	0.68	1.90	

(Source : GERI, Vadodara)

### 1.3.14 Check dams in Gujarat State

With the peoples participation in the last six years (2000-2006), 50113 check dams were constructed. The scheme was implemented with 60:40 in which Government contribution was 60%, in tribal area the scheme was started with 80:20. Now in phase-III, the contribution of the people has reduced from 40% to 20%. The break up of check dams constructed in various regions/districts are as given in Table 1.11.

**Table 1.11 District wise check dams in Gujarat**

Sr. No.	Name of district	Total no. of check dams
	<b>Saurashtra region</b>	
1	Rajkot	4670
2	Amreli	2971
3	Bhavnagar	5788
4	Jamnagar	6226
5	Junagadh	3633
6	Porbandar	395
7	Surendranagar	826
<b>8</b>	<b>Kachchh</b>	<b>1057</b>
	<b>North/Central Gujarat</b>	
9	Ahmedabad	100
10	Anand	5
11	Banaskantha	1426
12	Dahod	3570
13	Panchmahal	5177
14	Vadodara	1091
15	Gandhinagar	27
16	Kheda	272
17	Mehsana	438
18	Narmada	406
19	Patan	602
20	Sabarkantha	6098
	<b>South Gujarat</b>	
21	Bharuch	281
22	Navsari	645
23	Surat	1158

Sr. No.	Name of district	Total no. of check dams
24	Dang	1271
25	Valsad	1980
	<b>Total</b>	<b>50113</b>

(Source : BISAG, Gandhinagar)

### 1.3.15 Water related issues

- (1) The total availability of surface water is 38000 Mm<sup>3</sup>, of which only 16175 Mm<sup>3</sup> water is presently stored. Even after Narmada, 12000 Mm<sup>3</sup> of storage is to be created.
- (2) Central and South Gujarat has 71% water resources with 25% of land area. While Saurashtra, Kachchh and North Gujarat has 29% water resources with 75% of land area, Hence, water availability is not evenly distributed.
- (3) The annual per capita water availability in North Gujarat, Saurashtra and Kachchh are 343 m<sup>3</sup>, 540 m<sup>3</sup> and 730 m<sup>3</sup> respectively, which is less than even the minimum 1000 m<sup>3</sup> of water requirement.
- (4) The ground water in the North Gujarat area is overexploited. The water extracted at present is from 100 m to 300 m depth, consuming 42% electricity. The depth to ground water is increasing per year at the rate of 3 m to 5 m.
- (5) Due to overexploitation of ground water in 765 km long coastal belt in Saurashtra, the ground water in 10 km width is completely saline due to salinity ingress.

(6) 70% population is using ground water as domestic water. 4341 habitations have excess fluoride problem, 2575 habitations have high salinity problem and 1336 habitations have nitrate problem in ground water.

### **1.3.16 Solutions of water issues**

(1) As water availability in South and Central Gujarat is surplus, it is essential to transfer the surplus flood water towards North Gujarat, Saurashtra and Kachchh.

(2) North Gujarat is presently using ground water as the main source of water for irrigation. Surplus water of Narmada and Mahi needs to be diverted to fill all dams, ponds and rivers to increase ground water recharge.

(3) To prevent salinity ingress in coastal Saurashtra, series of check dams in the rivers, bandharas of sea and river junction and spreading channel inter basin transport of surplus water of Narmada are required.

(4) All ground water quality affected villages/ habitations for drinking water needs Narmada based and other surface water reservoir based regional group pipe water supply system is to be provided.

(5) To minimize the drought conservation of water, inter-basin water transfer of water, cultivation of low water requiring crops, adoption of drip and sprinkle irrigation in place of flood irrigation technique, Narmada base drinking water supply schemes and Sujalam Sufalam schemes are required. The supply of fresh water from Kalpasar reservoir will provide additional boost to socio-economic status.

#### 1.4 SAURASHTRA REGION

Saurashtra is a western most peninsular region of the state. It is situated between 20° 30' N to 23° 45' N latitude and 68° 45'E to 72° 15'E longitude. Geographical area of the Saurashtra region is 58804 km<sup>2</sup> which accounts for 31.25 % of the State. The region has 765 km coastline. The region, which earlier had 6 districts and 70 talukas has now, with reorganization in October, 1997, 7 districts (by formation of Porbandar district from erstwhile Junagadh district) and 77 talukas covering 4702 inhabited villages. There are about 71 small and medium river basins of which two rivers, Shetrunji and Bhadhar, may be defined as major.

The rivers in the Saurashtra (Bhadar, Shetrunji, Ozat, Limbdi Bhogavo. Machhu, Hiren) originate from the Central uplands and have developed radial drainage pattern. On account of several radially intruded basic dykes cutting through traps around Amreli and Jasdan, there are low and straight hill ranges, which is a characteristic feature of Saurashtra. The central part of the region forms an elevated table land, from where most of the rivers rise and flow radially. The uplands of Saurashtra, comprising sandstone- shale and basalt formations with elevations varying from 150 m to 500 m, slope radially to merge into the coastal tracts. The entire peninsula of Saurashtra (except coastal strips & parts of Surendranagar district) are under laid with hard basalt rock of the Deccan trap formation. In the Saurashtra region, there are three major hydrogeological units, namely, hard rock, soft rock and semi-consolidated rocks. All hard rocks (basalt) form multi-aquifer system like soft rock. The semi-consolidated rocks also support multi-aquifer system. The climates in Saurashtra have three seasons i.e. Summer, Monsoon and Winter. A large part of Saurashtra lies between 22.38 °C to 38.64 °C isotherm. The mean annual rainfall in the region (weighted average of all districts) is 568 mm. There is a significant spatial variation in the rainfall within the region. Saurashtra region in generally

covered by black soil. Some areas have shallow black soil and remaining areas have medium black soil. The coast line has saline and alkaline soil. The average surface water potential of Saurashtra has been estimated at about 6000 Mm<sup>3</sup>/yr, which is equivalent to 123 mm depth (22% of regional rainfall). Saurashtra having about 31% of the land area of State contributes just 11% of surface water potential.

### **1.5 OBJECTIVE OF THE PRESENT RESEARCH STUDY**

In Gujarat untill now 193 major and minor irrigation dams are constructed. The total designed live storage of these dams are 14668 Mm<sup>3</sup>. Out of 193 dams, Saurashtra region has 129 nos (including 2 major projects), Kachchh 20 and Gujarat region 44 dams. The live storage of Saurashtra dams are 2379 Mm<sup>3</sup>. There are 7 districts in Saurashtra, in which the largest number of 34 dams (27%) including Bhadar and Machhu are in Rajkot district. The live storage of Rajkot district's dams are 809 Mm<sup>3</sup> (34% of Saurashtra).

Saurashtra region has 71 rivers originating from the center and have short length and stiff gradients. All the rivers are debouching in to the Sea. The rainfall is very erratic and generally there are only 3 to 4 high intensity rains of short durations that make difficult to conserve all such water in dams. The average rainfall in Saurashtra is 568 mm. This region has 38 lakh ha agricultural land. The farmers generally grow only Kharif crops. There are 2.5 lakh oil engines and 2.4 lakh electric pumps for extracting ground water from wells and dugwells. The ground water is stored mainly in top 30 m to 40 m weathered and fractured rocks. About 70% domestic water supply is from ground water base.

Gujarat suffered drought in the years 1985, 1986 and 1987. The drought in Saurashtra was most miserable. The cities like Rajkot, Jamnagar had to be supplied drinking water through railway tankers. The total Saurashtra region

was affected by drought in three consecutive years. Kharif crops usually failed because of uneven rainfall. Therefore the farmers groups/ cooperatives and NGOs particularly of Saurashtra region have started open well recharge through PVC pipes and through check dams. Due to construction of check dams and existence of high permeability fractured and weathered strata in all rivers and drains, all the check dams are filled up, ground water is recharged to all near by vicinity wells even 3 to 4 inch rainfall. The farmers have used that ground water to protect their Kharif crops even in dry spell is prolonged and rains are not received as per requirement. In consequence Kharif production was sustainably increased. Again in 1999-2000 water scarcity had occurred in Saurashtra region. The positive results of the earlier constructed check dams have given a huge momentum for of Government-people participatory in check dams schemes. The Government of Gujarat has commenced people participation scheme called 'Sardar Patel Sahbhagi Jal Sanchay Yojana' on 17/01/2000. Farmers cooperatives, voluntary organizations, NRIs, industrialists, NGOs and even various religious heads have given mammoth response in this scheme. Farmers cooperative groups have constructed 50000 check dams thorough out Gujarat with contribution of 40% in Saurashtra region and 20% in tribal belt. Out of these, the highest number of check dams were constructed in Rajkot district and particularly in Bhadar Basin in the initial phase of the scheme.

The Bhadar Basin is the biggest basin of Rajkot district, covering Rajkot, Surendranagar, Junagadh, Jamnagar, Porbandar and Amreli districts. Bhadar-I is the major irrigation scheme which irrigate 17850 ha command. The Bhadar Dam water is also earmarked for Rajkot city and other rural villages for domestic water supply. Bhadar scheme is also supplying water to the industries in cities like Rajkot, Gondal, Jetpur, Dhoraji, Porbandar, etc.

Bhadar dam was constructed in 1965. It has command area of 17850 ha, with gross storage designed capacity of 238 Mm<sup>3</sup>, silting of 3.37 ha.m/100km<sup>2</sup>/year and dead storage of 14.16 Mm<sup>3</sup>. Due to heavy siltation the storage capacity has reduced to 202 Mm<sup>3</sup>. In Bhadar-I catchment 905 Check dams were constructed with the help of peoples participation. The actual silting observed in Bhadar is 5.752 ha.m./100km<sup>2</sup>/year (year-2000) against 3.37 ha.m./100km<sup>2</sup>/year planned in design. Further, there has been reduction in silt rate 3.717 ha.m. /100km<sup>2</sup> /year (Year-2004) after construction of a large number of check dams in the catchment of Bhadar-I project. Over a span of 42 years till 2007, the dead storage of 14.16 Mm<sup>3</sup> which was considered in design has changed to 35.78 Mm<sup>3</sup> due to silting. The impact of check dams on sedimentation in Bhadar-I is also a useful parameter for study.

In Bhadar project report, evaporation loss considered 18 %. Evaporation loss estimated 40 Mm<sup>3</sup>/year (1400 MCft/ year), However actual evaporation losses has observed to 28% /year. The impact of checkdams on variation of evaporation losses in Bhadar reservoir due to ground water recharge is important aspect of present study.

There is some loss of water in surface irrigation due to check dams in catchments. These check dams however, increases the ground water recharge. The design flood of the Bhadar-I was 2,00,000 cusecs and the dam overflowed only for 15 years in the period from 1965-1995. Hence the impact of checkdams, on flood water, sedimentation, irrigation, ground water recharge, ground water quality, ground water table etc. are important aspects of study.

Main objective of the study are:

- (a) Impact of water stored in check dams on Bhadar-I reservoir.
- (b) Impact of check dams in sedimentation /siltation in Bhadar-I reservoir.
- (c) Comparison of evaporation losses in Bhadar-I reservoir and check dams.
- (d) Impact on controlling flood routing of Bhadar-I dam due to check dams.
- (e) Impact of check dam on ground water regime of Bhadar-I catchment.
- (f) Impact of check dam on ground water regime of various taluka of Rajkot district.
- (g) Impact of check dams in ground water quality of Rajkot district.
- (h) Impact of check dams on cropping pattern & agricultural production in Rajkot district.