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<tr>
<td>BIS</td>
<td>Bureau of Indian Standards</td>
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<td>BOD</td>
<td>Biological Oxygen Demand</td>
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<tr>
<td>CAG</td>
<td>Comptroller And Auditor General</td>
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<td>CEPI</td>
<td>Comprehensive Environmental Pollution Index</td>
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<tr>
<td>CETP</td>
<td>Common Effluent Treatment Plant</td>
</tr>
<tr>
<td>CGWB</td>
<td>Central Ground Water Board</td>
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<tr>
<td>COD</td>
<td>Chemical Oxygen Demand</td>
</tr>
<tr>
<td>CPCB</td>
<td>Central Pollution Control Board</td>
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<tr>
<td>CSPC</td>
<td>Coastal Salinity Prevention Cell</td>
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<tr>
<td>DO</td>
<td>Dissolved Oxygen</td>
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<tr>
<td>DoEF</td>
<td>The Department Of Environment And Forests</td>
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<tr>
<td>FC</td>
<td>Faecal Coliform</td>
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<td>GEMS</td>
<td>Global Environmental Monitoring System</td>
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<td>GESCSL</td>
<td>Green Environment Services Co-Operative Society</td>
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<td>GICL</td>
<td>Gujarat Infrastructure Company Limited</td>
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<td>GIDC</td>
<td>Gujarat Urban Development Company</td>
</tr>
<tr>
<td>GoG</td>
<td>Government Of Gujarat</td>
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<tr>
<td>GPCB</td>
<td>Gujarat Pollution Control Board</td>
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<tr>
<td>GUDM</td>
<td>Gujarat Urban Development Mission</td>
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<td>GWRDC</td>
<td>Gujarat Water Resources Development Corporation</td>
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<td>GWSSB</td>
<td>Gujarat Water Supply And Sewerage Board</td>
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<tr>
<td>ICMR</td>
<td>Indian Council Of Medical Research</td>
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<td>LGB</td>
<td>Local Government Bodies</td>
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<td>MINARS</td>
<td>Monitoring Of Indian National Aquatic Resources System</td>
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<tr>
<td>MLD</td>
<td>Million Liters Per Day</td>
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<tr>
<td>MPN</td>
<td>Most Probable Number</td>
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<td>NRCP</td>
<td>National River Conservation Plan</td>
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<td>NWQMP</td>
<td>National Water Quality Monitoring Programmes</td>
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<td>NWRWS</td>
<td>Narmada Water Resources and Water Supply and Kalpsar Department</td>
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<td>SWDC</td>
<td>State Water Data Centre</td>
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<td>SEZ</td>
<td>Special Economic Zone</td>
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<td>SIPC</td>
<td>Salinity Ingress Prevention Circle</td>
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<td>SLF</td>
<td>Secured Landfill Facility</td>
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<td>STP</td>
<td>Sewage Treatment Plants</td>
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<td>SVNIT</td>
<td>Sardar Vallabhbhai National Institute Of Technology</td>
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<tr>
<td>TC</td>
<td>Total Coliform</td>
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<td>TDS</td>
<td>Total Dissolved Solids</td>
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<tr>
<td>TKN</td>
<td>Total Kjeldahl Nitrogen</td>
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<td>ULB</td>
<td>Urban Local Body</td>
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<td>VWEMCL</td>
<td>Vapi Waste and Effluent Management Company Limited</td>
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<td>WASMO</td>
<td>Water and Sanitation Management Organization</td>
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<td>World Health Organization</td>
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INTRODUCTION
CHAPTER 1

1.0 INTRODUCTION

The water resource scenario in Gujarat may be broadly divided into two time frames: the decades prior to 2000 and the decade between 2000 and 2010. The former period was marred by frequent droughts, water scarcity, drinking water supply through trains and tankers, and conflicts over water in most parts of the state. On the other hand, the last decade has seen comparatively very good scenarios with respect to rainfall, augmentation of surface water and ground water recharge through drainage treatments owed to the large scale construction of recharge structures. The realization of Saradar Sarovar Project (SSP) and initiatives like Sujalam-Sufalam linked to the project seem to have eased the pressure on existing water resources of the state. “The State of Water Resources” report is an effort to grasp the reality with respect to water resources of Gujarat and analyse it using a broader PSIR framework which is better suited to the state of environment reporting for India.

Increased access to Narmada waters over the last decade has truly justified the popular quote that Narmada is the life line of Gujarat. It has ensured increased accessibility and better quality of service delivery with respect to water, particularly in the urban areas of Gujarat. A rapidly urbanising Gujarat is bound to witness further rise in water demands. It will need planned investments in infrastructure and sewerage systems to further its water requirements. Gujarat’s strategy for water security will have to revolve around Narmada waters complemented by water augmentation through the treatment of its watershed and its water-efficient practices.

The resource situation in the state improved over the last decade due to multiple enabling factors including an exceptionally good rainfall during this period. The Narmada waters made a big difference to the water availability scenario in the state. The impact of all these factors has been further amplified due to enabling measures of the state government. While focusing on rapid economic growth through trade, commerce, industry and agriculture, the state government has proactively focused on the vital side of development like augmentation of water resources. A serious effort has been made to involve communities; relying on people and earning their trust has been a conscious choice for the government and it has been best exemplified through the success of initiatives like the Sardar Patel Participatory Water Conservation Project (SPPWCP) for check dam construction and institutional responses like WASMO.

The prime concerns of Gujarat’s water managers seem to be shifting from water augmentation to the redressal and quality management of water. The signs are obvious as the findings of this report suggest along with those of various other reports on the deteriorating quality of ground water and surface water bodies like various pockets of rivers, lakes and ponds. Gujarat needs to look for a paradigm shift in terms of managing its water holistically to sustain its hard-earned growth momentum.
Framework and Approach to the Study

With society becoming more concerned with environmental issues, there is a willingness to protect the environment and limit the damage caused by human activities. PSIR is a general framework for organising information about the state of the environment. The idea of the framework was, however, originally derived from social studies to be widely applied internationally for organising systems of indicators in the context of environment and, later, for sustainable development (Niemeyer & Groot 2008).

Environmental indicators have come to play a vital role in environmental reporting as they provide signs for communicating complex messages. In recent years, environmental indicators have become essential to assessing environmental impacts and reporting the state of the environment in India and various other countries. This has increased the influence of environmental indicators on environmental management and policy-making across all scales of decision-making as well as monitoring and evaluation (Niemeyer & Groot 2008; OECD 1999).

According to Kristensen (2004), the DPSIR framework is a chain of causal links starting with ‘driving forces’ (economic sectors, human activities) through ‘pressures’ (emission, waste) to ‘states’ (physical, chemical and biological) and ‘impacts’ on ecosystems, human health and functions, eventually leading to political ‘responses’ (prioritisation, target setting, indicators). It is obvious that not all issues or themes of a state-of-the-environment report need a full DPSIR presentation; in many cases some aggregation of DPSIR elements will only make them easier to work with and understand.

The framework assumes cause-effect relationships between interacting components of social, economic, and environmental systems, which are:

1. Cause of the problem: **Pressure** (P)
   - Economic, social, institutional or other pressures on the environment that may contribute to or cause particular environmental states
2. Status of the issue: **State** (S)
   - Condition or quality of the environment and trends in that condition brought about by human or other pressures
3. Impact of the issue: **Impact** (I)
   - Effects of the issue on people, environment and economy
4. Response to the issue: **Response** (R)
   - Measures taken by different stakeholders to improve the situation
The State of Water Resources (SoWR)-2012 is an attempt to understand and analyse the situation in the water sector of Gujarat. An analysis of the available data is expected to throw some light on water budgeting, distribution, and quantification of surface and ground water in the state. The analysis also focuses upon industrial, domestic and agricultural pollution. An extensive analysis has been conducted on the status of CETPs and STPs, sewage management in cities, and the local bodies of Gujarat.

A state-level consultation on water was organised in order to draw upon the experiences of various stakeholders and the knowledge of the scientific community from relevant fields. It was helpful in terms of getting to know about the various perceptions of multiple stakeholders about PSIR with respect to water resources of the state. These insights helped us to refine our understanding of the issues pertaining to the water sector and, accordingly, devise our research focus and methodology. Findings emerging from the analysis of data were also corroborated with stakeholder perceptions about the state of affairs with respect to water, relevant pressing issues, and the relevance of various responses by all concerned in order to address the emerging challenges to management and governance of water resources in the state.

Other than simple statistical analysis of the available data, trend analysis was the main tool for analysing secondary data from various sources. Inverse distance weighted (IDW) interpolation technique in GIS environment was used for the spatial interpolation of point data. On the basis of different time sets (May, Oct-Nov) of the data related to ground water depth, fluctuation in water depth was calculated over the period of time by using raster algebra. Ground water fluctuation maps were prepared on the basis of variations in the water table.
Administrative Divisions and Regionalisation in Gujarat

The state of Gujarat comprises 27 districts and 225 talukas (sub-district) comprising 18,618 villages and 242 towns. Kutch is the largest district of the state holding 23 percent of its total geographical area. For the purpose of this study the state is broadly classified into five geographical regions as depicted in Figure 2.2, namely South, Central, North, Saurashtra and Kutch regions. Large parts of the state comprise the plains concentrated more or less in central and northern Gujarat.

South Gujarat: The southern region includes the districts of Surat, Bharuch, Valsad, Dangs, Tapi, Narmada and Navsari. Its total geographic area is 23.22 lakh hectares. The region has the highest forested area in the state. Annual rainfall averages between 1,000 and 1,500 mm and the climate varies from semi-arid to dry sub humid. Deep black and coastal alluvial soil is predominant in this region.

Central Gujarat: The Central Gujarat region includes the districts of Kheda, Anand, Vadodara, Ahmadabad, Gandhinagar, Panchmahals and Dahod. The total geographic area of the region comprises 34.13 lakh hectares. The forested area is not extensive in the region and this region leads in agricultural development. Annual rainfall averages from 800 to 1000 mm and the climate is semi-arid while the soil is medium black in nature.

North Gujarat: The North Gujarat region includes the districts of Sabarkantha, Mehsana, Banaskantha, and Patan. Its total geographic area comprises 28.91 lakh hectares. This region has a very small area under forests. It receives 500 to 800 mm of annual average rainfall and the climate varies from arid to semi-arid. Grey Brown loamy, alluvial soils are predominant in this region.

Saurashtra: The Saurashtra region includes the districts of Amreli, Bhavnagar, Rajkot, Bhavnagar, Jamnagar, Surendranagar, Junagadh, and Porbandar. The total geographic area of the region consists of 60.95 lakh hectares. The climate here is dry sub-humid with very low average rainfall at 500 to 800 mm annually. The soil here is predominantly shallow to medium black and calcareous.

Kutch: The North-west arid region encompasses the Kutch district. This region receives very little annual rainfall between 300 and 400 mm - rendering it totally arid. The total geographic area of the region is 40.89 lakh hectares. Since sandy and saline soils are not supportive of agricultural activities the region has the lowest geographical area under agriculture. The Kutch region consists of the Ranns, which are salt-encrusted wastelands and rises only a few meters above sea level. Inundated during the monsoons they are divided into the great Rann to the north and the little Rann of Kutch to the east, the Banni Plains between the great Rann and the rocky mainland and the hilly region with the island belt of four rocky projections rising above the Rann, the Kutch mainland, and the southern coastal plains.
Figure 3.2: Regions of Gujarat
PRESSURES ON WATER
CHAPTER 2

2.0 PRESSURES ON WATER

2.1 Introduction
Water being central to human life it is obvious that change in the status of water has implications for human existence. It was along the banks of the major river systems where human civilisations flourished. Many civilisations have vanished due to water scarcity (droughts) or flooding. In a sense, the consumptive use of water and management of floods and droughts have existed as issues since time immemorial. Modern day development and life styles have the potential to change the pattern of not only water usage but also the very nature of water, and that usually happens due to demographic change, urbanisation, industrialisation and pollution of water.

Toxic pollution kills fish while the leaching of fertilisers trigger algal blooms (eutrophication) in surface waters. Highly polluted Sabarmati River basin has witnessed the similar phenomena where upstream communities no longer include mountain mullet or freshwater shrimp as they did in the past (Sharma & Gandhi 2012). While Amlakhed in Bharuch district has seen substantial reduction in the fish catch due to severe coastal pollution (SANDARP 2012). Heavy metals in the form of industrial effluents being dumped into water bodies also toxify fish varieties and humans via biomagnifications process (TERI 2000).

Pressures on water resources are growing and projections on growing water requirement only suggest that our water resources are under tremendous stress. Population increase leads to decline in the average amount of renewable fresh water available to each person. Hence, as the population increases water stress and outright scarcity become inevitable. A growing population coupled with rapid urbanization and industrialization in Gujarat has led to multiple demands on fresh water supply, thereby putting this vital resource under tremendous pressure. Globally United Nations’ estimate suggests that such processes will lead to a situation where almost 1/3rd of the world’s population would be facing chronic water shortage by 2025.

The phenomenon of climate change is only likely to compound these pressures. It is imperative for those concerned with the socio-economic development and governance of water resources to not only recognize these pressures but devise their responses in a way that renders water use sustainable so that our ecosystems become healthy and balanced.

The state of Gujarat is one of the front runners in the economic development and agricultural growth of the country. The state has also been bestowed with the longest coastline compared to the other states of India. Hailed as the microcosm of the Indian environment, it poses a greater
challenge to not only water users but also to water managers of the state. Along with other pressures heavy industrialization also exerts pressure on both the quantity and quality of water, urging greater attention from the planners and managers responsible for the governance of water in Gujarat. It would be, thus, imperative for all concerned to not only be aware of water quality in various parts of the state but to also locate responses necessary for the total elimination or minimization of the levels of critical contaminants in the existing water resources. Some of the parameters needed to be considered for this purpose have been summarised in the Table 2.1.

Table 2.1 Levels of Critical Contaminants

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Standard (ISO 10500:2011) (mg/l)</th>
<th>WHO third edition 2003 (mg/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Microbiological</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Faecal coliform</td>
<td>Zero</td>
<td>Zero</td>
</tr>
<tr>
<td>E Coli</td>
<td>Zero</td>
<td>Zero</td>
</tr>
<tr>
<td><strong>Heavy metals</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arsenic</td>
<td>0.05</td>
<td>0.01</td>
</tr>
<tr>
<td>Cadmium</td>
<td>0.01</td>
<td>0.003</td>
</tr>
<tr>
<td>Chromium (total)</td>
<td>0.05</td>
<td>0.05</td>
</tr>
<tr>
<td>Copper</td>
<td>0.05</td>
<td>2</td>
</tr>
<tr>
<td>Iron</td>
<td>0.3</td>
<td>No standard</td>
</tr>
<tr>
<td>Lead</td>
<td>0.05</td>
<td>0.01</td>
</tr>
<tr>
<td>Mercury</td>
<td>0.001</td>
<td>0.001</td>
</tr>
<tr>
<td><strong>Other inorganic</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fluoride</td>
<td>1</td>
<td>1.5</td>
</tr>
<tr>
<td>Nitrate</td>
<td>45</td>
<td>50</td>
</tr>
<tr>
<td>Cyanide</td>
<td>0.05</td>
<td>0.07</td>
</tr>
<tr>
<td>Chloride</td>
<td>250</td>
<td>No standard</td>
</tr>
<tr>
<td>Pesticide</td>
<td>Absent</td>
<td>Different values for different pesticides; values range from 0.0003 for lindane to 0.03 for chlorpyrifos</td>
</tr>
<tr>
<td><strong>Physical</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TDS</td>
<td>500</td>
<td>No health based values</td>
</tr>
<tr>
<td>Total hardness (as CaCO₃)</td>
<td>300</td>
<td>No health based values</td>
</tr>
<tr>
<td>Colour</td>
<td>5</td>
<td>No health based values</td>
</tr>
</tbody>
</table>

Depending upon the levels of these parameters, water uses from various sources in the state can be decided upon as a sound information base or data management system established on these parameters is crucial for the planning and management of water in Gujarat. Various chapters on Status, Impact and Responses in the rest of the report suggest that despite appreciable efforts on behalf of the state government a lot needs to be done in this direction.
This chapter about pressure on water in Gujarat attempts to identify various parameters creating stress on the water resources of the state putting, thereby, tremendous pressure on the governance machinery responsible for the management of water in Gujarat. Broadly speaking, this chapter reflects an attempt to understand the pressures on water resources of Gujarat in terms of demographic change, urbanization; economic growth driven by trade, commerce, agriculture and industrialisation as well as second generation issues related to water quality and climate change. Environmental pressure by its nature often causes negative impacts on the environment. Efforts to contain such negative impacts are discussed in the response chapter.

2.2 Demographic Pressures

Population growth contributes to environmental degradation in many ways. But it would be foolhardy to accept such an argument without a proper perspective on how it contributes to the negative impact on the environment in general and water in particular. Demographic influences are one of the many factors that affect and create pressures on water resources. In this context, it would be interesting to look at the demographic change in Gujarat and its implications for the water resources of the state. According to the latest census (2011), the total population of Gujarat constitutes almost five (4.99) percent of the total Indian population. As Table 2.2 reveals, Gujarat achieved a total population growth of 19.17 percent in the just-concluded decade of 2001–2011.

Table 2.2  Decadal Demographic Change in Gujarat (2001–2011)

<table>
<thead>
<tr>
<th>Year</th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991</td>
<td>21.36</td>
<td>19.95</td>
<td>41.31</td>
</tr>
<tr>
<td>2001</td>
<td>26.39</td>
<td>24.29</td>
<td>50.67</td>
</tr>
<tr>
<td>2011</td>
<td>31.48</td>
<td>28.9</td>
<td>60.38</td>
</tr>
</tbody>
</table>

Source: Census of India.

In an overall scenario of the state, a district-wise share of the population compared to the total population of the state is summarised in Figure 2.1. In this context, Ahmedabad and Surat seem to have the highest percentage of population compared to the rest of the state whereas districts like Narmada, Tapi and The Dangs seem to have the lowest percentage of populations compared to other districts of the state. This indicates that key urban centres like Surat and Ahmedabad have the highest demographic pressure compared to the rest of the state, which also means that a greater amount of good quality water would be required for their newly-added populations. Over 50 percent districts have populations in the range of 2–4 percent of the total population of the state and these districts are located across the regions of Gujarat.
Figure 2.1: Percentage Population of a District to the State Population (2011)

Figure 2.2 shows decadal population growth since 1901. It provides a clearer picture of the impact of demographic change in the state.
2.3 Urbanisation

Since almost 90 percent of population growth expectedly exists in urban areas it is obvious that the fresh water demand for domestic, industrial and waste treatment uses are likely to rise. It is also a well recognised fact that urban areas, globally speaking, lose huge amounts of water due to leaks and breaks in water supply systems requiring targeted efficiency and conservation efforts.

Other than industrial pollutants the major culprits of water pollution are, unplanned urbanisation and concentration of human population in smaller areas, which also act as stress-agents for the water resources around these urban centres and for the governance machinery.

Economic growth and rapid industrialisation go hand in hand with the urbanisation process. And Gujarat is no exception. The pace of urbanisation, which was significantly higher than the national average during the decade 1991–2001, is expected to remain high over the next two decades. Generally speaking, the landscape and the society of the state are rapidly getting urbanised. In the beginning of this century, Gujarat’s population was 9.09 million, of which 22 percent was living in urban areas.
During the last decade the city of Ahmedabad grew from 45 lakh to about 56 lakh. The state capital Gandhinagar has recorded a population of 2.9 lakh people. The Surat district has seen 42.19 percent growth in population terms which is the highest in the state. The Kutch district follows with a population growth of 32.03 percent, while the tribal district of Dahod has seen an increase of 29.95 percent.

In the decade between 2001 and 2011 the state witnessed a growth of 5.2 percent in its urban population. This works out to be 42.6 percent of the population living in urban areas and 57.4 percent of the total population living in rural Gujarat. Eight major cities of the state account for
24.38 percent (1,47,22,363) population of the state [Ahmedabad (55,70,585), Surat (44,62,002), Vadodara (16,66,703), Rajkot (12,86,995), Bhavnagar (5,93,768), Jamnagar (5,29,308), Junagadh (3,20,250), and Gandhinagar (2,92,752)] (Census, 2011).

Just a decade ago (2001) almost 62.6 percent of Gujarat was living in its villages! This rise in urban population, especially in a few cities, has created a tremendous pressure on the water resources of these cities with regard to drinking and other consumptive uses. When you add to this the issues of domestic waste water management and pollution of the existing resources, water management becomes a rather difficult proposition. In this context, urbanisation exerts a major pressure on water demands and sewage treatment mechanisms in the urban centres while also presenting a great challenge to the governance machinery responsible for providing cleanliness and hygiene to urban dwellers.

This also creates pressure on rural areas surrounding the major urban centres. One example is the well-known pilgrimage centre of Pushkar in Rajasthan, which both grew in population strength and as a tourist destination. This led to an unprecedented increase of relevant trade and commercial activities in the town. The Pushkar Lake, once the main source of the town’s water supply, is now in shortfall. Ground water pumped from nearby villages supplements the water supply to meet the town’s growing needs. This has adversely affected the ground water of these villages. Water tables have fallen making hand pumps and other sources dependant on ground water in the area redundant. It is a typical case of urbanisation and demographic changes impacting the water supply of an area. It is usually the rural population which stands to lose in such cases.

Water demand and supply scenario in key urban centres like Surat, Rajkot and Vadodara for the year 2005-2006 have been summarised in the Table 2.3.

Table 2.3 Water Demand and Supply Scenario in Rajkot, Vadodara and Surat

<table>
<thead>
<tr>
<th>Parameter/Urban Centre</th>
<th>Rajkot</th>
<th>Vadodara</th>
<th>Surat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total water demand (MLD)</td>
<td>155</td>
<td>270</td>
<td>580</td>
</tr>
<tr>
<td>Total water supplied(MLD)</td>
<td>132</td>
<td>270</td>
<td>580</td>
</tr>
<tr>
<td>Per capita water demand (LPCD)</td>
<td>129</td>
<td>184</td>
<td>198</td>
</tr>
<tr>
<td>Per capita supply(LPCD)</td>
<td>110</td>
<td>184</td>
<td>198</td>
</tr>
<tr>
<td>Population served by the official water supply system ( percent)</td>
<td>80</td>
<td>84</td>
<td>95</td>
</tr>
</tbody>
</table>

NB: The figures are for the year 2005-2006

Source: CSE 2012.
As the population and area of these cities increase, their search for water forces the city administration to venture far and wide in search of viable water sources to meet growing demands. For instance, for Rajkot and Surat, the situation has been summarised in Table 2.4

### Table 2.4  Traditional and Future Sources of Water in Rajkot and Surat

<table>
<thead>
<tr>
<th>City</th>
<th>Traditional source</th>
<th>Distance from city</th>
<th>Subsequent source</th>
<th>Distance from city</th>
<th>Current/Future source</th>
<th>Distance from city</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rajkot</td>
<td>Barrages on river Aji</td>
<td>11 km</td>
<td>Bhadar dam (River Bhadar)</td>
<td>65 km</td>
<td>River Narmada water from Malia canal</td>
<td>400 km</td>
</tr>
<tr>
<td>Surat</td>
<td>Borewells and ranney wells</td>
<td>Within the city</td>
<td>River Tapi (Ukai dam)</td>
<td>90 km</td>
<td>River Tapi</td>
<td>5 km</td>
</tr>
</tbody>
</table>

Source: CSE 2012.

Along with the rise in its urban population Gujarat has witnessed a rapid rise in its economic activities resulting in a rise in income levels. A significant income growth occurred during the last decade; the average annual per capita income (as on 2008–09) was Rs 49,251, which was 23 percent higher than the national average indicating an increase of almost 8.4 percent compared to the previous year. All these factors have implications for the drinking water demands of these cities. Ground water, which has been the mainstay for meeting this drinking water supply in urban areas of Gujarat, seems to have been overexploited (Mehta & Mehta 2011).

Gujarat’s industrial and economic growth continues to attract people from entire India looking for employment opportunities causing large-scale immigration from these states, particularly to the major industrial towns in Gujarat. Major urban centres like Vadodara, Surat, and Ahmedabad and more recently Kutch have witnessed this phenomenon for a long time. Immigration to these centres as well as other industrial towns is likely to increase as Gujarat looks forward to higher growth rates in the coming decades. This adds many dimensions to civic amenities like domestic and drinking water requirements of the urban and industrial centres of Gujarat.

### 2.4 Industrialisation

Gujarat being a leading industrialised state of India has been at the forefront in terms of industrial coverage. The state has a large number of industrial estates already under GIDC and with the establishment of Special Economic Zones (SEZs) and Special Investment Regions (SIRs) a much bigger component of the state’s economy and geographical area comes under industrial and allied activities. Almost 62 percent of the state’s geographical area comes under the influence of Delhi Mumbai Industrial Corridor (DMIC) covering 18 out of 27 districts in its influence zone.
The SEZs have been allocated, at different stages, have an area of 20761.93 hectares while the SIRs cover 373,100 hectares. These are huge areas allocated for expediting economic growth in the state and they will obviously need easy access to good quality water in order to achieve the expected growth targets both economically and healthwise.

**Figure 2.4: Special Economic Zones in Gujarat**

Source: Vibrant Gujarat Summit 2011.
Among the regions affected by this process include Saurashtra, Kutch and North Gujarat which means ground water extraction in these zones will create further pressure on ground water resources of these regions.

Both industrialisation and urbanisation if not well planned, could create undue pressures through pollution of surface water sources like rivers, lakes and ponds. For example, rivers like Mini, Vishwamitri, Sabarmati, Khari, Dhahdhar etc. have been found by CPCB and CAG to be extremely polluted. This will require suitable responses to deal with the additional pressure on the existing water resources in these areas. Response section of the report discusses various initiatives in this regard from the government and other stakeholders.
Thirdly, the water resources of its coastal regions are already scarce in nature. Several studies reveal that ground water in many parts of coastal Gujarat is heavily contaminated. Effluents are potential threats to the biotic components like fish and have potential to affect human health through the food chain and also through biomagnifications due to non-biodegradable and persistent types of pollutants such as heavy metals, chlorinated hydrocarbons, pesticides, oil components, and radionuclides (SANDRP 2012; TERI 2000). As it has the potential of affecting fisheries as an economic activity in these areas it would also have implications with regard to the livelihood security of the fishing communities of the area. Additional pressure due to increased industrial and allied activities warrant a suitable futuristic planning for the management of its water resources.
2.5 Competing Demands and Resultant Conflict of Interest Among Stakeholders

Increasing growth rates and increasing water demands of urban centres, industrial centers, and corporate parks may lead to inter-sectoral conflict of interest with respect to water. During 1990s several instances have been recorded where voices of protests emerged when water meant for specific sector was reallocated for different purpose. Irrigation schemes like Dharoi on Sabarmati have had to change their priority from irrigation to meet the drinking water needs of Ahmedabad. (Thakkar 1999) had recorded incidences of farmers opposing the diversion of the Sabarmati river waters to the city of Ahmedabad. A similar situation arose in the arid Saurashtra region of Gujarat where the reservoir water was diverted for urban use from irrigation.

2.6 Increasing Water Demands Due to Agriculture Growth

Agriculture is supposed to be the single largest user of water accounting for almost 70 percent of the total demand, although these patterns vary from state to state and country to country depending upon their development level, their climate and population size. Given the spectacular agricultural growth (9-10 percent) witnessed by Gujarat over the last decade, it would be worthwhile to look at how it has changed the overall cropped area creating, thereby, a higher demand for irrigation water. High agricultural growth also leads to increased water requirement for irrigation. Also, if the use of pesticides and fertilisers is not checked, it may lead to water being polluted. Figure: 2.7 displaying gross irrigated area and Figure: 2.8 displaying net irrigated area show an overall increase in the agricultural area included under irrigation in Gujarat.

**Figure 2.7: Gross Irrigated Area in Gujarat**

![Graph of Gross Irrigated Area in Gujarat](image)

Source: Water Planning and Project Wing, CWC, December 2010 and Directorate of Economics and Statistics, GoG.
Figure 2.8: Net Irrigated Areas in Gujarat

Source: Water Planning and Project Wing, CWC, December 2010 and Directorate of Economics and statistics, GoG.

Figure 2.9 shows the trend of percentage of net area irrigated in hectares by ground water resources (bore wells and tube wells) in Gujarat from 2001 to 2007–08. Though the trend is decreasing, the net ground water irrigated area from 2000–01 to 2007–08, yet the percentage for all the years was very high ranging from 78.7 to 86.7 percent.

Figure 2.9: Net Irrigated Areas by Ground water
2.6.1 Shift in Cropping Pattern

Gujarat is seeing some interesting phenomena with respect to the water sector. The state has seen increased availability of water due to the Sardar Sarovar Project (SSP) on Narmada, positive impacts of the recharge movement, schemes like Sujalam-Sufalam and interlinking of rivers coupled with exceptionally good rainfall during the last decade. At the same time there has been a high growth in the agricultural sector which is the highest consumer of water. Besides, a shift in the cropping pattern of water intensive crops like cotton, rice, wheat need to be examined in the light of water scarcity faced by the state in the decades prior to the year 2000.

In South Gujarat, cotton and sugarcane are the dominant crops with sorghum and rice losing ground. In Central Gujarat, the shift for major grown crops from 1990 to 2008–09 occurred from bajra, cotton and maize to rice, cotton and maize. Also, the area under wheat cultivation had increased to a great degree in the corresponding period.

In North Gujarat, the maximum percentage of cultivable area during 1990–91 was for bajra and maize while 2008–09 it was for bajra, cotton and wheat. New crops added in the decade 2000 and 2008–09 was groundnut with 13 percent of cultivable area of Sabarkantha under it.

In Saurashtra, area under cotton and wheat increased noticeably. The percentage of cultivable area under cotton in Surendranagar was 43 percent, 56 percent and 65 percent in the years 1900, 2000 and 2008–09 respectively. The districts of Rajkot, Jamnagar, Junagadh and Porbandar which had not grown cotton in the 1900s, started growing it in 2000s.

In Kutch, the mainly grown crop had shifted from bajra in the 1960s, 1970s, 1980s, 1990s and 2000 to cotton in 2008–09. Wheat production too, began in 2008–09 for the first time. Groundnut, mung and castor production had increased over time from 1990s to 2008–09.

The shift to water intensive crops like cotton, sugarcane, groundnut etc. over the recent years has added to the pressure on water resources with increased agricultural draft.

2.7 Water Pollution as an Outcome of Demographic Change, Urbanisation, Agricultural Growth and Industrialisation Process

If domestic waste water, predominantly comprising sewage, is dumped untreated into water bodies beyond a point, the waters from these sources become non-usable. The same holds true with regard to the industrial pollution of water. Excessive concentration of harmful material in water makes it redundant for consumption. Ground water resources seem to be at the receiving end due to these processes affecting, thereby, the entire water regime of an area.
Functioning of the ground water regime

Figure 2.10: Ground water Regime

Source: Foundation for Water Research, UK.

There is a dynamic relationship between surface and ground water, which means that, ground water pollution, can also affect surface water quality. The opposite also holds true. Figure 2.10 depicts the relationship between groundwater and activities of built ecosystems. Extreme ground water extraction, be it for drinking, domestic, agricultural, or industrial purposes can cause the drying up of other linked resources like rivers and lakes inducing an extreme fall in the water levels. The analysis shows that the phenomenon has already been recorded in all parts of the state except in South Gujarat since last two decades. However, the decades 2000-2010 has shown encouraging sign due to higher rainfall and recharge initiatives.
2.7.1 Pollution Of Water Due to Urbanisation and Demographic Change
Urbanisation has various facets with respect to water bodies within the city premises. Usually such water bodies perform multiple functions of ground water recharge, adding aesthetic value to our cities and towns besides performing many ecological functions like contributing to the moderation of temperature in the areas around them. Unfortunately, the replacement of ponds, lakes, and water bodies with construction sites has not only robbed us of aesthetic beauty but also distanced future generations from nature.

2.7.2 Industrial Pollution
Industrial pollution can cause tremendous pressure on water resources, particularly if it goes unchecked and unattended. Water pollution can have severe implications on the health of lives dependent on these resources. A case study is presented in the following sections to highlight these aspects of degradation of water quality induced by industrial pollution.

2.7.3 Agricultural Pollution of Water
Agricultural pollution of water may be understood in the context of water contamination as a consequence of agricultural practices. Water contamination occurs in drinking water environments due to runoff from farms bringing ammonia, pesticides, fertilisers, oils, toxic compounds, and animal waste into water bodies. Agriculture-led pollution of water bodies and ground water exert pressure on existing and newly-created sources of water.

Figure 2.11: Water Contamination in the Agricultural Runoff as a Source of Pollution

Source: EzineArticles.com

Gujarat has been facing adverse conditions like droughts, erratic rainfall pattern, climatic changes and unusual high temperatures during crucial periods which do not augur well for agriculture in the state. In spite of it, the state achieved about 10 percent growth in agriculture over the last decade. This was made possible due to assured irrigation as an outcome of many contributing factors like Narmada waters, water recharge movements like check dam
constructions, introduction of high yielding varieties, agrochemicals (fertilisers and pesticides), credit facility, and improved infrastructure.

Agriculture in the state has seen a reduction in the total consumption of pesticides. There has been a significant reduction from around 4500 million tonnes in the year 2002-02 to 2750 million tonnes in 2009–10. Findings of the Anand Agricultural University (AAU) suggest that there has not been a significantly adverse impact on the soil because of the pesticides. AAU surveyed 200 samples in the cotton and vegetable growing regions of South Gujarat. Pesticide residues were found in their samples but not to an alarming extent. The study argues that pesticides do not persist for a long time due to the climatic condition of the state.

Ever since the agricultural revolution started in the 60s, the consumption of chemical is fertilisers have increased rapidly. Increased agricultural production in Gujarat has also seen a rise in the use of is fertilisers over the past couple of decades. The consumption of nutrients like N, P, and K increased from 11,071 tonnes (1960–61) to 12,79924 tonnes (2005-06). Per hectare consumption of fertilisers in Gujarat stands at around 145 kg/ hectares in 2005-06. Fertiliser consumption in terms of nutrients (nitrogen, phosphorous, and potassium) of the state is summarised in Figure 2.12.

**Figure 2.12: NPK Consumption of the Total Fertiliser Consumption in Gujarat**

![Percentage of fertilizers in terms of N, P, K](image)

Source: Agriculture and Cooperation Department, Gujarat

Figure 2.12 shows that the application of nitrogen fertilisers in the total share of fertilisers is about 60 to 70 percent.

A report by Carewater-INREM Foundation on ground water and well water quality in the alluvial aquifers of Central Gujarat suggests that the current levels of nitrate samples post
monsoon and four months afterwards are below the safety limit in the deeper aquifers used for drinking water (INREM 2010).

Given the inherent existence of nitrogen in the soil structures, such a high level of nitrogen consumption as part of fertiliser use in Gujarat only adds to the possible threat of non-permissible levels of higher nitrate levels in water resources.

Despite these factors, as Gujarat’s population continues to grow the need for intensive agriculture will be required as is evident from the higher growth seen in this sector over the last decade. Combating agricultural pollution adds to the already complex water management scenario of the state. It will require an effort to explore the options to industrial agriculture with its polluting tendencies in order to keep our water sources safe and healthy making the development in the state sustainable thereby.

**2.7.4 Pollution of Ground Water**

There have been several reports on the pollution of water in 55 wells and tube wells. In the Luna village of Padara taluka in Vadodara district water turned red and yellow due to contamination. Luna and the surrounding villages are known for their drumstick production and often referred as Gujarat’s vegetable basket. Farmers from the area have reported decline in the vegetable yield (Counterview 2012).

**Figure 2.13 Ground Water Pollution in and Around Luna**

![Image of ground water pollution](source: Counterview 2012)

A seismological report by the Gandhinagar-based Institute of Seismological Research has established that the dye production unit was responsible for ground water contamination in and around Luna village. Complaints from the villagers, sarpanch, a proactive NGO, and follow-up by GPCB officials led to this report and further action (Counterview 2012).

The seismological report stated that chemical leakage from the western and northern sides of the company’s waste disposal tank may migrate to some distance through the weak planes and
contaminate the ground water. From the traces of colours or dyes present in the well water, it concluded that the pollution at Luna village could be due to leakage from the waste disposal tank.

The report indicated that the industry continues to use its waste storage tank beyond its life limit and even raised its height by three metres in 2006 to dump 50 per cent more waste than its capacity.

The Gujarat Pollution Control Board (GPCB), seems to have issued the closure notice and asked the company to prepare a time-bound action plan for the remediation and assessment of the ground water and soil pollution levels. As a result, the company has come out with a detailed remediation plan (Counterview 2012).

2.7.5 Pollution of Surface Water
Traditionally, water bodies like rivers, lakes, ponds, wells, etc. have been a major source of water supply relevant to domestic and drinking water needs. With the phenomenon of urbanisation and industrialisation becoming predominant, it is now imperative for monitoring agencies to ensure that polluted water be released into water bodies only after treatment with permissible pollutant contents. Cities in Gujarat, like most Indian cities, are having to deal with most of their water bodies receiving untreated waste water leading to subsoil water pollution and at times, even ground water pollution. The reports of Bhardwaj (2005) and CAG (2011) citing the pollution of lakes and ponds clearly indicate the same result. Their findings across various pollution parameters in the waters of Sursagar, Gotri and Gorwa lakes in Vadodara, Chandola and Kankaria in Ahmedabad are examples of the same phenomenon.

A similar trend has been seen with respect to four major river basins of Gujarat. As presented in Table 2.5 all the four major rivers- Sabarmati, Tapi, Mahi and Narmada are faced with pollution, albeit in selected patches within their course.

Table 2.5 Unfit Patches of Four Major Basins in Gujarat

<table>
<thead>
<tr>
<th>River</th>
<th>Total length (km)</th>
<th>Length unfit for Bathing or drinking ( percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sabarmati</td>
<td>325</td>
<td>49</td>
</tr>
<tr>
<td>Tapi</td>
<td>977</td>
<td>45</td>
</tr>
<tr>
<td>Mahi</td>
<td>522</td>
<td>44</td>
</tr>
<tr>
<td>Narmada</td>
<td>1382</td>
<td>35</td>
</tr>
</tbody>
</table>

Source: CSE (2012)

Rapid industrialisation requires a strong watchdog in the form of regulatory and monitoring agencies which should be always alert and well-equipped. GPCB in Gujarat has taken many
initiatives to respond to the situation but the problem seems far too big requiring large scale measures to effectively deal with the issue while keeping pace with the development of the state.

2.8 Pressures on Coastal Area
Ground water extraction from coastal aquifers beyond permissible limits causing the intrusion of saline water into the zone of fresh ground water, thus reduces the quality of water. This phenomenon is very common in hot climatic regions with a short supply of fresh water. Gujarat is one such region and hence salinity ingress may be considered as the second most potent source of pressure on its waters. Having a 1600-kilometre long coastline only makes water security more vulnerable.

Figure 2.14: Diagram Showing Intrusion of Sea Water

Source: Foundation for Water Research, UK.

The coastal areas of Gujarat have about 549 villages with a total population of more than a million. Out of its 27 districts, 13 have coastal borders. Some parts of the land, comprising 35 talukas, touch the seawater. The Gujarat coastal belt yields the highest fish catch compared to other similar areas of the country. This belt is very rich in ecosystems including mangroves, sea weeds, coral reefs, salt marshes, marine life, wetlands etc. (SAVE n.d.). Figure 2.15 shows the salinity affected coastal talukas of Gujarat.
Figure 2.15: Salinity affected Coastal Talukas of Gujarat in the year 2000
2.8.1 Salinity Ingress

Figure 2.17 and Figure 2.18 represent the salinity-affected area in hectares in all the saline blocks of HLC-1 and HLC-2 (High Level Committee) for the years 2000 and 2008. It has mainly covered the entire Saurashtra coastal belt with all the saline talukas of Rajkot, Jamnagar, Porbandar, Junagadh, Amreli and Bhavnagar. A similar trend occurs for the Mangrol block of Junagadh with the entire 8800-hectare area affected by salinity ingress along with the Kutiyana block of Porbandar with 6200 hectares of saline area (CSPC 2010).

In blocks like Maliya and Morbi of Rajkot, the entire 77000-hectare area remained saline between 1980s and 2011. Hence, availability of safe drinking water and drinking water-related health hazards has remained key issues of concern for villages in these saline areas.
Figure 2.17: Salinity Affected Areas in HLC-1

![Graph showing salinity affected areas in HLC-1](image)

Source: Ground Water Division, SIPC, Rajkot

Figure 2.18: Salinity Affected Areas in HLC-2

![Graph showing salinity affected areas in HLC-2](image)

Source: Ground Water Division, SIPC, Rajkot
2.8.2 Ground Water Mining and Salinity Ingress
Gujarat witnessed water shortage and a drought-like situation until the late 1990s. This condition was generally attributed to natural factors like poor and erratic rainfall, arid and semi-arid conditions of the state and its rocky terrain. Water scarcity in Gujarat was also attributed to the mismanagement of ground water resources and many termed the situation as “man-made water scarcity”. Over draft of ground water without any adequate recharge system had not only created scarcity but it has also led to the intrusion of saline water resulting in salinity ingress in large parts of the coastal area, particularly in the Saurashtra region of Gujarat. This has not only led to salinity ingress but also caused deterioration in the quality of water in the coastal regions (Hirway et al 2002). The indiscriminate overdraft of ground water in Saurashtra, North Gujarat and Kutch has depleted the water resources of these regions. Figures 2.17 and Figure 2.18 show the extent of coastal salinity in Gujarat until 2008. Of late, the situation is improving in many parts.

2.8.3 Storm Surges and Salinity Intrusion in Fresh Water Bodies
The regions faced with severe threats of storm surges are the Gulf of Khambhat, the Gulf of Kutch, and the western coast of southern Gujarat (Figure 2.19). A closer view of these regions provides the details of areas that would be inundated due to very high PMS at mean sea levels. Saline water intrusion in fresh water bodies takes place during storm surges.
2.8.4 Pressure due to Coast Based Economic Activities
Gujarat’s 1600 kilometer long coastline thrives with economic activities like ports, shipping, trade, ship building, ship breaking, fisheries, aquaculture, salt production, mining industries, tourism, navy and defense. On an average basis, Gujarat’s coast has a port at every 40 km.

The Gulf of Kutch is known for its mineral resources and oil terminals. Gujarat is also the biggest producer of the country’s marine fish. Its share in the nation’s marine fish production is more than one-fifth. The state also accounts for over two-thirds of salt production in India. A significant number of cattle herd owners including some from the nomadic tribes depend on coastal resources, coastal pastures, and the mangroves of these areas.
The major economic activities of this coastal region include salt pans, mineral industries, cement and soda ash industries etc. Gujarat ports are also important for a large chunk of India’s oil import. Other than these economic activities, this region also has major industries like cement, chemicals, petroleum and oil refineries, power plants and fertiliser plants. The coastline of the Gulf of Kutch has seen the establishment of major refineries because of the several ports and jetties constructed in the area.

Apart from population density, these economic and industrial activities also exert tremendous pressure causing severe environmental challenges for coastal sustainability. According to an estimate, 41 percent of the coastal population of the state lives in urban centres which are higher than the state average. Solid and liquid waste from industries is released into the sea. At the same time, the disposal of industrial waste from inland areas into the sea through pipelines makes the pollution problem more complex. All these pressures adversely affect the coastal environment causing erosion of the coastline, and the degradation of coastal seawater. Salinity and poor quality of drinking water in these areas are the primary reasons for the prevalence of diseases like flourosis and dysentery (INREM 2010).

Water management in the state needs to take cognisance of these pressures and challenges while devising strategies to meet the water demands by augmentation of water. But given the context it’s all the more important that the existing and already-created precious water resources are secured against pollution of all types.
STATUS OF WATER RESOURCES
CHAPTER 3

3.0 STATUS OF WATER RESOURCES

3.1 Introduction
Water resources in Gujarat are characterised by great deal of regional variations in terms of its richness and scarcity. The state’s water resources are mainly concentrated in the southern and central parts of the state. Saurashtra, Kutch and North Gujarat regions have limited surface and ground water resources. Geological and geo-hydrological situations like rocky terrain, deserts, and a 1600-kilometre long coastline and water quality issues have added to the complexities of the water sector in Gujarat.

The surface and ground water resources have dynamic and static facets with implications regarding the availability and quality of water in the state. Measurement of the dynamic nature of water in terms of flow rates has been significant for most developmental needs. The static nature like length and area of water bodies has been vital for actions like fisheries, navigation, watershed development, etc. This chapter tries to cover all these aspects of water resources in Gujarat.

Gujarat is known to experience uneven rainfall varying regionally from 400 mm to 2000 mm over 1,96,000 sq kms of the total geographical area. Seventy one percent of its total area is water deficient. Twenty nine percent areas of South and Central Gujarat have surplus water, which needs to be diverted to water scarce regions of North Gujarat, Saurashtra, and Kutch. While surface water availability is only two percent of the country’s total water availability, the population is five percent of the country’s total population. Due to insufficient surface water, there is massive over exploitation of ground water.

The comparison between total geographical area, population and surface water availability between India and Gujarat has been depicted in Figure 3.1.
Figure 3.1: Geographical Areas of Gujarat and India

Geographical Area India-Gujarat

- India-3,287,240 sq kms
- Gujarat-1,96,024 sq kms

94% 6%

Courtesy: Census of India

Figure 3.2: Population Gujarat and India

Population India-Gujarat 2011

- India-1210193422
- Gujarat-60383628

95% 5%

Courtesy: Census of India
Figure 3.3: Surface Water Availability in Gujarat and India

Source: Based on data from KALPASAR n.d.

Figure 3.4: District Wise Percentage Area Under Water Bodies (2000)

Figure 3.5 depicts a recent region-wise distribution of total fresh water resources in Gujarat.
3.2 Surface Water
This section broadly covers the discussion on various facets of surface water resources of Gujarat. Mainly it covers the rainfall, surface water availability and water bodies, river basin potentials etc.

3.2.1 Rainfall
Many parts of the state are extremely susceptible to drought conditions due to the erratic rainfall pattern in Gujarat. Saurashtra has a limited number of water bodies with rainfall normally ranging between 400 and 800 mm. The average annual rainfall is about 775.0 mm with a standard deviation of 75.1 mm. Gujarat mainland, comprising South, Central and North Gujarat, evinces maximum water concentration owing to rainfall ranging normally between 800 to 2000 mm.

The rainfall trend for monsoon season in five regions of Gujarat is presented in Figures 3.6 and 3.7 for the last two decades. These figures suggest that the rainfall in Gujarat has been reasonably high during the decade of 2001-2010 compared to the years during 1991-2000. Most parts of the state including the drier regions of Kutch, North Gujarat and Saurashtra have benefitted from this.

As discussed in the response section, Gujarat has seen record construction of recharge structures during last decade and this has resulted into an improved water harvesting ultimately leading to rise in Groundwater levels in the current decade.
Figure 3.6: District-wise average rainfall in Gujarat (1991–2000)

Figure 3.7: District-wise average rainfall in Gujarat (2001–2010)
3.2.2 Area under surface water bodies
The surface water bodies of Gujarat constitute major and minor rivers, canals, reservoirs, tanks, lakes, *talavs* (ponds), and brackish water bodies.

The percentage area under water bodies of each district (compared to the geographical area in hectares of the district) in the years 2000 and 2005 is presented in the following section. The trend has remained the same throughout this period with South and Central Gujarat covered by the largest area under water bodies followed by Saurashtra, North Gujarat and Kutch. A similar trend has been seen for fresh water availability in the four regions of Gujarat. South and Central Gujarat have maximum availability at 71 percent while Kutch has the minimum availability at two percent.

Figure 3.4 shows the area covered by water bodies for the year 2000. In Kutch district no data was available for the Ranns. The remaining parts of Kutch and the districts of Banaskantha, Mehsana, Ahmedabad, Bhavnagar, Amreli, Junagadh and the Dangs are covered by water bodies in the range of 0–2 percent of their total area. On the other hand, districts which have 2 to 4 percent of their area under water bodies are Patan, Surendranagar, Rajkot, Jamnagar, Gandhinagar, Sabarkantha, Kheda, Anand, Vadodara, Dahod, Bharuch, Surat, Navsari and Valsad. Only three districts of Panchmahals, Narmada and Porbandar have 4–6 percent of their geographical area under water bodies of various types. The Tapi district has the highest area under water bodies falling in the range of 8 to 10 percent.

3.2.3 River Basin Potential
The river systems of Gujarat may be divided according to the state’s regions. Broadly speaking, there are three major groups of rivers flowing in different directions. Narmada, Sabarmati and Mahi are the major rivers of Central and North Gujarat while the rivers Mithi, Khari, Bhadar, Shetrunji and Bhogavo flow in the Saurashtra region. South Gujarat’s major river systems are formed by Narmada, Tapi, Purna, Ambika, Auranga and Damanganga. Three rivers are perennial, namely, Narmada, Tapi and Mahi.

The natural run off from these rivers has created a huge water potential in the state, yet the inconsistent distribution of the resources coupled with topographic factors has led to only partial utilisation of this potential. To combat this drawback, the state has come up with several major and minor projects, adding to the surface storage capacity of these rivers.

Table 3.1 shows per capita availability of water in Gujarat from the four major river basins of Gujarat.
Table 3.1 Per Capita Availability of Water in Major River Basins of Gujarat (2010)

<table>
<thead>
<tr>
<th>River Basin</th>
<th>Average water Resources Potential ((BCM))</th>
<th>Estimate Population in 2010 ( Millions)</th>
<th>Per Capita availability of water in 2010 (cubic Metres )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mahi</td>
<td>11.2</td>
<td>14.64</td>
<td>753</td>
</tr>
<tr>
<td>Sabarmati</td>
<td>3.81</td>
<td>14.64</td>
<td>260</td>
</tr>
<tr>
<td>Narmada</td>
<td>45.64</td>
<td>20.50</td>
<td>2227</td>
</tr>
<tr>
<td>Tapi</td>
<td>14.88</td>
<td>20.64</td>
<td>721</td>
</tr>
</tbody>
</table>

Source: Water Planning and Project Wing, Central Water Commission (CWC) 2010

3.2.4 Surface Water Distribution

A total of 50,100 million cubic metres of water including surface water, ground water and storage capacity of reservoirs (excluding Sardar Sarovar) along with surface water resources, contributes to 38100 million cubic metres of water.

Figure 3.8 represents the regional distribution of surface water resources in Gujarat. Central and South Gujarat have maximum surface water availability of 31750 million cubic metres followed by Saurashtra, North Gujarat, and Kutch with 3600, 2100 and 650 million cubic metres respectively (NWRWS, 2010).

Figure 3.8: Region-wise Surface Water Availability in Gujarat

Source: NWRWS
3.3 Geohydrology and Ground water

The regional percentage distribution of 12000 million cubic metres of ground water resources in Gujarat has been shown in Figure 3.9. The pattern for ground water availability is not the same as for surface water. Saurashtra has a maximum ground water availability of 4300 million cubic metres followed by South and Central Gujarat, North Gujarat, and Kutch with 3950, 3300 and 450 million cubic metres respectively (NWRWS, 2010).

![Ground Water Availability in Gujarat](image)

**Figure 3.9: Ground Water Availability in Gujarat**

Source: NWRWS n.d.

The state of Gujarat has three distinct regions. The Saurashtra region comprising the districts of Bhavnagar, Amreli, Junagadh, Rajkot, Surendranagar, Jamnagar, and Kutch is the most rainfall scarce region which receives between 380 mm (in the northern part of the region) and 680 mm (in the southern part) of rainfall annually.

The development of irrigation in Saurashtra is mainly open-well or shallow tube-well based. These wells often dry out within a couple of months at the end of the monsoons. If the rainfall is insufficient, as is normally the case, these wells do not contain enough water to protect the main Kharif crop of groundnut and coarse cereals - bajra and jowar.

Figure 3.10 presents the percentage distribution of different types of geohydrological conditions present in Gujarat. This might explain the uneven distribution of ground water in different regions of Gujarat when studied in detail.
In this section Figure 3.11 represents ground water categorisation at taluka level with respect to the level of ground water development. The regions with less than 70 percent ground water development are considered safe. Most of the Saurashtra and South Gujarat regions fall within this category. The regions with more than 100 percent ground water development have been classified in the over-exploited category with no further scope of ground water extraction. The most parts of North Gujarat and some parts of South Kutch fall within the over-exploited category. The northern talukas of North Gujarat and some parts of southern Kutch fall within the critical category characterised by ground water development ranging from 90 to 100 percent.
3.3.1 Ground Water Fluctuation over Two Decades
The pre and post monsoon ground water fluctuations for the years 1990, 2000 and 2010 are shown in the Figures 3.12, 3.13 and 3.14. May was chosen as the pre monsoon month and November as the post monsoon month. Fluctuations were calculated by comparing below ground level water for May and November for each of these years. The data were provided by the Central Ground Water Board and Ground Water Resources Development Corporation.

The ground water fluctuations pre and post monsoons for the years between 1990 and 2010 in Gujarat’s mainland registered a rising trend. Yet, the 2010 fluctuations show a striking change from the year 2000 fluctuations with respect to rise in ground water table. Nearly the entire area of these regions registered a rise in the range of 0 to 2 metres after monsoons in 2000. The 2010 fluctuation map, however, shows the maximum region of North and even South and Central Gujarat registering a rise from two to four metres and greater than four metres after the rainy months.
Figure 3.12:  Ground water Fluctuations (May 1990 to Oct-Nov 1990)

Source: Based on spatially interpolated surface of the pitometer level data provided by Central Ground Water Board and Ground Water Resource Development Corporation
Figure 3.13:  Ground water Fluctuations (May 2000 to Oct-Nov 2000)

Source: Based on spatially interpolated surface of the piezometer level data provided by Central Ground Water Board and Ground Water Resource Development Corporation
3.4 Surface and Ground Water Use

Tables 3.2 and 3.3 depict the surface and ground water uses in Gujarat. They also give an idea about the sectoral demand scenario of the state.

### Table 3.2 Surface and Ground Water use in Gujarat

<table>
<thead>
<tr>
<th>Details</th>
<th>Surface water</th>
<th>Ground water</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage of domestic water requirements met from</td>
<td>18</td>
<td>82</td>
<td>100</td>
</tr>
<tr>
<td>Percentage of industrial water requirements met from</td>
<td>35</td>
<td>65</td>
<td>100</td>
</tr>
<tr>
<td>Storage available for irrigation (80 percent) (Assumed) (MCM)</td>
<td>21,988</td>
<td>9,200</td>
<td>26,956</td>
</tr>
</tbody>
</table>

Courtesy: Parthasarathy and Dholakia 2011.
Table 3.3  Ground water Draft in Gujarat (2004)

<table>
<thead>
<tr>
<th>Net Annual Ground Water Availability</th>
<th>Annual Ground Water Draft</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Irrigation</td>
<td>Domestic and industrial uses</td>
<td>Total</td>
</tr>
<tr>
<td></td>
<td>15.02</td>
<td>10.49</td>
<td>0.99</td>
</tr>
</tbody>
</table>


3.4.1 Drinking Water

3.4.1.1 Narmada-based drinking water supply grid
The Narmada water supply grid had been planned in order to supply drinking water to 75 percent of the state’s population. It has already created 156 filtration and treatment plants with a total treatment capacity of 2810 million litres per day. There are 11399 elevated storage reservoirs which have a capacity of 1204.7 million litres, 11055 storage tanks and pumping stations with a capacity of 2564 million litres, 278 R.O. plants, and 290 solar pumps. The bulk pipelines and distribution pipelines are 2214 kms and 118719 kms long, respectively, which supply an average of 2700 million litres daily. The figure for population covered in Gujarat by the water supply grid is claimed to be around 3.62 crores (Courtesy WASMO).
Figure 3.15: State-wide Water Supply Grid in Gujarat

Table 3.4 shows drinking water supply status in the villages of coastal districts in Saurashtra. The supply of water to these districts is managed by GWSSB.

Courtesy: WASMO
Table 3.4  Drinking Water Supply Status in the Villages of Coastal Districts in Saurashtra

<table>
<thead>
<tr>
<th>District</th>
<th>No. of villages</th>
<th>No. of villages partially covered under water supply</th>
<th>No. of villages not having water supply</th>
<th>No. of villages having water quality problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jamnagar</td>
<td>756</td>
<td>426</td>
<td>9</td>
<td>250</td>
</tr>
<tr>
<td>Rajkot</td>
<td>844</td>
<td>363</td>
<td>19</td>
<td>47</td>
</tr>
<tr>
<td>Bhavnagar</td>
<td>790</td>
<td>572</td>
<td>27</td>
<td>198</td>
</tr>
<tr>
<td>Amreli</td>
<td>613</td>
<td>250</td>
<td>1</td>
<td>92</td>
</tr>
<tr>
<td>Junagadh</td>
<td>923</td>
<td>411</td>
<td>51</td>
<td>302</td>
</tr>
<tr>
<td>Porbandar</td>
<td>186</td>
<td>139</td>
<td>2</td>
<td>65</td>
</tr>
<tr>
<td>Total</td>
<td>4012</td>
<td>2161</td>
<td>109</td>
<td>954</td>
</tr>
</tbody>
</table>

Source: Based on data from SIPC

3.4.1.2 Drinking water supply schemes

Historically speaking, drinking water supply in rural India was outside the government's sphere of influence. Open and private wells, ponds, and small-scale irrigation reservoirs were traditionally managed by the communities.

The Government of India (GoI) launched its Accelerated Rural Water Supply Programme (ARWSP) in a major way in 1972–73. Until 1986 it had ensured the provision of adequate drinking water supply through the Public Health Engineering Department (PHED). This phase was followed by the Technology Mission of 1986-87 that ultimately gave way to the Rajiv Gandhi National Drinking Water Mission in 1991–92. Now the focus was on water quality, appropriate technology intervention, and human resource development support, among other things. In 1999–2000, sector reform projects were introduced with an emphasis on community participation in planning, implementation and management of drinking water-related schemes which was later scaled up as the Swajaldhara scheme in 2002. WASMO has emerged as an organisation during this period.

The Swajaldhara Scheme launched in 2002 by Department of Drinking Water Supply to ensure community participation in drinking water supply at village level which was implemented in 14 districts of Gujarat. The Government of Gujarat (GoG)-funded Sector Reform Scheme, which was implemented in 11 districts. Kutch was covered by the Earthquake Rehabilitation and Reconstruction (ERR) scheme funded by GoI. Figure 3.16 shows the status of implementation of all three drinking water supply schemes at the district level. GWSSB had provided the infrastructure for these schemes; the implementation and maintenance at village level of the latter was monitored by WASMO.
Figure 3.16: Implementation of three Drinking Water Supply Schemes by WASMO

Source: Based on data provided by Water and Sanitation Management Organisation
Figure 3.17 shows the physical progress of Swajaldhara scheme implemented by WASMO. It provides an overview of the percentage of completed schemes vis-à-vis schemes approved by District Water and Sanitation Committees (DWSCs).

**Figure 3.17: Status of Implementation of Swajaldhara Scheme by WASMO**

Figure 3.18 shows a comparison between unfit villages (due to higher levels of fluoride, TDS and nitrate content in the available water) detected in the years 2003 and 2010. The blue bars show the number of unfit villages in 2010 and the red ones in 2003. Although the chart illustrates that the number of unfit villages decreased from 2003 to 2010, yet the numbers for 2010 are alarming.
This analysis shows the district-wise pattern of unfit villages in Gujarat. Data comparison reveals a remarkable reduction in the total number of such villages from 8059 in 2003 to 5260 villages in 2010.

### 3.4.2 Irrigation Water Resources

#### 3.4.2.1 Trend of total cultivable area and irrigated area trend for Gujarat

An overview of the irrigation status of Gujarat between 2000 and 2007 is provided in Table 3.5.

<table>
<thead>
<tr>
<th>Year</th>
<th>Estimated Population (‘000)</th>
<th>Geographical Area</th>
<th>Reporting Area</th>
<th>Net Sown Area</th>
<th>Total Cultivable Area</th>
<th>Gross Sown Area</th>
<th>Gross Irrigated Area</th>
<th>Net Irrigated Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000–01</td>
<td>50671</td>
<td>19602</td>
<td>18639</td>
<td>9433</td>
<td>12354</td>
<td>10440</td>
<td>3342</td>
<td>2806</td>
</tr>
<tr>
<td>2001-02</td>
<td>51556</td>
<td>19602</td>
<td>18639</td>
<td>9622</td>
<td>12357</td>
<td>10734</td>
<td>3572</td>
<td>2994</td>
</tr>
<tr>
<td>2002-03</td>
<td>52429</td>
<td>19602</td>
<td>18868</td>
<td>9481</td>
<td>12411</td>
<td>10631</td>
<td>3637</td>
<td>3046</td>
</tr>
<tr>
<td>2003-04</td>
<td>53290</td>
<td>19602</td>
<td>18868</td>
<td>9852</td>
<td>12412</td>
<td>11421</td>
<td>4111</td>
<td>3388</td>
</tr>
<tr>
<td>2004-05</td>
<td>54140</td>
<td>19602</td>
<td>18868</td>
<td>9747</td>
<td>12410</td>
<td>11257</td>
<td>4280</td>
<td>3528</td>
</tr>
<tr>
<td>2005-06</td>
<td>54979</td>
<td>19602</td>
<td>18868</td>
<td>9747</td>
<td>12410</td>
<td>11277</td>
<td>4420</td>
<td>3528</td>
</tr>
<tr>
<td>2006-07</td>
<td>55808</td>
<td>19602</td>
<td>18868</td>
<td>9747</td>
<td>12410</td>
<td>12175</td>
<td>4977</td>
<td>3528</td>
</tr>
</tbody>
</table>

Source: Water Planning and Project Wing, Central Water Commission (CWC) 2010

Source of data: WASMO, Central Laboratory, Gandhinagar
Figures 3.19 to 3.23 in the following section provide an in-depth analysis of the percentage of net sown area irrigated in the South, North, Central, Saurashtra and Kutch regions in Gujarat.

Figure 3.19 shows the trend of percentage net sown area irrigated by surface and ground water resources in five regions of Gujarat from 1990 to 2004-05 with five year intervals. Except for North Gujarat, the net irrigated area has been increasing steadily in South, Central Gujarat, Kutch and Saurashtra.

**Figure 3.19: Percentage of Net Sown Area Irrigated in South Gujarat**

![Graph showing percentage of net sown area irrigated in south Gujarat from 1990-91 to 2004-05](image)

Source of data: Directorate of Economics and Statistics 2009

**Figure 3.20: Percentage of Net Sown Area Irrigated in North Gujarat**

![Graph showing percentage of net sown area irrigated in north Gujarat from 1990-91 to 2004-05](image)

Source of data: Directorate of Economics and Statistics 2009
Figure 3.21: Percentage of Net Sown Area Irrigated in Central Gujarat

Source of data: Directorate of Economics and Statistics 2009

Figure 3.22: Percentage of Net Sown Area Irrigated in Saurashtra

Source of data: Directorate of Economics and Statistics 2009
Figure 3.23: Percentage of Net Sown Area Irrigated in Kutch

![Percentage of net sown area irrigated in Kutch](chart)

Source of data: Directorate of Economics and Statistics 2009

### 3.4.2.2 Financial expenditure on irrigation schemes

Scheme-wise and Five Year Plan-wise financial expenditure on major, medium and minor irrigation schemes from 2002 to 2007 are shown in Table 3.6 below.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Major and medium</td>
<td>7660.9</td>
<td>1348.0</td>
<td>1642.7</td>
<td>2010.9</td>
<td>1601.1</td>
<td>3452.5</td>
<td>40.14.0</td>
</tr>
<tr>
<td>Minor</td>
<td>1098.5</td>
<td>123.2</td>
<td>164.8</td>
<td>129.2</td>
<td>941.8</td>
<td>430.4</td>
<td>653.50</td>
</tr>
</tbody>
</table>

Source: Water Planning and Project Wing, Central Water Commission (CWC) 2010

### 3.4.2.3 Irrigation by source

The trend for net irrigated area by source of irrigation in Gujarat from 2000 to 2007 has been summarised in Table 3.7.
Table 3.7 Net Irrigated Area by Source of Irrigation (2000–2007)  
(Area in’000 ha)

<table>
<thead>
<tr>
<th>Year</th>
<th>Govt. Canal</th>
<th>Tank</th>
<th>Wells</th>
<th>Other Sources</th>
<th>Total Net Irrigated Area (All Sources)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Year</td>
</tr>
<tr>
<td>2000–01</td>
<td>348</td>
<td>15</td>
<td>967</td>
<td>1467</td>
<td>2434</td>
</tr>
<tr>
<td>2001-02</td>
<td>382</td>
<td>13</td>
<td>998</td>
<td>1592</td>
<td>2590</td>
</tr>
<tr>
<td>2002-03</td>
<td>380</td>
<td>14</td>
<td>1000</td>
<td>1637</td>
<td>2637</td>
</tr>
<tr>
<td>2003-04</td>
<td>600</td>
<td>26</td>
<td>977</td>
<td>1760</td>
<td>2737</td>
</tr>
<tr>
<td>2004-05</td>
<td>676</td>
<td>33</td>
<td>967</td>
<td>1810</td>
<td>2777</td>
</tr>
<tr>
<td>2005-06</td>
<td>676</td>
<td>33</td>
<td>967</td>
<td>1810</td>
<td>2777</td>
</tr>
<tr>
<td>2006-07</td>
<td>676</td>
<td>33</td>
<td>967</td>
<td>1810</td>
<td>2777</td>
</tr>
</tbody>
</table>

Source: Water Planning and Project Wing, Central Water Commission (CWC) 2010

Figure 3.24 shows the trend of net irrigated area by surface water, ground water, and other sources in Gujarat from 2000–01 to 2007–08. The trend for net irrigated area by surface water including canals and tanks has increased over the years. While the trend of net irrigated area by ground water, including the area irrigated by tube wells and other wells, has shown a declining trend from 2000 to 2007.

Figure 3.24: Net Irrigated Area by Surface Water, Ground Water and Other Sources

Source of data: Water Planning and Project Wing, Central Water Commission (CWC) 2010
3.4.2.4 Irrigation potential
The table 3.8 shows the ultimate irrigation potential by surface and ground water in Gujarat.

**Table 3.8  Irrigation Potential by Source**

(1000 hectares)

<table>
<thead>
<tr>
<th>Major &amp; Medium irrigation (Surface water)</th>
<th>Minor irrigation</th>
<th>Total (Major, medium &amp; Minor )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Surface water</td>
<td>Ground water</td>
</tr>
<tr>
<td>3000</td>
<td>347</td>
<td>2756</td>
</tr>
</tbody>
</table>

Source: Water Planning and Project Wing, Central Water Commission (CWC) 2010

Figure 3.25 and Figure 3.26 present a comparative scenario with respect to gross irrigated area to gross sown area during the years between 1990-91 and 2004-05.

**Figure 3.25: Percentage Gross Irrigated Area to Gross Sown Area (1990–91)**
Figure 3.26: Percentage Gross Irrigated Area to Gross Sown Area (2004-05)

Source: Based on data provided by Department of Agriculture, Gujarat

3.4.2.5 Irrigation scenario
About 52 percent of the total area of the state is currently cultivable, creating a massive irrigation water demand. There are 17 river basins in Gujarat’s main land, 71 river basins in the Saurashtra region and 97 river basins in the Kutch region. Although there exist more than 184 major and medium irrigation schemes in the state, several parts of North Gujarat, Saurashtra and Kutch regions suffer from severe water scarcity frequently. Forty talukas have been demarcated as overexploited, 10 as dark, and 7 as saline (NWRWS 2010).

Of the 125 lakh hectares’ cultivable area in Gujarat (2010), 20 lakh hectares were irrigated by ground water, 18 lakh hectares by surface water, 60 lakh hectares were rain-fed and 27 lakh hectares were cultivated by different projects and schemes. Figure 3.27 shows the percentage of irrigated area relative to the total area under irrigation under different resources and projects in Gujarat (ibid).
Figure 3.27: Percentage Irrigated Area to the Total Area Under Irrigation by Source

<table>
<thead>
<tr>
<th>Zone</th>
<th>Irrigation Potential Created in Lakh ha.</th>
<th>No. of WUA's registered</th>
<th>Corresponding Area in ha.</th>
<th>No. of WUA's handed over</th>
<th>Corresponding area in ha.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central Gujarat</td>
<td>5.21</td>
<td>603</td>
<td>129833</td>
<td>344</td>
<td>87062</td>
</tr>
<tr>
<td>Saurashtra</td>
<td>3.55</td>
<td>192</td>
<td>69793</td>
<td>134</td>
<td>49872</td>
</tr>
<tr>
<td>South Gujarat</td>
<td>3.86</td>
<td>500</td>
<td>186315</td>
<td>455</td>
<td>174163</td>
</tr>
<tr>
<td>North Gujarat</td>
<td>1.91</td>
<td>476</td>
<td>97484</td>
<td>370</td>
<td>71179</td>
</tr>
<tr>
<td>Kutch</td>
<td>2.61</td>
<td>168</td>
<td>39605</td>
<td>133</td>
<td>28457</td>
</tr>
<tr>
<td>Total</td>
<td>17.14</td>
<td>1939</td>
<td>523030</td>
<td>1436</td>
<td>410733</td>
</tr>
</tbody>
</table>

Source: Chaudhari et al 2012
3.5 Coastal Waters

3.5.1 Wetlands
Wetlands are areas of land that are either temporarily or permanently covered by water. Compared to other water bodies they are of crucial importance due to the role they play in supporting a large variety of plant and animal species adapted to fluctuating water levels. The development of wetlands may be attributed to the presence of water for a significant period of time. Wetlands are neither truly aquatic nor terrestrial but can have the characteristics of both. Depending on seasonal variations wetlands could be either aquatic or terrestrial or both and hence have enormous diversity depending on their genesis, geographical location, water regime and chemistry, dominant plants and soil or sediment characteristics.

Wetlands may be divided into five categories, namely, marine, estuarine, lacustarine, riverine and palustarine. Marine refers to coastal wetlands including rock shores and coral reefs while estuarine wetlands include deltas, tidal marshes, and mangrove swamps. Lacustarine wetlands refer to lakes, riverine wetlands are found along the rivers and streams, and palustarine refer to marshes, swamps and bogs (Space Application Centre (SAC 2010). The wetlands of Gujarat are classified as inland and coastal wetlands. A majority of coastal wetlands are concentrated around the Gulfs of Khambat, Gulf of Kutch, and the two Ranns (CSPC 2011 and Saline Area Vitalization Enterprise Ltd. (SAVE) n.d.).
3.5.2 Coastal Salinity

The state of Gujarat has the longest coastline of 1600 kms in India, covering around 1500 villages. Rapid salinity ingress has been observed over the last two decades along the coastal belt, which affects the ground water aquifers adversely. The entire coast had a sweet water regime, until the end of 1960s (CSPC 2011).

The coastal tracts in Gujarat consisting of consolidated, semi-consolidated and unconsolidated sediments, have given rise to multiple aquifer systems vis. confined, semi-confined and unconfined. The Gulf of Kutch is predominated by consolidated hard rock aquifers with poor to moderate yield and influenced by salinity ingress.

Saurashtra and Kutch coastlines are predominated by semi-consolidated formations of clay, sand stone, and lime stone. Although aquifers here are of good thickness, they mostly supply moderate amounts of water, which is mostly saline in nature (SAVE n.d.).
### Table 3.10 Comparative Extent of Land Salinity in Gujarat

<table>
<thead>
<tr>
<th>Level</th>
<th>Total Area (Million ha.)</th>
<th>Land affected by Salinity (Million ha.)</th>
<th>Percent of Land Affected by Salinity Percent (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>World</td>
<td>14894</td>
<td>100</td>
<td>7</td>
</tr>
<tr>
<td>India</td>
<td>3287</td>
<td>6.73</td>
<td>2.47</td>
</tr>
<tr>
<td>Gujarat</td>
<td>19.63</td>
<td>2.48</td>
<td>12.70</td>
</tr>
</tbody>
</table>


The low-lying terrain close to the Gulf of Khambat and Kutch is easily submerged by sea water. The coastal areas stretching from Bahavnagar to Kutch are affected by seawater intrusion in coastal aquifers. The Ghed area in Porbandar is affected due to drainage deficit (Courtesy SIPC).

Figure 3.29 depicts the extent of salinity ingress in coastal Talukas of Gujarat as shown below.
Reasons for salinity ingress in Gujarat

Due to salinity ingress and the subsequent degradation of water quality became visible only after the 1960s due to an imbalance between sweet inland water and saline seawater. This imbalance was mainly caused by over drafting of ground water caused by heavy electrical pumps, complex geological conditions, erratic rainfall, low availability of fresh water due to the number of dams along the major rivers, cultivation of high water intensive crops like sugarcane, banana, betel etc., rapid industrialisation and urbanisation causing ground water overdraft and indiscriminate disposal of waste water, and disposal of sewage into aquifer systems. Also, the coastal plains are evaded by numerous creeks and estuaries up to 4-6 kms within, causing salinity ingress.
Figure 3.30: Salinity Affected Villages in Saurashtra-Kutch

Figure 3.30 shows salinity-affected villages in the Saurashtra-Kutch coastal region of Gujarat. Altogether, 29 talukas across seven districts in Saurashtra-Kutch region are affected by salinity.
Figure 3.31: Extent of Salinity Ingress in HLC 1 Talukas of Gujarat

Source of data: SIPC, Rajkot

Figure 3.32: Salinity Affected Area in HLC 1 Talukas

Source of data: SIPC, Rajkot
Salinity prevention

Table 3.11 shows the current standing of the various salinity control structures that were proposed for construction in the HLC 1 and HLC 2 area to mitigate salinity. Villages and wells benefited by completion of the different structures are also mentioned.

Table 3.11  Status of Salinity Control Structures in HLC-1 and HLC-2 Areas

<table>
<thead>
<tr>
<th>Particulars</th>
<th>HLC-I Area</th>
<th>HLC-II Area</th>
<th>Total completed structures (HLC I &amp; II)</th>
<th>Benefited area Direct/Indirect in Ha.</th>
<th>Storage Capacity in Mcum</th>
<th>Villages Affected</th>
<th>Wells Affected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tidal Regulators</td>
<td>7</td>
<td>6</td>
<td>31</td>
<td>6</td>
<td>12</td>
<td>17170</td>
<td>174.815</td>
</tr>
<tr>
<td>Bandharas</td>
<td>10</td>
<td>12</td>
<td>77</td>
<td>14</td>
<td>26</td>
<td>13717</td>
<td>65.23</td>
</tr>
<tr>
<td>Recharge Reservoirs</td>
<td>4</td>
<td>2</td>
<td>43</td>
<td>11</td>
<td>13</td>
<td>6790</td>
<td>45.05</td>
</tr>
<tr>
<td>Checkdam</td>
<td>75</td>
<td>181</td>
<td>763</td>
<td>468</td>
<td>649</td>
<td>7435</td>
<td>22.96</td>
</tr>
<tr>
<td></td>
<td>120</td>
<td></td>
<td></td>
<td>120</td>
<td>12562</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recharge Tanks</td>
<td>7</td>
<td>5</td>
<td>55</td>
<td>13</td>
<td>18</td>
<td>1993</td>
<td>1.32</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>166</td>
<td>8800</td>
</tr>
<tr>
<td>Recharge Wells</td>
<td>200</td>
<td>198</td>
<td>1130</td>
<td>199</td>
<td>397</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>248</td>
<td>11338</td>
</tr>
<tr>
<td>Afforestation (Hact.)</td>
<td>10000</td>
<td>5867</td>
<td>40750</td>
<td>-</td>
<td>5867</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>245</td>
<td>10478</td>
</tr>
<tr>
<td>Nalla Plugs</td>
<td>-</td>
<td>4487</td>
<td>65400</td>
<td>-</td>
<td>4487</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>779</td>
<td>43228</td>
</tr>
</tbody>
</table>

Courtesy: SIPC
3.6 Development of Water Resources

3.6.1 Watershed Development
Land management is central to the overall sustainability of water management. Efficient utilisation of rainfall without creating water harvesting structures on land would result in failure of storage and recharge of water. Watershed as an approach to water conservation and development takes cognisance of this factor.

Watershed development was implemented in Gujarat since the introduction of the first set of watershed development guidelines in 1995-96. In the initial years activities under this programme mainly consisted of the Drought Prone Area Programme (DPAP), Desert Area Development Programme (DDP), and the Integrated Wasteland Development Programme (IWDP). These were mainly the area development programmes of the Ministry of Rural Development (MoRD). With the introduction of new Common Guidelines in 2008 all the individual Watershed Development Programmes were merged into a more comprehensive programme called the Integrated Watershed Management Programme (IWMP).

The IWMP scheme was started in 2009 and work under that scheme is still under progress. The Gujarat State Watershed Management Agency (GSWMA) is responsible for the management of this programme in the state. The IWMP is aimed at restoring ecological balance by harnessing, conserving, and developing degraded natural resources such as soil, vegetation cover, and water through the prevention of soil run-off, regeneration of natural vegetation, rain water harvesting, and recharging of the ground water table. The main idea behind this approach was to enable multi-cropping and introducing diverse agro-based activities aimed at providing sustainable livelihoods to people residing in the watershed area (Commissionerate of Rural Development Gujarat State n.d.).

Figure 3.33 shows the area covered, proposed during 2009–10, and the area to be covered for future watershed development projects in Gujarat.
There has been a marked shift from the earlier approach. Now IWMP focusing on GIS-based planning and management of watershed in the state. It also aims at convergence with other developmental schemes from relevant departments of the government. Gujarat has been able to plan for the next 18 years. As part of its watershed development effort, numerous interventions have become possible including the creation of conservation structures, land-based interventions, agricultural development, forestry work, animal husbandry, community development, and other relevant activities as shown in Table 3.12.
Table 3.12 Status of Water Conservation Work under Watershed Development

<table>
<thead>
<tr>
<th>Water conservation work</th>
<th>Administrative Approval</th>
<th>Total works completed</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Check Dams (upto 1 lakh)</td>
<td>14994</td>
<td>14839</td>
</tr>
<tr>
<td>B. Check Dams (above 1 lakh)</td>
<td>22673</td>
<td>23536</td>
</tr>
<tr>
<td>Bori Bandh</td>
<td>20697</td>
<td>52041</td>
</tr>
<tr>
<td>Farm Ponds</td>
<td>11343</td>
<td>12424</td>
</tr>
<tr>
<td>Village Pond (New)</td>
<td>1525</td>
<td>2998</td>
</tr>
<tr>
<td>Desilting / Renovation of Tanks</td>
<td>731</td>
<td>1133</td>
</tr>
<tr>
<td>Percolation tanks / Village pond</td>
<td>3995</td>
<td>4510</td>
</tr>
<tr>
<td>Borewell Recharge</td>
<td>2571</td>
<td>3320</td>
</tr>
<tr>
<td>Wells Recharged</td>
<td>6655</td>
<td>7419</td>
</tr>
<tr>
<td>Roof Water Harvesting tank</td>
<td>1722</td>
<td>2415</td>
</tr>
</tbody>
</table>

Courtesy: Gujarat State Watershed Management Agency (GSWMA), GoG

Figure 3.34 provides the total number of check dams constructed in different regions of Gujarat by different government departments for ground water recharge. The highest number of check dams has been constructed in Saurashtra followed by Central Gujarat, North Gujarat, South Gujarat, and Kutch. Rajkot of Saurashtra has the highest number overall of 20,744 check dams. In Central Gujarat, Panchmahals has the highest number of check dams at 11,051 and Anand the lowest at 302. In North Gujarat, Sabakantha has the maximum number of check dams at 10,791. The check dam construction has justified Saurashtra’s maximum ground water availability at 4300 million cubic metres followed by South and Central Gujarat, North Gujarat, and Kutch.

**Figure 3.34: Regionwise Check Dams Constructed in Gujarat**

Source: NWRWS
Figure 3.35 represents drainage density of the entire watershed area in Gujarat. A region-wise decreasing drainage density trend is seen in South and Central Gujarat followed by Saurashtra, North Gujarat and Kutch. The overall highest drainage density among districts was 2.54 km/sq km in case of Dahod and lowest of 0.33 in Ahmedabad.

![Drainage Density Map of Gujarat](image)

It is evident from the map above that South Gujarat is an area which is suited for drainage as well as area treatment. A large number of checkdams and recharge structures have already been constructed in Saurashtra. It requires proper area treatment to arrest massive water erosion happening in the region. On the other hand, there is a need to focus on South Gujarat region for drainage as well as area treatment in order to maximize the benefits of high rainfall witnessed by this region.

### 3.7 Hydropower Development

Table 3.13 gives an overall picture of Gujarat’s hydroelectricity development potential in terms of installed capacity.
Table 3.13 Status of Hydropower Development in Gujarat

<table>
<thead>
<tr>
<th>Year</th>
<th>Identified capacity as per reassessment study</th>
<th>Capacity Developed</th>
<th>Capacity Developed + Under construction</th>
<th>Capacity yet to be Developed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total (MW)</td>
<td>Above 25 MW (MW)</td>
<td>(MW) %</td>
<td>(MW) %</td>
</tr>
<tr>
<td>2010</td>
<td>619</td>
<td>590</td>
<td>555.0</td>
<td>93.22</td>
</tr>
<tr>
<td>2009</td>
<td>619</td>
<td></td>
<td>555.0</td>
<td>89.66</td>
</tr>
</tbody>
</table>

Source: Water Planning and Project Wing, Central Water Commission (CWC) 2010

3.8 Surface Water Pollution: Status and Trends

3.8.1 Water Pollution Inventory Status
The Central Pollution Control Board (CPCB) started national water quality monitoring in 1978 under the Global Environmental Monitoring System (GEMS). More recently, the CPCB collaborated with the State Pollution Control Boards in 27 States and 6 Union Territories for improving surface and ground water quality (CPCB n.d.). The Gujarat Pollution Control Board (GPCB) under the GEMS project has been monitoring the water quality of major rivers like Narmada, Tapi, Mahi, and Sabarmati. Six monitoring stations have been set up for monitoring surface water quality and two for ground water quality. As far as the major rivers are concerned, only four parameters have been measured including pH, dissolved oxygen (DO), biochemical oxygen demand (BOD), and chemical oxygen demand (COD).

Under the Monitoring of Indian National Aquatic Resources System (MINARS) project designed for water quality monitoring on the basis of waste water discharge into rivers, GPCB monitors 70 sampling stations located along various rivers and lakes in the state. Both surface and ground water quality are being measured under this project (GPCB 2010).

A few monitoring stations in Ahmedabad, Mehsana and Vadodara districts measured additional parameters like total dissolved solids (TDS), ammonia nitrate, total kjeldahl nitrogen (TKN), nitrite nitrogen, nitrate nitrogen, total coliform (TC) and fecal coliform (FC). These pollution parameters are also monitored for lake, reservoir, hand pumps, and well water quality in Gujarat. Although the coverage of water quality is quite good for the entire state, it has been inconsistent over time, with the number of sampling varying to a good degree over time.
GPCB has been monitoring pollution at selected locations in 26 rivers of Gujarat. This also included identification of effects of contaminants and industrial activities on the quality of surface and ground water. Surveys conducted by GWSSB (2002) and GWRDC (2006) to identify the pollution levels of nitrate, fluoride and salinity had missed key polluting parameters in lakes while the impact of human activities on the quality of rivers, lakes and ground water was not assessed.

3.8.2 Analysis of Water Pollution In Water Bodies of Gujarat
Strict water quality standards have been set up by organisations like the Indian Council of Medical Research (ICMR), World Health Organisation (WHO), and Bureau of Indian Standards (BIS) for water quality parameters to make users aware of and protected from water-related health hazards. BIS IS 2296:1982 tolerance limits set for inland surface water subjected to pollution has classified water into five classes depending on the best type of use that can be made of water with a particular quality. This criterion is used here in the analysis carried out for assessing the state of pollution in the different water bodies of Gujarat.

3.8.3 Biochemical Oxygen Demand
An important indicator of pollution, BOD measures the amount of oxygen required for the microbiological decomposition of organic waste in water. A high BOD concentration indicates fecal contamination or increase in organic particulate matter from non-human and animal sources. High BOD can lead to the formation of toxic byproducts while chlorination is used to treat water (United Nations n.d).

The trends of total percentage of observation for two decades from 1990 to 2010, for different water bodies in Gujarat with respect to BOD are shown here. Figure 3.36 shows an increasing trend in the percentage of observations having BOD below 3mg/l for major rivers in Gujarat, suggesting a gradual improvement in water quality with respect to organic pollution. BOD above 6 mg/l is considered critical in water bodies.

In 2010, the highest BOD recorded was 109 mg/l, at Lali monitoring station in Khari River. As a result the DO was as low as 2.6, which is considered intolerable even for the propagation of wildlife and fisheries. Additionally, high values of BOD ranging from 39mg/l to 63mg/l were noted at three locations: Vasna-Narol Bridge, Vautha village and Miroli on Sabarmati River. The DO value for these three locations was less than 4 mg/l. This might be mainly due to the discharge of untreated domestic waste water from the local bodies of the state.
As far as reservoir water quality is concerned, a healthy trend has been seen for the last two decades with the maximum percentage of observations falling in the safe category of BOD below 3 mg/l. The highest value of 3.43 mg/l was observed at Aji Dam 2, in Rajkot in 2009.

Source: Data provided in GPCB annual reports 1990–91 to 2010–11
BOD trend for lakes and talavs in Gujarat over the last two decades presents a critical picture of water pollution. BOD values ranging between 3 and 6 mg/l representing moderately polluted stretches has gone up since 2000. In 2010–11, the highest BOD of 19 mg/l was discovered in Bindu Sarovar, Siddhpur followed by Kankariya Lake in Ahmedabad with a BOD value of 10mg/l. The CAG report of 2011 also pointed out the discharge of untreated domestic sewage/industrial effluents into the lakes. It has also been alleged that quality tests were conducted in only 19 out of 2094 lakes/ponds present in the state.

Figure 3.38: BOD Status of Key Lakes/Talavs in Gujarat

![BOD status and trend for Lakes/Talavs](image)

Source: Data provided in GPCB annual reports 1990–91 to 2010–11

3.8.4 Chemical Oxygen Demand (COD)
COD is an important indicator of organic pollutants (both biodegradable and non-biodegradable) present in surface water bodies like rivers and lakes and waste water quality. There are no COD standards for drinking water because, ideally, it should be absent in drinking water resources. The permissible limit for COD in industrial effluents has been prescribed as 250 mg/l (CPCB standards).

Overall the Figure 3.39 reflects a healthy trend with the percentage of observations decreasing between 1992 and 2010 with respect to permissible levels of COD. In 2010, the highest COD of 353 mg/l was recorded at the Khari River. A 2006 paper on pollution in the Khari River of Ahmedabad published in the Economic and Political Weekly had reported direct effluent discharge of several water-intensive estates into the Kharicut canal, which flowed into Khari River, a tributary of Sabarmati. It had also pointed out that even after the setting up of CETPs by the Ahmedabad Municipal Corporation, some small and medium scale industries had continued
to discharge effluents directly into deep aquifers through tube wells by a process locally called ‘reverse bore technique’. Moreover, the Khari River and canal had served as a common platform for industries and villages along the riverbank, severely affecting the river’s health (India Water Portal 2006).

**Figure 3.39: COD Status and Trend for Major Rivers In Gujarat**

<table>
<thead>
<tr>
<th>Year</th>
<th>COD &lt;100</th>
<th>COD 100-250</th>
<th>COD &gt;250</th>
</tr>
</thead>
<tbody>
<tr>
<td>1992</td>
<td>30%</td>
<td>40%</td>
<td>30%</td>
</tr>
<tr>
<td>1994</td>
<td>20%</td>
<td>50%</td>
<td>30%</td>
</tr>
<tr>
<td>1996</td>
<td>30%</td>
<td>40%</td>
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<td>1998</td>
<td>20%</td>
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<tr>
<td>2000</td>
<td>30%</td>
<td>40%</td>
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<tr>
<td>2002</td>
<td>20%</td>
<td>50%</td>
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<tr>
<td>2004</td>
<td>30%</td>
<td>40%</td>
<td>30%</td>
</tr>
<tr>
<td>2006</td>
<td>20%</td>
<td>50%</td>
<td>30%</td>
</tr>
<tr>
<td>2008</td>
<td>30%</td>
<td>40%</td>
<td>30%</td>
</tr>
<tr>
<td>2010</td>
<td>20%</td>
<td>50%</td>
<td>30%</td>
</tr>
</tbody>
</table>

Source: Data provided in GPCB annual reports 1990–91 to 2010–11

In 2010–11, COD had ranged between 4 to 76 mg/l in lakes of Gujarat, reflecting a discharge of industrial effluents. The highest value of 76 mg/l was observed in Bindu Sarovar, Siddhpur, situated on the banks of Sabarmati in Mehsana district. Bindu Sarovar is famous for being a sacred *kund* for the ritual ceremony of maternal spirits (Matru Shraddh) in India.

**Figure 3.40: COD Status and Trend for Key Lakes/Talavs**

<table>
<thead>
<tr>
<th>Year</th>
<th>COD &lt;100</th>
<th>COD 100-250</th>
<th>COD &gt;250</th>
</tr>
</thead>
<tbody>
<tr>
<td>1992</td>
<td>30%</td>
<td>40%</td>
<td>30%</td>
</tr>
<tr>
<td>1994</td>
<td>20%</td>
<td>50%</td>
<td>30%</td>
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<tr>
<td>1996</td>
<td>30%</td>
<td>40%</td>
<td>30%</td>
</tr>
<tr>
<td>1998</td>
<td>20%</td>
<td>50%</td>
<td>30%</td>
</tr>
<tr>
<td>2000</td>
<td>30%</td>
<td>40%</td>
<td>30%</td>
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<tr>
<td>2002</td>
<td>20%</td>
<td>50%</td>
<td>30%</td>
</tr>
<tr>
<td>2004</td>
<td>30%</td>
<td>40%</td>
<td>30%</td>
</tr>
<tr>
<td>2006</td>
<td>20%</td>
<td>50%</td>
<td>30%</td>
</tr>
<tr>
<td>2008</td>
<td>30%</td>
<td>40%</td>
<td>30%</td>
</tr>
<tr>
<td>2010</td>
<td>20%</td>
<td>50%</td>
<td>30%</td>
</tr>
</tbody>
</table>

Source: Data provided in GPCB annual reports 1990–91 to 2010–11
In reservoirs monitored by GPCB, the COD trend showed a sober picture for the maximum number of places. For 2009 and 2010, the average value of all the observations made for COD was 11.9 and 10.25 mg/l. The COD trend, over the years is shown in Figure 3.41 with regard to the Aji Dam 2 location in Rajkot. It shows that commendable work on pollution control has been done this location after 1998 when the alarming record of COD was 457 mg/l.

**Figure 3.41  COD: Trend for Aji Dam in Rajkot District of Gujarat**

![Trend of COD at Aji Dam in Rajkot](chart.png)

Source: Data provided in GPCB annual reports 1990–91 to 2010–11

### 3.8.5 Total Dissolved Solids (TDS)

TDS is measured to quantify the amount of inorganic salts as well as the small amounts of organic matter present in water. TDS usually consists of calcium, magnesium, sodium and potassium carbonates, hydrogen carbonates, chlorides, sulfates and nitrates’ salt. It affects the taste of water and imparts hardness in higher concentrations. BIS has prescribed a desirable TDS limit of 500 mg/l for drinking water and the maximum permissible limit of 2000 mg/l in the absence of any alternate source.

Figure 3.42 depicts an inconsistent trend of TDS concentration in lakes and talavs of Gujarat, with an average of over 50 percent observations made each year falling within the safe TDS category for drinking water between 1990 and 2010. 1640 mg/l was the highest value of TDS recorded at Sursagar Lake followed by Padara Lake in Vadodara which recorded a TDS value of 1290 mg/l in 2010. Concerned over increasing pollution in Sursagar Lake, the Vadodara Municipal Corporation planned to install an aeration system and fountains in the lake.
The TDS trend of water in monitored reservoirs of Gujarat has been found to be within safe limits over the last two decades. More than 80 percent observations made for each year has been falling within the safe category. None of the samples showed their TDS value crossing the permissible limit set by BIS. However, in the Aji dam 2 in Rajkot and the Auranga weir in Abrama, the TDS values did cross the desirable limits of 500 mg/l.

Source: Data provided in GPCB annual reports 1990–91 to 2010–11

The TDS trend for well water in Gujarat from 2005 to 2010 is presented in Figure 3.44. Around 70 percent samples monitored for wells in Gujarat fall within the safe category for all the years.
except 2010. Yet the percent sample with TDS crossing the permissible limit of 2000 mg/l has increased from 2006 to 2011. A TDS value as high as 10168 mg/l was noted in the water of a bore well at GIC, Limbdi in Surendranagar in 2010–11. At the same station in 2009, the value had existed at 10356. In 2009 the highest recorded TDS was 21760 mg/l in a bore well of Ramdoot Industries at Halvad in Surendranagar. This could happen due to poor maintenance of CETPs.

**Figure 3.44: TDS status and trend for well water**

![TDS status and trend for well water](image)

Source: Data provided in GPCB annual reports 1990–91 to 2010–11

### 3.8.6 Total Coliform Bacteria

Total Coliform bacteria include Fecal Coliform bacteria like E. coli and some other naturally found bacteria in the soil. This parameter is monitored to check the safety of treated water and determine the need of disinfection. The presence of high TC concentration in water bodies indicates contamination by domestic sewage or animal droppings which could contain many disease-causing micro organisms (British Columbia n.d.).

The maximum tolerance limit of TC organisms (MPN (most probable number)/100ml) for drinking water after disinfection must be 50 or less. For bathing water it should be 500 or less. In no circumstances it should exceed 5000 (BIS standards).

The Figures 3.45 and 3.46 present the trend of TC organisms (MPN/100 ml) in the river waters of Vadodara and Kheda along with the Ahmedabad and Mehsana districts undertaken by GPCB over the last five years from 2005 to 2010.

A safe trend was seen for TC over the last five years with an average of over 70 percent observations falling within the safe limits of 50 MPN/100 ml in the river waters of Vadodara and
Kheda. In 2009 a value as high as 350 MPN/100 ml was noted in the Vishwamitri River near the Kalali Railway crossing, Vadsar Bridge Road in Vadodara. This value was reduced to 110 in 2010.

**Figure 3.45: Total Coliform status and trend in river water of Vadodara and Kheda**

The river waters of Sabarmati and Khari in Ahmedabad and Mehsana district had shown a dangerous trend of TC concentration over the last five years with values crossing the most critical level of 5000 MPN/100 ml at some monitoring stations. At the Geratpur monitoring station in Khari River in 2007 and 2010, the Coliform organisms MPN/100 ml present were 30,000 and 92,160 respectively. Even CPCB, while assessing the water quality trend for the rivers of India, highlighted Khari at Lali village in Ahmedabad as being critically polluted with Coliform bacteria recording a TC value as high as 750000. At the Vasna Narol Bridge point station too, in the Sabarmati River, TC MPN /100 ml was recorded at 8985. This indicates the presence of high degradation of water quality in certain river stretches around these locations (CPCB n.d.).

Levels of organic pollution and fecal-related disease-causing pathogen have been found to be well beyond prescribed levels despite many pollution control programs conducted by the state in stretches of the Sabarmati River in the outskirts of Ahmedabad. The Water Quality Review Committee set up in 2002 had failed to report the unauthorised disposal of industrial untreated waste in Sabarmati (CAG 2011).
Even the findings of CAG (2011) points out the higher levels of pollutants at certain points like the Miroli pumping station outside Ahmedabad city after its convergence with the GIDC industrial estate pipeline discharge. The values of BOD and Total Coliform (TC) have been found to be much beyond the permissible limit. BOD here ranged from 5 to 87 and TC from 93 to 24000 as against their permissible limits of 30 and 5000 respectively. This has defeated the objectives of the Sabarmati Cleaning Project under the National River Conservation Plan.

### 3.8.7 Instances of severe Pollution of Rivers, Lakes and Khadis

Three of the five most polluted river stretches in the country exist in Gujarat including the Amlakhadi in Ankleshwar, Khari in Lali village, Ahmedabad and Sabarmati in Ahmedabad. Severe pollution has destroyed estuarine fisheries in Amlakhadi. A 75.76 percent fish catch reduction has been recorded in this area in Bharuch district (SANDARP 2012).
Figure 3.47: Pollution in Amla Khadi

Source: SANDARP 2012.

Figure 3.48 shows the entry of a sewage stream in Sabarmati River downstream of Vasna barrage.

Figure 3.48: Direct Disposals from Sewage Stream into Sabarmati River

Source: SANDARP 2012.
Huge quantities of hazardous chemicals have been dumped into the Mahi River and the Gulf of Khambat by industries in and around Vadodara. The CETP in Damanganga has been discharging industrial waste water in Vapi amounting to 347 percent higher COD, 432 percent higher TDS, and 196 percent higher Ammonia nitrogen than laid down by the GPCB. A worse scenario unfolds on the banks of the Sabarmati, which has become a dumping site for industrial effluents from Vatva, Odhav, Narol and Naroda near Ahmedabad (Thakkar 2012).

Table 3.14 shows the impact of water pollution in coastal waters. In Bharuch district the reduction in fish catch went down to 75.76 percent in the last five years.

**Table 3.14 Reduction in the fish catches due to water pollution**

<table>
<thead>
<tr>
<th>Name of Fish</th>
<th>1999–2000</th>
<th>2003–2004</th>
<th>Reduction in 5 years (percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Catla catla</em></td>
<td>23,18,654</td>
<td>2,02,062</td>
<td>91.20</td>
</tr>
<tr>
<td><em>Labeo rohita</em></td>
<td>24,96,327</td>
<td>3,11,189</td>
<td>87.50</td>
</tr>
<tr>
<td><em>Cirrhina mrigala</em></td>
<td>15,14,284</td>
<td>23,449</td>
<td>98</td>
</tr>
<tr>
<td>Kalbasu</td>
<td>2,88,253</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>Minor carp</td>
<td>44,561</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>Bekti</td>
<td>14,827</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>Mahasheer</td>
<td>82,097</td>
<td>1,200</td>
<td>98.50</td>
</tr>
<tr>
<td><em>Wallago attu</em></td>
<td>10,52,359</td>
<td>39,390</td>
<td>96.25</td>
</tr>
<tr>
<td>Scorpion</td>
<td>1,26,662</td>
<td>150</td>
<td>99.80</td>
</tr>
<tr>
<td>Murrel</td>
<td>8,34,873</td>
<td>66,260</td>
<td>92</td>
</tr>
</tbody>
</table>

**Source:** SANDARP 2012

### 3.9 Control of Water Pollution in Gujarat

The vast gap between the demand and supply of water highlights the significance of recycling and reuse of waste water whose generation has increased manifold over the last few decades. One of the biggest culprits of water pollution in Gujarat has been the disposal of untreated domestic and industrial effluents. To mitigate this situation, the Government had formed 170 urban local bodies (ULBs) in the state to make provisions for sewage treatment. This section discuss the analyses and findings related to Local Government Bodies (LGB) data, their sewage disposal status, the existence of Sewage Treatment Plants (STPs) and other treatment facilities.

Although the legal provision existent since 1974 prohibits the disposal of untreated sewage and industrial effluents in any water body, the analysis of data on LGBs with facilities to treat sewage and report the status of its disposal shows that very few industries adhere to this provision. ULBs were supposed to conduct survey studies with regard to the level of contamination caused by sewage discharge, industrial effluents, solid waste and agricultural waste on river banks before implementing the National River Conservation Plan (NRCP) in the state, which is yet to happen (CAG 2011).
A district-wise distribution of ULBs has been presented in Figure 3.49. It is clearly visible that Junagadh has the highest number of local bodies (13), followed by Anand (12) and Jamnagar (11). The districts which have fewer than five ULBs are: Gandhinagar, Narmada, Navsari, Panchmahals, Patan, Porbandar and Tapi. Data for the Dangs district is not available.

**Figure 3.49: Number of local bodies district wise up to May 2010**

The sources of water supply to all these local bodies have been summarised in the Figure 3.50. Bore wells appear to be the most common source of water supply to all the districts’ local bodies except Dahod and Kutch. The Panoli Industrial Association was supplying exclusively to one local body in Bharuch district as of May 2010 while check dam water supply was catering to a local body in the Panchmahals district.
Figure 3.50: Sources of water supply local body wise May 2010

Source of data: Gujarat Urban Development Mission (GUDM)

Figure 3.51 presents the district-wise number of local body distribution with respect to the kind of sewage treatment facility adopted by them. Functional STPs were present in only ten districts viz. Ahmedabad, Amreli, Anand, Bharuch, Bhavnagar, Gandhinagar, Kutch, Surat, Vadodara and Valsad. ULBs in the districts of Banaskantha, Dahod, Jamnagar, Junagadh, Panchmahals, Porbandar and Tapi had no sewage treatment facilities while the STP in Bhavnagar was not under operation. As per CAG report (2011), it is clear that only 13 percent of ULBs in State have been discharging treated sewage water into rivers.
This is not to suggest there is no action on this front. It is reported that construction of a STP by Jamanagar Municipal Corporation is in the advance stages. As this analysis is based on data sets available up to the year 2010, the developments since then are yet to be recorded.

Despite the identification of four major rivers as most polluted in Gujarat by CPCB, the state government placed only the Sabarmati river under the National River Conservation Plan. To mitigate industrial pollution in Damanganga estuary, it is believed that the Common Effluent Treatment Plant (CETP) at Vapi laid a pipeline to discharge treated effluents into the deep sea (CAG 2011). Figure 3.52 shows water pollution in Vapi in South Gujarat.
Figure 3.52: Water pollution in Vapi district of Gujarat

Source: Outlook India 2008

Figure 3.53: Present location of sewage disposal

Source of data: Gujarat Urban Development Mission (GUDM)
The analysis given in Figure 3.53 shows that except for few ULBs in Kutch, Anand and Sabarkantha the LGBs in nearly all other districts dispose their sewage into surface water bodies. This analysis and CAG (2011) found that almost 10 municipalities of Gujarat were disposing their untreated sewage into lakes. This has serious implications as contaminated lake water can percolate and ultimately pollute the sub-soil water. It was also reported that in the Dani-Limbda area of Ahmedabad domestic sewage was being discharged directly into the Sabarmati River through storm drainage pipelines. It is also found that the untreated sewage and slaughter house waste pollution in the Gorwa lake of Vadodara, a major commercial and residential hub. The lake’s overflow has also polluted the Gotri Lake nearby. These rivers have not been monitored by GPCB.

**Figure 3.54:** Local body wise percentage area covered for sewage treatment

<table>
<thead>
<tr>
<th>Local bodies-wise area covered for sewage treatment (%)</th>
<th>(May 2010)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of local bodies</td>
<td>0 1 2 3 4 5 6 7 8 9 10 11 12</td>
</tr>
<tr>
<td>&lt;30</td>
<td>6 6 6 6 6 6 6 6 6 6 6 6 6</td>
</tr>
<tr>
<td>30-60</td>
<td>6 6 6 6 6 6 6 6 6 6 6 6 6</td>
</tr>
<tr>
<td>61-90</td>
<td>6 6 6 6 6 6 6 6 6 6 6 6 6</td>
</tr>
<tr>
<td>&gt;90</td>
<td>6 6 6 6 6 6 6 6 6 6 6 6 6</td>
</tr>
</tbody>
</table>

Source of data: Gujarat Urban Development Mission (GUDM)

Sixteen local bodies in Jamnagar, Junagadh, Sabarkantha, Banaskantha, Bharuch, Gandhinagar, Panchmahals and Rajkot have been discharging sewage water directly into the ground water and soak pits. Some of these districts have no sewage treatment facilities. A total of 10 ULBs in Anand, Kheda, Kutch, Mehsana, Patan, Rajkot and Surendranagar have been using sewerage water for crop irrigation.

Figure 3.54 presents the analysis of percentage area covered for sewage treatment under each local body. The ULBs in six districts have less than 30 percent sewage treatment coverage. Out of 170 ULBs 38 ULBs cover only 30–60 percent of the area under their jurisdiction as far as this facility is concerned. Around 64 ULBs in Gujarat cover 61–90 percent of their area for
this purpose. Seventeen out of 27 districts of the state have few ULBs with more than 90 percent of their area under some kind of sewage treatment facility.
Impact
Chapter 4
4.0 IMPACT

4.1 Introduction

Assessing the impacts on water resources of a state like Gujarat presents a challenge requiring one to take cognisance of the developmental achievements on one hand and foreshadowing the dangers to economic growth and sustainability along with maintaining ecological balance on the other. Water resources are central to both aspects. It is, in this context, that this chapter looks at the impacts of various pressures on water resources of Gujarat. Broadly speaking, impacts on water resources may be understood in terms of positive and negative outcomes of natural and human influences as discussed in the following sections.

4.2 Demographic and urbanisation impacts

As Gujarat continues to urbanise rapidly, it also impacts the per capita water requirement of the state. The urban population has a much higher per capita requirement of water compared to its rural counterpart. As far as the urban population is concerned, this requirement ranges between 135 lpcd and 250 lpcd depending upon the class of the city and drainage facility. Most urban centres have been forced to opt for ground water complemented by surface water supply. Of late, most of the big urban centres of Gujarat get their water supply through the Narmada water-based statewide grid. The SSP-based drinking water scheme aims at covering 131 urban centres. This scheme, once realised, can change the whole water supply scenario in these urban centres (Parthasarthy and Dholakia, 2011).

4.3 Impacts of recharge movement and good rainfall during last decade

Check dams and minor irrigation dams are acknowledged methods of ground water recharge in hydrology literature. Various initiatives in this sector have seen serious government efforts to get people involved while relying on them and earning their trust. This is visible in initiatives like the Sardar Patel Participatory Water Conservation Programme (SPPWCP) for check dam construction and institutional responses like WASMO. The Water Resources Department of GoG has undertaken the construction of 1.13 lakh check dams, 56000 boribunds, and 2.4 lakh farm ponds in addition to other 62,000 recharge structures. Figure 4.1 shows one such Check dam site in Gujarat.
As part of SPPWCP the government shared almost 60 percent of its funding; 40 percent was to be borne by the direct stakeholders and the beneficiary groups including NGOs involved in monitoring the quality of check dam construction. As a result, almost 1.3 lakh check dams were constructed in the decade of 1990–2010. This caused water levels to rise in various parts of the state and more so in the Saurashtra region. Now farmers have access to irrigation almost throughout the year.

While the beneficial side of such large scale intervention is well-documented in terms of recharge, it has also succeeded in arresting ground water mining responsible for causing ground water depletion as well as salinity ingress in the coastal areas. A more detailed study capturing the socio-economic benefits (Shingi and Asopa 2002) was conducted by IIMA. The study concluded that people’s participation formed the bedrock for the success of this scheme. It also cited benefits like greater accessibility to drinking water and fodder reducing the drudgery of women, and termed the intervention as recharge method with minimum ecological and human costs.

There is, however, another school of thought sounding a warning that such efforts at mass scale could prove detrimental from a basin perspective. They could have an adverse impact on downstream flows or surface and ground water users. It has been argued that this fact holds true, particularly, when it the intervention is carried out with reference to closed basins, i.e when all available supplies are fully allocated. An example has been made of the Aji1 reservoir on Aji River in the Saurashtra region of Gujarat. The former also happens to be a water scarce and closed basin. The city of Rajkot, which receives its water supply from this reservoir, is located downstream of this basin. A massive drive to create check dams and other water recharge structures since 1985 seems to have reduced the flow into this downstream reservoir impacting adversely the water supply to Rajkot, a major urban centre of Gujarat. This has been proved by
an extensive study (Molden and Sakthivadivel 1999) that scrutinised is the rainfall and inflow data for the reservoir between 1968 and 2000 (Giordano and Villholth 2007).

As discussed in the Status section, average rainfall in the different regions of Gujarat has been on the rise. This fact coupled with the state-wide grid of the Narmada waters along with water conservation and recharge measure including check dams on large scale have improved the water availability situation for different use sectors across Gujarat.

4.4 Dynamics of the ground water over the last two decades

After having a close look from Figure 4.2 and Figure 4.3, it is easy to see that the water table fell between May 1990 and May 2000 by 2 to 4 metres across the state, except in some parts of South Gujarat and Rann of Kutch. Table 4.1 shows the regional groundwater fluctuation over last two decades. In North Gujarat about 34 percent of area experiences more than 6 metres fall of ground water during 1990 to 2010. The period under discussion witnessed a general trend of decline of 0 to 2 metres fall as well as a rise of 0 to 2 metres in the water table across the state. However, the extreme situation of the earlier period still continues to haunt the region of North Gujarat. During the corresponding period, the Saurashtra region in general experienced a rise in its water table by 0 – 4 metres. This fact may be attributed to good rainfall in the last decade as well as to initiatives like augmentation of surface water and ground water recharge through the construction of recharge structures like check dams on a large scale. Although, there is a rise in ground water levels most part of the state, North Gujarat and Kutch have seen an overall fall even during the decade of 2000-2010.

Table 4.1 Groundwater fluctuation over last two decades

<table>
<thead>
<tr>
<th>Regions</th>
<th>1990-2000</th>
<th>2000-2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kutch</td>
<td>215492</td>
<td>-725870</td>
</tr>
<tr>
<td>North Gujarat</td>
<td>-1323886</td>
<td>-83535</td>
</tr>
<tr>
<td>Central Gujarat</td>
<td>-554412</td>
<td>184861</td>
</tr>
<tr>
<td>South Gujarat</td>
<td>231169</td>
<td>142137</td>
</tr>
<tr>
<td>Saurashtra</td>
<td>-2601952</td>
<td>2742142</td>
</tr>
<tr>
<td>Gujarat</td>
<td>-4033589</td>
<td>2259735</td>
</tr>
</tbody>
</table>

Note: Positive figures indicate rise, negative figures indicate fall. One metre rise/fall is not taken into consideration

Source: Based on spatially interpolated surface of data provided by Central Ground Water Board and Ground Water Resource Development Corporation
Figure 4.2: Dynamics of Ground water (May 1990 - May 2000)

Source: Based on spatially interpolated surface of the piezometer level data provided by Central Ground Water Board and Ground Water Resource Development Corporation
4.5 Impact on Agriculture

Gujarat has seen tremendous growth (10 plus per cent) in the agricultural sector over the last decade. For a state which was known more for its business communities dealing with trading, it’s not a small achievement. While focussing on rapid growth in industry and agriculture, the Government has proactively focussed on vital requirements like energy generation and augmentation of resources like water. Coincidently, this period has also witnessed exceptionally good rainfall which has probably helped in compounding the impacts of government initiatives many times over.

Increased water availability has led to, crops like wheat, cotton, banana, papaya, sugarcane, and tomatoes being cultivated in almost all parts of Gujarat including drought prone areas like Saurashtra. The farmers themselves are taking care of the check dams. The scheme is seen as a permanent solution to Gujarat’s water crisis with positive impacts like 138.47 MCM of ground water recharge, replenishment of 62225 wells, and protection of 20 lakh bighas of land (GoG n.d.).
The long-term sustainability of its growth story will rely on the sustainability of hard-earned improved water availability during last decade which is partly attributable to some visionary planning (SSP, Sujalam Sufalam, interlinking of rivers, check dam movement etc.) partly to the incidence of very good rainfall during this period.

4.6 Saradar Sarovar Project and Drinking Water Supply Grid

The Saradar Sarovar Project (SSP) represents aspirations of generations of development planners of the country at large and Gujarat in particular. Until 1999 Gujarat was infamous for its droughts and water problems. During this period the state would be faced, on average, with droughts or drought-like situations for almost seven years in each decade rendering over 4,000 villages dependent on tanker water supply. Transformation over the last decade in village-wise water supply through tankers over the last decade is shown in the Figure 4.4

![Figure 4.4: Villages With Tanker Water Supply (1991–2011)](image)

Source: Courtesy WASMO

Over the last decade the Sardar Sarovar dam was raised to the crest level of spillway EL 121.92 m. Until October 2010 the dam had generated 1920 million units of energy. Although the SSP is now operational yet the canal system remains incomplete. According to the NWRWS report as on December 2011, 1874 kms of bulk water pipeline schemes have been completed.

The state-wide water grid has started taking Narmada waters to thousands of villages. This grid essentially meant for bulk water transmission mainly from Narmada dam based surface water to water scarce and poor water quality habitations. It has made a big difference with respect to
water related health related issues. Bulk pipelines have been laid covering 1,987 kms in addition to the 115,058 km of distribution pipelines. Without the SSP, Gujarat and Rajasthan would not stand to benefit from the Narmada waters. The waters, which have been recharging severely depleted ground water, are also helping negate the adverse impacts of low rainfall. The equitable and volumetric supply of water as planned seems to be a distant dream. Equitable distribution of the SSP benefits necessitates strong political will on the state’s part (Aandahl 2010), as this will also lead to distribute the SSP benefits equitably and crucial to the goal of poverty reduction.

4.7 Water Pollution and increased demand for industry and agriculture

Gujarat being a leading industrialised state of India has been taking the lead with regard to the number of industrial estates, Special Economic Zones (SEZs), and Special Investment Regions (SIRs). Almost 62 percent of its geographical area falls under the influence of Delhi Mumbai Industrial Corridor (DMIC). Eighteen out of 27 Gujarat’s districts are in this influence zone.

The SEZs, at different stages, have been allocated an area of 20761.93 hectares while SIRs cover 373100 hectares. These are huge areas allocated for expediting economic growth in the state but will also have implications for water resources within their boundaries as well as the adjoining areas which will require suitable responses from the state and all concerned stakeholders.

The water requirements of these special zones being huge, they are more than likely to exert tremendous pressure on the water resources of their respective areas. They are also likely to have severe implications for the ground water in Gujarat, a state that is just shedding off its drought prone historical image. Huge requirements of water by these conglomerations can have implications for the regions of Saurashtra, Kutch and North Gujarat. Drinking water availability, irrigation water supply, and water quality may all be affected adversely. The case of the Coca Cola plant at Plachimada in Kerala highlights the complexities inherent in water-related issues and their bearing on resource availability and quality along with the overall ecological and public health of the area. In order to address the impending problems, recycling and reuse of water by the industry can be a better option.

4.8 Water Quality and Public Health

4.8.1 Village Level Water Quality

Safe drinking water access has always critical to the country. Thirty percent of urban and 90 percent of rural households still depend completely on untreated surface or ground water in the absence of safe drinking water. It has been reported that 21 percent of communicable diseases in India happen to be water-related. Fluoride, arsenic, iron, salts and micro bacteria are the most commonly found contaminants in ground water. Gupta (2011) points out that drinking water scarcity in Gujarat posed a serious threat to human and cattle populations until 2001. Billions of
rupees were spent on temporary knee jerk measures like drinking water supply by road and rail tankers adding to the poor water resources management. He further elaborates on the situation and attributes over drafting of ground water (as compared to annual recharge) to the serious water quality problems due to excessive fluoride, nitrate and salinity.

District-wise distribution of unfit villages based on data given by the Central Laboratory, GWSSB, Gandhinagar reveals a remarkable reduction in the total number of such villages; from 8059 in 2003 to 5260 villages in 2010. A district-wise picture of unfit villages for 2010 and 2003 is presented in the status section. The figure 4.5 shows the percentage distribution of unfit villages in five regions of Gujarat for 2010. Of the total 5620 unhealthy villages, Central Gujarat has a maximum of 1735 villages, followed by Saurashtra with 1266 villages. In Kutch the number of affected villages occurs least at 219.

**Figure 4.5: Region-wise percentage of unfit villages in Gujarat**

![Regionwise percentage unfit villages 2010](image)

Source: WASMO, Central Laboratory, GWSSB, Gandhinagar

This part of the section deals with the number of villages in Gujarat affected by poor water quality with respect to total dissolved solids (TDS), extreme concentrations of fluoride, and nitrate in water for the years 2003 and 2010. A district-wise comparative picture reflecting the number of villages affected by TDS, acute levels of fluoride, and nitrate for the years 2003 and 2010 are given in Figures 4.6 to 4.8. CSPC carried out a baseline study in 1165 villages during 2007–08 and found that 890, 753 and 337 villages were afflicted with a high incidence of kidney stones, gastric problems, and fluorosis. CAG Report (2011) also came out with a similar finding.

The number of villages affected by accessive TDS have reduced during last decade. In 2003 the total number of villages affected by higher concentrations of TDS in water stood at 2508; this
figure had dwindled to 588 by 2010. Kutch was seen as being most TDS-prone in 2010 with its 99 affected villages.

**Figure 4.6:** TDS unfit villages in Gujarat (2003 and 2010)

Fluoride is found to be the main cause of extensive health damage in several parts of Gujarat state. Fluoride affected habitations in Gujarat increased from 2,826 in the year 1992 to 4,187 by the year 2003 Gupta (2011). Some of the health hazards of excessive fluoride content in drinking water are dental fluorosis, bone deformities due to skeletal fluorosis among adults, anemia, loss of appetite, nausea and thyroid malfunction. The number of fluoride-affected villages stood at 4187 in 2003 and 1121 in 2010. The Sabarkantha district saw the highest number of affected villages (531) in 2003; this figure shrunk to 120 in 2010. INREM has been monitoring ground water quality constantly in conjunction with pertinent diseases like fluoroosis in many regions of Gujarat. The blue bars in the following three figures indicate villages for 2010 and red bars for 2003.

Source: WASMO, Central Laboratory, GWSSB, Gandhinagar
Figure 4.7: Fluoride unfit villages in Gujarat (2003 and 2010)

Source: WASMO, Central Laboratory, GWSSB, Gandhinagar

Figure 4.8: Comparative status of Fluoride in Gujarat (2000–2010)

Source: Based on Data Provided by CGWB
Our comparative analysis of the extent of fluoride prevalence in Gujarat is shown in the Figure 2.18 suggests that situation has improved for better during last decade. The number of Fluoride-affected villages have reduced from 4187 to 1121. Gupta (2011) attributes this to the state wide drinking water grid for bulk water transmission mainly from Narmada Dam based surface water to water scarce and poor water quality habitations. Bulk distribution pipelines have led to reduction in fluoride and other harmful contents in the accessible drinking water in several parts of the state. The number of villages rendered unfit owing to fluoride and TDS concentrations in water decreased sharply between 2003 and 2010. This would not only save us from a range of complexities arising due to poor water quality but also help save our hard-earned money in the public exchequer for better use.

Compared to other water-affecting factors, nitrate presents the most alarming picture by far. But in the case of nitrate the number of unfit villages has almost doubled. Higher doses of nitrogenous fertilizer applications in the agricultural fields and unsafe disposal of municipal wastes likely have impacted this. With 2521 nitrate-affected village in 2010 versus 1335 unfit villages assessed in 2003, the case for immediate monitoring and control of nitrate is more than obvious. Figure 4.9 is a disturbing testimony to this ground water reality. Safe disposal of municipal wastes, avoiding flood irrigation, and right doses of nitrogenous fertilizers are some of the measures to contain nitrate pollution of systems.

**Figure 4.9:** Nitrate unfit villages in Gujarat (2003 and 20010)

Source: WASMO, Central Laboratory, GWSSB, Gandhinagar

India Water Portal web page (2012) and CAG (2011) indicate absence of a system for ground level assessment and consolidation of data on water quality and its health impacts. It seems that
no system has yet been devised to consolidate water quality data generated by district laboratories to convey village-level information on water quality at the national level. But, the Ministry of Water Resources, GoI has developed this crucial system, at least for chemical quality parameters of drinking water. Waterborne diseases caused by the presence of contaminants like arsenic, zinc, iron, mercury, copper, chromium, cadmium, lead and non-biodegradable organic pollutants and their impact on human health have also not been assessed in the state.

4.8.2 Public Health

An analysis of the data on water borne diseases from 2005 to 2011 provided by the State Surveillance Unit, Health Department, Gandhinagar is presented in this section. A seven-year trend for each water-borne disease vis. typhoid, cholera, bloody diarrhea, acute diarrhea (AD), and acute viral hepatitis (AVH), along with a region-wise percentage distribution for 2011 has been depicted through the Figure 4.10 to Figure 4.14.

**Figure 4.10: Rising trend of typhoid fever in Gujarat**

![Figure 4.10: Rising trend of typhoid fever in Gujarat](image)

Source of data: Health Department, Governement of Gujarat.
Figure 4.11: Trend of cholera in Gujarat

![Cholera trend in Gujarat](image)

Source of data: Health Department, Government of Gujarat.

Figure 4.12: Acute Viral Hepatitis (AVH) trend in Gujarat

![AVH trend in Gujarat](image)

Source of data: Health Department, Government of Gujarat.
The trend analysis of water-borne diseases in Gujarat doesn’t reveal an appealing picture. The number of cases detected for typhoid and acute viral hepatitis, shows an increasing trend over the
years between 2005 and 2011 while bloody diarrhea shows decreasing trend. The number of cases detected over the period under analysis has incremented sharply for typhoid and acute viral hepatitis (AVH).

Rapid response teams (RST), responsible for monitoring disease-causing agents in the water throughout the year, have been formed at regional and district levels in order to control the prevalence of diarrhea in the state. Yet such action hasn’t succeeded in preventing the outbreak of water-borne diseases. Similar findings were reported in the Civil Report of CAG (2011).

Regionwise scenario with respect to prevalence of each water-borne disease vis. typhoid, cholera, bloody diarrhea, acute diarrhea (AD), and acute viral hepatitis (AVH) for the year 2011 has been presented through the Figure 4.15 to Figure 4.19.

A regional analysis of Typhoid in Gujarat shows Central Gujarat as being most prone to this disease with the highest number – 3815 – of cases detected in Ahmedabad in 2011. Ahmedabad is the leader among all the districts with the highest number of cases detected between 2005 and 2011. According to WASMO, Ahmedabad was home to 116 unfit villages in 2010. Of all the five water-borne diseases under analysis, Kutch has been the most prone to typhoid with 952 cases detected in 2011.

Figure 4.15: Region wise typhoid prevalence in Gujarat

![Regionwise typhoid percentage 2011](image)

Source of data: Health Department, Government of Gujarat.

South Gujarat has the highest prevalence of cholera, with 125 cases detected from an overall of 183 in 2011. Surat seems to be the most disease-prone district with 124 cases reported in 2011 followed by Ahmedabad in South Gujarat. In 2011, Surat had 183 unfit villages affected by drinking water quality health hazards (Cortesy WASMO).
Central Gujarat, once again, seems most afflicted by bloody diarrhea with 21056 cases reported in 2011. This is followed by 11508 such cases in South Gujarat. Kutch, on the other hand, reported only 0.3 percent cases with 124 detected cases of diarrhea in 2011. The number of cases in the same region was 525 in 2005 yet the number of unfit villages has increased from 203 to 219 from 2003 to 2010 (Courtesy WASMO).

Source of data: Health Department, Government of Gujarat.
Saurashtra reported 197318 cases and Central Gujarat 199124 out of the total acute diarrhea cases of 633158 in 2011. While Kutch seems to attract the highest number of typhoid cases, it is second most prone to Acute Diarrhea (AD) with 14651 cases, accounting for two percent of the total number of AD cases detected in Gujarat. Of all the diseases analysed here AD has had the severest effect on the state with numbers crossing 6, 000 in 2011; the numbers have actually reduced over the last seven years.

**Figure 4.18: Region wise acute diarrhea percentages**

![Regionwise Acute Diarrhea percentage 2011](image)

Source of data: Health Department, Government of Gujarat.

With 29070 cases detected in 2011, Central Gujarat again appears most vulnerable to acute viral hepatitis besides typhoid, bloody diarrhea and acute diarrhea. Kutch has been least vulnerable with 264 cases detected in 2011.
A regional analysis of all the five water-borne diseases earmarks Central Gujarat as the most vulnerable region followed by South Gujarat and Saurashtra. Kutch seems the least susceptible to all the diseases related to water. The regions in south and Central Gujarat are also the most water-abundant in the state. The data provided by WASMO suggest that the number of unfit villages in Gujarat stood at 5260 in 2010.

### 4.9 WASMO and Changing Drinking Water Scenario

The Sector Reform Programme was introduced in 1999–2000 with an emphasis on community participation in planning, implementation, and management of drinking water related schemes. It was scaled up as Swajaldhara programme in 2002. WASMO was constituted as a special purpose vehicle (SPV) for implementing this programme. Since then WASMO has played an important role in the participatory management of drinking water supply in Gujarat.

WASMO and Jyotigram are two institutional responses known to have wielded a key influence on Gujarat’s water sector. WASMO has provided a platform to all relevant agencies involved in providing water up to the village boundaries through the Narmada water-based state-wide grid. WASMO has contributed tremendously in the formation of Pani Samitis across the state ensuring, thereby, community participation in the planning, execution, operation, and maintenance of the village-level water supply schemes based on their own demands.

CAG (2011) also suggests that the targets achieved as part of the ‘golden goal’ of covering over 18000 villages’ so far is exemplary although the scope for improvement certainly exists. WASMO intervention has made community-managed drinking water a reality in the villages of Gujarat.

Source of data: Health Department, Government of Gujarat.
4.10 Impacts of Jyotigram on Ground water

The state introduced a scheme known as Jyotigram Yojana to provide a single phase, 24-hour, uninterrupted power supply to the state’s 18,065 villages and the 9,680 suburbs attached to these villages and 3-phase power supply for night hours in the agricultural fields. By rationing its power supply in agricultural fields, the scheme has had a widespread, positive impact on Gujarat’s agriculture. It seems to have brought about some order and discipline in the extraction of ground water while abetting the ambitions of some farmers encouraging them to grow crops like cotton and wheat (Shah et al 2009).

On one hand, the Jyotigram Yojana has led to the provision of high quality and steady power supply to farmers who are able to draw ground water for irrigation purposes on an optimal basis. This has, in turn, led to uninterrupted agricultural growth in a drought prone state with 70 percent of its area classified as arid and semi-arid.

Shah et al (2009) in their study of agriculture in Gujarat has shown that the scheme has yielded the maximum impact on the state’s agriculture by bringing about order and discipline in ground water extraction apart from sharply augmenting the growth of cotton and wheat.

While the 10th plan had predicted an agricultural growth rate of 4 percent, Gujarat continued to grow at 9.6 per cent per annum since 2000–01, at thrice the national average. The Public Service Innovation Award was conferred upon the state for the year 2010 courtesy of its Jyotigram Yojana.
RESPONSES
CHAPTER 5

5.0 RESPONSES

5.1 Introduction
A white Paper on Water in Gujarat (2000) had termed the state as one of the most water scarce and drought prone regions of India. Until 2000, droughts occurred almost once every five years on an average yielding an adverse impact on the local populace and overall development of the state. Over little more than a decade, the state has seen a shift in government responses ranging from fire-fighting tactics until the 90s to more integrated efforts towards drought mitigation and water scarcity reduction across the state.

Schemes like Sujalam Sufalam, the interlinking of rivers, plus a state-wide grid for domestic and drinking water supply have intensified the positive impact of good rainfall and an almost - complete SSP over the Narmada. Water and Sanitation Management Organization (WASMO) and Jyotigram are two institutional responses that have had major positive impacts on the water sector in Gujarat. The thrust on participatory village level institutions through WASMO has played an effective role in improving water management at village level with a definite scope for further improvement. Participatory village level institutions in case of watershed and irrigation management require strengthening and scaling up.

Given the positive developments of the last decade or so it may appear that Gujarat has overcome its water problems yet a lot remains to be done. Rapid industrialisation and urbanisation of the state have compounded the already complex water management issues faced by the state. Constitutionally speaking, water being a state subject, it is the responsibility of state governments to plan, develop and manage their water resources. Government responses have a central role to play while addressing the issues related to water. The following sections deal with many such responses from the government, civil society through community organisations, NGOs and industries for addressing various challenges faced by the water sector in Gujarat.

5.2 Water Scarcity Mitigation
The key water scarcity mitigation tools that changed the water availability scenario of Gujarat from 2000 onwards has had to do with progress made with respect to completion of Sardar Sarovar dam on river Narmada, creation of a state-wide drinking water grid, the Sujalam Sufalam Yojana, diffusion of Narmada canals, interlinking of rivers, filling of ponds, dams and rivers by Narmada waters, and the construction of check dams and other water harvesting structures along the rivers.
5.2.1 Government Responses

- **Knowledge Domain**

Gujarat’s relatively poor and unevenly distributed natural resources pose tremendous management challenges with regard to containing environmental degradation while still ensuring developmental momentum. All those concerned with the state need to have a comprehensive understanding of the development and natural resource equilibrium necessary for its sustained economic and social growth. Drawing up of the State of Environment Report can be seen as a response to this effect. The State of Water is one of the reports produced as part of this exercise.

The Establishment of Climate Change Department (2009) is also an initiative in the right direction as water-climate dynamics need to be understood correctly in order to ensure sound and sustainable water management in the state. This is all the more important as Gujarat has traditionally been a state affected by frequent droughts. Its long coast line (1600 kms) only compounds the problem as the rise in sea level aided by severe ground water depletion only serves to worsen the already existing salinity problems in coastal Gujarat.

The World Bank aided Integrated Coastal Zone Management Project (ICZMP), which identifies multi-disciplinary interventions to arrest further degradation of the sea coast including salinity ingress, is an important effort for a healthy and sustainable development of the state’s coastline.

It’s important to have insights on the climate–water relationship while relevant research studies should help us to develop an understanding of phenomena enabling suitable responses to deal with issues linked with climate change, industrial development, and water.

- **Check dam movement**

A water recharge movement has been witnessed in Saurashtra as a response to growing water scarcity conditions until late 1990s. A variety of socio-technical actions have been carried out under the movement, mainly led by local farmers, community leaders, and NGOs with financial support from a well to do migratory population from the area, particularly from settlers in cities like Surat, Ahmedabad and outside the state. As a result, this region has seen a sharp increase in agriculture-based livelihood incomes, primarily through increased ground water availability, along with an improved quality of life (Mudrakartha, 2008).

Due to the enabling role played by the state government in the context of recognising the value of such initiatives and drawing lessons from their outcomes while introducing proactive policies and technical expertise along with the financial support provided by various government agencies, Gujarat has witnessed a near mass movement regarding the construction of check dams, especially since 2000. Figure 5.1 depicts the rise in the number of Gujarat’s check dams as
a result of the movement that may not have been possible without the participation of the people and government post 2000.

Figure 5.1: Check dam constructions in Gujarat (1990–2011)

The Context: Poor rainfall and poor water conservation

Monsoon failures before 2000 led to acute drinking water shortage in the region of Saurashtra, Kutch, and North Gujarat. Of the total accumulated capacity of 2200 MCM water in 113 dams existing in the Saurashtra region, only 140 MCM water had been accumulated by 2000. This accumulated water had been reserved exclusively for drinking water supply. Thanks to good rainfall witnessed during the recently-concluded decade, such a situation has not repeated again. Gujarat had been implementing water conservation works earlier including the construction of check dams. Work was earlier carried out either through tendering or departmentally.

Progress was slow with only 2500 check dams constructed up to the year 1999. Of these, 1341 check dams were constructed during 1991–99 under the Government sponsored “Own your check dam” programme. The cost incurred was Rs 55 crore. Even the involvement of NGOs to speed up the progress did not yield results, since the latter work in clusters and in limited areas. After reviewing the aforementioned programmes the State decided upon the Participatory Water Conservation Programme for implementing water conservation across the state (NWRWS 2010).
- **Sardar Patel Participatory Water Conservation Project (SPPWCP)**

  As discussed earlier, the state government took cognisance of the intense awakening fomenting amongst the residents of water scarce regions of the state. This mass awareness complemented with the effort put in by social activiists and NGOs led to the construction of several water conservation projects in these regions. Voluntary contributions from the people supported activities in the context of rainwater harvesting to recharge ground water. This was done with a view to meet drinking water as well as agricultural needs. Taking a cue from such experiences, the government launched SPPWCP which has seen four stages of implementation so far.

  The first phase of the project, which lasted between 17–01–2000 and 20–02–2001, elicited an enthusiastic response from the Saurashtra region. The first monsoon itself witnessed overflows in over 7000 check dams. It led to farmers benefitting immensely from increased crop production. The second phase flagged off on 21-06-2001 with suggestions for improvement was concluded on 31–03–2003. The third phase (from 01–04–2003 to 31–03–2005) was noted for the 40 percent contribution it received from beneficiary farmers. Farmers in tribal areas contributed 20 percent of the total cost of the check dam.

  The fourth phase began on 01–04–2005 with a government contribution of 80 percent and the people's contribution of 20 percent (80:20) across the state. People’s participation enabled the construction of 67929 check dams under SPPWC stage I to IV. Figure 5.2 summarises the comparison of check dam constructions taken up by six different government departments in Gujarat over two different years 2007 and 2011.

  **Figure 5.2:** Construction of check dams by government departments
Source of data: SWDC

The number of check dams completed by the Narmada Kalpsar Department stood at 18,356 in 2000–2001, 49,435 in 2005-06, and 78,922 in 2010–11. Figure 5.3 presents a maximum of 55 percent contribution by NWRWS in the construction of small check dams in 2011, followed by the other five departments.

**Figure 5.3: Small check dam constructions by government department**

Source: SWDC
Check dams have been constructed by the NWRWS department under various schemes including the Sardar Patel Participatory Water Conservation Project (SPPWCP), Salinity Ingress Prevention scheme (SIP), Sujalam Sufalam Yojna, Vanbandhu Kalyan Yojna, SagarKhedu Sarvangi Vikas Yojna etc. Other than the regular check dams, the Water Supply department has also constructed underground check dams as shown in Figure 5.4.

**Figure 5.4:** An underground check dam

![An underground check dam](image)

Courtesy: GWSSB, GOG 2011.
Other than major surface water impounding structures created to augment the total water availability in the state, several water harvesting and conservation methods including check dams have been adopted by different departments of the state government. Table 5.1 gives an idea about the quantum of such structures in the state.

**Table 5.1 Quantum of main recharge structures**

<table>
<thead>
<tr>
<th>Water recharge structures</th>
<th>Total number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Check dams</td>
<td>87,179</td>
</tr>
<tr>
<td>Boribundhs</td>
<td>35379</td>
</tr>
<tr>
<td>Khet talavadi</td>
<td>130262</td>
</tr>
<tr>
<td>Deepened ponds</td>
<td>5551</td>
</tr>
</tbody>
</table>

Source: Gujarat state portal n.d.

A history has been created in water conservation thanks to increased water supply from the Sardar Sarovar Project (SSP), higher investments in check-dams and watersheds by the state in cooperation with communities, NGOs and the private sector coupled with good rainfall over the past decade. All this has led to greater water availability which, in turn, has boosted agricultural and economic growth in the state.

- **The Sardar Sarovar Project (SSP)**

The Narmada is the fifth largest river in India and the largest in Gujarat. It crosses Madhya Pradesh, Maharashtra and Gujarat to meet the Gulf of Cambay. The idea of SSP concretised as the construction of a dam over the Narmada in 1946-47. Sardar Vallabhabhai Patel first conceived this idea as the rationale underlying optimum river water utilisation for the nation’s welfare. The Sardar Sarovar Project, a multi-purpose venture, was formulated by GoG in agreement with commands contained in the Narmada Water Dispute Tribunal (NWDT) Award. The SSP has been a highly contested project in the history of Independent India. It has been at the core of Gujarat’s water security and overall development planning.

The Sardar Sarovar Project (SSP), due to its sheer size and potential to positively transform the water scenario of the state, may be termed as the most crucial response to water-related concerns of the state. The Sardar Sarovar Dam coupled with other complementary measures have the capability of transforming the water sector in Gujarat.

The project aims at providing major benefits of irrigation, hydropower and drinking water supply to the states of Gujarat, Maharashtra, Rajasthan, and Madhya Pradesh.
Table 5.2 Salient features of Sardar Sarovar Project

<table>
<thead>
<tr>
<th><strong>Location</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>State</td>
<td>Gujarat</td>
</tr>
<tr>
<td>District</td>
<td>Narmada</td>
</tr>
<tr>
<td>Taluka</td>
<td>Rajpipla (Nandod)</td>
</tr>
<tr>
<td>River</td>
<td>Narmada</td>
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<table>
<thead>
<tr>
<th><strong>Hydrology</strong></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Watershed area above dam site</td>
<td>88,000 sq. km</td>
</tr>
<tr>
<td>Designed flood</td>
<td>87,000 cumecs</td>
</tr>
<tr>
<td>Full Reservoir Level (FRL)</td>
<td>138.68 m (455 ft)</td>
</tr>
</tbody>
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<tr>
<th><strong>Reservoir</strong></th>
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<tr>
<td>Full Reservoir Level (FWL)</td>
<td>138.68 m (455 ft)</td>
</tr>
<tr>
<td>Maximum Water Level (MWL)</td>
<td>140.21 m (460 ft)</td>
</tr>
<tr>
<td>Gross Storage Capacity</td>
<td>0.95 Million ha m</td>
</tr>
<tr>
<td>Dead Storage Capacity</td>
<td>0.37 Million ha m</td>
</tr>
<tr>
<td>Live Storage Capacity</td>
<td>0.58 Million ha m</td>
</tr>
<tr>
<td>Annual evaporation</td>
<td>0.06 Million ha m</td>
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<td>Submergence at FRL</td>
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<table>
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<tr>
<th><strong>Dam</strong></th>
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<td>Type</td>
<td>Concrete gravity</td>
</tr>
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<td>Length</td>
<td>1210.02 m</td>
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<tr>
<td>Maximum height</td>
<td>163 m</td>
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<tr>
<th><strong>Canal System</strong></th>
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<tbody>
<tr>
<td>Narmada main canal in Gujarat</td>
<td>458 kms</td>
</tr>
<tr>
<td>Narmada main canal in Rajasthan</td>
<td>74 kms</td>
</tr>
<tr>
<td>Full supply level</td>
<td>91.45 m (300 ft)</td>
</tr>
<tr>
<td>Design discharge capacity in head reach</td>
<td>1133 cumecs</td>
</tr>
<tr>
<td>Design discharge capacity at Gujarat-Rajasthan Border</td>
<td>71 cumecs</td>
</tr>
<tr>
<td>Gross Command Area in Gujarat</td>
<td>34.268 lakh ha</td>
</tr>
<tr>
<td>Annual Irrigation</td>
<td>17.92 lakh ha</td>
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<tr>
<th><strong>Canal Distribution System</strong></th>
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</tr>
</thead>
<tbody>
<tr>
<td>No. of branch canals</td>
<td>38</td>
</tr>
<tr>
<td>Length of distribution system network</td>
<td>66,000 kms</td>
</tr>
<tr>
<td>Cultivable command area in Gujarat</td>
<td>18.45 lakh ha</td>
</tr>
<tr>
<td>No. of districts covered in Gujarat</td>
<td>12</td>
</tr>
<tr>
<td>No. of talukas covered in Gujarat</td>
<td>62</td>
</tr>
<tr>
<td>No. of villages covered in Gujarat</td>
<td>3393</td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th><strong>Hydropower</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of power houses</td>
<td>2 (one surface and one underground)</td>
</tr>
<tr>
<td>Power shared among states</td>
<td>MP, Maharashtra and Gujarat (57:37:16)</td>
</tr>
<tr>
<td>Total number of units</td>
<td>11</td>
</tr>
<tr>
<td>Total installed capacity</td>
<td>1450 MW</td>
</tr>
</tbody>
</table>

Source: nvda.nic.in
Figure 5.5 show the main Narmada canal whereas and Figure 5.6 shows the main site of SSP at Kewadia.

**Figure 5.5: Main Narmada Canal**

Source: sardarsarovardam.org
The completion of critical construction work with respect to SSP over the last decade has triggered the flow of Narmada waters into its canals stimulating power generation. Progress made in this context is is summarised in Table 5.3.

Table: 5.3 Current status of the of the Sardar Sarovar Dam

<table>
<thead>
<tr>
<th>Dam</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete work completed</td>
<td>96.43 percent</td>
</tr>
<tr>
<td>Irrigation by pass tunnel</td>
<td>Completed</td>
</tr>
<tr>
<td><strong>Hydropower House</strong></td>
<td></td>
</tr>
<tr>
<td>Canal Head Power House</td>
<td>50.396 million units energy generated</td>
</tr>
<tr>
<td>River Bed Power House</td>
<td>342.17 million units energy generated</td>
</tr>
<tr>
<td>Energy sharing ratio among MP, Maharashtra and Gujarat</td>
<td>57:27:16</td>
</tr>
<tr>
<td><strong>Canal System</strong></td>
<td></td>
</tr>
<tr>
<td>Narmada main canal length</td>
<td>458 kms completed</td>
</tr>
<tr>
<td>Branch canals completed</td>
<td>22 (263 kms from main canal)</td>
</tr>
<tr>
<td>Distributaries</td>
<td>271 completed (out of 376)</td>
</tr>
<tr>
<td><strong>Command Area Development (18.45 lakh ha proposed)</strong></td>
<td></td>
</tr>
<tr>
<td>Minor area development</td>
<td>5.36 lakh ha</td>
</tr>
<tr>
<td>Sub minor area development</td>
<td>3.69 lakh ha</td>
</tr>
<tr>
<td><strong>Drinking water supply</strong></td>
<td></td>
</tr>
<tr>
<td>Areas covered under State Wide Drinking Water Grid</td>
<td>Saurashtra, Kutch and North Gujarat</td>
</tr>
<tr>
<td>Total length completed</td>
<td>1888 kms out of 2700 kms planned</td>
</tr>
<tr>
<td>Number of villages covered</td>
<td>5206 out of 9633 planned</td>
</tr>
<tr>
<td>Number of <em>Pani Samitis</em> formed</td>
<td>450 in 2003–04 to 11649 in 2007–08</td>
</tr>
</tbody>
</table>

Source: Sardar Sarovar Narmada Nigam Limited n.d.
Benefits from SSP

As discussed in the previous sections SSP is a multipurpose project that stands to benefit the people of Gujarat in many ways. Most of its benefits are already being realised in terms of hydropower, drinking water supply, and irrigation and lately through the Sujalam Sufalam canal network, which continues to play an important role in ground water recharge. Some of the major benefits accruing from the projects are discussed as follows:

Irrigation: The proposed benefits were discussed during the initial phase of the project. These had to do with irrigation facilities being shared between the states of Gujarat (18.45 lakh ha), Rajasthan (75000 ha) and Maharashtra (37500 ha). In the case of Gujarat and Rajasthan, the benefits were mainly meant to percolate to drought prone areas and in Maharashtra to the tribal areas.

Drinking water supply: The Narmada Master Plan was envisioned covering 75 percent of the state through a state-wide drinking water grid reaching out to 9633 villages and 131 towns. This was to be jointly executed by the Gujarat Water Supply and Sewage Board (GWSSB) and Gujarat Water Infrastructure Ltd (GWIL) (WASMO n.d.). The Narmada waters flowing from SSP through its main canal are now being utilised to provide drinking water security through this state-wide grid.

Figure: 5.7  A pipeline for transferring the Narmada waters

Intra-village water supply and management is being executed through the institutional mechanism of Pani Samitis to ensure demand driven participatory management of water. It aims at covering the arid parts of Saurashtra and Kutch along with villages affected by salinity and fluoride.
Almost 30000 hectares of land area will be given flood protection in Gujarat. The project also aims to strengthen wildlife conservation by developing wildlife sanctuaries and national parks along the river banks as well as in the Kutch region.

**Other benefits:**

Additional benefits likely to accrue from the project would include fisheries’ development, recreational facilities, industrial water supply, agro-industrial development, forest conservation, increased employment, and tree plantation.

**Solar Energy Harvesting** over SSNL Narmada Canal: Harvesting of solar energy along the Narmada Main canal is one of the initially unforeseen yet important benefits. It also reflects the dynamic thinking of the project planners regarding optimising the benefits of this mega project.

A Re. 17.50 crore plant by the US-based Sun Edison has been projected for an annual generation of 1.6 million units of electricity. It will also conserve nine million litres of water by preventing evaporation. According to GSECL reports trial runs of the plant have indicated 15 percent extra power generation by canal-top solar panels compared to conventional installations. This is because water flowing under the panels kept it relatively cooler. Moreover, even if 10 percent of the 19000 km long SSNL canal network were to be used for this type of project, it had the capacity to generate 2400 MW of clean energy annually. Figure 5.8 shows one such site where such an installation is already done. Projecting the impact of such a project on land acquisition and water conservation, the reports mention, a project of this magnitude would save 11,000 acres of land requirement and two billion litres of water annually. The plant has already recorded 800 kW of peak energy production; Sun Edison has a total installed capacity of 45 MW of solar power in Gujarat.
Sujalam Sufalam Canal Network

Adopted in 2004, the Sujalam Sufalam Canal Network envisages a plan to divert excess water from Narmada canal into nine North Gujarat dams via a network of 100-kilometre long pipelines. It also envisages the construction of, unlined canals across 21 rivers of North Gujarat while building around two lakh farm ponds under the food-for-work scheme. The project is likely to benefit around 2.35 lakh hectares of water scarce regions in North Gujarat by recharging ground water through check dams and farm ponds in the area surrounding the canal’s passage.

A report examining the technical implementation of the Sujalam Sufalam Project submitted to the State Water Resources Department in June 2008 states that the area mainly held as the canal’s beneficiary has been struggling with "recurring drought almost in every three years because of a very high coefficient of variation." Nine dams of the region were filled up only up to "30 per cent of their capacity in the last 10 years." Which means that while reservoirs reserved for drinking water were in existence, there was no water available for irrigation? In that sense, the Sujalam Sufalam canal network, once completed, will address the irrigation needs of the drought prone areas. Salient features of the Sujalam Sufalam Project are summarised in Table 5.4.
Table 5.4  Main features of Sujalm Sufalam Project

<table>
<thead>
<tr>
<th>Feature</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total length of canal</td>
<td>337.535 kms</td>
</tr>
<tr>
<td>Number of rivers crossed</td>
<td>21</td>
</tr>
<tr>
<td>Highway structures approved by Road and Building Department</td>
<td>29</td>
</tr>
<tr>
<td>Number of railway crossings invited</td>
<td>7</td>
</tr>
<tr>
<td>Major Road designs finalised</td>
<td>99</td>
</tr>
<tr>
<td>Project budget</td>
<td>6237 crores</td>
</tr>
<tr>
<td><strong>Work completed (2005)</strong></td>
<td></td>
</tr>
<tr>
<td>Piyaj Dharoi pipeline supplying to Dharoi dam</td>
<td>256 kms</td>
</tr>
<tr>
<td>71 rivers of Saurashtra</td>
<td>Major check dams completed</td>
</tr>
</tbody>
</table>

Source: Narmada Water Resources and Water Supply and Kalpsar Department (NWRWS) n.d.

**Figure 5.9:  Sujalam Sufalam Canal network**

![Sujalam Sufalam Canal network map](image)

Courtesy: WASMO
Other major benefits of this canal network include draught-proofing in districts like Banaskantha, Sabarkantha, Patan, Gandhinagar, Kutch, Surendranagar, Panchmahals and Dahod, where water levels have dropped by 150–180 metres as against 30 metres earlier over the last 20 years. It will also provide irrigation facilities to the farmers of North Gujarat. Other than these two key benefits it will also provide safe domestic water supply to the above-mentioned districts and help address the water-related problems of 4038 villages in these areas.

- **Interlinking of Rivers**
  The National water policy (2002) makes a provision for water surplus regions rerouting water to water deficient areas while engaging in the equitable distribution of available water resources through integrated water resources’ management. These measures are expected to encourage overall development. Optimum water availability should be able to check forced emigration of the rural population to urban areas. The concept of interlinking rivers based on the above premises was implemented by GoG for utilising the large quantum of monsoon flow in South Gujarat flowing to sea. This involved the inter-basin transfer of flood water from Narmada’s main canal to en-route Rivers while also filling, village tanks and ponds with Narmada water (Government of Gujarat 2005).

**Project Status**

So far the following works have been completed under this project.

- *Inter-flow of water from Narmada to 11 rivers of Gujarat* vis Heran, Orsang, Karad, Mahi, Saidak, Mohar, Watrak, Sabarmati, Khari, Rupen and Banas.
- 700 small/large village tanks/ponds being filled by Narmada waters.
- Completing the *Sabarmati-Saraswati link* transmitting water from the main canal of the Dharoi Project to Saraswati River.

Work under progress as part of this project includes:

- *Sujalam-Sufalam spreading channel* (337 kms) expected to divert flood water from Kandana dam to Panchmahals and North Gujarat is under construction. Besides, *21 rivers* will be recharged from this recharge canal. Seven districts, 14 talukas and 508 villages will be benefitted.
- *Narmada Main Canal base pipeline project for North Gujarat*, which will divert 1233 million cubic metres of Narmada flood water to fill reservoirs of North Gujarat namely, Dharoi, Hathmati, Guhai, Mazam, Meshwo, Watrak, Mukteshwar, Sipu, Dantiwada and more than 5000 village tanks.
- *Harnav – Guhai Link, Kadana – Bhadar Link* and *Ukai – Purna Link* are also progressing under the project.

Some of the future works proposed under this project are listed below.
- *Damanganga-Sabarmati-Chorwad Link* aims at diverting surplus water of Damanganga, Par, Tapi and other enroute basins to Sabarmati Basin. It will capture water flowing wastefully into the sea which it will supply for irrigation and drinking purposes to Saurashtra.
- Plan to divert 1 MAF *Narmada flood waters to rivers and dams along the coast of Saurashtra*. The branch canal of Sardar Sarovar will cross 17 rivers.
- Plan to divert 1 MAF *Narmada flood waters to Kutch*.
- *Ukai-Gordha link canal* and *Dev-Sukhi link canal* are other proposed linkages.
- Through the National Water Development Agency (NWDA) GoI plans to link various link canals country-wide. The proposed links would benefit Gujarat by diverting excess waters from other parts of the country.
- *The Sarda-Yamuna-Rajasthan-Sabarmati link canal* would provide irrigation to two lakh hectares of area in Gujarat with 1.32 million acre feet of water.
- *The Par-Tapi-Narmada link*, 402 kms long, will divert annual 1350 million cubic metres of surplus water in the Narmada command area.

**Figure 5.10:** Tapi-Narmada Link Canal

Source: South Asia Network on Dams, Rivers and People (SANDRP) 2012
• *The Damanganga-Sabarmati-Chorwad link canal*, beneficial to Gujarat, has already been accepted by NWDA, as an intra-state link canal (NWRWS 2010)

**Current status:**

Contrary to the commonly-held negative perception regarding the feasibility of such projects, GoG managed to prove that half-a-dozen of their intra-state river linking schemes including Sujalam Sufalam, Sabarmati-Saraswati, and Bhadar-Mahi, has yielded positive results. They have helped to mitigate the scarcity of potable and irrigation water in the arid regions of North and Central Gujarat. While it is generally held that river inter-linking is a costly affair involving huge expenditure during land purchase, yet the Gujarat experience has proved that in the case of water scarce regions/states it merits priority (Expressindia 2009).

• **Kalpsar Project**

The Kalpsar Project also falls in the category of mega projects like SSP. Once completed, it has the potential to transform the economy of Saurashtra and the water scenario around the Gulf of Khambhat (Gulf of Cambay) which extends 200 km from north to south, its width varying from 25 kms at the inner end to 150 kms at the outer mouth.
The Kalpsar Project revolves around the creation of a fresh water reservoir in Gulf of Khambhat for irrigation, domestic and industrial water supply. It is doing so by enclosing an area of 2000 sq. kms of Gulf of Khambat with a dam across the gulf between Bhavnagar and Dahej. This fresh water lake will be filled by diverting the Narmada water from the Bhadbhut barrage.

The construction of a gulf closure dam is expected to store about 10,000 million cubic metres water inflows from the rivers Narmada, Dhadhar, Mahi, Sabarmati and some Saurashtra rivers, accounting for 25 percent of total surface water resources of Gujarat. The dam’s summit will serve as a surface transport link. It will also be deployed for the, development of fisheries and the reclamation of saline land around fresh water reservoir. Table 5.5 summarises the tentative features of the project.
Table 5.5   Key features of proposed Kalpsar Project

<table>
<thead>
<tr>
<th>Feature</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of dam</td>
<td>30 kms approx</td>
</tr>
<tr>
<td>Top width of dam</td>
<td>100 m wide</td>
</tr>
<tr>
<td>Full Reservoir Level</td>
<td>(+) 3.0 m</td>
</tr>
<tr>
<td>Live Storage</td>
<td>10500 MCM</td>
</tr>
<tr>
<td>Reservoir spread at FRL</td>
<td>2000 sq kms</td>
</tr>
<tr>
<td>Rivers debouching in reservoir</td>
<td>Sabarmati, Mahi, Dhadhar, Narmada, Limdi</td>
</tr>
<tr>
<td></td>
<td>Bhogavo, Sukhbadar, Utavali, Keri and Vagad</td>
</tr>
<tr>
<td>Expected life of reservoir</td>
<td>500 years</td>
</tr>
<tr>
<td>Construction period</td>
<td>5-7 years</td>
</tr>
</tbody>
</table>

Source: KALPASAR n.d.

The Kalpasar project is expected to be the world’s highest man-made fresh water reservoir in the sea, giving priority to irrigation and drinking water for Saurashtra and the Central Gujarat region. Six districts and 39 talukas of Saurashtra will get irrigation benefits.

Table 5.6   Benefits envisioned from Kalpsar Projects

<table>
<thead>
<tr>
<th>Category</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrigation</td>
<td></td>
</tr>
<tr>
<td>Water envisaged</td>
<td>6558 MCM</td>
</tr>
<tr>
<td>Irrigation area</td>
<td>10.54 lakh ha</td>
</tr>
<tr>
<td>No. of Canal system</td>
<td>3</td>
</tr>
<tr>
<td>Dam rejuvenation</td>
<td>60</td>
</tr>
<tr>
<td>Land Improvement</td>
<td>700000 ha</td>
</tr>
<tr>
<td>Extra land to be recovered</td>
<td>150000–200000 ha</td>
</tr>
<tr>
<td>Transportation (reduction in distance)</td>
<td></td>
</tr>
<tr>
<td>Bhavnagar - Dahej</td>
<td>100km</td>
</tr>
<tr>
<td>Bhavnagar – South Gujarat</td>
<td>150 km</td>
</tr>
<tr>
<td>Port Development</td>
<td></td>
</tr>
<tr>
<td>Bhavnagar port</td>
<td>To be revived</td>
</tr>
<tr>
<td>Dahej port</td>
<td>To remain out of proposed reservoir</td>
</tr>
<tr>
<td>New ports</td>
<td>To be developed on downstream of proposed reservoir</td>
</tr>
</tbody>
</table>

Source: KALPASAR n.d.

Once complete, this project will also facilitate the generation of renewable energy in the form of wind and solar energy, which will be used for transporting water from the reservoir to the canal. Once the port develops travel distance would be greatly reduced which, in turn, would help save time and fuel. The project proposes to reduce soil salinity and convert the coastal saline ground water of Saurashtra and Central Gujarat to fresh water. Both the Bhavnagar and Saurashtra regions will benefit from world class industrial estates like Dahej and Dholera.

Current Status:

Over Rs 60 crores have already been spent on the Kalpsar Project over the last 17 years on feasibility and assessment studies. The project has yet to get an environmental clearance. The state government’s plan to
build a barrage between Zanor and Bhadbhut (Bharuch district) to divert Narmada waters into Kalpsar dam has not justified the adverse impact it will cause to the livelihood of fishing communities living in the 17 villages of this area. The Government claims to complete the project in the next 5-7 years once all the assessment studies are over.

**Figure 5.12: Ports around the gulf of Khambhat**

![Ports around the Gulf of Khambhat](image)

Source: KALPASAR n.d.

- **Jyotigram Yojana - A Regulatory mechanism**

  Before 2003 Gujarat’s villages were faced with inconsistent electricity supply ranging between eight to twelve hours a day. The traditional system of power supply consisted of one common feeder of 11 KV catering to all the three sectors: domestic, industrial, and agricultural.

  A technical solution for providing uninterrupted power to domestic consumers and controlled supply to agricultural consumers through separate distribution infrastructure is under implementation through Jyotigram yojna. It required creation of a parallel infrastructure with about Rs.1115 crore capital investment, which includes erection of 11/22 KV lines in rural area in order to bring down transmission and distribution losses, erection of transformer centres and providing meter on village distribution transformer centres (Panda et al 2006).

  The scheme was made functional all over the state by 2006, electrifying 18065 villages and around 9700 hamlets. It took two-and-a half years, from October 2004 to March 2006, to implement the 1290-crore scheme fully, out of which 1115 crores came as a grant from GoG. The average expenditure per village was Rs. 6.72 lakhs (Energy and Petrochemicals Department n.d.).
Separate feeders provide a three-phased, eight hours a day, 440 volt uninterrupted power to agriculture while providing a single phased, 24 hours a day power to the domestic and industrial sectors. Also, in places where homes and farms exist together, a ‘switch over’ feeder (SDT) has been installed to change over from agricultural to domestic supply. Apart from resolving the power supply issue in the state, this scheme has also brought in agricultural reform through many of its socio-economic benefits.

- **Jal Sanchay Abhiyan**
  The state government implemented through this campaign an integrated scheme of Rs 1500 crores. The scheme encourages farmers to adopt micro irrigation/drip/sprinkler irrigation systems. The Gujarat Green Revolution Company Limited has been established to ensure its implementation in water scarce regions of Gujarat. The scheme also promotes the usage of bio fertilisers, manures, and anti-fungus medicines for better agricultural output. The scheme received very good response from farmers who have implemented it (GoG 2005).

- **Participatory Irrigation Management (PIM)**
  Gujarat introduced its Participatory Irrigation Management (PIM) to cover the state’s command area of irrigation projects. The aim was to involve farmers in the overall improvement of the irrigation system. The state has proposed transferring O&M responsibilities to WUAs at distributaries or minor levels (ADB 2010; GoG 2005).

  According to the Gujarat state portal website PIM has been successfully introduced in about one lakh hectares of land even though the legislation for PIM is yet to become operational. It also reports that most of the command of major projects like Dharoi, Guhai, Mazam etc in North Gujarat region is covered under this scheme (GoG 2005).

  The GoG passed the Gujarat Water Users’ Participatory Irrigation Management Bill in 2007 authorising the farmers to constitute Water Users' Associations (WUA) for the management of canals handed over to them, after rehabilitation by the Government (Gujarat state portal n.d.) The table 5.7 shows projections of PIM program in Gujarat.
Table 5.7  Projection for PIM programme in Gujarat

<table>
<thead>
<tr>
<th>Year</th>
<th>Area proposed to be handed over (Ha.) by</th>
<th>Total Area Proposed to be handed over (Ha.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Water Resources Department</td>
<td>Narmada Department</td>
</tr>
<tr>
<td>2010–11</td>
<td>110000</td>
<td>0</td>
</tr>
<tr>
<td>2011–12</td>
<td>115000</td>
<td>0</td>
</tr>
<tr>
<td>2012–13</td>
<td>115000</td>
<td>200000</td>
</tr>
<tr>
<td>2013–14</td>
<td>115000</td>
<td>250000</td>
</tr>
<tr>
<td>2014–15</td>
<td>120000</td>
<td>220000</td>
</tr>
<tr>
<td>2015–16</td>
<td>120000</td>
<td>350000</td>
</tr>
<tr>
<td>2016–17</td>
<td>120000</td>
<td>300000</td>
</tr>
<tr>
<td>2017–18</td>
<td>120000</td>
<td>245000</td>
</tr>
<tr>
<td>2018–19</td>
<td>120000</td>
<td>228000</td>
</tr>
<tr>
<td>2019–20</td>
<td>120000</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>1175000</td>
<td>1793000</td>
</tr>
</tbody>
</table>

Source: NWRWS 2010.

The Mid Term Appraisal by the Planning Commission appreciates the efforts of Gujarat and the state is keen to further popularise this concept in order to improve water use efficiency (GoG 2005).

- **Green Solar Building**
  Justifying the saying ‘Charity begins at Home’, GoG has taken the initiative of promoting green buildings in Gujarat. The Gujarat Pollution Control Board (GPCB) has recently come up with its first solar building as its new Head Office in Gandhinagar. The 80 kW energy generated by 100 percent usage of solar energy has been able to meet much of the building’s power requirement. For water conservation purposes, the building has two recharge wells with about 750 cubic metres of rain water harvested to ground water aquifers per season/year (GPCB 2011).
The Rajkot Municipal Corporation (RMC) in June 2010 decided to give tax incentives to people using solar heaters for water harvesting in their residential and commercial buildings. This initiative was taken to promote renewable energy in the state. Rajkot was also declared a solar city during the 11th plan of GoI (WBCSD 2012).

In addition, the Standing Committee of RMC has approved a sum of Rs 25 crores for implementing the construction of a feeder line from Nyari dam to Aji dam to address water scarcity in Rajkot. The presence of a large number of check dams over the Aji River causing regular water overflows has necessitated the completion of the feeder line over the next year and a half (Times of India, 2010).

**WASMO: A Special Purpose Vehicle**

Water and Sanitation Management Organisation (WASMO) is a special purpose vehicle of the state government and an autonomous organisation set up in May 2002. It was created to promote a demand-driven, decentralised, community-managed water supply programme in the villages of Gujarat through a mission mode. The major thrust behind the creation of this organisation was to bring about a paradigm shift in the role of the government- from a provider to that of a facilitator. It also aims at the citizens’ engagement at the user level in rural areas of the state.

WASMO has taken initiative at village-level for the construction and maintenance of underground pumps, storage reservoirs, stand-posts, pipelines, cattle troughs, tube wells and open wells, rainwater harvesting structures etc. with the help of local knowledge.

The GoG planned to cover 75 percent of the population through a state-wide water grid by 2010. This was to be done transporting the Narmada waters through a state-wide network of pipelines, storage tanks, storage reservoirs and treatment plants. The state-wide drinking water grid has enabled higher drinking water security, drought proofing, and sustainability. GWSSB and Gujarat Water Infrastructure Limited (GWIL) supported WASMO in terms of maintaining equitable water availability in all the regions of Gujarat via bulk transfer from Sardar Sarovar canals and the establishment of water treatment plants.

Guaranteeing the implementation of community-based water and sanitation programs, WASMO has acted as a common platform between coordination monitoring and support units (CMSUs), engineering support cells (ESCs), and implementation support agencies and Pani Samities.

The Gujarat government has taken its water resources to people’s doorsteps right down to the village level thanks to WASMO’s participatory distribution system which happens to be an UNO award winning initiative of Gujarat (WASMO n.d.).

WASMO has not only kept community participation central to its activities but has also succeeded in addressing the special need villages and gender concerns. In Dadampur village of
Abdasa taluka of Kutch district, for example, WASMO has installed, supported by the local community, a 640 WP solar PV and a submersible pump of 0.75 HP, with a discharge capacity of 20000 liters. This was done with a view to fulfill the daily water requirement of 5000 liters in summers. The Implementation Support Agencies (ISAs) training to villagers has helped them maintain the smooth operation of the solar water pump, ensuring consistent water supply during the months of erratic rainfall. With respect to gender concerns, WASMO has ensured involvement of women in their projects identifying them as the key users and managers of water.
WASMO has been conferred the 2010 CAPAM International Innovations Award under the category ‘Innovations in Citizen Engagement and Dialogue’. Earlier on, WASMO won the prestigious United Nations Public Service Award (June 2009) and the Prime Minister’s Award for Excellence in Public Administration in April 2008 (Courtesy WASMO).

5.3 Water Pollution Mitigation

Development gives way to development hazards. Gujarat is acclaimed for its economic growth of the past decade, particularly in the area of industrialisation and agricultural production. This has led to rapid urbanisation creating severe pressure on natural resources like land, water, and climatic elements. Pollution of air, water, land and noise continues to pose a great challenge to all those responsible for good governance in the state. Although the state government and its various arms have been actively engaged in addressing these challenges and finding suitable responses, Gujarat needs to walk that extra mile required of a developed country, particularly while dealing with pollution hazards for a liveable world.

Just as good quality water is central to the survival of all living beings, so is economic development important to sustenance. Water is central to both entities and also necessary for the
health of ecosystems. Along with rapid growth, Gujarat needs to protect its fragile environment. The best part of the story is that the leadership of the state is very conscious of this fact.

Gujarat has formed a group of eminent experts under the chairmanship of R. K Pachauri to supervise climate change in Gujarat and orient its officers who can then adopt suitable measures to address environmental concerns. This was done with an objective to transform the cities of Gujarat into green cities. This eco-drive, recognised by the Government of India, adjudged the state as the first green state of India on December 12, 2009. As mentioned earlier in this report, Gujarat is the only state which has a Climate Change department in all of Asia. What we need in this context is not only government responses but also the greening of life styles instigating social change in the consumerist culture. If Gujarat wants to be a green state, it will also require green culture, which is a greater challenge (Sheth & Mallik 2012). In this context, various responses to water pollution in Gujarat are discussed in the following sections.

5.3.1 Government Responses

There has been very encouraging response from the government’s side as far as monitoring the state’s water quality and pollution levels in different water bodies is concerned. Key institutions including the Gujarat Pollution Control Board (GPCB), Ground Water Resources Development Corporation (GWRDC), State Water Data Centre (SDWC), Gujarat Water Supply and Sewerage Board (GWSSB), WASMO, Coastal Salinity Prevention Cell (CSPC), Salinity Ingress Prevention Circle (SIPC) etc. have done commendable work towards collecting water quality data and mitigating water pollution in Gujarat. The CSPC and SIPC have worked exclusively towards resolving coastal water quality problems.

The GWSSB has worked towards providing safe drinking water to the state by setting up filtration, chlorination and treatment plants. It has also managed and implemented with success regional water supply schemes ensuring distribution up to the village level. The figure 5.15 shows a treatment plant set up by GWSSB.
Common Effluent Treatment Plants (CETP)

The concept of CETPs was introduced in the early 1990s to enable efficient treatment of waste water. CETPs have reduced the burden of construction and maintenance of effluent treatment plants on individual industries. Gujarat has 28 operational CETPs located in the districts of Ahmedabad, Vadodara, Bharuch, Surat, Valsad, Junagadh, Rajkot and Gandhinagar. The total capacity of these 28 CETPs accounts for 496.75 MLD. Six CETPs with a cumulative capacity of 210.04 MLD have been proposed in the districts of Surat, Jamnagar, Rajkot, Junagadh, Ahmadabad and Valsad (GPCB, 2011).

Sewage Treatment Plants (STPs) and Oxidation Ponds

The State State constituted an autonomous company, the Gujarat Infrastructure Company Limited (GICL) in a bid to combat the magnitude of sewage water, murky fallout of rapid urbanisation since the 1970s. The idea was to collect, treat and dispose sewage properly. GICL has facilitated the technical support of all urban local bodies in Gujarat for establishing STPs and municipal sewage water disposal facilities. The state has 43 operational STPs operated by different Municipal Corporations and Nagarpalikas. These are located in the districts of Ahmedabad, Vadodra, Rajkot, Surat, Anand, Gandhinagar, Bhavnagar, Valsad, Bharuch, Kutch and Kheda. Under installation are 17 STPs. The total numbers of 28 Oxidation Ponds are mostly
operated by various Nagarpalikas (GPCB, 2011). These numbers are far less than the actual requirement.

- **Environmental projects**

Key institutions like GPCB, GWRDC, NWRWS have been monitoring water quality parameters for many decades under various projects. Water Pollution monitoring and analysis of rivers, estuaries, ground water, lakes/talavs, wells, sea water, dams and reservoirs are being conducted by GPCB under the National Water Quality Monitoring Programmes (NWQMP). The main projects under the latter are GEMS (Global Environmental Monitoring System), MINARS (Monitoring of Indian National Aquatic Resources System), Water Quality Project, Kalpsar Project, Coastal Monitoring and Festival Monitoring. These are being funded by MoEF, CPCB, DoEF and other departments of Government. The GEMS project has been focusing on the monitoring of major rivers of Gujarat like Narmada, Tapi, Mahi and Sabarmati. Under the MINARS and Water Quality project, assessment of various minor rivers, other surface water bodies and ground water is being carried out.

In order to assess industrial and domestic pollution in coastal waters, the GPCB has identified 41 locations on coastline to be monitored monthly in 2010–11. Gujarat is one of the states in which cultural and religious festivals are celebrated with a lot of fanfare leading to severe pollution. During major festivals like Navratri, Diwali and Ganesh Utsav the pollution content in air and water is known to rise phenomenally. The monitoring of river bodies to study the environmental impact of Ganesh Utsav has, thus, been set in motion in the state by the GPCB.

A total of 158 urban local bodies (93 percent) in the State had not formed any sewage treatment plant (CAG 2011) and were discharging their domestic waste directly into surface and ground water bodies, on open lands and even into oxidation ponds.

- **E-governance**

E-governance has emerged as an innovation to bring about a paradigm shift in environmental management. The GPCB has used this medium to spread awareness about pollution control and management amongst citizens, businessmen, entrepreneurs, and government officials. Services include information spread to end users through bulk SMSes, monitoring of public actions and complaints, hospitals for various contingencies, generation of waste inventory etc. (Gujarat Pollution Control Board 2011).

**5.3.2 Civil Society and Industrial Response**

- **Solar powered aerator to mitigate pollution:**

A mobile solar aerator was installed at Gotri Lake in Vadodara in October 2011. This was done with the intention of reviving the health and aquatic biota of the lake by amplifying the presence of its dissolved oxygen. The aerator was developed by the Vallabh Vidyanagar-based Sardar
Patel University. The Vadodara Municipal Corporation plans to install a similar aerator in the highly polluted Sursagar Lake in the city (Times of India 2011).

- **Bio-remediation:**

TERI in New Delhi undertook the bio-remediation of 1500 tonnes of oil-contaminated soil at South Santhal CTF, ONGC, Mehsana Asset in May 2006. Oil zappers and specific nutrients were applied to the contaminated sites. After 135 days of application, biodegradation was discernible between 90.98 percent and 92.08 percent while the concentration of heavy metals was well within permissible limits.

- **Treatment and disposal of industrial waste water:**

The Green Environment Services Co-operative Society Limited (GESCSL) and Vatva Industries Association jointly spent Rs 100 crores to set up environmental infrastructure for collection, treatment, and disposal of industrial effluents in the estate of Vatva with 680 industrial units’ member in May 1998. The treatment capacity with regard to effluents per day is 16000 cubic metres. Internal collection system, CETP integrated with electro-oxidation system has treated a large proportion of non-biodegradable organic pollutants present in the industrial effluents.

To ensure the safe disposal of solid waste generated by 1200 industrial units the Common Secured Landfill Facility (SLF) with a capacity of 1100000 metric tonnes was also established. It won the Golden Peacock Environment Management Award in 2008 and, later, in 2010.

- **Vapi industrial pollution mitigation:**

In 2010 MoEF imposed a temporary moratorium on the highly polluted industrial estate of Vapi GIDC with a CEPI (comprehensive environmental pollution index) of 88.09. Water CEPI was 74.5 indicating the critical condition).

In response, GIDC prepared an action plan to start third party monitoring of industries and CETP by the academic institute-SVNIT, created a vigilance office of GPCB for the South Gujarat Region, put in place strict actions against defaulting units and developed an industry-wise plan to upgrade EMS.

The Vapi Waste and Effluent Management Company Limited (VWEMCL), which was then government operated, had commissioned an anaerobic treatment system to check inlet COD norms. It diverted its domestic effluents from Bil Khadi to CETP for further treatment while pipelines were upgraded to monitor marine outflow of pH, DO and TOC of CETP. Two unauthorised hazardous waste dumping sites were also cleared at the same time. These initiatives led to the moratorium imposed by the MoEF, GoI being lifted later.
• **Zydus SEZ CETP:**

An SEZ exclusively for Pharmaceutical companies called PHARMEZ. PHARMEZ was provided with a CETP to treat industrial effluents from member units through tankers after the removal of suspended solids through primary treatment. The CETP included conventional physiochemical treatment, a sludge-handling system, and a Reverse Osmosis and Multi Effect Evaporator for TDS removal (GPCB 2011).

### 5.4 Coastal Salinity Mitigation

Gujarat has the longest coastline of 1600 kms in India, covering around 1500 villages. Rapid salinity ingress has been observed along the coastal belt over the last two decades. This has affected ground water aquifers adversely. It is ironical that the entire coast had a fresh water regime until the end of the 1960s (CSPC n.d.).

The salinity ingress and subsequent degradation of water quality became visible only after the 1960s due to an imbalance between sweet inland water and saline seawater. This imbalance was mainly caused by the over drafting of ground water instigated by heavy electrical pumps, complex geological conditions, erratic rainfall, destruction of mangroves and other vegetation, low availability of fresh water due to the number of dams along the major rivers, cultivation of high water-intensive crops like sugarcane, banana, and betel, rapid industrialisation and urbanisation. All this led to ground water overdraft and indiscriminate disposal of waste water and sewage. In addition, the coastal plains are evaded by the 1600-kilometre long coastline of Gujarat dotted with innumerable creeks and estuaries up to 4-6 kms inside, causing salinity ingress. All this has had severe implications for the water sector in these areas calling for well-calibrated responses to address water salinity and allied issues.

The following sections explain various responses to water salinity in Gujarat. It would be interesting to see how government and other stakeholders respond to such an important issue central to not only public health but also to the region’s economy, ecology and climate.

### 5.4.1 Government Responses

• **Salinity Ingress Prevention Cell (SIPC)**

The SIPC of the Water Resources Department in the state has constructed many tidal regulator structures and *bandharas* to mitigate sea water intrusion along Gujarat’s coastline. To promote sustainable agricultural practices activities like horticulture plantation, cattle camp, exposure visits, vermin composting and demonstration of high yield variety crop have been set in motion
around the command areas of two existing Bandharas, namely, Khada and Bhogat in the Khajudra village of Una taluka and the Bhogat village of Kalyanpur talukas.

The SIPC has also made a huge financial investment in developing water harvesting structures with a huge potential for lift irrigation. These structures have helped reduce ground water draft and decrease, at the same time, further salinity ingress. A Participatory Irrigation Management (PIM) was implemented in the Medha Creek for water and land productivity (CSPC 2011).

A salinity ingress prevention study was taken up by SIPC in 2009 in the Una-Madhavpur stretch of the Saurashtra coastline. Brief details of this study are given below.

Table 5.8 Construction of tidal regulator structures and bandharas as response

<table>
<thead>
<tr>
<th>Particulars</th>
<th>HLC-I Area</th>
<th>HLC-II Area</th>
<th>Total completed structures (HLC I &amp; II)</th>
<th>Benefited area Direct/Indirect in Ha.</th>
<th>Storage Capacity in Mcum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tidal Regulators</td>
<td>6</td>
<td>6</td>
<td>12</td>
<td>17170</td>
<td>174.815</td>
</tr>
<tr>
<td>Bandharas</td>
<td>12</td>
<td>14</td>
<td>26</td>
<td>13717</td>
<td>65.23</td>
</tr>
<tr>
<td>Recharge Reservoirs</td>
<td>2</td>
<td>11</td>
<td>13</td>
<td>6790</td>
<td>45.05</td>
</tr>
<tr>
<td>Check dam</td>
<td>181</td>
<td>468</td>
<td>649</td>
<td>7435</td>
<td>22.96</td>
</tr>
<tr>
<td>Recharge Tanks</td>
<td>5</td>
<td>13</td>
<td>18</td>
<td>1993</td>
<td>1.32</td>
</tr>
<tr>
<td>Recharge Wells</td>
<td>198</td>
<td>199</td>
<td>397</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Afforestation (Hectares)</td>
<td>5867</td>
<td>0</td>
<td>5867</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Nala Plugs</td>
<td>4487</td>
<td>0</td>
<td>4487</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Courtesy: SIPC

The coastal region of Saurashtra stretching from Una to Madhavpur comprises part of the Junagadh district. This coastal stretch is 160 kms long with salinity affected villages numbering at 120. This is fertile agricultural land which came to be adversely affected by sea water ingress into coastal aquifers at shallow depths subsequent to the introduction of oil engines in the coastal areas in the 60s and electric motors in the early 70s. As a result, by the 1970s, good cultivable land was rendered useless while the wells became unsuitable for irrigation and drinking purposes. The State appointed its first High Level Committee (HLC-I) for this coastal reach and, according to its report submitted in 1978, about 1, 00,000 Ha of coastal land between Una-Madhavpur had already been affected by 1977 (SIPC n.d.).

The State started implementing various salinity control and recharge measures recommended by the HLC-I, viz. construction of salinity control structures like tidal regulators and Bandharas.
located along the coast and recharge structures like check dams, recharge reservoirs, recharge wells, recharge tanks located inland along the rivers, local streams etc. In addition to the construction of Nala plugs in the upper reaches of the area, afforestation works were also undertaken near the coast, initially, by the Gujarat State Land Development Corporation & the State Forest Department as per funds provided by the Salinity Ingress Prevention Circle, Rajkot (SIPC n.d.).

However Table 5.9 shows salinity ingress in certain areas has reduced considerably due to corrective measures taken by the government, NGOs, communities and favorable rainfall intensity during last decade. Figure 5.15 represents some of the salinity control impounding structures implemented in Gujarat.

**Table 5.9 : Extent of Salinity Ingress in HLC-I Talukas**

<table>
<thead>
<tr>
<th>Taluka</th>
<th>1990</th>
<th>2000</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mangrol</td>
<td>6</td>
<td>8.25</td>
<td>5.27</td>
</tr>
<tr>
<td>Malia (H)</td>
<td>4.75</td>
<td>6.87</td>
<td>5.7</td>
</tr>
<tr>
<td>Veraval</td>
<td>7.5</td>
<td>9.37</td>
<td>3.69</td>
</tr>
<tr>
<td>Kodinar</td>
<td>9.6</td>
<td>6.83</td>
<td>5.21</td>
</tr>
<tr>
<td>Una</td>
<td>7.2</td>
<td>7.75</td>
<td>5.42</td>
</tr>
</tbody>
</table>

Source: Salinity Ingress Prevention Cell (SIPC) 2012.
Figure 5.15: A Reclamation Bund by SIPC

Courtesy: SIPC

Figure 5.16: Tidal Regulators for salinity control

Courtesy: SIPC
The dissemination of river channels to recharge ground water enabling sweet water storage in the coastal area was proposed under a scheme. Out of the 360-kilometre proposed length, 125 kms have been completed benefitting 17529 hectares of land. Thanks to work on salinity control irrigation potential was created in more than 64634 hectares of land. An average rise from 3.06 metres to 7.72 metres was observed in the HLC 1 region in 2009 compared to 1988. Ground water saw an overall improvement in 11.84 percent of the salinity affected area (Courtesy SIPC).

Figure 5.17: View of a spreading channel

![Image of a spreading channel](ozat-madhuvanti_spreading_channel_year-2010)

Courtesy: SIPC

Non-cooperation between two departments can arrest development (Saline Area Vitalisation Enterprise Ltd. n.d.) as happened between SIPC and the Marine National Park Authority in Jamnagar. Conflicts between these two entities delayed the implementation of major salinity prevention schemes, enhancing salinity ingress in that region.

Other than the SIPC initiatives discussed above, salinity ingress has also been tackled by many other organisations. Some organisational responses are discussed as follows:

- **WASMO**

WASMO has done commendable work in the Kharaghoda village of Dasada taluka of Surendranagar, by installing an RO plant; bore well, a 450000-litre capacity pump, distribution pipelines, pumping machineries, and sanitation units to treat saline water with a TDS value of around 2200. This was done with the help of Pani Samitis and the local community (WASMO n.d.).
• **GEC**

The World Bank aided Integrated Coastal Zone Management Project (ICZMP), which has been identifying multi-disciplinary interventions to arrest the further degradation of sea coast while addressing the concerns of salinity ingress, is an important effort on the part of GECs regarding identifying and implementing interventions necessary for a healthy and sustainable development of the state’s coastline.

• **National Bank for Agriculture and Rural Development (NABARD) and District Rural Development Agency (DRDA)**

The GoI along with NABARD, DRDA, SAVA, and CSPC have launched a centrally sponsored scheme for the artificial recharge of groundwater through dug wells. The overexploited taluka of Porbandar was chosen as the chief location for the implementation of this scheme (CSPC 2011).

5.4.2 Civil Society Responses

Many Non Government Organisations (NGOs) are engaged very constructively in arresting the rise of salinity ingress in Gujarat. Some of the cases are briefly discussed in the following sections but this is by no means an exhaustive coverage of such efforts. These are some representative cases of civil society initiatives to address salinity ingress in Gujarat.

• **Coastal Salinity Prevention Cell (CSPC)**

CSPC is a non-profit company, a joint initiative of the Aga Khan Rural Support Programme (India), Ambuja Cement Foundation, and Sir Ratan Tata Trust. It has worked in the coastal districts of Amreli, Ahmedabad, Anand, Bharuch, Bhavnagar, Jamnagar, Junagadh, Porbandar, Kutch and Rajkot, covering 142,995 households in 450 coastal villages. It is associated with 17 partners including government and non-government departments, research institutions, corporate bodies, and communities.

CSPC has served as a knowledge bank for coastal salinity in Gujarat. It has evolved low cost community-based solutions for groundwater recharge through the construction of check dams, farm ponds, well ceilings, farm bunds, well renovation, percolation wells/tanks, bore wells, and the repairing and deepening of check dams and ponds.

To negate the adverse salinity impact on agriculture along the coastal belt, CSPC promoted the sowing of salinity tolerant crops, horticulture crops, and less water-intensive crops. Partnering with the Gujarat Rural Institute for Socio-economic Reconstruction Vadodara (GRISERV – BAIF), CSPC initiated a project to pilot salinity-tolerant horticultural activity with 65 farmers from the Mithivirdi village of Talaja taluka, Bhavnagar. The aim was to mitigate soil salinity by
sowing salinity-tolerant horticulture plants, vermi composting, and promoting drip and sprinkler irrigation systems.

Ten Roof Rain Water Harvesting Structures (RRWHs) linked with a drip irrigation system was constructed in the Maliya taluka of Rajkot district for the efficient irrigation of horticulture and vegetable plots. RRWHs provided water during both summer and winter, positively affecting income generation (CSPC 2011).

- **Kharash Vistarotthan Yojana (KVY) initiative**

As a nodal agency of Kharash Vistarotthan Yojana (KVY), CSPC has been tackling salinity issues in Gujarat. KVY has developed area-specific models for managing salinity in 120 affected villages of Saurashtra and Kutch since 2002. KVY’s partner organisations - AKRSP, ACF, VRTI, TCSRD, and the VIKAS-Centre for Development etc. have together implemented activities like water and land resource development, drinking water security, non-farm based livelihood development while monitoring other projects of this nature (CSPC 2011).

- **Aga Khan Rural Support (AKRSP) Programme**

The AKRSP has worked to mitigate salinity ingress along the Mangrol coast of Junagadh district covering 427 villages. It has done so by developing replicable models for community-managed economically sustainable drinking water schemes as well as river basin treatment (CSPC 2011). The focus of the programme has been to check salinity ingress. Its activities mainly include the construction of underground storage tanks for drinking water as well as check dams to recharge ground water levels and for direct well recharge.

- **VIKAS-Centre for Development**

This NGO has set up a Salinity Resource Centre to tackle salinity issues using an entrepreneurial model in the Talaja taluka, Bhavnagar. It provides services to various stakeholders. It has conducted studies on the extent, trends and impacts of salinity on the lives of the local populace and has also disseminated this information to villagers (CSPC 2011).

- **Foundation for Ecological Security (FES)**

FES has been working with the concept of developing a people-centric model to control salinity ingress and encouraging livelihood. It has restored six villages across the Khambat taluka in Anand district. The FES has enabled villagers to create a shelter belt to reduce the impact of salt-laden winds and reclaim saline-affected farmlands. FES interventions have led to the construction of many water conservation structures including farm ponds (CSPC 2011).
- **Saurashtra Voluntary Actions (SAVA)**

SAVA, along with the support of CSPC led to Jamnagar adopting the concept of water conservation through farm ponds in 2007. The project exerted a positive social impact through public participation and provision of interest-free loans to farmers in the district. Noticeable benefits of farms ponds included better agricultural risk management, increase in crop productivity, cultivation of Rabi crops, fuel saving during irrigation, control of salinity ingress by curtailing the use of ground water, and increased livestock rearing.

Figure 5.18 shows the significant impact of farm ponds on groundnut production in concerned villages under SAVA.

**Figure 5.18: Economic benefits from Farm Pond construction**

![Economic benefit of farm ponds 2009](source: marketplus knowledge networks pvt ltd and CSPC)

It is evident that farmers with farm ponds harvested better groundnut yields during the 2009 Kharif season than farmers without them. The groundnut yields for focus group farmers were more than twice as high compared to that of the control group farmers in the three villages: Bhatvadiya, Gokalpar and Jodhpur. The yield difference between focus group and control group respondents ranged from approximately 35 percent to 65 percent (vis-à-vis the yields of control group farmers) for the remaining three villages.
• **Ujas Mahila Manch and Vivekanand Research and Training Institute (VRTI)**

The Ujas Mahila Manch and VRTI in Mandvi have jointly promoted fodder banks in coastal areas to reduce fodder insecurity with the help of NGOs. This initiative should help develop dairy institutions and fodder banks in Kutch and Maliya (Rajkot) (SAVE n.d.).

• **Samreth Charitable Trust**

This trust, supported by Aragham, has addressed salinity reduction and drinking water issues in the little Rann of Rapar block of Kutch (SAVE n.d.). Fourteen earthen check dams have benefitted 623 families of 16 villages in Kutch, providing drinking water to people and cattle. Plus, the propagation of Gulmohar plantations in the region has led to reduced water and soil salinity, reducing health hazards. Additionally, 14 water communities have been formed for the maintenance and sustainability of water distribution and structures. Around 10 dug wells were constructed along streams for harnessing clean drinking water, reducing, thereby, the drudgery women undergo while fetching water during dry summers (Samreth Charitable Trust n.d.).

• **INREM Foundation**

Sea water intrusion and overdraft of ground water caused around 1000 coastal villages in Saurashtra and Kutch to register TDS values higher than 1000 ppm (INREM Foundation 2010).

INREM conducted a state-level assessment and developed an action plan by studying health impacts of poor water quality in the coastal areas of Gujarat in 2010. The study compared reasons, health facilities, and treatment costs related to salinity health problems like kidney stones across Kutch, Rajkot, Jamnagar, Porbandar, Junagadh and Bhavnagar. It made several recommendations including the formation of a salinity health mitigation centre to be run by Gram Panchayats. The intervention from government departments, WASMO and NGOs should be promoted to mitigate salinity related health problems by provision of clean drinking water (INREM Foundation 2010).

INREM also carried out an 18-year observation study (1994 to 2011) of the Flouroosis disease in Mehsana district, comparing the prevalence of dental flouroosis between families exposed to water from Dharoi in Gujarat against those weren’t. Some 282 families participated in this study.

Compiling ground water quality issues across India, INREM has set up a list of recommendations for consideration in the 12th Five year plan. These include, mostly, better water quality data centres and the definition of ground water quality standards (Courtesy INREM).
5.4.3 Responses by Industrial Sector

- **Ambuja Cement Foundation (ACF)**

ACF located in Junagadh and promoted by Ambuja Cement Company, has been working towards mitigating salinity issues in the Kodinar and Satrapada talukas of Junagadh district and Jafarabad taluka of Amreli district. With active participation of the local community, it has developed a demand-and-supply water management and agriculture model for efficient water utilisation. (CSPC 2011 and SAVE n.d.).

*Figure 5.19: Salinity prevention work done by ACF*

In Kodinar, the interlinking of water bodies like ponds, percolation tanks, tidal regulators, small streams and rivers was done to mitigate salinity. This innovation rendered the rivers perennial causing the water table to rise in Kodinar by 29 feet. As a result, farmers were able to cultivate up to three crops a year as against the previous record of one crop (SAVE n.d.).

- **Tata Chemicals Society for Rural Development**

Steeped in the philosophy of serving society with science, the Tata Chemicals Society for Rural Development has implemented its Okhamandal Samridhha Gram Pariyojna (OSGP) in 20 salinity-affected villages of Okhamandal taluka. This programme has enhanced the economic returns to farmers via increased agricultural productivity through crop diversification. It has also constructed many water harvesting structures to reduce salinity ingress and ensure drinking water security (CSPC 2011).
- **Ashapura Foundation, Kutch**

The Ashapura Foundation, established in 1960, belongs to one of the largest exporting groups of traded bauxite in the world. It operates in the Kutch region of Gujarat where it has undertaken rural development activities including water harvesting, agriculture development, animal care, education, and the ITI Ashapura Project.

By creating 62 storage tanks, 49 check dams, 47 nala plugs, 5 recharging dams, 44 farm ponds and 1 boribandh, the foundation has generated a water storage capacity of 2600 million litres in Kutch (SAVE n.d.).

- **Sanghi Industries Limited (SIL)**

A corporate company of cement plants and mines, SIL has installed a desalination plant of 55 lakh litres per day capacity in the Abdasa and Lakhpat taluka of Kutch District. Apart from meeting a 35 lakh litre water requirement of its own staff, SIL has been supplying 20 lakh litres per day to GWSSB. High quality water is being supplied to 30 villages of Abdasa/Lakhpat taluka, in a periphery of 40–50 kms. A significant decrease in malaria and cholera disease has been observed in these villages (SAVE n.d.).
CONCLUSIONS
CHAPTER 6

CONCLUSIONS

Gujarat’s microcosmic Indian environment continues to pose multiple challenges to both the users and the managers of its water resources. The water scarce years prior to 2000 were markedly different from the relatively water secure years of the past decade. The former was marred by frequent droughts, water scarcity, and drinking water being supplied through trains and tankers, and conflicts over water in most parts of the state. Water security in the last decade has gone up, relatively speaking, with an assured water supply aiding rapid economic and agriculture growth.

For a long time Gujarat had been faced with the two-pronged challenge of conflicts arising from the demand for consumptive uses of water and drought management. While the water security scenario improved over the last decade, the economic development model adopted by Gujarat and the urban water requirements have the potential to change the patterns of water use as well as the very nature of water.

Gujarat has a total of 50,100 million cubic meters of water that includes surface water, ground water, and the storage capacity of reservoirs (excluding Sardar Sarovar). The surface water resources contribute 38100 million cubic meters while the ground water resources contribute 12000 million cubic meters. Yet the inconsistent distribution of water resources coupled with the state’s topographic factors has led to only partial utilisation of its water potential. The state has come up with various major and minor projects adding to the surface storage capacity of its rivers while enabling ground water recharge in its parched regions.

Watershed development has been implemented in Gujarat since the introduction of the first set of watershed development guidelines in 1995-96. From DPAP to IWMP the focus has shifted from piecemeal solutions to a more integrated approach towards watershed management through GIS-based planning and management of watershed and convergence with other developmental schemes. However, robust grassroots institutions for watershed management are yet to emerge.

Demographic change, urbanisation, industrialisation, water pollution, and the development of rivers and coastlands have led to the disappearance of fresh water ecosystems. The replacement of water bodies by construction sites in the interest of real estate is not only robbing us of aesthetic beauty in our immediate vicinity but also distancing our future generations from nature. Competing demands and conflicting interests amongst stakeholders along with increasing growth rates and increasing water demands have caused inter-sectoral conflicts forcing the governance machinery to change its priorities while designing schemes or allocating water from them.
A 1600-kilometre long coastline dotted by around 549 villages with a population of over a million along with 12 coastal districts have rendered Gujarat vulnerable in the context of water security. Around 1500 villages in these areas have seen rapid salinity ingress over the last two decades, which has adversely affected ground water aquifers and the livelihood of a large number of people. Unabated ground water abstraction and disposal of effluents in the coastal region has been causing the intrusion of saline water into the zone of fresh ground water reducing, thereby, the quality of water supply in coastal Gujarat. Releasing of effluents in the coastal waters only compounds the problem further.

Availability of safe drinking water and drinking water related health hazards remain key concerns for villages in these saline areas. Salinity and poor quality of drinking water are the prime reasons for the prevalence of diseases like fluorosis, and dysentery in these areas. Dam construction across major rivers too, is causing increased salinity ingress in the estuarine areas of the river. However salinity ingress in certain areas has reduced considerably due to corrective measures taken by the government, NGOs, communities and favorable rainfall intensity during last decade. The Gulf of Khambhat, the Gulf of Kutch, and the western coast of southern Gujarat are prone to storm surges; the resultant salinity intrusion in fresh water bodies requires a dynamic system of monitoring and alert.

A phenomenal population leap in key urban centres over the last few decades has put tremendous stress on their water resources and civic infrastructure necessary for sustaining growth. In other words, both the landscape and society are rapidly getting urbanised. Unplanned urbanisation and the resultant concentration of human population in smaller areas are the major causes of water pollution; they also act as stress-agents as far as water resources are concerned. The rapid industrialisation and deployment of urban amenities, not to mention changing life styles almost uniformly across the agro-climatic regions of the state experiencing varying rainfall and water availability, continue to exert tremendous pressure in the form of increasing water demands and the need for pollution control mechanisms while compounding the challenges to the water governance machinery of the state.

Gujarat witnessed increased water availability and a relatively high growth in the agricultural sector over the last decade leading to an increased irrigation demand. Two thirds of the state’s total area (125 lakh hectare) is currently cultivable, which has led to a massive irrigation water demand. Growth in agricultural production over the last decade corresponds well with the net irrigated area which increased to 3528 thousand ha by 2007. The percentage of net ground water irrigated area over the last decade has remained very high ranging from 78.7 to 86.7 percent. The shift to crops like cotton, wheat, sugarcane, rice and increase in the net sown areas of crops like groundnut has added to the agricultural draft. Combating agricultural pollution has added to the already complex water management scenario of the state. Toxic pollution in surface waters warrants an effort to explore the options available to industrial agriculture with its polluting tendencies in order to keep our water sources safe and healthy for sustainable development.
Given the multi-faceted environment of Gujarat, the impact of climate change will further complicate the water availability and quality issues in the state.

The major causes for water pollution in an already water-scarce Gujarat are the industrial effluents, contaminants from agricultural runoff, and ground water mining related salinity ingress. Gujarat’s industrial estates under GIDC, Special Economic Zones (SEZs), Special Investment Regions (SIRs) and the fact that almost 62 percent of its geographical area is under the influence of Delhi Mumbai Industrial Corridor (DMIC) may require an altogether different strategy for water scarce regions of Saurashtra, Kutch and North Gujarat as ground water extraction and pollution issues may exert more pressure on the water resources of these regions.

The Gujarat Pollution Control Board (GPCB) monitors the water quality of major rivers like the Narmada, Tapi, Mahi, and Sabarmati under the GEMS project. In addition, the GPCB monitors 70 sampling stations located along various rivers and lakes under the MINARS project. Both surface and ground water quality are measured under these projects. For the major rivers, only four parameters including pH, dissolved oxygen (DO), biochemical oxygen demand (BOD) and chemical oxygen demand (COD) have been measured. At some monitoring stations in the Ahmedabad, Mehsana and Vadodara districts additional parameters like total dissolved solids (TDS), ammonia nitrate, total kjeldahl nitrogen (TKN), nitrite nitrogen, nitrate nitrogen, total coliform (TC) and fecal coliform (FC) are also being measured. These pollution parameters are also monitored for lakes, reservoirs, hand pumps and well water quality. While the coverage of water quality has been quite good for the entire state yet it’s inconsistent over the time and space, with a highly variable sampling frequency.

Data analysis conducted over selected water pollution parameters for the water bodies of Gujarat over the last two decades suggests an increasing trend in the percentage of observations with BOD below 3 mg/l in the major rivers of Gujarat. This reveals a gradual improvement in water quality with respect to organic pollution. At the same time, however, three locations including the Vasna-Narol Bridge, Vautha village, and Miroli next to the Sabarmati River reveal high values of BOD ranging between 39 and 63, possibly due to the discharge of untreated domestic waste water from the local civic bodies of the state. As far as reservoir water quality is concerned, a good trend has been observed over the last two decades with the maximum percentage of observations falling in the safe category of BOD below 3 mg/l. The highest value of 3.43 mg/l was observed at Aji Dam 2 in Rajkot in 2009. The BOD trend for lakes and talavs in Gujarat shows a critical situation with respect to pollution of these water bodies.

Overall the figure shows a good trend with the percentage of observations decreasing from 1992 to 2010 with respect to permissible levels of COD. Although direct effluent discharge of several water intensive estates into the Kharicut canal, which flows into the Khari River (a tributary of Sabarmati) led to the highest COD of 353 mg/l being recorded in 2010. In 2010–11, COD ranged between 4 and 76 mg/l in the lakes of Gujarat owing to the discharge of industrial effluents. In reservoirs monitored by the GPCB, the trend of COD has been reasonably under control.
An analysis of the data concerning TDS depicts an inconsistent trend of TDS concentration in the lakes and talavs of Gujarat. Aquatic life in these water bodies is non-existent at many places due to regular discarding of garbage in the lake by local people. The TDS trend of water in the monitored reservoirs of Gujarat has existed within safe limits over the last two decades. The TDS trend for well water in Gujarat shows that around 70 percent samples monitored for wells fall within the safe category in all the years except 2010. But the percent sample with TDS crossing the permissible limit of 2000 mg/l increased from 2006 to 2011.

A safe trend has been seen for Total Coliform Bacteria (MPN/100 ml) in the river waters of Vadodara and Kheda over the last five years, from 2005 to 2010. Although, in 2009, a value as high as 350 MPN/100 ml was noted in the Vishwamitri River near the Kalali Railway crossing on Vadsar Bridge Road in Vadodara. This value was reduced to 110 in 2010. The river waters of Sabarmati and Khari in the Ahmedabad and Mehsana districts revealed a dangerous trend of TC concentration over the last five years with values crossing the most critical level of 5000 MPN/100 ml at some monitoring stations. This indicates high degradation of water quality in the river stretches around these locations.

With demands increasing for domestic, irrigation and industrial uses of water, the vast gap between demand and supply has brought the significant role of water as purifying agent in the overall ecosystem sharply into focus. Waste water generation has risen significantly over the last few decades, disposal of untreated domestic and industrial effluents into water bodies being the principle culprit.

Some 158 urban local bodies (93 percent) of the state have yet to launch sewage treatment plants while functional STPs exist in only ten districts. Moreover, only 13 percent of ULBs in the state have been discharging treated sewage water into rivers. Barring Kutch, the ULBs of almost all other districts continue to dispose their sewage into one or the other surface water bodies. Almost 10 municipalities of Gujarat have been found to be guilty of disposing untreated sewage into lakes giving rise to severe implications for the hydrological regime of these water bodies. This has severe implications for public health as well. The trend analysis of five water borne diseases in Gujarat warrants a corrective measure immediately. The number of cases detected for three out of five diseases viz. typhoid, cholera and acute viral hepatitis, has shown an increasing trend over the years 2005 to 2011.

The government and other stakeholders took bold steps towards the augmentation and management of available water in Gujarat in the last decade. The government’s vision of strengthening Jalshakti as part of its overall developmental approach called Panchamrut has had a positive impact on drought-proofing and water harvesting. Its efforts have yielded positive results partly due to favourable climatic conditions. The state witnessed a trend of increasing rainfall in almost all its regions over the last decade, despite many regions being chronically drought prone due to erratic rainfall. Factors like good rainfall, the arrival of Narmada waters, and the massive recharge effort undertaken by communities and the government through the
watershed treatment have all come together to play an important role in the increased water availability, which has improved ground water tables, and increased access to drinking and domestic water in most parts of the state.

A state-wide water supply grid based on Narmada waters, presently in an advanced stage of development, is expected to provide drinking water to 75 percent of the state’s population. According to one estimate this water supply grid has already covered a population of around 3.62 crores in the state.

WASMO as a special purpose vehicle emerged in early 2000 for the implementation of the GoI-supported Swajaldhara scheme. The state government also pitched in with sector reform schemes in selected districts. Kutch, for instance, was covered by the Earthquake Rehabilitation and Reconstruction (ERR) scheme funded by GoI. GWSSB provided the infrastructure for these schemes; their implementation and maintenance was monitored by WASMO at village level. The number of unfit villages has decreased from 2003 to 2010 yet the numbers for 2010 are still a concern. Although drinking water quality remains an issue in some parts, particularly quantitatively, a lot has been achieved in terms of the substantial number of villages covered by WASMO.

Gujarat’s strategy for water security will have to revolve around Narmada waters for a long time. If complemented well with other augmentation efforts like watershed treatments and adoption of water efficient practices water scarcity may become a thing of the past. But the quality issues pertaining to water resources will require suitable responses either for total elimination or for minimising the levels of critical contaminants to acceptable levels.

Water related pressures and the status of resources in the state are linked to the microcosmic Indian environment of Gujarat and human activities in the state. The interplay of these two sets of forces impact the water resources in many ways. Rapid industrialisation requires a strong watch dog in the form of regulatory, always alert and well-equipped regulatory legislations and institutional mechanisms to check water pollution resulting from the inappropriate discharge of effluents into ground water aquifers or surface water bodies like rivers and ponds. A state-wide sound information base or data management systems on key quality parameters are crucial for this purpose.

There is a credible effort on in terms of addressing salinity issues in the state through ICZMP, a comprehensive assessment of affected areas in all the saline blocks as part of HLC-1 and HLC-2 (High Level Committee) covering the entire Saurashtra coastal belt. The state government is earnestly trying to respond to the situation through the Salinity Ingress Prevention Cell (SIPC) along with other NGOs and community efforts. Water management in the state needs to take cognisance of these pressures and challenges while devising their strategies, first, to meet the water demands by augmentation of water. Yet given the context of today, nothing is more important than safeguarding the existing and already-created precious water resources against
pollution of all types. This would not only save us from a range of complexities arising due to poor water quality but also help in saving people’s hard earned money in the public exchequer for better use.

The prime concerns for Gujarat’s water managers seem to be shifting from water augmentation to the redressal and management of the quality of water. There are obvious signs, as the findings of this report suggest along with various other reports on the deteriorating quality of ground water and surface water bodies like rivers, lakes and ponds, that there exists an alarming situation with respect to water pollution. Just as the state has set an example in taking lead to set up Climate Change department probably a model town planning framework to save, develop and conserve our water bodies is need of the hour. In this context, Gujarat needs to look for a paradigmatic change in terms of managing its water holistically to sustain its hard-earned growth momentum.
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Annexure I

List of participants for Stakeholder Consultation for SoWR

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