Chapter 2

Review of Literature
Water of river, Well, Pond etc. if used and managed efficiently will reduce the intensity of drought and Water Scarcity.
Chapter – II: Review of Literature

“Water, water
Everywhere,
But
Not a drop
To drink”

2.1 Introduction of Water as Resource:

From the Rhyme of the Ancient Mariner is perhaps a fitting description of the attitude of many consumers living in urban and rural areas today, who are increasingly looking towards water as a means of meeting some or all of their daily requirements. Looking at the global resources of the world, the total water resources of the earth are estimated to be 1400 million km cube. Out of this, the fresh water available for the human needs is a small fraction of it. This is present in the lakes, rivers, soils and underground aquifers. As fresh water supplies are further stretched to meet the demands of industry, agriculture and an ever-expanding population, the shortage of safe and accessible drinking-water will become a major challenge in many parts of the world. In the wake of several major outbreaks involving food and water, there is a growing concern for the safety and quality of water for consumption. While water is widely available in both industrialised and developing countries, it may represent a significant cost to the consumer. Consumers may have various reasons for purchasing water, such as requirements in Agriculture, Industries and Household purposes.
(Source: www.who.int/water_sanitation_health).
2.2 Agriculture in India:

India continues to be a predominantly agrarian economy with majority of its population depending on agriculture for livelihood. No wonder then that development of India as a nation rests on a sustained development of rural India. The predominantly rural nature of India emphasises the need to bring about sustainable development of the rural areas and its people. A number of conditions determine how much India’s poor share in the country’s growth, but the extent to which the growth stems from the rural economy, particularly agriculture, is the key. However, despite all the efforts over the years, growth in rural India has not kept pace with its urban counterpart. It has been overwhelmingly felt/considered that India’s rural development would essentially require an agriculture-led growth strategy. In short, the rural development strategy for India may perhaps focus along the following lines:

1) Agriculture-led growth as the main area of focus, under which,
some of the key objectives may be:-

a) Attaining and sustaining much higher levels of productivity per hectare.

b) Agricultural extension, research and development and crop diversification.

c) Bringing in larger areas under irrigation so as to reduce dependence on monsoon.

d) Enhanced focus on agricultural exports.

2) Much greater focus on building up rural infrastructure, with specific focus on power, roads, education, communications, health, sanitation and availability of safe drinking water.

In India, agricultural-productivity-led growth occurred in one major historical period, the Green Revolution, dating from 1965-66 to the early 1980s. The Green Revolution was centered on short-stemmed, high-yield wheat, and to a lesser extent paddy rice, with both crops depending on irrigation and intensive application of fertilizer.

The epi-center of the Green Revolution was Punjab and Haryana, and to a lesser extent other states of the North Indian Plains (as far east as Bihar) and southward to Rajasthan, Gujarat, and Maharashtra. High-yielding rice varieties made their impact most powerfully in West Bengal and Tamil Nadu. The introduction of Mexican wheat and Philippines rice hybrids together with higher usage of agricultural inputs and mechanisation resulted in India becoming surplus in food grains production. However, the Green Revolution initiated high rates of growth (pre-1980) in crop production could not be sustained in the last two decades of the 20th century. Growth rates fell from being 3.2 percent during the Green Revolution period to 1.7 percent during the 1980s and the 90s. For the most part, this decline is attributed to the sharp fall in yield growth from 2.6 percent in the 1980s to 1.0 percent in the 1990s. The spectacular growth in agricultural production in Punjab
and Haryana during the Green Revolution is attributed to several natural and man-made factors. Among the natural factors, Roul (2001) suggests the following:

1) Nature’s bounty in fertile alluvial soil of the Indo-Gangetic river systems of northern India.
2) Geographical and geomorphological advantage of perennial Himalayan rivers amenable for multipurpose dams supplying cheap power and water to the canal systems.
3) Topographical advantage to lay canal systems and road networks at considerably lower costs as against those in peninsular India.

The man-made factors, on the other hand included:
   - Consolidation of holdings.
   - Assured irrigation.
   - Rural electrification and supply of cheap power to agriculture.
   - Agricultural research and extension network.
   - Less exploitative agrarian structure.

Following the Green Revolution, high growth occurred in Punjab and Haryana and also to a lesser extent in other states of north India moving southward to Rajasthan, Gujarat and Maharashtra. In a majority of states in India, agriculture is rain-fed and therefore highly vulnerable to drought and climate variability, which can have disastrous economic and health impacts. Climate forecasting, farm income and weather insurance, and improved disaster planning can help reduce these impacts. Available water supplies are often used inefficiently, resulting in soil erosion, nutrient depletion, land degradation, and depletion of water tables. This creates a vicious circle of poverty, land degradation and low productivity. (Roul 2001).
Increased availability of small-scale water management technologies will significantly help small-scale farmers. Community-based watershed development projects have also demonstrated excellent results, but need to be scaled up and should be implemented in the State of Gujarat and elsewhere. Extending irrigation facilities on a much larger scale is vital. Of the 182.7 million hectares (This represents the largest acreage of cropland in the world) of land used for crop cultivation in India, only about 50 million hectares is currently irrigated, leaving the rest to be totally dependent on monsoon rains. Frequent droughts have played havoc amongst the farming community in India.

The main objective of the irrigation system is to distribute adequate water on time and in an equitable manner across various users and areas within the command area. If water is not sufficient, then it is allocated as per the priorities determined by the policy of the state government. With increasing competition and competing claims on water, the irrigation water is being allocated to other users and sectors. Like Power, Industry receive priority over all other users, followed by irrigation and drinking water. (Ballabh and Singh, 1997). Allocation of water within the command area of an irrigation scheme too is determined more by ad-hoc manner than by design. In the absence of regular and timely supply of water, the farmers also respond and make the best efforts to gain and control water as much as they can and thus try to minimise risk arising from uncertainties of delivery inadequacies and timeliness of water supply. (Ballabh et al., 1992).

Public sector irrigation in India is operating at considerable losses. The collection of the total costs on account of water charges have been inadequate to cover the expenses towards the operation and maintenance. The low cost recovery is partly due to under-assessment of the area irrigated by the public irrigation systems.
2.3 Competition and Challenges:

The growing demand for water poses a serious challenge to evolving more effective water polices to sustain growth in irrigated agriculture, promoting efficient allocation of water across competing sectors and users and preventing degradation of resource base without any conflicts. The current water management falls far short of the above expectations. Several case studies demonstrate that present water use patterns in many areas are unsustainable and that the water is becoming scarcer day-by-day and stage is being set for all round competition for capturing the fast depleting water sources.

The rapid increase in the use of water in agriculture, industries and urban township is causing scarcity of water down streams. In the absence of well-defined property rights in river stream flow, surface water sources are de fac’to open access resources and therefore, being over exploited, the riparian doctrine does not promote socially optimum use of water (Ballabhi and Singh, 1997). When a river basin cuts across state boundaries, the upstream state over appropriates water resources leading to inter-state disputes. There are several examples of inter-state disputes over water.

The best example of this is the Cauvery water dispute (Karnataka and Tamil-Nadu) which created dissatisfaction in both the states leading to conflict and riots. Growing scarcity of water and political economy of states often lead to conflict and riots. It also does not take into account regeneration of ecosystem and ground water recharge which often becomes counter productive and a necessity.

Another example to be noted here is, that the Kerala High Court upheld the right of the residents of Lakshadweep Islands against the excessive groundwater pumping by large farmers. (Saleth, 1993).
There are reports that pollution has created acute shortages of drinking water in Tamil Nadu, Gujarat and many other states. This often becomes so bad that people organise precessions and picket the Government offices protesting against the erring industrial units. Increasing water scarcity has led to diversion of water to cities and municipalities from reservoirs constructed for irrigation purposes. As more and more cities are experiencing water shortages and impact of fluoride, the State Governments are making provisions to bring water from long distances through pipelines. The most preferred source for bringing water from long distant sources is a dam constructed to provide irrigation water. For example, between 1976-77 to 1996-97 water allocation from a multipurpose reservoir to the cities varied from a minimum of 7 % to 100 % of the water stored in the reservoir. (Ballabh and Singh, 1997).

As water scarcity problem becomes severe, the local people start agitating and protests and demonstrations become a common phenomena. The most notable example is Coimbatore and Erode districts of Tamil Nadu where district administration had to mediate between water sellers (who were selling water to industrial units and urban centres through tankers) and farmers. Several negotiations had taken place since 1997 when conflict arose for the first time and agreements were signed between water sellers and purchasers (industrial units) and representative of farmers before the District Administration officials, which stood as guarantor. It was decided that no new deep bore wells could be sunk in the area. It has been reported that industry owners violated the agreement, as a result protest and conflict have become common features in the area (Jankarajan, 1999). In many arid and semi arid areas farmers believe that ground water transportation from rural areas to the urban areas and industrial units is the major cause for ground water depletion.

The competition for scarce water also leads to wide scale pilferage. It is quite common that farmers capture canal water and transport it
to non-canal command areas often at the cost of command area farmers. These farmers not only irrigate their own land but also sell it to other farmers at exorbitant prices. Similarly, the farmers also divert drinking water transported through long distance pipelines for irrigation purposes. The irrigation and water supply departments often do not have any control beyond the capture and release of water to the systems. How the water resources get allocated to different sectors and users is determined more by default than by design (Ballabh et al, 1999; Janakrajan, 1997).

The development of water markets has several positive impacts and water is made available to even those who do not have capacity to invest in deep tube wells. However, it has also adverse consequences in terms of sustainability of resources. The discourses on development of water markets in the Indian context have largely ignored the impact of water markets on the sustainability of resource base. Further, competitive deepening makes the distribution of access to ground water increasingly skewed in favour of large, resource rich farmers leaving the small farmers at increasing disadvantage in sharing the benefits of well irrigation (Vaidyanathan, 1999; Shah and Ballabh, 1997). Competitive deepening of wells for irrigation has also adversely affected quantity and quality of drinking water availability in rural areas. As a result, the number of “no sources” villages is steadily increasing over time (Agrawal and Narain, 1997).

Another dimension of development of water markets in the Indian context which is often ignored is that in many areas water markets are not yet fully developed and unequal trading relationship prevails between sellers and buyers which results in the exploitation of buyers not only through the mechanism of price but also through non-price mechanisms (Shah and Ballabh, 1993 & 1997 and Janakrajan, 1997). In several areas, water buyers have to pay compensation through crop share labour which is exploitative. Although the instances of open conflict between such buyers and
sellers are sporadic and infrequent, in many areas purchasers are resentful of their conditions. Often, conflict arises in surface irrigation system due to competing claims made by the farmers and those covered by the basin irrigation systems. (source: Governance Issues in Water Sector by Vishwa Ballabh)

Thus, the existing competition for water and political economy supports urban rich domestic users, industrial units and rich land owners. The loosers are small and marginal farmers, urban poor and people living in remote rural areas who are unable to meet their basic need of even drinking water (Ballabh, 2002 & 2003).

The increasing pollution and lack of proper sewage and effluent treatment further accentuate the problem of water scarcity. According to an estimate, total environmental cost of damage to India’s natural resources is in the order of US $ 9.7 billion annually and substantial portion of it could be attributed to damage to natural water bodies (World Bank, 1995).

The brief review above suggests that the governance in water sector is not able to achieve either preservation and conservation of water bodies and resources or equity and social justice in allocation of water to competing users and claimants. Some of the ills of governance in water sector were sought to be addressed through people’s involvement, and transfer of management of water services. These reforms are quite slow and the agencies which are responsible for bringing changes have hardly any interest in altering the situation (Ballabh, 2002). The responses of NGO’s and civil society organisations have been critical in identifying alternative technologically feasible and institutionally workable solutions. But it has not been able to make a dent on the system dominated by rent seeking, political contestation and anarchy in water management.

Analysing these claims and counter claims within a broad ambit of political contestation and defining politics as the complex and
aggregate of relationship of men in society, especially those relationships involving power and authority, several discernable features are visible on waterfront. First, contestation over water is not at one level but is being articulated and played at different levels; second, at each level of these contestation, there are dominant groups with each one interested in maintaining the status quo and third, although not by design, there seems to be a coalition of dominant groups from one level to another level who are politically motivated.

First of all, the politics of water discourse is dominated by thinking of perceived and projected water scarcity. Once this paradigm is accepted what follows is a discussion of a series of issues pertaining to practical solution of accepted principle such as how to increase supply, what technology to use and to what extent (Jairath, 2003). Connected with this is the political nature of policy formulation and implementation process, policy as contested by the different interest groups at all stages of its existence trying to shape it in particular ways (Mollinga and Bolding, forthcoming). The emphasis on big projects and the plan to connect river systems are the manifestations of this dominant thinking including prescription about how and in what manner peoples’ participation needs to be solicited in water management. The discussion about how and in what way policy is formulated and evolved is generally missing. The need for stakeholder’s participation in policy formulation is recognised and enlisted but their representation is highly questionable.

The allocation of water between the states and upper and lower riparian holders is being negotiated through Water Disputes Tribunal, an institution created under the Inter-state Water Dispute Act (1956). This Act provides for the central government to appoint a tribunal for adjudication of inter state water disputes.
The capability and credibility of this tribunal is apparent from the fact that, apart from delay in resolution of disputes, often implementation of award is not enforced. In fact, in case of Cauvery water dispute procedure has given way to direct negotiation between state governments mediated by the Government of India. This shows that tribunals are not able to resolve disputes. As water scarcity increases such disputes are also likely to increase in the region. Overall, this hydro-politics is constructed around the scarcity of water and management and devolution of power to the people’s institutions is often ignored.

In overall macro-hydropolitics, the capture and creation of water / irrigation becomes part of a grand strategy to mitigate water scarcity. The State of Gujarat not only designs mega projects but also promotes those policies and programmes which help the dominant class of users to capture and control of scarce water. Competition for capture of ground water for irrigation purposes results in steady decline of water table in the State of Gujarat. Conflicting interests among well owners and profit motive promote competitive selling of water (Shah, 1993; Shah and Ballabh, 1997).

Talking at the global level, the average per capita renewable freshwater is nearly 7000 M cube per annum. At present 3240 km cube of water is drawn and used annually for various purposes. For agriculture, it is 70%, for industry it is 25%, and the remaining is for domestic use (GOI, 1999).

2.4 Present Status of Water Resources in Gujarat:

The State of Gujarat is located in the Western region of India between 20 degrees 06 minutes NORTH to 20 degrees 42 minutes NORTH Latitude and 68 degrees 10 minutes EAST to 74 degrees 28 minutes EAST Longitudes. The land resources of Gujarat State are 5.96% of India's total land resources, roughly 2.63% of the country's freshwater resources, whereas it has 4.03% of the
country's population. Thus, the state has less advantage in terms of per capita rainwater availability as compared to other states in the country.

Water is prime and precious natural resource and must for all life on this planet. Water resources are limited in Gujarat state. The state has four district regions namely:

- South and Central Gujarat
- North Gujarat
- Saurashtra
- Kutch

About 95 % of total annual rainfall occurs during few days of monsoon period (June to September) because of South-West (SW) monsoon. The highest is in South Gujarat which is more than 2000 mm, whereas it is only 300 mm to 500 mm in North Gujarat and Saurashtra. It is minimum in the range of 200 to 300 mm in Kutch region. There are total 185 river basins in Gujarat, out of which 17 are in the North, Central and South region, and 71 in Saurashtra and 97 in Kutch region. Quantum of water resources available in South is 71.40 % and 10.60 % in the North and 15.80 % in the Saurashtra and only 2.2 % in the Kutch regions. (Graph 2.0), (Graph 2.1)

**TABLE NO.: 2.1**

**TOTAL WATER RESOURCES OF THE GUJARAT STATE**

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Region</th>
<th>Total Water Resources</th>
<th>Surface Water Resources</th>
<th>Ground Water Resources</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>South Gujarat*</td>
<td>35700</td>
<td>31750</td>
<td>3950</td>
<td>71.40</td>
</tr>
<tr>
<td>2</td>
<td>North Gujarat**</td>
<td>5300</td>
<td>2000</td>
<td>3300</td>
<td>10.60</td>
</tr>
<tr>
<td>3</td>
<td>Saurashtra</td>
<td>7900</td>
<td>3600</td>
<td>4300</td>
<td>15.80</td>
</tr>
<tr>
<td>4</td>
<td>Kutch</td>
<td>1100</td>
<td>0650</td>
<td>0450</td>
<td>2.20</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>50,000</strong></td>
<td><strong>38,000</strong></td>
<td><strong>12,000</strong></td>
<td><strong>100.00</strong></td>
<td></td>
</tr>
</tbody>
</table>

(* = South of Sabarmati River, ** = North of Sabarmati River)
2.4.1 Surface Water Resources of the Gujarat State:

With regard to (Graph 2.2) the surface water of the state, South and Central Gujarat are endowed with all the three large perennial rivers namely Narmada, Tapi and Mahi and smaller ones such as Damanganga. North Gujarat has very few rivers and they are seasonal in nature namely Sabarmati, Banas, Rupen and Saraswati. They carry stream flow during the monsoon period of 3 to 4 months only. The Sabarmati drains in to Gulf of Cambay, while the rest of the rivers drain in to the Little Rann of Kutch. The geographical area of the state is 196 lakh ha, from which the culture area is only 125 lakh ha.

**TABLE NO.: 2.2**

REGION WISE NUMBER OF WATER RESOURCES PROJECTS IN THE GUJARAT STATE

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Region</th>
<th>No. of water resources projects</th>
<th>Live storage capacity of reservoirs (MCM)</th>
<th>% w.r.t. storage capacity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>South Gujarat</td>
<td>29</td>
<td>10,400</td>
<td>69.34</td>
</tr>
<tr>
<td>2</td>
<td>North Gujarat</td>
<td>13</td>
<td>2100</td>
<td>14.00</td>
</tr>
<tr>
<td>3</td>
<td>Saurashtra</td>
<td>121</td>
<td>2250</td>
<td>15.00</td>
</tr>
<tr>
<td>4</td>
<td>Kutch</td>
<td>20</td>
<td>0250</td>
<td>01.66</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>183</td>
<td>15,000</td>
<td>100.00</td>
</tr>
</tbody>
</table>

(Source: GWSSB 2005)

2.4.2 Ground Water (GW) Resources of the Gujarat State:

The GW Resources (Graph. 2.3) of the state are limited to only 1/3 area of the state. (Alluvial area inclusive of sand stones) i.e. Central Gujarat, North Gujarat, Surendranagar district and some parts of Kutch. The state has suffered frequent droughts in last 30 years, the most severe being recorded in the year 1985 to 1988. The worst recorded drought of this century was in the year 1999. As in the
Graph 2.0  Total Quantum of Rainfall in Gujarat by Region (BCM)

S & C Gujarat  North Gujarat  Saurashtra  Kutch

51.951  24.53  36.514  17.21
Graph 2.1 Total Water Resources

- South Gujarat: 71% (Light Blue)
- North Gujarat: 2% (White)
- Saurashtra: 16% (Red)
- Kutch: 11% (Black)

Legend:
- South Gujarat
- North Gujarat
- Saurashtra
- Kutch
Graph 2.2 Surface Water Resources

- 84% South Gujarat
- 35% North Gujarat
- 9% Saurashtra
- 2% Kutch
Graph 2.3  Ground Water Resources

- South Gujarat: 28%
- North Gujarat: 33%
- Saurashtra: 4%
- Kutch: 35%
- Other: 28%
North Gujarat, Saurashtra and Kutch, available water resources are less than the requirements, drought or scarcity occurs at every 2 or 3 years. Drought occurs on an average 62% area of the state. The meteorological department has defined drought as a situation occurring in any area when the annual rainfall is less than 75% of the normal (source: GOI, Ministry of Irrigation and Power, report of the irrigation commission, vol. no. 1 page no. 160). According to Palmer, 1965 drought generally is defined as being meteorological, hydrological, or agricultural. However, the ultimate consequences of droughts have to be placed in the context of the effects on the social and economic activities of a given region. Thus, the climatic attributes of drought also need to be defined in social and economic terms, because it is in these contexts that water management becomes important.

**TABLE NO.: 2.3**

**OCCURRENCE OF THE DROUGHTS IN THE TWO DISTRICTS OF GUJARAT STATE**

<table>
<thead>
<tr>
<th>YEAR</th>
<th>MEHSANA</th>
<th>BANAS KANTHA</th>
</tr>
</thead>
<tbody>
<tr>
<td>1983 - 1984</td>
<td>678</td>
<td>995</td>
</tr>
<tr>
<td>1984 - 1985</td>
<td>172</td>
<td>172</td>
</tr>
<tr>
<td>1985 - 1986</td>
<td>1110</td>
<td>924</td>
</tr>
<tr>
<td>1986 - 1987</td>
<td>1111</td>
<td>1278</td>
</tr>
<tr>
<td>1987 - 1988</td>
<td>1111</td>
<td>1279</td>
</tr>
</tbody>
</table>

(Source: Annual Partner’s Meet 2002, IWMI, R.K. Nagar) (Graph 2.4)

As there is no perennial river in North Gujarat, Saurashtra and Kutch, surface water is not available in sufficient quantity, hence GW is utilised as the main source for agriculture (irrigation), industry and domestic purposes. (Source: Reference Manual for Hydrogeologists, GWSSB - 2005).

Due to the above fact, that the outflow (abstraction / exploitation) is higher then the inflow (recharge) the average depletion in GW level per year is about 3 to 5 m in these regions. The other effect of this can be seen on the withdrawal of the electricity in this region.
Graph 2.4 Droughts in two districts of Gujarat

- Mehsana
- Banaskatha


- 1983-1984: Mehsana 995, Banaskatha 678
- 1984-1985: Mehsana 172, Banaskatha 1110
- 1985-1986: Mehsana 924, Banaskatha 1111
- 1986-1987: Mehsana 1278, Banaskatha 1111
- 1987-1988: Mehsana 1279, Banaskatha 1111

Legend:
- Blue: Banaskatha
- Red: Mehsana
Out of the whole state North Gujarat consumes about 40% of the total power withdrawal of the state in abstracting the GW from more than 300 m depth through Tube Wells. As the abstraction is more than the recharge the ingress of sea water is present in the aquifers and salinity gets increased and the GW gets polluted in the coastal areas of Saurashtra and Kutch. As a result, more water is utilised / consumed through canals for irrigation and hence the problems of water logging and salinity are increased in soil of these areas and the cultivable land is turned in to non-fertile land / areas.

Further, as the Surface Water (SW) and Ground Water (GW) resources of the state become extremely limited it has become imperative to develop the water resources of the state through integrated planning. For equitable distribution of water amongst the state, social justice and resolution of the complex issues / disputes become necessary to be taken into consideration. For above matters, a formulation of general water policy and rules has become necessary and moreover controls have become necessary by taking stringent actions for scientific management and efficient utilisation of water against over exploitation of GW resources in the state. (Source: Reference Manual for Hydrogeologists, GWSSB - 2005).

Mehsana in North Gujarat is an intensively cropped district. There has been a steady increase in the use of GW for irrigation in North Gujarat in general and Mehsana area in particular. As the most villages are not being served by canal network, there are on an average 100 to 150 Deep Tube Wells (DTW) here. The water table is reducing at an alarming rate of 2 columns or 20 feet per annum and the farmers have to lower the columns in a bore wells by that much depth each year. (The GW Recharge Movement in Gujarat - R. K. Nagar, IWMI - Annual Partner’s Meet 2002).
### TABLE NO.: 2.4

**IRRIGATION POTENTIAL OF SURFACE WATER RESOURCES AND GROUND WATER RESOURCES IN THE STATE OF GUJARAT**

<table>
<thead>
<tr>
<th>Type of Resource</th>
<th>Ultimate irrigation potential Lac ha.</th>
<th>Irrigation potential created Lac ha.</th>
<th>Irrigation potential utilised Lac ha.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. Surface Water Resources</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Major &amp; Medium Irrigation Projects (excluding Narmada)</td>
<td>18.66</td>
<td>14.07</td>
<td>12.88</td>
</tr>
<tr>
<td>2. Narmada Project (incl. Conjunctive use of command GW)</td>
<td>17.92</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>3. Minor irrigation scheme</td>
<td>3.48</td>
<td>2.61</td>
<td>1.60</td>
</tr>
<tr>
<td><strong>Total: A</strong></td>
<td><strong>40.06</strong></td>
<td><strong>16.68</strong></td>
<td><strong>14.48</strong></td>
</tr>
<tr>
<td><strong>B. Ground Water Resources</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Govt. Tube wells</td>
<td>4.0</td>
<td>3.03</td>
<td>1.934</td>
</tr>
<tr>
<td>2. Private Tube wells</td>
<td>25.10</td>
<td>17.30</td>
<td>18.38</td>
</tr>
<tr>
<td><strong>Total : B</strong></td>
<td><strong>29.10</strong></td>
<td><strong>20.33</strong></td>
<td><strong>20.314</strong></td>
</tr>
<tr>
<td>Indirect benefit of Check Dams</td>
<td></td>
<td>2.0</td>
<td></td>
</tr>
<tr>
<td><strong>Total through Surface &amp; Ground Water</strong></td>
<td><strong>69.16</strong></td>
<td><strong>39.01</strong></td>
<td><strong>34.79</strong></td>
</tr>
</tbody>
</table>

(* Above figures are up to June 2002)

As far as India is concerned, the national commission on integrated water resources development has estimated that the total renewable freshwater resources are at 1953 km cube, which includes 432 km cube of groundwater. (GOI, 1999).
2.5 Region wise Fresh Water Availability in the State of Gujarat:

**TABLE NO.: 2.5**

**TOTAL FRESHWATER AVAILABILITY IN THE GUJARAT STATE**

<table>
<thead>
<tr>
<th>Name of the Region</th>
<th>Total Freshwater Availability (MCM)</th>
<th>Expected Population in the Year 2001 (million)</th>
<th>Expected per Capita Freshwater Availability in 2001 (M cube per annum)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S &amp; C Gujarat</td>
<td>37926</td>
<td>19.62514</td>
<td>1932</td>
</tr>
<tr>
<td>North Gujarat</td>
<td>6105</td>
<td>14.301765</td>
<td>427</td>
</tr>
<tr>
<td>Saurashtra</td>
<td>9287</td>
<td>12.648321</td>
<td>734</td>
</tr>
<tr>
<td>Kutch</td>
<td>1275</td>
<td>1.456348</td>
<td>875</td>
</tr>
<tr>
<td>Gujarat</td>
<td>54593</td>
<td>48.031574</td>
<td>1137</td>
</tr>
</tbody>
</table>


As per the figure, per capita availability of renewable freshwater in the state of Gujarat for the year 2001 was estimated to be only 1137 M cube per annum. Therefore, according to M. Falkenmark’s criteria, the state can be called “water stressed”. According to this criterion, if the level of annual renewable freshwater supplies falls below 1700 M cube capita, there will be local shortages of water. If it falls below 1000 M cube, water supply begins to hamper health, economic growth and human well being, and if it falls below 500 M cube per annum, then it becomes a primary constraint to human life. (Seckler et al., 1998). If we go by the indicator of physical water scarcity given by M. Falkenmark, then the per capita freshwater available is far below 1700 M cube per annum. The individual figures are also varies greatly. e.g.: in North Gujarat it is only 427 metric cube per capita per annum which is much less as compared to the per capita renewable freshwater availability of 500 M cube per annum, and water scarcity will be a primary
constraint to humans survival for life in this region. And because of this, the areas of North Gujarat are termed as “absolutely water scarce”. While in South and Central Gujarat, it is as high as 1932 metric cube per capita per annum. From this, one can see that almost about 70% (approximately) of the freshwater resources are in South and Central Gujarat. (Source: White Paper on Water in Gujarat, Edition: year 2000, Page: 15 & 16).

2.6 Overall Water Availability and Demand in Year 2010:

As per Gujarat Water Supply & Sewerage Board’s (GWSSB) figure, the supply and demand scenario for the state as a whole estimated water balance in the year 2010 are given below.

<table>
<thead>
<tr>
<th>TABLE NO.: 2.6</th>
</tr>
</thead>
<tbody>
<tr>
<td>WATER AVAILABILITY AND DEMAND IN THE YEAR 2010</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Supply</th>
<th>In MCM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground Water (GW) - Existing exploitation (1991 base)</td>
<td>10416</td>
</tr>
<tr>
<td>Surface Water (SW) - Existing exploitation (1991 base)</td>
<td>9019</td>
</tr>
<tr>
<td>Regulation and Artificial Recharge</td>
<td>6180</td>
</tr>
<tr>
<td>Recycling of sewerage water</td>
<td>710</td>
</tr>
<tr>
<td>GW - Ongoing &amp; Proposed schemes (till 2010)</td>
<td>10524</td>
</tr>
<tr>
<td>SW - Ongoing &amp; Proposed schemes (till 2010)</td>
<td>14191</td>
</tr>
<tr>
<td><strong>Total Supply</strong></td>
<td><strong>51040</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Demand</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic and Industrial use</td>
<td>2010</td>
</tr>
<tr>
<td>Irrigation</td>
<td>49030</td>
</tr>
<tr>
<td><strong>Total Demand</strong></td>
<td><strong>51040</strong></td>
</tr>
</tbody>
</table>

MCM = Million Cubic Meters, (Source. GWSSB, Gandhinagar, Gujarat, 2005)

From the table, one can analyse that to fulfil the demand of water in 2010, we have to recharge GW and to develop SW schemes on urgent and priority basis.
Graph 2.5  Total Freshwater Availability (MCM)

- S & C Gujarat: 70%
- North Gujarat: 11%
- Saurashtra: 17%
- Kutch: 2%

Legend:
- S & C Gujarat
- North Gujarat
- Saurashtra
- Kutch
It is estimated that the natural replenishment of water is 10862 MCM per year and the net availability of GW for exploitation is estimated at 11176 MCM per year. GW in a way plays a significant role to irrigated agriculture in Gujarat, by way of extraction mechanisms like dug wells, dug cum bore wells, tube wells and hand pumps. In North Gujarat mostly dug wells, dug cum bore wells and tube wells are most commonly used for the purpose of irrigation.

**TABLE NO.: 2.7**

**Future Water Requirement in Gujarat by Sector IN (MCM)**

<table>
<thead>
<tr>
<th>Name of the Sector using water</th>
<th>Total Water Requirement in the Year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1997</td>
</tr>
<tr>
<td>Agriculture</td>
<td>25672</td>
</tr>
<tr>
<td>Domestic</td>
<td>1374</td>
</tr>
<tr>
<td>Industrial</td>
<td>448</td>
</tr>
<tr>
<td>Livestock</td>
<td>224</td>
</tr>
<tr>
<td>Total</td>
<td>27616</td>
</tr>
<tr>
<td>% Agriculture</td>
<td>81.57</td>
</tr>
<tr>
<td>Industry</td>
<td>10.14</td>
</tr>
<tr>
<td>Domestic</td>
<td>7.72</td>
</tr>
</tbody>
</table>

From the graph above, it can be seen that, in future the percentage of water used in Agriculture is on top followed by Domestic and then Industrial purposes. Also, future requirement of Livestock is estimated at 284 MCM in 2025. Traditional method of harnessing rain-water and recharging the wells is the only option to think of. Different situations demand varying methods. But ushering in a revolution is not easy when you have to convince people that there is no personal gain involved, conveying a simple message of recharging of their wells or face a desert within three decades, along with a few simple charts of how to recharge the wells. That's how the revolution can be set initially. Most villages also maintain community ponds used by livestock. It is in this context that water management becomes important.
In past, water from bore wells suddenly turned saline after the quake, or due to the drought. Under these circumstances, one must look at the water resources in the state of Gujarat. It will vary from place to place depending upon the rainfall, the run-off and the availability of the surface water and the ground water. The following aspects also add in considering the water resources like the seasonal and regional variations of the rain-fall, variations in topography, vegetation, soil and geology, the presence of the small and large reservoirs which can lead to major imbalances in the availability of water in the different regions and in different seasons across the whole state. As the rate of the rainfall is very low, and owing to steep terrain which causes speedy run-off and arid climatic condition of the state and hard rock formations underlying most parts of the districts of Gujarat there is increasing salinity of the area day-by-day. The Rann of Kutch and the little Rann of Kutch have very limited surface water and ground water resources. As far as Saurashtra is concerned, it has medium rainfall but with high intensity of spells, radial drainage, heavy and medium black soil that allows limited infiltration of rain water, results in excessive runoff. Another reason is heavy evaporation from surface storage systems, along with poor storage of ground water in the hard rock formations underlying the whole of the region resulting in low surface water and ground water availability.

Based on the above, the state is divided into four district units on the basis of the water resources endowment, namely Kutch, North Gujarat, South and Central Gujarat and Saurashtra.

North Gujarat comprises of six districts namely - Banaskantha, Mehsana, Patan, Sabarkantha, Ahmedabad and Gandhinagar. It has 20% of the total geographical area of the state. It receives low to moderate rainfall and has arid to semi-arid climatic conditions. The western part i.e. Banaskantha district receives the lowest rainfall and the northeast part of Sabarkantha district receives the highest rainfall. The rainfall is highly erratic with very high year-to-year
variation for the entire region. The variation is as high as 65% in the arid western parts of Banaskantha, Mehsana and Patan districts. Here, one must note and take into consideration that there is a significant variations in the rainfall from Taluka to Taluka even within the district itself.

From hydrological point of view, Gujarat displays significant regional variations. North Gujarat has very few rivers and also they are seasonal in nature, that is, they carry flow only during the monsoon period of three to four months. Looking at this option available to us, one should think and re-think of adopting a method which can use minimal amount of water conserved for agriculture purposes and take maximum advantage of it by growing different types of crops in the area.

Agriculture, in its broad sense, includes not only crop production of various types, but also plantation, horticulture, sericulture, livestock, dairying, poultry, forestry, fishing, etc. Castes often decide the occupation of a person in most of the villages in India. Many people in villages practice agriculture, in addition to their respective occupations held by their forefathers. Hence, they do farming either as land owners or tenant cultivators or farm workers.

Many people in different parts of India are now gradually moving towards different directions within the agriculture sector. The tendency within the occupation of agriculture is towards growing more of cash crops, and cereal production is limited to the extent of domestic requirement only. This is because of the fact that the net income per hectare from non-food crops is found to be higher. In agriculture operations, normally there is a combination of crop production and livestock.
Thus, the overall view is that the rural occupational scene is still dominated by crop production. (Agriculture and Rural Development, Edition: 2001, Chapter-1, Socio-economic Structure of Rural India, page 11, para 6.1 Agriculture and Allied Sector).

2.7 Agro-Climatic Zones of the State:

Another aspect to be considered here is the Agro-Climatic Zones of the State. As there are totally eight different Agro-Climatic Zones in the State, and more of the Agriculture scenario is dependent on these, it seems to be a minor factor but it is not so. This is one of the major factors affecting the overall results, which is termed as a production of the State. (Agro-Climatic Map 2.1) and (Table No.: 2.8).
<table>
<thead>
<tr>
<th>Sub Region</th>
<th>District</th>
<th>Rainfall (mm)</th>
<th>Climate</th>
<th>Soil</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Southern Hills</td>
<td>Dang, Bulsar</td>
<td>1793</td>
<td>Sub-humid Semi arid, Dry</td>
<td>Deep Black Coastal Alluvium</td>
</tr>
<tr>
<td>2. South Guj.</td>
<td>Surat, Bharuch</td>
<td>974</td>
<td>- Do -</td>
<td>- Do -</td>
</tr>
<tr>
<td>3. Middle Guj.</td>
<td>Baroda, Kheda Panchmahals</td>
<td>904</td>
<td>Semiarid</td>
<td>Medium Black</td>
</tr>
<tr>
<td>5. North West Arid</td>
<td>Kutch</td>
<td>340</td>
<td>Arid</td>
<td>Gray Brown Deltic Alluvium</td>
</tr>
<tr>
<td>6. North Saurashtra</td>
<td>Amreli, Bhavnagar, Jamnagar, Rajkot, Surendranagar</td>
<td>537</td>
<td>Semiarid</td>
<td>Medium Black Calcareous</td>
</tr>
<tr>
<td>7. South Saurashtra</td>
<td>Junagadh</td>
<td>844</td>
<td>Dry, Sub Humid</td>
<td>Medium Black Coastal Alluvium</td>
</tr>
<tr>
<td>8. Bhal &amp; Coastal</td>
<td>Part of Ahmedabad, Bhavnagar, Kheda</td>
<td>650</td>
<td>Semiarid Dry</td>
<td>Medium Black Coastal Saline</td>
</tr>
</tbody>
</table>
In India, 70% of farmers are cultivators of small plots from which they can hardly get food security let alone sustainable incomes. Most of them are small and marginal farmers cultivating land less than 1 hectare in size, average size of which decreases by half every 15 years due to the rapid population growth. Today, nearly 60% of the farmers belong to marginal category with an average of 0.4 ha land. The decreasing land sizes call for better land use and cropping intensity. The drip technology helps marginal farmers to make the best use of their limited water resources through prudent use of water and increase their area under irrigation converting their unused land into agricultural productive land, thus, reducing the stress on two precious natural resources - land and water. It is very imperative that one must understand irrigation in its true context.

A number of assessment and socio-economic impact studies like a project of Dantiwada dam, in Gujarat and Dharoi dam also in Gujarat (source: A Socioeconomic evaluation of an irrigation project by J.H. Adhvaryu, A. S. Patel and H. F. Patel 1986) have been carried out in different regions of programme implementation in India. With Drip irrigation, there is greater participation of women in agricultural activities, thus allowing greater control of women on the activity and the income there from. The nutrition effect of the drip kits was also found to be very positive. With availability of vegetables and fruits for sale, some of them are also consumed by the family itself, which was not available to them earlier.

Water Management is required to mitigate the suffering of farmers due to droughts and also to enhance the crop productions, which works upon improving the accessibility and agriculture inputs that are crucial for enhancing the productivity of the different crops. This includes management of ground water, especially where it plays a major role of source of irrigation in dry areas. The wastage of the same can be minimised while pumping out the water and taking it to the required field areas. The water channel from well to
the field must be properly maintained. In this regard, the farmers need to be educated, and should be shown the correct methods and the new technology available today. The combination use of surface and ground water resources is found to be more helpful in the adoption of HYV (High Yielding Varieties) seeds and associated technology which requires more irrigation.

The main objectives of the development, while keeping the pace with the technologies, our immediate target should be to focus on bridging the gap that exists between farmers, the markets and the agricultural innovations of the green revolution in the country. In India, more than 70% of the farmers are small land holders, cultivating land, which is less than one hectare. They require technologies that are simple in design and of low cost and suitable for their small land size. Micro-irrigation technologies having high benefit to cost ratio and a rate of return of 100% are an ideal investment for small farmers as they are risk averse and can suitably employ their surplus domestic labour. Similarly, these technologies are designed for smaller plot sizes and therefore, do not attract the rich farmers, as they can afford expensive technologies to meet the irrigation demand of their large plots. The technologies available today free the farmer from the limitations of rain fed farming, enabling him to grow wider variety of crops, and cultivate all year round, higher cropping intensity. Good irrigation technologies and agricultural practices coupled with enhanced participation of the rural farmers help them increase income generation. (Source: http://www.ide-india.org/ide/socialimpact.shtml).

Along with economic development of farmers, it is desirable to take measures for enhancement of ensuring economic status of the village. By providing the villagers with business opportunities with promotion of technologies, each member of the distribution chain earns benefits of development. This will lead to better economic sustainability of the rural farmers and minimise their run to cities for jobs.
One can effectively process the actions and learning’s, which will decide our future actions, which in-turn will give us a clear action plan to formulate our strategies for the greater sustainability of new technologies adopted. For a greater sustainability aspect, a synergistic coalition of stakeholders i.e. the farmers, the manufacturers, research institutes and NGO’s have to be promoted for proper leveraging of resources and channelling of technologies. Between availability of low-cost technologies and generating awareness about them among small farmers based in remote villages, the government should take innovative and promotional steps in promoting the new techniques to generate awareness about the products among the marginal farmers. Moreover, Non-Governmental Organizations (NGO’s) like AKRSP (I), BAIF, and SADGURU constitute an important link in sharing a common mandate of development of marginal farmers through their improved access to market information and knowledge based on good agricultural practices, and they are viewed as important stakeholders in the development process. Since their inception, NGO’s have evinced a strong interest in disseminating and generating awareness on products to small and marginal farmers. NGO’s provide an excellent network for sales, distribution, awareness generation, credit provision through self-help groups, product installation and after-sales service. NGO’s also assists by advising farmers on good seeds, fertilisers and cropping patterns to suit their soil.

By creating commercial marketing channels and a network of like-minded NGO’s, one can achieve two important objectives. Firstly, as the system is commercially viable, it sustains itself for as long as there is a market demand for the products. The continuous availability of the products through the marketing channels is maintained. Secondly, the manufacturers, distributors and dealers respond to farmers’ collective market demands in view of their higher purchasing powers. The farmers have a degree of control
As part of this adaptation process IDEI came out with ADITI (Affordable Drip Irrigation Technologies) in the form of simple and ready-to-use packaged kits that can be broadly classified as bucket kit, drum kit, easy drip and customised kit. ADITI kits have been designed for a range of crops and are quite suitable for small and marginal farmers of the semi arid regions in India. Also, these kits are applicable in a wide range of plot sizes varying from 20 square meters to 1000 square meters, with prices ranging from Rs.250 to Rs.4000. Divisible and available in convenient packages (in the form of kits) which the farmers can install and maintain themselves, the farmers also have the option to begin with one unit and expand it later at their convenience. (Source: http://www.ide-india.org/ide/socialimpact.shtml).

One of the very famous and successful programmes is known as ADITI Programme: Micro Irrigation (MI) programme in India started in the year 1997 to address the irrigation problems of small and marginal farm families living in water scarce regions of India. Micro irrigation is a water-saving technology which enables slow and regular application of water directly to the roots of the plants through a network of economically designed plastic pipes and low discharge emitters. It maximises crop productivity through increase in the crop yield and also the area for cultivation, and protects the environment through conserving soil, water and fertiliser resources, and thus increasing the farmers’ income. (Source: www.ide-india.org/ide/socialimpact.shtml).

2.8 Ground Water Recharge Movement in North Gujarat:

Popular response to water recharge movement in North Gujarat has however, not been on the scale as large as Saurashtra. North Gujarat region comprising the districts of Banaskantha,
Sabarkantha and Mehsana also receive around 700 mm rainfall and are water scarce. Banaskantha and Sabarkantha, as the name implies, are the basin areas of the Banas and Sabar rivers respectively. The catchments of which extend to the neighboring state of Rajasthan. Dams built on these two rivers brought canal irrigation to some parts of these two districts. Mehsana on the other hand does not have a perennial river. Sabar and Banas rivers, however, flow through the eastern and western boundaries of the district, so the north-eastern and north-western parts of the district are irrigated on a limited scale by the dams built on these rivers.

Mehsana district is an intensively cropped district. There has been a steady increase in the use of groundwater for irrigation in North Gujarat in general and in Mehsana in particular. In most villages of the district, not serviced by the canal network, there are on an average 100 to 150 Deep Tube Wells (DTW). The water table is receding at an alarming rate of 2 columns or 20 feet annually and the farmers have to lower column pipe in the bore wells by that much depth each year. It is estimated that 10 to 15% of the tube wells that were 300-500 feet deep, have become dysfunctional on account of receding water table. (Source: The Groundwater Recharge Movement in Gujarat by R. K. Nagar. IWMI-TATA Water Policy Research Program, Annual Partner’s Meet 2002).

For the entire North Gujarat, well irrigation continues to be the most vital accounting for over 95% of the net irrigated area. Though at present, groundwater depletion by DTW’s is not as serious a problem in Banas and Sabar, intensive irrigated agriculture in these areas with groundwater (farmers cultivating rice in kharif and wheat in winter) may soon create a situation similar to that of Mehsana. Failed Monsoons in North Gujarat resulted in all the three districts suffering from severe drought in the last decade for four out of last 5 years when over 85% of villages (in the three districts) were affected. Groundwater recharge activity through popular participation is relatively new in North Gujarat. Its scale is also limited due to the geo-hydrological
Map 2.2

Ground Water Resource map of Gujarat

Lithology
- Coastal Alluvium
- Highlevel Alluvium
- Limestone and Clays
- Lowlevel Alluvium
- Precambrian Crystallines
- Sandstones Laterits
- Tapioca Basalts

Source: [details provided on the map]
Most part of the region is a flat terrain with sandy loam soil. The hard rock strata are very deep and water will not reach even when DTW's are bored at a depth of over 1000 feet. There are however, three aquifers at a depth of 70-150 feet, 200-300 feet and 400-600 feet. All the three-aquifer layers have been over exploited and the newer bores are being done at a depth exceeding 1000 feet. Farmers also drill new bores close to the existing failed bores, if they are unable to lower the column pipe any further. Gradually, the diameter of the casing and the column pipes currently in use has increased to 10" and 5" respectively. The idea of the farmers is to use 48-52 HP motors and draw as much water as they can from as deep a strata as possible.

**TABLE NO.: 2.9**

**Area irrigated by source in Year - 1986-87**

<table>
<thead>
<tr>
<th></th>
<th>MEHSANA</th>
<th>BANASKANTHA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrigated by wells</td>
<td>2581</td>
<td>2523</td>
</tr>
<tr>
<td>Net area irrigated</td>
<td>2643</td>
<td>2618</td>
</tr>
<tr>
<td>Gross area irrigated</td>
<td>3825</td>
<td>2791</td>
</tr>
</tbody>
</table>


The growing scarcity and ineffective institutional arrangements for capture, allocation and distribution compounds the growing water crisis and shortages. These crises are unlikely to be resolved by increasing the water supply. When requirement exceeds supply the extra supply created is diverted to already well off people. As stated in the preceding section, in the struggle for capture and control over scarce water, those left out are among the poorest of the poor.
our society – the poor and marginal farmers, and domestic water users both in rural and urban areas. Equitable water distribution of scarce water among multiple users poses a major challenge. Mismanagement of water in the deficient areas is also quite common. Thus, it will lead to governance and planning for water sector which includes following namely Agriculture, Household, Industries and Others. The definition of governance thus includes a range of organisations, public, private and co-operatives, and complex relationship(s) between and among them. Institutions of local government (such as panchayats); civil society organisations (ranging from social movements to non-governmental organisations, and from co-operative to civic associations); and private corporations and market institutions are all relevant participants in this context.

2.9 Issues for Discussion: Governance in Water Sector

The understanding of governance in water sector should begin with defining crisis and dilemma of “Water Resources Development” (WRD) (see Iyer, 2003). This dilemma basically advocates focusing on limited supply of water and our ability to learn to live with it. If this shift is recognised, the focus of governance in water sector needs to be shifted from ‘water resources development’ to water resources management.

This also means that focus needs to be shifted from big ‘WRD’ to primary and local water harvesting structure and watershed development programmes. Once this paradigm is recognised, it would entail several changes in design of governance of water sector. This has become particularly important because decentralised management of water sector is considered to be a better approach, on the other hand linking of rivers and creating basin level organisations for integrated water resources
management are suggested to resolve issues confronting water sector. The decentralisation of water sector and integrated approaches to ‘WRD’ need not necessarily conflict with each other. However, they do mean different systems of governance than what is in practice today.

Water comes in many forms, and these are typically governed by different legal, economic and cultural framework. However, there are proponents who argue that water need to be treated as economic good which suggests an intent to reconceptualise existing water governance framework, using an economic interpretation of common denominator and giving primacy to market.

When one considers water to be an economic good, it simply means that something has a recognised value, or it could mean more specifically that something has been commodified, i.e. turned into something that can be bought and sold in the market. The greatest criticisms of the ‘water as an economic good’ paradigm have been leveled against the second interpretation, which fosters a trend toward private, for profit control over water. Critics maintain that water is different from commodities and should be exempt from such a definition. Proponents argue that without assigning water the ‘true’ price of its use, it is being wasted, and use will be ultimately unsustainable to support human life and ecological health.

Trying to differentiate between water as a public economic good or a private economic good may be theoretically helpful by clarifying that water – not unlike land and other natural resources – is composed of a ‘bundle of rights’ allowing some aspects of water to fall under private control and/or to be consumed and withholding others in ‘the public domain’. The latter status undoubtedly pertains to the recognition of water as a necessity and to a host of direct and symbolic common values associated with water. While
market pricing is a tried and true way of regulating use of a scarce good, it is blind to anything that can not enter the market place. So, while in theory, one could specify all direct and symbolic values in economic terms, not all of them could realistically be reflected in the prices of economic commodities. The risk is that the economic value of water could come to mean simply its partial value as a commodity. The loss of access to all the rights in the bundle that are not reflected in the commodity market is a legitimate cause for concern. So if we seek to reconceptualise water as an economic good, how do we use pricing to regulate private consumption without endangering other private and public rights in the bundle?

The National Water Policy (NWP) adopted by the Government of India in April 2001 and Supreme Court directives to link major Indian rivers by 2016 would have large ramification on governance to water sector. National Water Policy emphasises participatory approach and argues for necessary legal and institutional changes which is necessary to implement the decentralised governance of water sector. As a result, several scholars are arguing for multi-stakeholders’ platform (MSP) and creation of institutions which can facilitate the above process.

The MSP alongwith integrated water resource management (IWRM) at various levels are new found approaches to resolve some of the issues confronting water sector. Both MSP and IWRM experimentation are at their nascent stage. Understanding the potential and constraint of these approaches and possible threat would help in designing appropriate strategies for such experimentation. It is, therefore, imperative that these aspects are analysed and understood in proper perspective so as to bring desired changes in governance of water sector for efficient equitable (including gender equity) and sustainable management of water resources and water bodies. (source: Shah, Tushaar and V. Ballabh (1993). “The Social Science of Water Stress: An Exploratory Study of Water Management Institutions in Banaskantha District”, Gujarat).
From the second half of the last century, agriculture in India has gone through enormous changes because of the introduction of green revolution technology. The technology demanded more control over irrigation than the large canal systems were unable to provide. Well irrigation was seen as a viable alternative to the bureaucracy controlled canal systems that led to sharp increase in the use of groundwater irrigation. Due to the large area being irrigated by groundwater in many locations, over-development and even depletion of aquifer systems is now quite common. Gujarat is no exception where groundwater supports more than 77 per cent of its irrigation water requirements. Though the depletion of groundwater resources has put many in a disadvantageous position, some have benefited from this situation of extreme scarcity. They are the resourceful farmers who invested in deep tube wells and hence could access and sell surplus water. Small and marginal farmers lost the race of chasing the water table and became buyers of water. Through an intensive village case study, this focuses on the politics of groundwater markets and its inter-relation with social differentiation and class-caste relations in Mehsana district of North Gujarat, which is famous for its widely developed groundwater markets and groundwater depletion due to excessive pumping. It places the issue of access to groundwater in the context of the specific agro-ecology, prevailing social relations of production, ineffective regulation of groundwater exploitation and inequality of land ownership. Further, it links the everyday shaping of groundwater rights to formal legal attempts at regulation of groundwater exploitation at the national and state level. (Source: A WIN-SOME LOSE-ALL GAME! SOCIAL DIFFERENTIATION AND POLITICS OF GROUNDWATER MARKETS IN NORTH GUJARAT by Anjal Prakash and Vishwa Ballabh).

Long-term observations of ground water levels in Gujarat have been made by the Central Ground Water Board. They have shown a decline of water levels up to 10.61 metres in shallow aquifers and up to 50.37 metres in deeper aquifers in the State.
As per information made available by the Government of Gujarat, the “Sardar Sarovar Canal and Mahi Pipeline-based drinking water supply Plan” has been prepared for sustainable drinking water sources for Saurashtra, Kutch, North Gujarat including Panchmahal districts with an approximate cost of Rs. 4,700 crores. Extensive work of recharge and water harvesting structures has also been taken up to solve the drinking water problem of Kutch District. The State Government have also informed that they have formulated a project for augmenting surface water recharge in over-exploited aquifers in North Gujarat region for O.E.C.F. (Japan) assistance amounting to Rs. 359.5 crores to solve the problem of drinking water and scarcity of irrigation resources in the region. Central Ground Water Board, while carrying out scientific exploration through drilling of wells in different parts of the country, has handed over 12 wells in Kutch District. (Source: FALL IN GROUND WATER LEVEL IN GUJARAT, PIB, GOI 2005).

Irrigation being a State subject, Irrigation projects is taken up for implementation by the State Governments themselves out of their own resources as per their priorities. The completion of a project depends on various factors, such as, its size, availability of land, clearances, geological conditions etc. Equally important are the funds allotted by the State Governments to individual projects.

The position of various ongoing Irrigation projects is reviewed every year during annual plan discussion of the States in the Planning Commission. In addition, Central Water Commission also monitors the progress of important projects. The Centre has launched Accelerated Irrigation Benefits Programme (AIBP) since 1996-97 for providing Central Loan Assistance to the States for completion of those irrigation projects which are in advance stage of completion or mega projects which are beyond the resource capability of the States. The National Bank for Agricultural and Rural Development (NABARD) is also providing funds under
Rural Infrastructure Development Funds (RIDF) for irrigation projects.

2.10 Water Scarcity:

Although the water availability in the country remains more or less fixed according to the natural hydrologic cycle, the per capita water availability is reducing progressively owing to increasing population, industrialisation and urbanisation. In 1955, per capita water availability was 5300 cu.m. which has come down to 2200 cu.m. In 1998 and by 2025, the availability will be only 1500 cu.m, at national average. According to the United Nations' criteria, any situation of water availability less than 1000 cu.m. per capita is considered as “scarcity condition”. Therefore, even at the end of 2025 A.D., India is not likely to face water scarcity situation at national level though uneven water availability may cause local water scarcity at some places.

The Government has initiated various measures through Command Area Development Programmes and National Water Management Programme Scheme to improve efficiency of irrigation water use in the country. The National Water Policy (1987) also provides for better water planning and management of the country's water resources. Inter-basin transfer of water is also being contemplated in order to use the surplus monsoon flow. As such, there is no apprehension of cutbacks in supply of irrigation water.

2.11 Water Management:

Due to competing sectoral water demands, particularly from energy and industrial sectors, the availability of water for irrigation in total water use is likely to come down from 83.3% in 1990 to 64.7% in 2050 A.D. To overcome this scarcity situation, the following two pronged strategy has been suggested.
a. Optimisation of water use efficiency.
b. Water conservation including rain water harvesting.
c. Control of population growth.
d. Conjunctive use of surface water and ground water to improve overall irrigation performance.
e. Augmenting the utilisable water availability through inter-basin transfer of surplus water.


The increasing emphasis on watershed development programmes especially for dry land plains in India is, a manifestation of the shifting priorities which till recently had rested on crops and regions having assured irrigation. For a long time, agricultural policies had overlooked the developmental needs of dry land as well as hilly areas having adverse agro-climatic conditions. The neglect was quite apparent in the fields of varietals and agronomic research as well as the credit and extension support. The more serious (but not so apparent) lapse, however, was in terms of land management and soil fertility. Also, a participatory approach for project implementation may not bring desired results in terms of enhancement of productivity and livelihood security. Finally, given the options, farmers prefer yield-augmenting technologies and are willing to pay for the cost. This in turn also helps bringing more effective (interactive) participation in the watershed programme.
2.12 Watershed Development:

In Urban India today, it has become a symbol of culture and refinement to talk about and to support environmental causes. But, not so in the rural areas, where farmers are trying desperately to make both ends meet. Environmental problems in urban areas have received much attention and action while the rural areas have not. Hence, 70% of the National population continue to deteriorate. The poor farmers have very little control over their destiny in view of irregular and/or heavy rains accompanied with fluctuating market prices. Furthermore, due to increasing pressure of population, there is demand for more land for agricultural and non-agricultural use. Unhealthy practices on available land have resulted in creation of vast stretches of wastelands due to soil salinity, water logging, and desertification and soil erosion. In fact, according to the Ninth Five Year Plan Document, soil erosion is contributing to degradation in about 45 per cent of the cultivable area of the country. The estimates of wastelands range from 76 million hectares to 175 million hectares. In a densely populated country like India, one cannot afford to let so much land remain idle. To make this land cultivable, the productive approach is through watershed development.

A watershed (or catchments) is a geographical area (Map 2.3) that drains to a common point, which makes it an ideal planning unit for conservation of soil and water. The idea is really quite simple and is perhaps as old as the history of farming. But, the benefits are manifold. It changes the entire landscape of an arid area making the land fertile, making growth of trees possible and checking soil erosion and water logging. The residents of the area covered by the watersheds are also organised into self-help groups and user groups. In fact, these user groups are the beginning point as well as the end point for Watershed Development programmes. Their initiative is crucial to the success of the programme and they are the ultimate beneficiaries. Evaluation reports have shown that
Map 2.3

Watershed Map of Gujarat

Source: Remote Sensing and Communication Unit, Gandhinagar
watershed projects cannot succeed without full participation of project beneficiaries. This is because their success depends on consensus among a large number of users. Despite problems, there are many success stories. Successful and sustainable projects include Ralegoan Siddhi, revival of johad in Alwar, Sadguru Foundation's activities in Gujarat, Watershed Development in Jhabhua and Sagar districts of Madhya Pradesh and externally aided projects like KAWAD, SDC, and DANIDA in Karnataka, World Bank Project in Andhra Pradesh and DANIDA project in Tamil Nadu. All of these successful projects have some characteristics in common - emphasis on social issues, social mobilisation, clear direction to the Government to accept principles of participatory management, transparent project monitoring and a strong sense of ownership by the local community. In fact, Ralegaon Siddhi has become a role model for people across the country to learn how people's involvement is instrumental to the success of watershed activities. Similarly, Sukhi Manjro in North India, Villages in Jamnagar District, Surendranagar District, in Naranka Village (District Rajkot), Rabarika Village. It stands testimony to the fact that the key to rural economy is the development of watersheds and the key to development of watersheds is participation of local farming communities. (Source: Article in the newspaper “The Hindu” dated Sunday, Jun 02, 2002). As per vora 2002, following are the positive impact/advantages of the watershed development programme in the State of Gujarat.

2.12.1 Advantages of Watershed development:

1. The impact of watershed development programmes has reduced the migration among farm workers from landed as well as landless households to urban areas in the states. To a large extent these migrants tend to seek employment in the industrial sector located in the “Golden Corridor” between Ahmedabad and Valsad. Of course, these kinds of movements are fairly common because of the inherent
inequality in industrial development across space. Such movements often take place because of the inadequate development of agriculture despite the fact that population density per unit of net sown area is quite low. To a large extent, these movements are associated with absence of water resources development in the water scarce regions. As per Visaria and Kothari (1984) clearly indicated that in 1971 the direction of net out-migration was mainly from the water scarce less developed districts of Saurashtra and North Gujarat to the more developed and industrialised regions in South Gujarat.

2. There is a significant positive impact on shift in cropping pattern (from Groundnut to Cotton) hence increase, in cropping intensity; there is no significant increase in on-farm employment on a sustained basis. Hence, migration remains more or less unaltered. What is concerning is that the positive impact on crop-shift and productivity as well as income remain confined mainly to those who received direct benefits from water harvesting structures like check dams.

3. Developing Common Property Resources (CPRs) is another important avenue through which large number of poor households could be benefited (Jodha, 1997; Chopra and Gulati, 2001).

4. The concept of participatory watershed management emphasises an inter-disciplinary, inter-sectoral and multi-institutional mechanism (Rhoades and Elliot). Participatory watershed management has been defined as a process “which aims to create a self-supporting system, which is essential for sustainability” (Wani et al, 2005).

5. Raising farm income.
6. Enhancing agricultural productivity.
7. Soil and water conservation.
8. Generating rural employment.
9. Reducing risk by diversifying crops in rain fed areas.
10. Due to increased irrigated area under watershed area helped
### Socio-economic impacts of watershed management programme in Naranka village (Dist. Rajkot)

<table>
<thead>
<tr>
<th>Sr.No.</th>
<th>Details</th>
<th>Survey Yr.</th>
<th>Survey Yr.</th>
<th>Increase (Per cent)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1983</td>
<td>1991</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>66 Farmers</td>
<td>66 Farmers</td>
<td></td>
</tr>
</tbody>
</table>

#### 1 Application of agricultural equipments

**A** Groundnut (Number)

- (1) Improved varieties: 14 to 091, Increase: 063.84%
- (2) Distance crop: 90 to 035, Increase: 032.70%
- (3) Crop protection: 16 to 084, Increase: 054.27%
- (4) Intercrop: 00 to 011, Increase: 010.28%

**B** Change in crop pattern (Hectare)

- (1) Wheat: 83 to 117, Increase: 041.00%
- (2) Sesame: 09 to 082, Increase: 081.00%
- (3) Castor: 00 to 009, Increase: *
- (4) Horticultural crop: 00 to 003, Increase: *
- (5) Plantation: 00 to 120, Increase: *

#### 2 Sources of irrigation

- (1) Area under irrigation (Hectare): 31 to 112, Increase: 261.00%
- (2) No. of wells: 72 to 110, Increase: 053.00%
- (3) Implants for water: 10 to 015, Increase: 050.00%
- (4) Water recharging (Hectare/Meter)
  - (A) Winter (Ravi crop): 31.1 to 112, Increase: 260.00%
  - (B) Summer (Kharif crop): 04.6 to 045, Increase: 878.00%

#### 3 Income from agriculture (Rs/Hectare)

- 22.83 to 046.81, Increase: 105.00%

* New work has started in this regard in this area.
in increasing crop productivity (shah, 2001).

11. Soil and water conservation measures adopted in the watershed development projects were helpful in augmenting water storage capacity and improving local water resources by reducing the rate of runoff, and increasing the ground water recharge. (Butterworth et. al, 2001).

12. Watershed development projects have greater potential to generate employment opportunities to the rural people. This was due to the increased availability of water resources, diversified cropping pattern including cultivation of labour intensive vegetable crops and other horticultural crops (Reddy et al, 2001).

Gujarat State is basically an arid to semiarid one, and hence sound management of water resources is very crucial for agriculture. At many places water logging and salinity poses problems. This problem however can be overcome by adopting modern micro-irrigation technologies: both drip and sprinkler irrigation systems.

### 2.13 Micro Irrigation System:

Micro Irrigation (MI) is the most efficient way of providing water to plants as it specifically delivers water to the roots of the plants (rhizosphere or root zone). The use of technology enables water saving of 50-70 %, increase in yield of 50 %, savings on fertilisers are 30 %, reduced weed growth and prevents soil erosion as the rate of application of water is very slow. (Source: www.ide-india.org/ide/socialimpact.shtml).

Micro Irrigation System (MIS) is a mechanism to provide water and chemical fertilizer in required quantity through network of plastic pipes and drippers. In MIS, water is directly applied to the root zone of plants, at frequent intervals at precise quantities and through a low - pressure pipe network. MIS is necessary to improve the productivity of irrigated land from the present low
levels, to improve efficiencies of Water, Energy, Nutrient and Human Effort in Agriculture, to conserve scarce resources such as Water and Electricity, to extend the benefits of irrigated agriculture to more people with the available water and to facilitate better crop management through Fertigation and Chemigation.

MIS consists of mainly two components namely Drip and Sprinkler irrigation systems.

2.13.1 The advantages of Drip Irrigation System:

1. Very high efficiency of water use.
2. More crop yield compared to other methods.
3. Decreased tillage.
5. Improved plant protection and reduced diseases.
7. Satisfactory use of poor quality of water.
8. Shorter growing season and production of earlier crops.
10. Low labour requirement and relatively low operation costs.
11. Use in hills terrain and problems soils.
12. Improved infiltration in soils of low intake.
13. Low pressure requirement: This permits this system to be used even in green houses.
14. No tail water loss and soil erosion.
15. Ready adjustment to sophisticated automatic control.
16. Mechanical operations can be done simultaneously with irrigation.
17. Constant optimal oxygen/moisture relation eliminates scraping and tilling.
18. There is no conflict between irrigation, spraying and...
harvesting.
19. Soils need no furrow renewals, nor is it eroded.
20. Weeding is eliminated.
21. Improved germination, avoids re-seeding.
22. Reduction in picking work.
23. Use of poor quality water.

2.13.2 The Advantages of Sprinkler Irrigation System:

(1) Considerably improved water utilisation over conventional method so that larger areas are irrigated.
(2) It generally offers the only method of obtaining adequate distribution of water on certain rolling of hilly lands where levelling for surface irrigation is not feasible.
(3) Land is saved as there is no loss for channels and bunds. It eliminates the need for farm ditches and more area is available for crop production.
(4) The overall irrigation efficiency is from 65 to 80% while that of the surface irrigation ranges between 25 to 60% only.
(5) It is suitable where depth of the soil is limited by a hardpan or other restricting layers.
(6) It is suitable on porous soil, such as sand, where water penetrates rapidly, and giving relatively excessive losses by deep percolation.
(7) It is adapted to light application of water for shallow rooted crops, in germination of seeds and during the seeding period.
(8) Sprinkler irrigation may be designed for smaller flows and is therefore preferred to over other methods. It is an economical method of irrigation where the annual requirement is low.
(9) Run-off and subsequent soil erosion can be eliminated.
(10) Leaching of salts from soil is effectively done as there are no drainage and salinity problems due to over irrigation.
(11) Uniform distribution of water over the irrigated area is possible with appropriate design and operation of the system.

(12) Due to reduced labour requirement labour can be used for other productive work on the farm. Mechanisation and automation is possible to reduce the labour cost.

(13) Fixed system can eliminate field labour during irrigation season.

(14) Better weed control due to elimination of channels and bunds that harbour weeds.

(15) Fertiliser can be distributed through the system for rapid effective response.

(16) Save fertilizers surface irrigation washes fertiliser below root zone.

(17) Can irrigate at night. This eases power problems as irrigation can be done at anytime. (Seminar on irrigation water management, 1992, Vol. II, Ch. 26, by R. S. Saksena, page 639).

This project study is based on the economically proven irrigation techniques in the arid and semi-arid regions of the North Gujarat; and the concluding evidences draw attention to improve the overall economics of the irrigation performance as a best suitable means in the State of Gujarat.