Competing Demands for Water in Sabarmati Basin: Present and Potential Conflicts[1]

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ABSTRACT

Water is essential for all forms of life and therefore it is invaluable. Although a renewable natural resource, water is exhaustible and has multiple uses and hence multiple demands. In many arid, semi-arid and hard rock regions of India, water resources have almost been completely exhausted and now water is not easily available even for drinking purposes. This paper attempts to study and analyse the competing demands for surface and groundwater and water-related conflicts in the Sabarmati basin lying within the administrative jurisdiction of the State of Gujarat in Western India. The study area is characterised by widespread industrialisation, intensification of irrigated agriculture and rapidly growing population in Ahmedabad and Gandhinagar cities situated within the basin of the Sabarmati river. The study revealed that the requirement of water for domestic, agricultural and industrial uses in the basin exceeds significantly the quantity of water available. This has led to conflicts among various uses as well as users of water. Growing industrialisation has led to pollution of the river Sabarmati and its tributaries which in turn has adversely affected the health of the rural people and crop yields in the affected areas. The nature of conflict and the problem of pollution are illustrated through case studies of three villages and one city, Ahmedabad, located in the basin. It is argued in the paper that the present pattern of use of water is unsustainable and that in future more conflicts would crop up. It is suggested in the paper that there is need for evolving an appropriate institutional structure for regulating the use of scarce water resources in the basin as also to resolve various types of conflicts among water users.

1. INTRODUCTION

When water supply was abundant or sufficient to meet all types of demands, there were no conflicts among its uses and users. However, over the years, demand for water has been increasing for all domestic, irrigation and industrial purposes. The traditional as well as newer sources of water are becoming inadequate for meeting the rapidly growing needs leading to different types of conflicts. Besides, water has bther roles also to play. It erodes, dissolves and transports substances and thus helps maintain ecology and environment (Golubev 1993). Therefore, it is now important to use water judiciously. Competition among water users is visible in many forms. The early symptoms of competition among water users are noticed in declining groundwater tables owing to

[1] Revised paper presented at IDPAD Seminar on Managing Water Scarcity: Experiences and Prospects, held at Amersfoort, the Netherlands, October 13-17, 1997.

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Several individuals and organisations helped us with information and ideas. We are thankful to them all.

excessive use of groundwater in agriculture by well owners. However, in more recent times, the competition has been visible in many other forms also including intra-basin conflicts between upstream and down stream users and between farmers and industrialists.

The main objective of this paper is to study and analyse the competing demands for water and water-associated conflicts in the Sabarmati basin. The Sabarmati basin was purposively selected for the study on the basis of familiarity of the authors with the basin, ease of access and availability of information about the basin from the Government of Gujarat (GOG). The basin was divided into three sub-basins, namely, up-stream, middle stream, and down stream for detailed study and analysis. The primary source of information about the basin was the Irrigation Department, GOG. Both primary and secondary data were used to study and analyse the present uses and demands of water in the basin. For collecting primary data, a mix of approaches was used. This included a transect through the Sabarmati basin and visits to several villages and a few towns in each of the three subbasins; discussions with the managers of surface irrigation systems in the basin; detailed case studies of three villages, one each located in up-stream, middle stream and down stream; and an in-depth analysis of present problems associated with drinking water in Ahmedabad city.

2. A CONCEPTUAL FRAMEWORK

A universally accepted paradigm of human behaviour is characterised by the notion of rationality. However, it is also widely reorganised that the 'rational' behaviour of an individual is tempered by the institutional environment in which the individual lives and works. The institutional environment or structure comprises, inter alia, socio-cultural, economic, legal and political norms. These norms permit or prohibit activities and behaviour of individuals in a particular action arena and interact with physical and technological factors and the characteristics of individuals, and thereby shape their shared understanding. Given the premise of rational individual behaviour and scarcity of water, competition and conflicts among water users are inevitable. To understand the conflicts in water use and management, it was therefore hypothesized that there are three sets of variables, namely, physical and technological factors, attributes of community, and institutional arrangements that guide individual decisions to appropriate and use water resources. These three sets of variables interact among themselves on one hand and with competing uses and demand of water, on the other, leading to various types of conflicts, which may or may not be resolved.

The physical and technological aspects of resources within a water basin help determine their availability and economically feasible uses. Knowledge of various physical factors such as rainfall, soil texture, nature and extent of ground water aquifers and overall hydrological cycle is important for efficient water management in a basin. Technological factors are equally important because they either constrain or facilitate an individual's capacity to capture the resource and use it. For example, the traditional lift system which depends upon human or animal power can only tap significant amount of water from the depth of roughly 50 feet (Dhawan 1983 P.9). In contrast, the modern water lifting devices using submersible electric motor pumpsets can lift water from depths of over 1000 feet or even more.

Water could be a means of livelihood for some people and a precious commercial commodity/resource for some others. Needs of a community in conjunction with its attributes and attitude towards a resource determine its use, management and conservation. Institutionalised rules associated with capture, distribution and use of water form the third set of factors that affect water use and management. These rules also determine who is eligible to make decisions in some arenas (Ostrom 1990). Institutionalised rules are functional rules, which are actually used, enforced and monitored. These rules either facilitate, constrain or forbid individuals to make choices. Since supplying a new set of rules is a public good, it suffers from under-supplies and individuals prefer to "free ride" instead of engaging in rule making, enforcing and monitoring.

The three sets of factors briefly described in the preceding paragraphs, i.e., physical and technological factors, attributes of community and institutional factors interact with physical and socio-cultural world and create a wide variety of situations. Individuals operating in those situations take various kinds of actions that suit their needs best. Through this interactive process, water is allocated among its competing uses. If the needs are not met satisfactorily, competition and conflicts among various uses and users is inevitable (Figure 1).

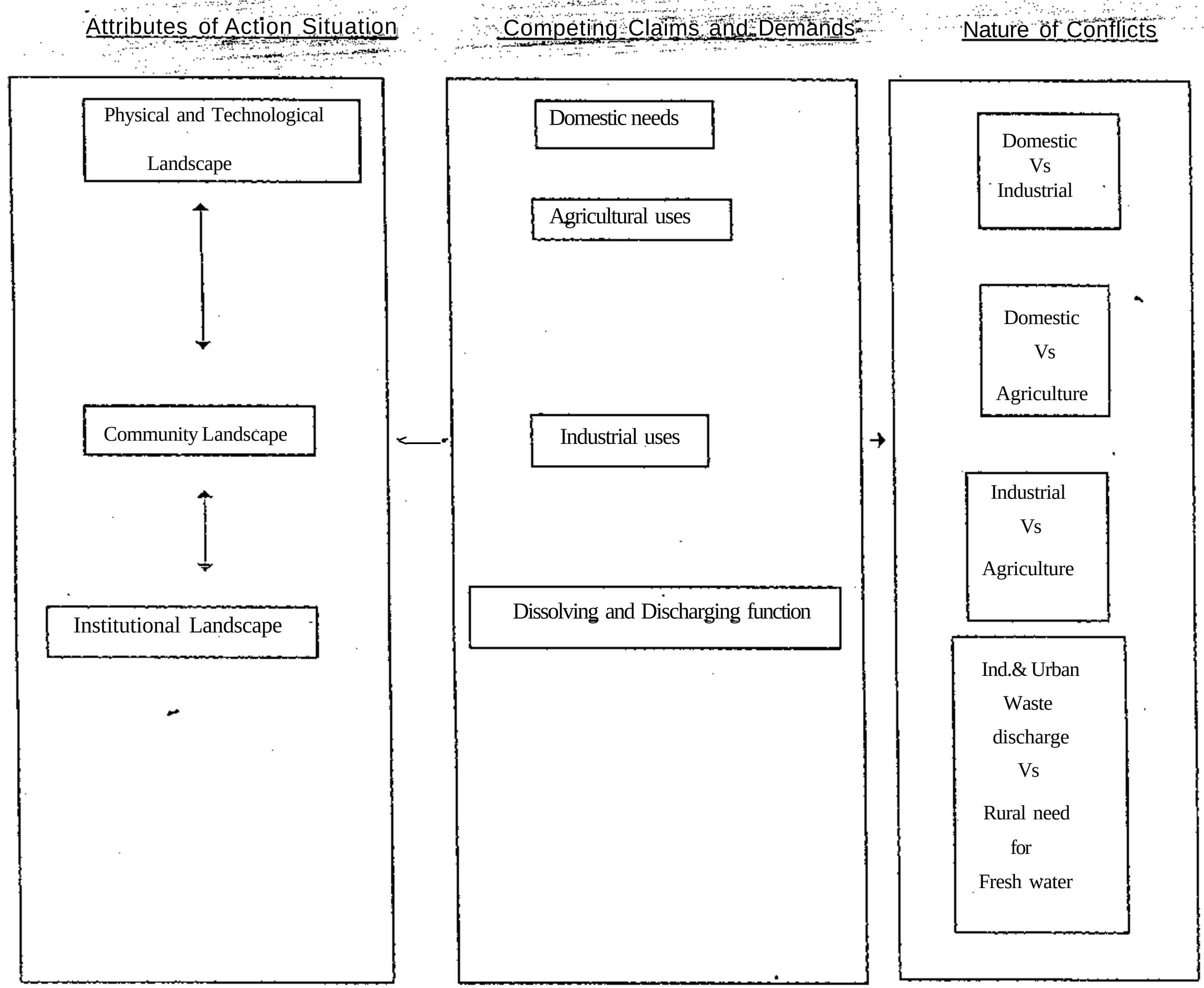

Figure 1: Conceptual Framework for identification of conflicts in water management

3. A PROFILE OF THE SABARMATI BASIN

3.1 Physical Features

The river Sabarmati originates in the Aravaili hills of Rajasthan state at an elevation of 762 metres above the mean sea level. After traversing approximately 48 km in the state of Rajasthan, it enters the Gujarat state. The river joins the Gulf of Cambay after traveling 323 km in Gujarat. The river has five major tributaries : Wakal, Sei, Harnav, Hatmati and Watrak, all of which originate from various parts of Rajasthan state. The Sabarmati basin is bordered by Aravalli hills on the North and North East and on the East by a ridge separating it from the basin of river Mahi (GOG 1996). The total drainage area of the basin is about 21,*674* sq km, of which 17,550 (80 per cent) is in Gujarat, and the remaining (20 per cent) in Rajasthan. The entire area of the districts Sabarkantha, Gandhinagar and about 75 per cent area of the Kheda district fall in the Sabarmati basin. In addition, parts of Mehsana, Ahmedabad and Banaskantha districts also dwell in the Sabarmati basin (Table 1).

Table 1: District-wise Area of Sabarmati Basin

Sr. No	**District**	**Total geographical area (km^2)**	**Area within the basin (km^2)**	**% area within the basin**
1	Sabarkantha	7390	7250	98.11
2	Kheda	7194	5439	75.60
3	Ahmedabad	8707	2378	27.31
4	Mehsana	9027	975	10.80
5	Gandhinagar	651	648	99.85
6	Banaskantha	12703	860	6.77

Source: GOG (1996), Integrated Plan of Sabarmati River Basin.

The basin is divided into three sub-basins on the basis of watershed subsystems. The area covering upper sub-basin and the catchment of the main river up to Dharoi dam is designated as Dharoi sub-basin. Constructed in 1978, the DhaVoi dam is located about 165 km upstream Ahmedabad in village Dharoi of Mehsana district. The second sub-basin, designated as Hatmati sub-basin, includes the catchment area between Dharoi dam and the confluence of river Khari. The river Hatmati is one of the main tributaries of river Sabarmati in this sub-basin and therefore termed as Hatmati sub-basin. The third is Watrak sub-basin, named after river Watrak, one of the main tributaries of river

Sabarmati. Both Hatmati and Watrak rivers originate from different parts of Rajasthan and they meet the river Sabarmati on its left after traversing about 105 km and 248 km respectively, from their origins (GOG 1996). Figure 2 shows an index map of Sabarmati basin.

These sub-basins could be further divided into sub-sub-basins, based on the watersheds of Hatmati, Watrak and their tributaries. In addition, the down stream Ahmedabad needs to be considered separately because it gets industrial waste from the Ahmedabad Municipal Corporation and Ahmedabad Urban and Industrial Development area. The areas affected by pollution are part of down streams of Hatmati and Watrak sub-basins. The polluted water flows into the villages located downstream Ahmedabad. Thus, unlike people living in the other areas of the basin, people in these villages find it difficult to have access to safe drinking water and protect themselves, their livestock and crops from the water polluted with hazardous substances. The salient features of three sub-basins of Sabarmati are provided in Table 2.

Table 2: General Features of the Sabarmati Sub-basin

Particular	**Dharoi Sub-basin**	**Hatmati Sub-basin**	**Watrak Sub-basin**
Catchment Area (Sq.km)	2640	5573	9337
Geology	hilly and rocky	rocks followed by alluvial plain	alluvial plain
Physiography	undulating dissected hills, sharp hills to hill slopes	gently sloping pediments to gently sloping alluvial plain	gently sloping to nearly levelled alluvial plain
Runoff	very high	high to low	low
Water holding Capacity	poor	good	good
Groundwater Formation	confined and semi confined aquifers	semi confined to unconfined aquifers	unconfined aquifer
Irrigability	Good	Good	not irrigable in some areas due to salinity in soil
Forests	traditionally well forested, now degraded	poor and degraded forest	no forest
Main Community	dominated by Bhil tribe interposed with new settlements	Caste based agrarian communities dominated by Patidars and Chowdharies	Caste based agrarian communities dominated by Patidars

Source: Compiled from GOG **(1996).**

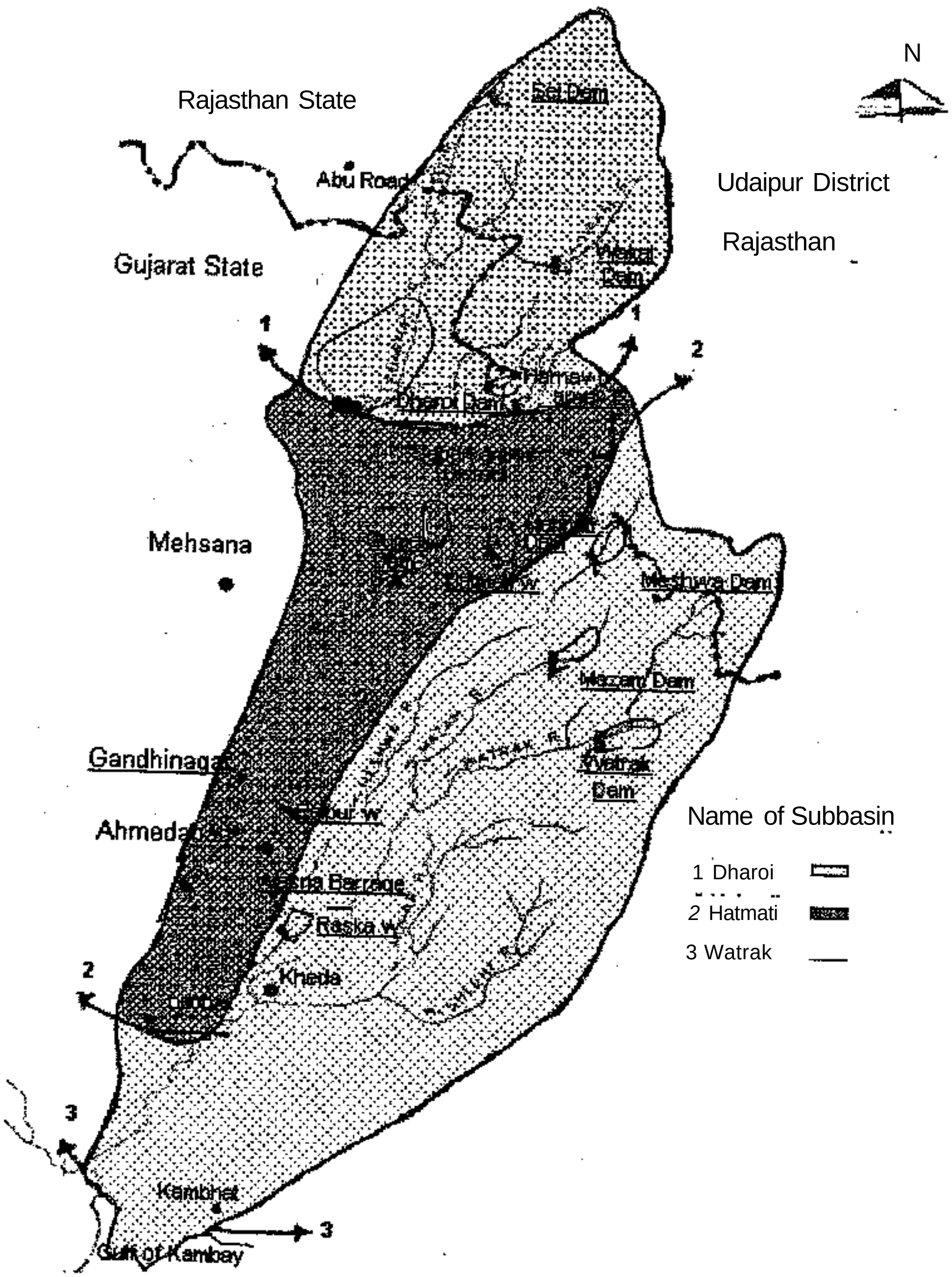

Figure 2: Map of Sabarmati River Basin (GOG 1996)

The upper sub-basin once had dense forests but the area is now thinned and degraded. The groundwater formation takes place under confined to semi-confined aquifers in the upper reaches followed by unconfined aquifers in alluvial plains of the lower reaches in Sabarmati basin. The geological configuration, type of aquifers, topography along with precipitation determines the total water yield and amount available for utilisation through surface and groundwater. These factors also affect the type of technology to be used to capture water, particularly groundwater.

3.2 People and Community

According to the 1991 census, the total population of the basin was about 9.28 million consisting of 4.82 million rural (52 per cent) and 4.46 million (48 per cent) urban population[3]. High urban concentration has important implications for water demand and supply.

The urban areas need more water for domestic uses than the rural areas. Any generalisation of settlement pattern for such a large area is fraught with danger. However, a cursory glance on population pattern suggests that it is somewhat unique. Among the rural areas, the upper sub-stream of basin is largely inhabited by tribal population. Although there are variations among the tribais, most of them belong to different clans of the Bhil tribe. The middle part of the basin is dominated by the Patidars and Chowdharies sparsely interspersed with Darbars and Rajputs. The lower part of the areas, particularly north of the Ahmedabad city, is mainly inhabited by the Darbars and Rajputs. Among these communities, the Patidars are particularly more enterprising and they have dominated the agrarian scene in Gujarat for the last one century or so. The North-Central part of Gujarat, where rapid growth is taking place in both commercialised agriculture and industrial sector forms part of the basin.

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[3] According to the 1991 census, urban population in Gujarat accounted for 35 percent as compared to the national average of 26 percent. In Sabarmati basin, only 52 percent of the total population live in rural areas and the rest 48 percent in urban areas. High urban concentration indicates intensive resource use and rapid economic activity in the basin.

4. DEMAND FOR AND USES OF WATER IN SABARMATI BASIN

The Gujarat State Water Resource Planning Group has estimated the total water requirement for the Sabarmati Basin as a whole and for the three sub-basins separately taking into consideration such factors as the size of rural and urban population, livestock population, industrial growth and demand for water for agriculture. According to their estimate, in 1997-98, the total water requirement in the basin was about 3846.17 MCM per year. Of this, the domestic water requirement amounted to only 298.35 MCM per year (7 per cent). Most (90 per cent) of the water is used in agriculture for irrigation purposes (Table 3).

Table 3: Estimates of Water Requirement in Sabarmati Basin

Requirements in MCM/year for						
Sr. No	**Sub-basin**	**Domestic uses**	**Live-stock**	**Indust-rial uses**	**Irriga-tion**	**Total MCM/ year**
1	Dharoi	8.76	**0.88**	2.00	163.79	175.43
2	Hathmati	276.62	**21.00**	26.00	1268.55	1592.22
3	Watrak	79.69	**8.00**	1.75	2055.85	2145.29
3912.94	Total	365.12	29.88	29.75	3488.19	

Source GOG (1996), Integrated Plan of Sabarmati Basin.

The figures in Table 3 are gross underestimates of the quantity of water used in the basin. This is mainly because the domestic water requirement was estimated based on the norms prescribed by the Government of Gujarat, which suggest 140 litres per capita per day for urban areas and 40 litres per capita per day for rural areas. The norms obviously are way below the actual quantities of water used. Many villages within the Sabarmati basin have access to as much water as available in the urban areas. As mentioned earlier, the economic activity in these parts of the basin is expanding rapidly leading to increase in rural incomes. The increase in rural incomes induces demand for modern sanitation facilities which in turn leads to increase in domestic requirement of water. The rural domestic water use has also increased due to decline in the real cost of collection of water, where water supply systems have been established either by village panchayats or by the Gujarat Water Supply and Sewarage Board (GWSSB). Therefore, the norm of 40 litres per capita per day for rural areas appears to be an underestimation. Our colleagues at IRMA have estimated that the per capita water requirement for an average villager in Vatrak sub-basin varies from 79 litres per day (Ipd) during monsoon season to 151 lpd during the summer season (Prabhakar et al. 1997). A recent study further suggests that domestic water use in Dharoi and Hatmati sub-basins varies from 35.6-145.6 lpd in rural areas and 64.2 to 240.0 in urban areas (Shunmugam and Ballabh, 1998).

Similarly, per capita the urban water requirement norm of 140 lpd is not sufficient, particularly in large cities like Ahmedabad. The Ahmedabad Municipal corporation at present supplies 152 lpd per capita with a large variation from area to area. It has also been estimated that for full satisfaction of the needs of urban people, the water requirement goes up to 270 lpd per capita, A study by M/s Tata Consulting Engineers estimated the demand for water in Ahmedabad city to be 75 litres per capita per day for huts; 150 litres for *chawls;* and 260 litres for houses, flats and bungalows (TCE 1997).

According to the 1988 Livestock Census, the basin had 2.81 million livestock population. According to the estimates made by Prabhakar et al. (1997), the total water requirement for the livestock would be about 92.345 MCM/year. The Gujarat State Water Resources Planning Unit estimated the water requirement for livestock as 10 per cent of the total domestic requirement, that is, 29.98 MCM/year; which is grossly underestimated.

The Planning Unit estimated the industrial water requirement based on the areas of industrial estates developed by the Gujarat Industrial Development Corporation (GIDC) and the size of the industries established there. For the industries, outside the GIDC estates, it has assumed the requirement to be 50 per cent of the water consumed by the GIDC estate industries. Besides, the estimate does not take into account the industrial waste dissolving function of water. Thus, the industrial water requirement also appears to have been underestimated. Overall, the estimated current use of water at 3912.94 MCM/year is a gross underestimation of actual water utilisation in the basin. The Gujarat Water Resources Planning Unit also estimated the potential treated for surface and groundwater utilisation in the basin to be 2910 MCM /per year (GOG 1996) vis-a-vis the current (1991) estimated water use of 3912.94 MCM/year. This means annually at least 1000 MCM more water was used than the estimated amount available even with the development of the potential in the basin. This ignores the underestimation of utilisation of water discussed above.

Assuming that the estimates of surface water availability are relatively more accurate than the estimates of groundwater, the additional water used is extracted from the groundwater sources. Besides, provision of irrigation to 45,548 hectares of land in the Mehsana district from Dharoi water reservoir and 33600 hectares of land in the down stream Ahmedabad districts are outside the basin area (GOG 1996). Purely from the point of view of competitive demand - supply equilibrium, the above empirical evidence indicates that the requirement exceeds the supply and .this leads to competition for capturing the scarce water. The growing competition for capturing the water sources is evident from frequent diversion of irrigation water for drinking purposes and reservation of water for industrial and domestic purposes (Moench 1995). This aggregate analysis, being indicative, does not portray a complete picture of the conflicts in water use and management in the basin. These conflicts are discussed in Section 7. Before we do that, it is necessary to analyse the role of surface irrigation projects in the basin as a source of water supply.

5. SUPPLY AND ALLOCATION OF WATER IN SABARMATI BASIN

There are two large, eight medium and 569 minor irrigation surface projects in operation in the Sabarmati basin. On the whole, the surface irrigation potential has been fully developed and there is no further scope for new surface irrigation projects in the basin (GOG 1996). The surface irrigation system, however, is fed by numerous seasonal water streams and tributaries of Sabarmati. The Sabarmati river is also not a perennial river and surface water flow almost stops after December-January. This imposes a serious constraint on the surface irrigation systems which serve not more than 25 per cent of their designed command area (Table 4). It may be seen from Table 4 that in 1995-96 the total cultural command area of all the surface irrigation systems taken together was 3,21,821 ha and the irrigation command area (ICA) 2,22,337 ha. However, the average area irrigated over the three-year period, 1993-94-1995-96, by the surface irrigation systems was only 55,333 ha which is less than 25 per cent of ICA[4].

The surface irrigation system is also unable to provide sufficient water required for optimum crop yields. For example, in the last two years, the Dharoi canal system provided only two irrigations to crops in its command which is significantly less than

[4] In terms of rainfall, 1993-94 was a normal year, in 1994-95, the rainfall was above normal and in 1995-96 below normal.

Table 4: Development of Surface and Groundwater in Sabarmati Basin (1991)

Project	Cultural command area (ha)	Irrigation command area (ha)	Actual average area irrigated (ha)[1]
Surface Irrigation[2]			
Major and Medium Projects			
Dharoi	74,322	56,678	29,424
Vatrak	23,008	18,341	9,356
Wasna Barrage	95,883	33,600	NA
Kharicut	14,563-	10,200	NA
Hatmati	56,671	27,200	6,257
Harnav	6,720	45,363	200
Meshwo	28,369	18,292	3,726
Mazam	8,000	4,717	2,112
Guhai	11,465	7,111	3,593
Waidy	2,820	1,235	664
Minor Projects[3]	569	24,269	NA
Total	**3,21,821**	**2,22,237**	**55,333[4]**
Groundwater irrigation[5]			
			Gross Irrigated Area
Public tube wells	...	...	32,171
Private tube wells	---	...	1,23,278
Dugwells	—	—	2,51,219
Total	—	...	**4,06,668**

Sources and notes

1. The average irrigated area has been calculated based on actual irrigation during 1993-94, 1994-95 and 1995-96.
2. Data on surface irrigation projects were collected from the Irrigation Department, Government of Gujarat.
3. Refers to number of minor surface irrigation projects.
4. Excluding areas irrigated through minor projects.
5. Data on groundwater were taken from GOG (1996), Table 2.20, p.20.

the requirement. In view of this, farmers make alternate arrangements for irrigation using groundwater. The groundwater irrigation therefore is the mainstay for most of the farmers in the basin. Exploitation of groundwater through deepening of wells and finding new and dependable locations for wells, particularly in the Hatmati sub-basin, have become common phenomena involving substantial cost for the farmers in the basin.

That groundwater is an important source of irrigation even in the canal command areas of Dharoi project is indicated by the fact that water tables had markedly decreased between post-monsoon period of 1992 and pre-monsoon period of 1993 in the majority of the wells (*66* per cent), located in Dharoi canal commands (Table 5). It should be noted that the rainfall was above normal in the year 1992-93 and canal water was provided to more than 31000 hectares of land in the Dharoi right bank canal command. Despite this, the water table had gone down. Similar situation prevails in other areas under surface

Table 5: Fluctuations in Subsoil Water Levels in Wells from Post monsoon '92 to pre-monsoon '93 in Sabarmati Basin

Sr. no	Range of fluctuations (rnt)	No. of wells	Percent of total No. of wells-
1	+ 1.51 and more	38	6.0
2	+0.51 to 1.50	68	10.8
3	0.01 to 0.50	77	12.2
4	Nil	-31	4.9
5	0.01 to-0.50	154	24.4
6	-0.51 to-1.50	154	24.4
7	-1.51 and more	109	17.3
	Total	**631**	**100.0**

Source: GOG (1995) Report on the Behaviour of Subsoil Water Table (1992-93): Sabarmati Reservoir Project-District Mehsana & Sabarkantha

irrigation system. Conjunctive use of water is *de facto* practised as farmers do not exclusively depend on surface irrigation alone. However, surface irrigation, being complementary to groundwater irrigation, has helped in checking groundwater depletion in the canal command area.

Dharoi reservoir was constructed to provide irrigation and drinking water to Ahmedabad and Gandhinagar cities. The reservoir also provides water to the Gujarat Electricity Board for its plants located in Ahmedabad and Gandhinagar cities. This water is recycled for domestic use after treatment. The original plan envisaged that a total of 161 million gallons of water per day would be supplied to these two cities. The Ahmedabad Municipal Corporation (AMC) and Gandhinagar Township agreed to share the cost of construction. Table 6 provides information about the maximum inflow (storage of water) in Dharoi dam and the amount allocated to these two cities. It may be seen from the table that, from 1976-77 to 1996-97, water allocation varied from year to year from a minimum of 7 per cent to 100 per cent of the water stored in the reservoir. In the drought years of 1986-87 and 1987-88 almost all water stored in the reservoir was allocated to these two cities. The State Government has also made a provision for carrying over to the next year the unutilised quota of water for drinking purpose in a particular year and the quota is not allocated until next monsoon begins. This indicates that water allocation to these two cities receives a high priority over irrigation.

Table 6: Year -wise total inflow (water stored) and allocation to Abmedabad and Gandhinagar Cities for drinking purpose

Sr. No.	Year	Inflow in MCM (water stored)	Allocation to A'bad & Gandhinagar in MCM	Percent of total inflow
1	1976-77	2096	251	11
2	3977-78	2583	200	**7**
3	1978-79	578	189	32
4	1979-80	366	116	31
5	1980-81	1256	175	13
6	1981-82	429	195	45
7	1982-83	359	205	**57**
8	1983-84	1286	183	14
9	1984-85	832	274	32
10	1985-86	361	133	*-36*
11	1986-87	135	127	93
12	1987-88	57	58	100
13	1988-89	773	123	15
14	1989-90	351	160	45
15	1990-91	1408	147	10
16	1991-92	640	194	30
\7	1992-93	2169	198	9
18	1993-94	1147	193	16
19	1994-95	2428	170	7
20	1995-96	299	252	84
21	1996-97	361	124	36

Note: Rounded off to the nearest full number

Source: GOG, Department of Irrigation, Dharoi Subdivision. Dharoi; Mehsana

In addition, the Government of Gujarat has made available some of the reservoir water recently for fluoride-affected 559 villages and 8 cities of Mehsana district and has reserved 63 MCM/year for the purpose. The GWSSB has been authorised to construct water distribution systems for those villages. If our discussion with the system managers is any indication, similar provisions are to be made for Sabarkantha villages and towns also. All these actions suggest that drinking water receives a priority over other purposes. Furthermore, cities and towns receive a priority over rural areas in allocation of drinking water. In fact, the higher priority for drinking water allocation is given not only at the time of water allocation but also when the reservoir itself is designed. For example, to enable higher allocation of water for drinking purposes, sluice gates for releasing drinking water are located lower than the sluices meant for releasing canal water.

6. COMPETITION AND CONFLICTS: EVIDENCE FROM CASE STUDIES

As we stated earlier in this paper, several case studies were conducted as part of this research to gain deeper insights into the nature of competition and conflicts among various uses and groups of users. In this section, we present those case studies.

6.1 Increasing Competition Upstream for Water: Lambadia Group Panchayat

In the upstream Dharoi sub-basin, the Lambadia Group Panchayat was selected for a detailed case study. The Panchayat consists of a cluster of seven villages, namely, Lambadia, Palpad, Tebda, Kharnia, Delka, Golwada and Cholia. The cluster of villages is located about 32 km away from Khed Brahma, which is the taluka headquarters. The river Sabarmati passes through the cluster of villages. All the villages, except Lambadia, are inhabited by the *bhil* tribe. The current inhabitants had settled there 2-3 generations ago. Prior to their settlement, the *bhils* were mostly hunters and gatherers and their livelihood was intricately linked to the surrounding natural resources (Ballabh and Thomas, 1995). The population within each of the villages however is dispersed in small hamlets of a few families each called *falias*. The topography of these villages is undulating and therefore, in the past, forests played an important role in reducing soil erosion and conserving water. According to the knowledgeable old villagers, deforestation and top-soil erosion have led to the decline of agricultural productivity over the years. This has compelled them to migrate in search of better means of livelihood elsewhere.

In all the seven villages, taken together, there were 964 households with a population of 5484 (1991 census) and only about 30 per cent land is cultivated. The main crops grown in these villages are pigeon pea, maize, black gram during rainy season and wheat during winter season. Irrigation is not developed extensively and less than 25 per cent of the cultivated area is irrigated. The only crop irrigated is wheat grown in the post-rainy season.

Water is required for two purposes, domestic use and irrigation. Traditionally, the domestic water requirement was met through the water stored in pits dug in rivulets and small streams draining into Sabarmati river. In more recent times, multiple sources have become available for meeting the domestic requirement of water. These include open dug wells, handpumps and panchayaf-supported drinking water supply schemes operated in one of the villages, Lambadia. Although availability of drinking water is not a problem in the villages, a few of the hamlets do not have sources located in their vicinity and, therefore, women have to walk 1-2 km to fetch water. The water table currently fluctuates between 60-90 feet, which is 20-25 feet lower than the level that existed about 25 years ago. The reason, as advanced by villagers, appears to be excessive use of water for irrigation which has been made possible by the introduction of diesel engines and development of surface irrigation system upstream on the tributaries of Sabarmati in Rajasthan, which according to them, hampers the recharge of groundwater. The problem is further accentuated by deforestation in upper reaches causing soil erosion and loss of top soil. These developments together have also reduced the inflow of water in Sabarmati. According to them, earlier, there used to be enough water in Sabarmati until April end but now it dries up by the end of February or the first fortnight of March.

It is interesting to note how irrigation spread in the area over the years. Till about 1970, the villagers were growing only monsoon crops and, during winter, they used to migrate to other parts of Gujarat and Mumbai in search of employment. When diesel pumps became a dominant source of irrigation in other parts of Gujarat replacing traditional human and bullock driven systems, the Patidars from other areas moved in here. Since there was a ban on purchase of land from tribals, the Patidars started renting out diesel pumps and pipeline to land owning tribal farmers for irrigating their crops. Usually, the sources of water were rivulets and streams or river Sabarmati. The owners of diesel pump sets received 25 per cent of crop share, or 50 per cent if he also met the cost of diesel and maintenance cost. The contracts normally had serious "agency problems". Several factors such as renewal of contract every year, a high degree of honesty among the tribals, and type of settlement in the area where homestead and agricultural fields are located side by side, helped diesel pumpset owners monitor and regulate the behaviour of their tenants (landowning tribals).

Gradually, over time many tribals were able to generate surplus income from improved agricultural production, which coupled with government supported credit and subsidy, helped them acquire diesel pumpsets of their own. At present, the government provides subsidy to the extent of 90 per cent (50 per cent from Integrated Rural Development Programme (IRDP) and 40 per cent from Tribal Development Corporation) to a tribal farmer in the area to acquire a diesel pumpset. In fact, a Large Agricultural Multipurpose Cooperative (LAMP) located in Lambadia sells more than 300 diesel pumpsets every year to the tribal community. This has helped to reduce the number of absentee water sellers in the area, who were claiming 1/3rd to 1/4th of crop produce in return for renting out diesel pumpsets. Capital was thus used by the Patidars to first augment farm income of tribals and then claim a share in it. About 20-25 per cent of the land is still irrigated using the rented diesel pumpsets. Now, even some of the tribals have also engaged themselves in water selling and appropriating rent. It is believed that now thousands of diesel pumpsets operate on river Sabarmati, its tributaries and rivulets.

6. 2 Mining Water for Profit: Dashotar Village

Dashotar village is located in Idar taluka of the Sabarkantha district. The village falls in Hatmati sub-basin of Sabarmati basin. The total revenue area of the village is 1620 hectares of which about 1416 hectares (87 per cent) is cultivated land. According to the 1991 census, there were 700 households in the village with a population 3288. In numerical terms, the village is dominated by Schedule Castes and Baxi Panch castes. However, agrarian scene is dominated by some 100 households belonging to the Patidar community. The main crops grown are cotton, maize, jowar, castor during monsoon season and wheat and lucern during winter season. During summer, farmers who own tubewells cultivate fodder crops. The village has a dairy co-operative society. Because of flourishing dairy business, a significant proportion of land is allocated to fodder crops in all the three seasons.

Water is required for domestic and irrigation purposes. Traditionally, domestic requirement of water was met through 'step wells' locally known as 'vav'. The construction of the *'vavs'* is done in such a manner that evaporation losses are minimized. Water is collected mostly by women using the steps for going down and climbing up. Two such wells are still in use in the village. These 'vavs' were built some 300-400 years ago. One well was for affluent upper caste and another for lower caste communities. A few old women from Schedule Caste families told us that they were not allowed to collect water from the 'vav' located in the middle of the village.

As the population grew, the number of wells increased in the village, particularly after the 1950s. However, the quality and quantity of water varied across the wells. A few old villagers told us that only a few people had the requisite expertise in locating good sites where good quality water was available in plenty. In addition, there were two tanks in the village, one of which was built by an erstwhile Zamindar. Tank water was used for domestic purposes other than drinking and for livestock. The tanks now are all in a dilapidated condition and a lot of silt has deposited in tank beds leaving no space for storage of water. Besides, construction of roads and a canal have reduced the catchment area of these tanks and hence the inflow of water into the tanks has also reduced. Consequently, they dry up even before summer begins.

Recently, when the demand for water increased, the village Panchayat constructed a water supply system. The old 'vav' was converted into a deep tubewell for the purpose. There was a provision for common washing and drinking water facilities near the Panchayat well. But the Panchayat well also proved inadequate and, therefore, a tube well was constructed about 0.5 km away from the village and water was transported through pipelines.

The water is supplied twice in a day for about 1-2 hours each time. The Panchayat charges a water tax for these services. The tax revenue is used to meet electricity and other costs of operation and maintenance. However, the amount collected is not sufficient for meeting even the operational costs. Recently, the village has also been brought under a Group Water Supply Scheme of GWSSB. The GWSSB scheme supplies water for domestic purposes. The quality of water supplied by GWSSB is reported to be better than that of the water from the village wells. However, by itself, none of these schemes can supply water sufficient for meeting the village requirements. The major complaint about GWSSB water supply is that it is erratic and uncertain. Overall, the water supply for domestic use, at present, does not appear to be a problem. A rapid survey of 5-6 nearby villages, however, revealed that it is becoming a serious problem in the area and those villages which are dependent upon only village Panchayat are facing acute shortage of water and the quality of water is also not good.

Water Use in Agriculture

The water use in agriculture in the village has undergone tremendous changes over the last four decades or so. In the traditional system, water was lifted from open wells in leather buckets using bullock power. This system was known as '*kos*'. The depth of well was not more than 50-60 feet. According to old villagers, there were more than 200 '*kos*' in the village until the early '60s when diesel pumpsets were introduced in the village. The pumpsets were used to lift water from open dug wells. When the yield of the wells started declining, farmers tried to capture water through making investment in vertical and horizontal bores in these open wells. As a result, the village had more than 50-60 dug-cum-bore wells. The pumpsets were energized by electricity in the early seventies. Over a period of the last five years, almost all farmers in the village have shifted to electricity. Introduction of electricity coupled with subsidized credit brought newer possibilities and many farmers went for deep tubewells. However, the number of deep tubewells did not increase much due to hard pan at about 80-90 feet from the ground level. For establishing a deep tubewell with good water yield, a farmer has to invest money in digging a minimum of four to five bore wells. This indicates that the success rate is hardly 20-25 per cent. At present, there are 20-25 deep tube wells and over 150 dug-cum-bore wells in the village.

A distributory of the Left Bank Canal of Dharoi reservoir project passes by the side of the village. The village fails towards the tail end of the distributory. As mentioned earlier, for a variety of reasons, the supply of canal water is erratic. Only about 20-25 per cent of the area of the village is in the command of the canal. However, the village records show that about 500 hectares of land is irrigated by canal and 150 hectares by tube wells. Many farmers lift water by diesel pumpsets and irrigate crops outside the command of the canal. In fact, some farmers have even invested in underground pipelines (3-4 km) to transport water from the canal. These farmers not only irrigate their fields but also sell water to other farmers. Such behaviour is not unique in Dashotar village. Similar pattern was reported from other villages located on both the right and left bank canals. Like in other parts of Gujarat (see Shah 1993), water markets are well developed in Dashotar and nearby villages. The primary purpose of investing in tubewells, diesel pumpsets and dug-cum-bore wells, as indicated by the farmers, is to have assured access to water for irrigation. Only when they have surplus water, do they sell water to others. Selling and buying of water, however, is widespread in the village. Despite tremendous growth in tubewell irrigation, the water table has not been declining as it is in other parts of north Gujarat such as Mehsana. Two factors have prevented the declining trend in groundwater table in the area. They are: hard pan which restricts access to ground mining, and canal water supply which, despite its supply being erratic and uncertain, helps recharge the aquifer.

6.3 The Death Knell for Ahmedabad City - Water Scarcity and Pollution

The Ahmedabad city is situated on the banks of river Sabarmati and is the seventh most populous city of India, with a population of 2876 million (1991 census). The population growth is estimated as 2 per cent per annum.

The geohydrology of Ahmedabad consists of thick alluvial deposits of Quaternary Age. There are alternating layers of sand, silt, clay and gravel in the alluvial deposits. A thick clay layer of 20-50 meters separates the deeper (>100m) aquifers from the upper unconfined acquifer. The deeper aquifers have a large extent and presently supply most of the water consumed in the city. In the sandy soil layers, the water table is found at the depth of 90m (Gupta 1993), The direct groundwater recharge, due to the percolation of rain water, is estimated as 15 per cent of the annual precipitation. The total area of the Ahmedabad city is about 269 sq. km of which the Ahmedabad Municipal Corporation (AMC) service area is about 190.84 sq.km. In AMC area, the service is provided by the organised water supply and sanitation system. The areas under the jurisdiction of Ahmedabad Urban Development Authority and Ahmedabad fringe areas are expanding

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rapidly. In these areas, the water supply is purely dependent on the groundwater. Further, it is has a decentralised waste water disposal system.

Until 1987, the Ahmedabad Municipal Corporation was able to supply 180 litres/person/day (Gupta 1993). The Ahmedabad city and metropolitan area around the city, continue to depend on groundwater only, and the dependence is going to increase in the coming years. Population explosion and the steep rise in the number of industries are the causes of serious concern. The alarming rate of increase in the demand for fresh water as well as the disposal of the sewage water and the industrial effluents pose major threats even to the city's existence.

Water Sources

For 2.876 million people living in the AMC area, the quantity of water provided is 430 MLD. Of this, 180 MLD (42%) is provided by Infiltration Wells and French (Radial) Wells situated on Sabarmati Basin (Table 7). While the slum dwellers draw water directly from the river Sabarmati (Pangotra and Shukla 1994).

Table 7: Sources of Water for Ahmedabad City

Sl.No.	Source	Quantity of water available in MLD**	Percent of total
1	Sabarmati		
	French Wells	145	29.84
	Dudheswar Water Works (Infiltration system)	82	16.87
	Sub Total	227	46.71
2	Tube Wells		
	AMC*	219	45.06
	East Ahmedabad	40	8.23
	Sub Total	259	53,29
	Total	486	100

•Apart from the AMC borewells, some privately owned borewells are also there. Lack of data prevented us to include their contribution to the total supply

**MLD - Million Litres Per Day

Source: TCE (1997), Water supply report Ahmedabad Muncipal Corporation

The city mainly depends on the subsoil water available from the tube wells (53.29 per cent). When the Sabarmati river dries up, the French Wells and Dhudheswar Water Works do not function at their maximum capacity. Thus, Sabarmati indirectly and directly affects the total water supply to the city. The dependence on groundwater and its excessive extraction has led to depletion of water table to the extent of 2-3 metres per annum (Gupta 1993).

The quantity of the Total Dissolved Solids (TDS) has been rapidly increasing over the past few years, apparently due to the intrusion of the polluted water into the French wells Table 8). Recent reports in the newspapers reveal that the fly ash content in the disposed slurry wastage from the nearby thermal power station also finds its way into these wells. This may increase the TDS to abnormal levels and make the water unfit for domestic usage.

Table 8; Water Quality in French Wells in Ahmedabad

Water quality parameters								
Sl. No.	Name of the French Well	**pH**	**Chlorides**	**TDS**	**Total Hardness**	**Turbidity**	**Colour**	**Alakli-nity**
			mg/1	mg/1	**mg/1**	**NTU**	Hazen Unit	**mg/1**
1	Acher	7.50	125	320	210	Nil	Colourless	**190**
2	Bhadreshwar	7.60	110	310	220	Nil	Colourless	200
3	Camp Hanuman	7.60	110	350	200	Nil	Colourless	200
4	Kotarpur	7.60	80	370	**180**	Nil	Colourless	170
5	Railway Brid	7.70	100	430	**140**	Nil	Colourless	**150**
	Standard Values							
	Desirable Limit	6.5-8.5	250	500	300	**5**	5	200
	Permissible Limit	6.5-8.5	1000	2000	**600**	**10**	25	600

*Railway Bridge (Sabarmati)
Source: TCE (1997) Ahmedabad City Water Supply Project.

The borewells contribute about 53.29 per cent of the city's total supply of water. There are *64* tubewelis' stations owned by AMC from which water is supplied for three hours each in morning and evening daily in summer and once for three hours in winter. The industries and bulk consumers have their own tube wells.

The supply is not metered for all the connections, except for bulk consumers. The depth of most of the AMC borewells has reached around 250 metres and the static water level has risen from 90 to 100 metres. Total Chlorides and TDS of all the borewells have already exceeded the desirable limits; this may affect the taste, corrodibility and palatability of water.

Excessive presence of TDS causes gastro-intestinal irritation and other disorders. The iron content in the Fatenagar tubewell water has exceeded the desirable limit (Table 9). This

Table 9 Quality of the Borewells' Water in Ahmedabad City

SL N.	Bor» Well N*.	Name of the Bare wells	Year of CON'	Total Depth	With drawal of water	Present Static water level	Qualify parameters				
				m	LLPD*	m	pll	CT	TDS	F	Fe**
								mg/1	mg/1	mg/1	mg/1
		Lal Darwaja Tube Well Station									
1	49	Compound Bore Well	1987	226.9	9.092	95 7	7.4	300	1118	1.010	0.001
2	52	Victoria Garden (Old Bore)	1987	253.6	18.184	92534	7.5	280	938	1.020	.002
3	62	Raikhad Old Bore	-'	-	-	-	7.5	300	953	0.986	0.001
		Brhrampurn Tube Well Station									
4	70	Vasant Rajab Bore	1990	254.5	18.184	98.146	7.0	380	1000	0.986	0.006
S	69	Bore- behind Urdu School	1970	-	18.184	94488	7.8	610	978	0.986	0.006
		Astodia Tube Well Station									
6	66	Petrol Pump Deripilha Bore	1996	243.8	18.184	94.488	7.8	610	978	0.986	0.006
		Pilot Dairy Tube Well Station									
7	78	Compund Bore	1972	-	18.814	96.102	7.0	580	1367	1.091	0.012
8	79	Municipal *Off.* Bore	1982	229.8	18.814	95.402	7.2	460	1422	0.891	0.010
		Jamalpur Tube Well Station									
9	67	Nr. Entrance Bore	1986	233.2	9.092	71,628	7.2	370	1200	0.101	0.102
		Ranchodpural Tube Well Station									
10	156	Compund Bore	1987	240.8	18.184	92.964	7.1	310	1098	1.091	0.012
11	15S	Rngicha Bore	1996	247.8	18.184	95.707	7.2	300	1121	0.981	0.080
		Madhavbaug Tube Well Station									
12	55	Nr. Gate Old Bore	1984	247.5	18.184	99.060	7.2	380	1321	0.702	0.021
13	59	Compund Bore	1990	259.1	18.184	99.060	7.2	520	1220	0.881	0.006
		Prakashnagar Tube Well Station									
14	92	Compund Bore	1976	226.3	9.092	73.152	7.5	350	1236	1.020	0.100
IS	95	Bngicha New Bore	1993	253.0	9.092	96.012	7.6	340	998	0.991	0.201
		Kanakaria Tube Well Station									
16	81	Old Compound New Bore	1994	257.9	18.184	105 16	7.4	430	1008	0.891	0.100
17	85	Swimming Pool Bore	1980	233.2	9.092	100.58	7.4	360	1122	0.916	0.006
		Fatchnagar Tube Well Station									
18	41	Store Bore	1978	196.9	18.184	79.858	7.3	410	1367	1.011	0.601
19	40	Compound Bore	1970	219.5	9.092	70.104	7.3	430	1298	1.060	0.601
		Pragati (Mccra) Tube Well Station									
20	$9	Slum Qu.vter Bore	1982	242.9	9.092	92.964	7.4	300	1107	1.010	0.002
21	86	Compound Bore	1988	256.9	18.184	92 964	7.5	320	1187	0.981	0.102
		Standard Valuei									
		Desirable Limit					6.5 to 8.5	250	500	1000	0.300
		Permissible Limit					6.5 to 8.5	1000	2000	1500	1.000

Notes:

Year of Construction

* Lakh Litres Per Day

Source: TCE (1997) Ahmedabad City Water Supply Project & Tata Consulting Engineers, Mumbai would affect the taste and appearance of the water and may promote iron-based bacteria also. Besides, the water table is rapidly falling in Western, Central and Eastern parts of the city. In 1940, the water level was about 12m to 15m; in 1984 it went down 60m to 80m; and in 1997 it was at 90m. So many tubewells have been abandoned due to their reduced yield and consequent increase in the pumping cost. But despite this, still, more and more tubewells are drilled by the Government agencies and private parties in response to the pressing demand for water. Thus, in future, the present unsustainable rate of withdrawal of water will surely lead to drying up of considerable part of the aquifer storage permanently (Gupta 1993).

Pilferage of Drinking Water for Irrigation.

As mentioned earlier, the AMC receives water from the Dharoi dam for drinking purposes. According to the original plan, 680 million litres of water was to be received by AMC per day. However, the actual supply depends upon the amount of water stored in the Dharoi dam. Supply of the water available from the Sabarmati ranges from 74 MLD (30 cusecs) to 294 MLD (120 cusecs). But the present demand of water is to the tune of 527 MLD (215 cusecs). Thus, there is a huge gap between the availability and requirement of water. During the offseason the city gets only 15 per cent of its water requirements.

The water released from the Dharoi dam travels 165 km through the river course to reach Ahmedabad. The farmers located upstream Ahmedabad town have constructed tubewells and convey the water to their fields through pipelines. *De jure,* farmers are required to take permission from the Irrigation Department, for pumping water from the river but they do not do so. They construct tubewells in their fields adjacent to the river and horizontally link them through pipelines to the riverbed on one side and to their fields located away from the river on the other. They not only irrigate their own fields but also sell water to their neighbours. The AMC therefore always complains that it does not receive the full quantity of water released for it from the Dharoi dam. Many farmers, on the other hand, claim that they have a natural/riparian right over Sabarmati river water since they are located upstream and their forefathers settled down in the area because of its proximity to the water source. The extent and amount of pilferage of water is not known but it seems to be substantial.

The ever growing gap between the demand for and supply of water, as discussed above, has led to the decline in quantity and quality of water supply to the residents of Ahmedabad city. Two coping strategies have emerged in response to the twin problems of declining quality and quantity of water. First, construction of private tubewells in the city has been going on at an alarmingly high rate. Second, to capture the maximum possible quantity of water during the limited period when AMC supplies water, residents use electric motor pumps of 0.5 HP or more to draw more than their fair share of water. This adversely affects the supply at the taiiend. In particular, the poor including slum dwellers who cannot afford to buy pumpsets suffer the most. The AMC's response to water scarcity is to find newer source of water and it is currently involved in a protracted negotiation with Government of Gujarat to provide water to Ahmedabad city from Narmada project.

6.4 Industrial and Urban Pollution and Impact on Downstream Villages

The river Sabarmati is dangerously polluted due to the disposal of municipal-cum-industrial wastes, and surface runoff from urban area and agricultural fields. The National River Action Plan (NRAP) programme identifies the Ahmedabad stretch of the Sabarmati river as one of the most highly polluted stretches in India (Pangotra and Shukla 1994). In terms of industrial development, Ahmedabad is one of the top ten cities in India with 15 to 20 per cent of its land occupied by industries. Every day, 470 million litres of polluted waste water is discharged from Ahmedabad city in the river Sabarmati which consists of 78 per cent of total waste water generated (Pangotra and Sfiukla 1994) .

Since 1987, some of the sewage water is diverted to one of medium irrigation systems, Fathewadi canal, and is used for irrigating agricultural crops. When sewage water is allowed to pass through the infiltration layer, it is automatically filtered and nitrogen, potassium and heavy metals present in it are significantly reduced. But the raw sewage water also contains pathogens which may cause cholera, typhoid and harbour salmonella bacteria, protozoa, eggs of worms and all types of viruses (Gupta 1993). Untreated or partially treated water could be used to provide limited irrigation only to selected crops such as fibre crops, trees, pastures and other crops which are not consumed by human beings. The treated water can be used to irrigate all types of crops. However, many researchers claim that irrigation with sewage and polluted water adversely affects changes in the grains size, storage life, taste, and cooking characteristics. Further, polluted water also causes wilting and drying of the crops irrigated and attracts several pests and diseases. This has been confirmed by a study of Gyaspur in Ahmedabad district and a survey of seven villages conducted by the Institute for Studies and Transformation (1ST), Ahmedabad. Some highlights of the study are presented in the following paragraphs.

Gyaspur Village in the fatal grip of Polluted Sabarmati River

Located on the downstream side of the Sabarmati river, the village Gyaspur is surrounded by the river on three sides. It is about 12 km away from the main Ahmedabad city. According to the 1991 census, population of the village was 5291 and number of households 1015 comprising Thakores (400 households), Prajapathis (65), Bharwads (72) and others (478). The total geographical area of the village is 826 hectares of which about 31 per cent is cultivated. Approximately 45 per cent of the cultivated land is irrigated. The main crops grown in the village are paddy, jowar fodder, pulses during rainy season and wheat during winter season. The villagers fear that they may have to leave the village because their cultivable lands are increasingly becoming unproductive. Besides contaminating the drinking water, the pollutants discharged in the river are leading to crop failures and abnormal rise in the incidence of different diseases. Since the late 1970's, drying up of crops and pest infestations have become very common in this village. A sharp rise in insect born diseases, skin diseases with common problems such as irritation, black patches, dry skin, and cases of abortions have also been reported by villagers.

Sources and Uses of Water

Water is mainly used for agricultural and drinking purposes. For agriculture, the sources are open wells, tube wells, Fatewadi canal and Sabarmati river. One tube well, which belongs to the Ahmedabad Municipal Corporation (AMC) supplies drinking water. Besides, there are forty eight open wells of which one is abandoned and three are dysfunctional. There are five tube wells which exclusively provide irrigation water. All these tube wells are privately owned by the farmers. Diesel pumpsets of 7.5-10 hp are used to draw water from Sabarmati river. There are at least 40-50 diesel pumpsets in the village. In addition, there are ten electric motor operated tubewells drawing water from the Sabarmati river. The Fatewadi canal irrigates about 24 hectares of village land.

AMC has constructed one of its waste water treatment plants in the village revenue area. AMC had also dug a deep bore well in the village way back in 1951 which was handed over to the village panchayat. AMC takes care of the maintenance and operation aspects. The overhead tank and underground pipelines are under the control of village panchayat. The bore well water is used for domestic purposes. The village animals are also dependent on the borewell water.

Consequences for Agriculture

The total area adversely affected downstream due to agricultural usage of the polluted water is about 4,500 hectares. Water seepage on the two sides of the river banks is about 250 metres which is aggravating the problems further. AMC constructed one drainage channel in 1942 to drain the sewage water from the Ahmedabad city into the Sabarmati river. The channel passed through this village. The sewage water was used for irrigation purposes. As per the farmers' perceptions, this practice in the beginning actually increased the fertility of agricultural lands in the village. In 1973-74, the supply was stopped. After the construction of the Dharoi dam, Fatewadi canal was excavated to supply a mix of sewage water and fresh water. The canal runs from the Dharoi dam to the downstream villages. The sewage water is treated at a plant located near the village before it is mixed with the fresh water.

Wilting and subsequent failure of growing crops in the agricultural lands adjacent to the treatment plant is a very common phenomenon occurring in the village. All over the village, pest infestations and disease attacks are on the increase and crop yields have gone down by as much as 50 per cent. The taste of the food grains has also deteriorated and so has their keeping quality; the storage life of the grains which in the past used to be twelve months is now reduced to less than three months. Now, the cultivation of high value cash crops like potatoes, papaya, sugar cane, water melon, sweet melon, guava, etc., is almost impossible.

In a study conducted by the Institute for Study and Transformation in seven downstream villages of the Sabarmati basin, 50 per cent of the respondents reported crop failures; 73 per cent yield losses; 69 per cent change in quality of grains and 93 per cent reported pest infestation in crops due to polluted water (Table 10).

Table 10: Perceptions of the Farmers, and Labourers about the Adverse Impact of Use of Polluted Water

Sl. No.	Village Name	No.of respondents	Crop failure	Yield Reduction	Pest Infestation	Quality Change
			No. of respondents attributed the factors to polluted water			
1	Hansol	16	5	7	14	10
2	AECP	-	-	-	-	-
3	Gyaspur	21	6	7	18	12
4	Saroda	18	15	16	18	16
5	Ramol	16	4	14	15	15
6	Bidaj	11	-	11	11	4
7	Vautha	17	16	17	17	12
8	Vataman	19	11	14	17	13
	Total	118	57	86	110	82

Source: 1ST (1996)

The impact of polluted water is not limited to the croplands and livestock only but extends to human beings also. The polluted water which stagnates in ditches and ponds in the village has become a good medium for breeding of mosquitoes. The incidence of malaria is very high in this village. Further, dangerous disease causing pathogens are carried to the downstream villages also. Besides, due to high soil moisture created by the water, a lot of shrubs and trees have come up on village common lands. The bushy growth of the shrubs and trees provide a safe hide out to thieves and other anti-social elements; leading to increasing number of thefts and looting, due to which the main path to Ahmedabad has fallen in disuse.

The *"kakus"* plant area is used for disposal of dead animals. The carcasses pose serious health hazards. The dogs who live on the rotten debris of the dead animals, catch a dreaded disease "rabies". Many men, women and children are bitten by those dogs every year and die of hydrophobia. The bad smell and pathogens generated from putrefaction of carcasses are spread throughout the surrounding areas making them uninhabitable. Most of the children in this area are suffering from swollen stomachs, jaundice and polio.

The Pirana sewage plant also emits bad odour and pollutes this village. Older people and children suffer from serious respiratory problems, vomiting, and headaches. According to a local doctor, incidence of diseases is highest during monsoon season and this, in his opinion, is due to the pollution created by the two treatment plants.

Until. 1960, the open well water was safe to use for all domestic purposes and no problems were encountered. But now the groundwater aquifer is also contaminated due to percolation of polluted water. The water stored in the vessels for two-three days causes dark and white spots on the vessels. The water drawn from the 200m deep borewells appears normal at first glance but the food cooked in the water develops a pinkish layer on top within few hours after cooking. The co-ordination between the pollution monitoring and the controlling agency is very poor and the powers of such agencies are restricted by the legal complexities. Added to it is the double standard used by the organisations involved in supply of drinking water to rural areas (Shunmugam and Ballabh, 1997 p. 10). The data supplied by two organisations AMC and GWSSB from an analysis of a sample of drinking water from a well of Gyaspur village, located downstream of Ahmedabad prove this point (Shunmugam and Ballabh 1998, p.9). The AMC concludes that the water is potable whereas GWSSB arrived at contradicting conclusion.

The industrial growth in the basin has not only contributed to the decline in the quantum of water available for other purposes, but also led to deterioration in the quality of water in the basin. This can be gauged by the fact that the industrial BOD load from the cities of Ahmedabad-Gandhinagar alone works out to about 30 per cent pf the domestic BOD load unlike Delhi and many other cities of India where industries contribute hardly around 10 per cent of the domestic BOD loads (CPCB, 1989 p.45).

7. CONFLICTS IN WATER USE AND MANAGEMENT IN SABARMATI BASIN: A SYNTHESIS

This section attempts to synthesise the analyses and discussions presented in the previous sections and identify the present and potential conflicts in water use and management in the Sabarmati basin. The synthesis is done with reference to the conceptual framework developed in the beginning of the paper.

We begin with the assertion, which is based upon the empirical evidence presented in the paper, that the total quantity of water used in the basin is more than the quantity supposedly developed from both surface and groundwater sources and that the demand for water has been rapidly increasing over time in both urban and rural areas. A conservative estimate suggests that the demand for water in the basin would increase to 4343/per year in 2001 and 5782 MCM/year in 2021 (GOG 1996). It is also projected that the domestic and industrial demands would increase faster than the demand for agricultural uses. This means that the present use pattern is not sustainable and that water is becoming scarcer day by day and the stage is being set for all round competition for capturing the fast depleting water sources in the basin. We have identified the following conflicts in use and management of water resources in the basin.

7.1 Conflicts between upstream and downstream users

The rapid increase in the use of water in agriculture in the upstream area, as typified by Lambadia case study, is causing scarcity in the downstream area. In the absence of well-defined property rights in river/stream water, surface water sources in the basin are *de facto* open access resources and therefore are being over-exploited; the riparian doctrine does not promote socially optimum use of water. Pumpsets owing farmers not only irrigate their own land but also sell water to others. In fact, many absentee owners of pump sets rent them to the land owners and appropriate quite a big chunk of the surplus generated by irrigated agriculture. The upstream of Sabarmati basin has hard rock geological formation and confined aquifer, and therefore the overdraft of water from such aquifers is difficult to replenish. Although the tension between upstream and downstream users in the Dharoi sub-basin of Sabarmati has not yet reached alarming levels, indications are that these issues would become important in the near future. Downstream people attribute the declining water availability to excessive withdrawals upstream.

A similar situation obtains in the alluvial plains of the basin. The extraction of water from unconfmed groundwater aquifer affects the movement of water. For example, in the late 60's and early 70's, the flow in Sabarmati declined significantly due to excessive withdrawal by the Ahmedabad Municipal Corporation (Moench, 1995). The decline in the river flow has been made good by increased releases from the Dharoi reservoir since 1976 (Patel, Sharma and Ramanathan, 1979). However, it appears that the increased withdrawals in the recent past for domestic and industrial purposes have adversely affected the availability of water in the vicinity of Ahmedabad and downstream villages.

7.2 Conflicts between agriculture and domestic uses

The excessive withdrawal of groundwater for agriculture as exemplified by the Dashotar case study in Hathmati sub-basin is leading to rapid decline of water table in the area. This has had an adverse impact on availability of potable water for domestic use in the rural areas. Farmers make substantial investment in informal water companies and transporting water to distant places for irrigation. They consider water lying beneath their land as their private property and therefore do not hesitate in mining as much groundwater as they can (Moench, 1995 and Singh,- 1997). Issues concerning regulation of groundwater withdrawal have been discussed by many scholars (see, for example, Moench 1993, Dhawan 1989, and Shah 1993). These studies point out that direct and indirect regulations have not helped in restricting farmers investment in the tubewells. The Sabarmati sub-basin is no exception to these general observations. In fact, these regulatory measures are counter-productive and have generated 'rent seeking attitude' on the part of the enforcing authority (Dhawan 1989, Shah 1993). Overall, the impact of regulatory mechanisms on extraction of groundwater is limited, and the rich and elite continue to benefit at the cost of the poor.

The government's response to the shortage of rural drinking water has been to bring more and more villages under the State-sponsored regional rural drinking water supply schemes. The schemes have mitigated the problem to some extent by supplementing the local water supply but they suffer from erratic power supply, bureaucratic inefficiency and inappropriate pricing (Prabhakar et al 1997). More and more water supply through long distance pipelines also means diversion of water from other uses to drinking purpose. For example, more and more of the Dharoi reservoir water is now allocated for meeting the drinking water needs of urban and rural areas.

7.3 Conflicts in allocation of surface water

The Government of Gujarat has clearly defined allocation priorities for surface reservoir water. Domestic use has the first charge on the water supplies available. This is followed by agriculture, industries and other purposes (GOG 1996). The main objective of the public irrigation systems is to allocate adequate water on time and equitably across various user groups and areas within the command. . If water is not sufficient to protect crops in the whole of a command area, then water allocation to the farmers is decreased proportionately and the crops grown in the tail end are left out (GOG 1990, See also Kolavalli et.al. 1994 for detailed discussion). For example, in years of scarcity right bank canal has received priority over the left bank canal from the Dharoi reservoir.

As between urban people and rural people, the former being more articulate, organised and politically powerful manage to appropriate more than their fair share of fresh water while the latter have to bear with whatever is left (Prabhakar et al 1997). This is evident from the fact that drinking water allocation to Ahmedabad and Gandhinagar cities receives priority over allocation to the rural areas from Dharoi reservoir.

7.4 Industrial Pollution and Rural People; Conflicts between Unequals

The magnitude of industrial pollution in the basin has been increasing at a rapid rate and it is the rural people who suffer from the pollution most. Several public interest litigations are pending in the Gujarat High Court. In a landmark judgement, the Gujarat High Court declared that "the polluter has to pay" and directed that no expenditure is to be incurred for treatment of industrial discharge from the public exchequer. The litigation was about the pollution caused by chemical industries located near Ahmedabad. The High Court issued directions to the State Government to close down the industries classified as specified industries causing damage to the water bodies. The Supreme Court of India in 1980 invoked Article 21 of the Constitution which guarantees the right to life and hence to water and environment and thereby restores the people's natural right to water quality. Similarly, the Kerala High Court upheld the right of the residents of Lakshadeep Islands against the excessive groundwater pumping by large farmers (Saleth 1993).

In Gujarat, the Narmada project is considered the lifeline and is expected to solve all the problems related to water (Moench 1995). Some of the areas within the Sabarmati basin which fall in the command of the Narmada canals, including Ahmedabad and Gandhinagar cities, are likely to receive from the project a substantial amount of their domestic water requirements if the current protracted negotiation between the AMC and the Government of Gujarat are successful. According to some informed sources, the Narmada water can reach up to Ahmedabad even if the height of the Sardar Sarovar Dam is not allowed to increase. If this happens, it would certainly solve the problems associated with drinking water supply in Ahmedabad. However, it is unlikely to resolve the conflicts associated with overdraft of water in rural areas, overdraft of water by industries and pollution caused by industrial discharge into the water bodies. To conclude, we could say that the total quantity of water used in the basin markedly exceeds the total quantity available and that the gap is going to widen over time. This has led to growing competition and conflicts among various uses and users of water. There is need for evolving an appropriate institutional structure for judicious allocation of water and regulating its use. Otherwise, there would be more competition, more pollution and more conflicts in the future.

8. THE RESPONSE AND ALTERNATIVES

Efficient and effective management of water in a basin requires that the software and hardware of it are in tendem with each other, the software being the legal aspect of water management, and the hardware being the political-cum-organisational involvement prevailing in the basin. The case studies demonstrated that this is hardly the case in the Sabarmati basin. There is complete anarchy in the use and management of both surface water and groundwater in the basin. The Irrigation Department has little control over even surface water systems beyond damming and releasing water for drinking and irrigation purposes. The hierarchy of claims on water is determined more by the default option. Rural people suffer most from the default option than by any systematic planning. Urban domestic uses get a high priority because of high density of urban population and its greater political weight. The primacy extracted by industry in its claim on water is on account of its concentrated economic power and its ability to pay high price for water. Defective pollution laws and their lax enforcement allow industry to impose water pollution diseconomies on rural population. Irrigation too gets a high priority over drinking water primarily because of the economic power that irrigators enjoy. In contrast to all these, people worst effected by drinking water scarcity are the poorest in the villages, people in remote rural areas, people in areas which are agriculturally least developed and people living in slum areas of urban fringes. Their vulnerability and powerlessness, their sparce distribution over a vast territory and lack of organisation all combine to deprive them of the political power and influence needed to deal with the water problems they encounter.

A discussion with some of the political leaders in the basin indicated that while everyone is suffering and ever willing to cooperate in the legal battles, people are disenchanted with the legal and bureaucratic hassles and delays. One of the reasons for the tardy progress in settling such cases is that the people who suffer from industrial pollution are poor, dispersed and not organised. Whereas those who pollute are economically more powerful and organised. The state policy also favours the polluters on the ground of industrial growth and employment generation. In fact, during the 1990 and 1994 assembly elections in Gujarat, villagers in the affected area tried to seek promise from the contestants for redressal of their grievances. The then Chief Minister, (late) Chimanbhai Patel, had promised that the norms of pollution control would be strictly enforced and none of the industries would be allowed to bypass these regulations. However, political expediency and powerful industrial lobby stalled all efforts to control the pollution and people of this area continue to suffer.

In the Sabarmati basin, Khari, a minor tributary of the river Sabarmati, carries heavy polluted loads from Vatva and Odhav industrial estates of GIDC before its confluence with river Sabarmati downstream of Ahmedabad city. It has also been reported that the directions of Gujarat Pollution Control Board for setting up of common effluent treatment plants in those industrial estates have not been heeded to by the GIDC (Shunmugam and Ballabh, 1997 p.21). The Ahmedabad Municipal Corporation protests against the industries upstream of Ahmedabad when it comes to pollution of river water on which it mainly depends for drinking water supply to the city. However, AMC itself is responsible for pollution of both surface and groundwater in the downstream villages due to the letting out of untreated and partially treated municipal sewage in the river. This shows that the double standards of organisations involved in as service providers and water pollution control (Shunmugam and Ballabh, 1998 p.9)

The response of NGOs to water scarcity and conflict in Sabarmati basin has been multifaceted. Some of the NGOs are experimenting, involving farmers in management of surface and groundwater. Others are engaged in collecting and disseminating information relating to consequences of mismanagement of water in the basin. These experiments and knowledge are of critical significance in expanding our understanding of the art of possible and some of the NGOs claim that they have identified technologies and institutuions that could mitigate the conflicts at the micro level. The NGOs experiments are, however, too small in scale to cope with the conflicts and the real dimension of problem. The government, on the other hand, believes that the water scarcity problem in the Sabarmati basin could be solved only by transporting water to the basin from water abundant areas. Such an approach is unlikely to resolve the conflicts associated with water use and users but it can perhaps reduce the intensity of scarcity. Besides, the solution will not be efficient and just and the poor and the weak would continue to remain marginalised.

The issues involved in water resources management in the Sabarmati basin can only be resolved through an integrated approach considering both the demand and supply of water resources and creating institutions which could effectively preserve water bodies of the basin. The Sabarmati basin supports millions of people having different interests and spread over a vast geographical area. Hence creating an appropriate institutional structure will involve enormous thinking and effort. The structure must be robust so as to cater to the needs of different water users belonging to different segments of society, having differential bargaining power and conforming to the political economy of the state. Such an institution should not only be involved in the allocation of water but also give a high priority to preservation and maintenance of water balance in the basin. This can only be achieved through creation of a network of user-owned and controlled water institution, at the basin level. The institutions should have ownership right over water bodies and should be empowered to determine important import and export of water to and from the basin.

9. CONCLUDING REMARKS

Like in most of the arid, semi-arid and hard rock regions of India, existing and potential demand for water in the Sabarmati basin also far exceeds the present and potential supply of water if the present pattern of and trend in water use continues unabated. The widening gap between the demand for and supply of water in the basin is leading to increasing conflicts among water uses and users. The rapid growth of industries, urbanisation and intensification of irrigated agriculture in the basin over the last few years have further aggravated the water scarcity problems and the competition for and conflicts over water use. In the absence of a clear-cut policy for allocation of water and regulation of water use and of an appropriate institutional structure for promoting sustainable and equitable use of both surface water and groundwater in the basin, conflicts among water uses and users are bound to increase in the future. There is urgent need to regulate and monitor water allocation and use and augment the availability of water in the basin through appropriate policies and institutional structures that are owned and controlled by network of water users but managed professionally.

The growing industrialisation and urbanisation in the basin have resulted in pollution of water in the Sabarmati river and its tributaries and consequent deterioration in the quality of both drinking water and irrigation water in the basin. Rural people living in villages down stream Ahmedabad are most adversely affected by the growing water and air pollution; their crop yields have declined drastically and incidence of waterborne diseases such as malaria, chorera, and typhoid has increased recently. Being poor and unorganised, the victims of the pollution cannot even claim any compensation from the industries and the Municipal Corporation who are responsible for their miseries. The industrial lobby is so strong that even the judiciary and political leaders find it difficult to do anything to ameliorate the lot of the poor victims of pollution.

The NGO's experiments, though valuable, are far too small scale compared to the nature of problem. The issues confronting Sabarmati basin can only be resolved through pragmatic management at the basin level taking into consideration demand and supply for water resources and creating institutions which could effectively preserve water bodies of the basin.

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