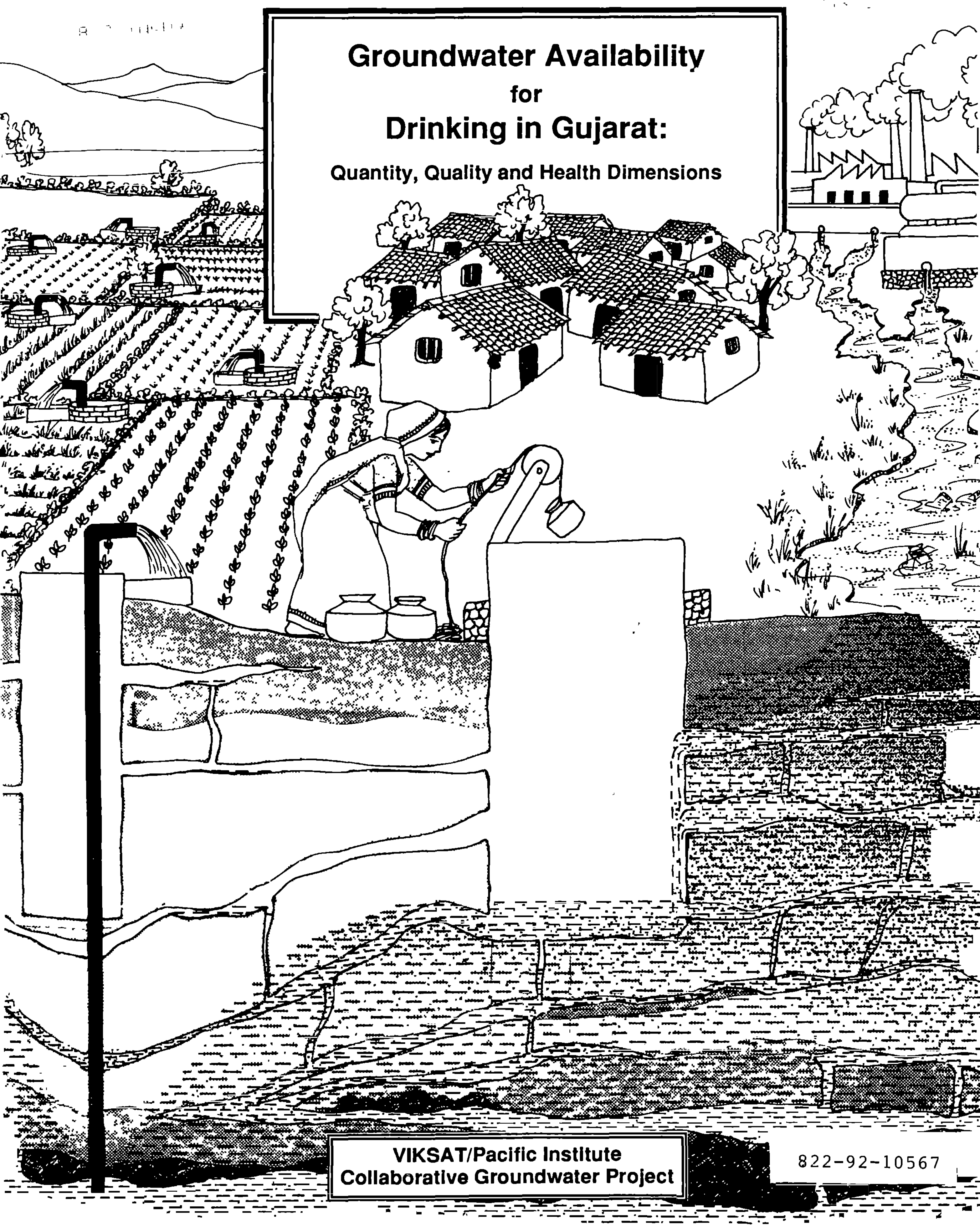
Groundwater Availability for Drinking in Gujarat:

Quantity, Quality and Health Dimensions



VIKSAT/Pacific Institute
Collaborative Groundwater Project

Groundwater Availability

for

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I Purpose

The purpose of this paper is to identify some of the linkages between health, quality, availability, and pollution for drinking water supply in Gujarat. Since a large proportion of drinking water needs are met from groundwater sources, primary attention is given to it. A brief overview of drinking water and related issues at the state level is presented first. Existing patterns of drinking water availability, quality and pollution are then discussed in detail with particular reference to health implications. This is followed by two case studies, one rural and one urban, that outline the health implications of current drinking water supply conditions in actual situations. The next section discusses equity, sustainability, and the importance of conservation in examining drinking water questions. Needs and ways forward are discussed in the last section.

Much of the data on which this monograph is based are of a qualitative nature. As a result, it should be taken as a first attempt to identify linkages, issues and potential solutions that deserve further investigation, not as a definitive statement.

II Overview

Water problems are becoming a central topic of debate in Gujarat. With the possible exception of perennial rivers in south Gujarat, surface sources within the state are extensively developed.[1] Groundwater tables throughout much of north Gujarat have been falling and overdevelopment is emerging as a major issue (High Level Committee, 1991, GOG, 1992). Water levels throughout much of Mehsana District are now dropping at annual rates of 5-8 meters, a dramatic increase from the roughly 1 m/yr decline prevailing until 1970 (GOG 1992). According to recent estimates, groundwater resources in 36 taluks, mostly in the north, are approaching overdevelopment.[2] Extraction currently exceeds recharge in a further 24 taluks (GOG 1992). The problem is, however, not just one of quantitative availability. Stream flows are highly seasonal. Most rivers in the north are not perennial while, in the south, 90% of the flow in rivers such as the Narmada occurs during the monsoon season. Quality is also an issue. Much of the groundwater in Gujarat is naturally saline or has contaminants, such as fluoride and nitrates, that limit its usability (Figures 1, 2, 3). Pollution from agricultural, industrial and municipal sources is also a major problem (Phadtare, 1989).

Water quality and quantity issues are linked. As pollution or other factors cause quality declines, new sources must be tapped to meet existing as well as emerging demands. This is particularly the case with drinking water

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[1] Even in south Gujarat there is a major debate over the existence of "surplus" water for allocation to water short regions. (Comments by Professor Y.K. Alag at the Workshop on Water Management, Sadar Patel Institute, Aug 3-4, 1992).

[2] Greater than 65% of available recharge in these Taluks is extracted.


INDIA
MAP OF GUJARAT
SHOWING DISTRICTS
PAKISTAN
RAJASTHAN
BANASKTHA
MEHASANA
SABARKATHA
GANDHINAGAR
KUTCH
AHMEDABAD
PANCHMAHAL
GULF OF KUTCH
SURENDRA NAGAR
KHEDA
RAJKOT
JAMANAGAR
MADHYA PRADESH
VADODARA
AMARELI
BHARUCH
JUNAGADH
BHAVANAGAR
SURAT
GULF OF KHAMBHAT
DANG
ARABIAN SEA
MAHARASTRA
VALSAD

Figure - 1

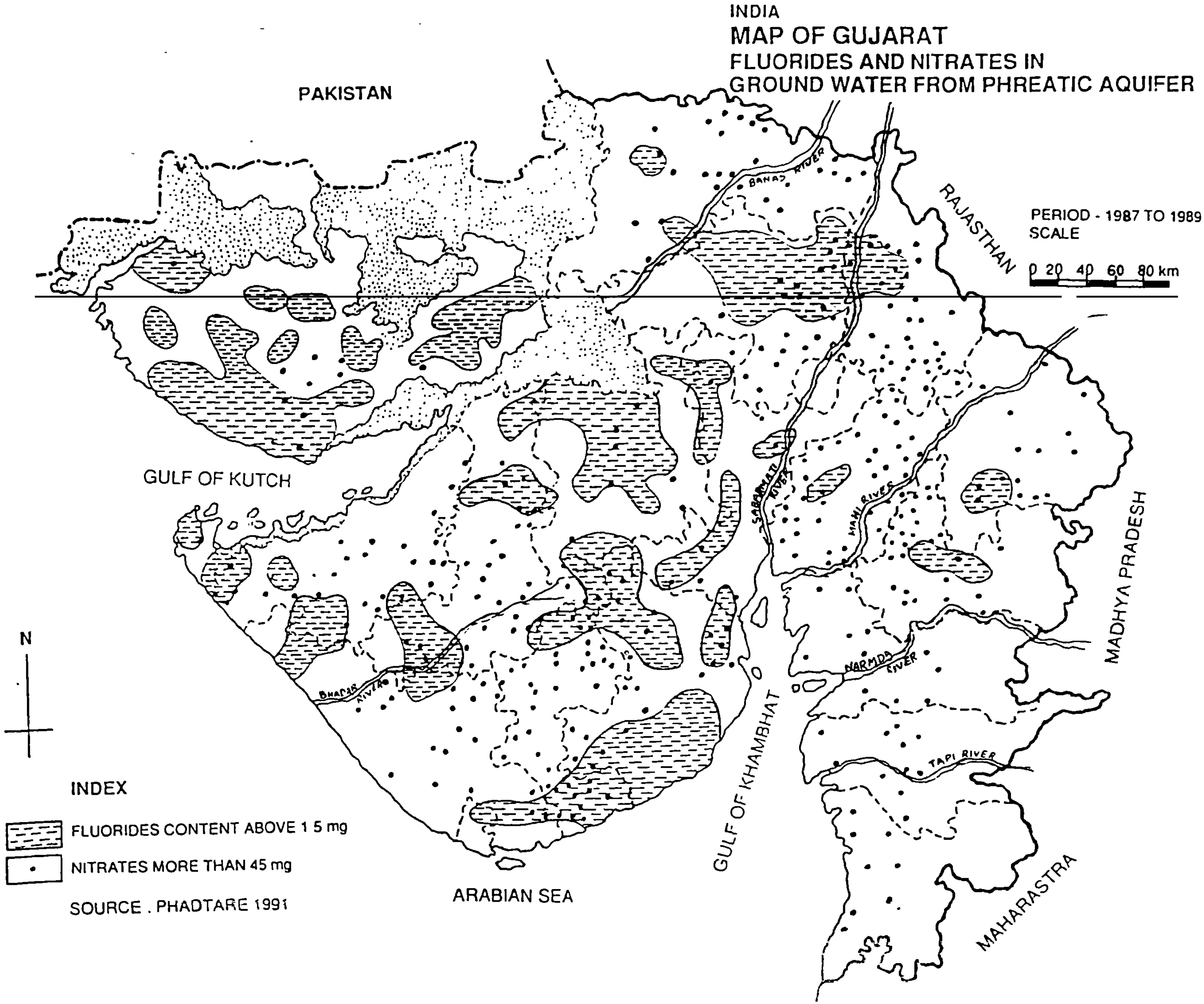
INDIA
MAP OF GUJARAT
FLUORIDES AND NITRATES IN
GROUND WATER FROM PHREATIC AQUIFER
PAKISTAN
RAJASTHAN
PERIOD - 1987 TO 1989
SCALE
0 20 40 60 80 km
BANAS RIVER
SABARMATI RIVER
MAHI RIVER
NARMDA RIVER
TAPI RIVER
BHADAR RIVER
GULF OF KUTCH
MADHYA PRADESH
GULF OF KHAMBHAT
ARABIAN SEA
MAHARASTRA
N
INDEX
FLUORIDES CONTENT ABOVE 1 5 mg
NITRATES MORE THAN 45 mg
SOURCE . PHADTARE 1991

Figure - 2

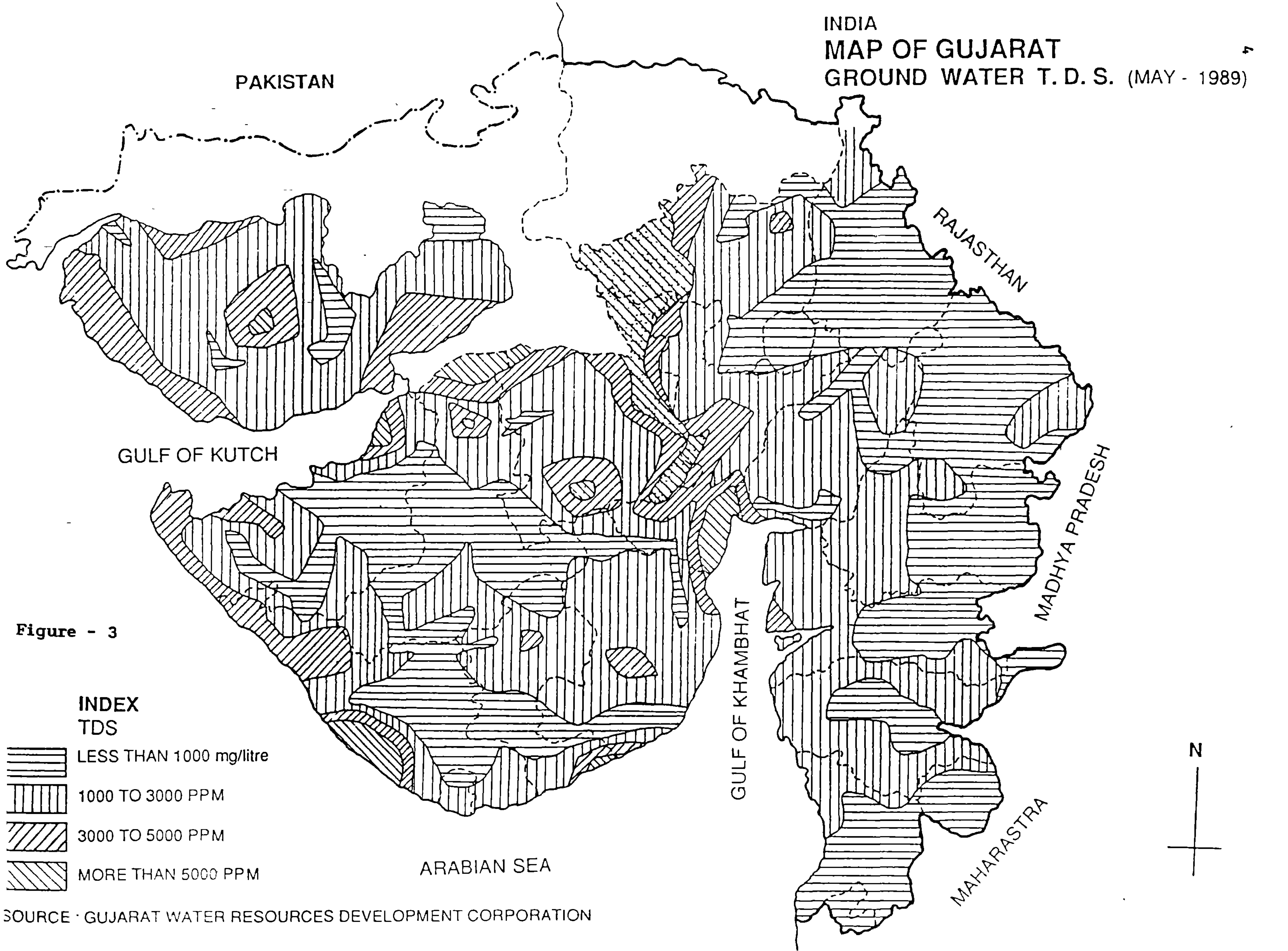
INDIA
MAP OF GUJARAT
GROUND WATER T. D. S. (MAY - 1989)
PAKISTAN
RAJASTHAN
GULF OF KUTCH
MADHYA PRADESH
GULF OF KHAMBHAT
INDEX
TDS
LESS THAN 1000 mg/litre
1000 TO 3000 PPM
3000 TO 5000 PPM
MORE THAN 5000 PPM
ARABIAN SEA
MAHARASTRA
N
SOURCE · GUJARAT WATER RESOURCES DEVELOPMENT CORPORATION

Figure - 3

where quality is critical to usability. Saline intrusion is affecting the quality of groundwater supplies traditionally tapped to meet municipal drinking needs in many coastal areas. The response of cities is often to drill wells inland or take water from irrigation supply schemes.[3] Under India's National Water Policy, drinking water has the highest priority (Ghosh & Phadtare, 1990b, p.434). Already most irrigation schemes in the state have been forced to divert water to meet drinking needs.[4] Instances of urban-rural conflict over water supply have developed due to this. Over the long run groundwater pollution problems will probably elicit similar responses.

Quantitatively, irrigation consumes by far the largest amount of water in Gujarat. Domestic and industrial demands are, however, growing. Gujarat's population doubled between 1901 and 1961, it doubled again between 1961 and 1991 (Gandotra, 1992). Much of this growth is in the urban areas. Furthermore, there has been a major shift in employment patterns. Agriculture has declined while non-agricultural employment has increased.[5] In general, it is clear that urban areas are growing much more rapidly than most rural areas and their water supply needs are growing with them.

Growing populations have caused an increased dependence on groundwater. Ahmedabad, which historically depended on shallow wells and surface water sources, now has over 450 deep municipal tubewells (CSE, 1985, p. 34). Private wells are also a major, if not the major, source of supply within the city area. Overall, there is a growing dependence on groundwater to meet municipal needs.

Despite a widespread awayness of emerging water problems, the debate over water is often fragmented and major factors affecting future water supply needs go undiscussed. One of these factors is the linkage between quantity, quality, and health in the supply of drinking water.

Improving the health status of Gujarat's population is a major development objective. To achieve this sufficient volumes of clean water are required for drinking and personal hygiene. Drinking water needs, although receiving the highest priority, tend to be regarded as a minor factor in the overall question of water allocation. They are volumetrically much smaller than agricultural demands and it has generally been assumed that they can be met with little impact on other users. Population growth, pollution, depletion of available water sources and the necessity of improving water supply if health concerns are to be addressed raise questions about the basic validity of this assumption. Thus, problems of water quality and pollution have major implications for water allocation and quantitative availability throughout the state.

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3 See article entitled: "Looming Spectre of Water Riots," Times of India, April 20, 1992.
4 Discussions with officials at the GWRDC and GWSSB.
5 Personal communication Dr. Y.K. Alag, based on NSS data.

The Sardar Sarovar Project (SSP) is widely portrayed as solving quantitative availability concerns. This will not necessarily be the case. The SSP is now expected to supply water to a population of roughly 40 million in 135 urban centers and 8,125 villages (Independent Review, 1992, p. 317). This represents an increase of 20% in the population the project was initially intended to serve but the amount of water available has not increased. Simply addressing the groundwater overdraft in Ahmedabad could require as much as 11% of the total water allotted for drinking under the SSP.[6] Ahmedabad is far from the only city with major overdraft problems. Furthermore, the SSP will not supply drinking water to areas having alternative surface or groundwater sources (Independent Review, 1992, p. 317). As populations grow, larger areas are provided with access to taps, and groundwater overdevelopment problems mount, the ability of allocations from the SSP to meet drinking needs will decline.

Although increased drinking water availability requires the identification of new sources of supply, a purely supply oriented policy is likely to be counterproductive. Fully tapped homes and businesses often use substantially more water than is actually needed. Encouraging this by focusing only on supply will reduce the water available for other productive uses and intensify tensions over allocation. Furthermore, simply increasing supply under conditions of poor sanitation and drainage often exacerbates existing health problems. Below 20 lpcd, water is unavailable for washing and other activities necessary to maintain a certain level of hygiene. Yet, there is little evidence that supplying more water to communities who receive 20 or more lcpd will improve health status if the inhabitants do not have access to working sanitation and drainage facilities. (Esrey & Habicht, 1986).

Approaches focused purely on supply can exacerbate aspects of the problems they are intended to address. Surface streams often play a dual role of providing drinking water and acting as sewers. They also recharge groundwater sources. Dams operated to provide municipal water supply often lead to a decrease in base flows, particularly in the dry season. As a result, pollution concentrations in the rivers rise decreasing their usability as drinking water sources and potentially contaminating adjacent groundwater. A vicious cycle can develop where the development of new supplies leads to the degradation of existing sources which, in turn, leads to further demands for new supply.

A variety of actions could, at least in part, address drinking water needs and associated health problems in urban areas with little increase in external supply. Repairing leaking water and sewer mains could increase both the

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[6] The overdraft in 1974 was estimated at 120 MCM (Pathak, 1985). Since then the urban area has expanded greatly and the overdraft with it. Gujarat has allocated 0.86 MAF for drinking water supply from the project. 0.86 MAF is equivalent to 1060.3 MCM. 120 MCM is 11.3% of 1060 MCM.

quantity and quality of water supplies reaching end users. Conservation in high-use sections of urban communities could also free substantial water for those areas (often within the same city) that face water shortages. Finally, treatment and re-use of waste waters could be a major source of new supply. These actions could have a variety of health benefits and reduce the pressure of increasing urban demands on new external sources of supply.

Little alternative exists to identifying new sources of supply in many rural areas. Even with improvements in urban supply systems, over the long term population growth and water quality problems will increase pressure on available supplies. At the same time, it is important not to minimize the value of maintaining base flows and using municipal water supplies as efficiently as possible when analyzing approaches to drinking water and associated health problems. Overall, meeting water requirements of growing populations and solving existing health problems requires water management approaches that integrate concerns related to natural quality, volumetric availability, sanitation and pollution.

III Drinking Water Availability

The volume of water available for drinking is an issue in both urban and rural areas. Most urban areas in Gujarat supply drinking water for only a few hours each day even in years of sufficient rainfall. Drought can cause large shortfalls and with it major social tensions.[7] Many urban areas are unable to maintain current levels of supply. In Baroda, for example, the municipal corporation was able to supply only 153 liters per capita per day (lpcd) in 1991 while in 1901 the supply was 246 lpcd. Projections suggest that the city will be only able to supply 97 lpcd in 2001 unless major new sources are found (Gandotra, 1992). Gandhinagar, the capital of Gujarat and residence of many government officials, uses an average 340 lpcd, a level nearly at par with use in the United States.[8] Ahmedabad, on the other hand, is only able to supply an average of 170 lpcd -- and much less than that in many slum areas. Rural areas face equal problems. During the 1987-88 drought the state had to supply water by train to rural northern areas in order to meet drinking needs. Even in normal years many villages have to be supplied by tankers. The following sections examine questions of urban and rural drinking water availability in more detail.

A) Urban -- The Ahmedabad Example

Population growth in Ahmedabad is causing severe strain on the ability of Municipal Corporation to provide sufficient water. Ahmedabad's population is increased 22.9% over the past decade whereas the increase in water supply for the same period is only 4% (Bhattacharya and Pandya,

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7 See article entitled: "Looming Spectre of Water Riots," Times of India, April 20, 1992.

8 Personal communication S.C. Sharma, chief hydrologist, Gujarat Water Resources Board.

1988, p. 2). Since independence decadal growth rates in the city have generally been near 45% (CPCB, 1989). For the most part, growth in the industrial and poorer eastern section of the city has occurred in an unplanned manner, further complicating the provision of basic services.

Groundwater extraction from the city's tubewells increased from 6.4 MCM in 1951-52 to 69.45 MCM in 1971-72. By 1980, 450 tubewells withdrew 128.7 MCM of water for domestic and industrial purposes (CSE, 1985). As early as 1974 estimates placed the annual extraction from aquifers underlying Ahmedabad at 200 MCM/yr -- 2.5 times the estimated annual recharge of 80 MCM (Pathak, 1985, p. 12). Drops in the water table of 1.5-1.9 meters per year are common with outlying areas reporting drops of 3-6 meters (CSE, 1985, p.34).

During the year, municipal water is supplied for roughly four hours a day, two in the morning and two in the evening. In drought years the city must curtail the already shortened hours it supplies water. Municipal authorities discontinued evening water supply to the walled city of Ahmedabad in May and June of 1992 because of the shortage of potable water. This left only two hours of water supply in the morning.

Because of water shortages new housing projects generally drill their own private wells. Builders are well aware of the problem of falling water tables and often drill below the level needed to meet current needs. One private apartment complex in Ahmedabad drilled its well 1200 feet deep to ensure access to water for the years to come.[9] In most areas municipal water supply is so intermittent that even individual houses who receive municipal water build private wells if they can afford it. These private houses and housing projects are thereby able to have access to as much water as desired 24 hours a day.

Houses and middle class apartments that cannot afford individual wells invest in water storage tanks. These tanks can be filled by leaving the tap on during the two hours in the morning when the municipal water comes. This ensures adequate water for the household as well as a reserve stock against intermittent municipal supply. The urban poor are not so lucky. They rarely have private connections to their living quarters and must rely on the few taps provided by the Municipal Corporation. As a result they can only use what they can carry on their heads. Frequently there are long lines at the taps so that water collection becomes a tense as well as time-consuming activity. In Kodiyar Nagar, one of Ahmedabad's numerous slums, a population of 10,000 has access to just 3 taps supplied by the municipal corporation.[10] Given the limited time water is supplied, individuals are only able to fill two to three pots, nothing more. This is typical of most slum areas. It is generally accepted that a minimum of 20-30 liters of water should be

[9] Personal communication, Dr Hanif Lakdavala, Director of Sanchetana.
[10] Data from Sanchetna, an NGO working with community health and awareness programs in Ahmedabad.

provided per capita (Lee and Bastermeijer, 1991, p. 6). However, it is rare that the urban poor have access to this amount. Studies done in Milatnagar, a slum in Ahmedabad, found that only 7.5 liters of water were available per capita.[11]

B) Rural

It is not only urban areas that face drinking water supply shortages. Rural areas are also grappling with increasing problems of water availability. Village ponds and pond wells are the main source of water supply in many areas where groundwater is limited or too saline for use (Patel, 1988). Especially in drought years, which Gujarat has had 10 of in the last 28 years, these ponds dry up or become too saline to use for drinking water.[12]

The number of villages classified as "no source", i.e. without a permanent source of water, has increased sharply. Although hard data are difficult to locate, the scope of the problem is illustrated by recent newspaper reports. In 1986 there were 12,250 villages that were classified as "no source". By 1987-88, when Gujarat was facing a one of its worst drought periods, 15,646 villages and 29 towns were under the "no source classification".[13]

Those villages that are lucky enough to have water supplies from borewells are often facing rapid declines in the water table. Drops in drinking and irrigation borewells are occurring throughout northern portions of the state. In Banaskantha District villages local farmers state that water levels in irrigation wells are dropping at rates of up to 12 meters per year.[14] Between 1978 and 1990 drops of 4-8 meters in unconfined aquifers and 20 meters in confined aquifers throughout Banaskantha and other northern districts are well documented (High Level Committee, 1991).

As the water table declines and drinking water demands grow, pressure will increase to divert further supplies from already strained irrigation schemes. Experienced officials expect that within 10-20 years most irrigation reservoirs will probably be earmarked for drinking water.[15] Even before new supplies are actually developed there are pressures to increase drinking water service areas. Water from the SSP, for example, was initially intended to supply 4,719 rural villages. The number of villages to be served has now increased to 8,125 (Independent Review, 1992, p. 317). Given steady increases in drinking water demands, conflicts are likely to erupt between agricultural users -- whose livelihoods may depend on access to irrigation -- and the populations dependent on drinking water. Switchovers are already occurring. The Amralla Regional Water Supply Scheme is pumping water for domestic use from sources

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11 Personal communication, Dr. Hanif Lakdavala.

12 See article entitled: "Looming Spectre of Water Riots," Times of India, April 20, 1992.

13 ibid.

14 Field visit to Banaskantha District, July 1992.

15 Personal Communication S.C. Sharma.

designed for agriculture.[16] During the 1992 drought newspaper reports stated that "almost all major and medium irrigation dams have now been linked to water supply schemes of major cities like Ahmedabad, Rajkot, Jamnagar, Baroda and Wadhawan" [17]

At present, rural areas are often forced to rely on water that is brought in by train or truck. Supply is often erratic and undependable. The government does not have enough tankers to cover all the villages that need water. Which villages receive water is often subject to political pressures. And the social situations within the villages mean that high caste villagers might receive water while the lower castes receive none.[18] Even where piped water supply schemes are present, breakages and water theft by residents near source areas often mean that those living near the end of the system receive little water. The net result is that villagers are often forced to depend on ephemeral and often contaminated surface water sources. Many simply leave their villages during the driest part of the year.

C) Health Implications

There is a growing consensus that the amount of water available for personal and domestic hygiene is as important a determinant of a community's health as the quality of that water. (Esrey and Habicht, 1986). "The provision and use of sufficient water, albeit of poor quality, could prevent the contamination of food, utensils and hands and the thereby reduce the transmission of major infectious agents of diarrhea" (Esrey and Habicht, 1986, p. 118). In their review of the existing literature related to water quantity, Esrey and Habicht find that where water use is low, "small increases result in health benefits, but the health benefits from an increase in the water above 20 liters per capita are not known" (Esrey and Habicht, 1986, p. 125). As previously mentioned, in many rural and urban areas of Gujarat, populations are receiving less than 20 liters of water per capita.

Aziz, Hoque et al further explain that it appears that most "endemic transmission of disease is not waterborne but water washed ... in most health impact studies in which significant reduction in diarrheal disease was detected, there had been improved access to water in quantity. In many studies that failed to detect an impact, only water quality had improved" (Aziz, K.M.A., Hoque, et al, 1990, p. 4). Water washed diseases are caused by transmission due to lack of water for personal and domestic hygiene. They include not only diarrheas (cholera, dysentery and unspecified diarrheas) but also worm (roundworm, hookworm, pinworm, guineaworm, schistosomiasis) skin (scabies, fungal ringworm, louseborn typhus) and eye infections (trachoma, conjunctivitis).

16 Personal communication, S.C. Sharma.

17 See article entitled: "Looming Spectre of Water Riots," Times of India, April 20, 1992.

18 See, for example, "Need to start 'water trains'," Times of India, April 22, 1992.

The importance of water quantity is often under emphasized in water projects that emphasize water quality. As Hardoy and Cairncross explain, there are political reasons behind the push for clean water. Water tainted by pathogens can affect anyone, including the engineer and government official. On the other hand, disease and hardship due to water scarcity affect only the poorest in a society, those who can do little about it. The impact of water scarcity manifests itself in dispersed and inconspicuous individual cases and not the sudden and dramatic newsmaking epidemics caused by biologically polluted water (Hardoy and Cairncross, 1990, p. 110).

The importance of having access to water in sufficient quantity cannot be overemphasized. Government organizations institute preventive public health programs involving immunization, pre-natal care, and child growth mon toring while ignoring the glaring problem of the water availability within the community. Although these programs have great relevance, without comprehensive development efforts that include ensuring adequate water and sanitation, their impact might be overshadowed by water washed diseases. In other words, a child might not die of an immunizable disease like measles, but rather succumb to repeated episodes of diarrhea. The morbidity associated with many of these diseases, affecting both children and adults, should not be ignored. For instance, diarrheal and other water related illnesses affect an adults working capacity and ability to earn. For many families that survive on daily wages, even one workday lost can mean no food for the day.

The means to remove water and human waste from the community is equally important as water availability. The interrelationship between water and sanitation is such that one without the other will have little impact on the health of the community (World Health Organization, 1989, p. 25). Especially where communities are receiving more than 20 lpcd it might be more cost-effective to invest in sanitation (Esrey and Habicht, 1986, p. 125). Adequate sanitation and drainage facilities carry potential infecting agents away from the community. "Adequate" sanitation implies the availability of sufficient water to flush human waste away. The lack thereof, even with the provision of sanitation facilities encourages the pool of disease producing agents within the community. Sewage and drainage facilities must also disperse or treat their effluents so as not to damage other communities. Sewers that run into rivers will affect the often poorer communities who live along the banks and use the river as a water source (World Health Organization, 1988, p.. 17).

Sufficient amounts of water combined with the absence of drainage facilities promotes mosquito and fly borne infections such as malaria, yellow and dengue fever, and filariasis. In urban slum communities in India the situation is especially acute during the monsoon period. Stagnant water dispersed throughout the community is filled with mosquito larvae and malaria becomes endemic.

D) Responses

Attempts to locate new sources and re-allocation of water from other uses characterize governmental responses to drinking water shortages. Each successive drought year sees the initiation of emergency well drilling and deepening programs. Long-distance pipeline projects developed to transport water from distant sources now supply water to many rural areas. Major surface water projects are looked at as solutions to drinking water problems in Gujarat.

Alternatives to increasing supply availability do not appear to have received close attention. Municipal water supply systems in cities such as Ahmedabad are often old and in urgent need of maintenance. Figures on loss rates due to leakage are unavailable. It is likely, however, that substantial increases in effective water supply could be achieved if loss rates were reduced.

In addition to improving supply systems, conservation could contribute greatly to water availability. There is a clear discrepancy between water use rates in many urban areas and drinking needs. The 340 lpcd used in Gandhinagar is double the 170 lpcd supplied in Ahmedabad and more than 45 times the amount used in some slum areas. Water use rates are well known to increase as access to private taps goes up. As long as individuals do not experience scarcity (or are able to avoid it via storage) the volume of water use does not concern them. In a strict sense, much of the water supplied to fully tapped urban households is probably wasted.

Incentives and techniques to encourage efficient water use could serve as a major "new" source of municipal water supply. This idea is not new. Officials at the National Dairy Development Board are considering re-designing milk processing plants in ways that reduce access to taps and encourage efficient water use.[19] In the many parts of the western United States the installation of efficient use technologies (such as low-flow shower heads, tap aerators, and low volume flush toilets) is required in all new construction and whenever houses are sold. These are important as a first step because they require little alteration of individual use pattern to be effective.

Finally, recycling water could be a major alternative to the development of new supplies. As the Central Pollution Control Board (CPCB) summarizes in its review of the Sabarmati Basin:

> "The limited information available brings out the intense pressure of ... irrigation, domestic, and industrials needs on the limited resources available. There appears to be little scope for future growth unless planned recycling is resorted to." (CPCB, 1981, p. 47)

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[19] Interview with Dr. Sen at National Dairy Development Board, March 4, 1992.

Recycling water would require treatment to levels suitable for drinking or substituting recycled water for new water in uses, such as irrigation, that do not require the same level of quality.

None of the above alternatives to the provision of new supplies are likely to be easy or inexpensive to implement. At the same time, continuous expansion of supply is itself expensive, will not solve many of the health problems associated with current water supply and sewerage systems, and appears unsustainable. Serious evaluation of the alternatives is required.

IV) Quality & Pollution

A) Key concerns

In Gujarat three factors, salinity, fluoride and nitrates, have a widespread effect on the suitability of groundwater sources for drinking purposes. In addition there are numerous localized instances of groundwater pollution. The true extent of quality concerns is, however, difficult to determine due to lack of data.

1) Basic Data

Lack of basic data place major constraints on the discussion of quality problems and their implications for water allocation throughout Gujarat. Although a large number of organizations collect water quality data no comprehensive base line studies exist for the state as a whole.[20] Furthermore, the quality of those data that are available is questionable. Often water samples are analyzed using old methods. In addition, control over sample collection and storage -- factors which can greatly influence the accuracy of measured parameters regardless of the analytical technique used -- is frequently poor.[21] Published sources of water quality data rarely mention the analytical techniques used or data collection and storage procedures. As a result it is difficult to interpret data, compare between sources, or determine which data sets can be trusted. Available data can be taken as indicative of overall patterns and emerging problems. They are not sufficient for accurately quantifying the implications of quality for health or allocation.

2) Quality

Coastal areas, western portions of Gujarat's central alluvial belt, and some of the older sedimentary deposits in Kutch have highly saline groundwater. Overpumping of groundwater for drinking, industrial, and agricultural purposes has caused sea water intrusion into many coastal aquifers. This problem is particularly significant in the highly permeable Miolitic limestone formations along the

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[20] Personal Communication, Dr. U.I. Bhatt, Chief Scientific Officer, Gujarat Pollution Control Board.
[21] Personal Communication, Dr. U.I. Bhatt

coast of Saurashtra. Saline intrusion affects large areas. As Shukla (1984) comments:

> "the switch to mechanized pumping of groundwater has led to a lowering of the water table from 10-35 meters and saline water intrusion due to a reversal of the hydraulic gradient. The increase in extraction from deepened drilled wells was used for sugar cane irrigation and processing. The consequence has been decreasing quality of drinking water for both rural and urban communities reliant on shallow dug wells. Over 12,000 wells were estimated to have been put out of use affecting 280,000 people." (Shukla, 1984)

Salinity in the central alluvial belt is of natural origin. Many of these are marine sediments and, therefore, inherently saline. Water tables are also often high in these areas causing salinization of near surface groundwater through evaporation. In Kutch, except for the Bhuj sandstones and a narrow belt of fresh water in coastal alluvium, most formations are saline.

Salinity affects the suitability of groundwater for drinking uses in a number of major urban areas and is causing cities to seek fresh sources often at a great distance. In Ahmedabad, for example, TDS levels in the water around industrial areas are as high as 3,000-4,000 ppm. According to government officials, Indian standards had to be relaxed from 2100 to 3500 ppm for Ahmedabad in order to match the levels authorities were finding.[22] As previously noted, much of Ahmedabad's water supply comes from groundwater and water tables are falling. High pumping levels combined with the leaky and interlayered nature of fresh and saline aquifers is causing salinity in many wells to increase. Over 30% of the open wells monitored by the GWRDC in Ahmedabad district have shown increases in dry season salinity over the past decade.[23] The entire dry season flow of the Sabarmati river has already been allocated for use by Ahmedabad and other cities (Phadtare, 1985, p. 12). As a result there are increasingly frequent demands for Ahmedabad to be allocated water from other sources. Since the only other sources are irrigation projects, these demands have significant implications for irrigation water allocations.

Similar quality problems leading to increasing pressures on quantitative availability are present in other areas. The city of Mangrol, on the Saurashtra coast, faces major problems of saline intrusion in the aquifers it has traditionally depended on for drinking supply. In response it has developed well fields inland and is piping the water into the urban area. This has major implications for rural communities, such as Amrapur where the Aga Khan Rural Support Programme is working, which often already face

[22] Personal communication, Mr. J.M. Barot, Joint Director, Gujarat Water Supply and Sanitation Board.

[23] Based on GWRDC data for their monitoring network of 56 wells in the district.

problems of groundwater depletion.[24] In north Gujarat the salinity of groundwater in many rural areas has forced the development of long distance rural water supply schemes. This often concentrates drinking water demands on the limited freshwater sources available causing or exacerbating depletion problems. Much of Kutch, for example, depends for drinking on water piped from wells in the Bhuj sandstones. Overdevelopment of these aquifers has been a well known problem for several decades.[25] Overall, the case of salinity best illustrates the link between quality and pressures on quantitative availability. The implications of fluoride, nitrates, and pollution are, however, much the same.

In addition to salinity, fluoride is a major natural contaminant in many groundwater sources. High fluoride levels in drinking water have been reported in parts of 13 states of India affecting approximately 25 million people (CEE, 1989, p.3). In Gujarat 11.2% of villages have drinking water sources that are contaminated by fluoride levels beyond acceptable limits.[26] Research done at Gujarat University found that 16 out of 28 randomly selected villages in Mehsana District exceeded the WHO maximum of 1.5 ppm.[27] Recent studies in Mehsana indicate the presence of fluoride in "all the aquifers down to a depth of 100 meters in almost the entire district" with concentrations ranging from 2-6 ppm (Phadtare, 1989, p. 64). Amreli District of Gujarat has villages with fluoride content as high as 11 ppm with an average of 4.4 ppm among 37 selected villages (CEE, 1989, pp. 25-26). High concentrations of fluoride have been found in other districts of Gujarat including Kutch, Surat and Bharuch.[28]

Nitrate levels exceed the WHO maximum of 45 mgl in many groundwater sources throughout the state. Many agricultural crops produced in the state require high doses of nitrogen fertilizers.[29] Animal husbandry activities and sewage are also prime potential nitrate sources. At the same time, nitrates can be produced by a variety of natural processes. Although pollution could be a factor, no data are available that would indicate the relative importance of natural versus anthropogenic sources for nitrates in Gujarat's groundwater. Regardless of source, nitrate contamination is a significant concern from the drinking water perspective. Nitrate levels as high as 800 mgl have been found in rural areas of Sabarkantha district. The average value of nitrate levels found in Sabarkantha was 200-300 mgl. Kheda District nitrate rates ranged between 125-200 mgl. Panchmahal, Mehsana, and Banaskantha are also characterized by high

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[24] Discussions with AKRSP officials and personal field work in the region.
[25] Personal Communication, K.C.B. Raju, Director, CGWB (retired).
[26] Gujarat Water Supply and Sanitation Board, cited in Draft copy of The State of Gujarat's Environment.
[27] Personal communication, Mr. Narayan, Phd student in Zoology department of Gujarat University.
[28] ibid.
[29] ibid, p. 65.

levels of nitrate pollution.[30] Maps prepared by the CGWB (Central Ground Water Board) show nitrate concentrations exceeding 45 mgl in over 370 sample sites scattered throughout the state (Phadtare, 1989). Ghatlodia, near Ahmedabad, reportedly has rates of over 100 mgl in its drinking water.[31]

3) Pollution

It is well known that uncontrolled disposal of industrial and municipal wastes has resulted in the extensive pollution of India's rivers and streams. Areas downstream from urban areas and industrial sites, especially peri-urban shanty towns and rural hinterland villages, are most affected. It is these areas that are often the most dependent on the river and river aquifer for their drinking water. Recent research by the National Environmental Engineering and Research Institute (NEERI) indicates that almost 70% of available surface water is polluted in India.[32] The water quality in Gujarat's rivers is no exception.

Newspaper reports of pollution are common and indicate the potential scope of existing problems. A recent article in The Business Standard, for example, indicates that Jetpur is one of the most polluted towns in Gujarat.[33] According to it there are approximately 1200 small-scale industrial units which use the rivers Aji and Bhadar to drain their effluents. The waters of these rivers are deep red with the subsoil in the area increasingly polluted. Mercury, chromium, zinc and cadmium have been found in both the rivers but people have no alternative drinking sources. The same article mentions that Rajkot, a city famous for beautiful saris, has tremendous water pollution problems from its approximately 300 dyeing plants.

The Sabarmati river, which runs through Ahmedabad provides a well documented example of the magnitude of surface water contamination. A comprehensive study by the Central Pollution Control Board in New Delhi tested the Sabarmati's surface water quality at various points along the river. They stated that in the Gandhinagar-Ahmedabad reach:

> "the Sabarmati becomes essentially a trunk sewer. Not only the treated/partially-treated/untreated effluents from the sewage collecting systems of CRPF colony Gandhinagar and the city of Ahmedabad join the river, but the entire sewage, sullage and industrial wastewaters from the fast growing suburbs and shanty-towns flow into the river through the numerous open drains really meant only to carry storm run-off, but now acting as open sewers for all types of waste waters" (CPCB, 1989, p. 43).

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30 Personal communication, J.M. Barot, GWSSB.
31 Personal communication, S.C. Sharma.
32 Reported by the Deccan Herald 01/26/92.
33 Business Standard, Calcutta, 12/11/91

Data on the actual load of industrial effluents are unavailable. Newspaper reports, however, give some idea of the potential magnitude of industrial pollution problems. The Hindu in their State of the Environment 1992 reports for Ahmedabad that "of the 1,000 chemical units half do not have treatment plants. The chemical units resort to unhealthy practices like working the effluent treatment plants when the pollution authorities come to the area and storing waste and releasing it in the night" (The Hindu, 1992, p. 119). Dye, pigment, textile and chemical plants around Ahmedabad are spewing their waste, often untreated, into effluent that reach the Sabarmati. As many as 139 organic chemicals, heavy metals and their salts, alkalies and acids are used in the manufacture of dyes alone.[34] River quality below the industrial estates is dismal.

In addition to industrial pollution, fecal coliform rates are high at all stations along the river. Ahmedabad's sewage treatment plants have a capacity of 380 mld, roughly 55% of the sewage flowing in. The rest is discharged directly into the river (CPCB, 1989, p. 43) Fecal coliform at four testing sites averaged between 46 and 991 MPN/100 ml, well above the 0 MPN/100 ml acceptable by WHO standards. (CPCB, 1989, p. 54).

Pollution of surface sources has strong implications for groundwater quality. Aquifers underlying Ahmedabad are hydrologically linked to the Sabarmati and, until controlled releases from Dharoi reservoir were started in the mid 1970s, there was a strong correlation between surface flows in the Sabarmati and groundwater pumping (Patel, Sharma & Ramanathan, 1979). In 1984 induced seepage from the Sabarmati River accounted for roughly 19% of the groundwater pumped in Ahmedabad city limits (Gupta, 1885, 1989). Since the lower portions of the Sabarmati are highly polluted, groundwater pollution related to seepage from the river is probably extensive. Although comprehensive data are not available, villages near canals draining industrial wastes are pumping red-colored water and State Pollution Control Board officials have found a variety of toxic materials well water adjacent to effluent outfalls.[35]

In addition to seepage from polluted surface sources, leaking distribution mains and pipes are additional hazards to the quality of water supply in urban areas. Leaking sewers often drain directly into shallow groundwater aquifers. Since residents in many urban areas such as Ahmedabad depend on wells to supplement inadequate supplies provided by the municipal corporation, leakage from sewers can be directly drawn into wells providing drinking water. In addition, sewage pipes and water pipes are often laid side by side. Intermittent supply and low pressures can under these conditions cause a mixing of sewage and drinking water. Finally, many housing colonies in cities such as Ahmedabad are not linked into the municipal water supply or sewerage systems. They depend on wells for water supply and

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[34] See The Hindu, 1991, The Survey of the Environment 1991, p. 103.
[35] Personal communication Dr. U.I. Bhatt.

septic systems or injection wells to dispose of waste. Since land availability in the urban areas is limited, wells for drinking supply and septic systems are often located in close proximity.[36] The potential for direct contamination is clear.

B) Health implications

1) Natural Quality

Of the three main natural factors affecting water quality for drinking in Gujarat, fluoride has received the most attention. Taste generally limits the use of saline water for drinking before short term health effects occur. Nitrate contamination at levels found in Gujarat can cause methaemoglobinemia in infants, carcinogenic nitrosomes in the stomach and gastric carcinomas (Lee and Bastermeijer, 1991, p. 16). The presence of these effects has not, however, been widely reported even in areas of high nitrate contamination. As a result, the primary focus here is on fluoride.

Prolonged exposure to fluoride levels in drinking water above 1.5 ppm can have serious effects on a persons physical health. Fluorosis affects humans in three different ways. Non-skeletal fluorosis causes gastrointestinal problems, muscle weakness, skin rashes and urinary tract ailments. Dental fluorosis causes mottled, pitted or chipped teeth. Children are especially vulnerable to this form of fluorosis. Skeletal fluorosis occurs after long-term exposure to high levels of fluoride concentrations (levels of fluoride above 3 ppm). Skeletal fluorosis involves the whole skeleton, especially the spinal column and causes pain and stiffness in the joints as well as mild to severe crippling (CEE, 1989, p. 4). It often affects people in their most productive years and can cripple to such an extent that they are unable to do any physical work. (CSE, 1982, p. 135). The economic implications of severe skeletal fluorosis on adult working members of a family are clear.

Humans are not the only beings affected by fluorosis. Sheep, cattle, goats and other animals can also suffer from skeletal deformities causing decreases in wool and milk production, incurring economic loss to their owners.

2) Industrial & Biological Pollutants

The health effects of different chemical pollutants have not been extensively monitored in Gujarat. Lack of data on groundwater contamination also makes it difficult to speculate on the potential magnitude of health impacts from pollutants with known effects. Furthermore, whatever effects are present may be obscured due to the prevalence of other diseases. What is clear is that the potential for groundwater contamination with a variety of toxic substances is widespread in industrial areas. Given the direct hydrologic connections between surface sources that are

[36] This is the case, for example, in many of the housing colonies in the Vastrapur area of Ahmedabad.

known to be highly polluted and aquifers it is highly likely that groundwater sources are becoming polluted and that health effects are present.

Biologically contaminated drinking water is well known as a causative agent for water-borne epidemics of diarrheal disease. The quality of water is especially important for children under two.(Esrey and Habicht, 1986). Newspaper reports indicate that water-borne disease is the cause of nearly 15 lakh deaths in India annually.[37] Ahmedabad residents regularly face epidemics of typhoid, cholera and diarrheal disease. These epidemics commonly occur among the poorer unplanned communities on the east side of the river. Even the wealthier communities are not spared. City newspapers often document the appearance of water-related illness. Recent examples include an article in the Times of India that states that 53 families were affected by typhoid because of "seepage of a drainage line" into the water supply.[38] Another article describes how 350 people were treated for severe diarrhea because of the same problem, "sewage water had mixed with drinking water".[39]

Episodes of cholera, typhoid and other diarrheal diseases that affect the urban areas are a common result of drinking water contamination by sewage. Water tests done by the Ahmedabad Public Health Laboratories show a trend of increasing percentages of water unfit for human consumption. Samples of drinking water taken in 1988 at different points within the city reveal that 38% of the water was considered unfit.[40] The lack of proper sanitation is an additional hazard to urban water supply. Human waste contaminates water source points where clothes and dishes are washed and people bathe. Shallow wells and borewells that are insufficiently protected due to poor design of their aprons, are prone to contamination by washing back of wastewater.

C) Responses

1) Quality

Governmental responses to natural quality problems have primarily focused on the identification and development of clean water supply sources. Typical examples of this are the Indo-Dutch projects in Mehsana and Banaskantha districts. These projects involve water supply to areas underlain by saline water through long pipeline systems. The Banaskantha project is discussed further in one of the following case studies. In addition to government efforts, MAHITI, an NGO working in the Bhal region, has successfully

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37 Deccan Herald, 1/26/92

38 See "Typhoid hits 53 families in Ahmedabad", Times of India, July 8, 1992.

39 See "Diarrheoa hits 350 in city", Times of India, June 30, 1992.

40 "Unfit" is defined as having a fecal coliform count of greater than 0. (Ahmedabad Municipal Corporation quoted in Bhattacharya and Pandya, 1988).

promoted the use of plastic lined ponds for storing rain water in rural areas with saline groundwater.[41]

Aside from supply side responses, methods for treatment of available water for use at the village level have been developed. In the case of fluoride these require the addition of alum in prescribed doses to drinking water supplies. However, as the experience of the Centre for Environment Education (CEE) demonstrated, they are not easily performed. Concentrations have to be added in exactly the right proportions and the water has to be stirred at a constant rate for at least 8-10 minutes to achieve the desired results (CEE, 1989, p. 14). Village women often have neither the time nor patience to perform such a task on each pot of water they collect. Furthermore, based on discussions with field workers involved in fluorosis control projects, the possible presence of side effects and effectiveness of the techniques are debated. Social factors may also be important. Villagers reportedly feel that if they defluoridate their own water the government will not feel responsible for providing other sources of water.[42]

Aside from local level treatment, fluoride, nitrate, and salinity problems can be dealt with through the use of distillation or reverse osmosis. Both these processes are energy intensive and require expensive centralized treatment facilities. An easier option, if sources of clean water are available, is mixing low and high quality water so that the concentration of contaminants remains below that where health impacts occur.[43]

2) Pollution

Little attention has so far been given to the most appropriate responses to pollution. The Gujarat Pollution Control Board (GPCB) is now attempting to control the release of industrial pollutants at their source.[44] These efforts face many obstacles. Local groups working in industrial areas report that factories close their effluent pipes just prior to visits by GPCB officials.[45]

Where biological contaminants are concerned, most major urban areas now chlorinate their water supplies. This is also the case with many long distance rural water supply projects. In urban areas, given the potential for contamination with sewer water, the efficacy of chlorination depends heavily on maintaining high concentrations throughout the supply system. Whatever its efficacy, chlorination does not affect the large amount of water supplied through private wells. Since many of these are shallow, particularly in slum areas, they can easily be contaminated by pathogenic organisms. This is also the case

41 Personal Communication Nafisa Barodt, Director MAHITI, an NGO working in the Bhal area of Gujarat.
42 Personal communication, Mr. Maink Joshi, Centre for Environmental Education.
43 Suggested as the most viable response by Dr. U.I. Bhatt.
44 Personal Communication, U.I. Bhatt.
45 Personal communication, Sheba George of Sanchetana

in areas where drinking water wells and septic systems are in close proximity.

Renovating and extending the water supply and sewerage systems could be an important response to emerging pollution problems. Controlling leakage from sewer pipes would reduce the potential for contaminating both groundwater and urban water supply networks. At the same time, improving the water delivery network would reduce the chances for sewage leaking into water mains. This, as previously noted, could also increase the amount of water available to consumers, thus addressing some of the availability problems. Finally, extending supply and sewerage networks, if they can be maintained, would reduce the chances of septic systems contaminating wells.

Another key factor in solving pollution and associated health problems is the maintenance of base flow levels in surface streams. Given the difficulty in controlling effluent releases, adequate flushing flows are required to remove and dilute pollutants. As the Sabarmati Basin Report recommended:

> "The real key to the success of any effort to restore Sabarmati to any reasonable quality levels will be to ensure minimum flows at all points and at all times in the river" (CPCB, 1989, p. 4, emphasis in original)

The need for flushing flows is a critical, generally unrecognized, component in the drinking water availability, quantity and health dilemma. Unless flushing flows are maintained, pollution of both surface and groundwater is likely to increase with its attendant impacts on health and the pressure to develop new water sources. At the same time, maintaining base flows represents another demand on already stretched water supplies. For the Sabarmati, roughly 50% of the live storage in Dharoi Dam would be required to keep base flows at the minimum level needed (CPCB, 1989, p. 4).

V Case Studies

A) Banaskantha Rural Water Supply

1) Physical Situation

The situation in Banaskantha District typifies some of the water problems rural Gujarat is grappling with in terms of water accessibility and quality. The area has been covered by a joint Indian-Dutch water supply scheme for the last 6 years and the projects' successes and failures have been well documented by government, NGO, and Dutch agencies.[46]

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[46] See, for example, the series of reports put out by the Kingdom of the Netherlands, Indian Government and Gujarat Water Supply and Sanitation Board documenting the implementation of the Santalpur Scheme.

The Santalpur Rural Water Supply and Sanitation Scheme was initiated in 1978 in response to severe constraints faced by villagers in finding potable drinking water. The lack of water availability led to large-scale yearly migration to Southern Gujarat and Northern Maharashtra. The Santalpur Scheme currently provides piped potable water to 102 villages identified as having "no water source" in 3 talukas in Banaskantha District.

After detailed hydrological investigations as to where water and recharge levels would be best, the project dug six tubewells in Shihori. From Shihori, water flows along a main pipe 134 kilometers to the farthest village. There are numerous offshoots that supply water to the many villages which are not along the main line. Each village has a standpost that has 6-8 taps. The project allotted 40 liters of water per capita and 15 liters of water per head of cattle.

The area served under the scheme is an arid desert region. Buffalo, goats and sheep are common and dairying and other animal husbandry activities are the major source of income for the residents. Although much of the soil is too saline for farming there are a few local crops. These include cotton, mustard seed, cumin and millets.

Before piped water was available to the villages, all water was obtained from local ponds. The pond and its environs served many purposes; clothes and dishes were washed there, bathing occurred on its banks, buffalo bathed in the water, etc.. Generally, village ponds had sufficient water for both animal and human consumption for four months of the year in the post-monsoon period. After this, water was generally too saline for human consumption but could be used as a source for cattle for a further four months. The remaining four months most ponds were completely dry.

The village of Jarusa in Santalpur taluka is a typical example of those served by the Indo-Dutch scheme. As is common in most of Gujarat, women are responsible for obtaining water for all household needs. Village women said that during the summer months before the introduction of piped water, they commonly had to dig 3-4 feet into the dry pond to obtain brackish water which they would use for drinking, bathing and cleaning. There were no other alternatives except to migrate to areas that received sufficient water during the dry months. Piped water has made their lives significantly easier. Now women only have to walk the distance from their houses to the 8 taps provided by the scheme. Depending on where they live in the village this could range from a few 100 feet to approximately 1.5 kilometers away. The women have to carry their own storage vessels with them. Two vessels can fit on their heads: a large one below and a small one on top. A third vessel can be carried by hand. The larger vessels hold between 13-15 liters of water and the smaller ones hold between 8-10 liters. The total weight carried is, therefore, between 21 and 25 kg. The women say they make this trip up to 10 times daily. Young girls are not exempt from this task; they just carry smaller, although still significant, quantities.

Although the water that is supplied by the pipeline is of good quality, sources of contamination abound. The area around the taps is muddy with the runoff of tap water. This area is commonly used for washing clothes and dishes of those who live further away from the water source. It is easier to bring materials for washing to the tap than carry the amount of water required to their homes. The people have to wade through this area to get to the standpost. Once the water is obtained it is transported to the home where it is deposited into larger storage vessels. It is from these vessels that women take water for drinking, bathing and domestic chores. This involves hand to water contact as cups are used to scoop out the water. Children have free access to the water storage containers.

2) Emerging problems

The project is facing increasing constraints at both the hydrological and management levels. Because of groundwater extraction for irrigation in the surrounding area, water levels in the six Shihori tubewells are dropping an average of 3 meters every year. One tubewell recorded a dramatic 30 meter drop in one year.[47] The dropping water levels along with the identification of new "no source" villages has added pressure to find new areas for water extraction. At present engineers are digging five more tubewells to connect to the scheme.

These new tubewells will not address emerging problems with water quality. Fluoride levels in all the tubewells, sometimes exceed the WHO limit of 1.5 mg./liter. (Kingdom of the Netherlands et al, 1992a, p. 40). The fluoride content in each of the wells fluctuates daily necessitating constant testing. One of the tubewells has been temporarily closed because of consistently high fluoride levels. The closure has reduced the water providing capacity of the project. With one well closed any additional problems disrupting the supplies from other wells can lead to inequity between the villages in access to water. Those near the source receive adequate water while villages farther away don't receive enough.

Dropping water tables and increasing fluoride levels are not the only constraints the project is facing. There are a host of management and implementation problems that are also important determinants of the projects' success. The underground pipeline is plagued by both manmade and natural breaks causing large loss of water due to leakage. Farmers break the pipes to divert water for irrigation purposes and to make watering holes for their buffalo. Trees and other roots also cause cracks and breaks in the pipes. The result in all these circumstances is that the villages below the break do not receive water. The cause and

[47] Personal communication, S. Harini, Santalpur Scheme Health Coordinator, Centre for Health Education Training and Nutrition Awareness

source of the leak are often not readily apparent. Different sections of the pipe must be broken and refitted to determine the exact point where the leak is occurring. This manual breakage and repair adds to the leakage problem. Villagers themselves have become so incensed at a three day delay of water that they break the dry pipes themselves.

3) Impacts on health

No detailed studies have been done on the health problems in the area or the amount of health status change that has occurred due to the introduction of the Santalpur scheme. Rural Gujarat's Infant Mortality Rate is 113/1,000.[48] Although average rates may not apply in individual villages, sources within the village of Jarusa said that almost every woman had lost at least one child. Good health, and child health particularly, is a complicated mix of child spacing, immunization, family education, cultural practices regarding breast-feeding and weaning, access to food and water and a variety of other factors. Intermittent water supply and distance from the water source to the home is likely to play a role in the health of the village. The amount of time a mother spends retrieving water could be time spent in cooking and feeding a sick child. Although villages normally have access to as much water as they need, distance from home to source and the amount of time spent carrying it home from the source is bound to affect the amount used within the home.

Water quality is monitored daily at the source. At that point there has not been any problem with bacteriological contamination of the water. Testing is not done at village sources and although it is improbable that water is contaminated as it leaves the pipe, potential contamination of storage vessels could be a major problem. The village of Jarusa has big, dirty puddles around the standpost. While women wait in line for water they place their vessels on the muddy ground. The vessels are later fitted into each other for carrying home. This is a potential source of contamination. Also, as mentioned earlier, women and children dip their hands into the storage containers when retrieving water creating another potential source of contamination. How often storage containers are cleaned varies from household to household. Health education efforts regarding proper water storage and retrieval techniques have recently been started by a local NGO.

The increasing fluoride content of the water, if not remedied, will eventually create health problems for those drinking the water. At this point, wells that are far exceeding the maximum permissible limits have been shut down. Most of the wells have at some point during their operation, exceeded the WHO limit. (Kingdom of the Netherlands et al, 1992b, p. 23). Dental and skeletal fluorosis are not yet considered a health problem. Fluorosis, however, takes years to develop and once the

48 See National Institute of Public Cooperation and Child Development, 1991, Statistics on Children in India, p.31

crippling effects of skeletal fluorosis appear they cannot be reversed (Teotia and Teotia, 1987, p. 700).

4) Potential Solutions

Solutions will have to be identified that will address not only the decreasing groundwater table and increasing fluoride contamination but also the local level management issues.

The Indo-Dutch project has listed several options it considers worth exploring. Two of these call for tapping into water sources developed for other purposes. One, the Deodar Rural Water Supply Scheme is located approximately 30 kilometers from the Shihori tubewells, and the other the Sipu reservoir, is located approximately 50 kilometers away. Water from both these sources would be used to inject into the network to increase production capacity and reduce the levels of fluoride (Kingdom of Netherlands et al, 1992, p. iv). In addition to increasing supply there has been some talk of restricting further expansion of irrigation tubewells within a 2 mile radius of the Santalpur well field to reduce demand. As of August, 1992, no action had been taken on this proposal (Kingdom of the Netherlands et al, 1992, p.3). Since groundwater extraction rights are linked to ownership of overlying lands it is also unclear how extraction restrictions could be implemented. Neither of the above options would address the problems of water theft and pipeline leakage which are inherent in most long distance piped water supply systems as well as this one. Since these factors are critical to ensuring water supplies for villages at the end of systems, ignoring them leaves major problems in the system.

As far as we know, local options for increasing water supplies have not been investigated in detail. Surface water storage in plastic lined ponds has been demonstrated to be viable option for drinking water supply in other drought prone districts of Gujarat (MAHITI, 1986). Storing local rainfall in such ponds could represent a viable alternative to increasing piped water supplies. Although this might require a high degree of local management, fluoride problems might be solvable by mixing water from surface ponds with that from well sources. Other options for increasing the utilization of local precipitation may also be available. Clearly surface ponds run a greater risk of biological contamination than water piped from groundwater sources. This issue would have to be managed if health concerns are to be addressed.

Health education is being conducted by the Centre for Health Education and Nutrition Awareness (CHETNA) in all villages covered by the Santalpur scheme. CHETNA concentrates on training village level health workers, but also personally conducts health education camps designed around issues related to water. There is thus an existing health education system which could be utilized to promote effective methods for avoiding or dealing with biological contamination if local surface sources are developed.

Overall, the inherent problems in long-distance water supply systems suggest that local alternatives should be investigated as a complement or alternative to existing piped supplies. Unless this is done the only readily available solution to address water related health problems appears to hinge on the further development of new sources or the identification of methods for treating available supplies.

B) Ahmedabad Slums

1) Physical situation

Massive rural migration into Indian cities without adequate infrastructural additions has led to the proliferation of slums in India's cities. 1982 estimates for Ahmedabad's slum population are that a total 536,359 people inhabited 1116 slums throughout the city.[49] Obtaining water for families is often a demanding task as the amount of existing standpipes is wholly insufficient for the population they are meant to serve and the water timings are not long enough to allow adequate access. Riots over water have been known to occur in Ahmedabad city.[50] The descriptions below of two Ahmedabad slums give a more detailed account of the problems faced by their residents.

Kodiyar Nagar

Kodiyar Nagar is a slum of 10,000 people along the edge of the River Sabarmati in Ahmedabad. It is predominantly Hindu area. The NGO Sanchetana has been working in the area for the last three years concentrating mainly on health programs. This involves the running of a small clinic, regular growth monitoring of children under three and health education meetings. The slum is fairly well laid out along a grid pattern with small individual dwellings on each side. Each dwelling is inhabited by 6-12 people. Many of the residents work in the nearby textile and dyeing factories where they can earn 30 rupees a day. When the monsoon arrives the factories close down and these people are out of work. Others in the community work transporting vegetables and fruits.

The slum generally receives water through three municipal corporation taps. When this investigator visited at the end of June, 1992, there had been no municipal water supply for the last one and a half months.[51] This was because the municipal corporation had discovered some illegal house connections; the "punishment" was to turn the

[49] Survey of slums in seven cities of Gujarat conducted by the Gujarat Slum Clearance Board and Core Consultants, 1982.

[50] See for example the article entitled: "Looming Spectre of Water Riots," Times of India, April 20, 1992.

[51] As of August 2, 1992 municipal supply had been reinstated for an hour in the mornings. Residents complained that the first half hour of flow the water was extremely muddy. They would let this water fall to the ground and collect water for the remaining half an hour. This water they would use only for washing. They were still collecting their drinking and cooking water from the factory borewells.

water supply off. The only other nearby source of water in the area is the river which the inhabitants consider too polluted to use for drinking or washing. There is a bone factory and other industrial factories in the area which discharge their wastes into the river directly above the slum. On a subsequent visit to the river it was apparent that some children and women do use the river water for washing purposes.

Due to the halt of the municipal supply, water was obtained from some nearby factories. The women can take as much as they can carry on their heads. Women and girls generally travelled to the factory in twos and threes. They said that the entire journey, including waiting in line, took two hours. They made this trip twice a day. Although the factories themselves receive municipal water, the amount that they receive is far below their needs. Each factory has its own borewell and the women indicate that it is the borewell water that they are using.

The women expressed concern over the quality of the water. They said often the water is yellow when they get it and turns red after boiling. They described the water as "tasteless". They believe that the bleaching powder that the factories use is contained in the water. As there are no other water sources nearby the women have no choice but to use this water.

None of the houses in Kodiyar Nagar had toilets and there were no community latrines. Men and women would defecate along the edge of the river in the early morning hours. Children would defecate in the narrow lanes in front of their homes.

Milatnagar

Milatnagar is another slum in Ahmedabad located along one of the two lakes of Ahmedabad. It has a predominantly Muslim population of 20,000 people. Most of the houses are on small, narrow lanes without proper drainage. The NGO Sanchetana has been working in Milatnagar for 8 years on various projects including health, income generation and women's issues.

Many of the men in the area work as rickshaw drivers and small vendors. Because Milatnagar is a Muslim area many of the women do not leave the house for employment. They do work within the home doing various small crafts that can be sold in the retail market. These included making jarus (brooms), small hair bows with embroidery, kites and candy wrapping.

The water supply situation in Milatnagar is a little less severe than Kodiyar Nagar only because of regular timed supply. Access is severely restricted, because the population is comparatively larger. Municipal taps and 5 private handpumps are the source of water for most of the area. A few of the houses have access to legal connections of municipal water and an unknown number have illegally tapped into municipal supplies. Handpumps generally belong to the person whose house it stands in front of. Neighbors can rent the use of the handpump for approximately 30 rupees a month. Water supplied by the municipal corporation is turned on from 6:30 to 8:00 a.m. and in the evening for an hour. According to local inhabitants, it often smells of sewage -- a reflection of the numerous leaks and, perhaps, numerous holes intentionally drilled into the system for illegal connections. Many of the women have to walk 10-15 minutes to reach the municipal supply. Men also leave the area to get water that they carry back in big drums by bike. Studies conducted by Sanchetana in this community revealed that only 7.5 liters of water were available per capita.

Latrines that had been built by the municipal corporation are in complete disrepair and used as garbage dumps. Some of the houses have their own toilets but most people go to an area near the lake to defecate. Children defecated outside the door of the home.

2) Emerging problems

Besides the already existing problems related in the above section there are potential emerging problems to consider. Continued population growth within the slum communities will further exacerbate existing water availability problems. Coupled with drought years and declining water tables, there will be an increased dependency on already strained municipal supplies.
If access to water does increase, for instance via projects such as the Narmada, ignoring the sanitation and drainage aspects of the problem could result in little change or even a negative impact on health status.

Both Kodiyar Nagar and Milatnagar face the probability of increasing levels of both biological and chemical pollution. As factory effluents and leaking sewage continue to pollute surface sources, users of borewell water will continue to drink potentially contaminated water.

3) Impacts on health

Unplanned and hasty urbanization appears to be increasingly correlated with the deterioration of existing water supplies, both natural and man-made. This coupled with the lack of adequate sanitation facilities creates a double hazard for slum areas. Both Milatnagar and Kodiyar Nagar are dealing with the health effects of inadequate water and sanitation. A range of the kinds of health problems each community is facing is discussed below.

Both slums have a high incidence of water-related diseases.[52] Before the monsoon approximately 60-70% of the children have severe boils, scabies or other sorts of skin and eye infections. Different forms of diarrheas and worm

[52] All information on the health status of the two areas comes from talks with health workers in the community and Dr. Annie Pukardan, the doctor who works in the clinic of both the slum areas. Generally, women and children attend the doctors clinic. The health discussion is thereby only a sample of what occurs in each area.

infections are also common as is iron deficiency due to hookworm. With the onset of the monsoon, diarrheal diseases comprise about 70% of the cases the Sanchetana doctor treats in Kodiayar Nagar. Marasmus (severe wasting due to malnutrition) is present in this community as well as consistently low weight for age children. Milatnagar has comparatively fewer cases of diarrheal disease than Kodiyar Nagar but they still comprise about 50-60% of the cases the doctor treats. Typhoid cases are common in both communities. The incidence of malarial cases significantly increases during the rainy season. Water-related disease often goes untreated. Many people, especially in Kodiyar Nagar, where many of the inhabitants are unemployed during the wet season, cannot afford the 4 rupees to be treated in the local clinic.

It is difficult, without further detailed research to pinpoint exactly how large a part restricted access to water and sanitation plays in the poor health status of both communities. There are many variables to account for the difference in diarrheal disease rates between the two communities. Whatever the mix, however, it is readily apparent that both areas are suffering from the range of diseases related to the absence of adequate water and sanitation facilities.

4) Potential local solutions

Ideally, solutions to existing water related health problems in both communities would hinge on improving water supply and sanitation infrastructure. This would include repairing and replacing corroded pipes, increasing and routinizing water timings and adding additional water pipes throughout the community to increase access to and decrease the amount of time spent obtaining water. The building and regular maintenance of community latrines combined with investment in proper drainage to remove water and waste from the community would also be important to address many of the water and sanitation related health problems. Continued community health education, done in a culturally sensitive manner as Sanchetana does, will further increase the chances that these additional inputs will make a difference in the quality of life of the inhabitants.

While increasing the volume of water supply is an important factor in addressing slum health problems it is not a complete solution in itself. Furthermore, many actions that are required to address health problems, such as repairing leaking water mains, are likely to increase available supply without additional water inputs to the system.

VI Ways Forward

This paper has discussed the linkages between drinking water availability and quality and health. In the process several key points have been made and needs identified.

First, the links between health, quality, and quantity of supply need greater recognition in drinking water supply planning. At present, most attention is given to the simple provision of more water to meet municipal demand. In urban areas, health, sustainability and equity objectives could, however, be better met through focusing efforts first on conservation, renovation/improvement of existing water supply and sewerage systems, and options for water recycling. In rural areas, options for storing and utilizing water locally available from precipitation could have similar benefits. Developing new supplies should be done only where absolutely required. As a first step, baseline studies are needed on the costs and potential of a conservation and renovation focused rather than supply focused approach.

Second, basic data are often lacking on a wide range of factors affecting drinking water. Where quality is concerned, baseline surveys of key parameters such as fluoride and nitrates are needed. Similar baseline studies are needed to monitor pollution from human sources. Where volume is concerned, basic data on extraction and use are needed. At present, municipal corporations have information on the volume of water they supply. Loss rates from urban systems are not well known. In addition, private wells supply a large percentage of drinking water even in urban areas. As a result, the actual amount of water supplied in urban areas is difficult to estimate. End use data are also important. Without them it is impossible to estimate where supplies are going to meet basic human needs or other, less fundamentally important, uses. Overall, the basic data required to examine drinking water issues are often lacking.

Third, the viability and economics of different conservation options require quantification if they are to be presented as an alternative to supply development. Without documentation it is difficult to determine how much conservation can really contribute to the solution of water supply problems. Furthermore, many of the potential economic and social benefits associated with conservation options (such as those associated with disease avoidance) are not captured in traditional water supply project analyses.

Fourth, the linkage between overdevelopment and pollution is rarely recognized. Maintaining base flows in rivers is required for both drinking supply and waste disposal purposes. Surface storage systems and over extraction of groundwater generally reduce base flows. As far as we know, no one in Gujarat has ever evaluated the costs from pollution of reducing base flows or the benefits in terms of population served of maintaining them. As the Central Pollution Control Board reported with regard to water quality, construction of the Dharoi Dam and Vasna Barrage on the Sabarmati "further aggravated the situation by reducing rather than enhancing the lean weather flows in the river" (CPCB, 1989, p. 50, emphasis in original). As a result, the problem of pollution is likely to increase if further surface or ground water are diverted to meet municipal and other needs. Thus, over the long run supply dominated responses could actually increase exposure to quality problems.

Finally, the issues involved in drinking water supply need wider discussion in the context of water allocation debates. As this monograph outlines, health and basic drinking needs will not be solved by simply pouring more water into existing systems. Water for drinking should, as it does, have the highest priority. Growing populations require sufficient drinking water. This does not mean, however, that supply volumes should be increased blindly as "demand" grows. "Demand" is a relative term. The quantity of water required depends on the efficiency of delivery systems and end-uses. It also depends on the range of end-uses for which "drinking" water is actually diverted and on the number of times water is reused. There is clearly a large scope for conservation in urban communities such as Gandhinagar where use rates are more than an order of magnitude higher than those "required" for drinking and sanitation. Recycling options have also not been investigated in detail. If a supply focused approach is retained, quality declines and growing demands are likely to further strain already overallocated water supplies. This will have major impacts both on other users and the natural environment.

BIBLIOGRAPHY

Aziz, K.M.A., Hoque, B.A., Huttly, S.R.A. et al (1990): Water Supply, Sanitation and Hygiene Education: Report of a Health Impact Study in Mirzapur, Bangladesh, Washington D.C.: The World Bank

Bhattacharya, R.D., and Pandya, C.B., (1988): "Drinking Water Quality in Ahmedabad City", paper presented for a conference on "Pollution Trends in Ahmedabad City and the State of Health", pp 14

CPCB (1989): Basin Sub Basin: Sabarmati Basin Report, Central Pollution Control Board, Government of India, New Delhi, pp 64.

CEE (1989): Fluorosis Control and Guineaworm Eradication: A Project Report, sponsored by Natl. Drinking Water Mission, Government of India, Centre for Environment Education, Ahmedabad.

CSE (1982): The State of India's Environment 1982: A Citizens' Report, Centre for Science and Environment, : The Ambassador Press, New Delhi.

CSE (1985): The State of India's Environment 1984-85: The Second Citizens' Report, Centre for Science and Environment, The Ambassador Press, New Delhi.

Esrey, S. A. and Habicht, J.P. (1986): "Epidemiologic Evidence for Health Benefits from Improved Water and Sanitation in Developing Countries", Epidemiologic Review, vol. 8, pp 117-128.

Gandotra, M.M. (1992): "Population Growth and its Impact on Water Resources in Gujarat," paper presented at the Workshop on Water Resources and Management in Gujarat, Sardar Patel Institute, 3-4 August.

Ghosh, G. & Phadtare, P.N. (1990b): "Policy Issues Regarding Groundwater Management in India" pp 433-457 in International Conference on Groundwater Resources Management, Bangkok, Thailand, Nov 5-7.

GOG (1992) Report of the Committee on Estimation of Groundwater Recharge and Irrigation Potential in Gujarat State, Narmada and Water Resources Department, Government of Gujarat, pp 57 + appendicies.

Gupta, S.K. (1985): "Scenario of Ground Water Development in Ahmedabad: Environmental Considerations" in Environmental Impact Assessment of Water Resources Projects, Proceedings international seminar held at WRTDC, University of Roorkee, Vol 1, pp 453-468.

Gupta, S.K. (1989): "Water for 2000 A.D.: A Scheme for Waste Water Renovation and Ground Water Recharge in Ahmedabad," Proceedings TRF Seminar on Ahmedabad 2001, Volume 10, Times Research Foundation, Ahmedabad.

Hardoy, Jorge E., Cairncross, Sandy and Satterwaite, David, (1990):, The Poor Die Young: Housing and Health in the Third World, London: Earthscan Publications Ltd.

High Level Committee (1991): Report of High Level Committee on Augmenting Surface Water Recharge in Over Exploited Aquifers of North Gujarat, Vols. I & II, Narmada and Water Resources Department, Gandhinagar, Gujarat.

Independent Review (1992): Sardar Sarovar, The Report of the Independent Review, Resource Futures International, Ottawa, Canada, pp 363.

Kingdom of the Netherlands, Government of India and Gujarat Water Supply and Sanitation Board (1992): India: Report on Mission 25 to Gujarat (GU-25),

Kingdom of the Netherlands, Government of India and Gujarat Water Supply and Sanitation Board (1992a): India: Hydrogeological Investigations for the Santalpur and Sami-Harij RWSS

Lee, M.D. and Bastermeijer (1991): Drinking Water Source Protection: A review of environmental factors affecting community water supplies, International Reference Center, Occasional Paper No. 15, The Hague, Netherlands.

MAHITI (1986): Project Proposal for Rain Water Catchment Pond Lining with Agrifilm, Mahiti Centre, Ahmedabad.

National Institute of Public Cooperation and Child Development (1991): Statistics on Children in India, 5 Siri Institutional Area, Hauz Khas, New Delhi

Patel, A.H., P. Sharma and K.R. Ramanathan (1979): "Integrated approach to the management of Water Supply for the city of Ahmedabad and its Metropolitan area" pp 325-335 in Gupta, S.K. & Sharma, P. Current Trends in Arid Zone Hydrology, Today & Tomorrow, New Delhi, pp 513.

Patel, P.P. (1988): Drinking Water Problem of Bhal Area in Gujarat, report to MAHITI-Uthan Trust, Ahmedabad.

Pathak, B.D. (1985): "General Review of Artificial Recharge Works in India" paper presented at the Seminar on Artificial Recharge of Groundwater, Sponsored by the CGWB, UNDTCD and UNDP, Ahmedabad, January, pp 17.

Phadtare, P.N. (1985): "Artificial Recharge Studies In the Mehsana and Coastal Areas of Gujarat State, India", paper presented at the Seminar on Artificial Recharge of Groundwater, Sponsored by the CGWB, UNDTCD and UNDP, Ahmedabad, January, pp 27.

Shukla, B.V. (1984): "Drinking water problem in coastal regions of Saurashtra", Journal of the Indian Water Works Association, vol XVI, no.1 p. 59-63

Teotia, S.P.S,, Teotia, M. et al (1987): "Deep bore drinking water as a practical approach to eradication of endemic fluorosis in India", Indian Journal of Medical Research No. 85, June 1987, pp. 699-705

World Health Organization (1988): Urbanization and Its Implication for Child Health: Potential For Action, Geneva: World Health Organization.