MOVING BHUJ TOWARDS WATER SECURITY

Final Report

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CEPT University

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The report documents the Bhuj story- its unique history and ACT’s activities in Bhuj, to highlight key lessons. CEPT intends to translate these lessons to develop generic guidelines that can be used in other cities and pave way for them to become water secure. This report is an attempt to describe the efforts of local resident groups in reviving the traditional water conservation practices in an attempt to make Bhuj water secure. The report traces the rich history of water management in Bhuj that deserves to be treasured.

The work on this report was carried out by a CEPT University team led by Meera Mehta and Dinesh Mehta and included Dhruv Bhavsar, Upasana Yadav, Aditi Dwivedi and Ami Patel.

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Acronyms

ACT	Arid Communities and Technologies
AMRUT	Atal Mission for Rejuvenation and Urban Transformation
BHADA	Bhuj Area Development Authority
CBO	Community Based Organizations
DCR	Development Control Regulations
DDWS	Decentralized Drinking Water Scheme
DEWATS	Decentralized Wastewater Treatment Systems
GIDC	Gujarat Industrial Development Corporation
IUWM	Integrated Urban Water management
JSSS	Jalsrot Sneh Samvardhan Samiti
lpcd	litres per capita daily
MLD	Million litres daily
NGO	Non-Government Organization
PGWM	Participatory ground water management
RRWH	Roof Rain Water Harvesting
SDG	Sustainable Development Goals
SLB	Service level Benchmarking
SLIP	Service level improvement plan
TDS	Total Dissolved Solids
ULB	Urban local body
WASMO	Water and Sanitation Management Organisation
WSUD	Water Sensitive Urban Design

1. Introduction

Water scarcity has become a major concern for cities. History teaches us that many civilizations were wiped out due to water scarcity. With climate change and resultant uncertain weather patterns, cities have become even more susceptible to water scarcity than ever before. The global community has also recognised importance of this issue in the "2030 Agenda for Sustainable Development", specifically, in the Sustainable Development Goal (SDG) on water to "ensure availability and sustainable management of water and sanitation for all" and the Target 6.4, which states that "By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity".

'Water scarcity is usually understood as a gap between available supply and expressed demand of freshwater in a specified domain. (Land and water division, 2012). It can be further elaborated as the ability to access sufficient quantities of clean water to maintain adequate standards of food and goods production, proper sanitation, and sustainable health care. Water, in absolute terms, is in short supply planet-wide. But in urban areas, water is increasingly becoming scarce. It is estimated that by 2025, 1800 million people will be living in countries or regions with absolute water scarcity, and two-thirds of the world population could be under stress conditions (Water Scarcity, International Decade For Action 'Water For Life' 2005-2015)

The urban landscape influences infiltration and evapotranspiration, complicating our capacity to quantify their dynamics across a heterogeneous landscape at contrasting scales. Impervious surfaces exacerbate runoff processes whereas runoff from pervious areas remains uncertain owing to variable infiltration dynamics (McGrane 2015).

This study of Bhuj, a city located in arid region of Kutch in India, demonstrates how the city that had withstood water scarcity for centuries has revived its traditional wisdom to work towards becoming water secure. Bhuj has annual precipitation of less than 300 mm and potential evapotranspiration of 1500-2000 mm. Such scant rainfall has resulted in haphazard digging of wells, which interfere with spring discharge and result in excess withdrawal from aquifers. In addition, contamination of aquifer through improper discharge of waste water constitutes major health hazards.

Kutch has survived centuries of low rainfall and droughts. Its survival was made possible due to the strategic water reserves created through traditional water management system of linking of lakes and wells. The entire water resource management system was designed to satisfy water demand of the

city even in a drought year. It demonstrated excellent application of knowledge and wisdom of the geo-hydrology of the region. However, this conventional wisdom appears to have been lost today.

While great care was taken by the founders of Bhuj to ensure that adequate water was available throughout the year, the city had faced serious crisis in recent years. This is partly due to total disregard of the local conditions related to the geo-hydrology by the planners and developers. Over the years, Bhuj has become dependent on water being brought from far distance.

This report is an attempt to describe the efforts of local resident groups in reviving the traditional water conservation practices in an attempt to make Bhuj water secure. The report traces the rich history of water management in Bhuj that deserves to be treasured.

History suggests that Bhuj not only met its water requirement efficiently but also planned well for the future. The integrated catchment system and water harvesting through wells and reservoirs, formed a resilient water management system. However, in recent years, the integrated catchment system has disintegrated, and Bhuj has become dependent on water being brought through Narmada canal.

This process of transition from a traditional system to a system dependent on external water resources is described in this paper. The paper highlights the efforts made by the community and NGOs in reviving the traditional wisdom of water harvesting in Bhuj. In particular, the role of Arid Communities and Technologies (ACT), a local NGO working on groundwater management is described. Since 2004, ACT has adopted a participatory approach, working with communities and local governments, to revitalise the catchment area. ACT has created awareness among residents and created community based organisations like the Jalsrot Sneh Samvardhan Samiti (JSSS), to carry out various activities. The key strength of ACT's efforts is also that it is backed by an in-depth technical assessment related to water resource systems in Bhuj through ongoing studies. Thus, ACT's efforts have combined the principles of water resource management through catchment revival, as well as aquifer mapping and protection. This includes reviving traditional efforts and folklore around these. The community awareness and mobilization further enhances these efforts and creates a local ownership.

This documentation of a unique participatory urban ground water management approach adopted in Bhuj is intended to serve as a background for developing a generic guideline for participatory urban ground water management in India.

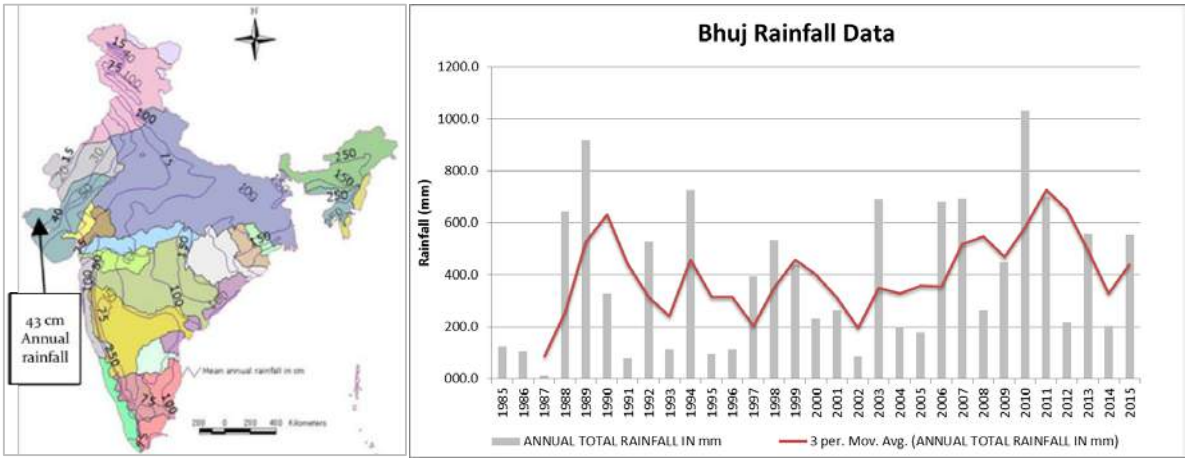
2. Evolution of Water Supply System in Bhuj

Understanding the importance of evolution of water supply system and its management is most crucial aspect for preparation of water security plan of any city. The Chapter describes the journey of Bhuj city from evolution of its traditional water supply system to its complete decline and its transition to centralised systems which eventually led to higher dependence on distant sources and complete neglect and misuse of its own groundwater source. It explains how the shift from traditional to municipal system cause neglect of catchment system and decline in groundwater levels.

2.1 The Unique Context of Bhuj in Kachchh

The land of Kachchh is more than 180 million years old. It was buried beneath the sea at several points during its history as the tectonic plates parted and collided over time. The process of sediment deposition and rock formation occurs constantly, regardless of the sea level. Therefore, the rocks that formed while this land was the sea floor (marine formations) became saline. The water stored in such rocks is, as a result, inherently saline. Any recharge that occurs over these marine formations is rendered unsuitable. Even where sweet water is found, it becomes saline at greater depths. The constant process of sedimentation meant that rocks formed when the sea levels receded, and these rocks store water that is inherently sweet. Only 15 percent of mainland Kachchh stores such water, and as such, only a small zone has the potential for substantial groundwater withdrawals (Suleman, 2003).

Figure 1: Rainfall in Bhuj



Source: Indian Meteorological Department (1985-2015) and Central Statistics Office (2015)

In addition, Kachchh falls in one of the most arid regions of India receiving around 430 mm of annual rainfall in comparison to the national average of 1152 mm. Moreover, it has a high coefficient of variance in annual rainfall at 65%. This means that the total amount rainfall can vary by upto 65% from the average year to year. This unpredictability magnifies the problem of water scarcity in Bhuj.

However, within the Kachchh region, Bhuj has a position due to its unique geo-hydrology and aquifer system. Bhuj resides on a large porous sandstone aquifer. This cretaceous sandstone belt is one of the few in Kachchh, and has enormous capacity to hold water for year-round municipal and agricultural use. The central part of the lake system catchment is located on a cretaceous sandstone belt, which acts as a spongy layer for recharging water. With fault lines on south, east and west, it forms a confined aquifer and has a reverse dipping against the slope of the area. There are predominant shale formations on the southern and northern parts of the catchment. The lake system's five receiver Lakes are located on this pervious sandstone belt, while the feeder lakes that make up the upper catchment system are located on impervious shale, preventing percolation until water can be moved into the urban area where it is most needed. When the aquifer is full, healthy and potable water is easily accessible by decentralized methods such as community wells. However, the lowering of the water table due to disrepair of the lake system has a compounding negative effect: the water becomes harder to reach through common wells and the portability of remaining ground water decreases, as a lower water-to-rock ratio increases water salinity, due to the highly-saline nature of sandstone (Jadeja, 2011).

Box 1: Unique geological features of Bhuj

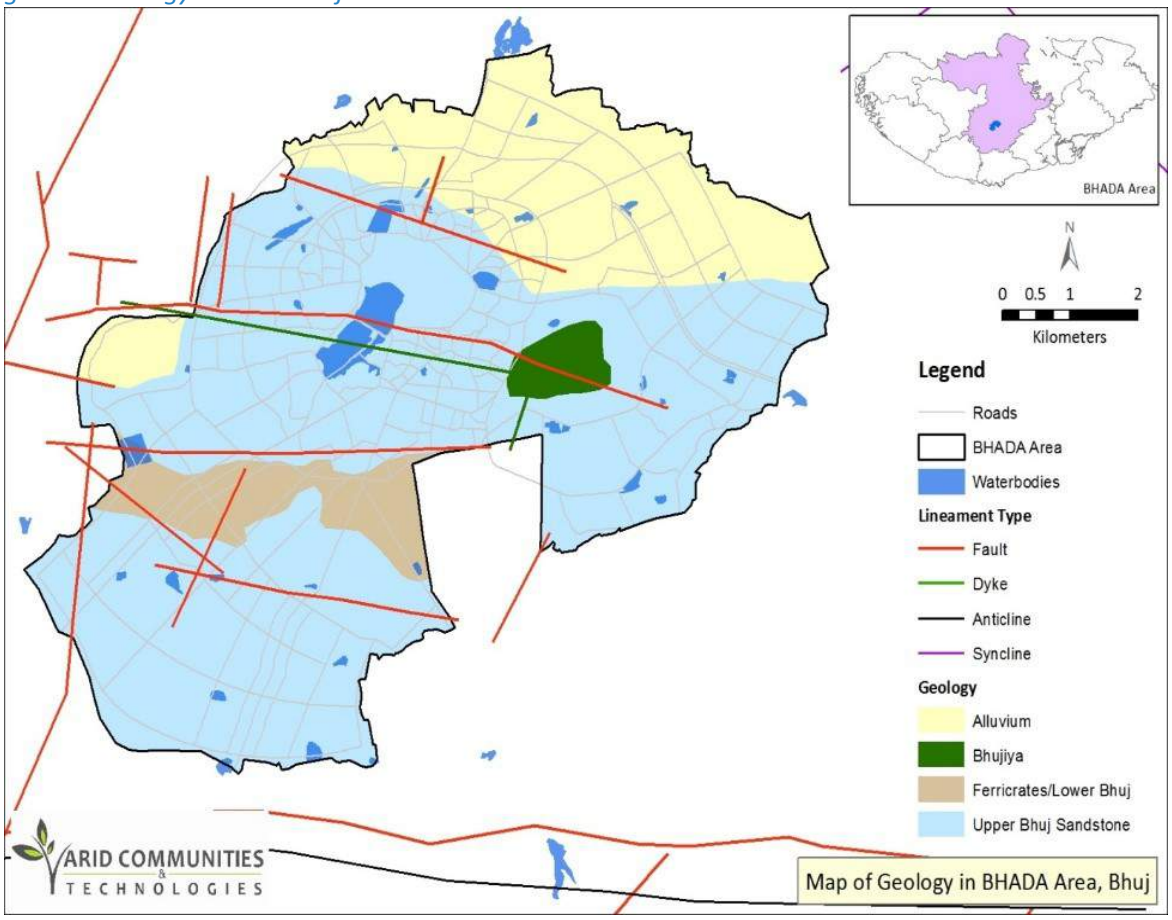
The rock formations of the area show their age ranging from Middle Jurassic to the recent age. Sedimentary rocks of Cretaceous sandstone and upper Jurassic times are found in Bhuj and it is mainly recognized as Bhuj formations. The main rock formations of the area are sandstone and shale with a few basaltic intrusions. The sand stones are arrenaceous and origillaceous type of different ages / different series. The oldest rock formations in the area are shale and fine grain sandstone of the Chhari and Katrol series of the Middle and Upper Jurassic. A huge thickness of non-marine sandstones of uniform character constitutes the youngest formation of the Mesozoic stratigraphy of Kachchh (Biswas,1977). It is named after its type section locality around Bhuj city of Kachchh. This formation is defined by the marine beds of Jhuran formation below the Deccan trap. There is frequent intercalation between the shale and sandstone, as well as with limited limestone deposits in the region. On average, the formation shows gentle dip towards south, ranging from 5° to 13°; at its shallowest the sandstone is only 18m deep, and deepens to 123m at its southern tip.

The formation is extensively exposed along the southern flanks of the northern and central hill ranges in two wide E-W strips. In the extreme west and east they are exposed as small inliers in the Bhuj formation at the central of the domes and anticlines. In the central and western parts of the Mainland, the lower, the middle and the lower part of the upper members are extensively exposed. The middle member is very well exposed in Khari river valley around Rudramata Temple, north of Bhuj.

This formation is divided into two parts known as lower Bhuj formations and upper Bhuj formations. The two layers are separated by a rock named letharite, which contains iron and whose thickness is approximately 0.5 to 1.5 meters. The belt of cretaceous sandstone is the region's only good aquifer, but has a risk of high salinity due to the naturally saline nature of the sandstone and proximity to iron and shale deposits. Apart from this, Basalt is found in areas around Bhuj, near to Bhujiyo hill.

Source: (Hunnarshala & ACT, 2011)

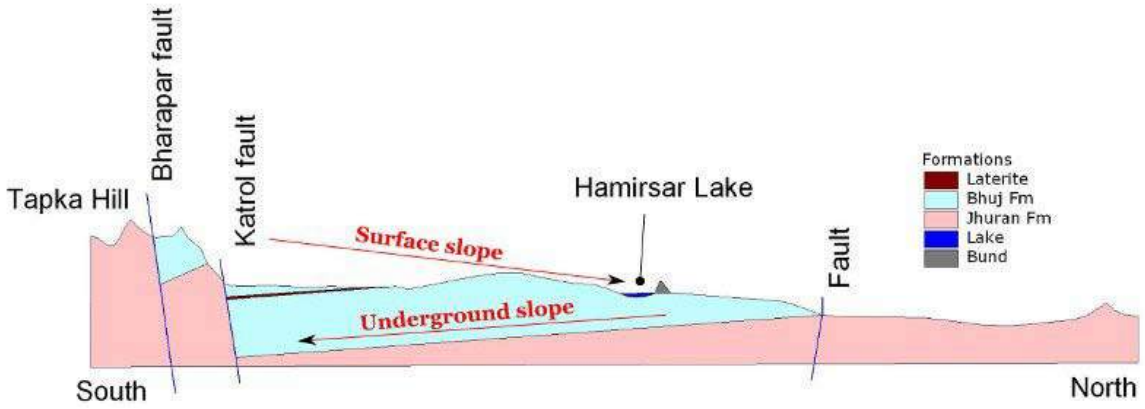
Figure 2: Geology around Bhuj area



Source: ACT, Bhuj

The surface rain water in Bhuj flows towards Hamirsar and the other city lakes. It can then penetrate the ground and gets stored in this enormous natural underground tank. With fault lines on south, east and west, it forms a confined aquifer and has a reverse dipping against the slope of the area. The underground water could then be tapped through one of the 60 wells in the city. The shale layer, below the sandstone, is water proof and makes sure that the water doesn't flow out of Bhuj Area underground. All the 'feeder dams', in the upper part of the catchment, are directly in contact with the shale layer. The water doesn't go underground and is therefore a great surface water storage which can be used to 'refill' Bhuj lakes when required. (Geology and Topography around Bhuj, 2016)

Figure 3: Schematic representation of Bhuj Aquifer



Source: ACT, Bhuj

2.2 Emergence of Bhuj and Development of Hamirsar Catchments (1500-1800 AD)

Bhuj, earlier known as 'Bhooj', dates back to more than 500 years. It was established in 1510 by Rao Hamirji in Kachchh, Gujarat and was later declared the capital of the region in 1549 by Hamirji Rao. The topography of Kachchh is in the shape of a tortoise shell, where the mount is demarcated by hill ranges running east-west. Bhuj is located near the foot of Bhujiya hill towards the south of the Kachchh hill range.

The location was strategic for two reasons. The hill on which Bhujio Fort was built was extremely defensible, and the area's geology included a cretaceous sandstone belt—one of the only in Kachchh—that provided a consistent source of groundwater for the young city and surrounding agricultural area. The local rulers combined the region's two river systems with a series of dams and canals to feed the artificial Lake that eventually earned the name 'Hamirsar.' Nearly 450 years of careful catchment management and development kept the aquifer healthy and continuously recharged, even during the periods of drought.

Development of the Hamirsar Lake System

During 1510 to 1549, from inception of Bhuj to its declaration as a capital, Hamirsar Lake system was developed to serve the city. During these forty years, a system for water management was designed and built to harness water from catchments. This system consisted of a series of lakes, water channels and canals and open wells in the periphery of the lake to facilitate recharge from lakes through the sandstone aquifers.

As documented by Raman (2014, pg 12), "The first work which was carried out after establishment of Bhuj in 1510 was deepening Hamirsar Lake in the heart of Bhuj and increasing its capacity (Mahajan and Bharwada). The major function of Hamirsar Lake was to recharge the groundwater and make

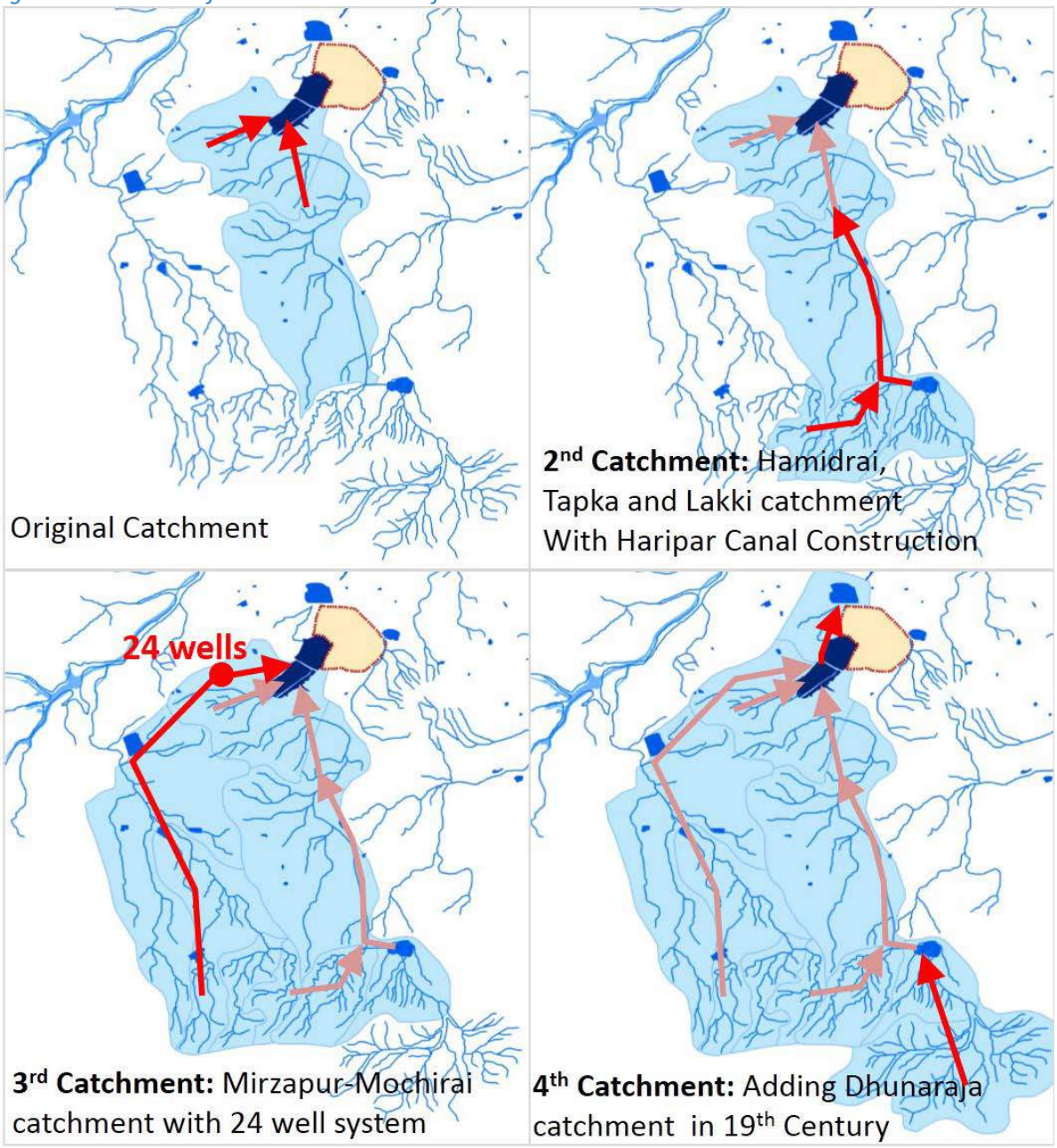
water accessible to the people of Bhuj through a system of open wells. In 1549, Hamirsar Lake which was originally a small talavadi named Hamirai after a Maldhari Hamir was converted into a big lake. It was after this that Bhuj was declared as the capital of Kachchh. The original area of water catchment was too small to fill the entire Hamirsar Lake. Hence, the king decided to harness water from two other adjoining catchments: the Hamadrai catchment and Mirzapur catchment through channels and underground tunnel". The system was designed such that the water from the catchments that fed into the lakes was harnessed to keep the lakes full with water.

Photograph 1: Links with southern catchments

Source: ACT, Bhuj

Initially, water was brought to Hamirsar Lake from the Hamadrai catchment through the Haripal canal. Another link to the same canal was made from the Tapka and Lakki catchments in the upstream. The water passed through the canal into the Badami Chhela catchment and ultimately to Hamirsar Lake. Later water from the Mirzapur catchment too was fed into the Hamirsar Lake using lined water channels. Water also reached the Hamirsar Lake via Mochirai catchment and Mangalam area. Both catchments could serve enough water to the city over years.

Figure 4: Evolution of linked catchments of Hamirsar



Source: Adapted from Raman (2014)

In late 19th century, the need for harnessing water from another catchment was felt. For this purpose, a dam in the Dhunaraja catchment was constructed. This dam held water coming from the ridge. This water was mainly used for irrigational purposes, and diverted to Hamirsar Lake only when water from other two catchments was not sufficient. As a mitigation measure during the overflow of the Hamirsar Lake during monsoon, a channel was constructed in the western part of the Lake that drained into the Pragsar Lake. This channel was used to prevent overflow of the Hamirsar Lake.

Box 2: Water Resource management: Similarity with Dhaloavira from Harappan civilization

Drawing similarities between the ancient Harappan civilization's metropolis 'Dholavira' and Bhuj, one realises that Bhuj had mastered its water resource management using the learning from Dholavira. Water conservation of Dholavira demonstrates the ingenuity of the people who developed a system based on rainwater harvesting to support life in a parched landscape, with scanty sweet water. Relying partly on rain-water and little from the ground, a complex water system comprising of large rock-cut reservoirs, were developed. Huge stone drains can be seen in the city the directed storm water to the western and northern section of the lower town separated by broad bunds, creating in-effect a series of reservoirs. The most imposing well was located in the castle and is possibly the earliest example of a rock cut well. The city also drew water from the seasonal streams flowing on the northern and southern faces of the fortification. The water from these streams was stored by a series of dams and partly channelized water into the lower town. Every drop of water was conserved to ensure survival. These practices are evident in Bhuj as well. One can see that ground water management was carried out through interlinking of various fresh water sources such as lakes, rivers and their catchments. As a result, the aquifers are recharged and water is available in wells even during the years of drought.

Source: UNESCO (2016) and Joshi (2008) as quoted by Raman (2014)

On the addition of Mirzapur-Mochirai catchments, Raman (2014, pg 13) reports "To ensure efficient operation of the water system, care was taken to maintain the entire system properly. This included regular cleaning of the water channels, through which water from the catchments were channelized to the Hamirsar Lake. This was done through the Chaubees Kuaan (twenty four wells). These wells were huge chambers constructed over the underground channel in the Mochirai Catchment through which regular cleaning and de- silting could be done."

Figure 5: Schematic map of 24 wells over underground channel

Source: Raman (2014), p.13

Over the years, Hamirsar Lake was deepened and separated into a three-Lake system - common to the Kachchh region. The three lakes were: the small Dhobi talav reserved for washing; the shallow Chattedi set aside as a wetland area for local and migratory fauna, and Hamirsar kept as a drinking water supplier to the city. These three lakes were usually kept at full capacity.

Management of the Catchment

The entire catchment system was well-managed and activities such as de-silting and cleaning of lakes, cleaning of channels in catchment areas, and cleaning of canals were done regularly. The lake system in Bhuj helped to recharge the aquifers and supply drinking water through wells. These wells included public wells on the lake's periphery and personal wells owned and used by a group of families or communities. Apart from maintaining wells and keeping checks on water extraction, various communities had different ways of managing their water demands. Some communities allocated a

specific quantity of water to a family based on the number of persons. Consumption was governed by allotted number of bucket withdrawals for each family.

2.3 Shift from the Traditional to a Municipal System

In 1815 Kachchh became a British protectorate and ultimately a Princely State, whose local ruler acknowledged British sovereignty in return for local autonomy. Bhuj was the Capital of Princely State of Kachchh. When the British East India Company annexed Indian territories, the water supply systems came under its direct purview (Uma Sankari, 1993).

There was very little effort made to augment water supply of Bhuj during the British regime, though in some parts of Gujarat, piped water supply was introduced. At the same time, there was very little effort to understand and improve the traditional systems – be it natural resource management, irrigation or drinking water. Raman (2014, pg 26) highlights the changes in land tenure system and the British quest for extracting large revenues. “The enormous drain of the village review by appropriation by the state led to disintegration of the traditional society and polity. At the local level, allocation for infrastructural arrangements such as irrigation systems – for their maintenance and management- were stopped.” The British introduced a more centralized system of management staffed by civil engineers, who were largely not familiar with the local water resource management systems. This twin effect of less fiscal resources and an unaware administration led to the neglect of the traditional water resources management system in Bhuj.

Bhuj had a moderate population growth till 1950. Since then, with the opening up of the railways and construction of a new road, there was a spurt of economic activities in and around Bhuj, leading to more rapid growth of population.

The traditional water system in Bhuj was sufficient to cater to the water requirement till 1960s. However, with the growing population, spatial growth of the city and resultant demand for water, it was decided to introduce piped water system in Bhuj. Once the piped system was introduced in 1968, the focus shifted to household level water supply connections. This led to a significant increase in average household consumption. As a consequence, the water demand in Bhuj exceeded the available supply in Bhuj, resulting in a need to “bring” water from outside. The urban development process in Bhuj during this period was focused on making development plans and T.P. Schemes, with a total disregard for the traditional systems of lakes, design of their catchment systems and water harvesting.

In 1968, water from the bore wells dug at Bhujodi village, nearly 20 Kms away from Bhuj, was used to meet the demand for water. Water from such a distance had to be piped into Bhuj, because the water

in the periphery of Bhuj was not potable due to high iron content.[1] Water from Bhujodi was brought through pipes to the city. A sump of 2 million litres capacity was constructed near Bhujiyo hill.

A distribution system was designed to supply water through pipes to households. . Water was supplied at a frequency of twice a week and at high pressure of9 metres. Household connections were metered. However, this had limited reach, catering to only about 600 households that took the connections out of a total of nearly 10,000 households.[2] Other households relied on fetching water from common public stand posts. Thus, despite the introduction of piped water distribution system, a majority of the households continued to rely on wells and public stand posts.

The first water stand post was installed near the 'Mahadev Gate' of the Hamirsar Lake. The first overhead tank of 0.5 million litres was constructed at the Madhav Gate in 1988. Other sumps of 0.8 million litres and 3 million litres of capacity were built in 1973 and 1985 respectively. As the city expanded beyond the fort boundaries, there was a need to construct new water distribution stations. In 1995, a new sump at Madhapar and an overhead tank at Shivakrupa were constructed. (Raman, From 'Bhooj to Bhuj': The rise and fall of resource management system, 2014).

The initial high cost of a metered connection may be a reason for limited number of water connections. The idea of paying for water by meters also may have deterred new connections as so far no household had paid for water. In 1972-73, meters were removed and a flat monthly fee was introduced. The monthly water tariff was changed frequently – from initial Rs 6 per month per house, to Rs 10 per month in 1983-84, and raised again to Rs 30 per month in 1993-94. As more household connections were taken, the demand for water increased. The introduction of sewerage in many parts of the city, had led to further increase in demand for water[3]. Thus, from early seventies, the gap between water supply and water demand had widened significantly. As more water connections were demanded, new sources of water had to be tapped.

Overall, these developments resulted in three processes which made it difficult to rely on the traditional water wisdom on which Bhuj, the capital of Kachchh was founded. We trace these below along with their impact on Bhuj city in terms of water supply and its overall environs.

Neglect of the catchments for Bhuj water supply

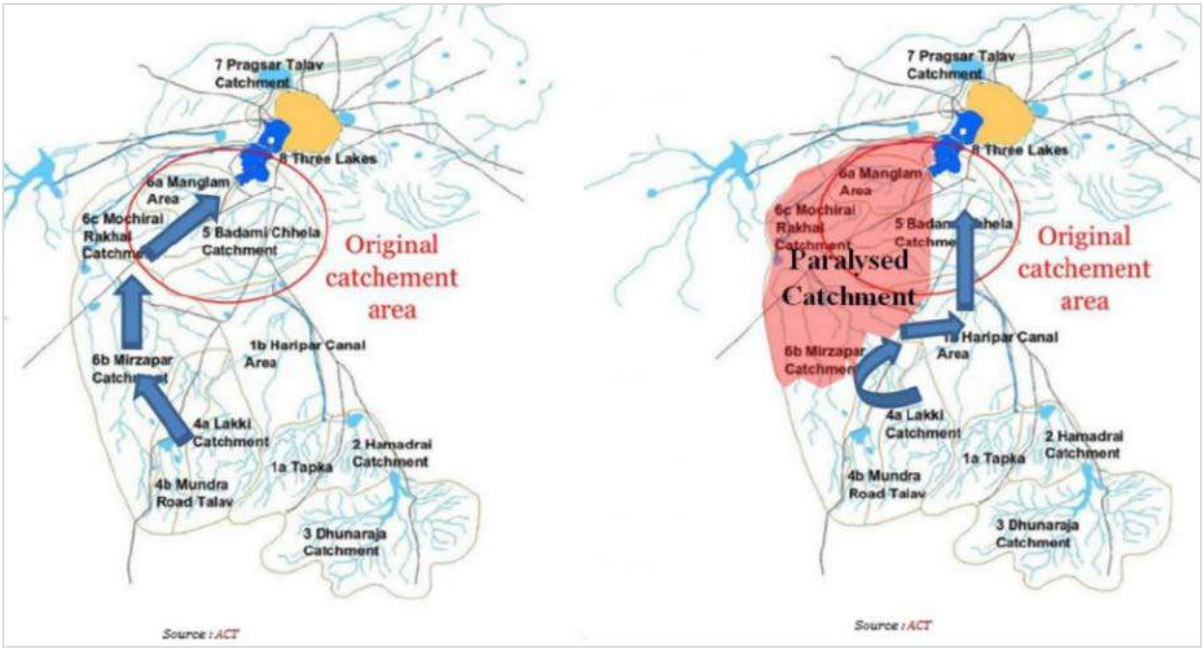
With introduction of piped water supply system, and the resultant rise in quantity of water demand, the civic authority had felt that the "traditional" water harvesting through watershed management

[1] Based on Raman (2014), derived from consultations and interviews with local resource persons.
[2] Based on Census of India for total population and Raman (2014) for number of households covered by initial water supply.
[3] As per norm, water supply should be at least 135 litres per capita per day for efficient functioning of sewerage system

and lake regeneration would not be able to supply adequate quantity of water. In addition, as the quality of water from immediate periphery of Bhuj was considered inadequate, water from ground water sources beyond Bhuj environs were considered necessary. Over time, during 1990s, greater dependence on water from outside became the norm.

The introduction of piped water using distant sources had a two-fold effect. The first was that water, for which one had to walk to the well or a public stand post was now easily available at home through taps. Despite the initial attempts to introduce metered supply demand management was a problem as the pricing was as flat charge and thus did not influence usage. Also, even the flat water tariff was very low at only Rs 10 per month. So water was not valued as a scarce resource as in the past. The earlier system of community based management of water demand had started to break down.

Figure 6: Impact of the neglect of Mirzapur Catchment



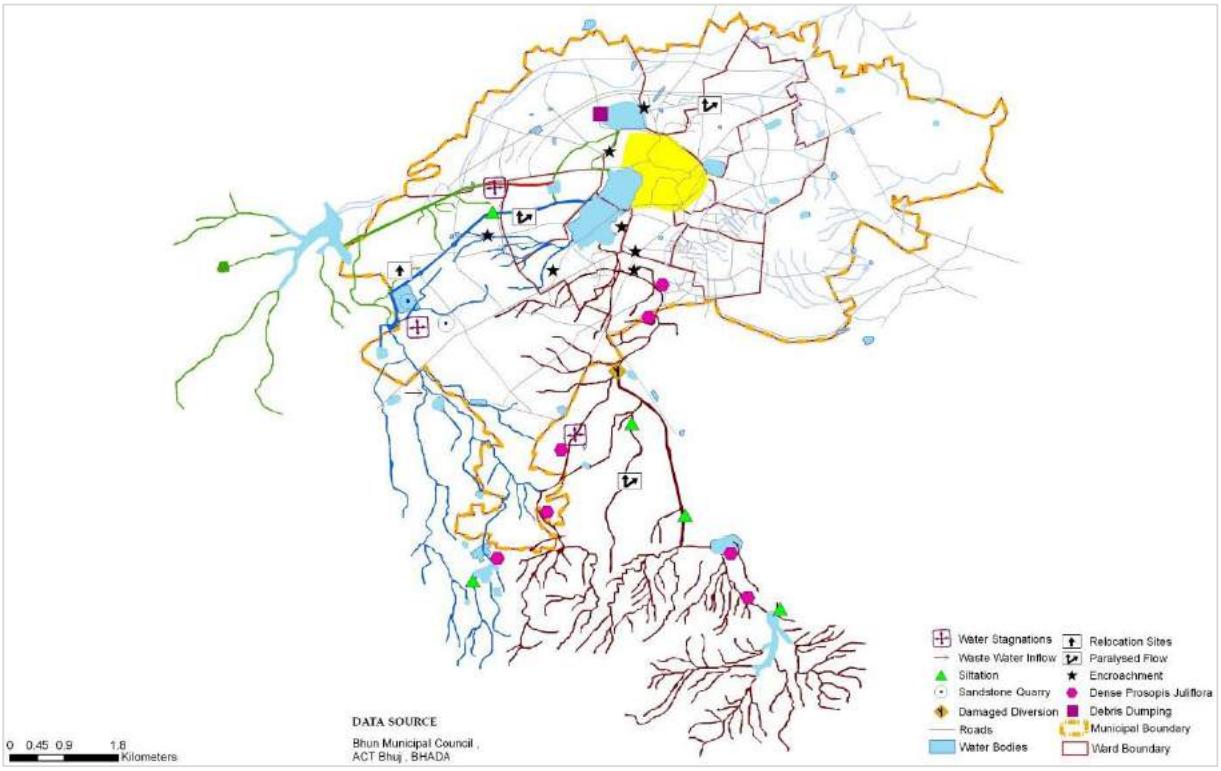
Source: Raman (2014), p. 45

Secondly, with a much greater share of total municipal water supply coming from external sources, there was a tendency to neglect the 'traditional wisdom' related to natural water systems. The systems set up in the early years for operation and maintenance of lake catchments was now being neglected. This was evident from the fact that a number of natural drains leading to lakes and drawing water from their respective catchments were lost due to construction activities. Many lakes were also lost as they were filled and converted to buildable land. Raman (2014) highlights a number of such examples. The first was the breakdown of the Mirzapur catchment during the mid-1980s to mid-1990s. The lake land in this catchment was allotted for residential purposes, which resulted in diversion and later paralysis of the entire Mirzapur catchment. The 24 chambers built in the Mochirai catchment for regular inspection have now become redundant along with the entire catchment.

Thus the neglect of catchments led to the drying up of many lakes, which then were taken over for residential purposes by realtors in the city. This had a double impact on Bhuj eco system. First, it reduced the water available in the lake system for the aquifer from which ground water can be drawn through a system of wells. Secondly, in days of high rainfall, the collapse of the carefully designed system led to flooding in many parts of Bhuj.

The second example illustrated by Raman (2015) highlights this. This pertains to Pragsar Lake which encompassed an area of over 54 hectares. It was designed nearly 500 years ago to capture the overflowing water from Hamirsar lake during heavy rainfall. However, with the neglect of catchments, it has often remained dry. As a result, the Local Council took the decision to sell the land for residential development. After the 2001 earthquake, debris from collapsed buildings were used to fill up the entire area, resulting in a death knell for Pragsar Lake. Importance of this lake was recognised in 2011, when heavy rains caused severe floods in and around Pragsar lake area.

Figure 7: Issues in urban water catchment area mapped



Source: ACT, Bhuj Municipal Corporation

Decline of the lake system in Bhuj

Apart from the main Hamisar lake, watershed of Bhuj has network of another 43 lakes located in and around Bhuj. These lakes were an important component of the water resource system of Bhuj city. These lakes formed an important part of natural watershed of Bhuj. However over the years these lakes were encroached upon and used for sewage and garbage dumping. Today many of these lakes

face serious threats of encroachment, eutrophication, and silt accumulation. Some of these lakes have disappeared and are completely built over. Once the sponges of city, today these lakes have turned into hazards. It is the disappearance of these sponges of the city that has exacerbated floods and sharpened the pain of droughts (Churning Still Water, 2012).

Figure 8: Water bodies in Bhuj area

Source: ACT, 2015

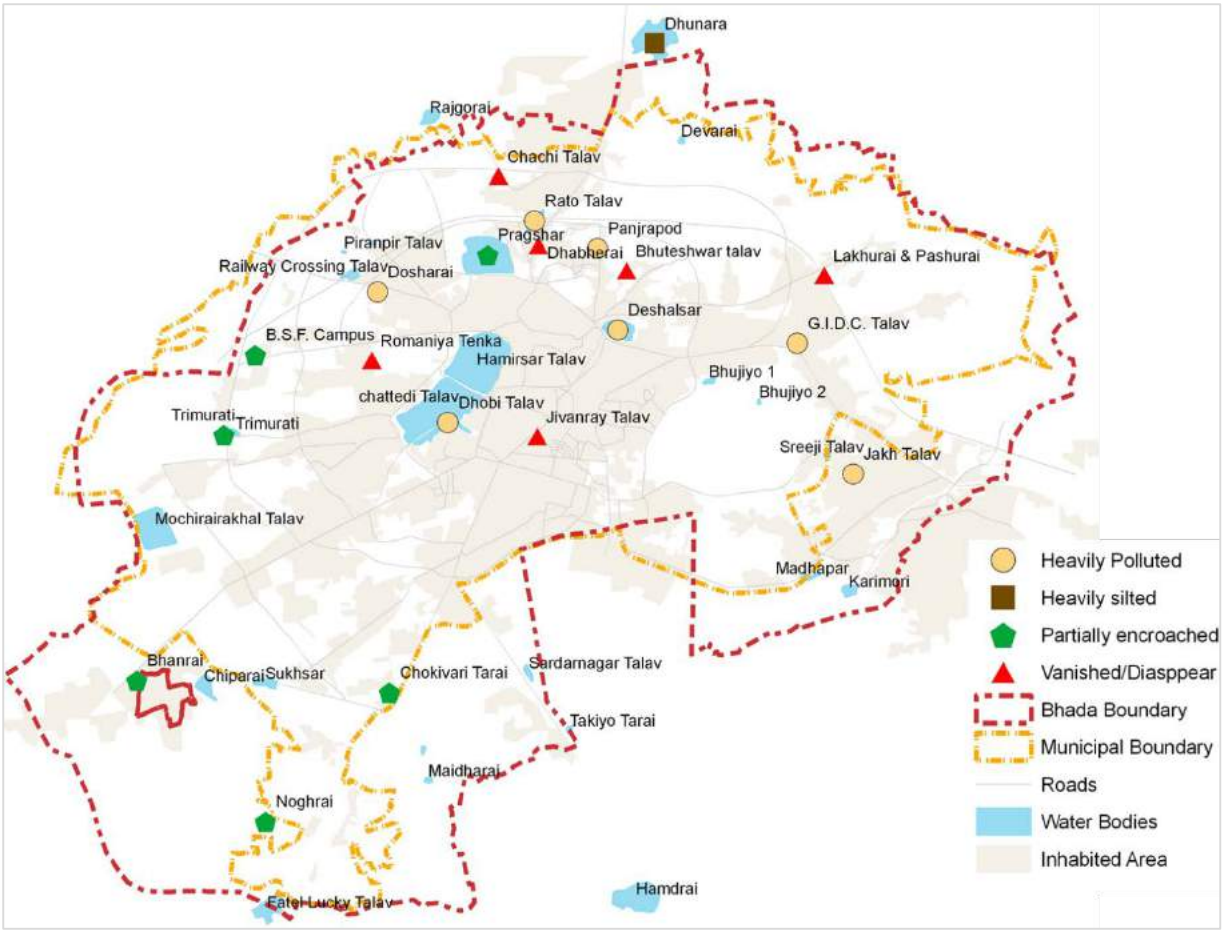
Table 1: Categorization of lakes based on condition

Category of lakes based on current condition	Number of lakes
Existing and visible lakes in "good condition" (eg. Hamisar lake)	29
Heavily Silted (eg. Hamdarai lake)	13
Heavily Polluted (eg. Deshalsar Lake)	11
Partially encroached (eg. Pragsar lake)	7
Vanished/ disappear lakes (eg. Jivanray lake)	6

Source: ACT, 2015

From Table 1, it is seen that more than half of the lakes of Bhuj are affected by encroachment, silting and pollution load. Several lakes are heavily silted and polluted. Some of the lakes have been blocked by encroachments and unauthorized development. Also improper maintenance has affected quality of water in lakes. These lakes do not help in recharge of aquifer through infiltration during rains.

Figure 9: Existing condition of Lakes



Source: ACT, 2015

Ground water in Bhuj – falling water levels and declining quality

Deterioration of watershed and lake system has affected both water quantity and quality of the aquifers. In the area underlain by Bhuj sandstone in Kachchh, water was available at the depth of 9 to 30 metres in the dug wells and the water table was 2 to 21 metres in the 1960. In the year 2000, water was available in dug-wells at about 30 meters and many bore wells had water at 100 meters (Standing the test of drought, 2000).

In 2015, water in dug-wells is available below 55 meters and the depth of borewells has reached about 200-300 meters. It is estimated that there are about 69 dug-wells and about 150 borewells within BHADA area[4]. Overexploitation of the ground water resources has depleted the underground aquifers. As the depth of water withdrawal increases, the quality of groundwater declines with increase in concentration of TDS, salinity and iron content. There is a high concentration of pollutants in the groundwater that makes it non-potable in many areas. The Total Dissolved Solids (TDS) concentration ranges from 750 mg/l in shallower areas to over 7000 mg/l in the deeper bores. This is an indication

[4] ACT estimates

that, as the water table goes down, the concentration of salts and iron increases. Additionally, since wells are dug deep (beyond 125m), they draw water from intercalation of sandstone with shale, yielding a very high saline content (Revival of Hamirsar Lake and its catchment - wetland and urban rural relationships, 2012).

In summary, one sees that in the last four decades water demand in Bhuj has increased due to several factors, e.g. introduction of pipeline, growing population, increased demand form educational institutions, and defence establishments. This has led to reliance on sources of water beyond the confines of the city. However, the approach of shifting the reliance totally to external water sources and making this available at very cheap rates has led to a different culture of water usage in Bhuj. As more water became available, the water conserving culture of Bhuj residents has given way to a water consuming culture. In this context, it is important to assess the participatory processes adopted by civil society organisations in Bhuj to revive the traditional water heritage and create awareness among people to understand and respect the water ecology of the region. In subsequent chapters, efforts by ACT, JSS and other civil society organisations are described.

3. Emerging Challenges and Opportunities for Water Security

In January 2001, a massive earthquake, with its epicentre at about 70 Kms from Bhuj, had devastating effect on Kachchh district. The earthquake killed nearly 20,000 people, injured 170,000 and destroyed over 400,000 houses. Bhuj suffered extensive damage. Its water supply system had to be retrofitted and reconstructed after the earthquake. Since then, Bhuj has been receiving water from Narmada canal and appears to have become water secure.

3.1 Municipal Water Supply in Bhuj

Over the past fifty years since the piped water supply system was introduced in Bhuj in 1968-69, there have been significant changes in sources of water supply for Bhuj municipal area. Bhuj municipality is the responsible government agency to ensure supply of drinking water to the residents. In exploring sources of water, the municipality went 11 km east of Bhuj boundary in Kukma village. Nearly 26 borewells in Kukma and 4 bore wells within the city supplied 2 Million Litres per Day (MLD) of water to Bhuj city in 1970. From these sources nearly 12 MLD of water is currently drawn. In addition, since 2004 Bhuj Municipality has received water from Narmada canal. In 2004, it used to receive 4 MLD. This has increased to nearly 20 MLD in 2015.

As per Municipal council records, Bhuj receives total of 32.5 MLD of water from different sources as per given table:

Table 2: Municipal council water supply in Bhuj: 2016

Sources	Quantity (MLD)
Kukma Borewells	12.0
Narmada Main line	14.0
Narmada Air valves	6.0
Bharapar Tubewells	0.5
Total	**32.5**

Source: As per discussion with Bhuj municipal council (water engineer) and GWSSB Bhuj office,2016

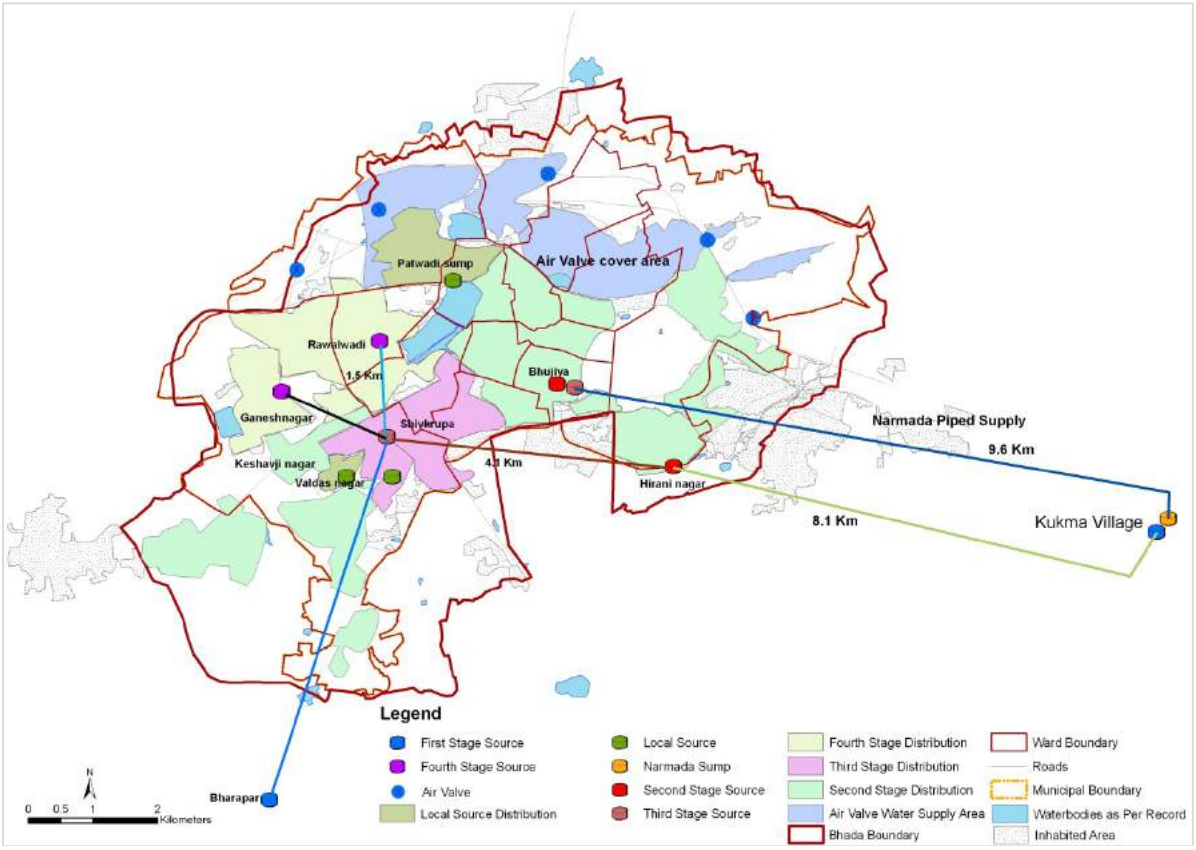
Water from Narmada canal is pumped at Malia and treated at Kukma in a filtration pond having capacity of 28 MLD. Water from Kukma is then pumped to Bhujia hills sump and distributed in city.

Ground Water from Kukma tube wells is pumped through rising main and collected in the underground sump of capacity 1.5 million litres situated near Madhapur. Water from this storage sump is then conveyed through rising main to the reservoir tank at Shivkrupa Nagar and then distributed to nearby areas and to Ganeshnagar and Rawalawadi sump. Water from tubewells located

at Bharapar is pumped to reservoir storage at Shivkrupa Nagar. There are also open wells/Borewells located within Bhuj Municipal area which supplies water to Valdasnagar sump and Patwadi sump and from there it is distributed in different areas.

Apart from above distribution system, Narmada air valves supply around 6 MLD of water in Northern peripheral areas. Water Distribution pattern and zones are depicted in Figure 10 below.

Figure 10: Distribution of Water in Bhuj



Source: Bhuj Municipal council, ACT

Water Supply quantity estimation

There is a lack of clarity as to how much water Bhuj actually receives from Narmada. Its reported bulk water purchase was only about 15 MLD in 2014-15 as per the information it supplied for the state government monitoring for Service level benchmarking (SLB).[5] However, as per the bulk water bills for Narmada collected from the municipality, in 2013-14, it seems to have received about 9 MLD, and has steadily increased each year reaching 29 MLD in 2015-16. This is contested by Bhuj municipality. They state that Bhuj gets around 14 MLD from Narmada water and around 6 MLD from Narmada Air

[5] As per information submitted by Bhuj city for Service level Benchmark for year 2014-15

Valves.[6] Lack of exact quantification of total water supply in city is one of major concern in formulation of water security plan for Bhuj city.

Table 3: Estimates of Quantity of Water Sourced by Bhuj Municipality (in MLD)

Year	Average quantity of water sourced by the Bhuj Council for municipal water supply in Bhuj			Estimated per capita supply *(lpcd)*	Average hours of supply per day
	Ground water sources	Narmada bulk water source	Total		
2008-09	13.9	4.3	18.2	107	1.0
2009-10	13.9	2.5	16.4	84	1.25
2010-11	13.9	2.5	16.4	83	1.25
2011-12	13.9	2.5	16.4	91	1.25
2012-13	14.0	6.0	20.0	103	1.25
2013-14	14.0	6.0	20.0	104	1.5
2014-15	12.0	15.0	27.0	135	1.0

Sources: Based on data submitted by the Bhuj Council to the Government of Gujarat for Service level benchmarking measurement.

Table 4: Estimates of Quantity of Water Sourced by Bhuj Municipality (in MLD)

Year	Average reported quantity of water sourced by the Bhuj Council from Narmada bulk water source as per SLB	Estimated quantity of daily water sourced from Narmada as per bills received by Bhuj Municipality
2011-12	2.5	8.6
2012-13	6.0	14.1
2013-14	6.0	18.2
2014-15	15.0	23.7
2015-16	16.0	29.1

Sources: Based on data submitted by the Bhuj Council to the Government of Gujarat for Service level benchmarking measurement.

Future Demand for water

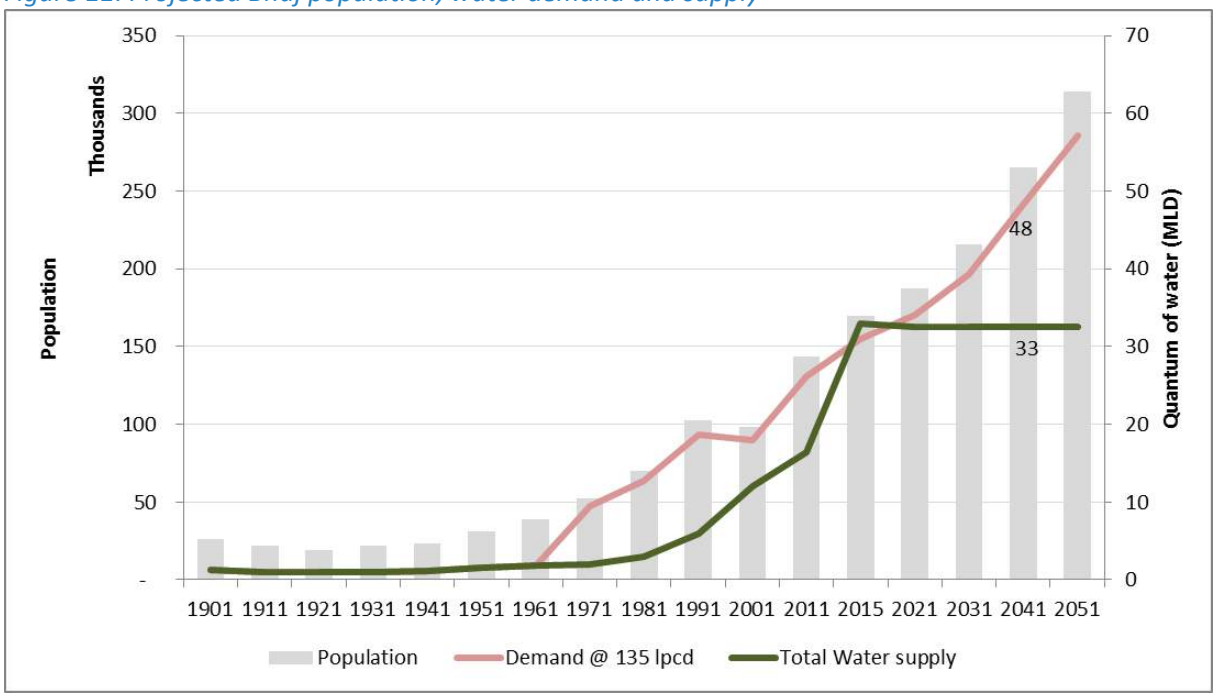
Pattern of demand for water in Bhuj has also changed over the years. In the 1940s, Bhuj population was stable and during these years the only source of water was wells and lake. It is estimated that water usage did not exceed 40 lpcd[7]. This meant that the total water demand was in the range of 1 to 1.5 MLD, and this was largely met through the traditional sources of supply. From 1950s, as population started to grow, and as the traditional systems of watershed management declined, there was pressure on water supplies. While demand for water supply started to rise to nearly 2 MLD, there probably was a stress on available supplies leading to shortages, particularly in newly growing areas. Demand for water increased dramatically with the introduction of piped water supply system in the

[6] The bills suggest that Bhuj received 8.6 MLD in 2011-12, 14.1 MLD in 2012-13, 18.2 MLD in 2013-14, 23.7 MLD in 2014-15 and till June-15 it had reached 29.1 MLD.

[7] 40 lpcd is the norm for rural water supply and it is assumed that in 1940s, Bhuj residents received no more that this norm, as there was no piped water supply and no sewerage system.

late 1960s. In addition sewerage system was also introduced in this period, which required a minimum level of water supply to remain functional. Thus, with these piped systems for water and sewerage, per capita water usage would have increased to about 135 lpcd. Thus, with continuous decadal growth of nearly 30% till the turn of the century, total water demand increased to nearly 30 MLD – more than 10 times in 30 years since 1970.

Figure 11: Projected Bhuj population, water demand and supply



Source: CEPT Analysis

3.2 Resolving inequities in the Bhuj water supply systems

An important aspect for ensuring water security in Bhuj is to ensure that there is equity in water supply and distribution. Like most cities in India, there are variations in access to the municipal water supply system in Bhuj. These are evident from an analysis of access to municipal water supply across different parts of the city, particularly the peripheral wards as well as growth areas outside the municipal boundaries.

Dependence on multiple sources due to inadequate supply

Despite the elaborate plan of bringing water from Narmada, there were still a large number of households that do not have access to municipal water supply. With Bharapar scheme in implementation peripheral areas are now covered with municipal water supply. But there is an issue of water quality in Bharapar as water is high in iron and silt content. Hence presently only 0.5 MLD of water is supplied to these areas and residents have to depend on other sources like private tube wells or tanker supply. The Bhuj Municipal council supplies water through tankers free of cost in areas where schedule piped water has not been provided. Municipal tanker makes an average of 44 trips

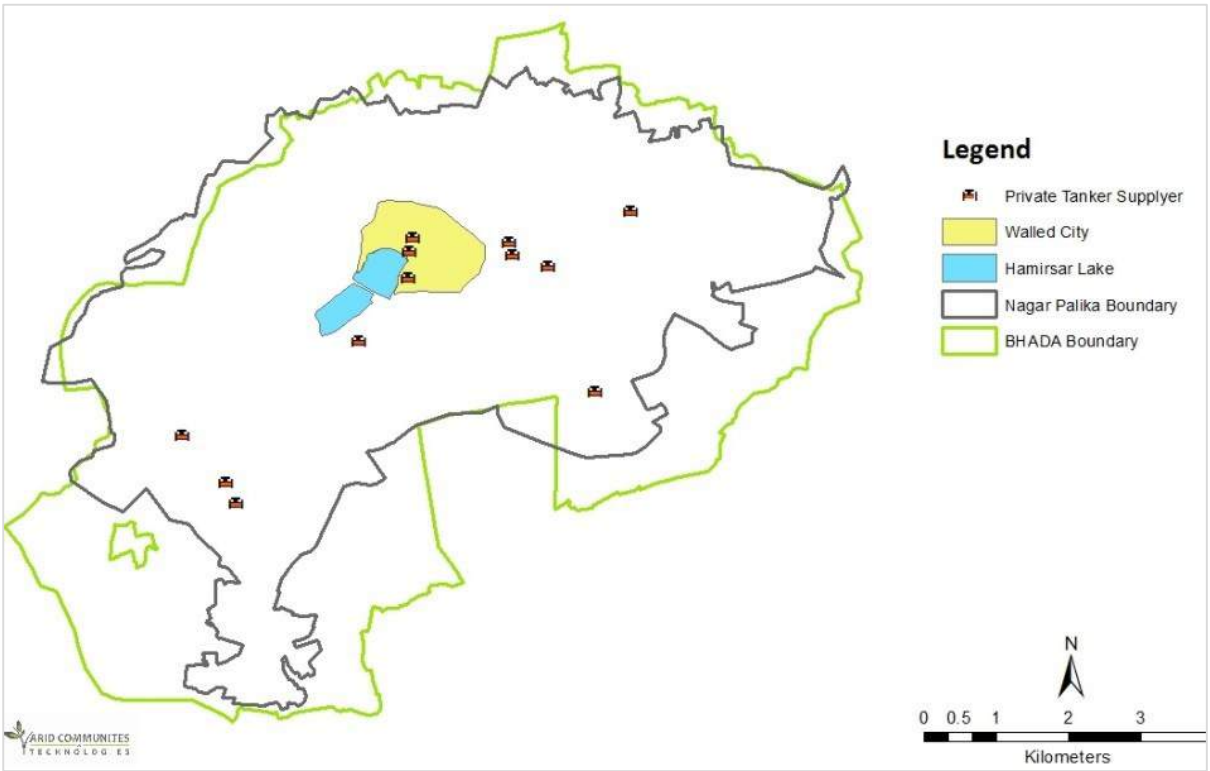
per day; of which 75% are free trips and other 25% are chargeable trips (for marriage and other occasions). Total water supplied by municipal tankers is around 1.8 lakh litres per day.

Photograph 2: Tractor pulled tankers for water supply

Source: ACT

Apart from municipal tanker supply, there is a huge market of private tanker water supply in Bhuj. There are total 12 suppliers who extract groundwater from borewells/open wells located in different parts of city. Groundwater level at these sources is found at a depth of 150-300 mts and quality of water varies between 1000-2500 TDS. Water is supplied through 75 tankers. These tankers make 420 trips every day. This suggests that around 2.1 MLD of water is supplied by private tankers in Bhuj City, which is about 6% of present municipal supply.

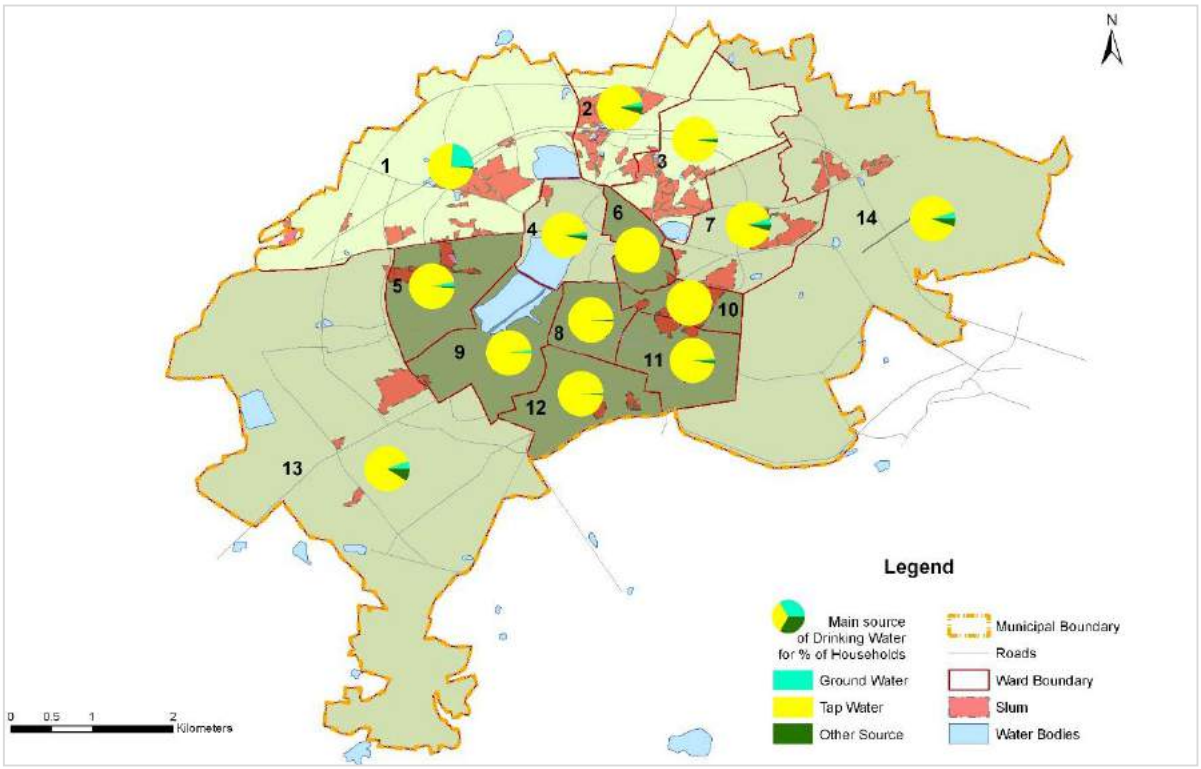
Figure 12: Location of groundwater sources of Private tankers in Bhuj



Source: ACT

Spatial analysis was also carried out for understanding distribution of individual water connection versus dependence on private wells for drinking water. It can be depicted from Figure 13 that wards which has less coverage of individual water supply connections or unserved areas are more dependent on private sources like dug wells, bore wells, etc.

Figure 13: Ward wise main source of drinking water for households



Source: Census of India 2011, Bhuj Municipality, Hunnarshala

Variations in Water supply in different areas

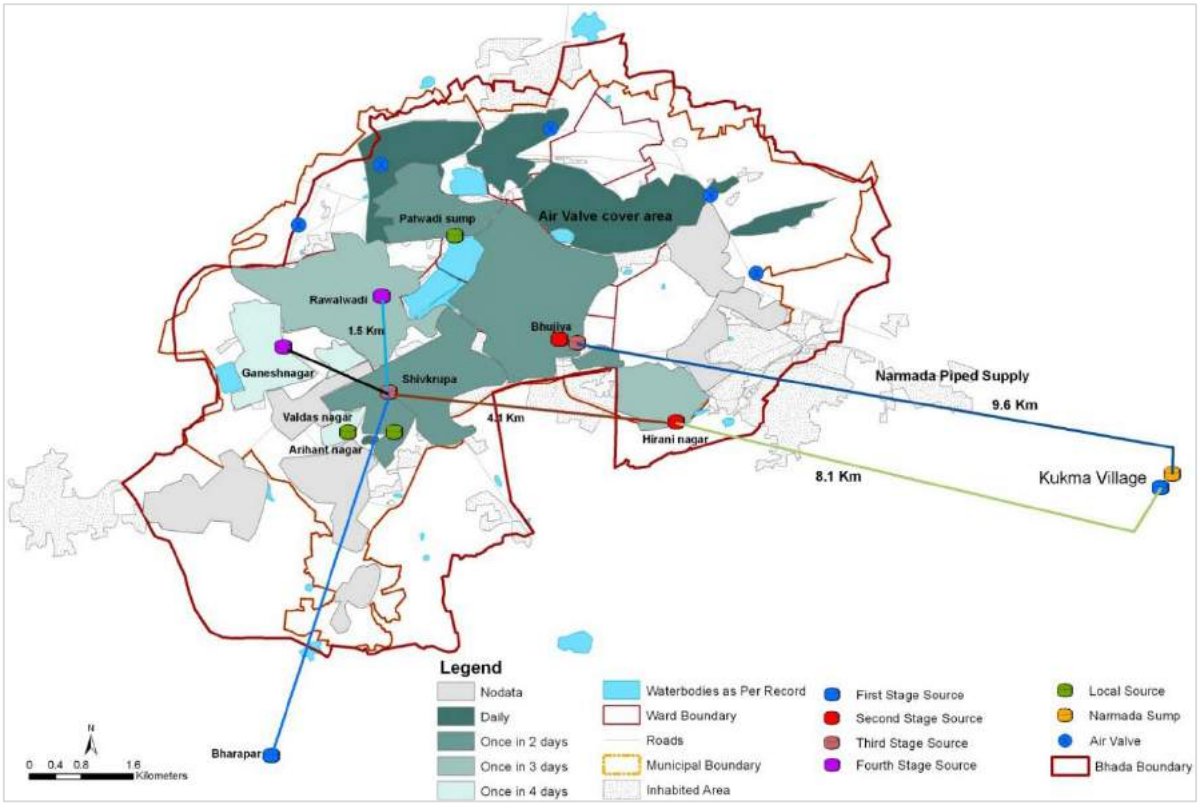
In Bhuj, there are large variations in access to water supply in different areas. Certain area receives water every alternate day while some areas receive water once in two, three or even four days. Deviations are also seen in same areas with areas nearby to sump receive water at full pressure while tail end consumers gets water at very low pressure.

Table 5: List of sumps in Bhuj with water supply duration

Sump areas	Water supply duration
Hirani Nagar (Madhapar)sump area	Once in 3 days
Bhujia sump area	Once in 2 days
Shivkrupa Nagar Sump area	Once in 2 days
Ganesh Nagar Sump area	Once in 4 days
Rawalvadi sump area	Once in 3 days
Patwadi sump area	Once in 2 days (Narmada air valve for drinking water: Once in 4 days)
Valdasnagar sump area	Once in 4 days
Arihantnagar sump area	Daily

Source: Bhuj Municipality, 2015

Figure 14: Water supply duration in Bhuj



Source: Bhuj Municipality, 2015

Water demand of Industries

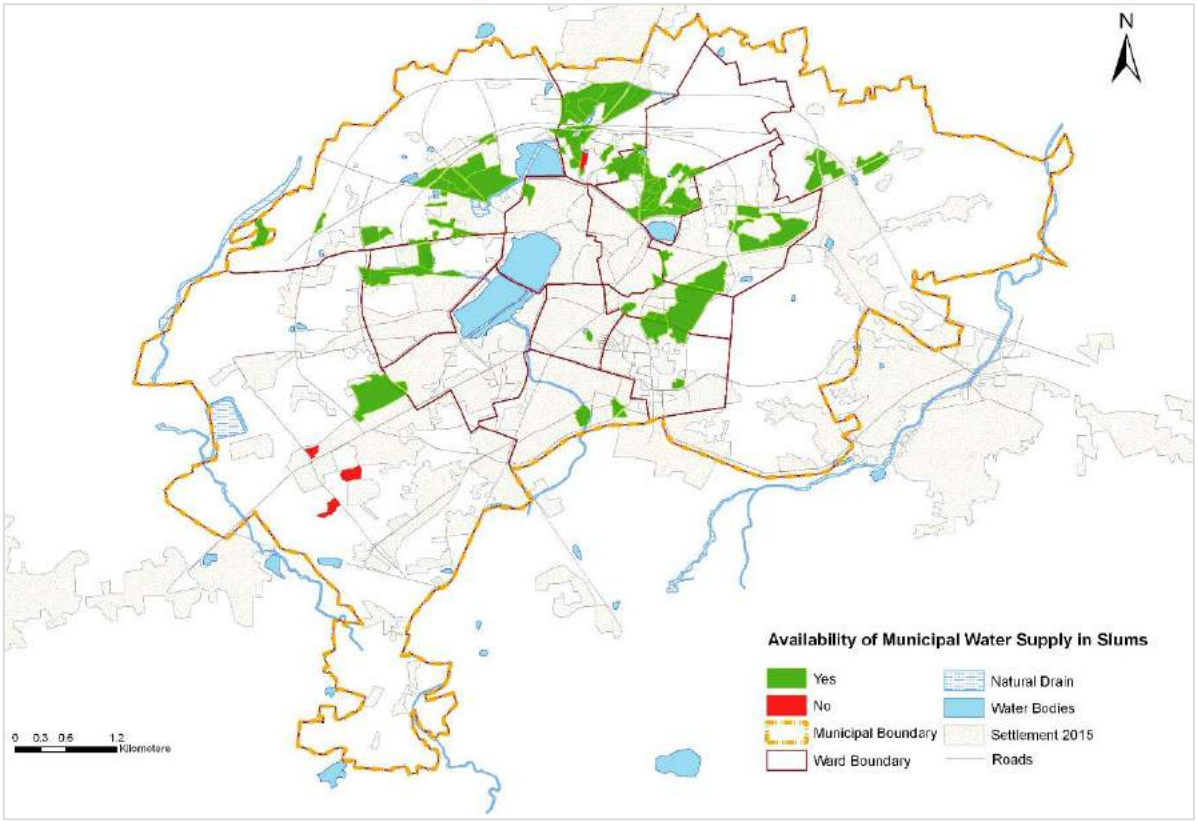
There is no provision of municipal water supply for the GIDC industrial area located within Bhuj city. Currently, they are depended on groundwater and private tanker for their water needs. There are a total 80 industrial sheds in Bhuj GIDC. Water requirement for each industrial shed varies between 2500 to 5000 litres/day. Besides there are some seasonal industries whose water requirement is 10,000 litres/day for duration of 4-6 months. Total industrial water need of Bhuj city fluctuates between 0.5 to 0.9 MLD, which is largely met through groundwater.

Based on available information the picture that emerges of Bhuj water supply is the increasing dependence on sources beyond the city's own jurisdiction, even if the extent of this dependence needs to be better assessed.

Inadequate supply in Slums

In Bhuj, there are 74 slums, covering nearly 40% of city population and spread across 6% of city's area. Almost all slums locations have municipal water supply except for four slums where provision of water supply is still pending.

Figure 15: Accessibility of Municipal water supply in Slums



Source: ACT, Hunnarshala

However, the issue of access to water supply in slums is not resolved simply by laying municipal water lines. In the slums of Bhuj, water is supplied only for an average of 12 days in one month and that too for short duration of only 20 minutes (SLB data 2014-15). Hence they have to depend on external sources like tankers or have to fetch water from neighbouring areas.

In most of slums households there is lack of any storage facilities for water, either for want of space or want of funds. For Middle class households, though water may be supplied only for a few hours in two or three days, they can store water and use it as and when they require it. Hence, while supply for few hours a day or for two or three times in a week may suffice for more non-poor households, water must be supplied for a few hours daily to poorer communities (Meena Nair, Venugopal Reddy, & Sita Shekhar, 2005).

Inequitable distribution of water supply in different areas of city and also between different socio-economic groups needs to be corrected by:

- Providing equal quantity and quality of water supply in all areas of Bhuj
- Providing services in unserved areas
- Delivering equal quantity and quality of water to slum settlements
- Providing incentives or subsidy to the most needy

3.3 Emerging challenges and opportunities

Thus emerging challenges faced by Bhuj for ensuring water security in future can be broadly summarized as:

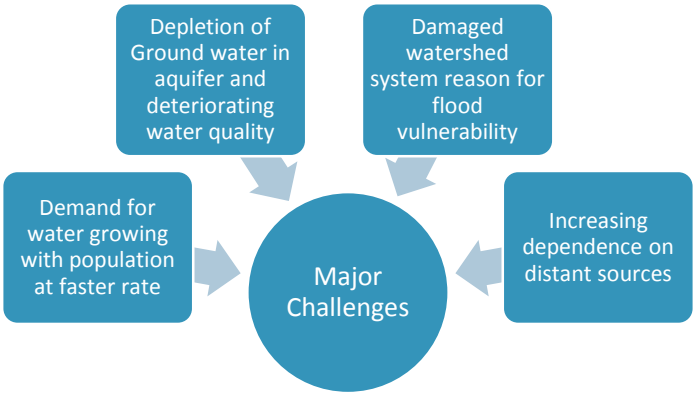
Demand for water is growing with rapid population growth: Bhuj is expected to grow at 25% decadal growth rates, which will double the population in next 35 years. Thus with increase in urbanization, demand for water will increase and existing sources would not be sufficient to cater future demand. This will pose greater challenge in providing safe and good quality water.

Depletion of groundwater in aquifer and deteriorating water quality: In Bhuj large numbers of households, Institutional and commercial properties are dependent on groundwater inspite of having municipal water supply system for both drinking and domestic purposes for meeting their water demand. Also high degree of groundwater abstraction for agriculture purpose is causing rapid depletion of groundwater in aquifers. Lowering of groundwater levels has a compounding negative effect on its quality as it increases water salinity ingress. The water level in the aquifer is dropping unsustainably, causing not just lack of access to water but declining potability of local groundwater.

Increasing dependence on distant sources: Bhuj city is currently dependent on water sources which are far from city and as population will grow and water demand will increase, this dependency will raise manifold in future posing more threat on water security.

Damaged watershed system reason for flood vulnerability: In years of abundant (600mm+) rainfall, another problem faced by Bhuj city is flooding. This is mainly due to the disrepair of watershed flood control system because of which excess water does not bypass nor is it moved effectively through waste weirs and out of the city causing flooding in many parts of city. Also, urbanization and the conversion of open space and agricultural land reduce natural percolation and recharge opportunities triggering flooding risk in city.

Figure 16: Major challenges to water security in Bhuj



To conclude, it can be stated that the supply of water in Bhuj is going to be a big challenge in future. The rapid increase in population, depleting groundwater resources and enhanced consumer needs are going to create a difficult situation. Thus water strategy for protecting, enhancing and conserving water needs to be addressed at earliest.

Opportunities to enhance water security

Approaches for water management of Bhuj city should consist of utilizing existing available ground water along with increasing recharge or infiltration activities which will improve groundwater quality simultaneously. Strategy should also include preventing surplus runoff to flow out of city by building adequate infrastructure for storage (ponds/lakes), by reducing abstraction of groundwater for domestic and other usages and by reducing distribution losses. Revival of lakes and watershed system, recharging of groundwater and rainwater harvesting have to be in the focus of urban planning and decision-making processes as these water sources, if protected and managed properly, will create tremendous potential to augment the overall water sources of city.

Revival of lakes and watershed system: Before introduction of the piped water in Bhuj, the entire urban water management system was dependent on the lakes. In such an arid and drought-prone area, the lakes served as a key source of water for storage and groundwater recharge, which has declined over the years. Historically, the Bhuj's lakes attract and sustain a variety of migratory birds including pelicans, flamingos, widgeons, mallards, and pintail ducks. The Lakes and reservoirs serve as a major recreational space for the city, providing the residents with rejuvenating places for relaxing. The traditional, religious and bathing rituals are still practiced when water fills the Hamirsar. This exhibits the water system's power to act as a social and religious binder ((Revival of Hamirsar Lake and its catchment - wetland and urban rural relationships, 2012)).

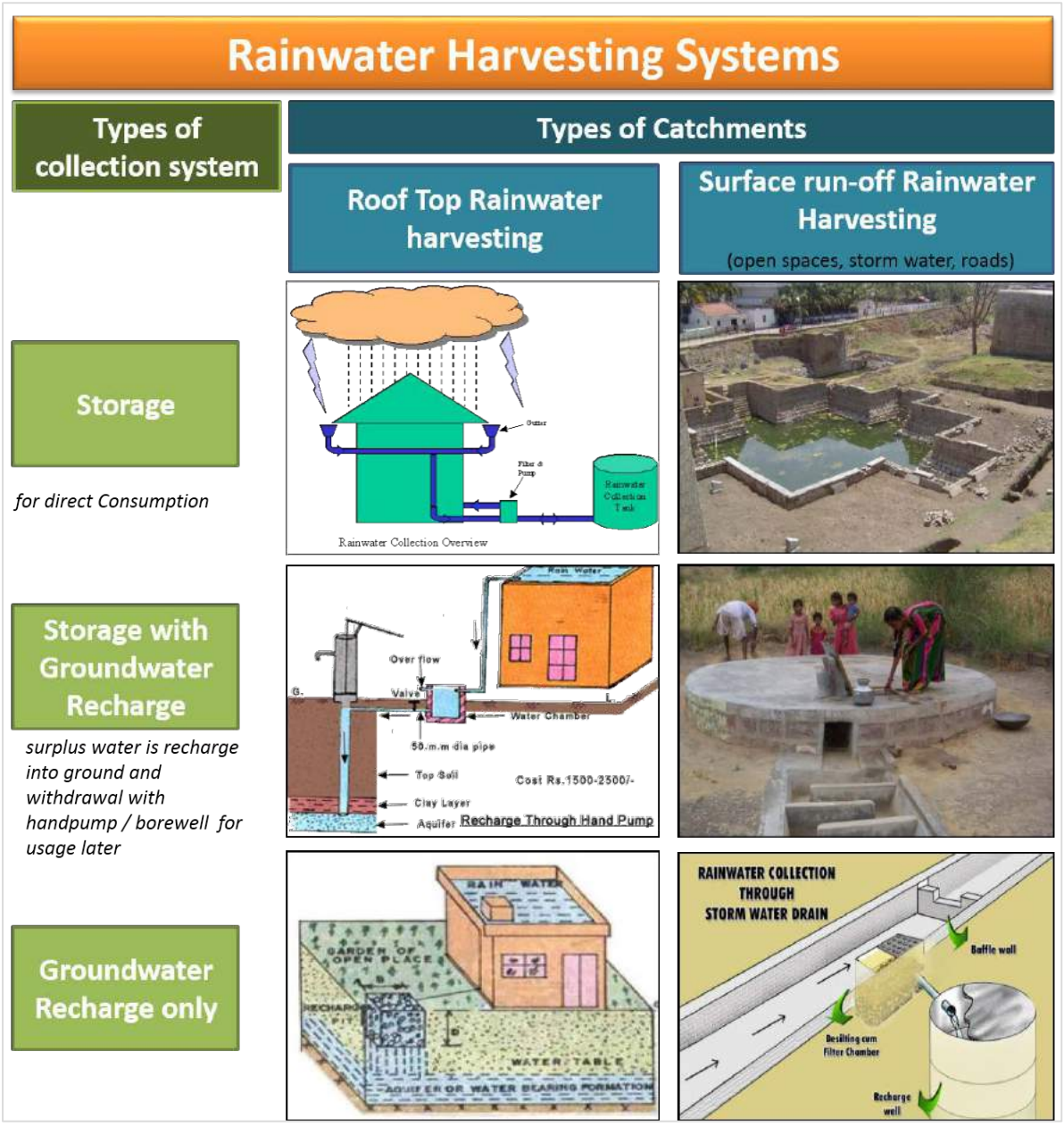
Hence, if Bhuj will revive its lakes and its watershed, it will not only serve as an alternative water sources but eventually will also increase groundwater levels in aquifer and will act as common interest for community involvement.

Potential of Rainwater Harvesting: Bhuj is characterized by low and highly variable rainfall pattern. But even in the years of low rainfall, intensity is high with large amount of rain falling in short period of times. Hence most of water is wasted as runoff and very little is absorbed in the ground. Also concreting of roads and paved surface area have reduced water infiltration capacity, which is causing the problems of water logging during rainy season.

One of the solutions to this could be through rainwater harvesting - capturing the runoff as it forms the most suitable approach to manage water at household or society scale. This method is effective in aquifer recharge by directing excess rain water into ground. Rainwater harvesting technique can

also be adopted at city scale through storm water drains and infiltration trenches on roads or through recharge wells inside lakes. Water harvesting addresses issues of inadequacy of water supply, declining ground water level & groundwater quality.

Figure 17: Different types of frameworks for Rain water harvesting systems



Source: Compiled by CEPT

For Bhuj, it is estimated that rain water harvesting potential is about 2000 million litres per annum, or 5.70 MLD. This is nearly one-fifth of the total water supply for Bhuj.

To give an estimate of the potential of supply augmentation through rainwater harvesting, a survey of selected educational institution campuses was carried out by ACT. According to the study, the annual demand for water by the student population was only 51% of the total rainwater that can be harvested on the campuses. Hence it is found that there is a high potential for education institutes to

be self-sufficient in their water requirements by adopting rainwater harvesting system. Priority should be given to all institutes which have large campuses to take up rainwater harvesting system.

However, an enabling environment and governmental support are essential for spreading the concept and implementation of rainwater harvesting systems on a city level scale. Mainstreaming in policy agendas, facilitating regulations, awareness raising, capacity building and technical know-how are all important for enhancing the use of rainwater harvesting systems.

Box 3: Case Study: Chennai's Rainwater Harvesting Initiative

Chennai is the first state to have 100% coverage of rainwater harvesting structures. Chennai city faced severe water scarcity during the year 2001 and that acted as a major stimulus for rainwater harvesting. A special campaign was launched as a people's movement during July 2001 to popularize rainwater harvesting by the institutions as well as individual households. It has had a tremendous impact in recharging the groundwater table all over Tamil Nadu. Amendments made to Section 215 (a) of the Tamil Nadu District Municipalities Act, 1920 and Building Rules 1973, have made it mandatory to provide RWH structures in all new buildings. To consolidate the gains, various measures have been taken up for rejuvenation of RWH structures created already in both public and private buildings, besides creating new ones. IEC activities will be continued in the Town Panchayats to sensitize all the stake holders to sustain the momentum. Rainwater harvesting was made mandatory by promulgating an ordinance during July 2003. All the citizens were directed through this ordinance to provide Rainwater Harvesting structure in all the buildings before 31 August.2003.

Impact: All the buildings, commercial as well as residential, are provided with rainwater harvesting structures. This has helped in improving the ground water table as well as in improving the quality of ground water. Moreover, during rainy season the dependence on the municipal water agency has come down. It has also acted as flood mitigation measure.

Figure 18: Various rainwater harvesting IEC posters by Tamil Nadu Government

Source: Chennai –A success story of Rainwater Harvesting by Mr. Shiv Das Meena and Rainwater tab on Directorate of Town Panchayats, TN website (http://www.tn.gov.in/dtp/rainwater.htm)

Box 4: Case study: Bangalore's Rain Water Harvesting system

The Bangalore Water Supply and Sewerage Board (BWSSB) has taken up various steps to improve its services with water conservation as one of its focus areas. RWH has been made mandatory for households in Bangalore city with a site dimension of 40 ft. x 60 ft. and above from year 2009 onwards. There has been a gradual increase in the number of RWH installation after the BWSSB amendment Act became operational. A 5 % rebate on the property tax is offered for residential property and 2 % for non-residential buildings within BMA for the first 5 years, when rain water harvesting is made as an integral part of the building constructed. Theme park, the first information and research centre on of RWH established jointly by BWSSB and KSCST, functions as a centre for creation and dissemination of awareness on RWH. BWSSB has been promoting RWH, in various ways such as publishing materials pertaining to RWH, conducting training programmes for plumbers and organizing awareness programmes for the public besides implementing RWH in their own office premises. BWSSB has also taken up installation of RWH in 40 of its buildings throughout Bangalore. BWSSB is also vested with the responsibility of monitoring the proper installation of RWH structures and BWSSB officials regularly check RWH storage tanks while taking water-meter readings.

Impact: Citizens have recognized and understood the value of RWH systems for meeting their needs; which will reduces dependency on BWSSB and conventional sources of water and Residents have invested their money to harvest rainwater, thus creating a sense of ownership.

Photograph 3: RWH Bangalore- RWH theme park, training of plumbers

Source: Bangalore Water supply and sewerage board, Rain water harvesting presentation, 2013 & Working paper on Rainwater harvesting Initiative in Bangalore city: Problems and Prospects by K S Umamani and S Manasi

Rainwater harvesting will help increase self-sufficiency in water supply, without being dependent on remote water sources. Availability of water at less cost will help households to move away from buying costly water through tankers. Rainwater harvesting can also be alternative water sources at times of irregular municipal supply as during that time households are forced to buy water from private/tanker water supplier. The potential of rainwater harvesting in Educational Institutions of Bhuj.

Table 6: Potential of drinking water supply augmentation through rainwater harvesting in Educational Institutions of Bhuj

Feasibility of Campus Water Harvesting and GW Recharge in Bhuj	
Education Units surveyed	54
Student Population	32,883
Drinking Water Demand (kilo litre)	7,892
Other Domestic Demand (kilo litre)	46,036
Gross annual Demand	**53,928**
Available Campus Area (sqm)	7,59,624
Gross Available Annual Rainfal @430 mm (kilo litre)	3,26,638
Dependable Rainfall (50 %)	1,63,319
Water Demand % against available Rainwater	**33%**

Source: ACT

DEWATS/ Wastewater treatment and recycling: Bhuj city must take into consideration wastewater treatment and recycling as additional water source, which could reduce the increasing water demand. Recycle water can be used in agriculture and industries which requires large amount of water and which currently is extracted from groundwater. The use of wastewater has been practised in many parts of the world for centuries. Whenever water of good quality is not available or is difficult to obtain, wastewater or drainage waters are spontaneously used, particularly for non-domestic usage like gardening, landscaping, washing, agricultural or industrial purposes. Hence, Bhuj should look at wastewater recycling as a long term option for meeting non-domestic water needs of city.

Thus, Water security for future will depends on how Bhuj manages and revive local water resources today and reduces its dependence on external water sources. This will require a concerted effort by linking together traditional and centralized water system along with people's participation for better management and secured water resources.

3.4 Participatory Management of Water Resources and Water Supply

A number of organizations play different roles in managing water resources and supply system. Management of water resources and water supply in Bhuj can be broadly classified into three categories as discussed below: Management of groundwater resources, Management of watershed system, and Management of Municipal water supply system

Management of groundwater resources

Groundwater is the major water resource available in Bhuj. Traditionally groundwater rights are more closely linked with the land rights. Hence, when we talk about the management of groundwater, major users/ stakeholders are most crucial since they are the major custodian of groundwater. In Bhuj, major stakeholders/users of groundwater includes residential society/ individual household owners, private tanker operators, industrial users, BSF/ IAF campuses, commercial building users, institutional users and irrigation users.

Major stakeholders/ Users of groundwater in Bhuj

- Residential society/ individual HHs
- Private tanker operators
- Industrial users
- BSF/ IAG campuses
- Commercial buildings (Hotels, restaurants, cinema)
- Institutional buildings (Hospitals, colleges, schools)
- Irrigation users

The major stakeholders and all players should be sensitized about scarcity of water. Early and continuous integration of all stakeholders in the planning, decision-making and implementation process is critical for the success of water secure planning of city. Stakeholder and public

participation and integration of urban-rural linkages in watershed can improve the scope of decision-making and can help to create long-term and widely acceptable solutions. Stakeholder engagement can break down barriers to information sharing and learning and speed up the identification, development, and uptake of solutions related to urban water management (Butterworth et al., 2011).

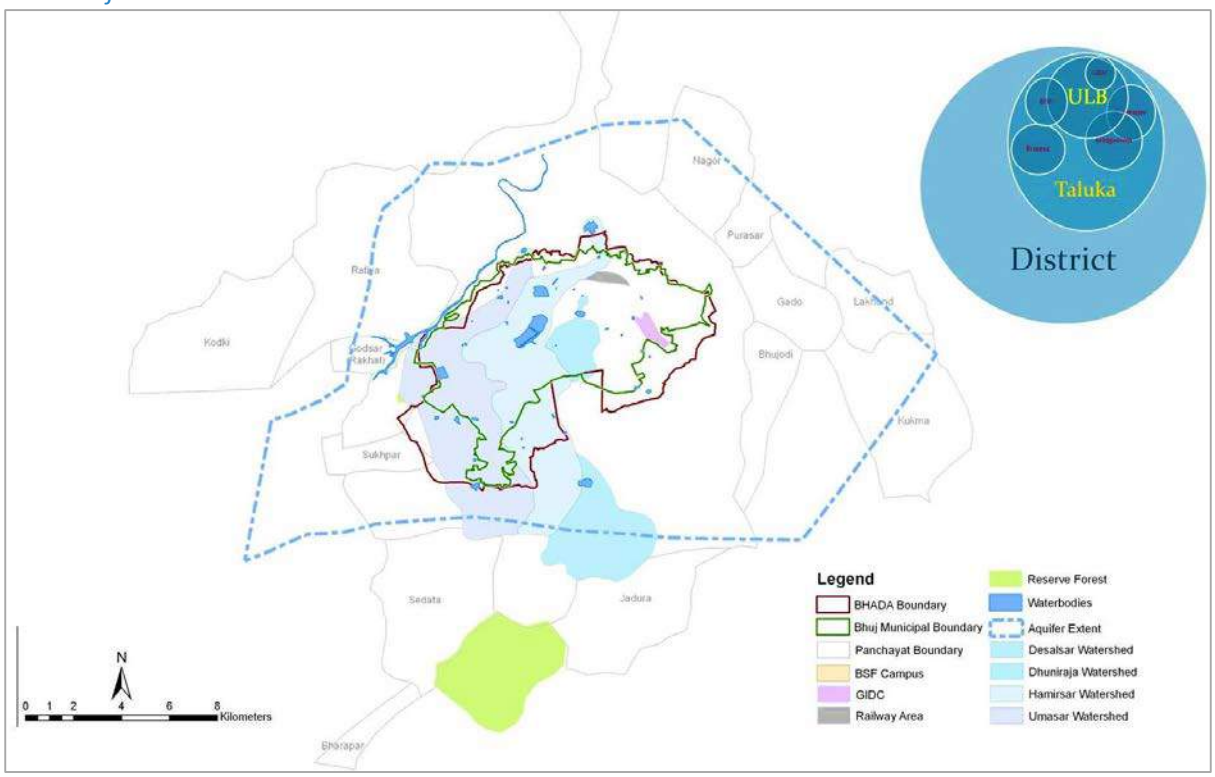
In Bhuj, ACT has already recognized the importance of people's participation and raised awareness among local community for reviving traditional water system in-cohesion with municipal water supply system. Different community groups are formed for creating awareness and supported by technical knowledge of geo-hydrology and water resources. Thus to achieve the water security in future inclusive effort of both government and local community in managing and improving local water resources is crucial.

Management of watershed system

It is important to understand that urban water cycle is closely linked to the watershed and hence when we talk about management of water resources for city, it is crucial to consider watershed/basin as a unit for administration. Watershed as one unit for management is critical, as changes in land-use pattern and deforestation at upstream end might have negative effect on the inflow quantity and quality of water and also abstraction of large quantity of water by irrigation users or urban areas will impact total water availability in other areas.

Bhuj, Watershed system is spread over an area of 56 Sq. km. It is covering diversified jurisdiction which includes Bhuj Municipal area, Bhuj urban development authority area, Madhapar town area, Agriculture area, Forest area, Army area and other rural areas. Since watershed system and associated lakes are located under different jurisdictions various political issues are arising to manage a particular water body or watershed. These political boundaries of various regions such as Urban area (municipality, Urban Development Authority, Revenue), Rural area (Gram Panchayat), various departmental controls over catchment areas such as irrigation department, forest department, BSF areas etc. increases complexity for management of such natural resources.

Figure 19: Representative diagram showing overlapping jurisdictions of multiple government entities over Bhuj Watershed



Source: Compiled by CEPT

All these lead to several problems because with reservoirs overseen by multiple government entities with different priorities there is a lack of coordinated effort. The poor maintenance of lakes and flood control systems, and a lack of political will to remove encroachments have made many watersheds defunct. It is important to restore canals and lakes to their historic (and necessary) size.

For improving management of water resources, BHADA should propose an integrated watershed committee with representatives from all government departments/authorities, important stakeholders as well as public representatives to have informed decision making and implementation process.

Management of Municipal water supply system

Urban water supply is a responsibility of urban local government. While the Central Government formulates overall policies for the development of the water sector in urban areas, the State Governments lays down detailed policies and sets up institutions for the proper development and management of water systems in their areas (e.g. Gujarat Water Supply and Sewerage Board (GWSSB), Gujarat Drinking Water Company Ltd (GWCL).

In Bhuj, multiple agencies are involved in managing supply of municipal water. The existing setup has institutions at the state level that allocate resources and provide major infrastructure, while local instituted in distribution of water resources to consumers.

Table 7: Institutional Set-up of Water supply in Bhuj

Agency/ Authority	Jurisdiction	Category	Roles and responsibilities
Department of Narmada, Water Resources, & Water Supplies	State level	Administration and regulation	Regulatory oversight of the water sector in the State Oversight of State government owned corporations involved in the implementation and operation of water schemes.
Gujarat Industrial Development Corporation (GIDC)	State level	Administration and regulation	Provision of retail water supply services in industrial estates owned by GIDC.
Gujarat Water Supply and Sewerage Board (GWSSB)	State level	Implementation and capital works	Mainly Implementing water supply and sewerage schemes for urban local bodies. Inspection of schemes where State government fund is provided.
Gujarat State Drinking Water Company Limited	-	Implementation and capital works	Bulk transmission and bulk supply of drinking water to local bodies, GWSSB, and Industrial estates
Sardar Sarovar Narmada Nigam Ltd.	State level	Implementation and capital works	Wholesale supply of Narmada water
Bhuj Municipal corporation	Local level	Operation and maintenance	Provision of water supply services for domestic purposes in the area of their jurisdiction
Bhuj Urban Development Authority	Local level	Operation and maintenance	Provision of water supply services for domestic purposes in the area of their jurisdiction

Source: Compiled by CEPT

Proper management of water resources and equitable distribution of water, as well as recharging of groundwater is critical for future water security of the Bhuj city. Further improvements required should also include various proposals such as:

- Better information for evidence based decision making
- Introducing incentives to improve efficiency in water systems
- Investments and pricing to take care of inequities and make the system more equitable
- Look at financing of water more carefully; Capital investments – what were done – and how could these have been done differently in the past. But also going forward – where should the new investments be? In what activities and where location wise etc.
- Activities needed versus different agencies and stakeholders
- Better involvement of stakeholders and clarity of authority to manage the full chain of water supply.

4. Pathways to water security: ACT's efforts in Bhuj

This chapter describes various actions taken by Arid Community and Technology (ACT) and its partners in the context of PGWM in Bhuj. ACT's approach in Bhuj can be considered different than other PGWM attempts in other regions in the sense that it incorporates a strong technical knowledge in disseminating information to the citizens through an equally strong citizens' forum. After the initial support, demonstration and hand-holding, ACT envisions that the citizen community as well as other institutional stakeholders will start to become self-sufficient in water resources management in future, leading to sustainable Participatory Ground Water Management (PGWM).

4.1 ACT approach to PGWM

Concept and inspiration

The ancestral water management system in Bhuj of integrated catchment management and decentralized supply through wells, was well thought of and ensured sustainable and abundant water supply to the city. Water sources such as wells were owned and managed collectively by the community which ensured the upkeep of the sources. Post colonization, this system broke down with the introduction of piped water supply. Now, Bhuj faces imminent water scarcity with increasing dependence on Narmada water. ACT, through its work and studies, believes that Bhuj has immense potential to be water secure and be self-sufficient by reviving the integrated catchment system and aquifer system though community participation. They argue that a paradigm shift is needed to improve water security in the region.

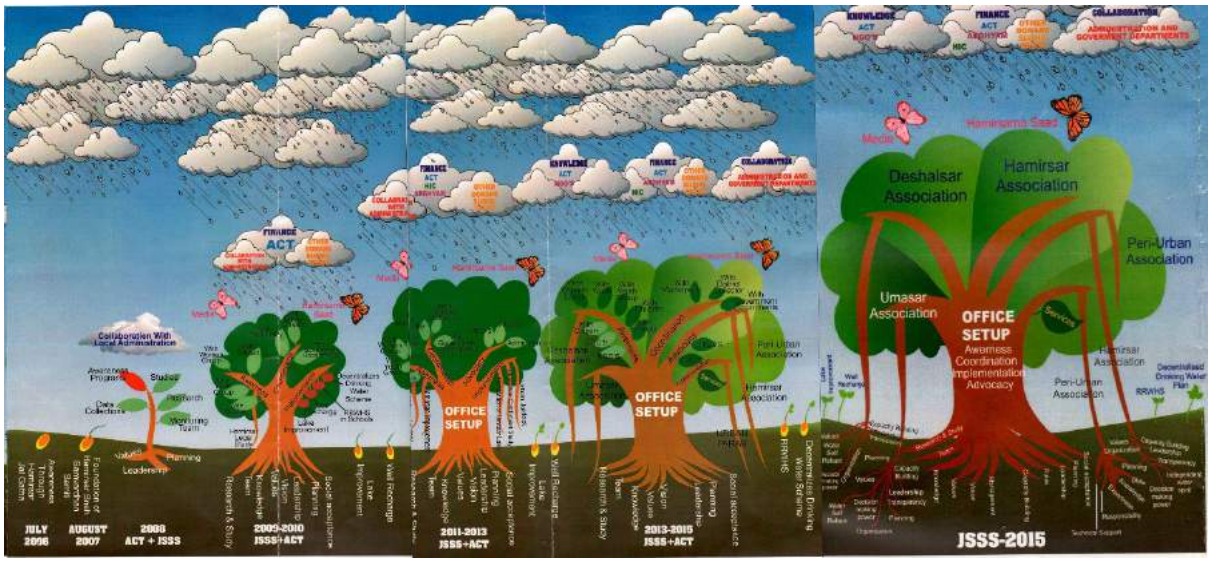
There have been many instances in rural areas of Kutch where communities have taken responsibility for their own water security. Activities have been initiated to transfer authority to the local institutions and enable rural people to participate in the decision making process. This has developed ownership and commitment towards ensuring efficient use of the resource. Drawing inspiration from the "Pani thiye Panjo", translated as "Let's make this water ours again" an initiative undertaken in the rural areas in the year 2006 by Water and Sanitation Management Organisation (WASMO) and partner organizations[8], ACT decided to replicate this framework in Bhuj. The basic framework included understanding the extent and complexities of the problem, mapping stakeholders and establishing their willingness and abilities to participate, motivating community and building capacity of stakeholders.

[8] Partners of WASMO in Pani Thiye Panjo were Sahjeevan, Kutch Fodder Fruit & Forest Development Trust (KFFFDI), Kutch Mahila Vikas Sanghathan (KMVS) and Shri Vivekanand Research and Training institute (VRTI)

ACT has envisioned a programme through a community forum, Jal Strot Sneh Savardhan Samiti (JSSS). In the initial stages the forum was supported by ACT in the form of studies, research, data collection, capacity building, planning and monitoring and also some finance. As the programme branches out into practical action regarding awareness, coordination, implementation and advocacy, and comes into its own, it is getting more and more support in the form of donors, technical assistance and media while ACT remains as its backbone.

The programme, with support of various community groups, has managed to create awareness among people of Bhuj about the traditional water management system and is making efforts to restore it.

Figure 20: PGWM in Bhuj as envisioned by ACT



Source: ACT, 2015

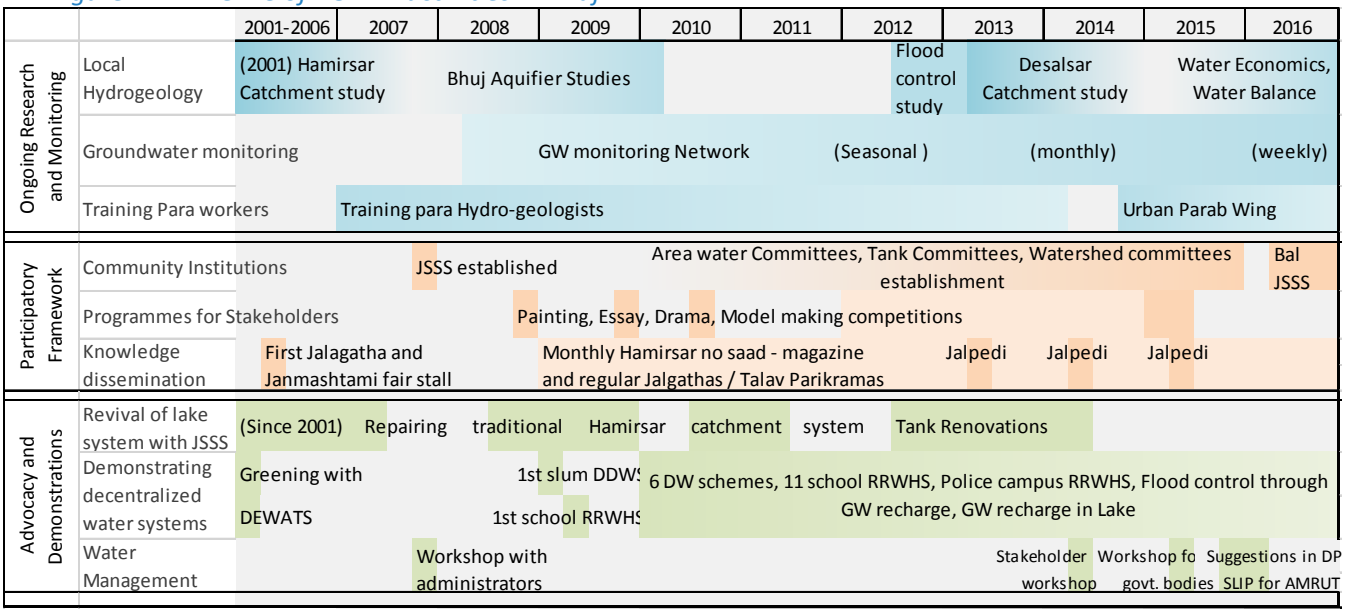
Timeline of activities

ACT has been working towards this agenda since 2001 through various studies and began its efforts through action in 2006 with awareness and knowledge dissemination activities, first of which was "Jal-Gatha". Soon a citizens' forum was formalized though the establishment of Hamirsar Sneh Samvardhan Samiti (later Jal Sneh Samvardhan Samiti). The movement gained momentum with widespread social mobilization activities aimed at all sectors of the society. Along with this, ACT undertook technical studies to understand the water system of Bhuj. Based on these studies, ACT then organized technical interventions and pilot demonstrations in revival of the Hamirsar system, flood control, groundwater recharge, rain water harvesting and decentralized drinking water supply systems. As of 2016, ACT is beginning to influence official decision makers, with the ACT team convincing the Bhuj Municipality and submitting a proposal on storm water management and ground water recharge to be incorporated into the Development Plan of Bhuj . ACT has also helped the municipality prepare a Storm water management plan under Service Level Improvement Plan (SLIP)

for the Government of India's flagship programme AMRUT. In future, ACT envisions, these activities will be carried out by the citizens' forum itself.

ACT's effort clearly highlight that successful PGWM is a continuous process and not a one-time activity. ACT's philosophy is illustrated through their tree diagram (Figure 20). Initially they sow seeds through formation of citizen committees such as JSSS, watershed association and Parabs. They help them grow and then move out. These become self-sufficient and grow independently. Thus PGWM efforts in Bhuj remain sustainable.

Figure 21: Timeline of PGWM activities in Bhuj

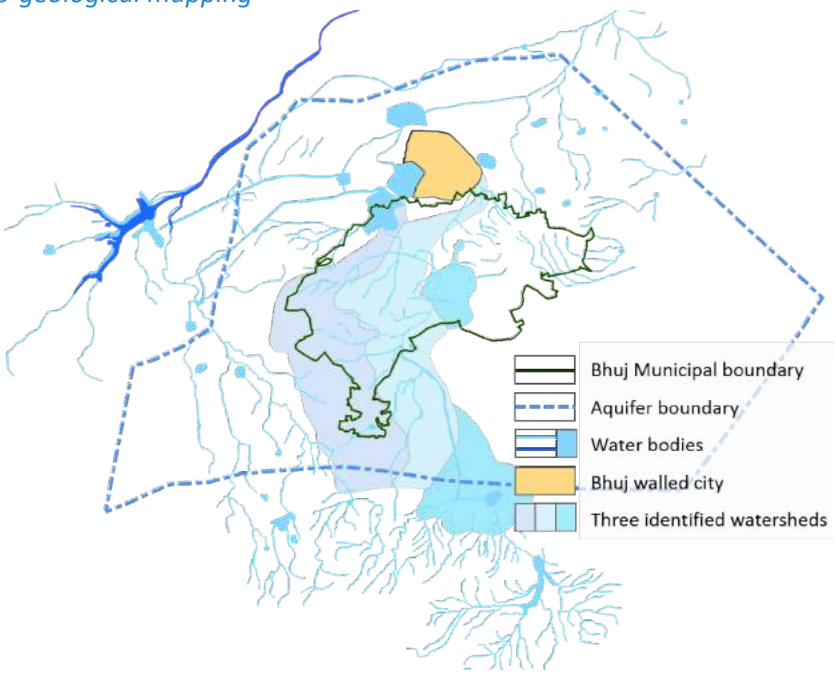


Source: ACT, Compiled by CEPT

Technical studies as the backbone of PGWM

In order to make informed interventions towards PGWM, ACT is continually in the process of refining its understanding of the existing system, both natural and man-made, including the sources of water, traditional practices, local hydrogeology and the water With the introduction of the piped water in Bhuj, the entire urban water management system, which was earlier dependent on the lakes, has shifted its focus. The three-Lake systems in Bhuj demonstrate the sound traditions of arid water resource management. Now, with water available 'in plenty' from Narmada, the traditional catchment system fallen in disrepair, and the lakes are running dry with the water table also reaching dangerously low levels.

Figure 22: Hydro-geological mapping



Source: ACT

The original catchment of Hamirsar, before the modifications made by old rulers, was only 6 sq km. this was then increased to 40 sq km by artificially joining neighboring catchments. According to ACT's calculations, only 175 mm of rainfall over this catchment is enough to completely fill Hamirsar. However in recent times, even with an average of 325 mm of rainfall, the lake was rarely observed full (ACT, 2015). This can be attributed to increased "concrete cover" with recent developments which leads to more runoff and less percolation of rainwater as well as broken links in the catchment system. Increased runoff and modifications in natural geography for human habitat in turn lead to the issue of localized flooding.

Beginning in 2001, the ACT team has attempted to map watershed in the region using GIS and Survey of India topographic sheets. The entire watershed and stream network in catchment along with slope and natural accumulation points like lakes were mapped and problems were identified which have led to the non-functioning of the system. A **Flood Control Study** was also carried out and an **Urban Watershed Management Plan** for the region was prepared in association with Alchemy Urban Systems Pvt. Ltd. and Hunnarshala. The issues that were identified were then addressed in a series of "revival drives" through the workings of JSSS.

Over time, ACT has built up a tremendous knowledge base about the local hydro-geology of Bhuj and inspired by the rural *Pani thiye panjo*, it has begun disseminating the knowledge amongst para workers or "Parabs". These para workers, as described in detail later in the chapter, assist ACT in its activities thus enabling it to exponentially expand its activities. Through observation during the course of their field work, ACT and the Parabs have built up an **understanding of the aquifer** of the area which is

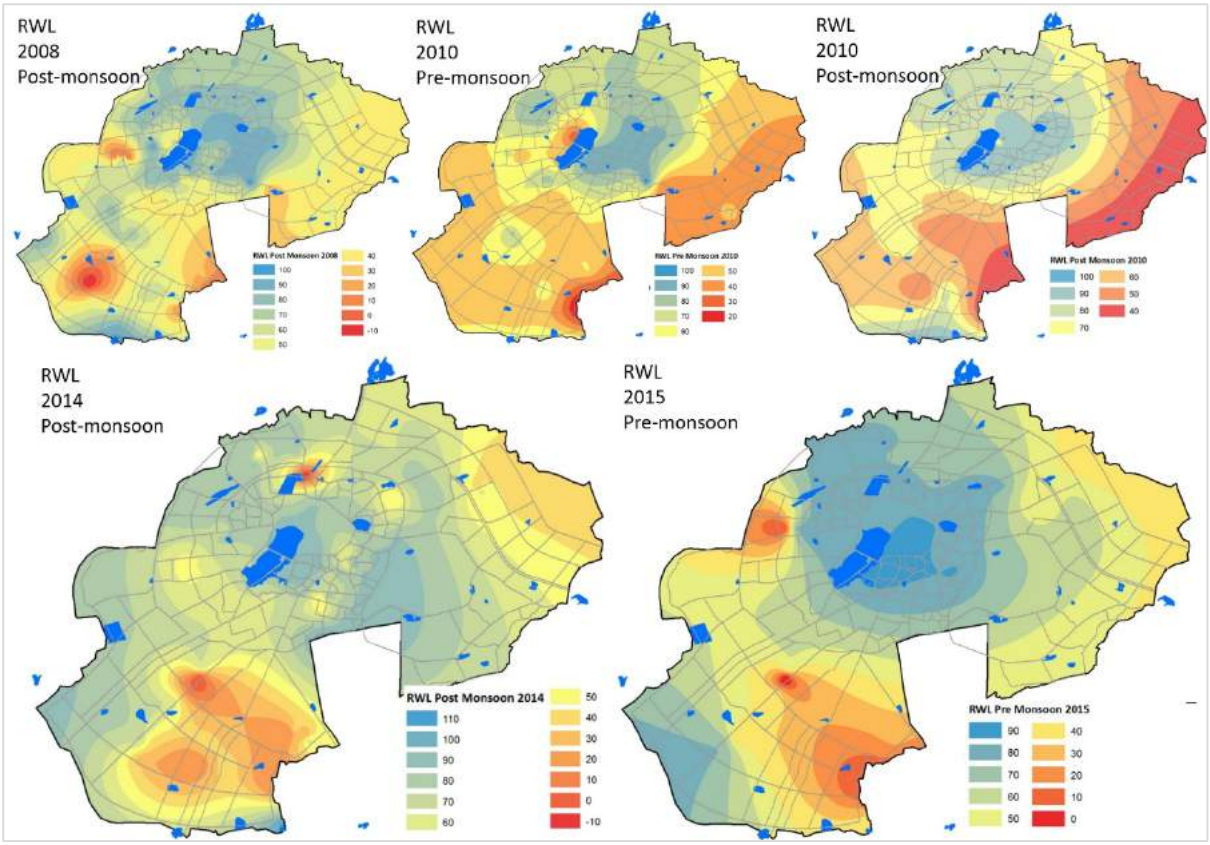
useful in making informed technical interventions in terms of recharge sensitive areas, water quality etc.

After hydro-geological studies were done and certain interventions carried out, it was felt that there was need to monitor the ground water system in order to assess the current situation as well as to track the outcomes of the activities undertaken for ground water recharge and rain water harvesting. Thus, a groundwater monitoring network was established between 2007 and 2008 within the urban boundary with a set of monitoring wells selected through careful sampling. The wells were selected considering that each well represents an area of 300 meters X 300 meters around it and the sampling represented a grid inside the urban boundary. In addition to this, the density of sample wells was increased in areas where recharge activities had been undertaken. This monitoring system today consists of 74 wells and readings are taken monthly in terms of Reduced water level and TDS. Pre and post monsoon studies of ground water levels and quality show improvement due to recharge activities. As more and more recharge interventions are done, ACT is considering a shift towards weekly monitoring of the same.

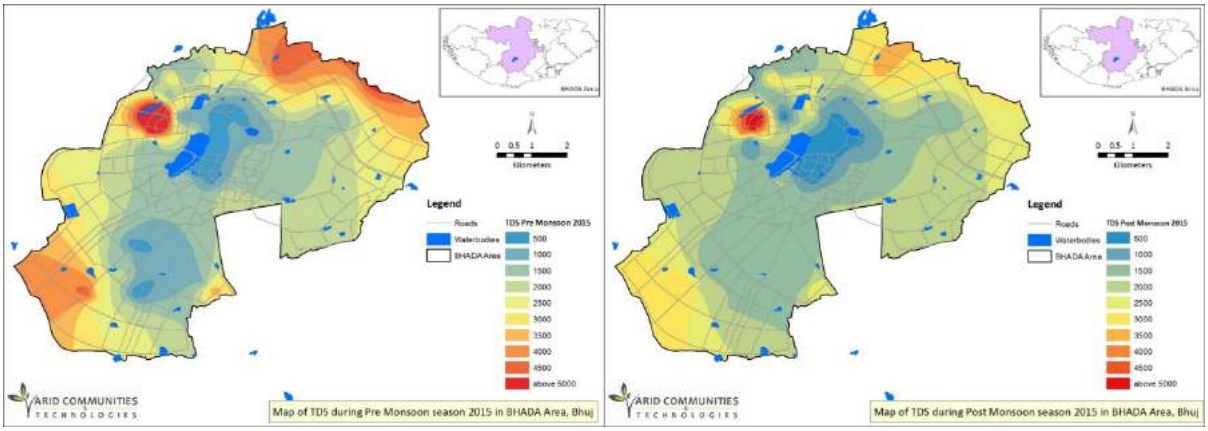
Photograph 4: Ground water monitoring activities

Source: ACT, JSSS

Figure 23: GW monitoring results- Water levels and quality[9]



Source: ACT, 2015



Source: ACT, 2015

ACT is also part of a partnership in implementing a project called "Homes in City" (HIC) along with 4 other organizations, Sahjeevan, Kutch Mahila Vikas Sangathan, Kachchh Nav Nirman Abhiyam and Hunnarshalaa Foundation. In this project ACT's role is to provide technical input for drinking water planning for slum areas and input to other development projects such as RAY etc based on its knowledge of Bhuj. The groundwater resource maps will be used for decentralized drinking water management planning in RAY project area where this partnership works closely.

[9] Source: Groundwater monitoring programme in Bhuj by ACT

More recently, ACT is undertaking a study of "Water Economics" in Bhuj. It intends to cover investments made by the State and costs of delivery of water to recommend a pricing policy that incentivizes the development and use of local water while ensuring cross subsides and financial viability for the ULB.

4.2 Participatory framework

Philosophy

Inspired by the rural "Pani thiye Panjo" initiative of WASMO, Sahjeevan and other partner organizations, ACT believes in rallying the community in order to harness the experience based wisdom of the community about geographical and hydrological conditions of the area as well as to create a sense of ownership in the community about "common Pool water resources", ACT and its partners have adopted participatory processes for their activities in Bhuj. However, participatory approach has been successful in rural context partly due to small size and a close knit community structure. These conditions do not prevail in urban areas. The scale is huge and the community is diverse. There are also multiple institutions and decision-makers who have to be brought on board.

ACT faced many challenges in this attempt to rally the community. The communities were heterogeneous and dispersed across the entire city. Grouping them was a challenge as they had different needs and were not bound by common interests or problems. There was haphazard use of water resources, over-extraction of ground water through private bore wells, encroachments on lake beds, etc. Moreover, lack of proper waste water treatment and solid waste management had led to degradation of all sources of water. Paradoxically, owing to the higher levels of education and awareness among urban citizens, acceptance of change was more difficult (Ghanashyam & Jatkar, 2015). However, despite these problems, ACT realized that the people of Bhuj have great affinity to Hamirsar Lake. The lake is a recreation place for people and also a religious place with many temples. The city is identified with the lake and people feel proud to see a lake filled to the brim. So the lake emerged as the common interest and rallying point and the programme was organized around the idea of the lake.

The programme has led to increased awareness of the residents of Bhuj towards the water problems. Involvement of people in various activities to revitalize the traditional lake system has inculcated a sense of ownership among people. People now recognize that the crisis of water security in Bhuj is real. They realize that it is not the responsibility of the government alone but a collective responsibility of all residents of Bhuj to mitigate the crisis.

Development of Community Institution

A workshop was held on December 2007 at Tapkeshwari temple to formalize a forum for organizing participatory activities. A citizen's committee was formed comprising of people who were interested in working on the revival of Hamrisar Lake. The committee was named *Hamirsar Sneh Samvardhan Samiti*' (HSSS). Later the committee realized that Hamirsar Lake couldn't be dealt with as a standalone project and being integrated system all water source and means must be incorporated. Thus the name of the committee was changed to ***Jalstrot Sneh Samvardhan Samiti (JSSS)*** (Ghanashyam & Jatkar, 2015) literally meaning "Water source development committee".

Photograph 5: JSSS working group meeting

Source: ACT, JSSS

The core group of JSSS consisted of a convener, Shri Tarunkant Chhaya, founder of JSSS and other members who would assist him. The second level of JSSS was constituted by extremely dedicated senior citizens, retired bureaucrats and elected representatives who guide actions. The third layer comprised of professional and salaried staff, which assisted technically and helped make definite deliverables. The dynamic, outer layer changes according to the need and provided technical expertise. Then came the general public, who drew maximum benefits out of the initiative (Ghanashyam & Jatkar, 2015).

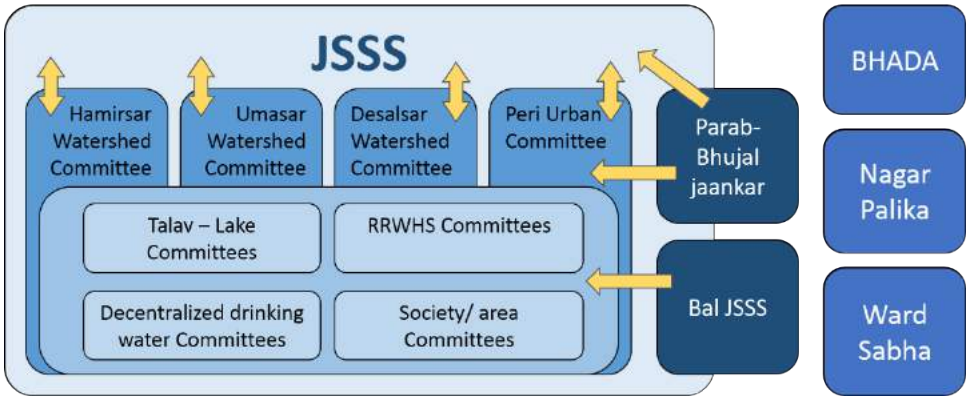
JSSS now functions as an umbrella organization in all activities related to community led urban water management. It is also part of a City Level Advisory Group established under the "Homes in the City" programme.

However, it was not feasible for any single entity like a committee or P*ani Samiti* to take responsibility of managing the water resources of the entire city. The city of Bhuj is spread over a large area and comprises several socio-economic groups and areas; there are slums, housing colonies, shopping districts and settlements, both inside and outside the ancient walled city. This called for JSSS, to think of a flexible, multi-layered organizational structure that would come into play for particular interventions. Therefore, with active facilitation from ACT, the organizational structure emerged at two broad levels.

While the core group and the other layers of JSSS remain more or less fluid, for each intervention of JSSS, smaller committees are formed which ensure financial management, constant supervision and

monitoring. They are made up of members from the specific areas who know their situations the best and can ensure the task undertaken is taken to its planned conclusion.

Figure 24: JSSS organization structure



Source: ACT, JSSS

Thus, under JSSS, there are 3 **watershed committees for Hamirsar, Desalsar and Umasar** lakes. Aside from these, **Talav (tank) committees** for all other smaller lakes are envisioned out of which several have been formed and have active members. JSSS forms local **Pani Samitis** (water committees) with every intervention they make as seen in the case of Jubilee colony and Shivra Mandap area described later. JSSS, ACT and Sahjeevan regularly conduct workshops for the capacity building of these committees as part of the Homes in the City Programme. More recently working groups have been formed wherein urban Parabs (para hydro geologists) are assigned to each committee for technical support, support in awareness activities and training programs.

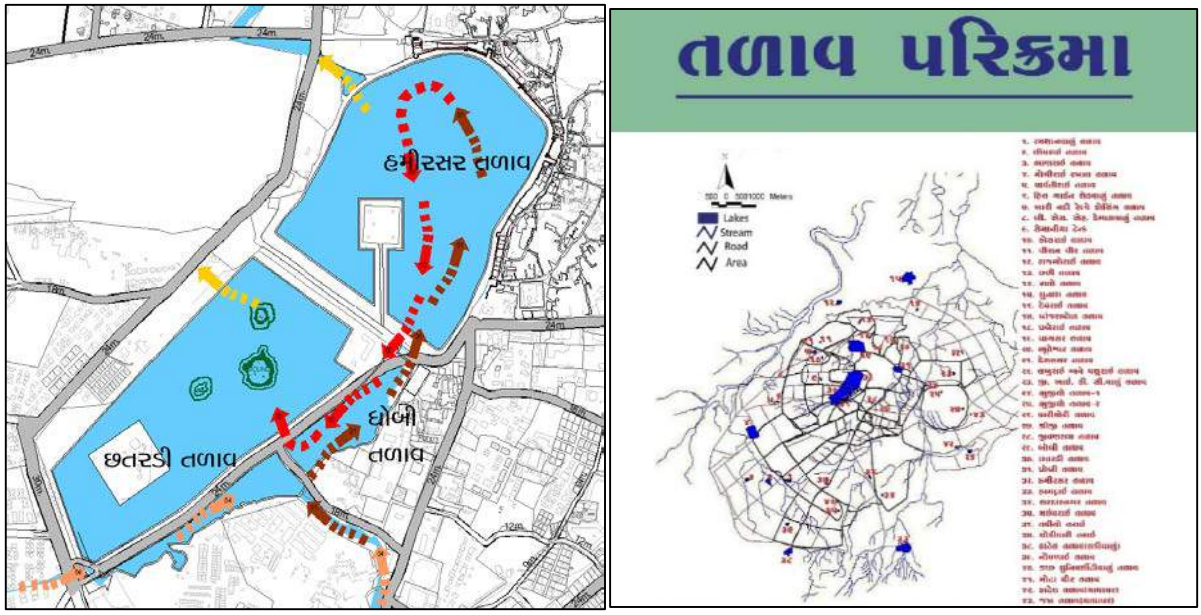
More recently, in response to children's activities organized by JSSS, a **Bal JSSS** wing has also come up. ACT believes that education of children in the matter of water will go a long way in ensuring sustainability of the project as these children will grow up to become future decision makers. BJSSS members are actively involved in Jalgatha tours and Talav Parikramas.

Programmes for stakeholders

Jalagatha and Talav Parikrama: Jalgatha were the first step towards active efforts in PGWM in Bhuj. It was conceptualized as heritage as well as educational walks along Hamirsar Lake and its catchment to help people understand the system. Titled '*Hamirsar Ek Jal Gaatha', it* was an effort to change the mind-sets of the citizens of Bhuj and motivate them to look at Hamirsar and other lakes in the system, as well as their catchments not only as picnic spots but also as water lifelines for Bhuj. The walk was designed in a manner that even senior citizens could undertake it, as the intention was to draw in a variety of participants.

The response to the *Jalgathas* was encouraging enough for ACT to conduct it on a regular basis. The participants across different *Jalgathas* included MPs, government and corporate sector members, journalists, religious leaders, senior citizens, members of *mahila mandals* and defence officials etc. A significant measure of its success was that people even paid a nominal amount to participate in the walks. The amount served to cover basic expenses.

Figure 25: Posters explaining water flow in Hamirsar and Location of water bodies in Bhuj for Jalgatha and Talav Parikrama



Source: ACT, 2015

Children's Programmes: Various programmes directed at raising awareness about water resources in children, and indirectly their families, were held. A drawing competition was held at Hamirsar in November 2008 or appreciating its beauty. A total of 520 children out of 22 primary schools in Bhuj participated in this. Similarly, a photography competition was held for professional as well as amateur photographers. A year later a Bal Sammelan (Children's gathering) was organized with the aim of creating awareness on issues related to urban environment and degradation of natural resources. In this programme 425 students of 9 schools in Bhuj participated. The main event of this gathering was a drama competition where children presented plays such as "Vyatha ek shaherni" (tragedy of city), "Ek khedutni vaat" (a farmer's story) and "Pariyavaranni Vyatha" (environmental tragedy) (JSSS, 2011).

In 2010 an essay competition was held for senior students on the subject of water pollution. Entries were submitted by 90 students out of 4 schools. ACT intends to publish this essay series as a book.

A water conservation model competition was also held for middle school children where they presented their own ideas.

Photograph 6: Painting competition for children organized at the lake

Photograph 7: Drama competition for school children (left), Jalgatha for school children (right)

Photograph 8: Exhibition of Water conservation model competition for children

Source: ACT, JSSS

Lake Protection Rally: The leaders from JSSS also organized a Lake protection rally to generate awareness amongst the citizens on the issue of disappearing lakes.

Photograph 9: Talav Bachav rally in progress

Source: JSSS, ACT

Knowledge dissemination

Training Para workers- Parabs: The term *parab* is traditionally used in Gujarat for one who manages the water hut that provides free water to thirsty travelers especially during summer. Now the same term is given to the para workers who work with village institutions to help them demystify groundwater management and develop technical plans.

The Parab concept was developed as a part of rural *Pani Thiye Panjo*. The main aim of training *parabs* was to provide appropriate and timely technical services to panchayats, *Pani Samitis*, NGOs, CBOs and individuals.

Photograph 10: A Parab in action

Source: ACT

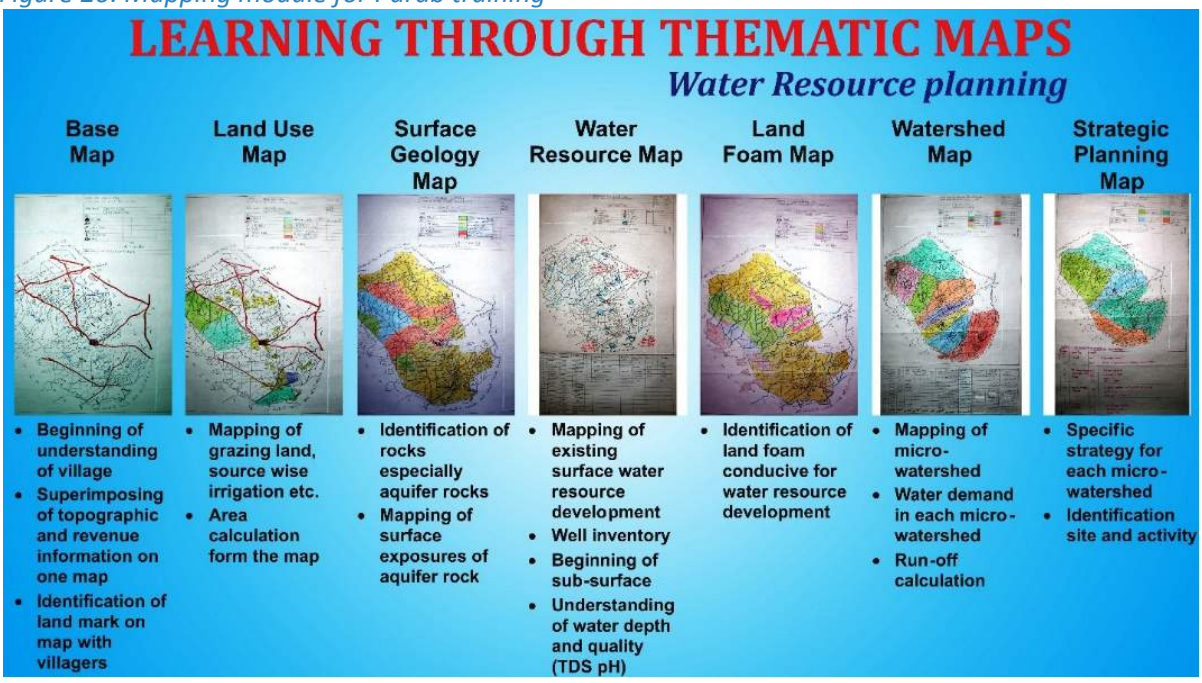
Parabs are drawn from local communities and many of them have not even completed basic schooling. Lack of formal academic education is not a limitation however, as they are given extensive training before they are sent to the field. With the intensive training and on-field experience, the *parabs* have now become para-professionals on Participatory Ground Water Management.

The entire capacity building of *parab*s is a collaborative initiative between ACT and the trainees and training consists of a 45-day course that is a combination of technical information, and traditional wisdom. The curriculum includes knowledge of geology, know-how about locating water harvesting structures, working with communities and basic knowledge of government programmes. The

programme is broken into a good mix of classroom sessions, backed by field work, in order to give a holistic experience to the trainees. At the end of the training, the *parabs* have the ability to conceptualise and plan for water resources.

Once the training is complete, parabs are encouraged by ACT to be self-reliant and practice their skills independently by providing consultancy services. The original intention was that each parab will provide advice to a group of villages in matters of irrigation, water resources management, soil and water testing and in turn be paid by them for it. They are now becoming local champions and an important link in participatory ground water management. People are slowly beginning to trust their skill and are seeking their help. A separate entity, Parab Water Management Pvt. Ltd. has now been set up and registered to further cement their credibility. Their initial breakthrough came when engineers from WASMO crosschecked their database for a project and endorsed its authenticity. Now, parabs from Parab Water Management Pvt. Ltd. also work as Resource Persons for Reliance Foundation and have been involved in CSR projects from IL&FS. ACT is trying to replicate the success of Parab as a local technical expert in urban context also. Given the skills that Parab acquired through training and subsequent practical experience, they can help local government in effectively implementing water related projects. The idea is to include the concept of Parabs as an integral part in urban PGWM framework.

Figure 26: Mapping module for Parab training



Source: ACT

Magazine and media: For revival of Hamirsar Lake, ACT along with JSSS publish a monthly magazine called 'Hamirsar no saad.' It talks about the lake and its revival and in more general terms, water and water resources. Aside from this, ACT and JSSS also get various articles published in local newspapers about their work and ongoing activities.

Photograph 11: Covers of previous issues of Hamirsar no Saad

Source: www.bhujbolechhe.org

Photograph 12: Newspaper clippings related to Bhuj PGWM activities


પાણીની યોગ્ય બચત થશે તો જ આવનારી પેઢી સલામત રહેશે

ભુજમાં હમારા જલ વિશે યોજાઇ શિબિર અનેક વક્તા જોડાયા


ભુજનું પ્રાચીન તળાવ જીવંત કરવા પોલીસના જવાનોએ પરસેવો રેડ્યો

Source: ACT

Jalpedi: The term '*Pedi*' in Gujarati means a community gathering. As a tradition, the day of *Jeth sud ekadashi* is associated with water in in Kutch. This day in Hindu culture is auspicious and reserved for fasting in deference to the deity Shiva. In Kutch, this day is culturally linked with water. On this day, which generally falls in July i.e. the beginning of the rainy season, "water holders" such as water

vessels, wells or tanks/lakes are cleaned and so that the rain god can rest peacefully on earth. Historically, the idea was to ensure enough space for water storage and rainwater harvesting in the new season. JSSS has used the cultural significance of the day and the custom of coming together in a very unique way by organizing the *pedis* in the villages as a water management day and naming it *Jalpedi*. The community members are encouraged to come together and engage themselves in various activities which would be useful in water management. They celebrate the *Jalpedi* by organising mass awareness campaigns about local water resource management or come together to clean and de-silt local water bodies.

Photograph 13: Activities during Jalpedi - Model to understand aquifer (left), Awareness stall (right)

Source: ACT

Janmashtami stall: In 2006 a JSSS stall was installed at the annual Janmashtami fair that celebrates the birth of Krishna. The chief objective of this stall was to disseminate information to the people with respect of importance of Hamirsar Lake and catchment area and possible rain water accumulation sites, and to get opinions regarding the lake.

Musical festival: A Kachchi Lok Sangeet programme was held in conjunction to the Jalgatha tour to emphasize the heritage value of the lake, the buildings and history of Bhuj. Later a similar Sur Sangeet Programme was again held at Hamirsar.

Photograph 14: Kachchi Music festival in progress at the lake

Slide shows and movies: JSSS, with ACT, regularly slide shows and movie screenings in order to generate awareness and build capacity of the citizens about the catchment system, water management, ground water and the aquifer. There are generally held in schools and at social gatherings.

Photograph 15: Slide shows and movie screenings for the community

Source: ACT, 2015

4.3 Advocacy and Technical Demonstrations

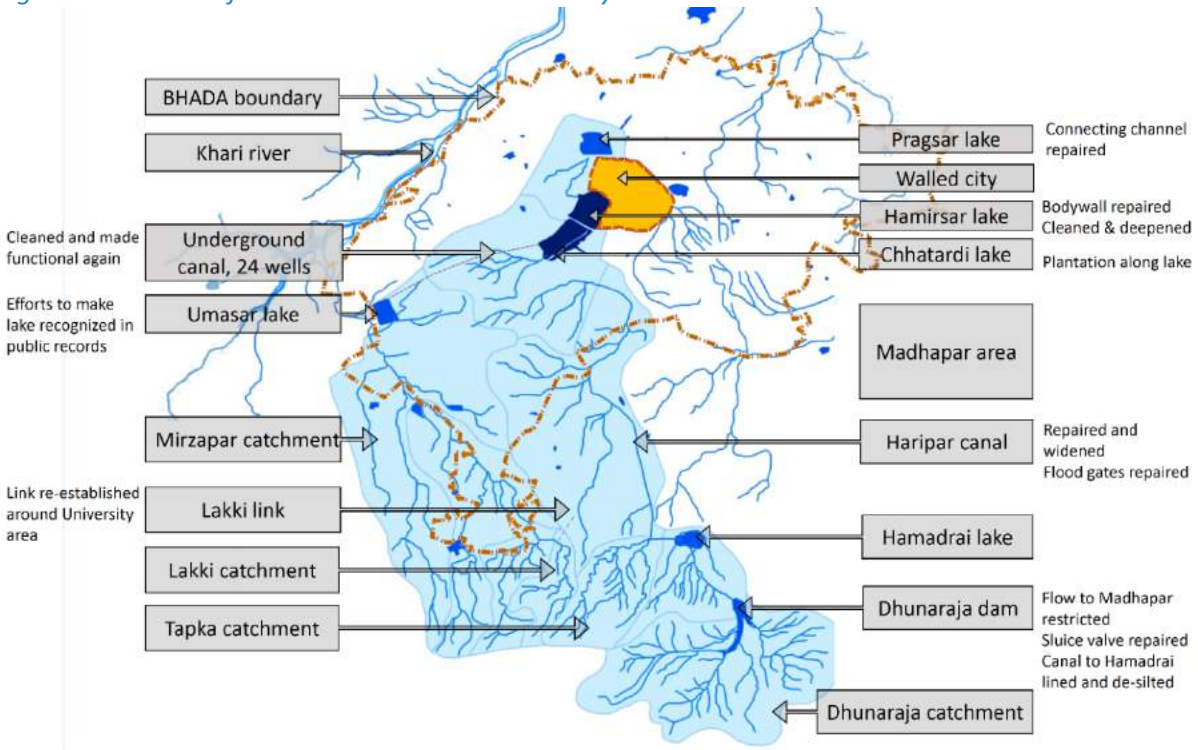
Based on the results of all studies and research, various technical interventions were carried out in the form of corrective actions or technology demonstrations with the aim of encouraging citizens to adopt them. These efforts were met with great success.

However, while citizen led movements and ACT's own efforts have brought about great success in the realm of water management in Bhuj, it also becomes important to involve the government institutions that are the decision makers especially in terms of investment in long term infrastructure. Thus, ACT also works towards advocating government support to make water related projects a priority.

Fixing the Broken Links: Revival of lake system with JSSS[10]

ACT was catalyst in bringing together various stakeholders like JSSS, other civil society groups, local government, the District Collector office, State Irrigation department and Forest department, for revival of the traditional catchment system.

Figure 27: Revival of Hamirsar catchment- summary



Source: Adapted from Raman (2013) and ACT interactions

In 2001, the channel known as Haripar canal, connecting Tapka with Haripar, was repaired and widened to allow the water from the catchment area to flow smoothly to the lake. The boundry wall surrounding Hamirsar Lake was also repaired in 2002, by the Irrigation department.

Runoff from the Dhunaraja catchment, is stored in the Dhunaraja irrigation dam. This water used to flow to Madhapar for irrigation through a sluice valve. This valve was broken and no water flowed to Madhapar. With efforts of JSSS, ACT and others, the valve was repaired and water from the dam was diverted to Hamadarai Lake through a lined, newly de-silted canal. Simultaneously the Dhunaraja dam was also de-silted to increase its capacity. In 2007, Bhuj Municipality funded the deepening of Hamadrai Lake thereby increasing its capacity.

[10] Source:
1. Adapted from Raman, K. (2014). From 'Bhooj to Bhuj': The rise and fall of resource management system. Ahmedabad: CEPT University.
2. Communication with ACT

The flood control gates on Haripar canal, which is linked with the Tapka and the Lakki catchment, were repaired. From the flood control gates, water flows through open canals in the city to the Dhobi Lake and from there towards the Chattedi and the Hamirsar Lake.

It was noticed that the Lakki link was encroached upon by recent constructions. This had caused regular flooding in Kutch University area. In 2010 a new link was made around the University to divert the water back into the catchment system.

To feed water into the Hamrisar Lake from the Mochirai-Mirzapur catchment, there is an underground canal and series of wells (24 wells). As a result of ACT and partners' actions, these wells have been cleaned and made functional again.

Umasar Lake, adjacent to the canal, gets water from the same catchment, was not recognized in public records. ACT and partners have made efforts to ensure that the lake is recognized.

Figure 28: Repaired Hamirsar body wall

Source: ACT

In the summer of 2008, JSSS organized a programme of offering self-labour called "Swantah sukhay radiyamanu Hamirsar – Shram yagna" which resulted in a lake cleaning drive for Hamirsar. Around the same time, de-silting of Chhatardi & Dhobi lakes was undertaken leading to a complete revival of the 3 lake system of Bhuj. The forest department contributed by plantation along the boundry of Hamirsar and Chhatardi, which serves as a wetland for migratory birds.

Photograph 16: Hamirsar cleaning drive by citizens

Source: ACT, JSSS

In 2009, the municipality funded the repair and widening of the channel serving as overflow link between Hamirsar and Pragsar Lake thus fully re-establishing the old catchment system.

Between 2012 and 2014 a series of drives led to restoration, and in turn protection, of 9 other, smaller lakes. All these efforts in reviving the complete catchment system have met with some success. With low rainfall of 25cm, it is now possible for the Hamirsar lake to get filled up which was not the case in the past.

It is also a fact that the demand for water has been rising and it is certain that the current shortfall in supply is unlikely to be met with revival of traditional efforts. It is precisely for this reason that ACT and partners have also focused their attention on rain water harvesting and water conservation efforts.

Demonstrating decentralized water systems

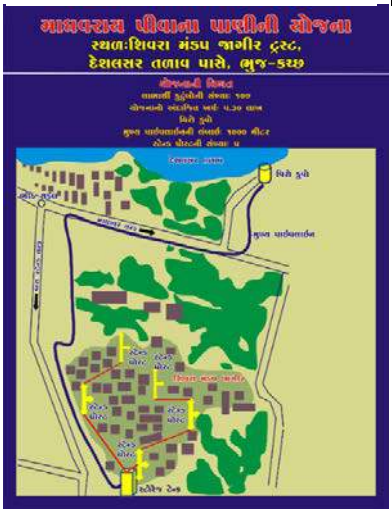
Decentralized drinking water schemes through well revival: ACT was a partner organization in HIC project for providing technical input for drinking water supply planning for slum areas as well as input to other development projects such as RAY.

After this project, ACT and partners have also demonstrated decentralized water planning in 6 slum areas. Four of these slums namely, Shivra Mandap Jagir Area (108 families), Bapa Dayalu Nagar Area (250 families), Ramdev Nagar Area (114 families), Kumbharvas Area (150 families), have their own drinking water schemes. Activities like establishing hand pumps, de-silting and bund repair of existing ponds; construction of drinking water wells, storage tanks, pipeline distribution system, stand posts etc, were carried out by ACT and its partners.

Box 5: Shivra Mandap Case of DDWS:

Shivra Mandap is a slum in the Madhavrai area of Bhuj. The slum is made up of people of the Meena community who make a living working as daily labour, vegetable sellers, household help etc. Their average family income per month is around Rs. 3000/- (Bharathi Ghanashyam, 2015). The area, in ward 11 of Bhuj, was considered the worst in terms of water availability due to irregularity in supply by the Municipality. Approached by the residents, JSSS and ACT took up this project to demonstrate a decentralized, self-sufficient water supply system with Participatory Ground Water Management. Within a period of one and half years, ACT ran an awareness and motivation campaign in the area, starting with social reconstruction to build up the trust of the residents. The women in the area, with support from Kutch Mahila Vikas Sangathan, formed a self-help group. A separate water committee called the Madhavrai Pani Samiti was also formed. The committee has office-bearers drawn from the community and includes women as well (ACT, Madhavrai (Shivra Mandap) Decentralized Drinking Water Scheme- Presenatation, 2013).

Figure 29: Poster for Shivra Mandap intervention



After doing a survey of all the wells in the vicinity, Vira Kuan, an old well (reputedly more than 200 years old) was identified as the best suited, on various criteria such as quality of water, availability etc.

It was then revived, cleaned and the water made potable. Work was taken up through a cost sharing arrangement, with residents of Shivra Mandap contributing their labor, Hunnarshala providing technical help and ACT provided financial help. With contribution from all families, the well was connected to an overhead tank, also newly installed. To pump water into the tank, an electric connection was taken out in the name of the committee. Out of the 125 houses in the slum, more than 40 have opted to have taps installed in their homes. For a payment of Rs 150/- per month, they get running water for one hour every alternate day. For those who cannot afford tapped water connections to their homes, there are 5 community stand-posts. The entire initiative is run, maintained and monitored by Madhavrai Pani Samiti which is responsible for paying the electric bills (ACT, Madhavrai (Shivra Mandap) Decentralized Drinking Water Scheme- Presenatation, 2013).

Photograph 17: Shivra Mandap public taps (left), Revitalized well (right)

Decentralized drinking water scheme through Rain water harvesting: Rain water harvesting forms the most fitting approach to manage water at a smaller scale. Water harvesting addresses issues of inadequacy of water and declining ground water levels. This is a result of poor infiltration of rain water in the subsoil due to paving of open area. For Bhuj, it is estimated that rain water harvesting potential is about 2000 million litres per annum, or 5.70 MLD (ACT, 2015). This is nearly one-fifth of the total water supply for Bhuj. Thus, with the idea of Roof Rain Water Harvesting, ACT surveyed the Governmental primary schools which were facing the problem of drinking water. Projects for rain water harvesting were initiated in 12 schools beginning with Shiv Nagar Primary school. These projects have demonstrated roof based rain water harvesting, storing nearly 1.15 lakh litre for use during the year while also using the surplus to recharge ground water with recharge bore wells. This is especially important in parts of the city which reside on the saline part of the aquifer where lowering of the water table further increases salinity.

Table 8: Summary of School RRWH by ACT

School	Students	Total potential from Rain Water (Ltr.)	Work done		Expense Rs.			Public contrib.	Donation
			Water Tank(L)	Recharge Bore + Hand Pump	Tank	Recharge Bore	Total.		
Shiv Nagar	445	80,000	35,000	Yes	66,601	35,000	1,01,601	33,350	33,251
Bakali Colony	300	28,000	25,000	No	64,000		64,000	4,000	64,000
Chandra Jyotiba	368	28,000	25,000	No	64,000		64,000	1,500	64,000
Hiten Dholakia	505	80,000	30,000	Yes	70,000	35,000	1,05,000	1501	70,000
Patwadi	310	90,000	40,000	No	1,00,000		1,00,000	3,600	1,00,000
Mundra Reloca.School	50	80,000	25,000	No	77,191		77,191	13,650	63,541
Mundra Reloca.School	50	80,000	35,000	Yes	1,09,987	40,000	1,49,987	31,000	78,987
School No.7 Police Headquarters	425	84,000	45,000	Yes	1,35,000	40,000	1,75,000	3,300	1,32,700
Umed Nagar Primary School	322	82,000	35,000	Yes	71,788	40,000	1,27,888	10,230	1,17,888
Total	**2,775**	**6,32,000**	**2,95,000**		**6,58,567**	**1,90,000**	**6,58,066**	**1,02,131**	**6,24,367**

Source: RRWH concept and experience (ACT, 2015)

Box 6: **Shiv Nagar Primary School Case of RRWH**:

In 2007, finding support in a very cooperative school principal, ACT chose Shi Nagar primary school as a pilot in their rain water harvesting project. In spirit of ACT's people's participation and contribution model, an awareness campaign was carried out to convince the students and their parents where the school arranged a small picnic cum 'Hamisar Yatra' with the help of JSSS.

They also arranged parents meetings and a film show explaining the Roof Rain water Harvesting Model. Financial support came in the form a donor 'Sushil Trust'. Bhuj Municipality also contributed a large amount in addition to smaller one from individuals. The students and staff also contributed one rupee per head.For the actual construction students, parents and teachers pitched in their labor. Thus, with the joint effort of JSSS, ACT, Sushil Trust, Students and teachers of Shivnagar Primary School and Bhuj Municipality, the Model was implemented in 2010. It consisted of 2 water tanks of 25000 litre and 10000 litre capacity each as well as a handpump. Later a recharge borewell was added to use surplus water for groundwater recharge.

Post implementation an RRWHS committee was formed including parents, teachers and students. A separate task force of students was created and tasked with the maintenance of the facility according to a timetable. They are responsible for cleaning of the tanks, filling water for day to day use also take care that water is not wasted in the school. The committee deals with regular repair and chlorination of collected water and has been trained by ACT and JSSS in use and maintenance of the system. During vacations and holidays, the same work is carried out by people in the neighborhood. JSSS visits the school for inspection pre and post monsoon season.

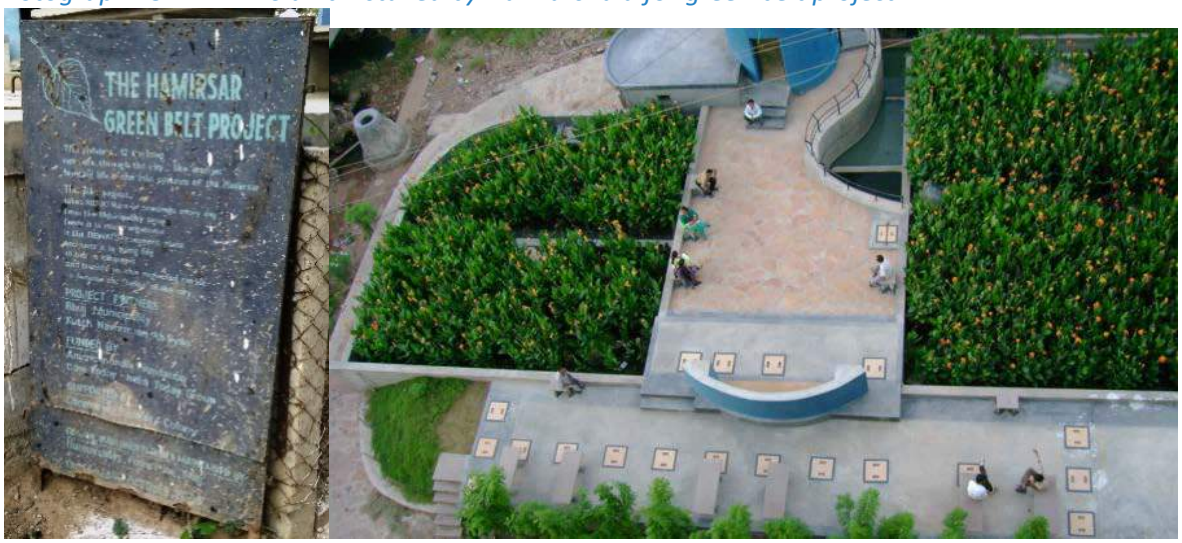
Photograph 18: Water tanks and handpump installed as part of RRWH at Shiv Nagar school

The school has now become self-sufficient in terms of drinking water and does not have to depend on erratic and poor quality Municipal water supply. The school is saving Rs 5000 per year by not calling private water tankers during shortage. Most students do not bring water from home anymore and some were even found to be carrying water back to their homes! They find the quality of water much better ("sweet water") than that provided by the Municipality. The number of students also increased in the school after the success of the model and the same water is also being used to prepare their mid-day meal. The model became such a success that three school teachers have adopted it in their homes and other schools have also showed interest in implementing it.

Source: (ACT, Shiv Nagar primary School Case study: A government School sets example, 2012)

DEWATS: Hunnarshala installed three DEWATS units in Bhuj to recycle 15,000 liters of sewerage and landscape 1 km of a rivulet's banks. Municipal waste water is fed to the DEWATS treatment plant and the treated water is used to greening of a rivulet's banks.

Photograph 19: DEWATS unit installed by Hunnarshala for green belt project



Source: CEPT, Hunnarshala

Flood control with Groundwater recharge systems: Increasing concrete cover as a result of Urban expansion and broken links in the traditional catchment system is believed to be the cause of regular flooding in Bhuj. As described previously, flooding in Kutch University was solved through rebuilding the stream link. However, as diverting water channels results in its addition to general run

off with no value addition to the system, ACT advocates using flood water for ground water recharge in common plots and grounds.

Figure 30: Plan for flood control with ground water recharge:

Source: ACT,2015

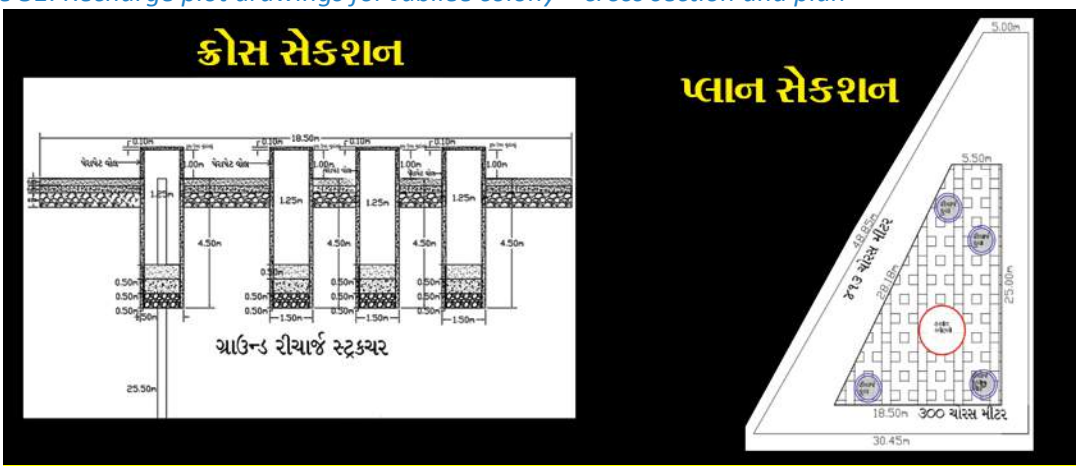
Box 7: Jubilee colony case of Common Plot RWH and flood control

In September 2011, a heavy downpour led to a flood in Jubilee colony of Bhuj. Water entered into the homes of the citizens and resulted in severe loss and damage of property. Desperate residents recognized that flooding was likely to become a regular feature, given the uncertainty and variable intensity of rains. JSSS volunteers took a transect walk of the area with the members of the colony and studied the flooding in the colony. The walk made it clear that the shape of the ground of the colony had become like a saucer where the height of the surrounding roads was higher. This had made it impossible for the surface water to get an outlet. The entire area therefore was getting logged and flooded. The construction work that was undertaken after the earthquake had blocked the seepages from surfaces. The outlets that carried water through storm water drain towards Jeevanram Tank were blocked and any solution that required letting the water out of the colony was impossible to work. JSSS organized a *Jalpedi,* an exhibition of posters and photographs on water that aimed at creating awareness. As a result all the members came forward to join hands and implement the solution in the colony. The solution was very simple but innovative. It was decided that instead of making efforts towards an impossible task of letting the water out, it is better to increase the capacity of the ground to absorb the water. It would help the water to permeate in the ground. More importantly, it could solve the problem of water logging on one hand and recharge ground water on the other. In future, it could come handy for the members of the housing association during summer or whenever there is water scarcity.

The ground of two common plots in the colony was deepened and three recharge wells were dug up to 18' to 20' depth. They were filled in layers with big stones, gravel and rough sand. In one of the wells, a recharge bore-well that went to 100 feet in depth was dug. This increased the water absorption capacity of the land and solved the problem of flooding in Jubilee colony. Out of the total expenditure of Rs 4 lakhs, 80 percent came as a grant from Arghyam, a Bengaluru-based grant-making organization (as ACT was going to use this as a demonstration plot to show-case the participatory water-management system and ground water recharging system) while the remaining 20 percent

came from contributions from the association. The Municipality contributed by providing the JCB for deepening the land in the common plot and digging the three wells. Today Jubilee Colony has become a role model for other residential areas who are approaching JSSS to help them solve their problems.

Figure 31: Recharge plot drawings for Jubilee colony – cross section and plan



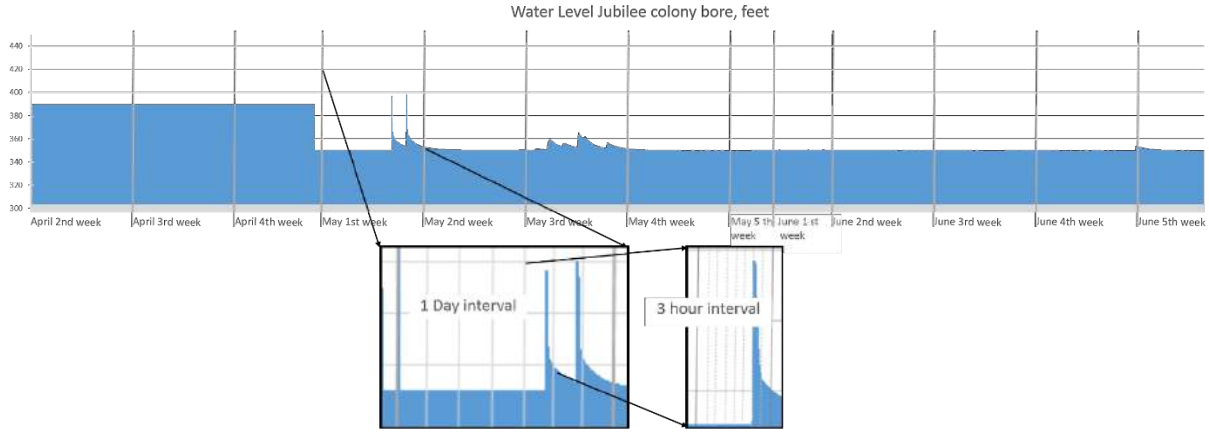
Source: ACT

Photograph 20: Jubilee colony intervention in action

Source: ACT

ACT has installed a water sensor in the recharge well recently which records the water level and other parameters every 10 minutes. Readings show that during the latest rainy season, ground water level spiked and then quickly dissipated in a matter of minutes proving the effectiveness of the recharge system.

Figure 32: Water level graph for April-June 2016 , Jubilee colony recharge borewell



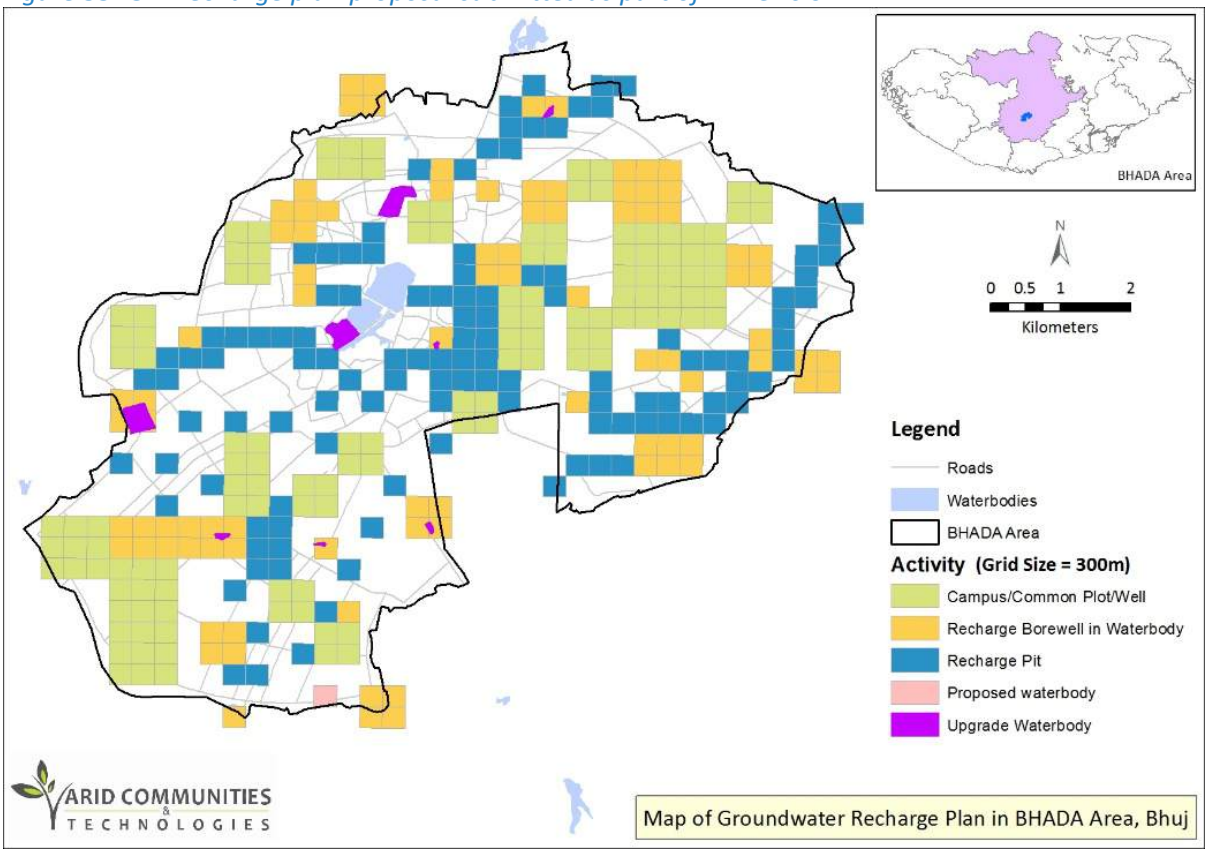
Source: ACT

Contributions to the Development Plan of Bhuj

Bhuj Area Development Authority is in the process of preparing a new development plan. ACT's efforts and suggestions led to the Municipality paying special attention towards the subjects of ground water and storm water drainage. ACT compiled a set of suggestions and proposals which are now in the process of being incorporated into the Development Plan.

Explaining the geology of Bhuj and observations from their ground water monitoring system, ACT suggested that Bhuj adopt a plan for ground water recharge based on a grid. This is based on their ground water monitoring network model which works on a grid system. Each grid box contains atleast one well that is already monitored in terms of Reduced water level and TDS and can hence be used to assess the effect of recharge activities. Assuming that each activity benefits an area of 300X300 sq m around it, ACT has suggested the following recharge activity plan.

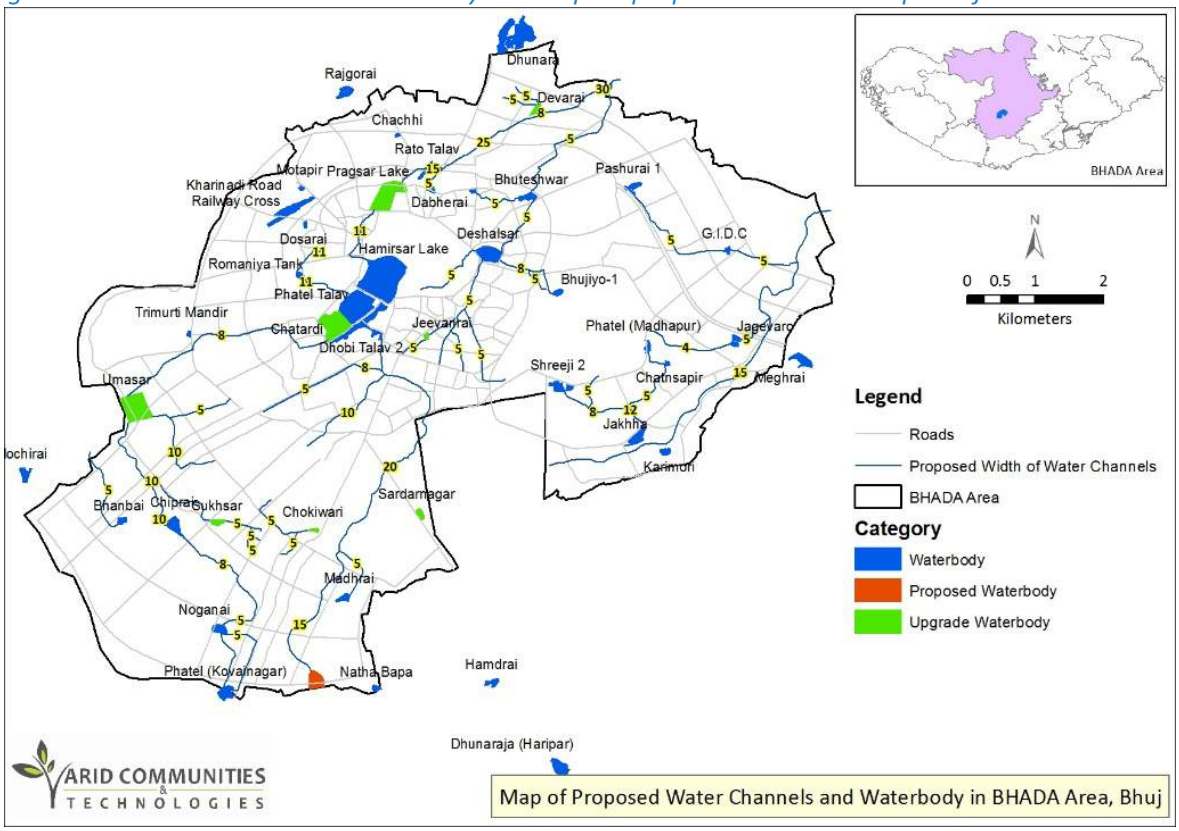
Figure 33: GW recharge plan proposal submitted as part of DP revision



Source: ACT, 2016

The plan proposes up gradation of several water bodies as well as the creation of a new lake with recharge borewells in all the lakes. Recharge pits are proposed every 60 m in existing water channels. To support this, another plan to maintain the channels was proposed. This is shown in Figure 34 . In addition to this, ACT suggested the use of common plots/ open grounds for collecting rainwater and using it for groundwater recharge.

Figure 34: Water channel and water body revival plan proposal submitted as part of DP revision



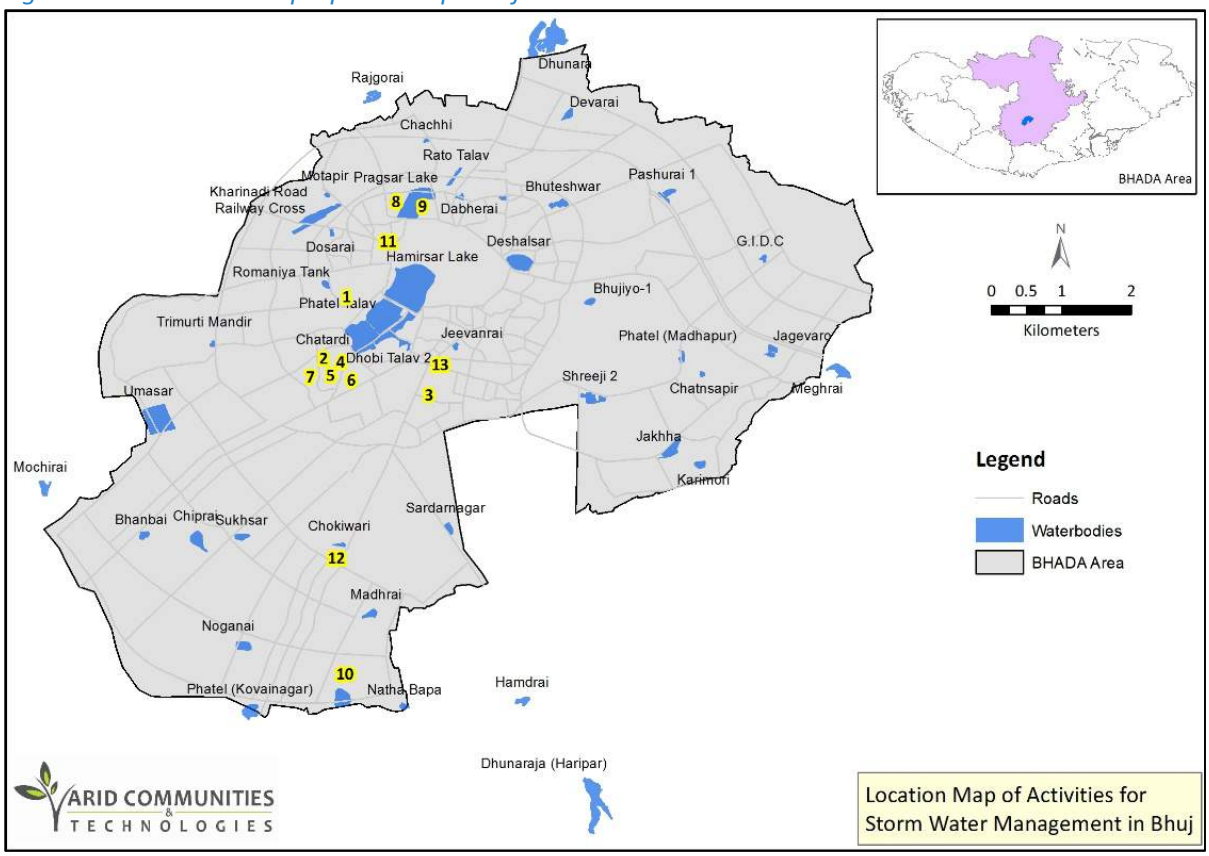
Source: ACT, 2016

Service Level Improvement Plan (SLIP) under AMRUT

Bhuj being of the cities in Gujarat covered by The Atal Mission for Rejuvenation and Urban Transformation (AMRUT) required the preparation of a Service Level Improvement Plan (SLIP). Out of the 5 sectors that the SLIP covers (Water supply, Sewerage, Storm water drainage and urban transport), proposals for Storm water drainage were done with the help of ACT. The submitted proposal contained specific schemes in the following areas-

- Widening drainage channels
- De-silting of existing 43 tanks
- Providing 50 recharge-wells in streams
- Converting about 160 common plots (approximately 32000 Ha) into recharge plots
- Repairing of existing flood control system
- Construction of a reservoir in upstream of watershed area
- Promotion of Campus level rainwater harvesting
- Setting up of storm water management system within municipality
- Preparing para cadre as storm water management squad

Figure 35: Interventions proposed as part of Storm water SLIP



Source: ACT, 2016

Sensitization workshops

An important lesson from ACT experience is that people's participation can be meaningful when informed discussions take place during consultations. Such consultations require experts to explain technical details to the lay persons. Thus, ACT conducts regular workshops with decision makers to sensitize them with water management practices and issues in context of Bhuj.

Efforts towards PGWM in Bhuj cut across a number of dimensions. The success of each of the activities described in this chapter depended upon other preceding activities. Thus we learn that a successful PGWM programme is multidimensional, requiring effort across social, academic, technical as well as governance spheres.

5. Way Forward: Evolving Guidelines and protocols

"Growing populations, rising incomes, and expanding cities will converge upon a world where the demand for water rises exponentially, while supply becomes more erratic and uncertain. If current water management policies persist and climate models prove correct, water scarcity will proliferate to regions where it currently does not exist, and will greatly worsen in regions where water is already scarce. Simultaneously, rainfall is projected to become more variable and less predictable" (World Bank Group, 2016).

For centuries, Bhuj had managed to ward off water scarcity by carefully managing its water resources and harnessing all the water that was available. However, with growth in population, the demand for water has increased and Bhuj has become highly dependent on water coming from distant sources. The issue is even more aggravated as Bhuj is located in arid zone and has a history of erratic rainfall patterns and severe droughts.

Underground aquifers are a vast natural reservoir, containing about 30 percent of the available freshwater. Groundwater storage provides a natural buffer against climate variability; it is thus vital not only for the economy but for a city's sustainability (adapted from World Bank report, 2016). Harnessing the ground water may mitigate the future challenges of growing demand for water and increasing competition for water resources between different sectors.

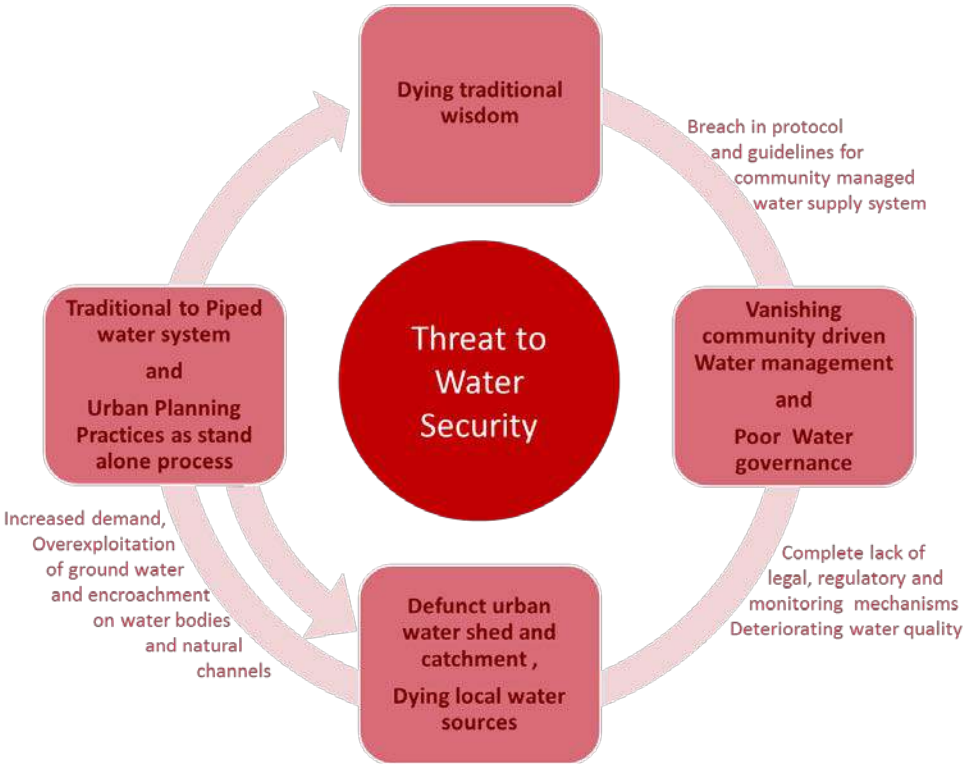
5.1 From a vicious to a virtuous cycle

When Bhuj municipality provided piped water supply in the 1960s, it was a great boon to residents of Bhuj, as they did not have to walk to the lake or wells to fetch water. Over the years, as the population grew and demand for water increased, the municipal water supply system sought additional water resources from far away, rather than learn and implement the traditional water management practices. Poor pricing policy for municipal water supply and absence of regulation for ground water abstraction did not provide any incentive to citizen to protect or conserve the local water resources. This ultimately resulted in decline in the use of local water resources and a neglect of the traditional water management systems. Overall, there has been a downfall in community led self-management of water sources, which led to ruin the community driven protocols that protected and conserved local water sources. It resulted in reduction of water flowing into the lakes and their drying up.

On the other hand, city population was rising and there was demand for land for housing and commercial activities. The dry lakes were seen as potential land available, and were even filled up with debris to make way for housing. This disturbed the natural urban watershed and catchment system. The surviving lakes often became places for discharge of waste water. Apart from this, failure

in water governance due to absence of any legal or regulatory authority led to total neglect of local water resources. In summary, the vicious cycle of neglect of local water resources poses a major threat for water security of Bhuj.

Figure 36: Vicious cycle leading to a threat to water security



Source: Developed by CEPT

How does one move from this vicious cycle towards a virtuous cycle?

The most important aspect to ensure water resources for Bhuj in next decades could be achieved by moving towards integrated urban water management. It will ensure ultimate goal of water security in city. This can be achieved through introducing various innovative approaches like Integrated Urban Water Management (IUWM), Participatory Ground water management (PGWM), Water sensitive urban design (WSUD) etc. These approaches have to be linked with urban planning. Such process must be backed by various pilot demonstration, awareness and capacity building programme for revival of traditional knowledge base for efficient water management. It would help in accelerate the activities related to revival of traditional watershed system through lake restorations and increasing recharge activities. Whole process of integrated urban planning and renewal of traditional water management system should be backed by a governance system that ensures sustainable water management.

Figure 37: Converting to a virtuous cycle and moving towards water security

Source: Developed by CEPT

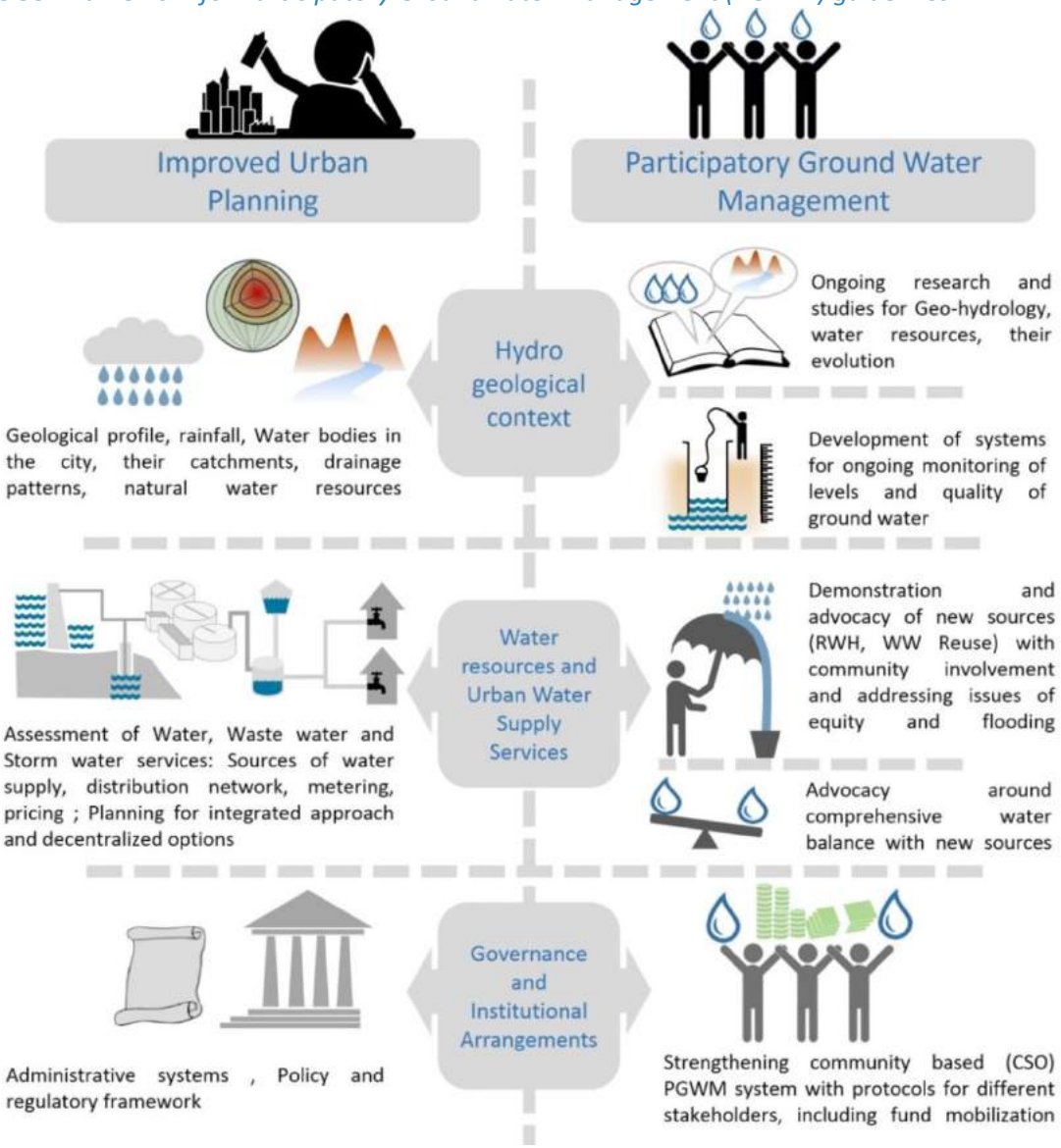
ACT and its partners have already began efforts and demonstrated various activities through PGWM approach, which helps Bhuj to move towards water security. The Bhuj experience of ACT and lessons from it would help in initiating such activities in other cities.

Building up of technical knowledge base and disseminating this knowledge to the citizens through strong citizens' forum is key to success of ACT's participatory ground water management (PGWM) in Bhuj. Dissemination of the technical information to the citizens through simple messages and various awareness activities (especially those targeting children groups) were helpful. One also sees that sensitisation of local officials, capacity building of civil society and government officers and demonstrations through pilot projects are essential for a successful PGWM. JSSS and its experience prove that it is essential to create specific institution for specific activities and institutionalize the various processes of PGWM to make it sustainable. It also shows that the citizens need to be involved in planning, implementing and monitoring through such institutions on a sustained basis.

Participatory approach in Bhuj can serve as a background for developing urban PGWM guidelines and initiating similar efforts in other cities. Guidelines and protocols for Participatory Groundwater Management (PGWM) should be considered around two broad areas; one for urban planners for improving the conventional planning approach to include water sensitive planning. The second guideline for PGWM should be aimed at civil society institutions for undertaking detailed field assessment of hydro-geological and water resource conditions.

The following framework with two sets of guidelines has been prepared after discussion with ACT about Bhuj experience and also based on the desk research on various PGWM / IUWM guidelines. These will be elaborated subsequently.

Figure 38: Framework for Participatory Groundwater Management (PGWM) guidelines



Source: Developed by CEPT

5.2 Guidelines for improving Conventional Urban Planning approach

In Conventional urban planning, water, sanitation and storm water sectors are often neglected or planned in isolation from each other. With an overt focus on land-use, the natural water resources are relegated to the background. In this context guidelines for improved conventional planning approach can help urban planners and water resource planners in designing integrated options for ensuring ecologically sustainable development.

Following broad areas will be included in these guidelines:

1. Assessment of geo-hydrological conditions of urban area: This would include Geological profile, rainfall patterns, and water bodies in the city, their catchments and drainage patterns as well as inventory of natural water resources.
2. Design of protocols for revival and restorations of natural watershed and water resources.
3. Assessment and planning for current water supply and sanitation services
4. Developing protocols for inclusion of geo-hydrology in land-use planning.
5. Assessment of Governance and institutional arrangements for developing enabling environment for integrated water resources planning and improved governance framework.

5.3 Guidelines for a PGWM framework

Communities are the central pillar in water security planning as they are the users as well as one would be most affected in severities. Water security in city would be sustainable in long run if it is backed by participatory institutional framework. In Bhuj, institution like ACT has already realised importance of participatory approach along with its technical knowledge about local resources. It is important to recognise the role of a technocratic institution like ACT that provides both technical knowledge as well as mobilises local communities.

In this regard, it is important to prepare guidelines to help similar institutions in other cities for undertaking PGWM initiatives in urban areas is essential. Such guidelines will include:

1. Assessment of geo-hydrological conditions of urban areas through research studies and detailed field survey. Development of system for regular monitoring for understanding impact of interventions over time, and for advocacy at higher levels
2. Assessment of water supply services and analysis of water cycle along with technical Interventions/ pilot projects for demonstration of decentralized water systems like RWH, well revival, DEWATS, flood control through groundwater recharge, etc.
3. Strengthening community based (CSO) PGWM system with protocols for different stakeholders and Creating awareness among communities about water resources and its proper management through various programmes.
4. Technical Training of workforce (like *Parabs*) who has in-depth knowledge of local geo-hydrology and water resources as well as transferring of such technical knowledge to key stakeholders.
5. In summary, success of Bhuj experience suggests that it can also be adapted in other cities. The guidelines and protocols to be developed on the basis of this experience would pave way for other cities to become water secure.

6. Bibliography

ACCRN (2014). A handbook of managing small urban lakes. ACCCRN.

ACT. (2012). Shiv Nagar primary School Case study: A government School sets example. Bhuj.

ACT. (2013). Madhavrai (Shivra Mandap) Decentralized Drinking Water Scheme- Presenatation. Bhuj.

ACT (2014). Report on 1st city stakeholder consultation meeting on Participatory Groundwater Management, ensuring self reliance in water security. Bhuj: ACT.

ACT. (2015). Flood Control Report. Bhuj.

ACT. (2015). Jalpedi 2015. Bhuj.

ACT. (2015). RRWH concept and experience: Presentation. Bhuj.

ACT. (2016). Journey of ACT through 2015-16. Partners' Meet March 2016. Bhuj.

Awidi, C., & Mushi, O. (2013). Urban water management in Dar Es Salaam: a case for an integrated approach.

Bal, M. (2015). Social-ecological system framework, understanding urban lake governance and sustainability in India. Erasmus university rotterdam.

Bamutaze, Y., Thiemann, S., & Forch, G. (2014). Integrated watershed management- a tool for urban water security, workshop results from Mbale, Uganda. Makerere university.

Batchelor, C. H., Rama, M. S., & Rao, S. M. (2003). Watershed develop: A solution to water shortages in semi-arid India or part of the problem. Land use and water resources research.

(2010). Bhuj water supply scheme, based on tube wells at Bharapar, DPR, Volume 2, Estimate and Drawings. Bhuj: Bhuj municipality.

(2010). Bhuj water supply scheme, based on tubewells in at Bharapar, DPR, Volume 1, Report and annexure. Bhuj: Bhuj municpality.

Buapeng, S., & Foster, S. (2008). Controlling groundwater abstraction and related environmental degradation in metropolitan Bangkok - Thailand. The World Bank.

Centre for Science and Environment. (2015). Retrieved from http://www.cseindia.org/

Chiwhane, M. P., Shastri, D. S., & Parbat, D. D. (2014). Use of Polluted River Water after the Treatment for Irrigation Purpose case study: Purandar lift irrigation scheme. Internation journal of modern trends in engineering and research.

Closas, A., Schuring, M., & Rodriguez, D. (2012). Integratted urban water management- lessons and recommendations from regional experiences in Latin America, Central Asia and Africa. WPP.

(2012). Concept paper for discussion, National project on aquifer management. New Delhi: Central Ground Water Board, Government of India.

(2008). Coping with water scarcity, an action framework for agriculture and food security. FAO.

Das, S. V., & Burke, J. (2013). Small holders and sustainable wells . Rome: FAO.

District Census Handbook, Kachchh District. (2001). Census of India.

Drough by design: the man made calamity in Bundelkhand. (2010, January 30). EPW.

Drought in Focus. (2015, October). Watershed and river basin management sepecialist group newsletter. IWA.

(2008). Economics in sustainable water management, training mannual and facilator's guide. Cap-net UNDP; GWP; Vanessa Celosse of EUWI-FWG.

Environment Management Group, U. (2011). Global drylands, a UN system-wide response. UN.

Foster, D. S., & Vairavmoorthy, D. K. (2013). Urban groundwater- policies and institutions for integrated management. GWP.

Hunnarshala foundation. (2013). Slum free city, Bhuj, Pilot and preparation.

G C Taylor, M. M. (1963). Groundwater in folded crateceous sandstone of the Bhachau area, Kutch, India with reference to the Kandla port water supply. Geological survey of india; United States Technical Cooperation Mission to India.

Geology and Topography around Bhuj. (2016, January). Retrieved from Bhuj bole Chhe: http://bhujbolechhe.org/ org: http://bhujbolechhe.org/en/infos/2-geology-and-topography-and-around-bhuj

Ghanashyam, B., & Jatkar, U. (2015). Jalstrot Sneh Samvardhan Samiti, collective strength for collective resource. Bhuj: Arghyam, ACT.

(1995). Guidelines for groundwater protection in Australia. Agriculture and Resource mangement council of Australia and New Zealand.

(2009). Guidelines for Managed Aquifer Recharge (MAR) - Health and environmental risk manageent. EPA Victoria.

Howard, K. W., & Gelo, K. K. (2002). Intensive groundwater use in urban areas: the case of megacities. University of Toronto, Ontario, Canada.

Hunnarshala, & ACT. (2011). Report on Proposal for decentralized drinking water supply in unserved areas of Bhuj. Bhuj.

Institute, I. W. (2016, May 4). Water Balance . Retrieved from International Water Management Institute: http://iwmi.dhigroup.com/hydrological_cycle/waterbalance.html

Jadeja, D. Y.; Hunnarshala foundation (2011). Decentralised water supply management in Bhuj.

Jadeja, D. Y. (2015). Experiences of aquifer mapping and groundwater monitoring in urban areas, case study of Bhuj. Bhuj: ACT.

Joshi, Jagat Pati (2008). Harappan Architecture and Civil Engineering. New Delhi: Rupa &Co.

JSSS. (2011). Hamirsar Awareness Campaigning: Calender/Poster. Bhuj.

JSSS. (2014). Jal Pedi: Reviving traditional system. Bhuj: ACT.

Khatri, K. (2013). Risk and uncertainity analysis for sustainable urban water systems. UNESCO IHE.

Land and water division, F. (2012). Coping with water scarcity - an action framework for agriculture and food security. FAO.

(2011). Managing water locally, an essential dimension of community water development. ICE, Oxfam, Water Aid.

Maurya, D. M., Thakkar, M. G., & Chamyal, L. S. (2002). Quaternary geology of the arid zone of Kachchh: Terra Incognita. Indian National Science Academy.

Meena Nair, Venugopal Reddy, & Sita Shekhar. (2005). Are they being served? CRC on public services for the poor in peri-urban areas of Bangalore. Bangalore.

Mehta, L. (2001). The manufacture of popular perception of scarcity dams and water related narratives in Gujara, India. Great Britain: World development, vol 29, no 12.

Michael Jacobsen, M. W. (June 2012). The future of water in African cities: Why Waste Water? International Bank for Reconstruction and Development / International Development Association or The World Bank.

Morris, B. L., Litvak, R. G., & Ahmed, K. M. (2000). Urban groundwater protection and management: Lessons from two developing city case studies in Bangladesh and Kyrghyzstan. UK Department of International Development.

Owen, D. R., Mirghani, D. M., Diene, D. M., Tunhof, D. A., & Taylor, D. P. (2010). Groundwater management in IWRM training mannual. GWP.

Palrecha, A., Kapoor, D., & Malladi, T. (2012). Wastewater irrigation in Gujarat, an exploratory study. International water management institute.

Platt, R. H. (2006, May). Urban watershed management sustainabiltiy, one stream at a time. Environment.

Praharaj, S. (n.d.). Rejuvenation of Water Bodies (Kunds) and Restoring Active Community Spaces in The Cultural Capital of India: Varanasi.

Raju, K. C. (2000). Down to Earth Article. Mandvi, Kachchh: Shri Vivekanad Research and Training Institute . Retrieved from Down to Earth.

Raman, K. (2014). From 'Bhooj to Bhuj': The rise and fall of resource management system. Ahmedabad: CEPT University.

(2012). Revival of Hamirsar Lake and its catchment - wetland and urban rural relationships. Bhuj: Bhuj Municipality and Arid Communities and Technologies.

Sadoff, C. H.-K. (2015). Securing water, sustaining growth. GWP/OECD Task, University of Oxford, UK.

Shah, M., & Kulkarni, H. (2015, July 25). Urban water systems in India, Typologies and Hypotheses. EPW.

Sivasubramaniyan, K. (1993). Towards revival of small water bodies. EPW.

Soussan, J., & Reddy, V. R. (2003, January 3). Evolving appropriate watershed policy. EPW.

Standing the test of drought. (2000). Retrieved from Down to earth.org.in: http://www.downtoearth.org.in/coverage/standing-the-test-of-drought-17472

Steenbergen, F. v. (n.d.). Local groundwater regulation. ARCADIS Euroconsultant, land and water management group.

Sundaresan, J. (2011, December 10). Planning as commoning: transformation of a Bangalore lake. EPW.

Taylor, G. C., & Pathak, B. D. (n.d.). Geology and groundwater resources of the Anjar Khedoi Region, Eastern Kutch, India.

The NSW Groundwater Quality Protection Policy, A component policy of the NSW State Groundwater Policy. Department of Land and Water Conservation, New South Wales.

Uma Sankari, E. S. (1993). Understanding groundwater balance: Physical features, institutions and challenges. In Water management trditions in India.

UNESCO (2016). Dholavira: A Harappan City - UNESCO World Heritage Centre. Whc.unesco.org. Retrieved June 2016, from http://whc.unesco.org/en/tentativelists/5892/Water conservation. (n.d.). Retrieved from www.timbaktu.org: http://www.timbaktu.org/our-programmes/ecology/water-conservation/

Water conservation. (n.d.). Retrieved from www.timbaktu.org: http://www.timbaktu.org/our-programmes/ecology/water-conservation/

Water security and produced water. (2013). Retrieved from http://ixpower.com/water/faq-water-security-produced-water/

World Bank Group. (2016). High and Dry: Climate Change, Water, and the Economy. Washington, DC. Retrieved from https://openknowledge.worldbank.org/handle/10986/23665

Water scarcity: International Decade for Action 'Water for Life' 2005-2015. (2016). Un.org. Retrieved 1 October 2016, from http://www.un.org/waterforlifedecade/scarcity.shtml.

Knowledge Management and Advocacy Partnership for Participatory Ground Water Management in Bhuj

The Centre for Water and Sanitation (CWAS) at CEPT University has been established to focus on improving water and sanitation services in India. The Centre carries out various activities – research, training, advocacy to improve delivery of urban services.

CEPT University is the Knowledge Partner to Arid Communities and Technologies (ACT) for ground water management activities in the city of Bhuj, Gujarat. Through CWAS, CEPT is supporting ACT in documentation of processes related to Participatory Ground Water Management (PGWM) in Bhuj. Based on this study, CWAS plans to develop guidelines to promote Participatory Ground Water Management in Indian cities.

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