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The Gujarat State-Wide Water Supply Grid: a step towards water security

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Gujarat is one of India's economic powerhouses, but its geographical conditions mean that most of the state's districts face water deficits. In 2002, emergency arrangements to meet water shortages were replaced with a longer-term strategy: the construction and management of the State-Wide Water Supply Grid. This scheme moves towards connecting 47 million people to safe, potable water supplies. It has also positioned Gujarat as a pioneer in India in terms of moving towards water security and conservation, a policy choice that has boosted economic growth and made important strides towards human development.

Keywords: India; Gujarat; water security; infrastructure; water supply; social benefits

Introduction

Though it is one of India's industrial and agricultural powerhouses, Gujarat is also one of the most water-scarce states in the country, with a water availability of around 900 m^3 per capita per year, which is only 58% of the national average of 1545 m^3 (WASMO, 2013). More importantly, the state's topographical, hydrological, climatic and soil conditions result in large regional variations in the availability of water, leaving most of Gujarat's districts with water deficits. This situation seems to have worsened in the last 40 years: 3 to 5 years in every decade have been marked by drought, and with each episode, the communities' coping resources are further strained (Dass, 2006).

Up until 2002, this situation called for yearly crisis management and emergency arrangements, including a financial cost of INR 1250 million to1500 million (1 USD is equivalent to INR 55) to send water tankers to the regions facing temporary and recurrent shortages. Added to this, and even without accounting for social and environmental costs, the Gujarat Water Supply and Sewerage Board (GWSSB) (2003) estimated that households were spending around INR 7000 million to 8000 million (USD 127.27–145.45 million) every year to secure water supplies, mostly in purchases from private vendors. The annual social cost of water scarcity is put conservatively at INR 20,000 million (around USD 363.63 million) (GWSSB inaugurated technical support unit, 2013). These past measures were been temporary and costly, and urged Gujarat's government to reform its water sector (Parul, 2006).

Over the last decade, Gujarat has emerged as a pioneer in the country in the move towards water security and the efficient management of water resources. The highest priority has been awarded to drought-proofing the state via investments in water infrastructure, the implementation of an inclusive and long-term water policy, and the

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involvement of rural communities in managing local infrastructure and water supply services. Since 2002, the state's water sector has been building a State-Wide Water Supply Grid to address absolute and relative water scarcity as well as issues of access equity. From the moment the first elements of the State-wide Water Supply Grid were constructed, with the Sardar Sarovar Canal Based Drinking Water Supply Project at its core, the rural and urban landscapes began to change. (The Sardar Sarovar Canal is also known as the Narmada Canal.) The scheme, to be completed in 2013–2014, makes bulk water transfers from water-surplus to water-scarce areas, a policy that can potentially bring about substantial development benefits for at least 47 million people in this Indian state.

The government of Gujarat has stopped diverting resources in relief works to mitigate the socio-economic impacts of weather inclemencies and taking ad hoc measures to address latent water-scarcity issues. Instead, it has started investing in a series of infrastructure developments designed to recharge depleting aquifers, improve water quality, mitigate the burden poor water quality imposes on human health, and encourage new productive activities. These efforts could turn into an engine for human development. The grid, a combination of bulk water transmission pipelines, water treatment plants, service reservoirs and the longest water distribution network in the world, brings water to the state's most remote and fraught areas.

Gujarat's water profile

The wide heterogeneity in Gujarat's topography, hydrology, climate and soil conditions results in a geographical imbalance in water resource endowment. In fact, 70% of the state is arid or semi-arid and prone to droughts (Patel, 1997). Rainfall is unevenly distributed, as clearly reflected in the annual rainfall patterns observed over the last 35 years and summarized in Table 1.

At least once in every three years, Gujarat experiences a deficit in rainfall. In regions where water availability is heavily dependent on annual rainfall, drought has caused severe drinking-water shortages. Scanty and unpredictable rainfall, intensified irrigation and saline soil formations compromise water security in North Gujarat, Saurashtra and Kachchh. This is aggravated by a salinity ingress rate of 2 km per year along 1600 km of coastal aquifers (Gupta, 2001; WASMO, 2013). Further challenges arise from the fact that groundwater can only be extracted in 34% of the land area (see Table 2).

By the turn of the millennium, Gujarat had lost about 27% of its groundwater resources. Unsafe and unsustainable exploitation of groundwater sources affected 90% of the state's area, and 87% of the municipal corporations that depended on groundwater sources (Kumar & Singh, 2001). Indiscriminate groundwater mining has meant that any shortfall in rainfall almost immediately generates a 'drought condition' and water scarcity for agricultural activities and drinking water in certain regions. This has also contributed to

Table 1. Rainfall trends.

Region	Average annual rainfall (mm)	Rainy days
South Gujarat	>1100	120
Central Gujarat	800–1000	30–70
Saurashtra	400–800	20–30
Kachchh	<400	10–20

Source: Gujarat Water Supply and Sewerage Board (2013).

Table 2. Regional water resources availability.

Region	Total water resources (MCM)	Surface water (MCM)	Groundwater (MCM)
Central and South Gujarat	35,700	31,759	3,950
Kachchh	11,000	650	450
North Gujarat	5,300	2,000	3,300
Saraushtra	7,900	3,600	4,300

Source: Narmada, Water Resources, Water Supply and Kalpasar Department (2013).

the grave deterioration of water quality in at least 25% of Gujarat's habitations and caused extensive health damages (WASMO, 2013; Gurajat Jalseva Training Institute (GJTI), 2013).

Drought and acute water shortages also resulted in heavy setbacks in health, nutrition, education and the environment. These challenges intensified as population exploded, lifestyles turned more urban, dietary habits changed, the socio-economic profile of the state changed, and agriculture intensified around the production of water-intensive crops. In response to this scenario, Gujarat has sought to overcome some of the development challenges posed by physical water scarcity.

A paradigm shift

Gujarat's vision of achieving water security is based on tapping new water catchment areas, transferring bulk water by interlinking water-scarce and water-abundant basins, recycling wastewater and desalination. It mainly relies on the multi-state, multi-purpose Sardar Sarovar river-valley project. With this, the water sector in Gujarat is trying to push for a significant paradigm shift away from dependence on groundwater towards intensifying the utilization of surface water from the Narmada River to attain water security. This project has been built to address absolute and relative scarcity and make better use of existing water endowments. At the same time, water harvesting projects, conservation initiatives and supply and demand management practices have conjointly been put in place to increase the reach and scope of the grid, and the benefits it can bring to the population.

On the supply side, the grid includes reservoir construction; the conjunctive use and conservation of groundwater; re-use and recycling of wastewater; the construction of check dams and pond deepening with the Sardar Patel Participatory Water Conservation Scheme; and building and augmenting infrastructure to make bulk water transfers from surplus to deficit areas. On the demand side, initiatives include community-based, participatory irrigation management projects; prevention of salinity ingress; and the protection of arable lands from erosion and floods.

The grid includes 387 projects making inter-basin water transfers from areas with surplus surface water to water-scarce and quality-affected areas. It includes works based on the Sardar Sarovar Canal, the Sujalam Sufalam Yojana initiative for river inter-linkages and some 179 Rural Regional Water Supply Schemes. In its entirety, the grid aims at connecting 75% of Gujarat's population, approximately 47 million people, to safe and potable water sources. Some of the benefited 15,009 villages and 145 towns are tail-enders, 700 km away from the command area (Gupta, 2004; GWSSB inaugurated technical support unit, 2013).

To reach the most scorched regions of Saurashtra, Kachchh, and Central and North Gujarat, 51 bulk pipeline projects oversee the construction of 3250 km of bulk water transmission mains. By April 2013, 2654 km had already been built and 37 projects completed. These mains have connected 72.65% of the households in Central and North Gujarat, 82.88% in Saurashtra, 96% in Kachchh and 35.57% in South Gujarat to the State-Wide Water Supply Grid (Singh, 2013). Additionally, 2654 km of bulk water transmission pipelines, 156 water filtration and treatment plants, 120,769 km of distribution networks, 11,640 elevated service reservoirs and 11,365 underground reservoirs have been completed. Responsible for storing up to 3.86 billion litres of water, treating 2.81 billion litres and ultimately supplying almost 3 billion litres per day, these works have been at the technical forefront of the state's efforts to enhance water security (Gujarat Water Supply and Sewerage Board, 2013a, 2013b). By May 2013, 25.6 million people in 11,235 villages and more than 13.4 million urban dwellers in 131 towns were already part of the grid, totalling 39 million beneficiaries (see Table 3).

In 1990–91, Gujarat's ninth five year plan incorporated the government's decision to use water from the Narmada River to supply drinking water to Kachchh, North Gujarat, Saurashtra and Panchmahals (Planning Commission, 1990). The Drinking Water Supply Master Plan, based on the Narmada Main Canal, allocates 0.86 million acre-feet (1060 million cubic meters) of water to meet domestic consumption in 131 urban centres and 9633 villages (Sardar Sarovar Narmada Nigam Ltd, 2013b). The Narmada Main Canal has come to be known as the lifeline of Gujarat. At 458 km, it is the longest irrigation canal in the world. It was designed to transport more than 11.5 km^3 every year (Bunsha, 2006). The system includes 634 structures: 289 for communication, 114 for water control, and 231 for drainage (Sardar Sarovar Narmada Nigam Ltd, 2013a).

The aggregate length of the grid's entire distribution system is estimated to be 120,769 km. On its own, the canal network of the Sardar Sarovar Canal–based Water Supply Project, the grid's main component, will be 75,000 km long. Construction of the branch canals, distributaries, minors and sub-minors is still underway; the Narmada Main Canal was completed in 2008. As of December 2012, progress had made in over a quarter of all envisioned works: 30 out of the 38 branch canals had been built; 2233 km of tributaries finalized (44%); 32% of the 18,413 km of scheduled minors installed; and 21% of the 48,058 km of sub-minors constructed. It is expected that the entire Narmada Canal distribution system will be completed in 2014–2015 (Sardar Sarovar Narmada Nigam Ltd, 2012).

Largely thanks to the Narmada-based component of the grid, natural water endowments are no longer conditioning people's access to water in the arid regions of Kachchh and Saurashtra. Off-taking at km 385.814 of the Narmada Main Canal, the Kachchh Branch Canal runs for 360 km to secure water for these severely water-stressed regions. Through this connection, 801 villages and 8 cities in that district were receiving an average of 220 million litres per day (MLD) as of May 2013. The Maliya station also supplies 360 million litres daily to 1045 villages and 23 towns in the districts of Rajkot, Jamnagar and Probandar. Management practices can still be considerably improved to minimize losses, but the increases in water availability already represent a pivotal development for these regions.

In July 2008, people in Kachchh had to make do with 44 litres of water a day. By April 2013, the amount of water delivered had tripled, to 122 litres per capita per day. Furthermore, it is expected that upgrading works in 36 pumping stations will secure additional water supplies to Saurashtra and Kachchh. The capacity of the pumping stations at the head works in Navda was enlarged from 350 MLD to 440 MLD in August 2012.

Table 3. State-Wide Water Supply Grid, scheme progress.

	Planned schemes and foreseen coverage				
	No. of bulk pipeline projects	Length (km)	Distribution systems	Villages covered	Towns covered
Sardar Sarovar/Narmada Canal	51	3,250	123	9,633	131
Rural Regional Water Supply Schemes	–	–	198	5376	14
Total	51	3,250	321	15,009	145
	Completed schemes				
	No. of bulk pipeline projects	Length (km)	Distribution systems	Villages covered	Towns covered
Sardar Sarovar/Narmada Canal	37	2,654	85	7,455	118
Rural Regional Water Supply Schemes	–	–	181	3,852	14
Total	37	2,654	266	11,307	132
	Progress				
	Schemes	Villages	Towns		
Sardar Sarovar/Narmada Canal	28	1,763	7		
Rural Regional Water Supply Schemes	21	738	0		
Total	49	2,501	7		

Source: Sardar Sarovar Narmada Nigam Ltd (2013a, 2013b).

In April 2013, an even larger pumping station was habilitated and began supplying 600 MLD, of which 170 ML is transferred to 2325 villages and 38 towns in Bhavnagar, Rajkot, Junagadh and Porbandar. At these head works, 19 pumps operate at an average capacity of 26,526 m^3/h. In addition, investments of INR 1.7 billion are planned to strengthen and enhance water facilities in Saurashtra and Kachchh. A new parallel bulk pipeline has been envisioned to cover the segments of Chavand–Porbandar, Budhel–Kadiyali, Navda–Gadhada–Chavand, Amreli–Visavadar and Chavand–Amreli (Gujarat Water Supply and Sewerage Board, 2013a, 2013b).

Even with the reassurance Kachchh has obtained from having been connected to the grid, local sources have dried up to such an extent and water become so limited that emergency measures have had to be put in place. This year alone, 130 villages and 30 habitations (groups of families living close together) were included as part of a contingent master plan to drill 72 tubewells and deploy 48 tankers. As of May 2013, 59 bore wells had already been drilled and water supplied by tanker to 12 villages and 28 habitations. It ought to be mentioned that this still-challenging situation is already an improvement over the critical scenario faced in 2001–2002, when 298 villages in Kachchh had to be supplied by tankers (Gujarat Water Supply and Sewerage Board, 2013a, 2013b).

The hard engineering works behind the Narmada Canal and the overall grid have helped mitigate water scarcity in dry areas across Gujarat and are responsible for supplying half of the 3000 MLD that flow across the state’s drinking-water taps. However, infrastructure alone cannot deal with the communities’ pressing water needs. Local utility offices are being created in the municipalities encountering the most acute difficulties and where branches of the water supply board have not been yet established. Since February 2013, a new zone technical unit is operating in Saurashtra and Kachchh and in the districts of Porbandar, Junagadh, Amreli and Bhavnagar. This office has been specially staffed with technicians and engineers from the GWSSB to address the water-scarcity challenges that emerge in these regions during summer (Sandesh, 2013).

Particularly in the hot summer months, or at times of delayed or insufficient monsoon rains and prolonged periods of drought, farmers resort to drawing water directly from the main and branch canals. When such illegal activities are widely carried out, they can compromise the service delivered to villages at the tail of the pipeline. The taps are there, but drinking water fails to flow as a large number of pumping sets are sunk into the Narmada Canal, air valves tampered with, pipelines broken and water extensively drawn out. Damaged infrastructure jeopardizes, on the one hand, drinking-water security and safety, and on the other, the delivery system farmers themselves rely on for their livelihoods. Moreover, the limited water resources available in the state call for use prioritization (awarding utter importance to drinking water) and improved management practices. In this manner, economic and environmental activities can improve as progress is achieved in human development.

Starting in 2013, 32 teams have been deployed all across Gujarat to obtain first-hand information on the status of the pipelines, cross-check water accounting recordings and identify the sources of intended and unintended nonrevenue water. These groups patrol the pipelines and canals and protect the engineering works that deliver water to the most water-scarce areas in the state. Each of the teams in this task force is constituted by two members from the GWSSB, one officer from Gujarat Water Infrastructure Limited, one representative from the local office and three policemen. In addition, institutional efforts are being put into obtaining real-time information on the ground situation and gathering feedback on how to regularize and strengthen the management of the canal and the water distribution network.

Tapping the benefits

Water is a prerequisite for a minimum standard of health and the sustaining of productive activities. It is also a multifaceted social, cultural, economic, religious and political resource that facilitates or leads to the creation of a range of capabilities that condition an individual's ability to function and interact with his or her environment. This sheds light on the potential role water has not only as an important development indicator but also as a key driver of human development and a medium to create human capabilities.

Unfortunately, in places where water security cannot be assured, resource management often conditions the overall status of human health, education, and social and economic activities. It also influences the standing of certain demographic and gender groups and the state of the environment. This in turn restricts access to opportunities and their realization, compromising development at the individual, household, community and macro levels. In contrast, running water within the household premises is often a prerequisite for a better quality of life; it can open up social, educational and employment opportunities for men and women, improve health, and enhance incomes. In Gujarat, the role water can play as a development engine has now been acknowledged, and it is informing policy choices.

From 2001 to 2012, the government invested financial, physical and human resources worth INR 115.93 billion towards balancing water demand and supply. In present value, this amount is more than thrice that of the INR 34.65 billion spent the previous decade, from 1991 to 2000, and four and half times the INR 25.75 billion allocated for water throughout the 1980s (Narmada, Water Resources and Water Supply Department, 2013). The priority Gujarat has given to its water-supply sector has also surpassed allocations at the national level for drinking water and sewerage development in percentage terms. Between 2002–03 and 2011–12, state investments in the water sector represented 4.96% of the total budget, 2.7 times the 1.86% allocation made at the national level (Gujarat Water Supply and Sewerage Board, 2013b).

The creation of the State-Wide Water Supply Grid highlights the potential linkages between improved, timely and reliable access to water, in terms of quality and quantity, and poverty alleviation, overall socio-economic development and enhanced quality of life. This work constitutes an important departure from some of the traditional approaches that have limited water access to only certain selected urban centres. In that regard, the implementation of the Narmada Canal-Based Water Supply Project and the continuous execution of Rural Regional Water Supply Schemes have made relevant progress. The grid has mostly aimed at reaching many remote and far-flung rural communities, mainly benefiting villagers and people outside major urban centres. The GWSSB estimates that out of the more than 39 million inhabitants covered by this initiative as of March 2013, 26 million reside in rural areas, whilst the remaining 17.7 million are urban dwellers (Figure 1).

The availability of water has positively impacted on many aspects of individual, household and community well-being in a large number of villages and towns in Gujarat. This process has taken place thanks to improved public policies and institutions. A prosperous region and society can thus not afford to overlook the mutually reinforcing links connecting poverty and access to water. It has been estimated that every INR 55 (1 USD) spent in the water sector brings about productivity gains and health cost reductions averaging INR 440 (8 USD) (United Nations Development Programme (UNDP), 2006). Regarding the agricultural sector, the Narmada Canal has created positive externalities and productivity multipliers, as discussed by Kumar, Jagadeesan, and Sivamohan (2014) in this issue.

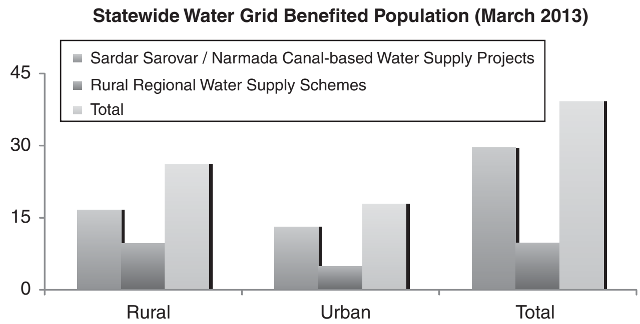

Figure 1. Addressing rural–urban divides in access to drinking water. Source: GWSSB records. Elaborated by the author.

An initial way of assessing the compounded effect that Gujarat's socioeconomic transformation has had over the last decades, and most particularly from 2001, onwards is partially reflected in the United Nations Human Development Index (HDI). According to India's Human Development Report (HDR), Gujarat has made consistent improvements in this measure (Planning Commission, 2001). In 1991, the HDI was 0.431 (Kumar, 1991); 10 years later it was 0.479 (Hirway & Mahadevia, 2004). By 2007–08, this index had seen a dramatic rise of 0.048, reaching 0.527 (Joshi, 2009). Two years later, in 2009–10, the index had increased to 0.688 (Debroy, 2013; Ministry of Finance, 2011–2012).

These gradual HDI improvements capture reductions in school absenteeism, the inclusion of women in remunerated economic activities, and improvements in health, especially in rural areas. There, the developmental gains from investments in drinking-water supply have opened up a wide array of opportunities to dwellers and contributed to general family welfare. Back in 2002, only 22% of the state's households had water connections. By 2010, domestic taps were available in 58.67% of households, and merely a year after, the coverage had reached 69%. Already at the beginning of 2013, this figure had jumped to 76.73%, more than double the national level of 34%.

In terms of basic household amenities, India's 2011 HDR shows the state performing slightly better than the 91% national average, with at least 93% of the households having access to an improved source of drinking water (Planning Commission, 2011). In urban areas, 95.6% of households had access to an improved source of drinking water by 2008–09, a benefit also extending to 91.4% of rural households. In Gujarat, 69% of the households receive tap water, 11.6% obtain their water through a hand pump, 9.6% from a tubewell, 7.1% from a well and the remaining 2.6% from springs, rivers, canals, tanks, ponds, lakes or other sources.

Varying local conditions call for locally feasible alternatives. In the tribal and hilly areas, where the population is scattered in small hamlets across vast areas, tailored solutions have many times been proposed by the communities themselves. These arrangements have varied from tapping spring water (when that source has been available) to developing gravity-based systems that operate without electricity, modifying standard pumps to suit local conditions, installing solar water pumps and hand pumps, building cluster storage systems and operating some 7527 mini pipe schemes.

During the 1980s, 38,426 hand pumps were installed, and 71,465 more during the following 10 years. From 2001 to 2012, more than 100,310 such devices were set up, almost as many as those installed in the previous two decades together. As a result of these efforts, 42.55% of households in the tribal areas now have connections (Gujarat Water Supply and Sewerage Board, 2013a, 2013b). Nationally, there is one hand pump for every 250–300 inhabitants. In Gujarat, there are currently 152,036 hand pumps in the tribal belt alone, each one serving around 41 persons (James, 2011). However, it is to be assessed how many of these hand pumps are actually functioning and how the installation of these devices is affecting groundwater levels. In many regions, pumps have broken down and been left unrepaired, instead being replaced by new ones. Each new hand pump adds to the maintenance bill the state has to foot, even when these investments do have positive development externalities in the benefited areas.

Water in adequate quantity and quality is one of the key drivers of public health. Improved water sources and water in adequate quantity generate important synergies in human development outcomes and outputs. Though water quality significantly deteriorated in 2000 and again in 2002–03, the Gujarat Jalseva Training Institute recorded a decrease in the number of villages facing problems due to excessive fluoride in 2011–12 (GJTI, 2013). The affected habitations totalled 1226, less than one-third of the 4341 dealing with these issues 10 years before; and 1215 settlements registered high levels of nitrate, compared to 1336 in 2000. Over the last decade, all these previously affected habitations and villages have been supplied with alternate and safe sources, as a result of which the health situation has improved substantially. The town of Ganeshpura, for example, recorded a fluoride concentration of 3.35 mg/L in February 1997, and when tested again in December 2010 this had fallen to 1.0 mg/L (Sim & Leong, 2011).

Water from the Narmada is good in quality and does not show any significant signs of bacteriological or chemical contamination. Since industrial development in the Narmada basin has been less intensive than in other major basins, the river faces fewer pollution problems even when discharge of untreated sewage is bound to degrade water quality (Banerjee, 2007). This suggests that areas incorporated into the grid and relying on water from this surface source are less likely to experience previously faced health problems due to high nitrate and fluoride concentrations. Moreover, water flowing from the Narmada River is considerably lower in total dissolved solids and salinity than most of the local groundwater sources upon which many villages and urban centres entirely relied before. In many Rural Regional Water Supply Schemes, water from local sources is blended with Narmada water to comply with drinking-water quality standards (Sharma, Dixit, Jain, Shah, & Vishwakarma, 2008, 2011). Key industrial players in the state have also acknowledged the good quality of water coming from the river. Industrial plants are able to use it without having to undertake major treatment processes (Adani Group, personal communication, 8 May 2013).

To reinforce and further all the progress already attained, the GWSSB has developed 156 filtration and treatment plants, with an aggregate daily capacity of 2.810 billion litres. This way, water is made potable at the distribution point in 10,937 villages. These plants use a series of effective technologies to tackle various quality problems, for example, filtration, sedimentation, reverse osmosis, aeration, chlorination, etc. Furthermore, when quality problems are too severe or are identified in very remote areas, reverse-osmosis plants are built as a last resort. The existing 278 facilities award priority attention to coastal and tribal areas and are for the community to build, own, operate and transfer (BOOT). With time, it is expected that local populations will develop the capacities to take full responsibility for the operation of the reverse-osmosis plants installed in their communities. Thanks to all these measures, households have reported ample health gains from enhanced access to safe water and the adoption of simple practices (for instance, chlorination) to assure that water is fit to drink (WASMO, 2013).

With 76.16% of villages chlorinating their water sources, common ailments have become less prevalent, especially amongst infants and children, who are usually the worst affected by outbreaks of water-borne diseases. Since the grid's first pipe was laid, the death rate by infectious and parasitic diseases in Gujarat has gradually dropped, from 17.3% in 2002 to 14.91% in 2011. In 2005, 470,675 cases of diarrhoea resulted in 15 deaths. By 2011, the number of cases had fallen to 367,450 and no deaths were reported (Commissioner of Health, Medical Services and Medical Education, 2013). At present, 12,030 ultraviolet plants and 550 reverse-osmosis installations are operating in schools around the state. By 2007–2009 more than 87% of schools in the state had drinking-water facilities (WASMO, 2013).

Healthier people incur lower medical costs; they also avoid the associated expenses of seeking treatment, buying drugs and commuting to the health care facilities, and the forgone time spent being ill and receiving care (Jain, 1996). Healthier children miss fewer days at school, contributing to the overall educational attainment Gujarat has seen in the last decade. Similarly, healthier adults do not interrupt their engagement in productive activities carried out in the household as well as in the formal and informal employment sectors. Even in the absence of detailed studies quantifying the impact of improved access to water on health and income in the state, it can be confidently stated that with such progress, household incomes have become less vulnerable to health shocks.

As taps reach Gujarat's villages and distribution works expand to reach their many households, the burden of fetching water and attending to rudimentary sanitation is greatly alleviated from women and girls (World Health Organisation, United Nations Children's Fund, 2010). In predominantly agrarian and pastoral communities, women and young girls sometimes have to walk up to 8 km and spend up to 3 hours everyday collecting water (Jhabvala & Bali, 1991; Vyas & Gupta, 2001). Access to water is thus a springboard to foster their development, education, health, income opportunities, empowerment and overall societal standing. Equally important, the institutionalized participation of women in community-level water management bodies, (*pani samitis*) has helped overcome the social barriers restricting their involvement in public and decision-making activities.

The long distances separating households from water sources also affect the time the female groups of a society have at their disposal to undertake any other activity and condition the volume of water they are able to secure on a given day. In Kachchh, Surendranagar and many of the tribal areas, this time frame may be considerably extended especially during the summer season, as local sources dry up and water has to be fetched from alternative and more distant places. In 2004, before the Narmada scheme had reached many areas in the state, women in the 'no water source' villages of Chodungri, Marvada and Gonguvada in North Gujarat sometimes had to walk more than 1 km to fetch water to fulfil domestic needs, an endeavour that occupied 3 to 4 hours every day (Upadhyay, 2004).

For girls, school attendance rates are highly sensitive to water availability and distance to water sources. With water available closer to every household and at an increasing number of schools, girls and boys face fewer impediments to attending school. In 1999–2000, the drop-out rate in elementary school (from I to V standard) in Gujarat stood at 20.83% for girls, 23.77% for boys and 22.3% in total. A decade later, census figures showed a considerable improvement in the completion of primary education. In 2010–11, the dropout rate was 2.11% for girls and 2.08% for boys. In 2001, 79.66% of males and 57.8% of females were literate, and the overall rate was recorded as 69.97%. Ten years later, the aggregate effect of macroeconomic growth in the state and the improvement of local conditions in its many villages has already had an encouraging impact on education and in narrowing the gender gap in school attendance and academic attainment. In 2011, 85.38% of men and 66.77% of women were literate, and total literacy reached 79.31% (Directorate of Economics and Statistics, 2012, 2013).

However, even with encouraging progress in educational attainment, women's participation in community activities is still limited by cultural barriers, traditionally lower literacy rates and the workload they are responsible for in both remunerated activities and domestic chores. Any constraints to their participation in community-based water management systems will compromise real representation, equity, effectiveness and affordability. Local bodies for water resources management have made targeted efforts to institutionalize the active involvement of women in decision-making and administrative activities. As of May 2013, more than 72,000 women have become pani samiti members, and they head these local bodies in 879 villages (WASMO, 2013).

The blue policy paths ahead

Water has come to mean one thing to Gujarat: a path to prosperity. It has become very important in maintaining and further enhancing the state's transformation. Its absence, on the other hand, has been equated with struggle, poverty, hardship, distress, and delays in socio-economic development. For decades, economic and industrial development in certain areas in Gujarat was severely constrained by insufficient water resources (Vyas & Gupta, 2001). Following a significant change in public policy, the state has now begun to capitalize on the large water-related investments that have been made in poorly endowed regions. It has also began to build upon the more generalized progress in poverty alleviation that has followed the surge of wide-spread availability of drinking water in the state.

In the past, notwithstanding the severity and frequency of water quantity and quality issues affecting Gujarat, policy measures remained mostly ad hoc, remedial, and oriented towards crisis management. Not even when naval vessels had to be ordered to ship 8 million litres of drinking water from Mumbai to Gujarat in 2000 were longer-term policies envisioned. At times of drought, local sources went dry, water extraction intensified, and tankers, trains and ships were dispatched to distribute water until the situation improved. As people migrated, quarrelled and struggled to protect their livelihoods, many communities dispersed and disintegrated. At the same time, deterioration of groundwater sources became a growing concern, but it was awarded little priority. Water security received negligible resources and attention and remained a side issue in the political agenda (Hirway, 2005; Hirway & Mahadevia, 2004)

In 2002, the government started to move away from the previous piecemeal and ad hoc policies and began to shape a resilient, durable and comprehensive approach to water management. Since then, large investment commitments in physical, social and managerial infrastructure have been poured into extending the network of the State-Wide Water Supply Grid, implementing the Sujalam Suphalam Project and supporting 450 regional schemes. These initiatives have now reached almost all water-stressed and water-quality-compromised habitations in both rural and urban areas. As sufficient and higher-quality drinking water is been made available throughout the year, especially in the critical summer months, health and hygiene conditions continue to improve, lagging regions catch up in terms of socio-economic development, and communities are brought together under, *pani samitis* to actively manage their water assets and requirements.

To realize the potential development spill-overs and externalities this project can bring to the state and its people, water authorities will have to strengthen their efforts beyond infrastructure creation and augmentation. The challenge ahead is to mobilize the physical, financial, human and social capital required to keep the grid's vast infrastructural network running efficiently. Beyond operation and maintenance needs, keeping Gujarat's water secure also calls for renewing and expanding partnerships with stakeholders that can support the government's efforts to continuously improve the water sector, strengthen data-collection systems, and take the necessary legislative steps to protect the existing structures from damage and unlawful use of the water they carry.

With time, the implementation of a sector-wide strategy will, make momentous strides to ward water security, improve the quantity and quality of water-supply services, extend water provision to uncovered habitations, strengthen and recharge local resources, and eventually deliver water-supply services 24/7. The construction of the State-Wide Water Supply Grid, however, represents a decisive step towards ensuring "sustainable water supply and sanitation services in the rural and urban areas to accomplish basic health and reach the hygiene levels leading to socio-economic development, peace and happiness in the society" (GWSSB inaugurated technical support unit, 2013).

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References

Banerjee, R. (2007). Review of water governance in the Narmada River basin. Water Governance Project, Background Papers. New Delhi.

Bunsha, D. (2006). Heights of intolerance. 23/11 Frontline 108.

Commissioner of Health, Medical Services and Medical Education. (2013). Registration of births and deaths act. Government of Gujarat (GoG). Retrieved from http://www.gujhealth.gov.in/vs-publications.htm

Dass, A. (2006). *Building upon the adaptive capacity to livelihood resilience in arid, semi arid and flood prone regions*. New Delhi: Winrock International India.

Debroy, B. (2013, August 6). Gujarat's data on social indicators shows positive impact of policies. Retrieved from http://blogs.economictimes.indiatimes.com/policypuzzles/entry/gujarat-s-data-on-social-indicators-shows-positive-impact-of-policies

Directorate of Economics and Statistics. (2012). Socio-economic review 2011–2012. Government of Gujarat, Gandhinagar.

Directorate of Economics and Statistics. (2013). Directorate of economics and statistics. Socio-economic Review 2012–2013. Government of Gujarat, Gandhinagar.

Gujarat Water Supply & Sewerage Board. (2003). Sardar Sarovar Canal Based Drinking Water Supply Master Plan. Water Supply Department, Government of Gujarat, Gandhinagar.

Gujarat Water Supply and Sewerage Board. (2013a). GWSSB, Government of Gujarat, Gandhinagar.

Gujarat Water Supply and Sewerage Board. (2013b). Background note for plan discussion, annual plan 2013–2014. Water Supply Department, Government of Gujarat, Gandhinagar.

Gupta, R. K. (2001). Human rights dimension of regional water transfer: Experience of the Sardar Sarovar project. *International Journal of Water Resources Development*, *17*, 125–147.

Gupta, R. K. (2004). Water governance in Gujarat state, India. *International Journal of Water Resources Development*, *20*, 131–147.

Gurajat Jalseva Training Institute (GJTI). (2013). Gujarat Water Supply & Sewerage Board, Government of Gujarat, Gandhingar.

Hirway, I. (2005). Ensuring drinking water to all: A study in Gujarat. *4th IWMI-TATA annual partners research meeting*. Anand: Institute of Rural Management.

Hirway, I., & Mahadevia, D. (2004). *Gujarat human development report*. Ahmedabad: Mahatma Gandhi Labour Institute.

Jain, D. (1996). Valuing work: Time as a measure. *Economic and Political Weekly*, *31*, 46–57.

James, A. J. (2011). *India: Lessons for rural water supply; assessing progress towards sustainable service delivery*. The Hague: IRC International Water and Sanitation Centre and Delhi.
Jhabvala, R., & Bali, N. (1991). *My family my work - a sociological study of SEWA's urban members*. Ahmedabad: SEWA Academy.
Joshi, M. B. (2009). Water for "GDP" or "HDI"?. The golden dilemma for Gujarat. Columbia Water Centre (CWC). Seminar on Water for Future - Issues & options.
Kumar, A. S. (1991). UNDP's human development index: A computation for Indian states. *Economic and Political Weekly*, *26*, 2343–2345.
Kumar, D. M., & Singh, O. P. (2001). Market instruments for demand management in the face of scarcity and overuse of water in Gujarat, Western India. *Water Policy*, *3*, 387–403.
Kumar, D. M., Jagadeesan, S., & Sivamohan, M. V. K. (2014). Positive externalities of irrigation from Sardar Sarovar project on farming enterprise and domestic water supplies. *International Journal of Water Resources Development*, *30*, 91–109. doi: 10.1080/07900627.2014.880228.
Ministry of Finance. (2011–12). Economic survey. *Union Budget & Economic Survey*. Government of India (GoI). Retrieved from http://indiabudget.nic.in/survey.asp
Narmada, Water Resources, Water Supply and Kalpasar Department (2013). Unpublished documents. Gandhinagar: Government of Gujarat.
Parul, C. (2006). Drought risk assessment using remote sensing and GIS: A case study of Gujarat (ME thesis). Indian Institute of Remote Sensing, Dehradun & International Institute for Geo-information & Earth Observation, The Netherlands.
Patel, P. P. (1997). *Ecoregions of Gujarat*. Vadodara: Gujarat Ecology Commission.
Planning Commission. (1990). 9th five year plan. Government of Gujarat, Gandhinagar.
Planning Commission. (2001). *National human development report, India*. Government of India.
Planning Commission. (2011). *National human development report, India*. Government of India.
Sandesh (2013, February 17). GWSSB inaugurated technical support unit to address summer water scarcity problems. Gujarat: Rajkot City.
Sardar Sarovar Narmada Nigam Ltd. (2012). The Sardar Sarovar project. Retrieved from http://www.sardarsarovardam.org/Client/ContentPage.aspx
Sardar Sarovar Narmada Nigam Ltd. (2013a). Components of the projects: Features of Narmada. *Main Canal*. Retrieved from http://www.sardarsarovardam.org/Client/ContentPage.aspx
Sardar Sarovar Narmada Nigam Ltd. (2013b). Narmada - the lifeline of Gujarat, project at a glance. Retrieved from http://www.sardarsarovardam.org/Client/Index.aspx
Sharma, S., Dixit, S., Jain, P., Shah, K. W., & Vishwakarma, R. (2008). Statistical evaluation of hydrobiological parameters of Narmada River water at Hoshangabad city, India. *Environmental Monitoring and Assessment*, *143*, 195–202.
Sharma, S., Dixit, S., Jain, P., Shah, K. W., & Vishwakarma, R. (2011). Evaluation of water quality of Narmada river with reference to physico-chemical parameters at Hoshangabad city, MP, India. *Evaluation*, *1*, 40–48.
Sim, J. M., & Leong, K. M. (2011). Feasibility study on fluoride removal in drinking water in Mehsana, India. *International NGO Journal*, *6*, 224–228.
Singh, M. (2013). Statewide drinking Water Supply Grid: An efficient water management. Water Supply Department Government of Gujarat. Gujarat Water Supply & Sewerage Board. Presentation for India's Water Week, 2013, Delhi.
United Nations Development Programme (UNDP). (2006). *Human development report: Beyond scarcity: Power, poverty and the global water crisis*. New York, NY: UNDP.
Upadhyay, B. (2004). *Gender roles and multiple uses of water in North Gujarat* Working paper 70. Colombo: International Water Management Institute.
Vyas, J. N., & Gupta, R. K. (2001). Editorial. *International Journal of Water Resources Development*, *17*, 5–8.
World Health Organisation, United Nations Children's Fund. (2010). *Progress on sanitation and drinking-water, 2010 update*. Geneva: World Health Organization.