The role of water technology in development: a case study of Gujarat State, India

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Type of tool: technology
Location: Gujarat State, India

Introduction

This article traces the historical water problem in Gujarat both for drinking and irrigation that affected the development of the State, caused regional imbalances and increased incidence of rural poverty. Technological initiatives like the State Wide Water Grid, Micro Water Harvesting, Inter-Basin Transfer of Water and Power Sector Reforms have changed the entire water scenario in the State. There has been a great deal of emphasis on peoples' participation in water governance as well.

Water challenges in Gujarat

Gujarat has just 2.28% of India's water resources and 6.39% of country's geographical area. This is again constrained by imbalances in intra-state distribution. The State has an average annual rainfall of 80 cm with a high coefficient of variance over time and space and as a result droughts have been frequent. Out of 185 rivers, the State has only eight perennial rivers and all of them are located in southern part. Around 80% of the State's surface water resources are concentrated in central and southern Gujarat, whereas the remaining three-quarters of the State has only 20%. On average, three years in a cycle of 10 years have been drought years. Since Indian independence in 1947, the drought years of Gujarat have been as follows: 1951, 1952, 1955, 1956, 1957, 1962, 1963, 1965, 1968, 1969, 1972, 1974, 1980, 1985, 1986, 1987, 1991, 1999, 2000 and 2003 (Gupta, 2004).

Before the year 2001, drinking water scarcity posed a serious threat to human and cattle populations in Gujarat. Governments had to spend billions of rupees on temporary measures to supply drinking water by road tankers and sometimes even through special water trains. The State, which generally had a track record of peace and harmonious social ethos, even witnessed 'water riots' due to severe water scarcity compounded by poor water resources management.

Over drafting of ground water (as compared to annual recharge) caused serious water quality problems due to excessive fluoride, nitrate and salinity. The number of fluoride affected habitations increased from 2,826 in the year 1992 to 4,187 by the year 2003. The fluoride concentration in these villages ranged from 1.5 mg/litre to as high as 18.90 mg/litre. Fluoride has been the cause of extensive health damages in many parts of Gujarat. Dental fluorosis causes permanent pigmentation of teeth in children and bone deformities are caused by skeletal fluorosis even in adults. Other serious problems experienced due to high concentration of fluoride have been aneamia, loss of appetite, nausea and thyroid malfunction which sometimes results in brain impairment of children and adverse impact on foetus, in some cases causing abortion or stillbirth in expectant mothers.

The water problem also led to intra-state migration from drought prone regions like Saurashtra and Kutch (Western & South Western Gujarat) to the Central and South regions of the State. Often this migration of people was accompanied by the migration of livestock population and also caused the shift of prime workforce of hundreds of thousands of people, dislocating them economically, socially and culturally. Therefore, the regional imbalances in Gujarat were accentuated because of increasing water scarcity (Gupta, 2003).

Earlier most of the drinking water supply was based on ground water for which deep tubewells with high capacity pumping machinery were being utilised in the State, leading to tremendous electricity consumption and high carbon footprints of water supply.

Technological initiative for drought proofing

During last one decade the State drew up an ambitious strategy for creating a '*State Wide Drinking Water Grid*' for bulk water transmission from sustainable surface water resources to water scarce and poor water quality habitations. Large scale infrastructure has been created which includes 1,987 km of bulk pipelines and more than 115,058 km of distribution pipelines. 10,781 hydraulic structures like elevated storage reservoirs with a total capacity of 1,164 million litres and 10,683 storage sumps and high ground level reservoirs with a capacity of 2,504.80 million litres have also been constructed in the State. Along with this 151 water filtration and treatment plants with a total capacity of 2,750 million litres per day (MLD) have been constructed. About 2,250 MLD of treated water is delivered to more than 10501 villages and 127 towns in the State, ensuring safe and assured water supply to about 65% of State's population in draught prone and water quality affected areas through the water supply grid.

Evaluation of the technical initiative for drought proofing

This major technological initiative has not only largely solved the drinking water problem but has also made a significant impact on water quality problems faced earlier.

Reduction in fluoride

All these efforts have resulted in considerable relief from the problem of excessive fluoride contamination. As per a recent survey, only 987 habitations have been found to be affected and the range of fluoride content has also been reduced considerably.

Table 1. Status of fluoride affected habitations

District	No. of Total Habitations	As per 2003 survey	As per recent survey	Maximum Fluoride level (PPM)
Ahmedabad	727	120	20	7.20
Gandhinagar	424	132	2	6.27
Patan	651	246	43	13.25
Mehsana	851	176	2	4.40
Sabarkantha	2438	531	9	6.93
Banaskantha	1736	521	20	5.75
Surendranagar	696	205	72	8.72
Rajkot	871	126	120	5.40
Jamnagar	756	52	5	2.00
Junagadh	925	76	48	2.80
Porbandar	184	46	0	3.70
Bhavnagar	804	108	66	6.40
Amreli	650	49	146	3.20
Kutch	1126	34	6	3.20
Vadodara	2187	438	189	5.81
Narmada	722	49	0	2.60
Kheda	2101	406	52	10.03
Anand	920	96	17	5.89
Panchmahals	2531	401	86	6.40
Dahod	3168	286	0	12.50
Surat	3258	44	29	2.20
Bharuch	790	21	30	4.00
Valsad	3923	2	25	1.79
Navsari	2080	22	0	--
Dangs	326	0	0	--
Total	34845	4187	987	

Source: Gujarat Water Supply and Sewerage Board, 2009

Less expenditure

This has also resulted in sharp decline in expenditure on tanker water supply in the State from 2003-04 onwards which is another indicator of creation of water security in the State.

Table 2. Annual expenditure on tanker supply from 1990 to 2009

Year	Village	Cost (Rs. in Million)*
1990-91	896	23.40
1991-92	1,943	92.90
1992-93	700	14.00
1993-94	1,803	83.00
1994-95	724	24.96
1995-96	1,619	96.30
1996-97	1,642	123.95
1997-98	1,447	62.19
1998-99	1,215	41.02
1999-2000	2,987	346.20
2000-2001	4,054	436.94
2001-2002	2,959	348.11
2002-2003	3,961	475.36
Sub-total		**2,168.06**
2003-2004	600	47.38
2004-2005	869	92.32
2005-2006	398	77.06
2006-2007	207	17.08
2007-2008	188	14.17
2008-2009	326	13.94
Sub-total		**261.95**
Total		**2,430.01**

Source: Gujarat Water Supply and Sewerage Board, 2009 * 1 US $ ≈ Rs.46

Reduction in carbon footprints in water supply

In several villages, the borewells are now utilised as a dual source and the operational hours have been reduced. Based on a random survey, it has been observed that a significant saving has been achieved in electricity consumption that is now available for alternative uses, proving to be an eco-friendly achievement. Solar pumps have also been commissioned in 260 villages in the State and about 200 more solar pumping systems will be installed in the near future. In various parts of the State, including coastal and tribal areas, roof top rainwater harvesting structures have also been taken up in public buildings, schools and individual household level, which is also resulting in substantial electricity savings. Comprehensive energy audits for various group water supply schemes have also resulted in energy savings.

Table 3. Emission savings in drinking water supply

Sr. No.	Particulars	Energy Saving MWh per annum	Equivalent Carbon Dioxide Emission per annum in tones
1.	Piped water supply to villages and towns	65,905.00	14,696.82
2.	Savings due to energy audit	5,184.78	1,156.21
3	Solar based pumping systems	611.16	136.29
4	Rooftop rain water harvesting	386.74	86.24
	Total	72,087.68	16,076.14

Source: Gujarat Water Supply and Sewerage Board, 2009

Paradigm shift

With a paradigm shift from dependence on drinking water supply by tankers, trains and deep bore wells to safe surface water, much of the fluoride affected habitation have been covered by piped water supply.

Technological interventions like defluoridation through reverse osmosis have also been taken up in some villages. In the remaining villages safe water sources have been identified or created and are being used for drinking water purpose. Thus, a 'vicious circle' has been transformed into a 'virtuous cycle' with a win-win situation for water, energy, environment and health sectors and with considerable economic benefits. In short, this is Gujarat's technology oriented response to the existing and future water stress and insecurity due to climate change.

New water governance model

The creation of the Water and Sanitation Management Organisation (WASMO) was a significant shift in the role of governance from provider to facilitator by empowering village level institutions through extensive capacity building and pro-active facilitation. Since its inception, WASMO has brought about effective citizens' engagement through its innovative governance model for facilitating the successful community led water supply programme throughout the State of Gujarat. Now more than 16,740 Village Water and Sanitation Committees have been formed in the State and are ready to take the responsibility for managing of service delivery and water resources at the decentralised level. More than 6,500 villages have already commissioned the infrastructure and water conservation projects in a demand driven mode. Another 4,547 villages are presently implementing the decentralised community managed rural water supply programme in their villages with a strong sense of ownership.

WASMO's strength lies in its organisational professionalism, innovations in governance, and strong partnerships with about 48 civil society organisations. The rural community is the central focus of WASMO's decentralised approach. Its innovation has led to the scaling up of reform processes to cover the entire State. Its professionals have created an enabling environment which has resulted in the community being fully empowered to take ownership of their water service delivery wherein operation and maintenance is done through tariff mechanism devised by consensus in the village assembly. It has also been able to institutionalise the rural water quality monitoring and surveillance programme. The majority of villages are now able to monitor their water quality teams which are duly trained. WASMO's innovation by Gujarat has emerged as a model for learning and exchange, influencing policy initiatives in the water sector at the country level. WASMO has also been given the United Nations Public Service Award in the category of fostering participation in policy-making decisions through innovative mechanisms (Modi, 2010).

Inter-basin water transfer through Sardar Sarovar Project

The Sardar Sarovar Project on river Narmada is a multi-State, multi-purpose river valley Project, borne out of deliberations of a constitutional body, following the principles of ‘Equality of Right’ and ‘Equitable Utilisation’ of the whole course of an Inter-State River. This unique project will irrigate 1.905 M ha of land, increase the agricultural production by 8.7 million tons per annum (worth US $ 430 million), generate environment friendly hydropower with installed capacity of 1,450 MW, supply drinking water to 8,215 villages and 135 urban centres of Gujarat (around 20 million population), generate 1 million jobs (mostly in rural areas), and prevent rapid processes of desertification, salinity ingress and rural to urban migration being experienced in many parts of Gujarat. The command area and drinking water supply areas of the project are exactly the worst water scarcity-hit areas of the State (Gupta, 2003).

Table 4. Sardar Sarovar Dam height and storage increase in the Sardar Sarovar Project

Stage	2003	2004	2006	Ultimate
Height	100 m	110.64 m	121.92 m	138.68 m
Gross storage	2,602.6 MCM (3.00MAF)	3,700 MCM (3.00 MAF)	5,265.8 MCM (4.27 MAF)	9,460 MCM (7.7 MAF)
Live (usable) Storage	_ _	_ _	1,565.8 MCM (1.27 MAF)	5,800 MCM (4.77 MAF)

Source: Sardar Sarovar Narmada Nigam Limited 2009

Increased dam height and storage

With a concerted strategy and satisfactory compliance of the project obligations in terms of rehabilitation of project affected persons and environmental measures, the dam height was raised to 100m in 2003, 110.64m in 2004 and 121.92m in 2006. This facilitated a much higher increase in storage of Narmada waters.

Raising the dam height and the corresponding increase in the storage capacity have significantly improved the water supply. The real benefits of the project which were awaited for almost 15 years have now started flowing. Diversion of Narmada water to the main canal of the project (world's largest lined irrigation canal) was just 705 MCM in the year 2001, but it spectacularly increased to 5,195 in 2003 and to 6,194 MCM in 2004. Although the water flow has been decreased in subsequent years due to consecutive good monsoons, it remained to the extent of 4,201 MCM in 2005, 4,292 MCM in 2008 and 5,870 MCM in 2008 and 5,870 MCM in 2009. The construction of the main canal was also completed in the year 2008 and water supplies to neighbouring State – Rajasthan – were initiated in March 2008, fulfilling real objective of this project as an Inter-State River Project.

Not only this, with the command area being covered to the extent of around 500,000 ha, significant interlinking has been achieved in many rivers by the interbasin transfer of Narmada waters using the Sardar Sarovar Canal Network.

Hydro Power

Another long pending issue was that of operationalising the 250 MW Canal Head Power House (for want of required water head in the reservoir). We operationalised this power house in August 2004, and thereafter a river bed power house of 1,200 MW capacity was also put into operation in a phased manner starting from February 2005 to June 2006. The hydropower generation that commenced in the Sardar Saroval Project since August 2004 has resulted in the generation of 15,070 million kWh of electricity up until March 2010.

Micro Water Harvesting

The miseries of millions of small and marginal farmers due to vagaries of nature and difficult terrains have been reduced through rainwater harvesting by micro irrigation structures implemented through people’s participation.

Sardar Patel Participatory Conservation Project (SPPWCP)

This scheme stipulated that checkdams and village tanks/ponds could be taken up for construction by a beneficiary group or any Non-Governmental Organisation (NGO) with technical and financial assistance from the District Panchayat (local representative body). They were initially required to contribute 40% of the estimated costs (later reduced to 10%) and the rest was to be funded by the Government depending upon the progress of the work. In 2007 they were also given the option of contributing their 10% by way of physical labour and, therefore, increasing their sense of belonging to the project by 'the gospel of dirty hands'. Six prototype designs were circulated with a maximum cost of Rs. 1,000,000.

However, the beneficiary groups were also given the latitude to take up the work as per their own design if necessary and feasible. The technical scrutiny and work supervision would be done by the engineers of local body. The entire responsibility of the quality of construction of work, however, would rest with the beneficiary group/NGO under continuous guidance and technical inputs from the Government technical staff. Maintenance works for these micro water harvesting structures would be carried out by the beneficiary group at their own expense. A total of 353,937 checkdams and village ponds/tanks have been created in the last eight years providing direct benefit to over 13 million people in rural Gujarat.

Drip irrigation - Gujarat Green Revolution Company Limited

Gujarat has created the Gujarat Green Revolution Company Ltd, a special purpose vehicle to popularise the adoption of drip irrigation among farmers. GGRC offers attractive subsidy-loans to adopters, but more importantly, it has fast-tracked and simplified the administrative procedures for accessing these. Farmers contribute only 5% of the cost initially; GGRC provides a 50% subsidy and helps arrange a loan for the 45% balance. Around 100,000 ha are covered by drip irrigation, and most of these have been moved to high-value crops (Gulati, 2009). It has been estimated that around 74.1 million kWh energy has been saved in just one year due to the adoption of drip irrigation by Gujarat Green Revolution Company – a body especially created for the purpose.

Jyotigram Scheme (technological initiative in power sector for irrigation needs)

Like elsewhere in India, unreliable farm power supply in Gujarat had been anathema for farmers as well as rural society as a whole. Uncontrolled farm power subsidies led to unsustainable increase in ground water withdrawals and left the Gujarat Electricity Board nearly bankrupt. To control farm power subsidies the government began to reduce the hours of three phase power supply used by tubewell owners while providing 24 hours single/two phase supply sufficient for domestic users. In response, farmers in many parts began using capacitor to run heavy motor-pumps on two-phase or even single phase power. This resulted in poor power supply environment in rural areas.

International donors and power sector professionals advocated metering of tubewells and consumption-linked charging for farm power. However, for a variety of reasons, farmers strongly resisted metering. Researchers had advocated a second best policy of intelligent rationing of farm power supply by separating feeders supplying power to tubewells. In 2003 the Gujarat government implemented the Jyotigram Scheme (JGS – the 'lighted village' scheme), which incorporated the core ideas of the second best strategy of intelligent rationing. Jyotigram's aim was to provide three phase power supply to Gujarat's 18,000 odd villages; but this could be done only if effective rationing was imposed on farmers. During 2002-2006 around US $260 million were spent on the project, to ensure 24 hour, three-phase power supply for domestic and commercial uses in schools, hospitals etc. and eight hours a day, three-phase full voltage power supply for agriculture, i.e. continuous and full voltage power especially for agriculture at predictable timings for villages across Gujarat. By 2007/08, all the 18,066 villages were covered under JGS. With this, Gujarat has become the first State in the country where villages get three-phase power supply, and farmers get three-phase, uninterrupted power supply at 430-440 voltage for eight hours according to a strict, pre-announced schedule.

Jyotigram pioneered real-time co-management of electricity and groundwater for agriculture, found nowhere else in the world. Farmers were also happy that they were spared the very high repair and maintenance cost that poor power supply imposed on them. Moreover most farmers welcomed Jyotigram for limiting competitive pumping of water and addressing the common property externality inherent in groundwater irrigation. Ground water and power rationing through the Jyotigram scheme not only increased efficiency of water and power utilisation for agriculture, but also freed up these resources for the rural nonfarm economy to grow.

Higher access to water not only had a land augmenting effect, but also allowed for multi cropping and growth of high value fruits and vegetables like mango and banana (that require much water). More water has also been available for livestock, animal husbandry and fisheries, which are significant sectors in Gujarat's economy.

Evaluation of technological initiatives: economic, environmental and social benefits

There have been wide ranging impacts of both large scale water management and micro water harvesting in improving ecology of other rivers, reversing the trend of depleting water tables and generating tremendous growth in agricultural production.

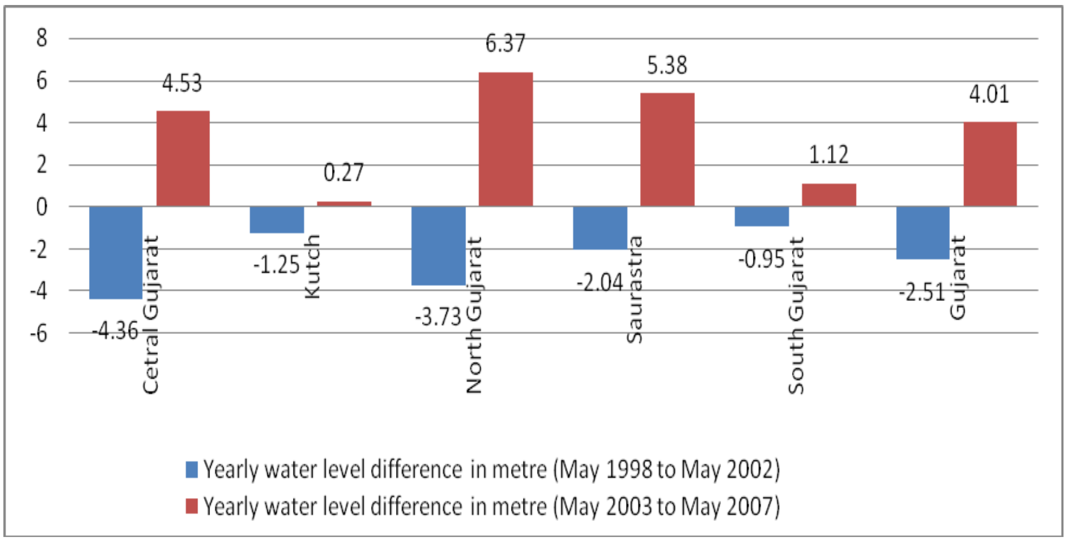
Greening of other rivers

Narmada water has been released in the dry beds of Heran, Orsang, Karad, Dhadhar, Mahi, Saidak, Mohar, Shedhi, Watrak, Meshwo, Khari, Sabarmati and Saraswati rivers. The ecology and water quality of these rivers have drastically improved over the last couple of years. In addition to minor rivers, around 700 village tanks have also been filled-up with Narmada water as part of drought management measures, which has substantially improved the water availability for irrigation in these villages.

Increasing water tables

The average depletion of water levels in north Gujarat before the launch of this massive programme was around 3m per year, which by now would have cumulatively declined almost 20-26m – leading to a sharp rise in electric consumption for withdrawal of ground water. But there has been a reported average water level rise of about 4m during recent years.

Figure 1. Ground water level fall/rise (in metres)



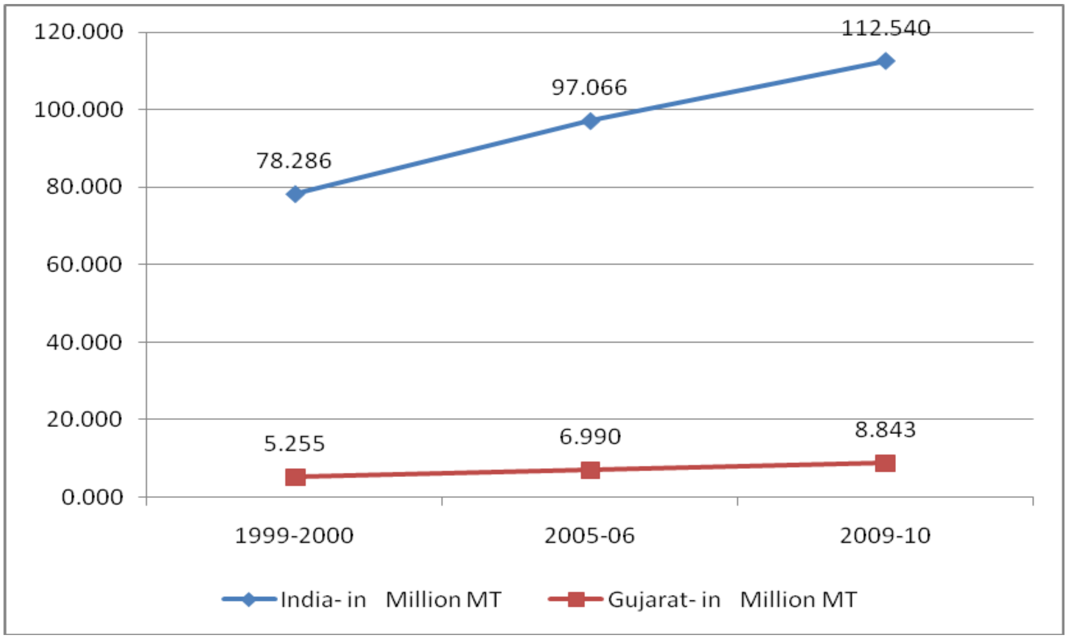
Source: Narmada, Water Resources, Water Supply and Kalpsar Department, 2009

Boost to the rural economy

Myriads of micro water harvesting structures dotting the landscape of Gujarat have led to the reduction in soil moisture evaporation in the surrounding agricultural fields and have facilitated the creation of orchards in places which barely used to produce single rain fed crops. Employment opportunities have been created for local residents, agricultural production has been enhanced, leading to rise in household incomes. The living standards and the average productivity of milch cattle has also gone up due to year-around availability of fodder.

The average annual growth rate of milk production of the State during last decade has been recorded as 6.83% whereas the same of entire country has been 4.38%.

Figure 2. Comparative growth of milk production in the last ten years



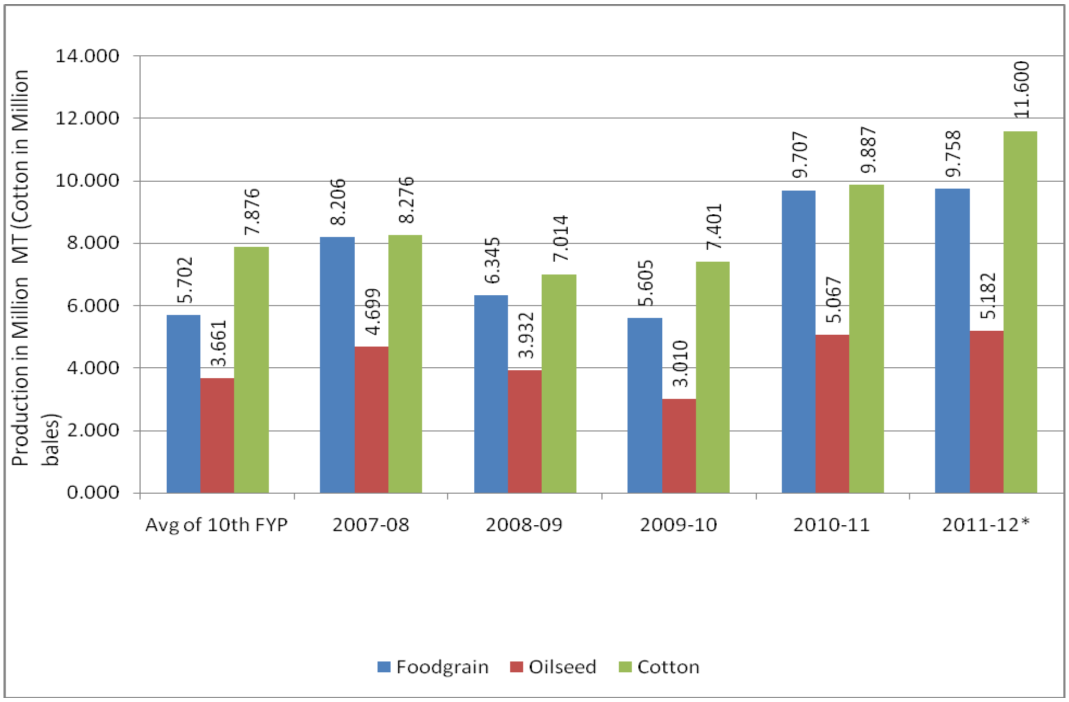
Source: Directorate of Animal Husbandry, 2010

This is in turn has bolstered the rural economy of Gujarat, particularly for the 4.2 million families of the State who rear animals for their livelihood.

Outstanding performance in agriculture

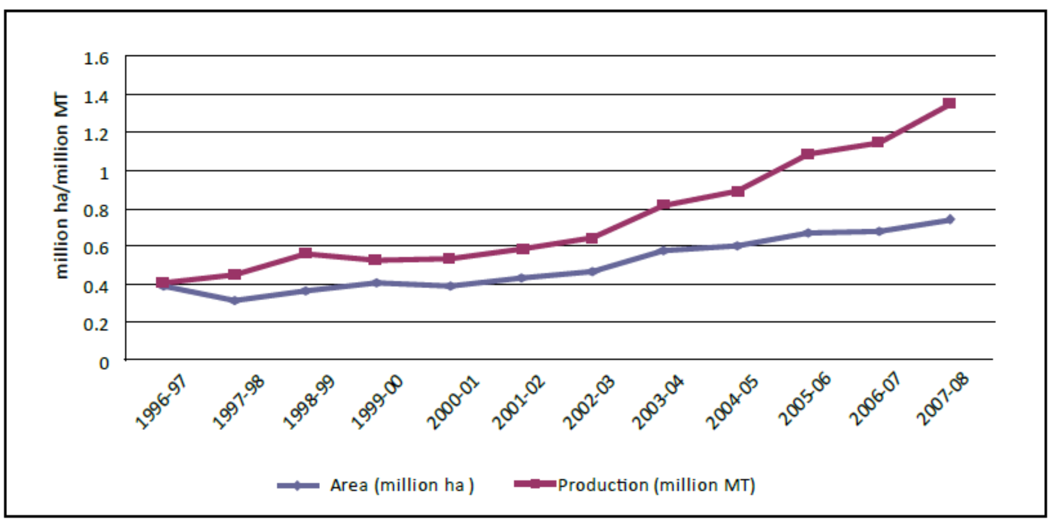
The cumulative effect of all these innovative technological and participative water management initiatives has been an increase in productivity of the major crops of the State, despite 0.1^0 to 0.9^o average increase in temperatures recorded at various locations during the last couple of years. As compared to other States in India, Gujarat is an outstanding performer in agriculture, growing at the rate of 9.6% per annum. Though there is high volatility in the agricultural growth rate for almost all States in India, performance of Gujarat's agriculture is more than thrice the figure for the whole of India. The International Food Policy Research Institute, in a 2009 document, has especially commended Gujarat’s recent growth in cotton, fruits, vegetables and wheat production.

Figure 3. Agriculture production scenario



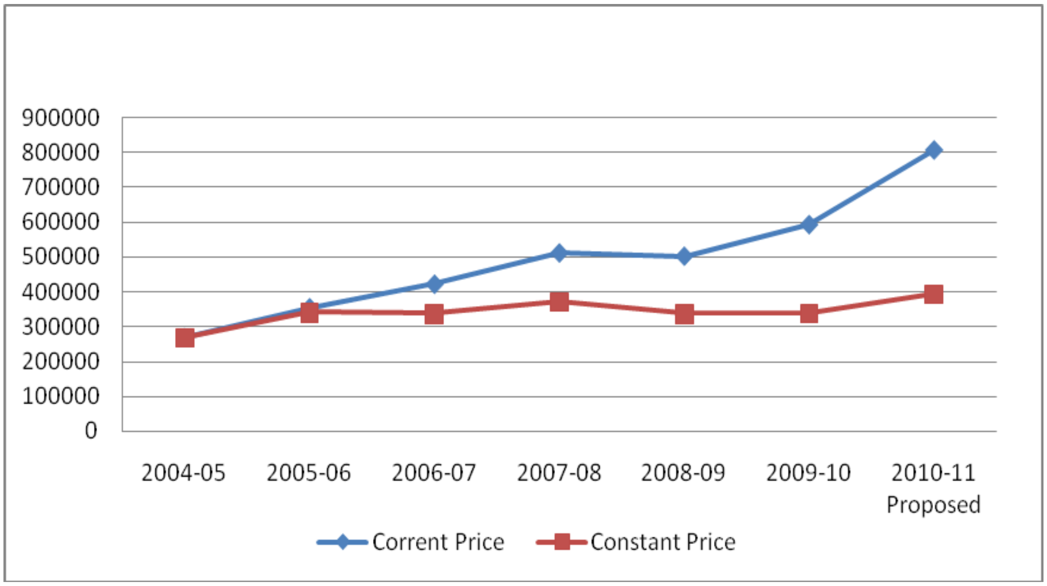
*Data of 2011-12 is provisional
Source: Agriculture and Cooperation Department, 2011

Figure 4. Area and production under total fruits and vegetables in Gujarat (Area in Million ha, Production in Million MT)



Source: Directorate of Horticulture, 2011

Figure 5. Growth in agriculture income (Rs in Million)



Source: Agriculture and Cooperation Department, 2011

Conclusion

The most important lesson that emerges out of the foregoing discussion is that technological initiatives to improve the drinking and irrigation water supply have to be duly complimented by grassroots people's participation in management of water distribution. The decentralised community managed water supply programme in Gujarat has proved to be an emulative model for the entire country. Another very significant lesson is the balanced importance that has been given to both micro-water harvesting and large water resources development projects, leading to unprecedented agricultural growth in the State. Increased water availability and reduction in consumption of conventional power has also led to a reduction in the carbon footprint of water supply, further promoting the development of a low carbon economy in the State.

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