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## Exploding Some Myths

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# GUJARAT'S AGRICULTURAL GROWTH STORY:
## Exploding Some Myths

**M. Dinesh Kumar, A. Narayanamoorthy, OP Singh, MVK Sivamohan, Manoj Sharma and Nitin Bassi**[1]

**Abstract**

*The agricultural 'growth' seen in the recent past in Gujarat is nothing but a good recovery from a major dip in production occurred during the drought years of 1999 and 2000, because of four consecutive years of successful monsoon and bulk water transfer through the Sardar Sarovar project. The real 'miracle growth' in Gujarat's agriculture appears to have occurred during the period from 1988 to 1998. The analyses presented in this paper provide important lessons for water management in other semi arid and arid regions of the country, not only because of their implications for agricultural production, but also their positive linkage with advancements in human development and economic growth.*

### GUJARAT'S AGRICULTURAL GROWTH STORY

The poor growth in agriculture in the recent years has been a matter of grave concern for the policy makers in India (Planning Commission, 2008; Bhalla and Singh, 2009). The blame has been on poor natural resource conservation policies; poor design of subsidies; inadequate investments in irrigation; inefficient pricing of water, electricity and other inputs for crop production; poor agricultural pricing policies, and regulations such as ban on inter-state trading of crops, particularly the cereals. But, least has been written about how poor management of water economy is causing long term effects on Indian agriculture, particularly in regions which are historically agriculturally prosperous.

In this backdrop, Gujarat's agriculture sector has been in the focus for the 'high growth' it has recorded in the early years of the new millennium (see Gulati et al., 2009; Shah et al., 2009). The state has clocked an impressive growth rate of 9.6% in the sector. The key state interventions, which have potential implications for agriculture in the state, are as follows: improved quality of power supply in agriculture; large-scale water transfers from land scarce and water-abundant south Gujarat to land rich & water-scarce north Gujarat; decision to meter new agro wells; setting up of the Gujarat Green Revolution Company for promote micro irrigation adoption; and decentralized water harvesting.

But, some researchers have attributed this phenomenal growth to selected policies adopted by the state in water and electricity sector. For instance, the most recent article by Shah et al. (2009) argued that agricultural growth in the state has mainly come from three factors: increase in gross cropped area (GCA); increase in productivity (yield per ha); and increase in farm gate price. They further argued on the basis of very limited data for a short time period of 7 years that north Gujarat, Saurashtra and Kachchh have mainly contributed to the GCA expansion. They assessed that the irrigated areas of Saurashtra, Kachchh and north Gujarat generate much higher wealth as compared to the canal irrigated areas of south Gujarat from every unit of water used for crop production.

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This was attributed to the presence of many lacs of small water harvesting structures, which are claimed to have been built through community mobilization in these regions, and which provided 'supplementary irrigation' to crops; and a highly productive well irrigation, which was supported by an 8-hour un-interrupted power supply to farmers under a new scheme called 'Jyotigram Yojna'. Some others have shown that in the post liberalization period (1990-93 to 2003-06), agricultural growth in Gujarat has been higher than in the pre liberalization period, while in the country as a whole it decelerated (Bhalla and Singh, 2009).

One needs critically examine into this 'growth story'. Such an exercise can provide clues on framing agricultural policies for the country as a whole, given the fact that Gujarat is a 'microcosm' of India because it displays significant regional differences in socio-economic conditions, the agro-ecology (soils, climate and topography), the water resources endowment, and the condition of rural infrastructure. We begin with the proposition that 5-6 year duration is too short a time frame for one to make any assessment of agricultural growth in a state like Gujarat, which has a highly fragile agro-ecological systems; and that the real miracle growth had occurred in the previous decade (from 1988 to 1998), and that the impressive growth displayed recently is nothing more than a recovery of the sector after a major dip in outputs owing to severe droughts.

This paper attempts a reality check on the 'miracle growth' in Gujarat's agricultural production by looking at the gross value of the outputs from agriculture over a reasonably long period of time. Subsequently, the key sub sectors which have contributed to this growth are identified; and the trends in cropped area, yield and total production are systematically examined. Further, the factors which might have actually changed the agriculture growth scenario in the state are identified. In order to identify this, the factors which have the potential to be the drivers of agricultural output growth in the region are identified, on the basis of the physical, socio-economic, environmental, institutional, and policy contexts. In other words, an assessment of the real constraints to agriculture growth is made. The paper also examines how these constraints have been overcome over a period of time.

## AGRICULTURAL GROWTH: SOME THEORETICAL PERSPECTIVES

Agricultural growth in any region can occur because of: 1] growth in crop output; 2] increase in value of the given output; 3] diversification of agriculture towards high valued crops and livestock products (Bhalla and Singh, 2009). Here, the growth in output can result from two major phenomena. First, the output of a crop can increase due to a variety of reasons, including crop technology adoption, irrigation supplement to rain-fed crop, precision irrigation, availability of adequate soil moisture due to rains and better soil nutrient management; or increase in area under the given crop. Second, the value of the given output in the market can increase due to changes in demand-supply situation, which is particularly important in the case of non-cereal crops and perishable products such as fruits and vegetables, and where the sufficient infrastructure for storage is either absent or economically unviable. Third, the farmers can shift to high valued crops or livestock, which give higher returns from unit of land and unit of livestock, respectively. Such a shift can be often subject to high crop risk or market risk (Kumar and Amarasinghe, 2009). But, availability of good credit facilities, marketing infrastructure, research and extension services and technical inputs can faster this process.

Hence, several factors can drive agricultural growth, those factors are related to environment; institutions market (Bhalla and Singh, 2009; Gulati et al., 2002); policy factors; infrastructural factors (Bhalla and Singh, 2009; Shah et al., 2009); and science/technology (Bhalla and Singh, 2009). Some of the environmental factors here are: the availability or failure of rains and snow, changes in atmospheric temperature, humidity, wind speed and sunshine (exogenous) and changes in soil moisture regime and soil nutrient regime (endogenous). The infrastructure related factors are: the presence of irrigation facility, presence of roads for transport, presence of storage and market infrastructure, precision irrigation technology. That said, it is important to consider that creation of both irrigation infrastructure (wells, reservoirs (both small & large), canals, pumps) and installation of precision water application technologies will have their effect, only if the resource availability situation is good or does not get altered. In the face of resource depletion (like reduced inflows into irrigation reservoirs or groundwater depletion, showing up in declining well yields, the potential benefits of extended irrigation infrastructure in the form of expansion in irrigated area cannot be derived. The input price policy can be one which encourages efficient use or one which encourages wasteful use of input resources such as water, fertilizers and pesticides. For the first one to happen, the price has to be raised to reflect the value of the resource, and for the second one, the price has to be lowered or input subsidy is raised. While the positive impact of first one will be both long term and short term (Pearce and Warford, 1993) that of the second one will be short term. Conversely, the negative effects of the first measure, if any, would be rather short lived, and that of second measure would be long term. The best example is electricity pricing for groundwater pumping.

Institutional factors such as property rights in land and water will have long term impacts on the equity and efficiency and sustainability of resource use (Pearce and Warford, 1993; Tobani, 1997), here use of land and water. Similarly, good extension services will have both short and long term impacts on yield, by encouraging farmers to adopt better crop varieties, or better input use technologies or better agronomic practices. Produce price regulations, particularly through enforcement of minimum support prices, will have significant impact on allocation of land for a particular crop (Bhalla and Singh, 2009). Also, agricultural trade can have severe effects on the market value of crops, which the trade affects. But, in the long run, the volume of production of that crop itself can change. In which direction the change takes place depends on whether the trade policy encourages import or export of the commodity in question, and the comparative advantage of the region in question in terms of producing that crop.

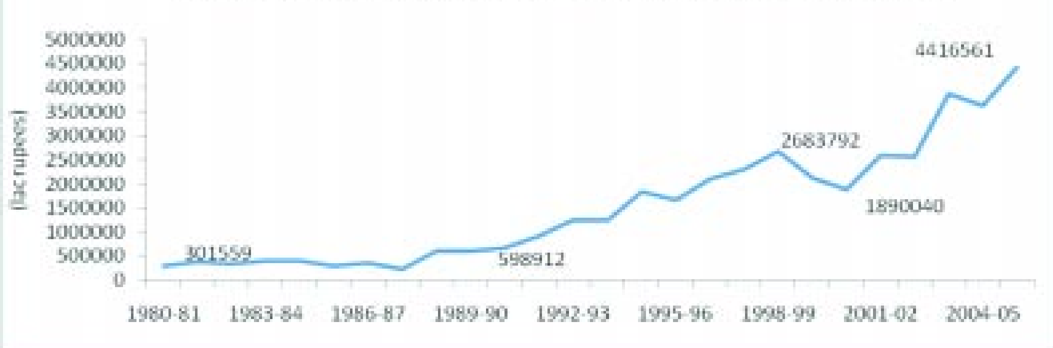
Lastly, the science & technology can have far reaching consequences, and can often overcome the constraints induced by the environmental factors. This has been adequately demonstrated in India, which experienced the impacts of high yielding varieties of major cereal crops, brought in by the Green Revolution. Introduction of a new high yielding variety or a drought resistant variety can have both short-term and long-terms effects on crop productivity, depending on the environmental factors. In a region which is highly vulnerable to droughts, a drought-resistant variety of a dominant crop will have significant impact on both the area under the crop and the yield of the crop, if significant drought proofing measures are not in place. But, in the face of deteriorating soil quality (or primary productivity of soils), the potential benefits from high yielding varieties cannot be derived. This is called "technology fatigue".

The drivers of growth in agricultural could be too many, and the final outcome of introduction of these drivers would be a result of the interplay of different drivers. A policy to boost groundwater irrigation will be make the desired effects on irrigated area, unless sufficient groundwater is available for exploitation or sufficient arable land is available for expansion of cropped area. To sum up, it would be meaningless to make linear or even unidirectional projections of the impacts of one set of interventions, be it policy related, institutional, market, technology related or infrastructure related, without knowing the interactions amongst various actors.

## GUJARAT'S GROWTH: LONG TERM OR SHORT TERM?

Gujarat witnessed one of the worst droughts of the last century for three consecutive years from 1985 to 87 (Bhatia, 1992). Drinking water had to be transported to Rajkot by train, the cost of which was more than the cost of desalination of seawater at that point of time. It is also known that the state witnessed another severe drought for two years from 1999 to 2000. A graphical representation of the value of agricultural outputs in Gujarat for the period from 1980-81 to 2005-06 is given in Figure 1. It can be seen that during these years, as data on value of agricultural output from the state shows, the agricultural outputs fell remarkably. The fall was to the tune of 56 per cent from 1984 to 1987, and 30 per cent from 1998 to 2000. The effect of 1987 drought will be for the crop year of 1987-88 and that of 2000 will be for the crop year of 2000-01. Hence any growth projections which consider these years (i.e., 1987-88 and 2000-01) as the base year can give a misleading picture of the growth scenario.
In order to study the agricultural growth in Gujarat, the data for 11 years from 1988-89 (corresponding to the good rainfall year of 1988) to 1998-99 are taken. This was compared against the growth figures for the period from 1998-99 (corresponding to the normal year of 1998) to 2005-06. In both the cases, the current prices, instead of constant prices were considered. This can create some distortions, as the agricultural SDP figures are not corrected for inflation. But, this may not pose much of a problem as we are concerned with growth comparisons for two time periods and therefore the relative growth rates. On the other hand, if we consider the value output at constant prices, it can create more distortions, as we would be ignoring the actual rise in market price realized for many crops owing to the increased demand, which is very much a source of agricultural growth.

**Figure 1: Growth in value of agricultural outputs in Gujarat**




Our analysis shows that agricultural growth during the 11-year period, which included the initial years of economic liberalization, was dramatic, and the annual compounded growth rate clocked a figure of 20.8 per cent. Prior to that agriculture in Gujarat did not grow much, from 1980-81 till 1987-88 due to several factor, most important of which was the severe drought of 1985-87. Also, the growth during the subsequent period (i.e., 1998-99 to 2005-06) was a meagre 7.4 per cent. The growth in real terms in the first case would, however, be a little less than 10 per cent, whereas that in the second case would be much lesser at around 4 per cent, if we consider the inflation adjusted prices. Hence, we can safely argue that the real "miracle growth" in Gujarat's agriculture occurred during the decade from 1988-89 to 1998-99. These analyses question the validity of the recent argument made by Gulati et al. (2009) and Shah et al. (2009) that Gujarat witnessed "miracle growth" during 2000-01 and 2007-08, which was unheard of in the history of the state.

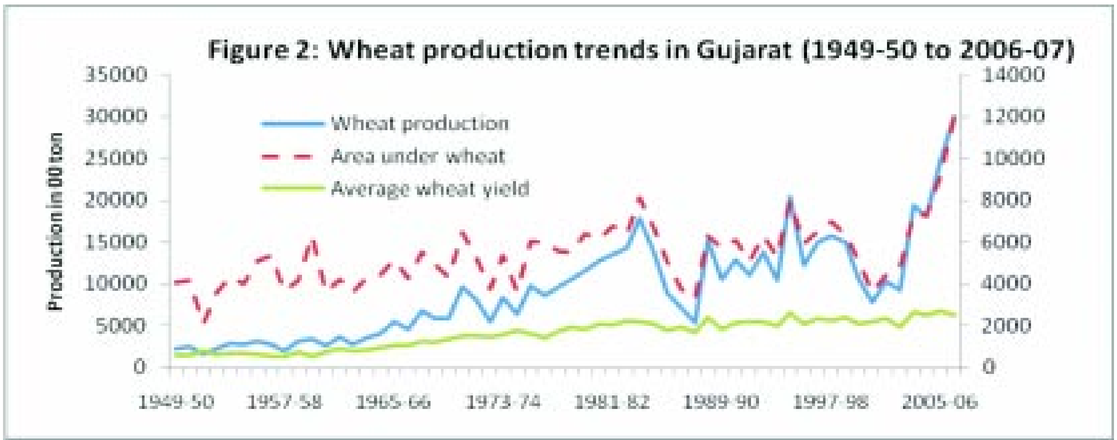
## WHERE HAS THE GROWTH COME FROM?

It is important to find out the crops which have actually contributed to this growth. This is crucial to identify the factors that are driving this growth. For this, the changes in gross value of total agricultural outputs (at current prices) during the period from 1980-81 to 2006-07 were analyzed using data from Central Statistical Organization, and compared against that of individual produce. Our analysis shows that the increase in gross value of agricultural outputs in the state was in the tune of 41,150 crore rupees. Five major agricultural produce, which have contributed to the growth, are: milk, followed by cotton, horticultural crops, groundnut and sugarcane. Wheat and paddy take 6th and 7th place. This clearly shows that dairy production remains to be frontrunner in Gujarat's agricultural growth parade.

Table 1: Contribution of Milk and Crops to Gujarat's agricultural Growth from 1980-81 to 2005-06

| Sr. No | Name of Crop and Dairy Product | Total Increase in Value Output (crore) | % Contribution to the Value Increase in Gross of Agricultural Output |
|---|---|---|---|
| 1 | Milk | 8995.70 | 21.90 |
| 2 | Cotton | 6162.90 | 15.00 |
| 3 | Horticultural crops | 5691.40 | 13.80 |
| 4 | Groundnut | 4955.60 | 12.00 |
| 5 | Sugarcane | 2422.50 | 5.90 |
| 6 | Wheat | 1943.30 | 4.70 |
| 7 | Paddy | 1167.80 | 2.83 |
| 8 | Total Rise in Output | 41150.0 | |

Source: authors' own estimates based on GOI, 1996; GOI, 2004 and GOI, 2008

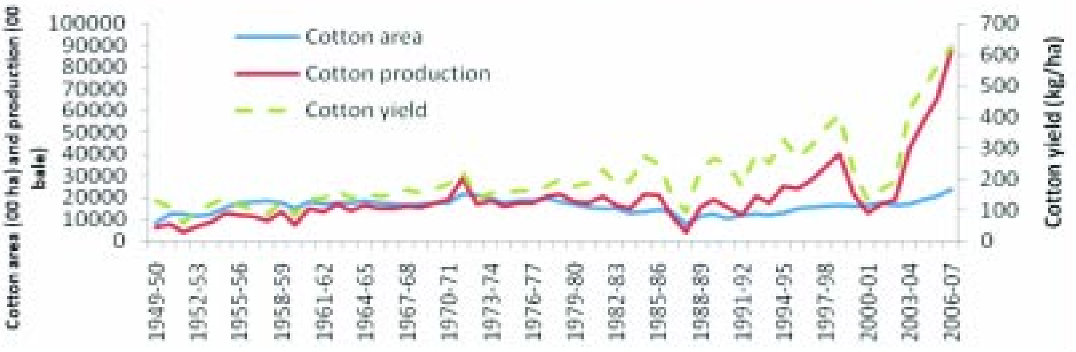



Now, one can also argue that the recent growth is the result of policy measures adopted by the state. For instance, it is vehemently argued that introduction of Bt. cotton, which has caught like "wild fire" in Gujarat, had mainly contributed to the growth. Further, it is argued that area expansion in wheat is occurring as a result of improved groundwater situation owing to extensive, decentralized and small scale water harvesting in Saurashtra, Kachchh and north Gujarat has driven the growth (Shah et al., 2009).

But, analysis of historical data (source: Crop, area and outputs of major crops in Gujarat, 1949-2006, Government of Gujarat) show a totally different trend. The real, dramatic and steady growth in wheat production in Gujarat occurred from 1949 onwards, with improvements coming from expansion in irrigated wheat replacing rain-fed wheat, and then from 1970s mainly the result of adoption of high yielding varieties. But the yield effect almost disappeared after 1985, with no remarkable change in average crop yield, and further increase in production came from increase in area under the crop. But, what is more important is the fact that the production has become highly erratic, with sharp declines in production during drought years (i.e., from 1985-87 and then from 1999-2000). There is also a perfect correlation between production and area under the crop.

Now let us examine what has happened to cotton, a major crop for Gujarat even today accounting for nearly 13.5 per cent of the total value of the agricultural output in the state. Over the 60-year term, the cotton production in the state has steadily increased 14-fold, and most of this increase came from yield effect and not so much from the area expansion, as is evident from Figure 3. The average yield of cotton in the state has been steadily increasing from a mere 130kg/ha in 1949-50 to 624kg/ha in 2006-07. This could be due to two important factors: 1] replacement of rain-fed cotton by irrigated cotton; and 2] greater use of high yielding varieties of cotton. Though there has been a marked and consistent increase in area under cotton during 1994 and 2006, this did not get translated into production gain, and there was a sharp decline in yield during the drought years.

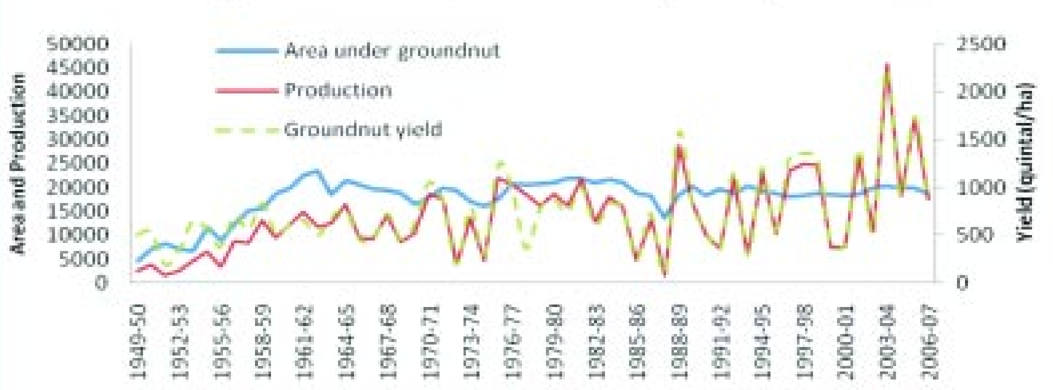
**Figure 3: Trends in cotton area, yield & production in Gujarat**




Another important crop which has the potential to turn around the agrarian scenario of Gujarat is groundnut, Saurashtra being known as the "groundnut bowl" of India. The area under groundnut, which is the most dominant kharif crop of Saurashtra region, has been hovering around 2.0 m. ha during the past 3 decades or so, after a slow decline from a peak of 2.3 m. ha in the early 60s. An exception is the shrinking of area which occurred during 1987-88, the third year of the most severe drought of the century. This is quite understandable, as the farmers in the region were facing extreme water shortages after two years of drought and did not want to take a major risk.

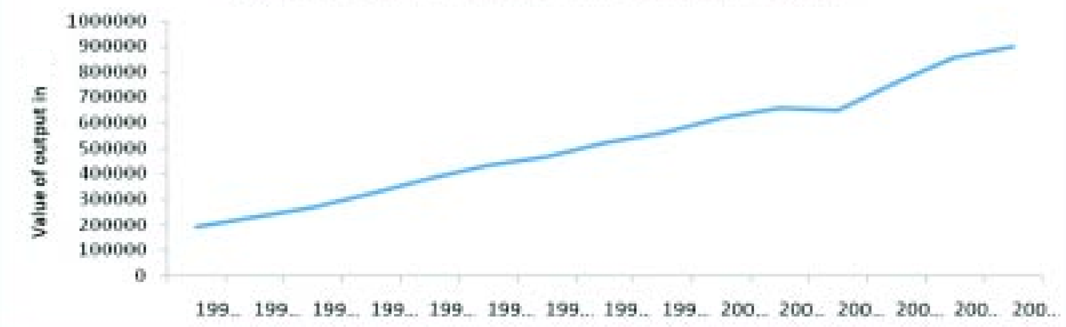
But, what is more striking is the fluctuations in crop output, which can only be explained by the inter-annual yield fluctuations. During virtually every drought, the yield went down drastically (1985-87, 1993, 1999 and 2000) touching the lowest of 203 quintals per ha in 1987. So, the major determinant controlling groundwater production in Saurashtra is the yield, which depends fully on monsoon. The "recharge movement" started in Saurashtra in 1988, comprising recharging of dug wells by individual farmers. But, neither this nor the decentralized water harvesting initiative launched in 1998 by the government of Gujarat (IRMA/UNICEF, 2001) do seem to have helped protect the groundnut crop during the drought years of 1999 and 2000. In fact, the yield fluctuation is even severe after 1988, and has become a regular phenomenon (Figure 4).

Figure 4: Trends in groundnut area, yield & production




The analysis of area-yield-production trends in three distinct crops of Gujarat reveals the following important points about agricultural production in the state. First: the production of crops, which have rain-fed component, is highly vulnerable to droughts, with the droughts impacting on the crop yield.

Figure 5: Trends in value of Milk output in Gujarat

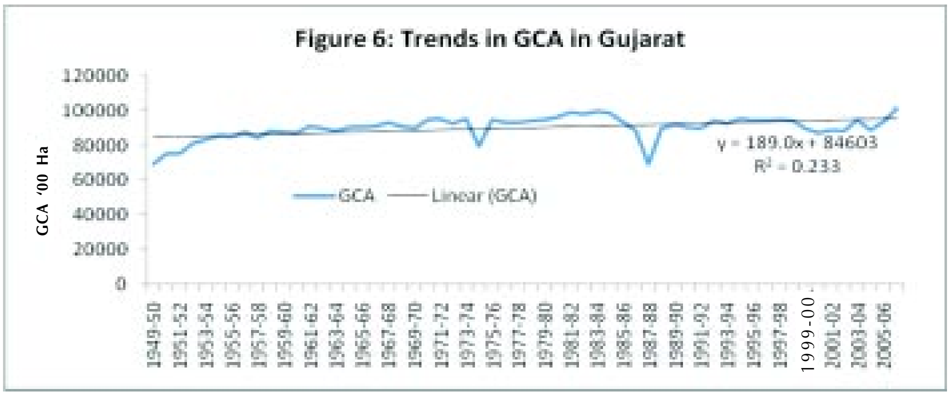


The impact of drought on the cropped area is not perceptible. In the case of winter crops, the drought hits the production as a result of farmers reducing the area under the crop in the wake of poor availability of water from the wells or from the surface irrigation systems. It appears quite clearly that the cotton yield and therefore production is now becoming highly susceptible to monsoons unlike in the past. The reason is production of irrigated high yielding cotton varieties, which have replaced low yielding rain-fed varieties, is heavily dependent on the availability of water not only from the rains but in the aquifers and surface reservoirs. Since during droughts, both groundwater and surface water availability decline sharply, either the crop fails or the yield is severely affected.

Now, the most important farming enterprise in Gujarat, in terms of contribution to agricultural growth is dairying. Analysis of data for 15 years (all that is available) shows that it has grown consistently and at a fast rate. The annual compounded growth rate (at current prices) was estimated to be 11.7 per cent. This is a very high growth. What is most important is the fact that this is the only farm produce in the state which had not suffered any setback during the drought years. While the milk output showed a minor decline during 2002-03, this was attributed to very low paddy and wheat area during the year, which might have affected the animal fodder availability. But, researchers have ignored this aspect of Gujarat's agrarian economy. It appears that dairying is still the most favourite of Gujarat's farmers, accounting for more than 21 per cent of the wealth generated from agriculture. This remarkable achievement can be attributed to the vibrant dairy institutions in north and south Gujarat which procure milk from farmers and pay remunerative prices, and the excellent processing and marketing infrastructure.

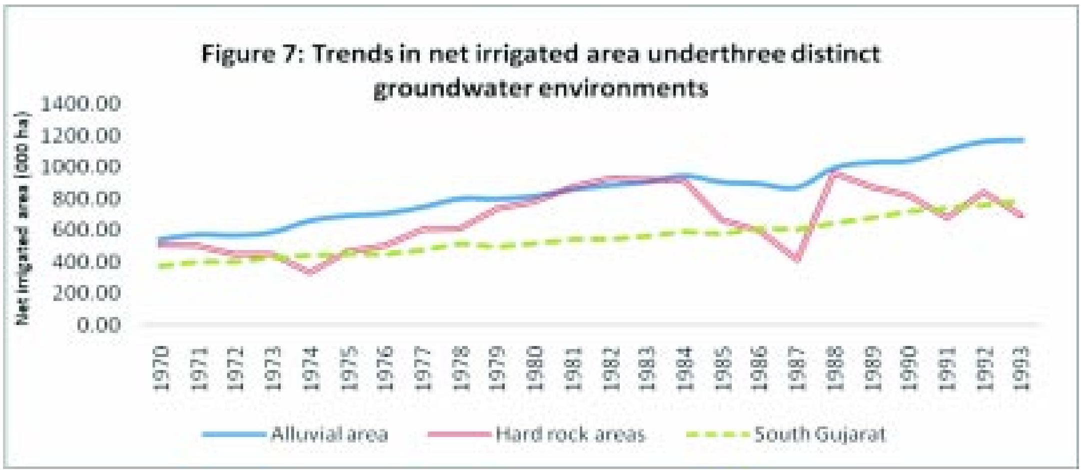
## WHAT IS HAPPENING TO THE GROSS CROPPED AREA?

Having examined the trends for a three important crops and milk, it is now necessary to gauge the changes at the aggregate level, including all the crops grown in the state. The aim is to see the nature of growth and the type of factors which might have influenced the growth. For this, we have examined the trend in gross cropped area over a substantially long period of time, i.e., 58 years. The analysis of data for the period from 1949-50 to 2006-07 (source: GOI, 1996; 2004; and 2008) shows that there was a negligible long term growth in gross cropped area. This is equal to adding nearly 560 ha of land to the cropped area every year. This is statistically insignificant for a state which has a total cultivated area of 10 m. ha. A closer look at the data for different time periods show that the GCA peaked in 1983-84 (9.949 m. ha), and when started declining during droughts and then slowly recovered.



A second major depression was observed during the drought of 1999 and 2000. But, the recovery after that was never substantial enough to attain the original peak GCA in spite of consecutive wet years. The only exception was a sudden increase in GCA noticed in 2006-07, with the area jumping from 9.3 m. ha to 10.126 m. ha.

So, it seems that till 1984, several factors including expansion in public irrigation schemes, massive rural electrification and the institutional measures for encouraging private investment for groundwater irrigation such as heavy subsidy for electricity in the farm sector, the institutional financing for well development and subsidies for well drilling and installing pumps have driven major growth in cultivated area in the state, through increase in cropping intensity with the help of irrigation. Tube well irrigation has seen an explosion in the alluvial areas of the state, whereas in the hard rock areas of Saurashtra and Kachchh, energized open wells had helped expand groundwater irrigation.




However, the GCA had stagnated after this, with occasional drops encountered during meteorological droughts. While the changes in electricity tariff policy had been catalytic to greater exploitation of groundwater, following the removal of electricity meters from farms and introduction of flat rate pricing, the constraints induced by the limited water resources, especially groundwater resources in many parts of the state had inhibited further expansion in cropped area. This is more so for hard rock areas underlying the entire Saurashtra region and Sabarkantha district of north Gujarat which have very meagre groundwater stock, and the only source of replenishment of aquifers is the rainfall. As Figure 7 shows, the net irrigated area from all sources started declining sharply during droughts, remarkably affecting the GCA. Further, even many good rainfall years do not seem to cause recovery, and the net irrigated area in these hard rock areas seem to be descending after 1988. But, mining of the available "groundwater stock" in alluvial aquifers using tube wells had facilitated conversion of some of the rain-fed crops into irrigated crops in north Gujarat, as is evident from Figure 7, which shows consistent increase in net irrigated area in that region. But, many farmers who have lost direct access to groundwater due to steep rise in cost of well irrigation had reduced their irrigated area.

**WHAT CAN CHANGE THE AGRICULTURAL FUTURE OF GUJARAT?**

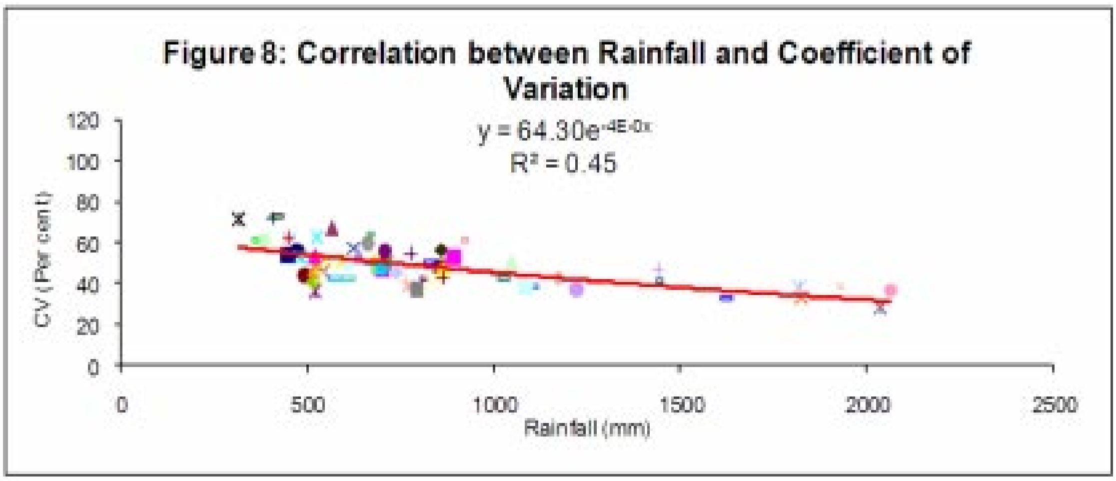



Figure 8: Correlation between Rainfall and Coefficient of Variation

At the aggregate level, Gujarat is one of the water-scarce regions of India with the per capita renewable water resource availability falling far below the 1700 $m^3$ per annum mark. But, there is sharp variation in water resources endowment of the state, with the mean of average annual rainfall varying from 350 mm in Kachchh to 2,000 mm in Valsad in the south (IRMA/UNICEF, 2001). The variability in rainfall also increases sharply with lowest variability in the high rainfall regions in the south and south eastern parts to the highest variability found in Kachchh, followed by Saurashtra and north Gujarat (Figure 8). The entire south Gujarat receive moderate to high rainfall varying from 900mm to 2,000mm. Saurashtra has an average mean annual rainfall of around 550mm, and north Gujarat has rainfall varying from 900mm in the eastern parts to around 400mm in the western parts. The per capita renewable water resources is 1832$m^3$ per annum in South Gujarat, 427$m^3$ per annum in north Gujarat, 734$m^3$ per annum in Saurashtra and 875$m^3$ in Kachchh. It may be mentioned here that the relatively high renewable water resource in Kachchh, in comparison to north Gujarat, is by virtue of the low population density in the region (IRMA/UNICEF, 2001; Kumar, 2002).

Most of Gujarat's surface water resources are concentrated in South Gujarat, with many perennial rivers such as Mahi, Narmada, Tapi, Karjan and Damanganga and carry huge amount of flows annually. Due to low variability in rainfall, the variability in annual stream flows is also low, increasing the dependability.

In contrast to this, north Gujarat, Saurashtra and Kachchh have very poor surface water endowment and the rivers and rivulets there have only limited seasonal flows. Due to high inter-annual variability in rainfall, the stream flows also vary remarkably from year to year. The numerous major and medium irrigation schemes built in these three regions during 60s, 70s and 80s impound the monsoon runoff from around 91 basins in Saurashtra, around 100 rivulets in Kachchh, and a few small & big river basins in north Gujarat viz., Sabarmati, Banas, Rupen and Saraswati), and are over-designed (Kumar, 2002).

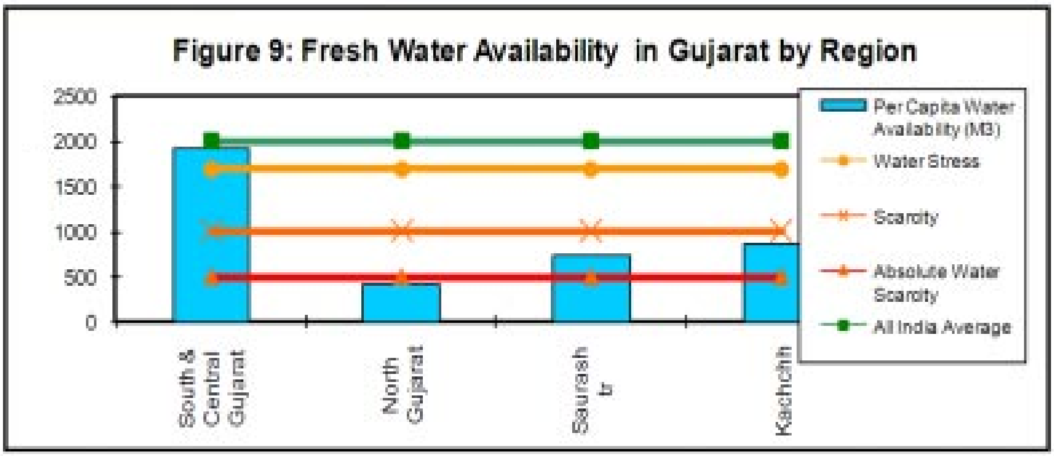



**Figure 9: Fresh Water Availability in Gujarat by Region**

Because of this, there is hardly any outflow from these reservoirs even in good rainfall years. From a macro perspective, several of the small & large basins in these regions have no residual catchment upstream of these reservoirs. Also, they have negligible residual catchments downstream. On the other hand, groundwater resources in the water-scarce arid and semi arid regions of Gujarat are already "over-exploited" or are on the verge of it. Further exploitation of groundwater for expanding irrigation is not possible in any of these regions. On the contrary, during droughts, irrigated agriculture can drop sharply, as recharge to aquifers decline while irrigation water requirement goes up. This is one reason why the agricultural outputs fall more sharply these days in the event of droughts making the growth very erratic.

Therefore, water harvesting, which otherwise is an innovative concept capable of generating a lot of social and economic benefits in water-rich regions (Ilyas, 1999), does not work in these naturally water scarce regions from the point of view of improving water availability at the basin level, and making an economically viable proposition (Kumar et al., 2008; Kumar and Amarasinghe, 2009) In fact, intensive water harvesting is already causing a lot of negative consequences for downstream areas by reducing inflows into downstream reservoirs, and reducing the flows essential for ecosystem health (Kumar et al., 2008) or even reduce the groundwater availability in the down-stream areas as found in the case of a basin in Alwar (Raj and Bijarnia, 2006). The fact that some of the reservoirs, which are affected, are earmarked for public water supply, such decentralized water harvesting activities often lead to conflicts (Kumar et al., 2008). One of the many factors which make small water harvesting structures economically unviable in naturally water scarce regions is that the water impounded by these small reservoirs is never diverted for beneficial uses, and instead gets evaporated (Kumar et al., 2006).

At the same time, the still un-utilized surface water in South Gujarat basins can be transferred to the water-scarce regions of north Gujarat, Saurashtra and Kachchh, which still have a lot of arable land which can be brought under irrigated production, though the economic viability of the same need to be ascertained. Some scholars in the recent past had argued for transfer of surplus water from the Narmada for recharging the alluvial aquifers in north Gujarat, using gravity recharge by spreading water in the fields, and the initial analysis had shown that this is economically viable. But, pricing this water appropriately and introducing electricity tariff reform is very crucial to make sure that the full economic value of the water is realized in this use (Ranade and Kumar, 2004). In view of this, the recent initiative to transfer water from water abundant south Gujarat to north Gujarat through Narmada Main Canal is a great step forward. This would not only rejuvenate the ailing agrarian economy of north Gujarat, but would also improve the sustainability of groundwater resources in the region, which is the region's lifeline.

Another source of agricultural growth in Gujarat is crop water productivity improvements, especially in the water scarce regions of north Gujarat, Saurashtra and Kachchh. The aim will have to be raising the returns from every unit of water used up in agricultural production. Different regions of Gujarat put together around 40 different crops, many of which are amenable to micro irrigation systems such as drips and sprinklers. Some of them are: cotton, castor, groundnut, potato, vegetables such as brinjal and chilly, banana, sugarcane, fruit crops such as lemon, pomegranate, gooseberry and mango. Most of these crops, except mango, banana and sugarcane are grown extensively in the water scarce regions of the state. According to research conducted by International Water Management Institute (IWMI), these systems can actually result in real water saving when used for row crops, in semi arid and arid climates with deep groundwater table (Kumar, 2009). As an outcome of a project initiated by IWMI called "North Gujarat Groundwater Initiatives", many thousands of farmers in the region have adopted MI systems for row crops, accompanied by shift in cropping pattern to highly water-efficient crops such as pomegranate, chilly, lemon, potato and vegetables[1]. A survey of 114 farmers showed remarkable increase in crop water productivity due to this (see Table 2). The average farm income rose up by Rs. 99,442 per annum, and was most significant in the case of orchard growers.

Table 2: Impact of Micro Irrigation Technologies on Crop (applied) Water Productivity on Selected Crops in North Gujarat

| Sr. No | Name of Crop | Crop (applied) Water Productivity (Rs/$m^3$) | |
|---|---|---|---|
| | | Before adoption of WST | After adoption of WST |
| 1 | Potato (micro sprinklers) | 7.04 | 17.99 |
| 2 | Cluster bean (micro sprinklers) | 7.68 | 15.77 |
| 3 | Pomegranate (drips) | NA | 41.37 |
| 4 | Groundnut (micro sprinklers) | 4.13 | 9.36 |
| 5 | Cotton (drips) | 10.32 | 18.81 |
| 6 | Chilli (drip) | 34.87 | 148.1 |

Source: authors' own analysis based on primary data, 2009

## WHAT HAS ACTUALLY DRIVEN THE RECENT 'TREND'?

What clearly emerges from the analysis is that the real growth in agricultural production has occurred during 1988-89 to 1998-99. The growth rate was not only high but also steady. Another important fact vis-à-vis growth is that the sectors, which have mainly contributed to this growth, are milk, cotton, fruits and vegetables, sugarcane and groundnut and wheat is only the last among the six. The "growth" observed in the recent past (from 2002 onwards) is nothing but a good recovery from a major dip in production occurred during the drought years of 1999 and 2000.

Our contention is that two important factors have contributed to this recovery: 1] the occurrence of four successful monsoons in the state after 2000; and 2] the steady expansion in area irrigated by the Sardar Sarovar Project canals, which have started supplying water to the water-scarce regions of north Gujarat. This needs further elaboration.

From our analysis of past growth trends for three important crops, it is clear that with good monsoons, agriculture in Gujarat had grown substantially with steady expansion in either cropped area or yield growth. As against this, in drought years, the production has always suffered with shrinkage in area under irrigated winter crops, and sharp reduction in yield of crops sown in kharif, including cotton and groundnut. In other words, "criticality" of rainfall for Gujarat to sustain its agriculture production has even gone up as compared to the pre-green revolution period. The four consecutive years of good rainfall, remarkably improved groundwater recharge, increased the storage in surface reservoirs throughout the state, and improved soil moisture conditions. The reduced pressure on aquifers for irrigation due to availability of water from surface reservoirs, reduced irrigation water requirement for crops due to improved soil moisture regime, and increase in replenishment together made a huge positive impact on groundwater balance, making more water available for subsequent years.

Secondly, the import of water from Sardar Sarovar reservoir through canals under SSP had in the very recent years boosted the agricultural production at least in a few districts of south (Bharuch, Baroda and Narmada districts) and north Gujarat (Ahmedabad and Gandhinagar). Though the distribution and delivery canals are still not ready for delivery of water to the fields in the entire command (of 1.8 m. ha), the length of the completed network is reasonable enough for farmers in many areas to tap water from the system. Table 3 provides the overall progress in the construction of canal network of SSP.

Table 3: Progress in implementation of SSP.

| Sr. No | Type of Canal | Total length when completed (km) | Length** (km) | Physical progress (%) |
|---|---|---|---|---|
| 1 | Main Canal | 448 | 448 | 100.00 |
| 2 | Branch Canals | 2585 | 1773 | 68.60 |
| 3 | Distributaries | 5112 | 1497 | 29.20 |
| 4 | Minors | 18413 | 4941 | 26.80 |
| 5 | Sub-Minors | 48058 | 10055 | 20.90 |
| | **Total** | **74626** | **18724** | **25.00** |

Source: Desai and Joshi, 2008
** As on March, 2008

The total volume of water utilized from Narmada Canal System in the initial phase of the command as on March 2008 was 1800 MCM. The gross area irrigated by this could be in the range of 2.4-3.27lac ha, depending on an assumed delta of maximum 30 inches (750mm) to a minimum of 22 inches (550mm). In addition to this, Narmada Main Canal discharges water into several rivers of central and north Gujarat en-route Rajasthan. They are Heran, Orsang, Sherdi, Dhadhar, Saidak, Watrak, Meshvo, Sabarmati, Khari, Rupen, Banas, Pushpawati and Saraswati (Desai and Joshi, 2008). To exploit the situation, farmers put up engines; lift water from the canals and rivers and transport it to the fields. The area under wheat and cotton in the area around Narmada Main Canal had dramatically gone up during the past few years. The bumper production in cotton and wheat achieved in the recent years is a testimony to this. Narmada waters have also started producing several indirect benefits by replenishing the aquifers and raising water table, as the rivers which are receiving Narmada water are in the alluvial basin with dewatered aquifers.

What a project like Sardar Sarovar could do to the semi arid, alluvial areas of the state, which are expected to receive water from its canal network for irrigation, can be guessed from a quick assessment of agricultural scenario in south Gujarat. It is agriculturally one of the most prosperous regions of India, and is also socio-economically forward. What characterize the region's agriculture are the two water abundant gravity irrigation schemes, viz., Ukai-Kakrapar and Mahi. With the introduction of canal water, the farmers of the region have taken up cultivation of paddy-wheat, and cotton-wheat and perennial cash crops such as sugarcane and banana. The irrigation from canals had augmented the groundwater. The farmers who do not receive canal water are able to dig shallow tube wells and use groundwater for irrigation. The two schemes together irrigate around 5.20lac ha of land. Hundreds of thousands of farmers in the area who purely depend on canal water for irrigation. The paddy, sugarcane and cotton yields are one of the highest in the region. The continuous replenishment of groundwater enables farmers' easy access to well water for irrigation as water table is very shallow. In years of reduced inflows into the reservoirs, or the area not receiving sufficient rains, the farmers could still grow the traditional and high valued crops using the groundwater, which is available in plenty.

Therefore, it is clear that apart from augmenting irrigation, what canal water supply can provide in areas facing groundwater overdraft is release of the stress on aquifers and "groundwater banking" for bad years. Hence, attempts to estimate the water productivity in canal irrigated crops by merely looking at the total volume of water supplied by canals and the economic value of outputs generated from canal irrigated fields would be highly misleading. The two additional benefits are the economic value of the outputs that can be generated from the replenished groundwater, and the positive externalities it induces on the cost of groundwater abstraction and the environment by raising water table (Shah and Kumar, 2008).

## FUTURE OF INDIAN AGRICULTURE: LESSONS FROM GUJARAT

In spite of the constraints induced by poor water endowment, Gujarat had achieved significant strides in agriculture through modernization, diversification, good infrastructure for production and marketing. This is particularly significant for milk, horticultural crops and cash crops. But, the spurt in the recent years (after 1998-99) has become very erratic, and vulnerable to droughts, with sharp falls in production in such years. The phenomenon throws up some very important lessons for other fragile agro ecologies of India. The state's water and energy policy had catalyzed uncontrolled exploitation of groundwater with mining in many areas. The state hadn't seriously thought on the sustainable use of its water resource so far. In the process it had used up all its renewable water resources, both surface and underground, and also most of the groundwater stock available in the alluvial basins of semi arid areas. The 'criticality' of rains to the state's agriculture had become greater than ever before[2]. This is a dangerous situation.

The state's agricultural policy makers, for quite some time believed that one way to protect the economic interest of the farmers is to subsidize electricity and providing good quality power and subsidized canal water. The policy of providing subsidized electricity to the farm sector was a wrong one[3]. While providing good quality power to the farm sector, as done under "Jyotigram Yojna", is a good step for deriving maximum economic benefit from energy use in agriculture, equally important is the need to introduce metering and charging for every unit of electricity consumed (IRMA/UNICEF, 2001; Kumar, 2005). Only this can motivate farmers to use water and electricity efficiently. Recent research shows that when confronted with marginal cost of using electricity, farmers tend to use electricity and water more efficiently, by improving physical efficiency of water use, by allocating water to crops which give higher returns from every unit of water, and improving the entire farming system, resulting in overall farming system water productivity (Singh and Kumar, 2008; Kumar, 2009). The recent decision of the state government to provide new power connections for agro wells on farmers' agreeing to install meters and pay on the basis of consumption is a welcome step to revert this trend.

There is no doubt that the initiative of the state government to promote micro irrigation systems, through its subsidiary called Gujarat Green Revolution Company, had paid good dividends. Electricity tariff reforms will change the situation altogether for the better, with much greater adoption of drips and sprinklers, as farmers would be concerned with the use of every drop of water they pump out from underground. While certain policies had fuelled agricultural growth in the entire state for more than a decade, it now appears that such a growth would be unsustainable. Agriculture has become highly vulnerable to the occurrence of meteorological droughts. The state now has taken major step of transferring water in bulk from the water-rich, land-scarce regions of south Gujarat to water-scarce, land rich regions of north Gujarat and Saurashtra to reduce this vulnerability.

Such interventions to reduce drought vulnerability through improving water security, positively impact on human development, on which the state government has given a major thrust. A recent work involving analysis of data from 145 countries showed that, improving water security of a region, expressed in terms of sustainable water use index (SWI) improves the human development (HDI) by reducing mortality and malnutrition (Kumar and Mudgerikar, 2009).

While groundwater was a "drought buffer" in agriculturally prosperous semi arid and arid regions, the depletion of the very resource due to its unsustainable use is now posing a threat to future agricultural growth. This is now also evident in many parts of Rajasthan, Punjab, Andhra Pradesh, Tamil Nadu, Karnataka and Madhya Pradesh. The yield of wells is declining sharply in hard rock areas, with increase in number of wells not adding to well irrigated area (Kumar, 2007). In Saurashtra, for instance, the well irrigated area had declined in many districts. The situation would be even more critical in areas which do not receive surface water resources.

To overcome its groundwater crisis, Gujarat government launched a massive programme of decentralized groundwater recharge. This seems to have been driven by the general notion that more structures meant more water. There were no hydrological and economic consideration involved planning water harvesting systems in any of the basins. Most of these interventions were concentrated in basins which are already "closed", leading to dividing of the water rather than its augmentation. Often, structures are over-sized (Kumar et al., 2008). Also, evaporation losses from impounded water increase due to increase in reservoir area (Kumar et al., 2006). All these lead to poor economics. The states like Gujarat which are facing groundwater depletion problems should now look beyond such piecemeal solutions, and try to tackle groundwater depletion through long term, institutional and policy measures.

While water harvesting, large water systems and water imports all have a place in water management, the chances of achieving desired results from the same would depend on the hydrological planning of the basin water resources. The catchment and basin hydrology needs to be studied and the scale, at which various small water harvesting systems and large water systems can be taken up in the basin, need to be assessed based on proper estimates of dependable yield of the basin and the water demands. Potential for water demand management in agriculture, with diversification of cropping system to accommodate water efficient crops, and use of micro irrigation systems also needs to be explored. Further deficits can be filled through water imports, like what has been done in the case of Gujarat under the SSP. Only such an approach can ensure sustainable and equitable use of basin water resources for sustaining agricultural growth.

**Notes**

1 The project is currently managed by Society for Integrated Land and Water Management (SOFILWM), Palanpur.

2 The reason is that the agriculture in the semi arid and arid parts of the state is heavily dependent on normal monsoon not only as a source of critical moisture supply for kharif crops, but also as the source of recharge for the aquifers, as groundwater stocks are already exhausted. The other source of water for the people in three regions is the storage in the minor, medium and large reservoirs.

3 The electricity pricing policy, which the state had followed for nearly 12 years, had contributed to the groundwater over-exploitation, while triggering short term growth and benefiting a few large well owning farmers through electricity subsidies (Kumar and Singh, 2001; Kumar, 2007). The State's revenue loss through subsidy was to the tune of Rs. 4,100 crore in 2002-03 alone (GOI, 2002).

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**REFERENCES**

Bhalla, G. S and Gurmail Singh (2009) Economic Liberalization and Indian Agriculture: A State-wise Analysis, Economic and Political Weekly, December 28, 2009.

Bhatia, Bela (1992) Parched Throats and Lush Green Fields: Political Economy of Groundwater in Gujarat, Economic and Political Weekly, July.

Desai, S. J. and M. B. Joshi (2008) Narmada Water Plays Its Role-Capturing Initial Trends from Gujarat, presentation, Sardar Sarovar Narmada Nigam Ltd.

Government of India (2002), Annual Report on the Working of State Electricity Boards and Electricity Department – 2001-02, Planning Commission (Power and Energy Division), Government of India, May, 2002.

Institute of Rural Management Anand/UNICEF (2001) White Paper on Water in Gujarat, Government of Gujarat, Gandhinagar.

Planning Commission (2008) Eleventh Five Year Plan, 2007-2012, Agriculture, Rural Development, Industry, Services and Infrastructure, Government of India, New Delhi.

Government of India (1996) State-wise and Crop-wise Estimates of Value of Outputs from Agriculture (1980-81 to 1990-91) Central Statistical Organization, Dept. of Statistics, Ministry of Planning & Programme Implementation, Government of India.

Government of India (2004) State-wise and Crop-wise Estimates of Value of Outputs from Agriculture (1990-91 to 2001-02) Central Statistical Organization, Dept. of Statistics, Ministry of Planning & Programme Implementation, Government of India.

Government of India (2008) State-wise and Crop-wise Estimates of Value of Outputs from Agriculture (1999-00 to 2005-06) Central Statistical Organization, Dept. of Statistics, Ministry of Planning & Programme Implementation, Government of India.

Gulati, Ashok (2002) "Challenges to Punjab Agriculture in a Globalizing World," paper based on the presentation given at the policy dialogue on Challenges to Punjab Agriculture in a Globalizing World jointly organized by IFPRI and ICRIER, New Delhi.

Gulati, Ashok, T. Shah and G Shreedhar (2009): Agriculture Performance in Gujarat since 2000: Can Gujarat be a 'Divadandi' (lighthouse) for Other States? IWMI and IFPRI, New Delhi.

Ilyas, S. M. (1999) "Water Harvesting towards Water Demand Management and Sustainable Development," Journal of Rural Reconstruction, 32 (2).

Kumar, M. Dinesh (2002) Reconciling Water Use and Environment: Water Resources Management in Gujarat Resource, Problems, Issues, Options, Strategies and Framework for Action, Report of the Hydrological Regime Subcomponent of the State Environmental Action Programme supported by the World Bank, prepared for Gujarat Ecology Commission, Vadodara.

Kumar, M. Dinesh (2005) Impact of Electricity Prices and Volumetric Water Allocation on Energy and Groundwater Demand Management: Analysis from Western India, Energy Policy, 33 (1): 39-51.

Kumar, M. Dinesh and O. P. Singh (2001) Market Instruments for Demand Management in the Face of Scarcity and Overuse of Water in Gujarat, Western India, Water Policy, 5 (3): 387-403.

Kumar, M. Dinesh (2007) Groundwater Management in India: Physical, Institutional and Policy Alternatives, Sage Publications, New Delhi.

Kumar, M. Dinesh (2009) Water Management in India: What Works, What Doesn't, New Delhi: Gyan Books.

Kumar, M. Dinesh, Shantanu Ghosh, Ankit Patel and R. Ravindranath (2006) Rainwater Harvesting and Groundwater Recharge in India: Critical Issues for Basin Planning and Research, Land Use and Water Resources Research, 6 (1).

Kumar, M. Dinesh, Ankit R. Patel, R. Ravindranath and O. P. Singh (2008) Chasing a Mirage: Water Harvesting and Artificial Recharge in Naturally Water Scarce Regions, Economic and Political Weekly, 43 (35): 61-71.

Kumar, M. Dinesh and Upali Amarasinghe (Eds) (2009) Water Productivity Improvements in Indian Agriculture: Potentials, Constraints and Prospects, Strategic Analysis of the National River Linking Project (NRLP) Series 4, Colombo: International Water Management Institute.

Kumar, M. Dinesh and Arun Mudgerikar (2009) Water, Human Development and Economic Growth: Analyzing the Linkages, proceedings of the National Conference on Hydraulics, Water Resources, Coastal and Environmental Engineering, HYDRO 2009, Pune, 17-18 December, 2009.

Pearce, David W. and Jeremy Warford (1993) World Without End: Economics, Environment and Sustainable Development. New York: Oxford University Press.

Ray, Sunil and Mahesh Bijarnia (2006): 'Upstream Vs Downstream: Groundwater Management and Rainwater Harvesting', Economic & Political Weekly, July 10.

Shah, Tushaar, Ashok Gulati, Hemant P., Ganga Sreedhar and RC Jain (2009) Secret of Gujarat's Agrarian Miracle after 2000, Economic and Political Weekly, December 26, 2009.

Shah, Zankhana and M. Dinesh Kumar (2008) In the Midst of the Large Dam Controversy: Objective, Criteria for Assessing Large Water Storages in the Developing World, Water Resources Management, 22: 1799-1824.

Singh, O. P. and M. Dinesh Kumar (2008) Using Energy Pricing as a Tool for Efficient, Equitable and Sustainable Use of Groundwater for Irrigation: Evidence from three Locations of India, proceedings of the 7th Annual Partners' Meet of IWMI-Tata water policy research program, International Water Management Institute, South Asia Regional Office, ICRISAT Campus, Hyderabad, 2-4 April 2008.

Thobani, Mateen (1997) Formal Water Markets: Why, When and How to Introduce Tradable Water Rights, The World Bank Research Observer, 12 (2): 161-179.

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