India Water Week 2012 – Water, Energy and Food Security : Call for Solutions, 10-14 April 2012, New Delhi

ROLE OF DECENTRALISED RAINWATER HARVESTING AND ARTIFICIAL RECHARGE IN REVERSAL OF GROUND WATER DEPLETION IN THE ARID AND SEMI-ARID REGIONS OF GUJARAT, INDIA.

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ABSTRACT

The assessment of groundwater resources for the Gujarat state for the year 2007 reveals a noteworthy shift in a large number of assessment units from the Critical to Semi-critical/safe category in the semi-arid Saurashtra region, when compared with 2002 . This issignificant against the backdrop of decline of ground water levels and ground water depletion in large part of the arid and semi arid regions of the country . The Saurashtra region was facing problems of declining ground water levels and ground water depletion prior to 2002 but in the post 2002 scenario there has been an overall steady rise and stabilization in post monsoon ground water levels .Although,Saurashtra experienced above average rainfall during the period but the limited period available for infiltration of rainfall during the monsoon does not allow significantly enhanced recharge due to the limited storage of the underlying aquifers. The analysis of the drivers indicate that the intervention of decentralized rain water harvesting and artificial recharge to ground water taken up on a mass scale in the Saurashtra and Kachchh regions have prolonged the period ofrecharge to the aquifers during post monsoon season resulting into this miracle of stabilizing the ground water levels and even reversing the trend of ground water depletion.
Keywords: assessment unit, ground water, trend, recharge, rainwater harvesting, reversal, departure.

INTRODUCTION

The Gujarat government has undertaken some unconventional initiatives in managing the groundwater economy, the mainstay of its irrigated agriculture. For one, the government has enthusiastically made common cause with farming communities in undertaking decentralized rainwater harvesting and groundwater recharge work. By adopting an aggressive recharge strategy that has contributed significantly in stabilizing the ground water levels and even reversing the trend of ground water depletion Saurashtra region of Gujarat has become a role model for other states to follow.

This movement had started as a mass movement in late 1980’s. Subsequently the Gujarat government lent strong support to communities and NGOs to expand this work in a participatory mode under the *Sardar Patel Sahakari Jal Sanchaya Yojana*. The scheme performed best in Saurashtra region; but for the state as a whole, by December 2008, nearly 5,00,000 structures were created—1,13,738 check dams, 55,917 *bori bandhs*, 2,40,199 farm ponds, besides 62,532 large and small check dams constructed under the oversight of the Water Resources Department of the Government of Gujarat all in a campaign mode.

What is driving force for this miracle of stabilizing the ground water levels and even reversing the trend of ground water depletion in the semi arid Saurashtra region of Gujarat? Is it a succession of good monsoons? Or the Sardar Sarovar Irrigation project? Or because of things the farmers and the government of Gujarat have done? This paper attempts to unlock the secret of Saurashtra’s groundwater miracle during the recent years. If the miracle is caused by acts of God—like favorable monsoons— it is of relatively little policy interest. However, if government policy drivers are behind the miracle, the Saurashtra story acquires great significance for the lessons it offers to other States in the country about how to kick-start rapid buildup of ground water resources in arid and semi arid regions.

The Gujarat State is situated in western part of India, between North latitudes 20° 06’ 00” to 24° 42’ 00”andEast longitudes 68° 10’ 00” to 74° 28’ 00” (**Fig 1**). Gujarat has nearly 1600 km long coastline, whichis the longest as compared to any other state in the country. The State has common boundaries with thestatesof Rajasthan, Madhya Pradesh and Maharashtra and shares international border with Pakistan in northwest.Droughts are frequent in North Gujarat, Saurashtra and Kachchh regions due to poor and erratic rainfall.

The climate varies from humid in the south through sub-humid in the central part to semi-arid and arid in the northern and western parts. The state receives rainfall mainly during southwest monsoon period. The normal rainfall shows steep reduction from 1843 mm in the extreme south in Dangs district to 405 mm in Kachchh district. The distribution of normal rainfall in the state is depicted in **Fig 2.** The year 2007– 2008 was a good rainfall year in general. Above average rainfall with respect to decadal average was recorded in all the districts. Departure (+ve) from the average varies from 0.11% to 92.10% whereas negative departure varies from 0.15% to 30.46%. The topography and rainfall virtually control the runoff and ground water recharge.

Fig. 1. Location map of Gujarat with four distinct regions

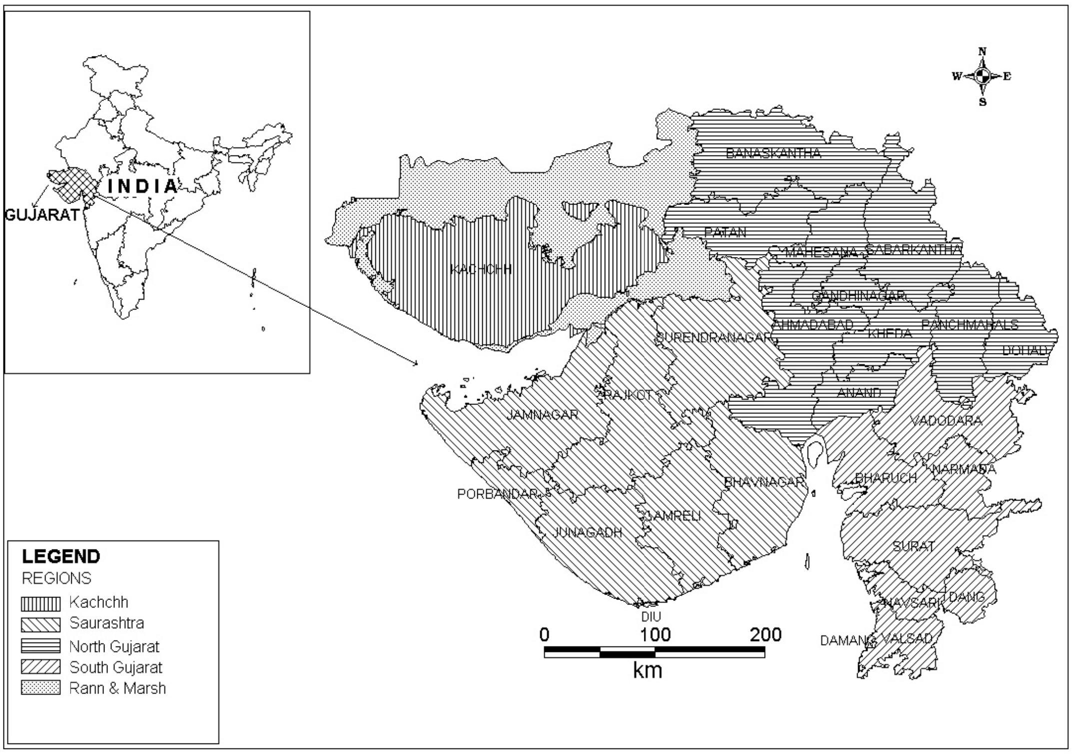
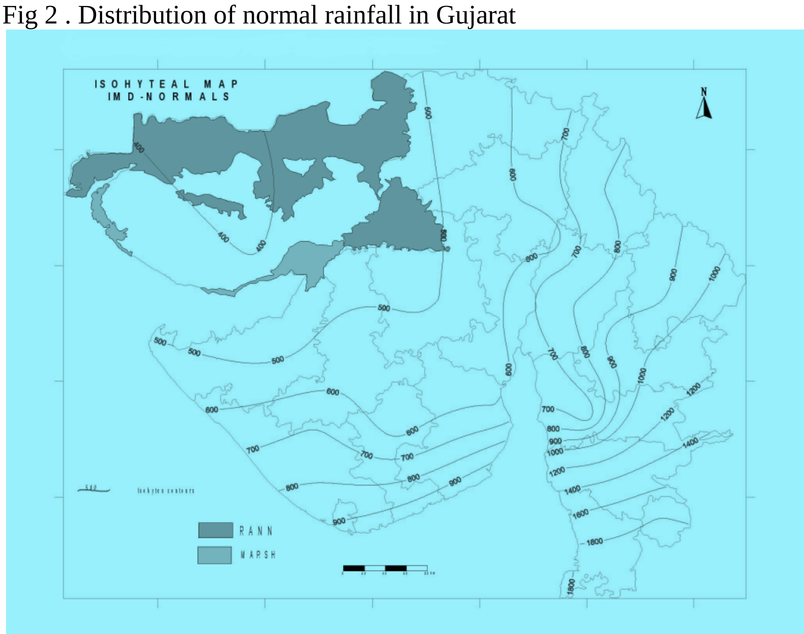


Fig 2 . Distribution of normal rainfall in Gujarat



HYDROGEOLOGY

The high relief areas in the eastern and north-eastern parts of the state occupied by the Deccan Traps and the Achaeans respectively have steep topographic gradients resulting in high run-off, and therefore, provide little scope for ground water recharge. The ground water potential in this terrain is limited. The large alluvial tract extending from Banaskantha district in the north to Surat and Valsad districts in the south constitutes the largest most potential ground water reservoir in the state. The aquifers are extensive, thick, hydraulically connected and are moderate to high yielding.Almost the entire Saurashtra and Kachchh regions are occupied by a variety of hard and fissured formations including basalt and consolidated sedimentary formations with semi-consolidated sediments along the low-lying coastal areas. The compact and fissured nature of rocks gives rise to discontinuous aquifers with moderate yield potential. The friable semi-consolidated sandstone forms an aquifer with moderate yield potential. The coastal and deltaic areas in the state form a narrow linear strip and are underlain by Tertiary sediments and Alluvium. Though highly potential aquifers occur in these areas, salinity is a constraint for ground water development. Ground water withdrawal requires to be strictly regulated so that it does not exceed the annual recharge and also that it does not disturb the hydrochemical balance leading to seawater ingress. The quality of ground water in both hard rock and alluvial terrain is, by and large, suitable except in the coastal areas, estuarine tract and the Rann where the degree of mineralisation in ground water is rather high and salinity is common. Salinity in ground water is also noticed in the arid and semi-arid tract.

GROUNDWATER RECHARGE ASSESSMENT

The methodology published by the Groundwater Estimation Committee[3],(Ministry of Water Resources,Govt. of India 1997)has been utilised by the Narmada,Water Resources and Water Supply Deptt., Govt. of Gujarat,for assessment ground water recharge in the state of Gujarat for computations for the years 2002 and 2007.As per this methodology total annual ground water recharge is obtained as the sum of recharge in the monsoon season and recharge in the non-monsoon season, where in each season, the recharge comprises of recharge from rainfall and recharge from other sources .The assessment is carried out at the level of "*Taluka*" which is smallest administrative unit in the state.

The ground water recharge due to rainfall in the monsoon season has been estimated by ground water level fluctuation method .The water level fluctuation method is based on the application of ground water balance equation, which is stated in general terms as follows for any specified period,

Input -Output = Storage increase

In the above equation, the terms input and output are used in the general sense, referring to all components of ground water balance, which are either input to the unit, or output from the unit of ground water system taken up for resource assessment (*Taluka*). Hence input refers to recharge from rainfall and other sources and subsurface inflow into the unit. Output refers to ground water draft, ground water evapo-transpiration, and base flow to streams and subsurface outflow from the unit. Recharge in the monsoon season and non-monsoon season is estimated separately.

For purposes ofmonsoon recharge assessment in Gujarat receiving the main rainfall from South west monsoon water level fluctuation method has been used.The monsoon season has been taken as May/June to October/November for all areas. Generally, a well hydrograph follows a definite trend like stream flow hydrograph with a peak followed by a recession limb. The recession limb in the post monsoon period, particularly in hard rock areas, is categorised by two slopes: a steep limb from September-October to October-November and other gentle limb from October-November to May-June. The steeper limb indicates that whatever rise has taken place during the monsoon period, of the total, a significant part is lost soon after the end of rainfall. The rate of recession of the water level is relatively rapid in the beginning, for a period of 1-1.5 months immediately after the water level rises to maximum. Due to less demand for ground water in view of adequate moisture in soils, the resource available during this period is not fully utilised.

Recharge during the monsoon season

The recharge during monsoon seasonhas been computed as follows:

$R= Rrf+Rsc_{sc} + Rt_{f} +Rrif_{wc} +Rwc_{t}$, where

Rrf_{rf} = Recharge from monsoon rainfall

Rsc_{sc} = Recharge due to seepage from canals

Rt_{t} = Recharge due to seepage from storagetanks and ponds

Rrif= Recharge due to return flow from irrigation in the area

Rwc_{wc} = Recharge from water conservation structures (check dams and percolation tanks)

The estimation of recharge due rainfall is based on water level fluctuation/rainfall infiltration method,whilethe estimates of recharge due to irrigation return flows (Rrf), recharge from water conservation structures (Rwc) , recharge due to seepage from canals (Rsc)and recharge from storage tanks and ponds (Rt) has been made based onthe norms given by the GEC97 .

Recharge in non-monsoon season

As the normal rainfall in the non-monsoon season in Gujarat is less than 10% of the normal annual rainfall, the recharge due to rainfall in the non-monsoon season has been taken as zero. The total recharge in the non-monsoon season is obtained as the sum of recharge from rainfall in the non-monsoon season and recharge from other sources in the non-monsoon season.

GEC 97 Norms for recharge : Various components are described hereunder.

Recharge from other sources

Recharge from other sources, namely return flowfrom irrigation ($Rrif_f$), tanks (Rt_t) and from water conservation structures (Rwc_c) have been estimatedas follows.

Return flow from irrigation

The recharge due to return flow from irrigation may be estimated, based on the source of irrigation (ground water or surface water), the type of crop (paddy, non-paddy) and the depth of water table below ground level, using the norms provided below (Table 1).

Table 1. Recharge as percentage of application

Source of irrigation	Type of crop	Water table below ground level		
		<10m	10-25 m	>25m
Ground water	Non-paddy	25	15	5
Surface water	Non-paddy	30	20	10
Ground water	Paddy	45	35	20
Surface water	Paddy	50	40	25

Recharge from storage tanks and ponds

1.4 mm/day for the period in which the tank has water, based on the average area of water spread. If data on the average area of water spread is not available, 60% of the maximum water spread area has been used instead of average area of the water spread.

Recharge from water conservation structures (percolation tanks and check dams)

50% of gross storage, considering the number of fillings, with half of this recharge occurring in the monsoon season, and the balance in the non-monsoon season.

ANALYSIS OF THE DRIVERS OF GROUND WATER RECHARGE

To explore what has been the role of each of the drivers contributing to groundwater recharge, a regional level analysis of estimates of groundwater recharge for the periods 2002[4] and 2007[5] has been carried out. To this end, Gujarat has been divided into four distinct regions as outlined in figure **1**and the salient features of these regions in terms of hydrology, ground water occurrence , agricultural practices and socio-economy are presented in Table 2 .

Table:2 Salient features of the four Distinct Regions of Gujarat

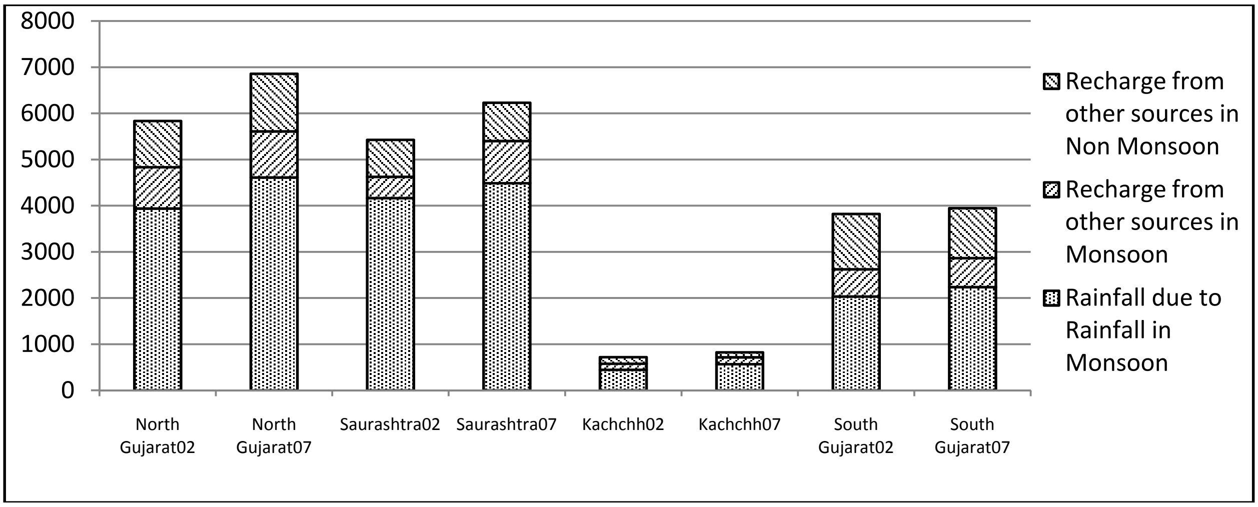
Regions	Districts	Features
North Gujarat	Ahmedabad, Gandhinagar, Patan, Mehsana, Dahod, Banaskantha, Panchmahals and Sabarkantha.	Arid to semi-arid climate; groundwater is the main source of irrigation; alluvial aquifer system that is over-exploited; enterprising farmers; highly developed dairying and dairy co-operatives.
South Gujarat	Anand, Kheda, Vadodara, Bharuch, Surat, Narmada, Navsari, Valsad and Dangs.	Humid and water-abundant part of Gujarat; large areas under canal irrigation systems such as Mahi, Ukai-Kakarapar,Karjan, DamangangaandSardarSarovar;Conjunctive use of groundwater and surface water through farmer initiative; enterprising farmers; strong Dairy cooperatives.
Saurashtra	Amreli, Bhavnagar, Junagadh, Jamnagar, Porbandar, Rajkot Surendranagar,	Arid to semi-arid climate; groundwater the main source of irrigation; hard rock aquifers have poor storativity; open dugwells are the main source of irrigation; Agriculture dependent mostly on monsoon; withdrawal of monsoon is a cursefor kharif crop.
Kachchh	Kachchh	Arid to semi-arid climate; groundwater the main source of irrigation; Limited area with tubewells in productive aquifers and large area with hard rock aquifers havingpoor storativity with open dugwells are the main source of irrigation;Agriculture dependent mostly on monsoon; early withdrawalof monsoon the curse of kharif crop.

For gaining an understanding of the role various sourceswhich contribute to ground water recharge in the state,it is important to look at the contribution of each of them in making up the total recharge. The table 3 gives a region wise disaggregation of the estimated contribution of rainfall and other sources to the ground water recharge for 2002 and 2007 scenario.The same is graphically presented in fig. 3 for the sake of easy comprehension.

Table: 3 Region wise Ground water recharge in Gujarat during 2002 and 2007

Sl.No.	Region/State	Monsoon		Non Monsoon	Total annual groundwater recharge (MCM/yr.)
		Recharge from rainfall(MCM/yr.)	Recharge from other sources (MCM/yr.)	Recharge from other sources (MCM/yr.)	
1	North Gujarat2002	3939.31	895.81	1001.26	5836.40
2	North Gujarat2007	4613.80	995.92	1247.87	6857.59
3	Saurashtra2002	4166.56	459.90	801.78	5428.24
4	Saurashtra2007	4490.03	911.69	829.41	6231.13
5	Kachchh2002	449.34	131.61	142.15	723.11
6	Kachchh2007	570.38	146.27	108.68	825.33
7	South Gujarat2002	2034.60	587.78	1200.82	3823.20
8	South Gujarat2007	2238.97	628.87	1079.97	3947.81
9	Gujarat State 2002	10589.81	2075.10	3146.01	15810.92
10	Gujarat State 2007	11913.18	2682.75	3265.93	17862.17

Figure 3.Region wise contribution of different sources to the ground water recharge in Gujarat during 2002 and 2007



HYPOTHESIS

While some of the drivers for recharge to groundwater work state-wide while others are region specific. Thus rainfall is the most important contributor to ground water rechargethroughout the state during the monsoon season.As a result, the impacts could be felt everywhere .Besides, in the South Gujarat region having large no. of reservoirs and a large network of irrigation canals ,the seepage from reservoirs and return flows fromsurface irrigation are major contributors to ground water recharge . The contribution from seepage from reservoirs and flow irrigation to recharge is comparatively less important in other regions of the state. Whereas in Saurashtra, North Gujarat and Kachchh regions in the state which have relatively large areas under groundwater irrigation the seepage from ground water irrigation forms the second most important driver to ground water recharge. However, some other interventions are by their nature confined to one or more of the four regions. For example, if canal irrigation underwent major changes, its impact will be strongly felt in southern Gujarat where much of canal irrigation is located. Contrary to this, if the increased availability of water through canal irrigation system has been a major driver for building up of ground water resources in Gujarat, we should not expect to see large impacts in North Gujarat, Saurashtra and Kachchh which have only a small share in canal irrigated area in the state. “Decentralized Groundwater Recharge” activities are concentrated in Saurashtra and Kachchh;hence its impact is more likely to be visible in these regions.This implies that groundwater recharge activities which are concentrated mostly in Saurashtra, North Gujarat and Kachchh regions would reflect region specific impact on groundwater recharge if they form a dominant driver for recharge. The expected influence of various drivers on groundwater recharge in different regions of Gujarat is given in table 4.

Table 4 . Expected Influence of different drivers on recharge to groundwater in Gujarat.

	Drivers responsible for	Regions likely to be affected

	ground water recharge	South Gujarat	Kachchh district	North Gujarat	Saurashtra
1	Rainfall	↑↑↑↑	↑↑↑↑	↑↑↑↑	↑↑↑↑
2.	Canals	↑↑↑↑	↑	↑↑	↑↑
3.	Storage tanks and Ponds	↑↑↑↑	↑↑	↑↑↑	↑↑↑
4.	Irrigation return flows	↑↑↑↑	↑	↑↑	↑↑↑
5.	Check dams and percolation tanks	↑	↑	↑↑	↑↑↑↑

It is against this background that a disaggregated analysis of driversof recharge to groundwater in Gujarat was taken up to isolate the policy drivers most responsible for the build up in ground water resources in Saurashtra region in particular.

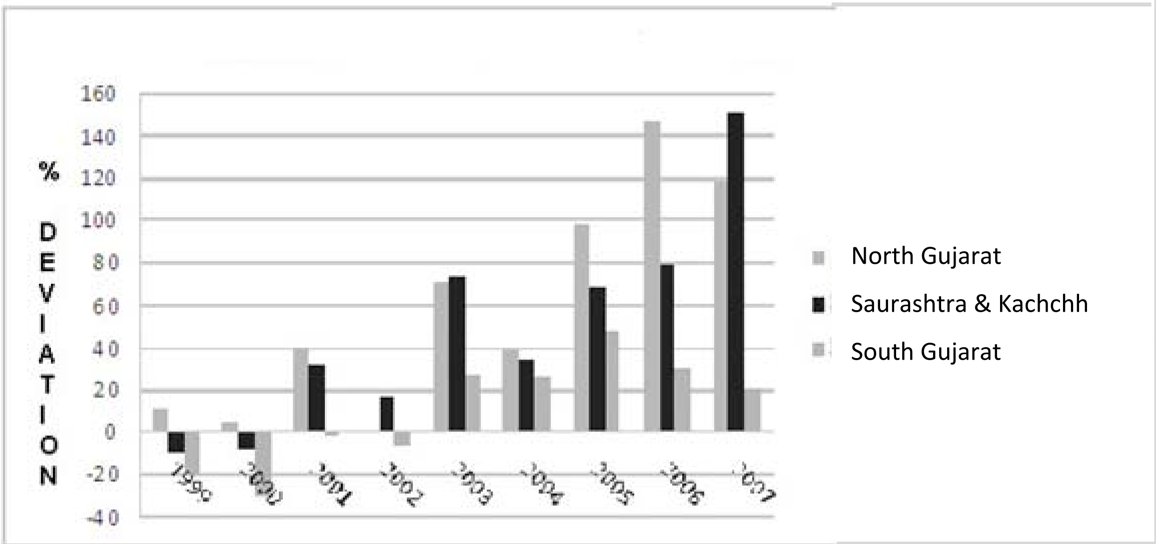
DISAGGREGATED ANALYSIS

The contribution of various drivers for groundwater recharge in the state of Gujarat has been subjected to district wise analysis for different regions. These data are given in table 3 and the graphical presentation in Fig 3. A careful study reveals the following.

Recharge during Monsoon Period

Much of Gujarat—especially the drought-prone regions of Saurashtra, Kachchh and North Gujarat have received above normal rainfall during the years post 1999-2000. During 2002, when almost all of India experienced shortfall in rainfall precipitation, Gujarat too faced an overall shortfall. However, drought hit was only southern part which is well-covered by canal irrigation. The drought-prone regions mentioned above all had above or near normal rainfall as shown in fig.4 below.

Fig 4.Deviation from normal rainfall in different regions of Gujarat



The total recharge from rainfall has been of the order of 10 590 MCM/yr in 2002 and 11 914 MCM/yr in 2007 reflecting an overall rise in Groundwater recharge to the extent of 12% in the state as a whole. But the increased contribution towards recharge varies from nearly 8% in Saurashtra to about 27% in Kachchh. The North Gujarat and South Gujarat regions have recorded an increase in recharge due to rainfall to the extent of 17% and 10% respectively. Groundwater recharge in the monsoon from other sources has increased from 2 075 MCM/yr in the year 2002 to about 2 683 MCM/yr in the year 2007 recording an increase in contribution by nearly 30% when considered with respect to the year 2002. This increase is of the order of about 7% in South Gujarat, 11% in North Gujarat and Kachchh regions and 98% in Saurashtra region.After the 2002-03 drought, monsoons have been kind to most parts of India except in 2009. Yet, it was only Saurashtra region of Gujarat which experienced rapid buildup of ground water resources during these years.

Recharge during Non-Monsoon Period

In the non-monsoon season there is no contribution from the rainfall in 2002 as well as in 2007 to Groundwater recharge. However, recharge from other sources during the non-monsoon season in the state has increased from 3 146 MCM/yr to about 3 266 MCM/yr recording an increase of nearly 4%. While North Gujarat has recorded a maximum increment in this component to the extent of 25% as compared to 2002. In the Kachchh region, the contribution has in fact decreased by nearly 24%. In Saurashtra region, there has been a nominal increase by about 3% as compared to 2002. However, in South Gujarat region dominated by the canal irrigation, the contribution of recharge from other sources decreased by nearly 10% as compared to 2002.

Annual Recharge

If we look at the overall position of change in the Groundwater recharge, it is seen that in the state as a whole there has been an increase in recharge to the extent of nearly 2050 MCM/yr. Across the regions, the increase in groundwater recharge varies from nearly 3% in the South Gujarat to about 14% to 15% respectively in Kachchh and Saurashtra regions. In North Gujarat region, the total Groundwater recharge has increased by about 18%.

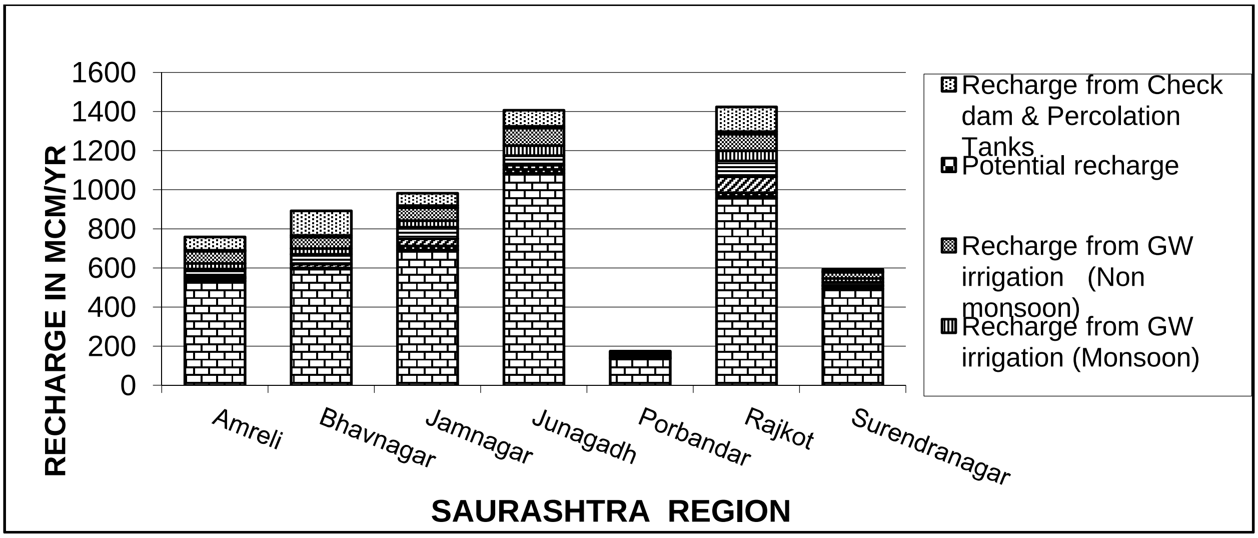
Assessment

An analysis of the various drivers of recharge reveal that maximum increment in the groundwater recharge to theextent of 607 MCM /yr has taken place in the monsoon season from recharge through other sources. This include recharge from canals, seepage from storage tanks and ponds, surface water irrigation and from check dams and percolation tanks.With a view to demystify the increase in groundwater recharge in the Saurashtra region, component wise analysis of recharge in respect of the above said drivers has been carried out ,which is given in table 5. It can be seen from a perusal of this table that recharge from check dams and percolation tanks, the singular and most important component of increase in groundwater recharge in the Saurashtra region which has contributed about 480 MCM/yr is an important driver for the miracle of stabilization of Groundwater levels in the post monsoon season. This effect of decentralized rainwater harvesting and artificial recharge to ground water is vivid in fig 5.

Fig.5 Saurashtra: Contribution of different drivers to ground water recharge (2007)

Table 5. Saurashtra region : Ground Water Recharge in MCM/Yr (2007)

District	Monsoon Recharge	Recharge from canal	Recharge from surface water irrigation	Recharge due to Seepage from Reservoirs & Tanks	Recharge from Check Dam & Percolation Tanks	Recharge from GW irrigation (Monsoon)	Recharge from GW irrigation (Non monsoon)	Poten-tial recharge	Annual replenish-able ground water resource
Amreli	533.51	13.16	41.24	7.26	67.8	28.23	62.31	5.01	758.51
Bhavnagar	594.75	4.74	50.03	20.94	125.95	29.21	58.46	8.48	892.56
Jamnagar	691.33	21.85	59.11	36.67	63.41	33.07	66.14	10.79	982.37
Junagadh	1083.73	20.48	47.66	22.66	81.35	51.55	89.88	8.89	1406.20
Porbandar	136.71	3.18	7.42	1.09	4.45	8.23	8.54	5.41	175.03
Rajkot	956.88	27.76	81.4	81.87	126.09	51.27	85.21	12.94	1423.42
Surendra-nagar	493.12	14.55	14.35	4.67	10.33	20.21	30.65	5.14	593.02
Total	**4490.03**	**105.72**	**301.21**	**175.16**	**479.38**	**221.77**	**401.19**	**56.66**	**6231.12**



INCREMENTAL RISE IN POST MONSOON WATER LEVELS

When groundwater levels are dropping in large parts of the country, Gujarat is the only state whose groundwater balance has turned positive during the recent years. This is amply demonstrated by increased incremental rise in post monsoon water levels in Saurashtra and North Gujarat regions between 2001 (CGWB[1]) and 2006(CGWB[2]).

Fig.6 Water level fluctuation between Pre- and Post- Monsoon Water levels in Gujarat ,2001

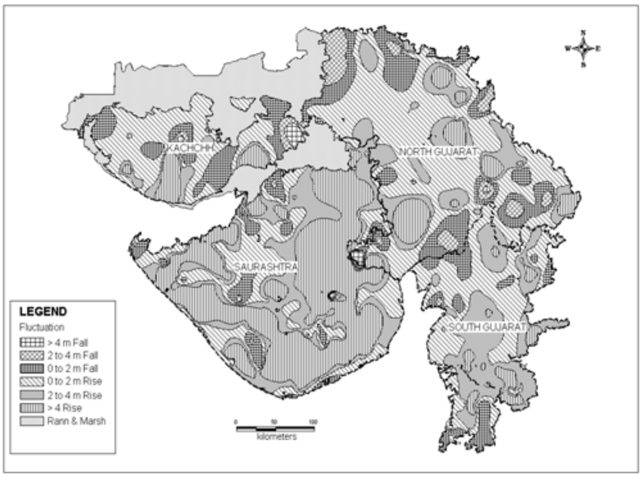
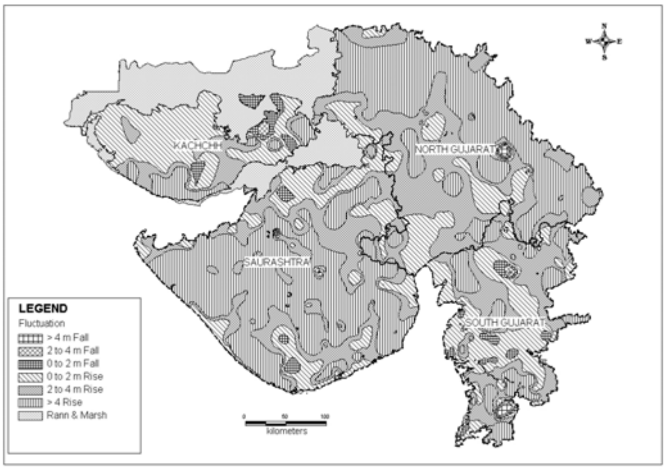


Fig. 7 Water level fluctuation between Pre- and Post- Monsoon Water levels in Gujarat ,2006



A comparison of the water level fluctuation maps showing incremental rise in post monsoon for the years 2001 (Fig.6) and 2006 (Fig.7) shows that during 2001, the ground water levels recorded decline in about 27 600 sq.km area .Whereas, in 2006, the situation was reversed and the area recording decline in post monsoon ground water levels was drastically reduced to only about 4 400 sq.km. This means that in an area of nearly 23 200 sq. km, the post-monsoon declines were reversed. This improvement in the situation is mostly confined to Saurashtra and parts of North Gujarat which witnessed decentralized construction of check dams/percolation tanks on a massive scale.

IMPACT ON GROUND WATER RESOURCES

The assessment of groundwater resources is carried out periodically in the state of Gujarat for planning the development and management of ground water resources in a scientific manner. This helps in taking timely measures to notify the areas for regulation of ground water development as well as to take measures for improvement of ground water situation in the areas, where it has become critical or approaching criticality. The assessment of ground water resources for the years 2002 and 2007 has been carried out based on the Ground Water resources Estimation Methodolgy-1997 recommended in the Report of the Ground Water Estimation Committee, published by the Ministry of Water Resources, Govt. of India in 1997.

As per the ground water resource estimation completed recently for the Gujarat state for the year 2007 a noteworthy shift is seen in a large number of assessment units *(Taluka)*from the Critical to Semi-critical/safe category in the semi-arid Saurashtra region, when compared with 2002 (Table 6) .The salient features of shift in the status of assessment units from a given category to a different category has been compiled from the Report on Estimation of Ground water resources and irrigation potential in Gujarat State(2002) and the Report on Assessment of Ground water resources and irrigation potential of Gujarat State (2007) prepared by the Narmada ,Water Resources and Water Supply Department,Govt. of Gujarat .

A perusal of the table 6 reveals that the total number of OE,Critical and semi-critical *talukas* in the state has reduced from 105 in 2002 to 54 in 2007. Region wise comparison across the state shows that Saurashtra has the largest share of 33 talukas which have witnessed increased availability of ground water and shifted to safe category of development. The North Gujarat region follows the tally where increased water availability in 17 talukas, have led to a shift from higher category of ground water development to safe category . While Kachchh and South Gujarat regions do not reflect any significant change in the number of talukas in different categories.

Table 6. Status of Ground water development in Gujarat State (2002 - 2007)

	Year-2002					**Year 2007**				
Region	No. of **OE**Taluka	No. of**Critical** Taluka	No. of**semi-critical** Taluka	No. of **Safe** Taluka	No. of**Saline** Taluka	No. of **OE** Taluka	No. of**Critical** Taluka	No. of**semi-critical** Taluka	No.of **Safe** Taluka	No. of**Saline** Taluka
North Gujarat Region	24	8	23	**29**	7	22	5	10	**46**	7
Kachchh Region	3	1	4	1	1	3	2	2	2	1
Saurashtra Region	2	3	32	**32**	2	1	0	4	**65**	2
South Gujarat Region	1	0	4	42	4	0	0	5	42	4
TOTAL	30	12	63	**104**	14	26	7	21	**155**	14

CONCLUSIONS

Well known for aggressive adoption of decentralized rain water harvesting and artificial recharge to ground water, the semi arid region of Saurashtra in Gujarat has charted out a new course for building up of its ground water resources. It is stage of ground water development and rise in post monsoon water table, which has posted an impressive growth since 2002. This paper analyzed the drivers of ground water build up through disaggregated analyses of performance of four distinct regions of Gujarat, viz., south Gujarat, North Gujarat, Saurashtra and Kachchh. The rapid strides made in augmentation of ground water resources in Saurashtra region of Gujarat deserves replication in the semi arid and arid hard rock regions of the country suffering from secular decline in water levels and ground water depletion ,in spite of reasonably good rainfall.

In interpreting these regional trends vis a vis the recent ground water resources assessment, it emerges that if Saurashtra, and to lesser extent, North Gujarat, would not have benefitted as much as they have in the absence of the mass-based water harvesting and groundwater recharge movement. During the relatively good monsoons of 2003 to 2006, the vast corpus of check damsand, percolation ponds increased the availability of groundwater that made it possible to see the visible large scale impact possible on the ground water scenario and a noteworthy shift in a large number of assessment units from the Critical and Semi-critical to safe category in the semi-arid Saurashtra region and to a lesser extent in north Gujarat, when compared with 2002.

Acknowledgements
The author would like to place on record his thanks to theChairman, Central Ground Water Board for permission to publish this paper.

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