Groundwater Recharge Management in Saurashtra, India: Learnings for Water Governance

Introduction

Gujarat is one of the most water scarce and drought-prone regions in India (IRMA, 2000). The water utilization pattern of Gujarat, a predominantly semi arid state in western India, is 89% for irrigation, 7% for domestic and drinking water, and four percent for industry and other uses (IRMA, 2000). With many rivers in the State reduced to seasonal flows, and with surface water bodies drying up, the competition between various uses and users for the common groundwater resource was increasing. Being the most affected, the farmer community was a worried lot. Interestingly, the response of the government and the civil society to the recurrent water scarcity situation had been different. The farmers’ response is the theme of study for the thesis.

During mid-eighties, some farmers from Dhoraji-Upleta and a few other villages in Rajkot district of Saurashtra region of Gujarat State discovered an opportunity to improve their well water supplies by diverting rainwater into the wells. The activity involved diverting the ‘run off’ water from their farmlands into their dry wells through a small pit to trap the silt so that only fresh water is delivered into the well. Farmers who carried out such ‘dug well recharging’ realized that their crop yields were ‘more’ compared to those who did not ‘divert’ the runoff water. Over a few years, with a quest for tapping more water, the progressive among the farmers abandoned the direct dug well recharging and adopted more comprehensive groundwater recharge through construction/repair of other water harvesting structures such as check dams, farm ponds, tanks and earthen bunds; in the process they have also made many innovations that reduced not only the cost but also improved water storage, both over the surface and in the subsurface. The funds for all these actions were raised locally, and or donated by local philanthropists, or by the pioneering leaders themselves; most of the support during the initial years was in the
form of material with the condition that farmers carry out civil work themselves. The water harvesting activity expanded geographically with scores of villages joining year after year thanks to the disaggregated, selfless leadership that emerged, and continued for more than two decades now, converting the activity into a social movement around water. The movement is aptly remarked self-propagating and self-energising (Shah, 1998) since there has been no overarching leadership either in the form of an individual or an institution at least for the Saurashtra region.

Although it is two decades since the dug well recharge efforts began (in mid-eighties), there has been no systematic, intensive research done to inquire into the impact of these efforts either on livelihoods or on the social and technical aspects of the approach. The variety of innovations carried out by the farming households, promoted by local leaders and non-governmental agencies have not been studied at reasonable scale for their technical veracity or for suggesting improvements. There have been, however, some quick, limited studies, that examined some of these innovations, and a few anecdotal studies; back-of-the-envelope computations were made by some to arrive at the quantity of water harvested simply by estimating the number of wells covered and a certain quantum of water recharged per well, or per water harvesting activity. These studies were mostly by non-governmental research agencies, and were largely based upon the information and data provided by the local leaders, farmers and other local agencies. Notably, there have been no such studies by government agencies. Further, there have also been no systematic, longitudinal studies essential to scrutinise the evolving techniques and technology of well recharging or the science of it (in terms of hydrogeology, for instance).

When the above scenario is examined from the point of view of water governance, there appears to be disturbing disconnect not only between constituent actors but also between actions on the ground and actions in the policy domain. Noteworthy is the weak link of the government departments with the dynamic village communities and the non-governmental agencies that have made the social movement happen.
Therefore, the Central Research Question is formulated as:

What are the socio-technical and socio-economic processes and mechanisms that contributed to the origin and sustenance of the Saurashtra Groundwater Recharge movement over the past two decades? What lessons can be drawn for water governance?

Objectives

The objectives of the study are:

- Identify the gaps in understanding by focussing on the recharging efforts, the technology (hydrogeology, economics), resource sustainability (institutions, scaling and governance), social aspects (collectives, user groups), and socio-economic impacts (lifestyles) through livelihood changes (crop yield changes, livestock).
- Identify the key drivers that sustained the recharging movement over the past two decades including the socio economic impacts at the household level as well as the village level;
- What are the ways in which the groundwater recharge could be quantified at village level;
- How can the socio economic benefits derived by farmers be linked to the recharge activity?
- Whether the movement has the necessary elements and characteristics to continue to be effective in future?
- What lessons can be drawn for water governance from the Saurashtra recharging movement experience?

The study considers the recharge activity in the background of adaptation efforts of communities in the study villages. The socio economic impacts are traced at the household level as well as the village level.
Methodology & Study Areas

After an initial literature review, a reconnaissance visit was made to various parts of Saurashtra during 2002-03 to look at the different types of recharge experiments carried out by various farmers and non-governmental organisations. The survey provided an indication of the range of local innovations attempted by people under local leadership. However, in most places, check dams have become the most preferred mode of ground water recharge while the initial direct dug well recharging of late eighties was abandoned somewhere down the time line. The survey also indicated that the farmers were benefiting from the recharge activity in terms of agriculture and animal husbandry, the two most prominent livelihood occupations in the region. The on-going watershed programmes that were launched by Government of India in mid-nineties have helped to link up with government funding. The basic difference between the recharge activity and the watershed programme was that every village now had opportunity to be covered in toto aimed at benefitting all the participating families. The watershed programme also has institutional support in the form of implementing support agency (ISA).

Three study sites were chosen comprising six villages (including hamlets) across three talukas: Ambaredi in Jamkandorna taluka, Vithalpar and Jalsikka in Wankaner taluka, and Haripar-Kerala and Bella in Morbi taluka-all in Rajkot district located in Saurashtra region of Gujarat state in western India. These are the villages (and talukas) which have had long association with the local leaders such as Premjibhai Patel, Jayanthibhai Raval and Oddhavji Raghavji Patel respectively. Some of these villages have participated in the earliest pioneering experiments along with the local leader. Over a period, the leaders realised the need for institutionalising their efforts and hence have formed and registered NGOs, namely Vruksh Prem Seva Trust (VPST), Sarvodaya Seva Sangh (SSS) and ORPAT Trust respectively. These organizations as well as their leaders have diverse backgrounds, work culture and ideology. While Vruksh Prem Seva Trust was founded and headed by a former businessman turned social activist, Sarvodaya Seva Sangh is run by a staunch follower of Gandhian principles and ORPAT Trust is run by a former
teacher turned leading entrepreneur in electronics goods and watches by establishing the company called ORPAT.

The selection of study villages was guided by criteria that included village composition, type and nature of the organizations and the variation in the hydrogeology. The predominant rock type in the study villages is basalt. The villages chosen had a mix of patels, kolis, Brahmins, rajputs, rabaris, harijans and STs, the composition varying from village to village. Like in Saurashtra region itself, in most of the study villages, patels formed a majority. The common factor across all these villages is that they have taken up water harvesting activities as a major activity.

Two types of questionnaire were included in the research design: one, the village questionnaire that captured the larger scenario; and, two, a household questionnaire that was administered on sample households comprising 10-15% based on the village population. The survey was carried out during 2003-4. The sample households were selected based on proportionate stratification done with a view to understand the equity and sustainability aspects of distribution of benefits from the water harvesting structures in particular and the recharge movement in general. It may be mentioned that all the sampled households are engaged in agriculture and or animal husbandry; therefore the sample households have a direct concern with groundwater recharge. When animal husbandry is the primary occupation for certain households, the fodder security from within the village becomes important as it impacts their livelihood.

Further, an in-depth study of select villages was carried out to develop insights into the critical elements of the various facets of the movement. There are two reasons for this: [a] The non-governmental organisations supporting the recharge movement are considered pioneers, and could achieve remarkable degree of people’s participation. The research study would provide an opportunity to understand the approach of the NGOs, and how they have deployed technology, resources and the institutional form to achieve the targets set by themselves initially, and later as part of the national watershed programme. The leaders’ target driven approach was embedded in their own vision of favourable
transformation of the livelihood economies through water enhancement. [b] The stratified sampling helps understand the degree of participation, and the degree and extent of benefits accrued across the sample categories so important for access equity and sustainability of the programme. The village survey provides the changing socio-economic conditions that represent not just livelihood economics but also the human growth and prosperity. Analysis of ‘plough back’ into (water) resource management at individual and village levels indicates sustainability and the stake of the people in the programme proliferation essential for building ecological resilience.

**Analysis and Study Findings**

The thesis looked at the resource adaptation strategy by the study villages with particular reference to water. The farmers adopted a socio technical approach to not only enhance groundwater availability but also adapt to the limitations of hydrogeology, with or without an explicit understanding of the complexities of the hydraulics of groundwater. Mollinga (1998) has described the conceptual framework of a socio technical phenomenon while tracing its emergence to Uphoff (1986) and Huppert (1989). He states that a comprehensive understanding that integrates technical and social science perspectives underlies the basic assumption that irrigation is inherently a socio-technical phenomenon. He further argues that social shaping or social construction approach to irrigation technology investigates the social dimensions of irrigation artefacts\(^1\). The social dimension comprises three aspects, namely, social requirements for use, social construction and social effects or benefits. Put differently, social requirements are defined as enabling conditions essential for irrigation technologies to operate.

The thesis extends the socio technical approach to groundwater which can be described as follows: Groundwater problems are socially constructed, and so are the solutions. Groundwater is thus not just a technical resource but also a social resource. Therefore, an approach that combines both social and technical approaches is most appropriate.

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\(^1\) Mollinga reserves the term artefacts to mean technology for the hardware component of irrigation (Mollinga, 1998:13).
The adaptive approaches encompass the socio technical approach because the social science perspectives are very much an integral part of the social action for water management. The social action also integrates innovations—all by people in this case—in technologies such as recharge techniques, type and composition of pumpsets driven by diesel and electricity to suit local conditions, well structuration in terms of depth, radial horizontal bores and depth limitations, and cropping decisions described herein. The thesis describes how irrigation and irrigation technology have shaped the agrarian livelihood decisions as a function of social benefits related with agriculture and livestock, how the communities have coped in the absence of any formal support from official technical agencies, and how the local leaders have tried to fill in this gap by their innovations and experimentation. The leaders have also made beneficial use of the cultural aspects.

In the analysis, the study has examined the changes in the income per household from agriculture, livestock and other sources for the year under study (2003-04) compared with previous year (till 2002-3). The reasons for the change in income were studied from the point of view of agricultural adaptation by the farmer families that included analyzing landuse change, crops and cropping decisions, changes in cropping intensity, changes in the type and composition of the irrigation technology, pumping hours etc. Improvements in agriculture also lead to improvements in fodder situation, and hence income from livestock, in particular, milk income. Further, the study also examined the adaptation strategies as a function of the quantum of groundwater recharge and groundwater availability. The study also analyzes the influence of assured electricity availability for a certain number of (8) hours per day for agriculture, and the quick adaptation by farmers in the form of adding electricity driven pumpsets to the existing diesel pumpsets, and also phasing out diesel where possible. The direct evidence in terms of increase in the number of pumping hours, installing pipeline networks in place of flood irrigation etc. is also examined through field data. As part of adaptation, the decision making by farmers is also examined in detail on all the above aspects. Finally, the relationship between

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2 Hereinafter, my use of the term adaptive approach would subsume socio technical approach applied to groundwater.
recharge and stage of groundwater development have been examined and concluded that they are not simplistically related.

The following are the significant findings:

**Income Enhancement of study villages**

Out of the three common sources of income that comprise total income of a farmer household in the study villages, let us consider agriculture as the primary or major income source, livestock as the secondary, and non-agriculture ‘other sources’ as tertiary. Other sources here include income from agriculture and non-agriculture labor, kirana business, bicycle repair, carpentry, pottery, etc., as applicable in the given village context.

People from Haripar, Kerala and Bella are engaged mostly in kharif and partly rabi agriculture. Summer agriculture occupation is almost nil. This forces them to seek additional work. An important tertiary source of income comprises wages from diamond cutting and polishing units established in and around Morbi. With increased availability of water in the study villages, there was more focus on increasing agriculture (including livestock management) income. Table 1 shows the average income per annum per household (/HH) for the study villages for the reference year 2003-04 and the previous year in order to understand the income change due to enhanced availability of water due to recharge activities.

Table 1: Change in income during 2002-3 and 2003-4 in study villages

<table>
<thead>
<tr>
<th>Village</th>
<th>Total income 2003-4</th>
<th>Total income 2002-3</th>
<th>Change</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Rs. 200219</td>
<td>Rs. 172032</td>
<td>Rs. 28187</td>
<td>% +16.38</td>
</tr>
<tr>
<td>Vithalpar</td>
<td>Rs. 94548</td>
<td>Rs. 79235</td>
<td>Rs. 15313</td>
<td>% +19.33</td>
</tr>
<tr>
<td>Jalsikka</td>
<td>Rs. 267929</td>
<td>Rs. 136154</td>
<td>Rs. 131775</td>
<td>% +96.78</td>
</tr>
<tr>
<td>Haripar</td>
<td>Rs. 224333</td>
<td>Rs. 178143</td>
<td>Rs. 46190</td>
<td>% +25.93</td>
</tr>
<tr>
<td>Kerala</td>
<td>Rs. 173800</td>
<td>Rs. 130000</td>
<td>Rs. 43800</td>
<td>% +33.69</td>
</tr>
<tr>
<td>Bella</td>
<td>Rs. 273662</td>
<td>Rs. 224818</td>
<td>Rs. 48844</td>
<td>% +21.73</td>
</tr>
<tr>
<td></td>
<td>Rs. 1234491</td>
<td>Rs. 920382</td>
<td>Rs. 314109</td>
<td>% +34.13</td>
</tr>
</tbody>
</table>
From the Table 1, it is also seen that all the villages have made gains in total income between year 2003-4 and the previous year; the highest gain, that is of almost 97% increase) in cropping intensity (Table 6.3) was made by Jalsikka (described below); the lowest change in income was made by Ambaredi, of 16.4%. Bella, Haripar and Kerala made income increases of about 22%, 26% and 34% respectively while Vithalpar made only 19% gain which also corresponds to lower range of its cropping intensity. This shows that the income increase is majorly agricultural income, including from livestock. 
The agrarian income change has been approximately 27%, 23%, 94%, 35%, 40% and 30%, for Ambaredi, Vithalpar, Jalsikka, Haripar, Kerala and Bella; the trend corresponds approximately to the cropping intensity (Table 6.3). However, the variation in terms of quantum of change is due to the differential ability of the farmers in terms of investing capacity, inter alia. For example, Jalsikka has recorded highest cropping intensity of 97%; while the amount of irrigated area has increased, there is also a net shift of 16% of land from temporary fallows to unirrigated category (Table 6.4) only in case of Jalsikka.
What factors contribute to this variation in agriculture and livestock income across study villages?

The watershed activity has been common across all the villages. The size and the pattern of spending across various components of watershed activities have been uniform. Given this context, it is important to inquire into factors that contributed to the differences in agriculture and livestock income between the villages. In the case of the study villages, the determining factor has been the variation in the adaptive strategies by the people connected with their primary agriculture and livestock occupations. The adaptive strategies concerned mostly with decisions related to crops, crop types, wells, WEM, pipelines and pumping pattern. It is also important to note that hydrogeology was another determining factor. Decisions regarding well deepening or new wells, horizontal bores at well bottom to enhance effective well yield, types of pump sets to add or replace are other technological decisions farmers took based on their own understanding of the hydrogeology and water availability. The encouragement to continue with the water harvesting activity was provided by the concurrent social processes that were creating a water renaissance type of ambience; leaders such as Shyamjibhai Antala, Premjibhai
Patel, Odhavji Patel, and institutions such as Swadhyaya Parivar and the Swaminarayan Trust spearheaded these processes at different levels and with different geographical coverage. There was an enabling environment created for disaggregated local leadership to emerge; the local leadership has actually utilized the deep social and technical foundations of the water-centric movement to expand the menu of water harvesting activities. They have also utilized the opportunity of the government of India-sponsored watershed programme by making it more biased towards water harvesting activities. The more than 90% of the total watershed budget spent on the water harvesting structures in the study villages by the NGOs is a clear indication of the local bureaucracy’s tacit approval of the extant social and technical innovations.

**Cropping Intensity**

The average cropping intensity for all the six villages has increased by 34.3%, from 122.1% during 2002-03 (FY03) to 156.4% during 2003-04 (FY04); each village also has shown a positive change. Change in cropping intensity is higher for Ambaredi and Jalsikka at around 40% compared to Vithapar, Haripar and Kerala at 25% each, and 13.9% for Bella, which is the lowest among all.

The key findings of analysis can be summarized as follows: [i] There has been a definite positive increase in the land under irrigation in all the villages. [ii] The increase in cropping intensity across all villages is a clear indication of land sown more number of times than previously. [iii] The additional land under irrigation during 2003-04 has come from hitherto unirrigated land and or uncultivated fallows. This is seen across all the villages except Jalsikka where the unirrigated land has reduced due to conversion into irrigated land. In case of Vithalpar, the change from unirrigated to irrigated land (w.r.t year 2002-3) is more or less constant but with increase in cropping intensity which indicates two things: one, that the land has been put to cultivation more than previously; two, that farmers have recognized that the limits to irrigation availability have reached ‘as of now’. In the case of latter, with more technological solutions related to soil and water conservation practices and crops, there could be ‘stretching the limits’ by improving water efficiency (Seckler et al 2003). [b] There is still some scope available for Jalsikka to bring land under irrigation provided water is accessible. Put differently, this implies
that there is scope for improved management of water. In the case of Haripar, Kerala and Bella too, there is significant amount of land that remains unirrigated. Nevertheless, farmers of these villages have also recognized limits to irrigation caused by hydrogeology of their villages (that is water yield from wells) under the present circumstances. This can be seen in the fact that the farmers first went in for kharif crop stabilization and then rabi crop, not focusing much on the summer crops except for some crops like vegetables. Hardly 10-25% of the land is generally under summer crop. These aspects that came out during the focus group discussions indicated the strategy of farmers to modify cropping practice to suit the water availability. Further, the farmers have also displayed their awareness of the ‘hydrogeology’ of their villages as seen, for example, in their restriction of depth of wells. These aspects are discussed later in this summary.

**Soil and water conservation and groundwater exploitation**

Except for Vithalpar, farmers from all villages have shown that appropriate cropping decisions would help ensure significant total income as discussed in the foregoing. However, sustained income is very much dependent not just on cropping decisions but also on continued access to, and, availability of water. For example, Ambaredi has shown that favorable hydrogeology will facilitate increased recharge commensurate with use, that is, annual extraction. This is evidenced in the stage of groundwater development, which is just 37.85%-very much in the safe category (Figure 15). In contrast, Vithalpar shows overexploitation conditions (98.91%) even with lowest agriculture and livestock income of all study villages. The major source of water is from river Mahanadi, which the farmers have to pump to their fields on one side of the river. The thickness of the weathered zone is also small. The change in cropping intensity too has been the lowest only after Bella which also anyway has severe hydrogeological limitations. Notably, the river Mahanadi that flows along south of Vithalpar has been treated for 35 kilometers as part of Lunsar Mahal cluster of 30 watersheds by the Sarvodaya Seva Sangh. Forty eight check dams were constructed across the river Mahanadi that includes 3 check dams falling under Vithalpar watershed; the watershed also implemented one pond and 10 nalla plugs and some plantation. This has enabled flows for several months in a year in the river Mahanadi; the major source for Vithalpar therefore is direct pumping from river.
Therefore, the number of pump sets on the river has doubled. Then, what factors caused the significant difference in the agrarian income? The answer lies in the fact that the entire watershed of Vithalpar was not covered intensively with soil and water conservation structures such as farm bunds, farm ponds, and inland check dams across lower order streams as in the case of other villages such as Ambaredi. Although the direct pumping from river Mahanadi has doubled, it has also increased the recurring costs due to the use of diesel pumps. The well to household ratio remains high at 1:4.7; with low soil moisture retention due to absence of intensive soil and water conservation measures, Vithalpar raised low per capita income. This typical case calls for technical support both for agriculture and water management aspects.

**Changes in WEM and WEM Composition**

All the villages showed significant increase in the number of hours of pumping per day per household during kharif-in the range of 1.5 to 2.0 times, in case of Ambaredi, Bella and Jalsikka, while more than twice in case of Vithalpar, Haripar and Kerala. During Rabi, the increase is a minimum of two times for Ambaredi and Jalsikka, three times for Vithalpar, six, eight and thirteen times for Bella, Kerala and Haripar. During summer, Ambaredi, Vithalpar and Jalsikka registered many times increase over the small number of hours, namely from 6 hours per day which is useful for vegetables and such crops. This analysis corroborates the findings about the transformation of unirrigated land into irrigated land, increase in cropping intensity, and the adaptive strategies of farmers to ensure irrigation security for kharif and further irrigation for critical rabi crop useful for livestock fodder security. Further, this data provides direct evidence about availability of water due to recharge activity in the absence of any other source such as canals or tanks in the areas. To make use of the water, farmers have to invest in water extraction mechanisms (WEM).

Analysis of data on the water extraction mechanisms reveals interesting trends: [i] Diesel pumpsets were the most common mode of pumping since electricity connection was not easily available until the introduction of the Jyoti Gram Yojana (JGY). Ambaredi had both diesel and electric pumpsets; it had reasonably good access to electricity for irrigation due to its big village status and presence of influential patel farmers.
Introduction of JGY during 2000-4 in the study villages under which electricity supply is made available for at least 8 hours per day has altered the composition of WEM; with increased income returns farmers bought more pumpsets, and often chose to go in for electric motors (EM). [ii] Farmers prefer EM as against diesel pumpsets due to the high recurring cost of diesel as against fixed slab rate of electricity based on the horse power (HP) of the motor. The changing WEM composition shows that Ambaredi, Vithalpar and Bella. Haripar and Kerala represent the typical scenario that existed pre-JGY, that is, cent per cent diesel pumpsets, more so because the JGY was introduced during 2004 in these villages. The data in the table above pertains to 2003-04. Jalsikka shows a predominance of electric motors. Very few diesel pumpsets existed earlier; with the introduction of JGY during 2000-01, and the fixed slab rate, farmers bought more EMs for use on the well while diesel pumpsets were continued for use along the river. Focus group discussion revealed that farmers preferred to have a combination of diesel and electric pumpsets, in spite of higher recurring costs of diesel pumpsets, because of certain advantages of diesel pumpsets over the electric pumpsets. These include flexibility for direct pumping from check dams and not restricted by the eight hours of electricity supply. Patel dominated villages such as Haripar, Kerala and Bella, and Ambaredi did not hesitate to invest in diesel pumps in order to cultivate as much land as possible. In specific, the majority Patel farmers of Haripar, Kerala and Bella have cultivated kharif crop in full agriculture land followed by rabi crop in part; part of the rabi crop comprised the continued cotton crop from kharif. Summer crop was almost not raised due to non-availability of water. Simply put, farmers pumped for highest number of hours during kharif and minimum during summer; in case of Haripar, Kerala and Bella, it has been almost negligible corroborating with unfavorable hydrogeology.

**Comparison of recharge values**

It is seen that the general rainfall pattern for both the clusters of villages is similar. Table 2 gives recharge values computed by different methods. Method 1 under column B gives recharge estimates obtained by WL & SY method. Column E under Method 2 gives recharge values obtained by Regression method. Column C gives the long term taluka average rainfall obtained for the years 1901-2002; column D gives the recharge calculated using regression method for long term average rainfall. Column E again gives
the recharge obtained by the same regression method but proportionately rectified for the 2003 year rainfall of 740 mm. Method 3 is the CRU-NUT_MONTH method; the recharge values obtained are given in column F. The actual RF of 2003 sourced from official sources, month-wise, is substituted in the output of a CRU file which is used as an input to the NUT_MONTH method to estimate recharge for the year 2003. The recharge values of the two clusters are different although the rainfall is same; the difference is perhaps due to the soil characteristics and climate parameters. Method 4 estimates the recharge values as given in column G using the Regression equation for the district average rainfall. Columns F and G also bring in the variation possible in the recharge value estimation.

Table 2: Comparison of Recharge values for the year 2003

<table>
<thead>
<tr>
<th>Village</th>
<th>Method 1</th>
<th>Method 2</th>
<th>Method 3</th>
<th>Method 4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>WL &amp; SY method (mm)</td>
<td>Taluka long term average Rainfall (mm)</td>
<td>Recharge for taluka average rainfall in col. C (mm)</td>
<td>Recharge for rainfall proportionate to actual total RF of year 2003</td>
</tr>
<tr>
<td>Ambaredi</td>
<td>81</td>
<td>625.90</td>
<td>46.9</td>
<td>55.45</td>
</tr>
<tr>
<td>Jalsikka</td>
<td>70</td>
<td>584.05</td>
<td>39</td>
<td>49.41</td>
</tr>
<tr>
<td>Vithalpar</td>
<td>63</td>
<td>584.05</td>
<td>39</td>
<td>49.41</td>
</tr>
<tr>
<td>Haripar</td>
<td>55</td>
<td>584.05</td>
<td>39</td>
<td>49.41</td>
</tr>
<tr>
<td>Kerala</td>
<td>30</td>
<td>584.05</td>
<td>39</td>
<td>49.41</td>
</tr>
<tr>
<td>Bela</td>
<td>53</td>
<td>584.05</td>
<td>39</td>
<td>49.41</td>
</tr>
</tbody>
</table>

Source: Computed from field data

There is however, difference in the recharge amounts as shown in Table 2 not only due to rainfall pattern, distribution and quantity, but also due to soil constants. The number of zero or negligible recharge years and rates of recharge on an annual basis, discussed in
detail in the main thesis, also support this. The rainfall-recharge analysis also showed that recharge of 100 mm is most likely for a rainfall range 550-750 for Ambaredi, while recharge of 80-120 mm is likely for rainfall range of 580-750 mm for Jalsikka. Lesser recharge of 60 mm and above is likely for a rainfall range of 340-550 mm. The quantum of recharge for Ambaredi is found to be more than that of Jalsikka for the same rainfall windows due to comparatively more favourable soil conditions and rainfall frequency cycle. The frequency cycle of rainfall for Ambaredi is also shorter compared to Jalsikka cluster as discussed elsewhere. Further, the recharge is found to be more consistent for Ambaredi than Jalsikka in view of favourable soil constants.

Let us examine how recharge values obtained above compare with the findings from the long term rainfall-recharge relationship.

The long term analysis has revealed that for a rainfall of 550-750 mm, the most probable recharge estimated for Ambaredi was around 100 mm, while for Jalsikka, it was 80-120 mm for the corresponding rainfall in column B of Table 5.12. Clearly, these values are higher than the recharge values estimated by the above methods for the corresponding rainfall: for Ambaredi, it ranges from 55.45 to 81mm, and for Jalsikka cluster, it is 30 to 70 mm. The difference is contributed by the uncertainty factors for each of the Recharge Methods. The difference is by and large less than 20% between any two methods which is acceptable as per the norms of the Government of India. In particular, the WL & SY method differs from the CRU by less than 20% for all villages except for Kerala. The hydrogeological conditions in Kerala are quite different, including the clay soil conditions that affected recharge adversely.

Analysis also shows that the AET and PET ratio is 1, and is the same for both clusters. Therefore, factors that should be affecting recharge would be the soil characteristics, discussed elsewhere. When we consider the soil composition, the more silty composition of Ambaredi soils facilitated enhanced recharge compared to the clayey soils of the Jalsikka cluster. In addition, the presence of a 2 m-thick lithomarge layer as shown by well inventory in Jalsikka, Haripar, Kerala and Bella between 10-13 metres depth below
ground level has created well digging problems as well as hindered recharge. This is evidenced by the total depth of wells in Ambaredi which is around 20 m as compared to that of Jalsikka cluster of 10-13 m below ground level. However, within the Jalsikka cluster, Jalsikka and Vithalpar villages are again comparatively better in terms of soil characteristics or soil constants; however, due to all these villages falling in the same CRU node, separate analysis was not possible.

The values of recharge obtained by various methods and shown in Table 2 can be considered to be agreeing reasonably well given the complexity of the recharge process and the physical systems. It is seen that the general rainfall pattern for both the clusters of villages is similar. The rainfall and recharge seem to be closely correlated, although there is variation in terms of quantity in both the clusters. The long term average rainfall for Ambaredi and Jalsikka clusters is 625.9 and 584.05 mm respectively.

Other socio economic data such as the cropping intensity, crop returns, income per household, investments in WEM and other farm equipment have all been analysed as described in the foregoing. Jalsikka and Vithalpar have shown more productive agriculture and animal husbandry activities among the Jalsikka cluster mainly because of two reasons: (i) the wells of depths are around 20 m in Jalsikka and Vithalpar, while in the other villages, namely, Haripar, Kerala and Bella, the depth of wells is 10-13 m; (ii) there is direct pumping of water from the rivers in the case of Jalsikka and Vithalpar which to a certain extent countered the disadvantage of shortage of water due to lower recharge. While Jalsikka and Vithalpar are able to take two crops, Haripar, Kerala and Bella are able to take only one crop (including that of the six-month cotton crop).

**Leadership & Social Movement**

Disaggregated leadership played a key role in converting a simple dug well recharging activity into a movement. The disaggregated leadership has raised not only awareness but promoted actions through donations, technical support and leveraging religious and political leadership. They have also utilised the cultural resources such as the identity of Saurashtra peasantry, entrepreneurship, kinship and philanthropy effectively to mobilise
funds to conduct the initial experiments as well as sustain it.

What are the social factors that contributed to the conversion of a simple dug well recharge activity into a social movement across Saurashtra? The study examines in depth the framing strategies adopted by the leaders who employed narratives as a means of building future scenarios of prosperity through water conservation activities. The leaders themselves played an important role in terms of not only story telling by themselves, but also by those who benefited by the recharge techniques. To expand the movement, the spiritual and religious leaders were cleverly drafted in, who exhorted farmers by giving slogans such as “the water in your farm belongs to you, and the water in your village belongs to our village”; and “if you quench the thirst of Mother Earth, she will quench yours.” Innovative leaders such as Premjibhai Patel of VPST and Shyamjibhai Patel of SLMT have carried out experiments, and alongside produced manuals along with sketches, and how-to-do procedures. Thousands of pamphlets, booklets, posters, videos and other audio visual material were produced and disseminated in water campaigns, jal yatras and conferences. Politicians were included by design along with spiritual, religious and local leaders to convey the message of dire need to address water scarcity. The then Chief Minister and his cabinet colleagues were made part of the conferences to enable them witness the action and the euphoria; clearly, this strategy worked and the powers that be formulated some farmer-friendly schemes such as the SPPWCP, 80:20 and 60:40 schemes. Later entrants into the movement have devised unique methods of contributing to water conservation activity; for instance, SJT has purchased 20 JCBs (earth excavators) which were provided almost free of cost against request by any village for earth work so that maximum rain water is captured in storage structures created such as ponds, tanks and check dams. In almost all the cases, the organizations have involved the diamond, textiles and gemstone industry businessmen invoking not only the kinship factor but for developing the parched Saurashtra. Since most of those businessmen from different parts of Saurashtra retained their roots, they found a ready connection and vested interest.

Analysis shows that the Saurashtra recharging movement was not something that was planned by any one organization or a group of organizations; the movement gradually
took shape out of the pioneering efforts of a few farmers and was built up in local nodes, promoted ably by a number of local leaders and organizations. Interestingly, even today, there is no overarching organization that addresses entire Saurashtra although the domain of work is chosen as Saurashtra by organizations such as SLMT, SJT, JKT and others.

What qualifies it as a recharge movement is that it has a critical mass in terms of participation of villages and farmers. However, there are still many villages which are not part of the movement as the study reveals. The watershed programme that started after almost a decade of the recharge movement supported by private entrepreneurs has given a shot in the arm as it has led to more systematic, area based efforts leading to visible and tangible impacts. Although the watershed programme is launched all over the country, what makes it unique in Rajkot district where the study villages are located is the heavy bias towards water conservation related activities by the implementing support agencies (ISA) constituting 80-90% of the expenditure (Source: Progress reports of VPST, JKT, SSS).

An Agenda for Water Governance

UN-Water (2008) states that decision making on water resources management has to involve all stakeholders to contribute to the ‘Integrated water resources management (IWRM)’ process that promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems’ (GWP, 2000). This is nothing but water governance that envisages the mechanisms, processes and institutions allowing plurality of both government and non-governmental range of actors (UNDP, 1997) at different levels including the PRIs to work together.

Improving the database

Chapters 1 and 3 of the thesis have shown that, in arid and semi arid regions, in particular, groundwater forms a very important and most dependent source of irrigation.
Saurashtra’s typical inverted topography and hydrogeology further demand improved ways of water resource management as historically areas such as Saurashtra have been traditionally devoid of surface water harvesting structures (section 1, chapter 3). Wells have had been the major form of groundwater extraction in Saurashtra from the usually limited overburden thickness (Chapter 3). Modern research of say past 50 years (although in the context of locating hydrocarbons) has found that the tectonic disturbances have produced several faults, both small and of regional extent (Bhattacharya et al. 2004; Pandey, 2000; Biswas & Deshpande, 1983; Rathore, 2001) as discussed in Chapter 3. Such lineaments would further enhance the groundwater potential if detailed hydrogeological mapping is done on a village to village basis in a systematic manner. The District Groundwater Management Studies (DGMS) already initiated (section 3, Chapter 3) should be prioritised to cover such priority talukas and villages so that a comprehensive taluka/district wise information and database is generated with village/gram panchayat as the base unit. As part of the DGM study, pilot villages/gram panchayats can be identified for detailed study wherein the water levels in wells are monitored on a year to year basis intensively for a five-year period (to take care of the periodicity of drought conditions). These water levels along with other data such as the groundwater draft for agriculture and other purposes could be used to estimate recharge as shown in Chapter 5.

It may be mentioned that the government of Rajasthan (neighbouring state of Gujarat) has adopted IWRM as its core strategy for implementation of the State Water Policy of 2010; the State is currently implementing an ambitious GP IWRM Planning and implementation in 11 districts as part of the European Union funded Water Sector Reforms Programme (EU SPP). The gram panchayat assesses its own water resources availability, estimates water demand, and plans for IWRM measures to reduce the demand-supply gap over a period of time. A key aspect is the convergence of funding sources both current and potential, irrespective of source of funding. This data from gram panchayats fills an important data gap in the current scenario. Water sector reforms allow improvement of all other water related data and infrastructure benchmarking for dynamic performance review and improved planning on a year to year basis.
Linking action and research domains

Absence of strong links between the Saurashtra recharging movement and the research and academic institutions is a crucial missed opportunity for the much needed water sector reform. There have been significant research findings from both government and non-governmental domains on recharge techniques and recharge processes. While the official research is more under controlled conditions, the latter occurring on the ground has almost no scientific rigour or data generated save for qualitative information (Chapters 1 and 3). It is therefore essential that strategies and systems are evolved to strengthen these linkages to enhance the quality of research and research findings so as to make them more effective and more useful for farmers, in particular, and to water sector stakeholders in general.

Integrated Water Resources Management

The Saurashtra groundwater recharging movement can be termed as a unique innovative approach that has transformed agrarian based livelihoods putting into action the so-called integrated water resources management (IWRM), the core socio-technical action being the groundwater recharge. The study has shown that, similar to the localized groundwater draft, recharge too builds up water levels in localized areas, thus reversing the process. Here, the term ‘local’ may well be taken to imply ‘village’ level because all the measurements and computations relate to village. However, for meeting with sustainability and equity concerns as basic principles of IWRM framework, it is important that there is an area treatment (watershed approach as in the study villages), impoundment of volumes of water (check dams, ponds and farm ponds), and connectivity to the aquifers (check dams, subsurface check dams and a smaller overburden with a shallow hard rock as in study villages), and enough hydraulic pressure from the volumes impounded (rivers flow for several months). In the study villages, all these four basic conditions as exemplified in the parenthesis are found to be met with resulting in a continuous inflow into the wells. Further, the overall ‘efficiency’ of the aquifer is also
enhanced, as seen in the study villages, by repeated cycles of extraction and replenishment of groundwater through wells by households for irrigation (Chapter 6); the replenishment is facilitated by the impounded water in the check dams across rivers or streams flowing for many months beyond monsoon. Furthermore, due to general increase in the soil moisture (Chapter 5) over the years, the greenery everywhere has increased significantly, for example, in Ambaredi and other neighbouring villages covered under watershed programme. Put differently, the ecological resilience is put in motion, with the key indicator of flow of water for longer duration in a year being the major driver. The IWRM approach-in disguise on the adaptation canvas of the study villages is another missed opportunity confirming the disconnect of the academic and research institutions with the recharge movement.

**Capitalise the social capital**

Laws, policies and guidelines without critical compliance of the user serve no tangible purpose. At the same time, it is noted that the bureaucracy that formulates these falls short of conviction to ensure compliance. The innovations and experiments that generally happen in the public domain such as the pani panchayat experiment by Anna Hazare, water harvesting and rejuvenation of river by Tarun Bharat Sangh under the leadership of Rajendra Singh and Saurashtra recharging movement (Chapter 2) have succeeded because of the social capital generated which is critical for equity, environmental sustainability and efficiency-the three basic principles of IWRM. The Saurashtra recharging movement has successfully created a mindset for recharge, and judicious use of water followed. The movement has also enhanced people’s ability to cooperate on mutual and communal basis, to share knowledge, skills and experiences for individual and common good. The IWRM becomes more complete if the social capital is properly made use of to dovetail with the research gains by researchers and academics, and supported by policies and policy instruments designed from time to time.

Empowering the community
In the context of groundwater, if the farmers have an idea about the quantum of water that is getting recharged on a year to year basis, village wise, then the cropping decisions they make would bring more economic and environmental benefits. It may appear ambitious to recommend for recharge estimation by farmers in view of the complexity surrounding recharge estimation; however, as shown in Chapter 5, the primary groundwater draft can be estimated using the CRU-NUT_MONTH method when no data is available at local level. This month available on the net (http://www.cru.uea.ac.uk/) has data upto the year 2002 only. For computation of recharge for years beyond 2002, one can use long term average values and the corresponding rainfall. The implementation decisions from rabi (winter crop) onwards would be better for the same year, and sowing decisions for the following year. This of course requires some help from local educated youth, who can be trained. Similarly, if the water level fluctuation can be obtained by farmers with a little training, then the WL & SY yield method can be used to estimate the recharge. In Indian conditions, WL & SY method is relatively easy and can be computed (maybe using a simple MS Excel programme); the results may tend to be slightly on the higher side due to reasons described in section two of Chapter 4.

To sum up, it may be stated that there is no dearth of knowledge, experience or social capital; there is just the dearth of political will and leadership at the governance levels. Decentralisation is a hugely required process set in motion, but empowerment is imperative. The Saurashtra movement has shown that people are raring to go, especially because their livelihoods are at stake. We have a golden opportunity under an otherwise dark cloud.

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