Is It Possible to Revive Dug Wells in Hard-Rock India through Recharge? Discussion from Studies in Ten Districts of the Country

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Abstract

Groundwater exploitation in hard-rock India is leading to high distress amongst farmers. Various water conservation schemes have been tried and piloted, but no idea has scaled up to the national level. An idea of revitalizing groundwater use, individual as it is, and if still individual-based, could possibly succeed. Recharging through dug wells is one such thought. After mass movements in Saurashtra in the mid-1990s, no effort has been made to promote the idea nationally, till now. The current national program on artificial recharge of dug wells hopes to do so. But this idea can succeed only if farmers see any value in it and try to make it successful. A survey of 767 farmers owning dug wells in 10 districts of India shows that there is immense potential in, yet constraints to, dug-well recharge. A comparison of dug-well recharge with the average annual natural recharge over hard-rock areas of 116 mm shows that there is almost an equal potential in recharging groundwater irrigated areas through dug wells. Surveyed farmers also expect a great increase in water availability, especially during the dry seasons. However, farmers are wary of this recharged water flowing across to their neighbors. They expect to gain around 30% from their recharged water, but agree that there would be a common gain by recharging groundwater together with their neighbors. The farmers' estimated cost of Rs 10,000 for the recharge structures is not such a big constraint, nor is siltation, for which they suggest numerous innovative solutions. Managing dug-well recharge locally is critical. Should it become mandatory for farmers to apply in groups of 10, as our sampled farmers suggest? Should the national program be structured such that farmers are transferred the subsidy and they can construct the structures in April or May as they unanimously prefer to do? Instead, should the policy be to promote local businesses around recharge, so as to harness the experience of well drillers, who also operate during the same summer months?

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More such tuning is needed over implementation of the dug-well recharge program to create demand from farmers, catalyze enterprises locally around recharge and establish monitoring programs to measure the benefits from the first upcoming season in 2009 over lakhs of recharge structures.

Introduction

The existence of individual farm-based irrigation facilities has been one important reason for the increase in irrigated areas in India for the past 3-4 decades. Whether the water for this irrigation comes from a reservoir or from the ground beneath, the farmers are at ease when they do not have to depend on a faraway control for irrigating their fields. This facility however comes with its drawbacks. On the one hand, it gives the farmers the luxury of adjusting their times towards their field activities and, on the other, it also puts the entire onus of assuring water availability to the farmers. This was fine in the initial years of groundwater development, but not so now. The boom, peak and burst of the groundwater revolution are now well known. The farmers, especially in the hard-rock regions are desperate. After expectations that arose from rising incomes due to groundwater-based irrigation, they now face prospects of even more investment, greater risk and uncertain yield (NIH 1999). This crisis has led to distress and agony in the farmer community, who wish, but without hope, towards some strategy to salvage their irrigation infrastructure (Janakarajan 1999).

Spreading canals all across this landscape is not a viable option given numerous physical and economic constraints. Debates often travel towards local options for water capture and on that front, numerous efforts have been initiated. But unlike the development of groundwater irrigation as an individual effort, these local efforts at water conservation have been primarily community efforts requiring collective action by a group of people. Hard as it is to sustain such efforts, much energy often goes towards bringing about such community action. Is there any individual alternative by the farmers themselves that can help in water conservation and sustaining the groundwater-based irrigation?

The Central government has initiated the national program for artificial recharge through dug wells in primarily hard-rock districts of the country which also experience a high stage of groundwater exploitation. It is anticipated, over different phases, to utilize several million wells (aimed at 4.55 million) as recharge structures (Shah 2008; Mohandas and Gupta 2009). Most of these wells are located on private land owned by farmers. The recharging of these private wells is being coordinated by state-wide implementation structures that differ from one state to another. Currently, i.e., early 2009, the two states that have gone on an overdrive for this program are Tamil Nadu and Gujarat. Other states are in earlier stages of organizing the implementation structures, identifying beneficiaries and going ahead with execution. By the monsoon of 2009, a few lakhs of wells would be covered by this program. The monsoon will provide us with pointers for testing this idea and its future potential.

The final end point and, in fact, the most crucial point in this entire structure is the well-owning farmers. Once a recharge structure is attached to a farmer's well, utilizing this facility to perform recharge or enhancing and maintaining it in the future rest mainly with the farmers.

What do the farmers think of such a mode of doing recharge with their wells? Do they feel there is a significant potential benefit to themselves (and others) by such recharging? Do the farmers have other models and ideas to contribute?

Should such questions have preceded the implementation of the national program itself? Currently, the program is structured so that there is identification of farmers, transfer of funds and expectation that farmers would construct recharge structures. There is less thinking on how village-level implementation should proceed and what support will be available to the farmers during and after construction of recharge structures.

In the past, success of such mass ventures by the farmers has proceeded only due to innovation by farmers themselves. The Saurashtra well recharge movement, which later on provided a base for community action on the check dam movement, succeeded because of a massive communication program by civil society groups that highlighted the need for water conservation amidst several years of drought. Farmers, charged by the idea went ahead and invested their own money and effort towards constructing recharge structures for their wells. Even today, much experience gained from these experiments in the mid-1990s is helping the farmers in Saurashtra to acquire higher yield of water in different ways (e.g., through horizontal bores, etc.).

If an idea such as having distributed recharge of dug wells across the country needs to succeed, it needs to start from the farmers' need and thinking, and channeling it in this direction. For that, it is first essential to know what the farmers think about this idea and how much benefit they would accrue from it.

Worldwide, the need for enhancing recharge to groundwater started being felt on a large scale in the early twentieth century (Todd 2004), and especially in the US, various experiments have been carried out continuously for many decades. These experiments have established different ways of doing recharge – basin-spreading, stream channeling, well recharging, etc. California in the western US has been a pioneer in artificial recharging. Most of recharging in California takes place through basin-spreading in areas such as the Santa Clara aquifer. There are also well-recharging experiments conducted in the coastal areas to prevent ingress of saline water into freshwater aquifers. The source water for recharge is not only through rainfall runoff but also through imported water supplied by canals as in the case of the Santa Clara aquifer. Interestingly, 2,000 wells in a Basaltic aquifer have been used for recharge in southern Idaho Snake Plains aquifer where the fractured rock provides ample space for recharge. These experiments from the US have given some estimates on recharge rates after experience over several decades. Todd reports some of these recharge rates that generally hover around a few thousand cubic meters per day but with high variation from 200 m^3/day to 50,000 m^3/day.

In the Indian context, water harvesting and the concept of groundwater recharge are deep-rooted in cultural practices (Rosin 1993). Today, many NGOs, private consultants and farmers have been trying out different types of well-recharging efforts. The technologies are highly varied with much action on the ground. However, to have millions of farmers take up recharging on their dug wells requires a massive participation from the farmers themselves. This study has been designed to gauge how farmers themselves perceive the value of their dug wells, if they see recharging as an effort worth enough and how they see the possible benefits from recharging. The purpose is to provide constructive inputs to current efforts in this direction.

The Larger Picture

Before going ahead into issues regarding well recharge, let us look at the large-level potential of this idea. For this we utilize published data from the Central Groundwater Board (CGWB 2004). Nationwide data on groundwater balance on district levels are available from this publication. Using this we have earlier categorized and added layers of similar district-level data to create a large data set on groundwater, agriculture and related information (Krishnan et al. 2007). One of the layers added was the hydrogeology of the district. For our analysis here, we take only those districts which have more than 75% of their area in either Basaltic or Crystalline Granitic formations. In our data set, we have 112 such districts spread across mainly 11 states. The total annual groundwater recharge across these 112 districts is equal to 10,141,965 ha.m and the total area of these districts is 87,342,454 ha. This gives a recharge per unit area of 0.116 m^3/m^2, i.e., 116 mm of recharge per unit area. This is an average value over this entire hard-rock region of the country; therefore, it will show variations depending on regional factors such as rainfall, infiltration properties, etc. However, it gives us a rough number useful for discussion. Note that this recharge is subject to base flows and other natural flows and, therefore, the net available groundwater is a lesser quantity.

Table 1. Dug-well densities in wells/ha of groundwater irrigated area for different river basins.

Cauvery	ERF_Bet_Go_Kr	ERF_Bet_Ma_Go	ERF_Bet_Pe_Ca	ERF_Sca	Ganga	Godavari
0.52	3.69	2.10	1.35	1.33	1.09	2.12

Krishna	Mahanadi	Mahi	Narmada	Pennar	Sabarmati	Subarnarekha	Tapi
0.73	3.52	1.79	0.88	0.36	1.19	2.41	1.14

Now consider a dug well of 20 m depth with a diameter of 8 m, i.e., a total volume of roughly 1,000 m^3. If this well is used as a recharge well and fills to capacity once a year, then the volume of recharge is equal to 1,000 m^3 (we use representative dimensions due to lack of availability of national level data on well dimensions).

Further, we used data from the Agricultural Census 2001 on the number of dug wells. We obtained data from the same 112 hard-rock districts on the number of dug wells and net area irrigation by groundwater irrigation.

Table 1 shows the well densities calculated for each river basin only across the hard-rock districts. The minimum well density is reported for the districts lying in the Cauvery River Basin, i.e., 0.52 dug wells/ha of groundwater irrigated area and a maximum of 3.69 dug wells/ha for the east flowing rivers lying between Godavari and Krishna.

The total number of dug wells in these 112 districts is equal to 4,257,918 supposedly irrigating 5,420,434 ha. No doubt, these data have errors, especially in the data on net irrigated area (Dhawan 1990). But we use these here due to lack of alternatives and to get rough values. The average dug well density is 4,257,918/5,420,434 = 0.78 wells/ha over these 112 hard-rock-dominated districts.

The effective recharge per unit area of this dug well is therefore as follows:

Recharge per unit area = Recharge from single well * well density

That is, 1,000 m^3 * 0.78/10,000 m^2 = 0.078 m, i.e., 78 mm, i.e., 67% of the current recharge.

But what are the assumptions here? We are assuming that this 1,000 m^3 of recharge would have otherwise flowed downstream without recharging into any downstream aquifer. We are assuming that the net base flows or natural flows from recharged water would be the same as before so that there is an increase in water availability with this additional recharge. Also assumed here is that it is possible to recharge using dug wells during storm events, in spite of any water-level increase (by a Hortonian or Dunne mechanism;[2] a hydrologic way of putting a common sense question: "How would water recharge from wells during rains when water level rises so much close to the surface?"), a point which is countered by some observers especially in the hard-rock areas (Kumar et al 2008).

Also assumed are the quality of water recharged through the dug well which if silt-loaded could reduce infiltration through the well. In short, if all these assumptions are valid, we have a potentially powerful idea of using dug wells for recharging the aquifers and augmentation of current recharge by a significant amount. That is, of course, if a lot of wells do such recharging.

Debates Surrounding Dug-well recharge

Discussions surrounding such a distributed mode of groundwater recharge through dug wells center on some key issues:

1. Is there surplus runoff available for recharge through dug wells? Would this water recharge into the aquifer downstream through ponds, etc.?
2. Considering that this recharge water also carries silt load (and agrochemicals) would the pore spaces close to the well get choked?
3. Would we ever have a mass number of recharge wells in place to achieve a significant increase in water availability?
4. During monsoons, when recharged water already saturates the low specific yield aquifers is there more space left at all?

[2]There are two main theories explaining surface runoff in catchments. The classical *Hortonian mechanism* propagated by Horton describes runoff as the excess water beyond the infiltration capacity of the soil (Horton 1945). The infiltration capacity reduces with rainfall and after a sufficient time, it is limited by the vertical hydraulic conductivity of the soil. In this conceptualization, if the rainfall rate is above this infiltration limit, runoff occurs. The classical theory of runoff considers this mechanism to be uniform over the landscape and the varying runoff patterns are explained by the variations in precipitation and in local soil conditions. However, such conditions were observed to be true mainly in semiarid catchments with a deep water table. In field conditions, this theory failed to explain phenomena such as pockets of runoff generation from local depressions and from hollows. An alternative mechanism was proposed by *Thomas Dunne* in the 1970s according to whom runoff occurs when locally the water table rises to the surface (Dunne and Black 1970). Such locations are generally depressions and topographic hollows that are recipients of subsurface flows. In such locations, the water table is locally at the surface and any precipitation has to flow as surface runoff. These two mechanisms: infiltration excess overland flow and the saturated overland flow together explain most types of surface runoff observed in small catchments that finally lead onto larger streams and rivers.

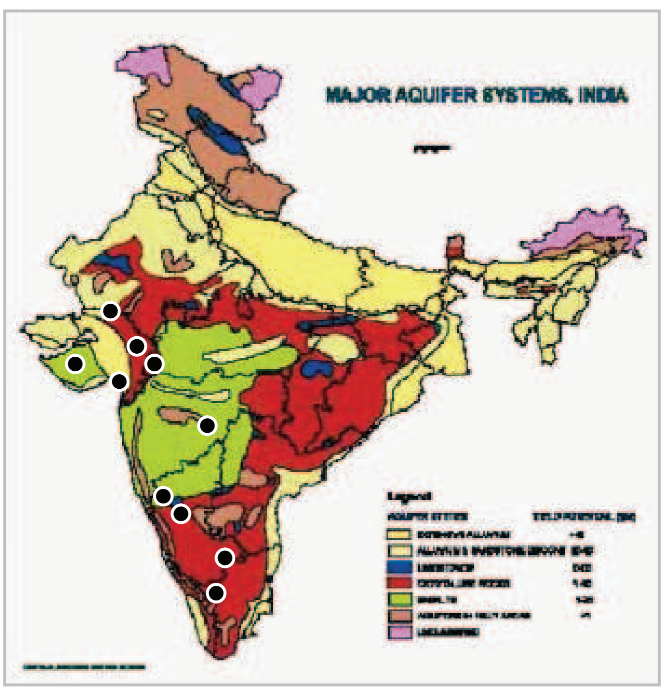
Given such questions, we have designed this study to answer some of them:

1. What are current strategies being adopted by farmers for innovative management of dug wells in hard-rock areas?
2. What potential further exists for innovative strategies such as recharge of dug wells? How do farmers perceive the potentials benefits and risks in such strategies?
3. How can dug-well recharge programs be best implemented in hard-rock areas of the country?

These studies were performed in 10 districts along with partners. Gadag (G) and Haveri (H) districts of Karnataka; Anantapur (A) in AP; Jhabua (J) and Dewas (D) in MP; Rajkot (R) and Khambat (Anand), (K) in Gujarat; Yavatmal (Y) in Maharashtra; Dungarpur (D) in Rajasthan and Dharmapuri (D) in TN with 5 villages chosen at each site. Appendix 1 gives the names/organizations of the research partners for our study. A planning workshop was conducted in mid-December, 2008 to discuss issues and arrive at researchable points. The finalized methodology was designed and fieldwork started by the end of December till the end of January, 2009.

The study areas are all located in either Basalt or Crystalline rock areas of the country except for Khambat, which is a saline-affected coastal alluvium area where the dug-well recharge program of the government is being implemented (Figure 1).

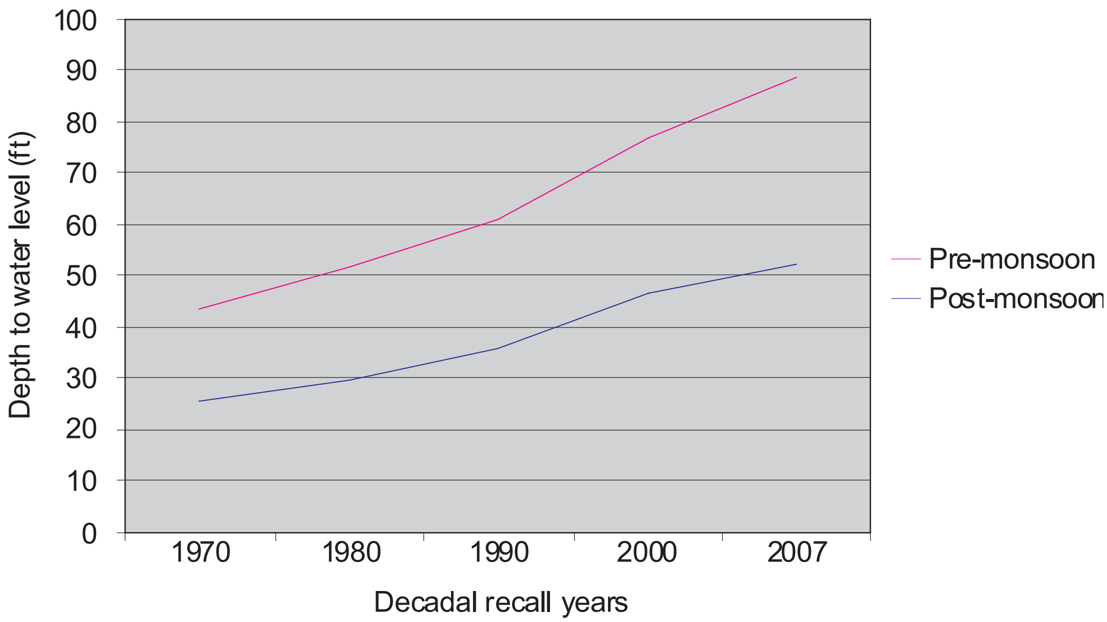
Figure 1. Locations of sites overlaid on the hydrogeology map of India.



Source: Aquifer systems map is from cgwb.gov.in/images/aquifer_map.jpg

Figure 2 shows the trend in average pre- and post-monsoonal depth to water levels over the study sites. These values have been obtained as recollected knowledge during group discussion in each of the five study villages of each site. Since 1970 there has been a steady perceived drop in water levels by roughly 4-5 feet per decade. Along with this, as reported by the sampled farmers, the number of dug wells has increased but has been overtaken by bore wells in the past 2 decades.

Figure 2. Average pre- and post-monsoonal depth to water table in dug wells as reported by group discussion in the study sites in 1970, 1980, 1990, 2000 and 2007 seasons.



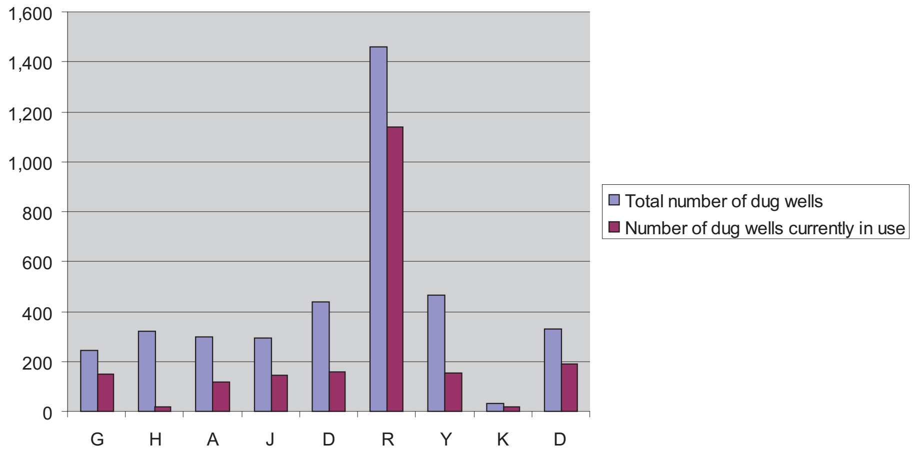
Roughly 42% of dug wells and 48% of bore wells are abandoned. This reflects the massive investment by farmers which has now gone waste because of fall in water levels and greater competition for water from new irrigation wells in the study villages.

Volume of Wells and Perception on Recharge Potential

Data on well dimensions are lacking from any of the surveys conducted by different agencies. Volume of well storage is important in determining the total capacity of recharge possible from wells. However, this alone is not sufficient. The rate of recharge, especially during storm events is crucial. Studies indicate that in some hard-rock areas, the water level shows a sudden rise up to the ground level during rainfall events. This might be due to the Dunne type of runoff mechanism prevailing in such watersheds. In such cases, the rate of infiltration from wells would drop down rapidly and recharge would not be possible till the water level drops down again. Here, we utilize the farmers' own observations of drainage time from their wells to calculate the average recharge rate possible from their wells.

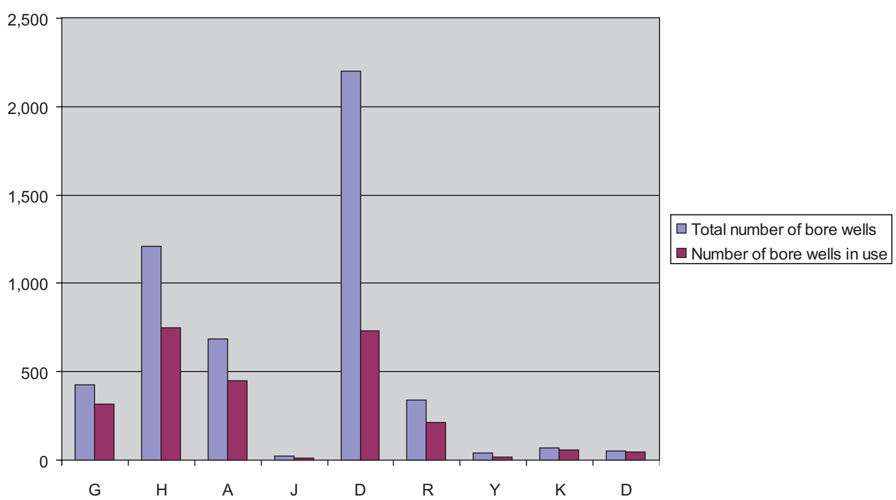
Figure 3. Currently existing and in-use (a) dug wells, and (b) bore wells, for different study sites.

(a)



Note: For both figures 3a and 3b, letters in the X axes denote the first nine study sites given in Table 2.

(b)



We sampled 800 wells whose average depth and average diameter are 41 ft. and 12.6 ft., respectively. There is variation in well size from site to site, with a maximum diameter of 60 ft. in the Haveri District in north Karnataka.

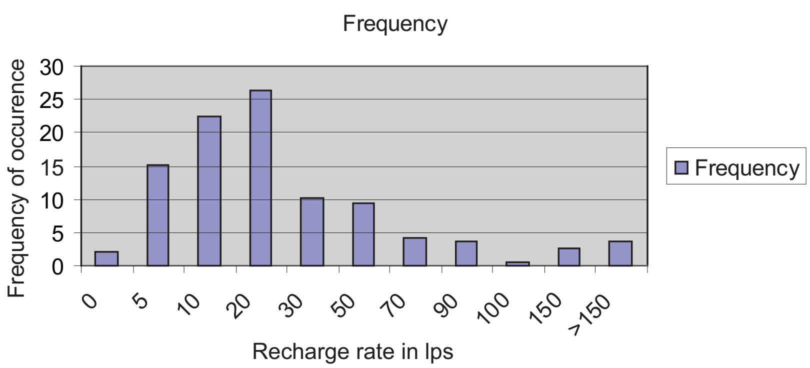
Table 2 shows the volumes of wells in cubic meters calculated from our field studies in eight sites. The average volume from 767 wells is 467 m^3. Also collected is the time it takes to drain out the well completely which is 30 hours on average. The drainage or recharge rate shown in Table 3 is calculated as volume of well/time of drainage.

Table 2. Volumes of wells (in m^3) calculated from different study sites.

Gadag	Haveri	Anantapur	Jhabua	Dewas	Rajkot	Yavatmal	Khambat	Dungarpur	Dharmapuri
327	820	1,067	215	507	192	234	248	327	440

The distribution of reported recharge rates from sampled wells is shown in Figure 4. The reported recharge rates are highly skewed. Since the number is not a typical Cartesian quantity and, in fact, shows a tendency towards log-normal distribution, we take the exp(average(log(Recharge Rate))) instead of the more commonly used simple average that exaggerates the extreme high values (Tarantola 2005). We get this transformed average value as 3.22 liters per second (lps). The minimum average of 2.6 lps was reported from Anantapur and the maximum average of 6.05 lps from Dewas.

Figure 4. Cumulative frequency of recharge rate in l/s from sampled wells.



Athavale (2003) reports a recharge rate of 225 m^3/day (2.6 lps) from a recharge well in central Mehsana in 1983, 192 m^3 /day (2.22 lps) and 2,600 m^3/day (30 lps) from injection methods in coastal Saurashtra, 45 lps from a pressure injection test by the Gujarat Water Resources Department near Ahmedabad city in 1974, 43.3 lps from an injection experiment using canal water in Haryana by the Central Groundwater Board. All these experiments were conducted in primarily alluvial aquifers. For hard-rock aquifers, the National Geophysical Research Institute experiment in Anantapur showed a recharge rate of 40 lps.

As compared to these numbers, Todd reports recharge rates varying from 2.3 lps to 570 lps. It should be especially noted that in hard-rock areas the presence of veins or fractures near the recharge well can carry off the recharge water into a deeper aquifer and can impact the recharge rate to a great extent. The distribution of values of recharge rates will show high skewness across wells.

Table 3. Well recharge rates (in lps) reported from study sites.

Gadag	Haveri	Anantapur	Jhabua	Dewas	Rajkot	Yavatmal	Khambat	Dungarpur	Dharmapuri
3.46	3.1	2.62	3.4	6.05	2.56	1.15	1.63	2.71	4.54

Next we also collect data on the number of times farmers perceive their wells to fill up during the monsoon if recharged. This is a purely estimated quantity since farmers have not yet experienced such recharge.

Table 4. Expected number of times wells would drain out with recharged water annually

Gadag	Haveri	Anantapur	Jhabua	Dewas	Rajkot	Yavatmal	Khambat	Dungarpur	Dharmapuri
0.63	0.715	7.78	3.58	2.5	2.89	1.61	0.96	3.1	2.8

The average number of times of recharge is 2.83. Using the volumes of wells and the number of expected times of recharge, we compute the expected volume of recharge as well volume * expected number of times of recharge.

Table 5. Expected volume of recharge from dug wells (in m^3) annually.

Gadag	Haveri	Anantapur	Jhabua	Dewas	Rajkot	Yavatmal	Khambat	Dungarpur	Dharmapuri
198.27	561.75	8,578	876.73	1,361.93	559.47	363.37	233.403	1,030.18	1,112.17

The average recharge volume of wells is 1,591.62 m^3. Using this average recharge capacity of the dug well in our initial calculation on potential of such recharge, the result is: 1,591.62 m^3 * 0.78 / 10,000 m^2 = 0.124 m, i.e., 124 mm, which come to 7% more than the average current recharge calculated previously as 116 mm. This is a really significant number; in other words, the average recharge over groundwater irrigated hard-rock areas can be increased by over 100%, but as mentioned in the earlier parts of the paper, we can make this statement over several assumptions.

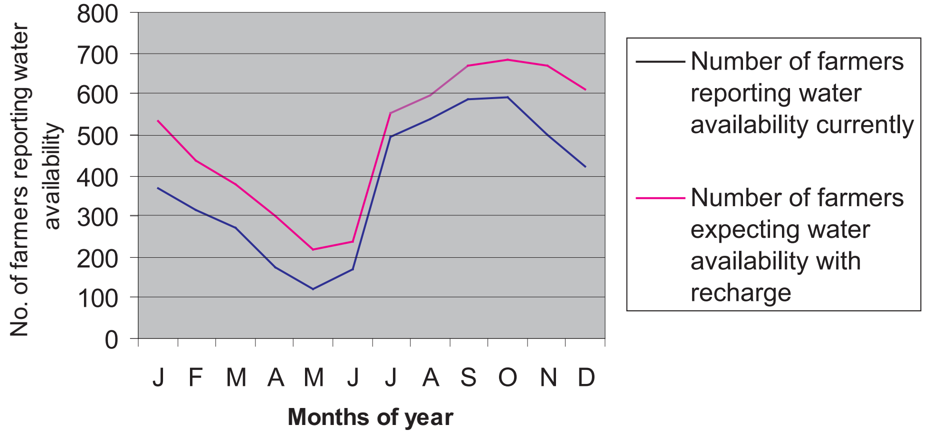
For the 112 districts, if there are 4.25 million wells recharged, then we will have, the following results: Total recharge = 4.25 million * 1,000 **m^3,** i.e., 4.25 billion **m^3** of recharge.

Altogether 101 billion m^3 of recharge are occurring annually over these 112 districts (CGWB 2004), i.e., a net increase of around 4% over this total groundwater recharge. Considering only the groundwater irrigated areas in these districts, we have a total of 9.99 m^3 of recharge occurring now. So we have a potential net increase of 42%.

Next, Figure 5 shows the number of farmers in our sample of 900 who perceive water to be available in their wells in a particular month with and without recharge. On average, there is a 36% increase in the number of wells which are expected to increase water availability with recharge. This increase is more in the dry seasons than in the wet seasons. It reflects more the need that people wish with the recharge, and less with what would actually happen.

What is sure from these expected potential benefits of recharge is that there is a demand from farmers for such an option. The numbers reported here are perceptions and results of a survey and are therefore not to be taken as actual figures. However, in the face of lack of such information, this is the best we have, at the least indicating the farmers' potential hope with dug-well recharging.

Figure 5. Number of farmers reporting water availability in their dug wells currently and with recharge



The question now is what are the constraints to going ahead for recharge? Why are farmers not implementing recharge structures by themselves when they come to know about them? As compared to the cost of enhancements to the well, such as deepening and boring, the cost of constructing a recharge structure is not too high. If the farmers feel that this would be beneficial, they would have gone ahead by themselves. So, what prevents them from doing so?

Constraints to Implementing Recharging of Dug Wells by Farmers

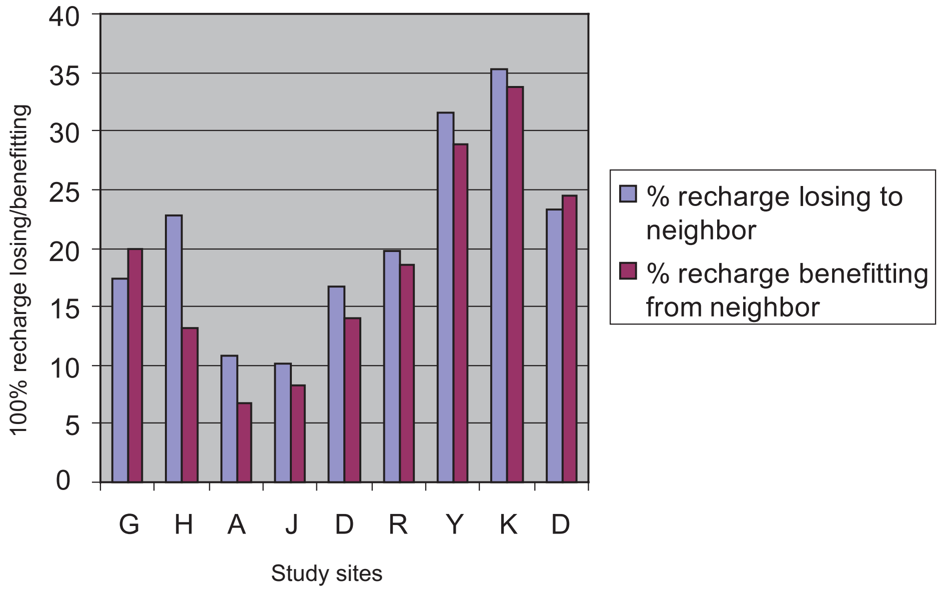
One constraint to farmers adopting dug-well recharge is their perception about whether the recharged water would be available to them for pumping. Naturally, if there are conduits for water to flow across to other nearby wells, they would be disinclined to recharge. This was evident from our survey. Moreover, if there are deeper wells nearby, one would be less inclined to recharge.

Our sample of 767 farmers feel, on average, that their water yield reduces by 16% on average and the level of their well water goes down by 4 ft. when their neighbors pump from their wells. Therefore, there is always this perception of sharing a common aquifer; this perception is carried over to recharging too.

Except for one, all sites see a greater expectation of loss of water to neighbors rather than gain from neighbors by recharging. In general, there is no reason to expect this over a reasonably large data set, but here we see a common trend (except for the first site) of greater expectation of loss. This is a sure impediment to recharge. Unless the neighbors also recharge, the present farmers would not take much effort towards recharging.

There is wide variation over the well construction and estimated costs of well recharge structure which average to around Rs 10,000, i.e., Rs. 6.28/m^3 of annual recharge (from previous calculation of average recharge = 1,591.62 m^3/well). That itself is a significant investment since the returns from recharging are not as directly evident as those from, say, well deepening. There is always the risk that the water that is being recharged would not be available to oneself. Further, around 60% of the sampled farmers report that the water collection points in or near their farms lie above (in terms of elevation) their wells. This means that either they use a field channel or more surely, make arrangement for underground boring to transmit water to their

Figure 6. Expected percentage loss of recharged water to neighbors or benefits from neighbors across different sites.



Note: The letters in the X axis denote the first nine study sites given in Table 3.

wells. Such types of underground boring to transmit water to the wells for recharging have been in vogue in parts of Saurashtra. But that involves a further investment of say, Rs 5,000, or more. Around 45% of the sampled farmers report that they would require investing on such type of underground boring and pipes.

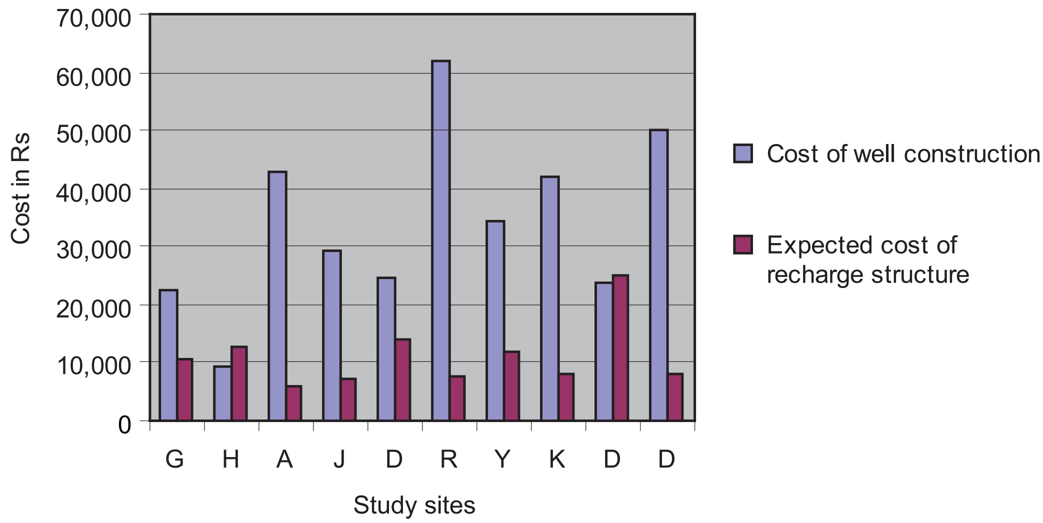
An unexpected problem reported by farmers is the possible caving in of the well, especially in unconsolidated formations. Some farmers feel that since the recharged water falls to the bottom of the well from a height, it could deepen the sides of the foundation of the well resulting in caving in of the well. In this context, care has to be taken to let the water flow along the sides of the well so that it does not create an impact at the bottom.

Siltation is reported as a potential problem by 67% of sampled farmers. But they also mention numerous innovative ways to counter siltation, e.g., using mosquito nets, planting thorny shrubs to capture waste, small bunding to arrest direct transport of silt, etc. Farmers seem confident that siltation, though a problem, can be countered.

All these are reflected in the choice of farmers when asked what they would do with Rs 4,000. Around 45% of farmers chose recharging, while 43% chose to deepen their wells. Well deepening is psychologically an accepted proposition for an individual private well owner to invest in for increasing well yield. On average, farmers in our sample have spent Rs 16,200 for well deepening.

Here some points of comparison can be made between recharging and well deepening as investments for increasing well yield. The more the farmers invest on wells the greater the increase of their risk. Each additional investment is a sort of "protection" for all earlier investments made on the well. There is always a chance that with one additional deepening, the well yield will suddenly increases significantly. The farmer is playing a risky game, and with each additional investment, the game gets riskier. Additionally, the larger the number of farmers investing in deepening the greater the reduction of the benefits to individual farmers.

Figure 7. Reported average costs of well construction and average estimated local costs of recharge structures.



Note: The letters in the X axis denote the study sites given in Table 3.

This logic gets reversed in the case of well recharging. If farmers recharge instead of deepening, there is increasing individual benefit when more farmers recharge. One gains when others invest too. Up to a limit, there is decrease in risk with each additional investment.

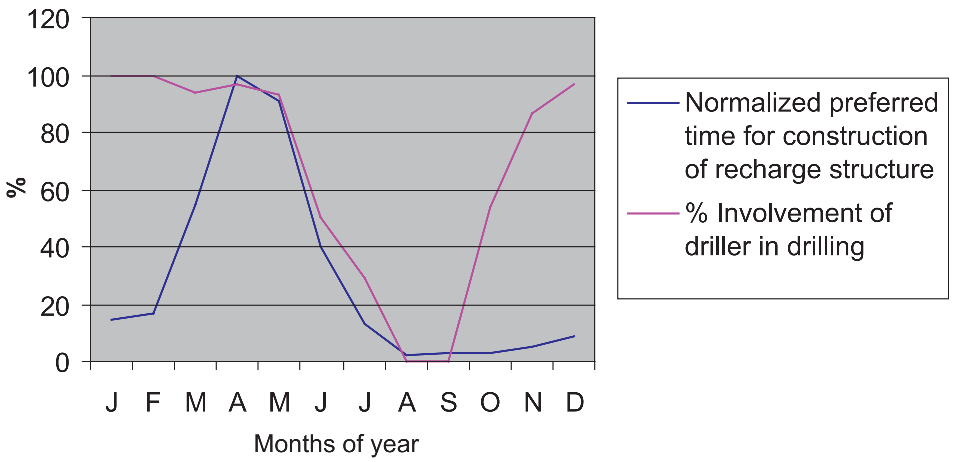
Therefore, the economics of well deepening and recharging are diametrically opposite to each other. Somewhere there is a balance, which is currently tilted towards well deepening. The stage is therefore set for more recharging.

Management of Recharge Structures

Perceiving recharging as one means of resuscitating dry or semidry dug wells, it seems possible that the current mode of implementation of the national program on artificial dug-well recharge would face some constraints. To begin with, expecting individual farmers to construct recharge structures with a subsidy of Rs 2,000 or Rs 4,000 means that the program has sufficient interest in the farmers. Enabling recharge is not just about constructing the structure, but also making flood water pass through it, cleaning the structure of silt and other waste that collect near it and making repairs when required. All these need a proactive farmer who sees a benefit, common if not personal, in recharging.

As opposed to just 20-30% of benefit if a neighboring well recharges, almost all farmers agree that if they as well as their neighbors recharge there would be benefit to all of them. Further, 93% of sampled farmers felt that it would be good if farmers applied for recharging as a group, even though they implement it individually on their wells. They reported that an average of 10 farmers should apply together for recharging. The number 10 probably comes form their intuition of finding a balance between the hassle of arranging a group application and the benefit of larger numbers of farmers recharging together.

Figure 8. Comparing preferred time for constructing recharge structures and times of well construction.



Farmers are also accepting alternative ideas for recharge. Gujarat farmers in our sample were already practicing recharging of dug wells using canal water. This was very much so in the Mahi tail command area of Khambat where the Irrigation Department has innovated a unique mode of water distribution through underground sumps. The canal water is used by farmers for recharging their dug wells, a practice being followed for at least a decade. On average, farmers reported that they could spend up to Rs 5,000 towards pipes and other material, if there was a scheme at recharging their wells through canal water. However, such a scheme is not possible at many places since such canal water is not available everywhere. Mention must be made here of a similar mechanism of water distribution being followed currently in the Sardar-Sarovar command area of Gujarat where farmers have been spending as much as Rs 1,000-5,000 per ha towards pipes and pumps for accessing water from the branch and minor canals.

The timing of constructing recharge structures is also critical. The structure needs to be constructed before the monsoon, before a sufficient period so that there is time for the concrete to cure and stabilize. April was reported to be best month for constructing recharge structures and, on average, 12 days, were reported as necessary to construct the structure. April is also a time when construction of wells is at its peak. This brings us to an interesting link between well construction and well recharge. Figure 8 compares the relative yearly schedules of well drillers with the reported preference of farmers for constructing recharge structures. The graph points to April as a time when drillers are engaged in well construction, so why not involve them in constructing recharge structures too?

We interviewed 30 drillers across the sites about their views on recharging as an option for dug wells. Interestingly, drillers too report an average of around Rs 10,000 for constructing the recharge structures. They slightly prefer May to April as the best time for constructing the structures, and suggest a higher number (22, on average) of farmers to recharge together for getting greater benefit, perhaps discounting the hassles in group applications by farmers. However 2/3 drillers showed interest in participating not only in taking up constructing recharge structures as a business but also playing a role in monitoring them and seeing the impact from the monsoon. On average, they report the need to charge Rs 8,600 for constructing a recharge structure and also showed interest in getting trained on these aspects. Well drillers, especially in the hard-rock areas, show a high sense of local knowledge in their areas as shown by previous studies (Krishnan 2008; Krishnan et al. 2009): so why not utilize their expertise towards a natural extension of their profession?

What is the best way to do recharge? How much common benefit will it result in? What is the best way to implement the program at the village level? These questions need to be asked more to check the worth of this idea. If it works, farmers will pay and take it up by themselves. Probably the monsoon of 2009 will answer some of these questions.

Thoughts and Ideas

Whether localized governance of groundwater in hard-rock areas is to be pursued is probably not a question today. How to do it comprises the important questions: through pricing (water, energy), legal regulation, or community institutions? Whatever the framework, whether as a combination of these ideas, water supply augmentation and demand management are both to be taken care of, directly through regulation or through indirect instruments such as pricing. Recharge of dug wells offers one option for local augmentation of water supply, an option that deeply involves the ultimate stakeholders, the farmers. Through this mode of supply augmentation by their own efforts, they would perhaps get attuned to thinking about demand management. So far, groundwater has always been sourced from recharge naturally through rainfall or ponds, or from canals. But once the farmers get involved in water supply, it could change their thinking forever. In that vein, recharge of dug wells should be seen within the broader framework of how to address groundwater governance locally and not in isolation.

Records of dug-well recharge could also potentially become an instrument where the records of millions of dug wells can be sequenced and maintained in a database which can be accessed. It could be a means of information exchange from, and to, the farmer. Crucial hydrogeological and hydraulic data can be passed by the farmer, whereas, scientific and policy information can be passed down to the farmer. If this idea is utilized towards these objectives and strengthened through appropriate institutions at different levels, then there is much that can be gained through this program. Dug-well recharge can be the backbone of a mass scientific experimentation involving millions of farmers and giving an opportunity to test many of the new ICT innovations. The Tamil Nadu recharge program is attempting a bit in this direction by maintaining electronic records and hoping to get constant feedback from farmers.

However, in this discussion on dug-well recharge, we should not forget the other competitive ideas which are also being tried today: group-owned wells in tandem with recharge ponds, bore-well recharge, small to large surface water harvesting structures and underground dykes – the list is endless, as many as the different groups that have been experimenting with these ideas. As mentioned earlier, instead of losing ourselves in just one of these possibilities, we need to think on the broader context of how they all fit together, what is relevant where, and how they will enable supply and demand management of groundwater locally.

A last note should be made of uncertainty – both epistemological and experimental; i.e., from methodology as well as data. Within this study, especially when we sample just a few hundred wells out of millions, the question arises of sampling and representativeness of the sample. This, we try to counter slightly, but certainly not in its entirety, by taking two data sets, one over a national level (that is close to being exhaustive, but error-prone), and the other of our own sampled data that have better control of data errors. We have attempted to utilize both these data sets in order to support the analysis in this paper.

The next question on uncertainty and perhaps more important is on methodology. Looking at the physical context, a unit of aquifer of watershed and a time scale observation of a few seasons are essential to make any statement of reasonable accuracy. In hard-rock areas, especially, there have been research groups which have worked on a single 1 km^2 plot of fractured rock for decades in arid Arizona to finally conclude very high uncertainty. Here, we have relied on localized farmers' and well drillers' knowledge gathered through years of observation, but who have had no scientific training. As such, it is subject to opinions, perceptions and biases as opposed to the more objective, repeatable and potentially error-minimizable nature of scientific data. Neither is one a substitute for the other, only complementary. We have therefore, tried to refer to scientific studies and utilize them as much as possible. Any additions on that front would be valuable.

Appendix 1. Research partners for the study.

Site	Research partner
Gadag	Navchetana Rural Dev Society
Haveri	SCOPE
Anantapur	Hirudia Raj
Jhabua	GATE
Dewas	GATE
Rajkot	SAVARAJ
Yavatmal	Vivek Kher
Khambat	INREM, Upen Mahida
Dungarpur	PEDO

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