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Hydrological opportunities for water harvesting and recharging vary significantly from year to year in accordance with the variation in excess runoff from catchments. For groundwater recharging to be efficacious, artificial recharge systems need to be designed and built properly so as to put runoff water directly into the aquifer.

Groundwater availability and land use pattern affect the technical feasibility and economic opportunity for adoption of different water saving technologies. Pressurised irrigation systems would find greater acceptance among resource rich farmers who are not able to irrigate their entire field, or farmers who have low yielding wells. Micro-tube drip systems and sub-surface irrigation systems are more suitable for water buyers and partners in tubewell commands.

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Water Policy Research

Highlight

Micro Management of Groundwater in North Gujarat

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Micro Management of Groundwater in North Gujarat[1]

RESEARCH HIGHLIGHT BASED ON A PAPER TITLED:

"MICRO MANAGEMENT OF WATER IN NORTH GUJARAT: ISSUES, PROSPECTS AND DIRECTIONS FOR FUTURE"

North Gujarat is experiencing severe groundwater overdraft conditions caused mainly by indiscriminate pumping. Groundwater is, by and large, the only source of water for agriculture and dairy farming, which form the backbone of the rural economy. Government interventions to arrest the decline of groundwater and mitigate its effects through decentralized water harvesting initiatives such as desilting have met with little success. Recently the government planned to take up large-scale promotion of pressurized irrigation technologies. However, this is not based on sound understanding of the micro conditions that determine the scope and limitations of these technologies. Analysis shows that there are severe constraints in local water harvesting due to high year to year variations in excess runoff rates and small catchments. Also, most farmers in the alluvial areas of north Gujarat have no incentives to adopt the energy-demanding, pressurized water saving technologies owing to their "water surplus" and "energy starved" situation.

Figure 1: Alfalfa is the Backbone of the Dairy Industry in North Gujarat

The IWMI-Tata action research project on sustainable groundwater management, launched in 30 villages of Banaskantha district in north Gujarat, aims to evolve supply and demand based alternatives for sustainable groundwater use in the region.

CONSTRAINTS IN PROVIDING RELIABLE LOCAL SUPPLIES

There are 40 ponds in 19 of the project villages, which are the locally available water harvesting systems. Village ponds normally integrate very small catchments. According to a study carried out by Tahal Consultants for the government of Gujarat, the average mean runoff potential from a 1.0 sq. km catchment with 50 percent dependability will be 0.06 MCM (60,000 m^3) for north Gujarat. The runoff in poor rainfall years (having more than 50 per cent dependability) will be far less than 60,000 m^3.

Constraints to Supply Augmentation in Banaskantha:

- Small catchment areas available for village ponds
- Low runoff potential with high inter-annual variability
- Lack of free catchment areas upstream of Dantiwada and Sipu

[1]The research covered by this IWMI-Tata Research Highlight was carried out with generous support from Sir Ratan Tata Trust, Mumbai under IWMI-Tata Water Policy Programme. The research paper can be downloaded from the IWMI-Tata Website http://www.iwmi.org/iwmi-tata.

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Figure 2: Desilting in Progress in a Village in Mehsana, North Gujarat

High spatial variation in the mean annual rainfalls, with corresponding variation in the runoff rates, is another issue. The mean values of 50 percent dependable runoff will be low in low rainfall areas. Again, there is higher inter-annual variability in annual rainfall in areas of low mean annual rainfall. For instance, the coefficient of variation (CV) in rainfall is 48.7 percent for Danta which has a mean annual rainfall of 795 mm, while it is 53 percent for Vadgam, which has a mean annual rainfall of 648 mm. Moreover, the gradient of the runoff dependability curve will be high in low rainfall areas. Due to these two factors, the runoff corresponding to high dependability will be extremely low in the region. The very low surface water potential is one major constraint for local water harvesting for direct uses in irrigation. Now let us take the case of Palanpur, which has a mean annual rainfall of 682.2 mm with a CV of 353.6 mm. In one out of six years, the rainfall would be less than 328.6 mm. The runoff corresponding to this rainfall is only 0.0225 MCM per sq. km, which is hardly sufficient to irrigate 4 ha of land.

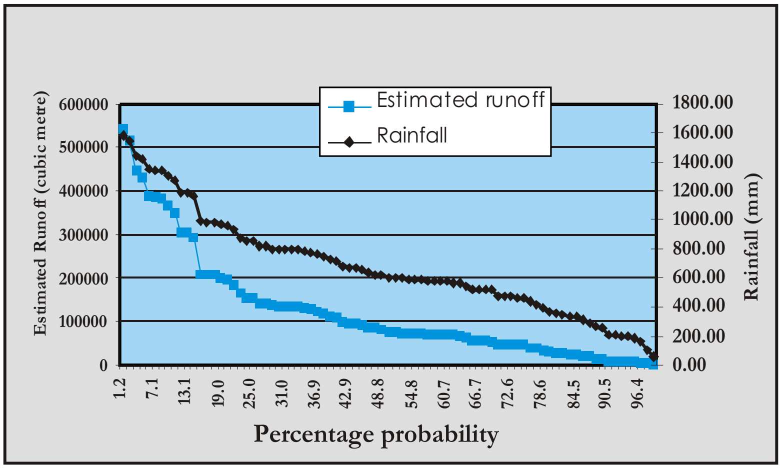
The existing irrigation schemes also pose constraints for building new water harvesting schemes in good catchment areas of the region. The potential for local water harvesting is low in the upstream of the catchment areas of Dantiwada and Sipu. There are several villages falling in the upper catchment of these two schemes in Dantiwada taluka. Building of water harvesting structures could lead to reduction in flows to the reservoirs, except in very high rainfall years during which the reservoirs overflow. However, analysis shows that such years are very low in these situations as the reservoirs are designed for runoff of very low dependability (below 50percent). Owing to the poor reliability of water supplies from local systems, they are not suitable for drinking water supplies.

Hydrological Opportunities for Augmenting Groundwater

On one hand, the high inter-annual variability in rainfall and runoff reduces the reliability of local water harvesting systems, on the other hand, it increases the hydrological opportunities for these systems. The excessively high runoff in some of the years increases the potential of local water harvesting systems in terms of the amount of runoff that is available for harnessing.

For instance, in Palanpur, once in every six years, we can have a minimum rainfall of 1035.8 mm. For this rainfall, a one sq. km. catchment yields a runoff of 0.23 MCM. Thus, the quantum of

Figure 3: Probability of Occurrence of Rainfall and Runoff



water, which is generated from 100 ha catchment, with one-sixth probability is sufficient to irrigate nearly 46 ha in one season. The rainfall and estimated runoff with different probabilities of occurrence are given in Figure 3. Large potential for water harvesting exists downstream of Dantiwada and Sipu reservoirs in Banaskantha district, as they are free catchments.

In areas such as Danta in the eastern hilly tracts of Banaskantha, the minimum runoff that will be generated once in six years from a one-sq. km catchment will be as high as 0.559 MCM, which if captured underground can irrigate an additional area of nearly 110 hectares.

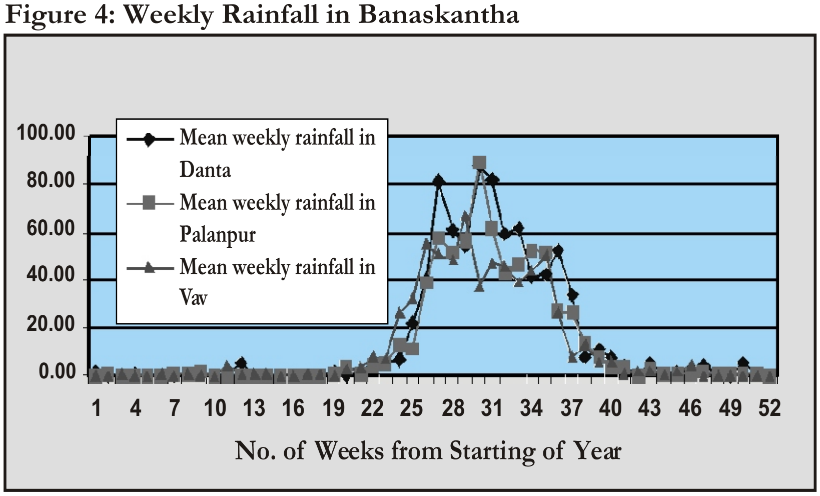
The deep unsaturated zones in the depleted alluvial aquifers provide excellent opportunities for recharging. This is complemented by the sandy soils, and the presence of local ponds that act as sink for the local sheet runoff. But, at present only desilting is practiced. This is not sufficient for getting optimum recharge of the stored water. During high rainfall years, the runoff generated even from a small catchment of 100 ha will be extremely high. This runoff is generated in a small amount of time given the fact that high rainfall events that generate runoff are very few, as indicated in Figure 4.

The storage capacity of village ponds, e which are generally of the size of 0.01 to 0.05 MCM (1 to 5 ha), will be too insufficient to capture all the runoff. The rate of percolation of water through the soil zone will be low. Also, owing to the large depth to groundwater table, a good fraction of the water while percolating down through the dry soil zone (vadose zone) will get absorbed by the soil particles as hygroscopic water. Therefore, recharge tubewells are required to increase the rate of intake of water. They can link the water in the pond to the aquifers that are tapped.

Constraints for Adoption of Water Saving Technologies

Irrigation accounts for 90 percent of the diverted water in north Gujarat. The most water intensive crops here are alfalfa, wheat, castor, cotton, and st bajra. Groundwater is the largest source of irrigation (92 percent). Wheat takes the largest share of pumped groundwater (1492 MCM), followed by castor (1186 MCM). The pattern is more or less same in Banaskantha district. The two most common water saving technologies are overhead sprinklers and conventional drips. These pressurized systems need additional pressure (1.5 kg/cm^2) to run. The additional energy required for irrigating one ha of wheat with overhead sprinkler or

Figure 4: Weekly Rainfall in Banaskantha



Who will be Ready Adopters of Water Saving Technologies?

- Farmers in hard-rock areas having wells with poor discharge rates
- Farmers with large landholdings but insufficient water
- Well owners having residual pressure in their well outlet
- Farmers in areas where power availability is abundant with respect to groundwater availability

micro sprinklers would be 290 kWh. The cost of supplying this electricity is nearly Rs.1200 but the farmer will have to pay an additional Rs.1750 as the pump capacity requirement would go up by around 3.5 HP with increase in discharge. Since, farmers pay for electricity on connected horsepower they show unwillingness to any addition to pumping capacity.

There are varieties of situations in the project area which determine the actual incentives for farmers to go for pressurized irrigation systems. First, there are situations where the installed pump capacity on the farmer's well is more than the pump capacity required for lifting water to the surface or overhead tank and there is residual pressure in the well outlet. In such situations, the farmer will have incentive to go for pressurised irrigation systems.

A very common situation is when the farmer ses purchases water from a well owner or he is a partner of a tubewell company. In such situations, the additional pump capacity requirement would go up in accordance with the well discharge. Also capital and operating cost of pump per unit area increases with reduction in area under operation. Therefore the incentive to go for pressurized irrigation system will be much lower for small and marginal farmers.

Overhead sprinklers, which are movable, benefit those farmers who have larger holdings, but the percentage of farmers having large holdings is small. However, there is also the advantage of using the additional pumping capacity. The farmers, by being able to maintain the gross well outputs, can irrigate a larger area which provides a strong incentive to go for pressurized irrigation systems. An important constraint in adoption of pressurized irrigation systems is the inability of tubewell partners and water buyers to irrigate frequently, which is vital for enhancing water use efficiency. A large number of farmers do not own independent wells, and are either water purchasers or partners in tubewells (Figure 5).

People are more inclined to augment supplies by building water harvesting structures to solve local water problems and they hardly appreciate the importance of demand management. There is a general lack of awareness about water saving technologies among farmers. For instance, most farmers feel that sprinklers cannot be used for crops, such as mustard, *bajra*, and *jowar* which is

Figure 5: Wells vs. Operational Holdings

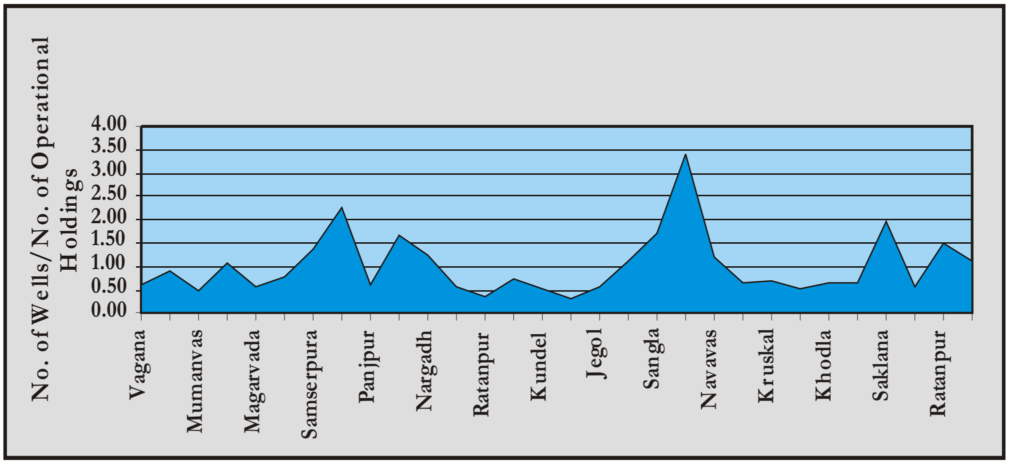
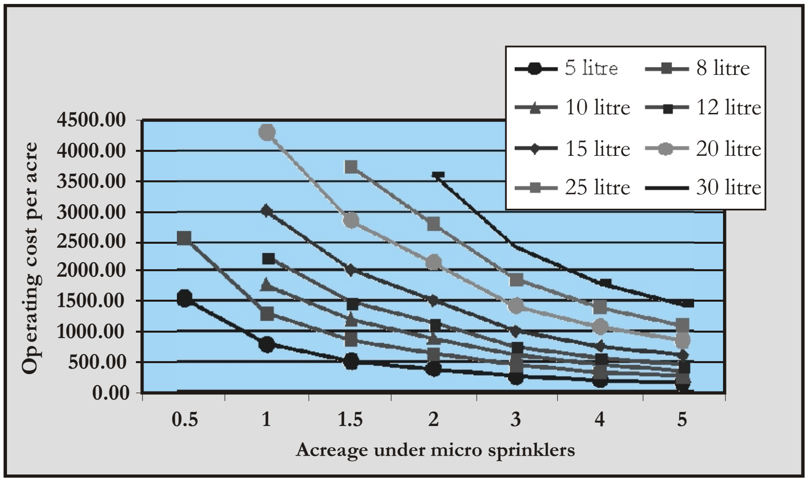


Figure 6: Estimated Unit Operating Cost of Micro Sprinklers for Different Discharges and Areas



not true. The political economy of subsidies in water saving technologies has also contributed to this situation. Many farmers have purchased sprinkler systems just to avail of the benefits of the government subsidy. Since the government pays the subsidy directly to the manufacturer, the farmer gets the systems at a discounted price and manufacturers have no incentive to develop cost effective technologies.

Drip irrigation systems are the best in terms of enhancing water use efficiency. They are best suited to horticultural crops and row crops like castor, cotton, and *variali* (fennel), commonly grown in the region. But the farmers do not ain maintain correct spacing between plants and rows which is essential for proper functioning of drip systems.

Physical Opportunities for Adoption of Water Saving Technologies

In villages where groundwater occurs under hard rock conditions, open wells and dug-cum- bore wells are used for irrigation. These wells have poor yield characteristics and run for 2-3 hours a day, much less than the hours of power supply. This is the most ideal situation for adopting water-saving technologies. Farmers can go for overhead sprinklers for crops such as wheat, bajra, jowar, mustard, and elephant grass. Micro sprinklers and mini sprinklers would be suitable for alfalfa, which almost every farmer grows. Drip systems will be feasible for crops such as castor, fennel, cotton, chilly, and brinjal.

For large farmers having their own independent wells, but not sufficient water, conventional pressurized irrigation systems would be technically and economically feasible. In alluvial areas where the wells run continuously and restricted power supply limits the area under irrigation, if the farmer

Figure 7: An Overhead Sprinkler in Action

installs an additional pump, he will be able to irrigate much larger areas with pressurised irrigation technologies.

Sub-surface irrigation systems and micro-tube drip systems do not require pressure head to run. These non-conventional water saving technologies are technically feasible for tubewell partners and water buyers.

What would Work in Banaskantha?

Recharge ponds in alluvial areas need to be designed to capture the excess runoff that occurs during high rainfall years. Installation of recharge tubewells could help take water from the pond directly to aquifers, and increase the water capturing capacity of the system. The water draining from the local catchments of village ponds carries a lot of biological matter, including human and animal waste. This could cause major health hazards as groundwater could get contaminated with nitrites. Catchment areas of village ponds need to be cleared, protected, and vegetated. Watershed management activities need to be taken up in the hilly upper catchments of the Banas river basin in Danta and Dantiwada talukas.

Figure 8: Micro-tube Drip System Irrigating Vegetables

What Would Work in Banaskantha?

- **Installation of recharge tubewells** to take water directly to the aquifer and increase water capturing capacity of the system
- **Vegetation and Protection** of catchments of village ponds and watershed activities in the hilly upper catchments of Banas river basin
- **Sub-surface and micro-tube drip** irrigation systems for water buyers and partners in tubewells
- **Pressurised irrigation systems** for farmers with independent tubewell that are unable to irrigate their entire land area.

Pressurized irrigation systems would find greater acceptance among resource rich, large farmers who have independent irrigation sources, but are unable to cover their entire command with traditional irrigation practices and farmers who have poorly yielding wells, and are not able to utilise power supply fully. Pressurised systems will find the least acceptance among farmers whose irrigation sources have abundant supply potential, but are constrained by power supply.

Sub-surface irrigation systems and micro tube drip irrigation systems will make sense for water buyers and partners in tubewells. Sub-surface irrigation systems could be used for all row crops. Though they are very expensive, during droughts, regular water buyers would be inclined to go for these systems.

The opportunities available for generating higher returns from water efficient irrigation technologies would depend a great deal on agronomical practices. In the case of pressurised irrigation technologies, since energy overheads are more for small plots, small and marginal farmers will have to make higher investments in agronomical practices like mulching, use of organic manures, and proper spacing of plants, which in turn can help improve water and land use productivity.

IWMI-Tata Water Policy Program

The IWMI-Tata Water Policy Program was launched in 2000 with the support of Sir Ratan Tata Trust, Mumbai. The program presents new perspectives and practical solutions derived from the wealth of research done in India on water resource management. Its objective is to help policy makers at the central, state and local levels address their water challenges – in areas such as sustainable groundwater management, water scarcity, and rural poverty – by translating research findings into practical policy recommendations.

Through this program, IWMI collaborates with a range of partners across India to identify, analyse and document relevant water-management approaches and current practices. These practices are assessed and synthesised for maximum policy impact in the series on Water Policy Research Highlights and IWMI-Tata Comments.

The policy program's website promotes the exchange of knowledge on water-resources management, within the research community and between researchers and policy makers in India.

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