Towards Greater Accountability and Efficiency in Groundwater and Energy Use in Indian Agriculture

Initial Report from a Field Pilot in Gujarat, India

Ram Fishman, Vijay Modi, Kapil Narula, Sahil Gulati, Sandeep Mahajan, Nikunj Parekh, Dishant Patel, Ankur Patel, Anil Kumar Rohila, Upmanu Lall

Overview

Indian agriculture is heavily reliant on groundwater and on the energy required to pump it. The World Bank estimates that 70% of agricultural production and 50% of the population depend on this resource (World Bank, 1998), and groundwater pumping is estimated to be responsible for large fractions of electricity consumption (nationally, this share is estimated at around 20%, and in some water intensive rural areas like North Gujarat it can exceed a staggering 50%.

The economic and environmental sustainability of this enterprise is now increasingly doubtful. Water table declines are pervasive (Fishman et al, 2011; Fishman, 2011; Shah, 2010; World Bank, 2010) and groundwater pumping is blamed for much of the unaccountability and inefficiency of the energy sector (Morris, 2006; Planning Commission, 2011). Given the importance of irrigation and power for India's development, the groundwater-energy crisis is a major constraint to sustained growth. Despite this, the technological potential to increase water use efficiency (and thus reduce energy and water usage without compromising agricultural production) is still not being utilized by India's farmers. For example, about 95% of farmers still flood their fields through open channels (Indian Ministry of Water Resources, 2001). The source of irrigation has shifted dramatically to groundwater over the last two decades, facilitated by non-metered provision of electricity and the ability of each farmer or group of farmers to develop wells with little regulation of well capacity or aquifer yield assessments.

This lack of accountability and the widespread agricultural electricity subsidy is responsible for this crisis. Most agricultural electricity consumers in India are not metered and are charged for the electricity they use to pump water at a low and flat rate, if at all. Since groundwater is itself not regulated in any way, farmers face no marginal cost on groundwater usage. Attempts to restore metering and the full pricing of electricity in agriculture, however, have consistently failed for political reasons (Dubash 1997: Morris 2006), leaving policy makers with no real policy tools with which to address the crisis, other than rationing the power supply, leaving debilitating effects on other sectors of the economy. And while the Indian Electricity Act, 2003, calls for universal metering of all consumers, none of the groundwater use-intensive states have yet been able to achieve this goal. This is due to the fact that farmers in these areas have been resistant to attempts to meter their water use for fear of being billed for excess water use, thus increasing their input costs.

Against this background, a novel policy mechanism to introduce metering and incentivize water and energy use efficiency was recently co-piloted by the Columbia Water Center (CWC), the Government of Gujarat, and the Northern Gujarat Utility Company (UGVCL). Recognizing the political difficulty of charging farmers the full cost of electricity, the mechanism indirectly introduces a marginal cost, by transferring to farmers financial savings (in generation costs) that result from voluntary reductions in usage. These reductions are calculated against a baseline allotment that is calculated on the basis of each pump's horsepower (all farmers receive power for an equal, rationed duration), and were rewarded on a per KwH basis.

The study area is perhaps one of the most severely groundwater depleted locations in India (Columbia Water Center, 2010). Contrary to prevailing beliefs, the pilot, which was launched in April 2011, has shown that a majority (75%) of about 115 eligible well owners were willing to be metered in order to participate in the study, and that meters were not tampered with. This is a policy breakthrough with potential implications for large parts of India: for the first time in decades in groundwater scarce parts of the country, a public utility was able to effectively meter farmers' electricity usage and bill them on the basis of this usage, all on a completely voluntary basis. In the mean time, significant numbers of farmers received the incentive based on consumption below the baseline.

Study Area

The study area is located in one of the most groundwater depleted parts of India. Water tables are as much as 250 meters deep, having declined at a rate of 3m/a over the last three decades. Borewells now reach as deep as 300m and require pumps of 60-70 HP to lift water (Columbia Water Center, 2011). More than 50% of power supplied by the regional utility, UGVCL, is used for pumping groundwater. Our field measurements showed usage of up to 10,000 units (KwH) per hectare of irrigated land annually, several times greater than reasonable estimates of the national average. At such depths and energy intensity, the value of the energy used for pumping water may become comparable to the net value of the crops that are irrigated with it.

Pilot Design

UGVCL and the Government of Gujarat (GoG)chose a conservative architecture for the pilot. The compensation rate was chosen at a modest 2.5 Rs/unit (a unit is one KWh) that reflects UGVCL's power procurement costs. By comparison, agricultural consumers in the area currently pay a flat rate that averages out to about 0.5 Rs/unit, most non-agricultural consumers are charged at a rate of above 4 Rs/unit and the real cost of power supply is closer to 5 Rs/unit (Planning Commission, 2011). The real social cost is higher still because of the impacts on groundwater tables.

In addition, the GoG wanted to avoid monetary transfers to consumers. Instead, it compensated them through reductions in their flat rate bills. UGVCL charges its agricutural consumers a flat rate, horsepower-based tariff that is worth about 15%-

20% of the value of the typical electricity consumption, if priced at 2.5 Rs/unit. In effect, this put a cap of 15%-20% on the amount of electricity consumers could be rebated for saving.

UGVCL provides power supply to agricultural consumers for eight hours per day. However, UGVCL official reports to the GoG indicate agricultural cosnumers use a total number of annual hours which takes into account lower usage during certain times of the year. Therefore, the annual entitlement was established by multiplying this annual number by the load of each participating pump, and then divided across months on the basis of aggregate consumption data from the area (Table 1). UGVCL normally adminsiters its flat rate bills on a bi-monthly basis. Because of the starting time of the pilot, it divided the year into six billing cycles as shown in Figure 2. Based on aggregate past consumption data from the area, the breakdown of these hours into the six billing cycles was determined (Table 1).

For the target population, UGVCL selected the 136 consumers served by four particular feeders (branches of the electricity grid) belonging to the Kukarwada substation.

Pilot Implementation

Prior to the announcement of the program, UGVCL staff performed a verification of the load of all consumers in the pilot area. During February-March 2011, UGVCL representatives visited all 136 consumers in the pilot area and offered them to participate in the pilot project. The terms of the offer were as follows:

- Participating consumers will receive bi-monthly entitlements of electricity usage amounting to the product of their pump's[1] load and a certain number of hours for the period (Table 1).
- Participating consumers will allow UGVCL to install and regularly (once a month) read a meter on their electrical connection.
- UGVCL assures participating consumers that the metering will not be used for introducing unit based billing, but only for the purposes of rebating them for voluntary reductions in energy usage.
- Participating consumers are free to withdraw from the program at any time. They may continue to pursue their present pattern of electricity usage, and will not be penalized for usage that exceeds the determined baseline entitlement.
- Should consumers raise their horsepower during the pilot period, their baseline will not change and remain frozen in the original level (in terms of electrical units).

Pilot Results

1. **High degree of farmers' willingness.** As noted above, one of the principal doubts of the possibility of introducing market-based mechanisms for agricultural electricity use revolve around the lack of trust and willingness of farmers to install meters. However, of the 113 eligible consumers who were offered to participate (136 in total), 83 had consented, yeilding an acceptance rate of over 70%. Even though concerns and suspicions about future billing were common (and were the main driver for the other consumers to refuse), most consumers seemed to be attracted by the possibility of obtaining the financial benefits. Thus, a pervasive

[1] The baseline load was determined by UGVCL as the smaller of the consumer's measured connected load (measured prior to the onset of the pilot) and the consumers' contracted load (used to calculate the consumer's flat rate bill).

conceptual hurdle to the introduction of market based mechanisms in agricultural power use was disproved.However, we should note that both UGVCL and Columbia Water Center (CWC) staff engaged in an intensive awareness campaign to allviate farerms' concerns and questions.

2. **Compliance:** There was no evidence of farmer tampering with meters. In only three cases did UGVCL equipment indicate meter malfunction, and each case intentional tampering was ruled out.

3. **Administration:** Since the pilot began on April 1st, 2011, UGVCL has been able to take regular meter readings without interruption and calculate and issue six bills. While CWC staff supported UGVCL throughout, this proves the feasibility of administering the scheme.

4. **Energy Usage and Rebates**. Table 1 and Figure 2 display aggregate amounts of baseline and actual electricity consumption for the six billing periods of the 2011-2012 pilot experiment. Baseline consumption levels were determined on the basis of aggregate consumption data from the area, and are shown to have predicted actual consumption reasonably well, outside of the monsoon season (July-October). The unusually abundant monsoon season in 2011-2012 is probably responsible for the lower than usual consumption levels during July-August, during which all participating consumers received rebates.

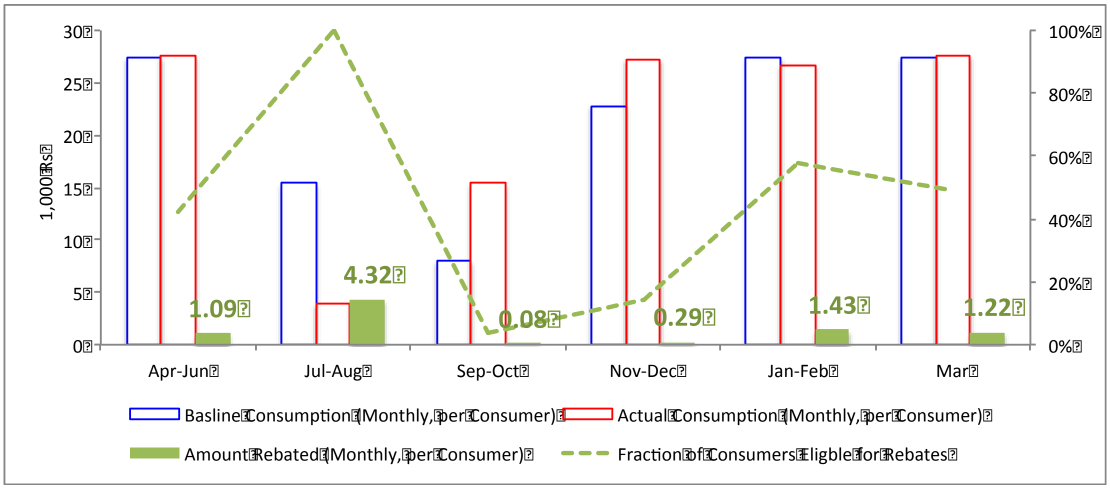

Figure 2: Energy consumption by and rebates made to the 83 agricultural electrcity consumers who participated in the 2011-12 pilot experiment. The monetary value (in Rs) of baseline (red outlined bars) and actual (blue outlined bars) consumption, the number of cosumers who received a rebate (dotted green line) and the amount rebated to them by UGVCL (solid green bars, with value lables), per month, per consumer, are plotted for each of the six billing cycles.

It is important to note that the 2011-12 pilot in Gujarat provided little evidence to suggest the mechanism led to aggregate reduction in power and water usage. However, the pilot was quite conservative in its design: the rate of compensation was very modest, at Rs 2.55/KwH, which is low in comparison to both the actual cost of supply and the price of around Rs 5/KwH normally charged non-agricultural consumers, and only modestly higher than pump rental rates in local informal water markets. Furthermore, compensation was capped by the fixed annual cost the farmer currently pays. In addition, the way shareholders of cooperative wells, which are common in this particular area, share the pump's time forces them to coordinate their irrigation practices, and seems to have made it hard for individual farmers to respond to the incentive. Finally, it seemed, anecdotally, that farmers, were not aware of low cost ways to improve the efficiency of water use. Farmers in the study area are already experiencing significant water scarcity which may have led many farmers to implement most "low-effort" ways to save water.

5. **Validity of the Baseline Model.** Daily metered consumption data obtained during the pilot has revealed that pump load levels remain mostly stable from day to day, validating the conceptual basis of the model. At the same time, this data revealed inaccuracies in the method used by UGVCL to determine these base *loads*. We found that using loads from daily consumption data provided for more accurate baselines and we recommend, going forward, to use these loads for baseline calculations. In addition, the determination of baseline *hours* in a uniform way on the basis of aggregate consumption data inevitably leads to inaccuracies. Consumers who happen to use their pumps in excess of average hourly usage will not be compensated for some of their savings, and those who happen to fall below it will receive rebates unwarranted by any actual reductions in usage. Under the assumption that the incentive had no impact on actual consumption of electricity, these `erroneous' rebates amounted to about $300 per consumer during the year. As mentioned above, we also found that the variability of the monsoon rainfall can have large impacts on energy consumption. We recommend, going forward, to either eliminate the rainy season from the program, or to unify it into a single billing cycle with a lower baseline level of at most two hours of energy supplied to farmers per day. Doing this would have reduced the amount of unwarranted transfers per consumer per year by about 50%.

Table 1: Result of 2011-2012 Pilot - Energy Usage and Rebates

Unit	Billing cycle	1	2	3	4	5	6	
	Time Period	Apr-Jun	Jul-Aug	Sep-Oct	Nov-Dec	Jan-Feb	Mar	Annual
	Baseline hours per day	8	4.35	2.3	6.55	8	8	
Months	Duration	3	2	2	2	2	1	12
	Number of Participating Consumers	83	83	83	83	83	83	83
Horsepower	Total Contracted Load*	5,334	5,334	5,334	5,334	5,334	5,334	5,334
Horsepower	Total Baseline Load*	5,078	5,078	5,078	5,078	5,078	5,078	5,078
10,000 KWh	Total Baseline Consumption	27.3	10.2	5.3	15.2	18.2	9.1	85.2
10,000 KWh	Actual consumption	27.5	2.6	10.2	18.1	17.7	9.1	85.2
10,000 KWh	Aggregate Difference baseline-consumption	-0.2	7.6	-4.9	-2.9	0.4	-0.1	0.0
	Number of Consumers Eligible for Rebate	35	83	3	12	48	41	
10,000 KWh	Total Units Rebatable by Eligible Consumers	1.6	7.6	0.1	0.2	1.5	0.7	11.7
10,000 Ra	Value of Baseline Consumption at 2.5 Rs / unit	68.2	25.6	13.3	37.9	45.5	22.7	213.1
10,000 Ra	Total Flat Rate Bill (All Consumers)	10.8	7.2	7.2	7.2	7.2	3.6	43.0
10,000 Ra	Amount Rebatable (Without Cap)**	4.1	19.1	0.1	0.5	3.7	1.7	29.3
10,000 Ra	Amount Rebated (with Cap)**	2.7	7.2	0.1	0.5	2.4	1.0	13.9
1,000$ / consumer	Value of Baseline Consumption at 2.5 Rs / unit	1.46	0.55	0.28	0.81	0.97	0.49	4.56
1,000$ / consumer	Total Flat Rate Bill (All Consumers)	0.23	0.15	0.15	0.15	0.15	0.08	0.92
1,000$ / consumer	Amount Rebatable (Without Cap)**	0.09	0.41	0.00	0.01	0.08	0.04	0.63
1,000$ / consumer	Amount Rebated (with Cap)**	0.06	0.15	0.00	0.01	0.05	0.02	0.30

* Contracted Load refers to the registered power of each consumer's pump used to calculate consumers' flat rate bills. Baseline load refers to the pump capacity, as measured by UGVCL prior to the start of the experiment for the calculation of baseline consumption. UGVCL did not want to change the contracted load of participating consumers but determined the baseline load as the minimum between contracted and measured load, which is why it turned out lower than contracted load.

** Amount rebatable refers to the difference between actual and baseline consumption for those consumers who went below baseline. The amount actually rebated may be lower because of the cap imposed by UGVCL's decision to compensate consumers by reducing their flat rate bills. Once that bill was reduced to nothing, additional reductions in consumption below baseline were therefore not rebated.

Moving Forward

The pilot project has now concluded its first year (out of three). In its first year, it has demonstrated the potential to engage a large number of agricultural power consumers and shift them to metering and to usage-based billing. Conversations with participating farmers have revealed that the first rebates have helped build a sense of trust in the scheme that replaced prior suspicions. However, there are still no indications of associated reductions in energy usage, nor of increased adoption of water saving technologies. In fact, the difficulty of identifying water saving technologies, especially low-cost technologies that would be economically attractive to farmers, has emerged as a major hurdle. The coming two years of the experiment can help shed more light on farmers' responses.

As explained above, there are several conditions specific to the pilot's design parameters and the study area that could be impeding a proactive response from farmers in terms of reducing energy and water usage. The successful 'proof of concept' should, therefore, be followed by additional experiments in different parts of the country where agricutlrual and hydrological circumstances are different. If properly designed, such experiments can help to determine the extent to which the compensation of farmers at the full marginal cost of power, through the mechanism suggested here, can alter farmer's irrigation and crop choices. Determining an appropriate compensation scheme for farmers has the potential to shift irrigated agriculture in India to more water and energy efficient trajectories.

In addition, further developments of this market-based mechanism should also be explored, such as the charging of farmers for usage in excess of their allotment.

Indeed, the specific instrument used in the 2011 pilot is not a necessarily a policy recommendation for how groundwater should ultimately be priced. Rather, it emphasizes that a transition to metering and marginal cost pricing could be achieved, and accepted by farmers.

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