Real-time Co-management of Electricity and Groundwater: An Assessment of Gujarat's Pioneering 'Jyotirgram' Scheme

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Historical Backdrop

Despite massive public investments in canal irrigation, Gujarat agriculture has come to depend heavily on irrigation with wells and tubewells. During the 1950s and 1960s, farmers used mostly diesel engines to pump groundwater. However, as rural electrification progressed, they began switching to submersible electric pumps, especially as diesel pumps are unable to **chase** declining water levels. Major expansion in the use of electric pumps occurred during the late 1980s as the Gujarat Electricity Board (GEB) changed to flat tariffs linked to the horse power of pumps. Until 1988, farmers were charged based on the metered use of electricity. However, as electric tubewells increased to hundreds of thousands, rampant corruption began to plague meter reading and billing. Farmers also complained about the tyranny and arbitrariness of the GEB's meter readers.

The new flat tariff system introduced in 1988 produced major beneficial productivity and equity impacts on smallholder irrigation. Since the marginal cost of electricity to tubewell owners was zero, they were induced to aggressively sell water to their neighbors, typically marginal farmers and share-croppers unable to afford their own tubewells. Competition among sellers pared down the prices of pump irrigation service in local informal water markets, which greatly benefited the poor. Flat tariff also expanded groundwater irrigation, increased the utilization of tubewells and reduced the GEB's cost of metering and billing over electric tubewell connections. However, the ill-effects of flat tariff were serious too. For example, it led to groundwater over-exploitation and it meant that farmers had to pay electricity charges even during the monsoon when they used little irrigation. Most seriously, flat tariff became sticky and gradually increased GEB's losses in supplying power to agriculture. These could have been controlled if the GEB had gradually raised flat tariff in tandem with the increase in power consumption in agriculture. However, farmer lobbies strongly opposed government efforts to raise flat tariff, leading to mounting losses to the GEB on account of agriculture (Joshi et al. 2005).

Given the circumstances, the government had no option but to gradually reduce the power supply to agriculture. During the 1980s, farmers got 18-20 hours of 3-phase electricity/ day; this came down to 10-12 hours by the turn of the millennium. Moreover, the quality and

timing of the power supply deteriorated, too. Power supply came with low voltage, often during the nights and with frequent trippings damaging motors. The poor and inadequate supply of power to agriculture became the key issue in Gujarat's mass politics (Shah et. al. 2003*)*.

The GEB also found it difficult to ration the power supply to tubewells without hitting the power supply to domestic and other rural uses. Normally, single-phase power that can run domestic appliances was provided 24 hours, but 3-phase power required to operate tubewells, grain mills and other heavy equipment was restricted to 10-12 hours. To beat this system, farmers everywhere in Gujarat began using capacitors (locally called *tota)* to convert two or even single phase power into 3-phase power to run their tubewells. This reduced the voltage downstream which affected the village community, while tubewells continued to operate unhindered for 18-20 hours/day. The rural society and its non-farm economy were held hostage by the burgeoning groundwater economy of Gujarat. Power engineers considered capacitors to be the gateway to an improved power factor (pf) (PRAYAS 2004),[1] but in rural Gujarat, farmers turned these into an instrument for power-theft.

It was commonly argued that the way out of this imbroglio was to meter tubewells, improve the amount and quality of power supplied to farmers, and charge metered tariffs. Shah et al. (2003) had, however, argued that though correct in principle, taking this route in present conditions would resurrect the logistical problems of metering, for the resolving of which Gujarat (and other Indian states) had changed to flat tariff in the first place. They argued that this would attract massive farmer opposition, and, if the experience in other states was any indication, imply political hara-kiri for any leader who championed it. Instead, Shah et al (2003) argued for a second-best solution of separating feeders supplying power to tubewells from other rural feeders and undertaking 'intelligent rationing' of power supply to tubewells in a way that emulates a high-performing canal irrigation system. In particular, Shah et al. (2003) recommended that: (a) flat tariff on farm power use should be raised gradually to approach the average cost of power consumed by a tubewell; (b) low-cost off-peak night power should be judiciously used to keep the average cost of farm power supply low; (c) intelligent scheduling and management of 'rationed' power supply to the farm sector should be the central element of the strategy of effective co-management of groundwater and electricity use in agriculture. Shah et al. (2003) anticipated that "Farmers will no doubt resist such rationing of power supply, however, their resistance can be reduced through proactive and intelligent supply management by (a) enhancing the 'predictability' and 'reliability' of power supply; (b) improving the 'quality' in terms of voltage and frequency, and minimizing trippings; and (c) better matching of power supply with peak periods of moisture stress."

During 2001-2, this proposal, henceforth referred to as the IWMI proposal, was presented and discussed in several workshops and conferences in Gujarat as well as in other states. In Gujarat, the IWMI proposal (Shah et al. 2003) was shared with the Minister of Power, Gujarat Electricity Regulatory Authority as well as the Chairman of Gujarat Electricity Board. The IWMI proposal seemed timely since around then, Gujarat was in the midst of a major power sector

[1] Motors running irrigation pumps have a pf of 0.7-0.8, which the use of a capacitor can raise to 1. A 100 kVA transformer can be connected to 26 motors of 5 hp with capacitors instead of 18 without getting overloaded. Capacitors improve the voltage and reduce the load on the transformer and, in general, curtail power loss in distribution.

restructuring exercise with a loan from the Asian Development Bank (ADB). Power generation and transmission/ distribution were unbundled, with the latter task taken over by five regional power distribution companies, each mandated to operate on commercial principles. The key impediment in the exercise was farm power. The ADB's answer was metering of farm power supply. But in view of stiff farmer opposition, the Government of Gujarat had to go slow on this move and, as a result, the ADB suspended the release of the loan installment. Instead of metering tubewells, however, in September 2003, the Government of Gujarat launched the *Jyotirgram Yojana*, which included some of the key recommendations of the IWMI proposal but also went far beyond them, and unleashed a new wave of rural development in the state.

Jyotirgram Scheme

Jyotirgram Scheme (JGS) was launched initially in eight districts in Gujarat on a pilot basis, but by November, 2004, it was extended to the entire state. By 2006 over 90 % of Gujarat's 18,000 villages were covered under the JGS. This was a massive operation,[2] which involved laying a parallel rural transmission network across the state at an investment of Rs.1, 170 crores. Feeders supplying an agricultural connection were bifurcated from those supplying to commercial and residential connections at the sub-station itself. Meters on distribution transformer centers were also installed on both sides of feeders to improve accuracy in energy accounting (MGVCL 2007).

Figure 1a. Electricity network before JGS.

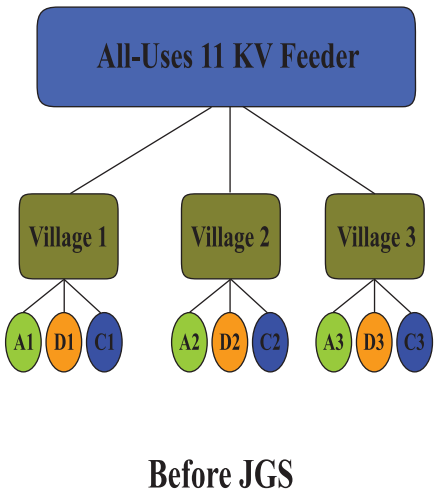
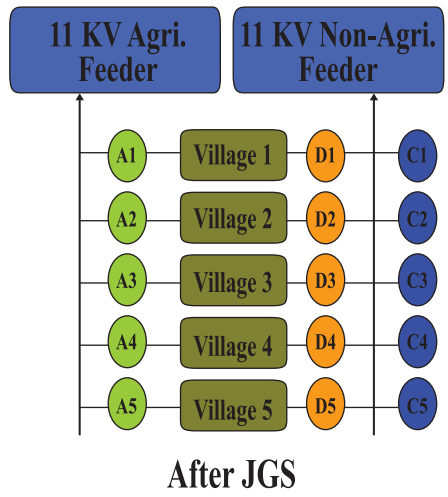


Figure 1b. Electricity network after JGS.



[2] It involved total rewiring of rural Gujarat. 48,852 km of high-tension lines and 7,119 km of low-tension wires were added. 12,621 new transformer centers were installed. 1.2 million new electricity poles were used. 1,470 specially designed transformers were installed. 182,000 km of electricity conductors and 610,000 km of low- tension PVC cables were used. 30,000 tonnes of steel products were used.

Pre-JGS, at the lowest level of 11KV feeders served a group of 2-5 villages wherein all connections (domestic, agricultural as well as commercial) were through this feeder (see Figure 1a). Post-JGS, however, the feeders were bifurcated into agricultural and non-agricultural feeders (see Figure 1b). This meant that certain feeders only served farm consumers and connections while the rest served the domestic and commercial customers. Meters on agri-feeders were meant to identify the source of any 'significantly-greater-than-expected' demand. Rural Gujarat thus rewired, and two changes occurred: (a) the villages began to be provided with a 24-hour power supply for domestic use, schools, hospitals and village industries; (b) farmers began getting 8 hours of daily power supply at full voltage on a pre-announced schedule. Every village is to get agricultural power during the day and night in alternate weeks that are pre-announced.

JGS is held out as a win-win solution for everyone involved. Studies by IRMA as well as Ahmedabad based Centre for Environment Planning and Technology (CEPT) have narrated a myriad of ways in which JGS has improved village life. Both these studies, however, glossed over the new dynamic that the JGS has catalyzed in Gujarat's agriculture. In early 2007, IWMI undertook a quick assessment of the impacts of the *Jyotirgram* Scheme (JGS) in 55 villages spread over 10 districts with the help of local researchers. The study laid particular emphasis on its impacts on Gujarat's groundwater economy. The individual case studies developed by local researchers can be obtained from t.shah@cgiar.org. This paper synthesizes these case studies to evolve a preliminary assessment of JGS impacts and its lessons for the co-management of electricity and groundwater. Our findings on JGS impacts on the quality of rural life, and on the non-farm economy are in total agreement with the highly positive assessment of IRMA and CEPT studies and, as such, we deal with these in summary form but discuss in greater detail the agrarian impacts of JGS that have so far remained unexplored.

Jyotirgram Impacts on the Quality of Rural Life

Today, rural Gujarat enjoys a 24-hour power supply of and at a quality that is unrivalled by rural areas elsewhere in India because of the JGS. All our case studies uniformly attested that for common villagers of the state, JGS has resulted in a tremendous improvement in the quality of daily life. Power cuts, which were endemic, have become almost non-existent, and so have voltage fluctuations. For a long time before the JGS, rural life as well as the economy were afflicted with an unpredictable, frequently interrupted power supply that was also of low quality and that made it impossible for people to organize their daily chores or economic activity. Women were constantly worried about securing domestic water supply; livestock keepers had to time milking and feeding of cattle according to the power supply; school teachers and students were anxious about power outages while using laboratory equipments, computers, television sets etc. For instance, during Gujarat's hot summer, the inability to operate fans made the afternoon heat insufferable in schools, shops, workshops, homes and rural hospitals. JGS put this unease and anxiety to rest. The temptation, especially among the young, to move to towns has declined as village life has become markedly less irksome and more comfortable after JGS. The JGS has helped to bridge a major divide between rural and urban life. An improved power supply has led to better drinking water supply for longer hours, improved street lighting, use of television, radio, kitchen gadgets and fans. Women

in many villages used the time saved from household chores for supplemental income generation. The JGS paved the way for the better functioning of schools, primary health centers, dairy co-ops, and better communication.

Jyotirgram Impacts on Non-farm Rural Economy

The JGS has given a big shot in the arm to existing and new non-farm economic enterprises, generating new livelihoods and jobs. The JGS has reduced the cost of non-farm businesses such as flour and rice mills, which now do the same amount of work by consuming less power because they get full-voltage, uninterrupted 3-phase power supply round the clock.[3] Many of those we interviewed reported 30-35 % fall in their bimonthly power bill, during post JGS (Talati). Many rice mills owners we met told us that they were able to increase their daily output by three times, create more local employment opportunities and enjoy a reduction in maintenance and repair costs, breakdowns and working capital requirement. Many shops, especially those vending perishable food items, telephone exchanges and Subscriber Trunk Dialing STD booths, computer training centers had to make significant investment in invertors or generators during pre-JGS. Today, inverters and gen-sets have by and large disappeared and commercial outfits are now able to operate in a continuous manner because of JGS. In Banaskantha as well as Bhavnagar villages, we found diamond polishing units shifting to villages to save on expensive rental space in towns. And, as a result, the demand for labor in this sector has increased so much as to create farm labor shortages, especially during harvest time. In some of the villages, flour mills that were running at great cost with diesel engines during pre-JGS, have now turned electric. In the Bhavnagar District, JGS stimulated growth in employment, and wage rates, in diamond polishing, tailoring, knitting, cool drinks, welding, and small oil mills. Many women, unable to commute to the urban centers of diamond polishing trade, have now begun to work in newly opened diamond cutting/polishing units in their own villages. According to a local leader, “thanks to JGS, Bhavnagar villages have witnessed more progress and better incomes during the last 3 years than in (the) 50 years before (JGS).” According to another, “JGS has good and bad things for farmers, but it has only good things for the village as a whole.” Some dairy farmers averred they produced more milk simply because buffaloes felt happier in the comfort of electric fans. In most districts, electronic and electrical repair shops experienced major improvements in efficiency and speed. Welding machine owners and tire puncture shops improved their business substantially. The demand for electronic products such as TV sets, DVD players, and tape recorders increased rapidly. Cold drinks and frozen food shops experienced 10-20 % increase in business, especially during long summer months. Tailors improved their productivity and income by up to 40 % by attaching electric motors to their sewing machines.

[3] Thus, non-farm units making illegal use of tota’s paid commercial rate for power on metered basis and did not extract a subsidy, which to ta-using farmers did.

However, there is one sector of the non-farm economy that was hit hard by the JGS, i.e., the motor/pump repair and service industry. Its fortunes have always been tied to poor quality power supply. During recent decades, rural Gujarat had witnessed booming ancillary trade tied to tubewell irrigation. Some of this involved drillers, rig owners, cement pipe manufacturers, gangs specializing in laying buried pipeline networks, specialists for taking submersible motors out of tubewells and for installing them inside tubewells, specialists for adding new columns to chase falling water levels. Some more had to do with the maintenance and repair of tubewell equipment, especially pumps and motors, manufacturing and installing capacitors (*totas)*. This second trade proliferated as rapidly as Gujarat's farm power supply deteriorated. But with JGS, these pump repairing units and motor-winders have fallen into bad days. According to M.S. Patel, one of our research partners, JGS has killed 3 birds with one stone: 1) it has provided succor to tubewell owners by easing the huge burden of maintenance and repair they had to shoulder all these years; 2) it has saved GEB from big losses; and 3) it has also saved groundwater tables from receding. The only non-farm trades that are adversely affected by JGS include motor rewinders, capacitor makers and pump repairers (Patel).

Jyotirgram Impacts that Tubewell Owners Laud

The farmers we interviewed welcomed five major changes that the JGS has brought about:

1. *Continuous power supply*: Before JGS, numerous tripping in farm power supply made it impossible for farmers to keep their irrigation schedules. Frequent tripping wasted water and power; motors suffered increased wear and tear; and tubewell owners, water buyers as well as hired laborers suffered forced idle time during the power outages. By providing power with greater continuity and fewer interruptions, JGS has benefited farmers.

2. *Full voltage*: Low and fluctuating voltages, in part due to the rampant use of *tota*s by farmers themselves, was another problem. This resulted in the frequent burn out of motors, and high wear and tear. Post-JGS, there was no need for capacitors due to regulated power supply, which besides improving voltage also helped to improve order and discipline in electricity use in agriculture.

3. *Reliability and predictability*: Before JGS, farmers could never know in advance precisely when power would be supplied and withdrawn. Tubewell owners and their customers were always on tenterhooks, waiting all day for power to come so they could begin irrigation. Auto switches were widely used on tubewells, which got switched on as soon as the power supply started. After the JGS, farmers get their ration of 8 hours of power during a fixed time schedule, known to everyone, during day and night in alternate weeks, making irrigation scheduling easier for tubewell owners and their customers.

4. *Externally imposed restraint*: Some farmers, though not all, grudgingly recounted that the JGS successfully attacked the common-property externality inherent in groundwater irrigation. It did this by effectively putting a cap on collective groundwater withdrawal

in a 'uniform' and 'just' manner. Farmers everywhere recognized that unbridled pumping of groundwater must eventually prove the highway to disaster. Farmers also knew that on their own they would never forge collective self-regulation. JGS has done it for them by rationing power uniformly on all tubewells across the state.

A similar sentiment was expressed about the use of capacitors (*totas*). Many farmers felt guilty about the use of *totas*, but used them simply because everyone else did so. Post-JGS, all farmers have been forced to give up the use of totas. With the separation of tubewell and non-tubewell feeders, use of *totas* to run tubewells has become technically impossible for most farmers. Moreover, the use of totas is also vigorously monitored and heavily penalized. The sense of relief was particularly notable in hard-rock areas like Sabarkantha, where wells run out of water before pumps run out of power during a day. Before JGS, there was a frenzied urgency among *tota*-using tubewell owners here to pump as much groundwater as they could under a 'use it or lose it' regime. By abolishing *totas*, the JGS took the first big step towards a sustainable groundwater management regime that most tubewell owners welcomed.

5. *New connections*: When the JGS was completed, the Government of Gujarat lifted the virtual embargo on new tubewell connections and began offering new connections in a planned manner, depending upon the availability of groundwater and power.[4] In parts of Saurashtra, where a profusion of check dams and recharge structures have increased recharge to the hard-rock aquifers, new connections were released. This was also the case in some parts of central and south Gujarat.

Jyotirgram Impacts that Farmers Loathe

If the above paragraphs suggest that all farmers are as unreservedly happy with JGS as housewives, students, owners of non-farm trades and enterprises are, nothing could be farther from truth. In fact, the negative sentiment among farmers is stronger and more widespread than the positive feeling. Farmers viewed full-voltage, reliable power supply as nothing more than a sugarcoating on the bitter pill of rationed power supply. Particularly peeved were tubewell owners in the groundwater abundant areas of central and southern Gujarat who operated their tubewells for up to 18-20 hours daily using capacitors (*totas*). Now they are forced to make do with just 8 hours. Vibrant water markets, which have been central to Gujarat's groundwater irrigation economy, are also essential for the viability of tubewell investments that have been in existence for eight decades (Shah 1993). Howver, these are now under siege because of effective power rationing.

[4] Every year, the government determines how many new connections can be given out in the entire state depending on the groundwater level and power available. Allocations made to districts, circles, divisions and feeders were advertised through local newspapers inviting applications for new Tatkal connections. The connections are then given out on a first-come-first-serve basis. Such a system ensures that the GEB has a fairly strong control over new tubewells in the state.

Farmers we interviewed were bitter about promises unkept, e.g., 8 hours of continuous, full voltage, 3-phase power (ToI 2002). Farmers still face frequent trips, lower than full voltage and effective hours of daily power supply of 6 to 6.5 hours against the promised 8 hours. Night power supply every alternate week is another sore point. Night irrigation is inconvenient and hazardous, and finding labor to work in the fields at night is a trying exercise. The crucial issue, however, is effective rationing. Many farmers complained that "it is unfair on the government's part to divert agricultural power for residential users. Agriculture is the back bone of the village economy. When agriculture itself is threatened, how can a village enjoy better life?" (Talati). In Vadodara, farmers lamented that "the government has pursued rural development at the cost of agriculture" (Modi). In Dahod, tribal farmers complained, "but for us farmers, Jyotirgram has benefited all else" (Sheikh). In Kheda, all our respondents, including women members of families, strongly felt that villages should not enjoy 24x7 power supply if it comes at the cost of agriculture. Some suggested that 24 hours single phase power should be supplied to the residential users; 3-phase power line to industries and water works should be separated; and a uniform 12 hours continuous power supply should be ensured to farm and non-farm producers (Talati).

Jyotirgram Impacts on Marginal Farmers and the Landless

The brunt of the adverse socioeconomic impact of the JGS fell on the water-buying marginal farmers, tenants and landless farm laborers. This large section of Gujarat's agrarian poor depends upon tubewell owners to sell them reliable pump irrigation at an affordable price; and ironically, the much-despised *tota* system ultimately benefited these classes. With drastic diminution in pump irrigation sales, the agrarian poor are left in the lurch. We encountered only three situations where this did *not* happen. First, in water-stressed hard-rock areas like Bhavnagar where, owing to the limited availability of water in wells, pump irrigation markets were all but absent even before the JGS. Here, the small and marginal farmers who were rain-fed farmers before the JGS continue to be so even after JGS without any further worsening of their position (Oza). Second, in canal irrigated areas where canal irrigation, high tubewell density, high water tables and good well yields combine to make 8 hours of power sufficient for meeting the villages' irrigation demand. During post-JGS, the terms of share-cropping have remained largely unchanged, which means that landowners have absorbed the JGS shock (Bhatt). Third, in the prosperous and groundwater-rich South Gujarat, where most farmers had their own electrified bore-wells and water markets were limited. Post-JGS, what little pump irrigation trade that existed shrank even further, and we found there was no major increase in the water price (Soni).

Almost everywhere else, our researchers found that marginal farmers and landless laborers were hit hard in several different ways, e.g., (a) groundwater markets shrank, and irrigation access to buyers declined; (b) pump irrigation prices in cash sales post-JGS increased 40-60 % or more everywhere;(c) landless laborers cultivating leased land faced reduced availability of irrigation; (d) they also faced reduced opportunities for farm work as the total irrigated area declined (Padkaar 2007). Often the bottom of the agrarian pyramid comprises migrant tribal laborers, the *Harijans* and low castes that are often the least skilled and adapted to non-farm trades where JGS has opened up new vistas for growth and prosperity.

Assessment

Evaluations of JGS so far have focused mostly on the non-farm economy and the quality of domestic life – where JGS impacts are unambiguously salutary. Our study has a larger ambit in that it covers JGS's impact on the political economy of groundwater irrigation in Gujarat, and as a result, it also points at some negative impacts that need addressing. In summary, our assessment of the impacts of JGS on different stakeholder groups is summarized in Table 1.

Table 1. Impacts of the 'Jyotirgram' scheme on different stakeholder groups.

Stakeholder group	Positive (+)/Negative (-)
Rural housewives, domestic users	+++++
Students, teachers, patients, doctors	+++++
Non-farm trades, shops, cottage industries, rice mills, dairy co-ops, banks, co-operatives	+++++
Pump repair, motor rewinding, tubewell deepening, etc.	- - - - -
Tubewell owners: quality and reliability of power supply	+++
Tubewell owners: No. of hours of power supply	- - -
Water buyers, landless laborers, tenants	- - - - -
Groundwater irrigated area	- - -

Source: Authors' assessment based on case studies

In tribal districts like Dangs and Dahod, where the groundwater economy is small and primitive, JGS's impacts can be seen in the improvement of quality of rural life as well as in the non-farm sector. However, its agrarian impacts are subdued. Here, groundwater use in agriculture is small; exchange of pump irrigation service is often a kinship-based transaction; and 8 hours, if provided, is too much power supply for most wells, which in any case operate often with diesel pumps. People's perception of JGS is entirely positive here, because they see its beneficial impact on shop keepers, artisans, local employment, public health centers, schools (Sheikh). However, the agrarian dynamic of JGS comes to the fore only in areas where agriculture and rural livelihoods have come to depend critically on the working of groundwater markets.

Political Master-stroke

JGS offers a case study of astute political management by intervening in an arena surcharged with animated mass politics. International lenders and power sector professionals have been surprisingly naive in coming to grips with the politics of metering tubewells. A study of farmer attitudes towards tubewell metering by Joshi and Acharya (2005) in North Gujarat showed the overpowering sense of antagonism and suspicion that farmers displayed on the issue. Over the past decade, mass-based resistance to metering has stopped the moves by several other states in this direction. Yet, the ADB made universal metering a condition in its power sector reform loan to Gujarat. And in 2002, ADB withheld the release of funds when Gujarat failed to make progress on metering tubewells. "It was not released as the conditionalities of coming

up with the Electricity Reforms Bill—empowering the Gujarat Electricity Board for cent per cent metering of the farm sector and corporatising its generation, transmission and distribution networks was not passed in the state assembly." (ToI 2002).

The IWMI second-best strategy—designed to minimize farmer resistance—too would have invited some resistance. However, Gujarat government's strategy of projecting JGS as an intervention to "to provide continuous 3-phase power supply to the rural area for upliftment of rural population" (EPD 2007), was a political master stroke to create a powerful rural support base to counter tubewell owners' resistance to power rationing. "The central purpose of this project is to remove disparities between urban and rural areas in the power supply and in other services available to the people" (MGVCL 2007). Before JGS, farmers, their families and most others viewed farmers as victims of a reformist government that is insensitive to their plight. The JGS, however, won supporters even within farm families, and even among some farmers. The JGS was not imposed, but it was actually marketed to village communities. For example, a village panchayat had to pay a registration fee of Rs 1,000 and 30 % of the cost of rewiring. It was first launched in the poorest districts such as Dangs, where its impact was bound to dazzle. It was also implemented early on in prosperous districts like Anand with its high water tables. Here, non-farmers placed a high value on improved power supply environment, and farmers were less worried about power rationing. Last to be covered were North Gujarat and the Saurashtra districts, where farmers would be hit hard by power rationing. Village contribution was waived in all these 'problem' districts that have high groundwater dependence and low water levels.

The JGS could do this because it realized that for decades, rural life i.e., homes, shops, schools, public health centers, had become hostage to the groundwater irrigation economy. By far the majority could not realize that they had to suffer power cuts, low voltages, frequent outages and trippings largely because of tubewell irrigation. By separating tubewells from the rest of the village, the JGS liberated the village life and economy from the shackles of the political economy of power subsidies for tubewells.

Jyotirgrams and the Energy-irrigation Nexus

Against its original objectives of improving the rural power scenario and the viability of the. Gujarat Electricity Board (GEB), the JGS has proved to be an outstanding intervention. During the past 5 years, Gujarat has emerged as one of the best performing states in the management of its power sector. The GEB, with its annual losses falling from Rs. 2,200 crores in 1999-2000 to Rs 475 crores in 2002-03 and perhaps even more since then,[5] is turning around. Farm power tariff, which stagnated at Rs. 350HP/year and Rs. 500/HP/year for pumps less and more than 7 HP, respectively, have been raised to Rs. 800/HP/year.[6] Agricultural power subsidies were a

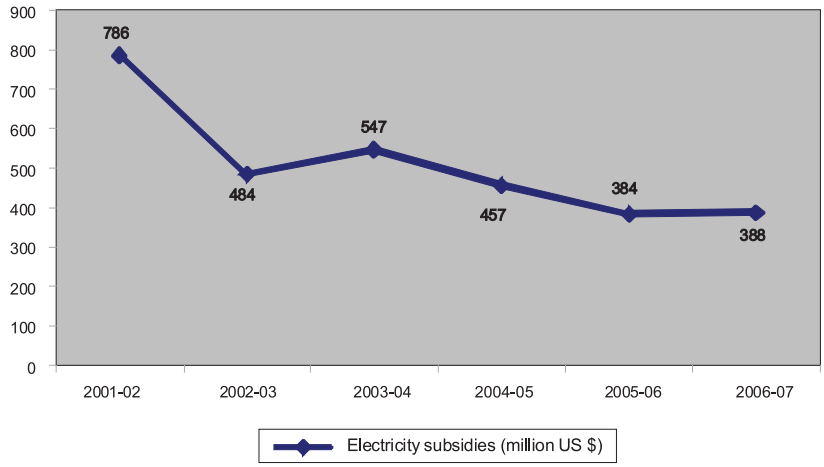
[5] MGVCL (Madya Gujarat Vij Company Ltd.), the new 'corporatized' version of GEB in central Gujarat, has made operating profits in 2005-06, for the first time in several years.

[6] This has not been easy with strong farmer organizations resisting all moves to rationalize the tariff. In 2002, Chief Minister Modi tried to raise this from Rs. 350-500 to Rs. 1260/HP/Yr and the move was immediately opposed by the Bhartiya Kisan Sangh (BKS). After sustained agitations, the rate was fixed at Rs. 850/HP/Yr. For metered connections, the tariff remains Rs. 0.50/kWh; and for Tatkal connections, it is Rs. 0.70/unit.

millstone around the neck of Gujarat's electricity industry, and it is still an issue, but JGS has created a wherewithal to 'manage' farm power subsidies within acceptable limits. As the IWMI proposal had pointed out, the problem with pre-JGS power tariff policy was not only that it led to large power subsidies; the problem was also that the government had no control over the volume of subsidy extracted by *tota*-using tubewell owners. With effective power rationing in place, JGS has transformed a degenerate flat tariff into a rational flat tariff, with the government having firm control on the total volume of farm power subsidy.

Since over 90 % of groundwater withdrawal in Gujarat occurs through electrified tubewells, electricity consumption is an accurate surrogate of the aggregate groundwater withdrawal. Government figures suggest that farm power use on tubewells has fallen from over 15.7 billion units/year in 2001 to 9.9 billion units in 2006, a nearly 37 % decline. This has resulted in halving the aggregate farm power subsidy, from US$788 million in 2001-02 to US$388 million in 2006-07 (Figure 2), and also causing a considerable decline in the aggregate groundwater draft. Although some of the decline may be caused by the two successive good monsoons in 2005 and 2006, there is unmistakable evidence of tubewell irrigation shrinking.

Figure 2. Reduction in Gujarat government's electricity subsidies (million US$).

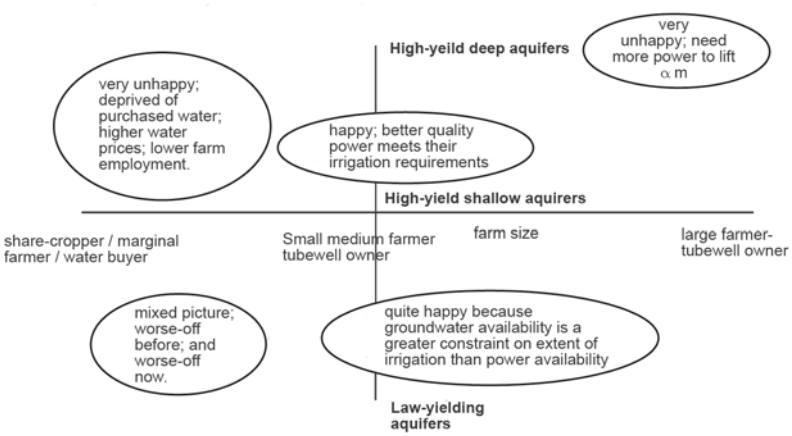


Source: Patel, 2007

Agrarian Impacts

Dazzled by what 24x7 3-phase power supply can do to village life and non-farm economy, many lay observers and even researchers like IRMA and CEPT have glossed over the agrarian distress JGS has been causing. True, some of the reduction in groundwater withdrawal represents saving of waste; but a good deal more represents reduced irrigation, lost output, livelihoods and employment. The angst this is causing among the farming community is all too clear from the accounts provided by our research partners. But the depth of the angst is not uniform as suggested in Figure 3. The key determinants of farmer angst are two: a) size of the landholding and b) the nature of the aquifer. In depleted alluvial aquifers of Mehsana and Patan, farmers who can pump their deep tubewells, continuously feel adversely affected because

Figure 3. Jyotirgram's impacts on diverse sections of Gujarat's farming community.



the power ration restricts their area irrigated. But farmers in hard-rock areas are less affected because water available in their well during a day is a more binding constraint on their pumping than the hours of daily power supply. Small farmers owning tubewells are happy with improved power quality although they miss their water selling business. Landless share croppers and water buyers are adversely affected everywhere, as water markets have shrunk and water prices have soared 40-60 %, driving many of them out of irrigated agriculture. The full import of rationed power supply has yet not been felt by farmers, because 2005 and 2006 were both good monsoon years when wells were full and water levels close to the ground. Come a drought year, and farmers will find the JGS ration of power too meager to meet their irrigation needs.

It is very likely that Gujarat's agriculture is still in the transitory phase of adjusting to post-JGS groundwater irrigation regime. Our hypothesis is that post-JGS, farmers will increasingly turn to water saving crops and irrigation technologies, experience renewed interest in gravity-flow irrigation and give a new impetus to water harvesting and groundwater recharge work that can improve their well's yield. The Government of Gujarat is already doing a good deal to support movement in this direction; but more can and needs to be done, if anything, to limit farmer distress arising from rationed farm power supply. A great deal of farmer frustration arises from promises un-kept. For example, JGS promised farmers 8 hours of continuous, full voltage daily power supply. These un-kept promises can be addressed by better housekeeping and tighter operational management. Pre-JGS, the Electricity Board had some justification perhaps in 'not' treating the farm user as a customer because he paid a subsidized rate; but under JGS, real farm power subsidies are a fraction of what they were pre-JGS. Hence, it is time electricity companies began treating the farmer as a customer deserving quality service.

Who Benefited from Farm Power Subsidies?

It has always been a matter of intense debate in Indian literature on precisely who the beneficiaries are of electricity subsidies under a flat tariff regime. Most analysts have argued that farm power subsidies essentially benefit the large farmers who own most electric tubewells.

The analysis offered by Howes and Murgai (2003) for Karnataka was a classic statement of the perverse nature of the electricity subsidy under the flat tariff regime, which distorted power economics, depleted groundwater and enriched the rural rich.

All the evidence we collected suggests that the brunt of rationed power supply under JGS has fallen not on tubewell owners but on marginal farmers and landless laborers. To ascertain this position better, our research partners went back to their respondents for a second round of enquiry (Table 2). This confirmed that post-JGS, the groundwater irrigation through water markets has seriously shrunk in many districts, hitting the water buyers hard. In response to rationed power supply and the abolition of the use of the *tota*, tubewell owners have made good their losses from the reduced volume of pump irrigation sales by increasing pump irrigation prices from 30-60 %, reducing the cost of wear and tear and enhancing bargaining power to make favorable deals with marginal farmers and share croppers. It is the latter who have lost from the abolition of the *tota* system and from the shrunken pump irrigation markets. This is evident from the reduced opportunities for irrigated share cropping, and in marginal farmers being eased out of the pump irrigation economy. The JGS experience shows that controlling electricity subsidies and groundwater overdraft do not come without a significant social cost in the form of causing more misery to the agrarian poor who are miserable in the first place.

Table 2. Responses from eight research partners on the second round of questions.

Researcher	District and number of farmers consulted	Has the area irrigated by tubewells declined after JGS?	Are metered tubewell owners more or less keen to sell water compared to flat rate tubewells?	Do metered tubewell owners charge a higher water price compared to flat rate tubewells?
1. R.K.Shah	Patan (8)	Yes, to some extent	Significantly less	No clear data
2. Paresh Rawal	Banaskantha (9)	No clear picture[a]	No clear data	Yes, 50 % higher
3. Nila Oza	Bhavnagar (8)	No decline[b]	No water markets	Not applicable
4. Jayesh Talati	Kheda (7)	25-40 % decline	Yes. Much less keen	Yes, 30-40 % higher
5. Tushar Hathi	Anand (36)	Significant decline in tobacco irrigation	No data	No clear data
6. R.C. Popat	Rajkot (8)	15-20 % decline	Metered tubewells stopped selling	Not applicable
7. Sonal Bhatt	Anand (10)	No decline[c]	No difference	No difference
8. M.S. Patel	Sabarkantha (25)	No decline[d]	Much less keen	Yes, 30-35 % higher
9. M.G. Sheikh	Jhalod([5)	No decline	No major difference	No difference
10. Rama Shah	Sabarkantha (8)	Significant decline	Much less keen	Yes, 40-60 % higher

Source: Based on the 10 case studies

Notes: [a] Because last 2 years had good monsoons

[b] In hard-rock areas of Bhavnagar, water availability in wells was a more binding constraint on area irrigated than electricity availability. Power rationing thus had no impact on irrigated area

[c] But there is evidence of lengthening of irrigation interval

[d] However, water buyers often do not get water when they need it

The Government of Gujarat has made metered tariff mandatory for all new tubewells. Our studies also suggest that metering too comes with a 'welfare cost', because metered tubewell owners manifest a markedly less interest in selling water to their poor neighbors than flat tariff paying tubewell owners, even though the former pays a highly subsidized rate per kWh. In Rajkot, after the JGS, "farmers having meter-charged power have stopped selling water" (Popat). In Kheda, our researcher wrote "it is true that metered tubewell (TW) owners are less interested (in) sell(ing) their water when compared to flat tariff TWs" (Talati). In the Sundha village of Banaskantha, we found farmers with 20 hp flat tariff tubewell "sell(ing) at Rs. 40/hour while Rs. 60/hour is taken by metered tubewell owners with 20 hp pumps" (Rawal). In the Patan District, our research partner wrote: "tubewell owners under flat charge sell more to other farmers and irrigate more land, but those with meters use their tubewells only for their own irrigation and prefer not to give water to other farmers… they are always conscious that the meter is running and, therefore, refuse to irrigate others' land" (R.K. Shah). In Anand, "farmers having a flat rate electricity connection maximize their sale through reducing water rates, provided a buyer is available.."; our researcher found the water-price formation a complex affair but asserted that "generally, flat rate connections supply water at a cheaper rate than metered connections" (Bhatt). In Sabarkantha, "metered tubewell owners are less prepared to sell water, while flat rate tubewells are more eager to sell provided they have surplus power. In the Bavsar village, flat rate tubewells of 10-15 hp sell water at Rs. 25-30/hour, while metered tubewell owners charge Rs. 35-40/hour" (Patel).

In the course of our interactions, a major area of farmer concern was the growing tension between farmers and distribution company field staff. Our research partners felt that the electricity companies need to alley farmers' fear of their staff, especially now that the practice of using capacitors is nearly abolished. Before 1988, farmer resistance to metering arose in some part because of the tyranny and arbitrariness of the meter readers. Flat tariff was comforting because it minimized the contact between farmers and electricity board staff and contained the latter's arbitrariness. We found that this antipathy is returning. An area of priority action should be to establish a relationship of trust between farmers and electricity company staff. One way to do this is to rethink the purpose of metered tariff collection in a regime of stringent power rationing. When power consumption at feeder level is tightly metered and monitored, metering each tubewell offers limited scope to improve energy budgeting and accounting. However, from the viewpoint of improving irrigation access to the agrarian poor and reducing farmers' antipathy towards distribution company field staff, metering of tubewells may have serious adverse impacts. Even if tubewells are metered for energy audit purposes, if their owners are subjected to flat tariff, their behavior would change instantly. And, as a result, instead of reticent water sellers charging high monopoly premium from their poor buyers, metered tubewell owners in groundwater abundant areas would turn into aggressive water sellers expanding groundwater irrigation opportunities for the poor in their neighborhood.

The Case for the Last IWMI Recommendation

It is the alleviation of the misery of the agrarian poor that imparts new significance to the only recommendation of the IWMI proposal (Shah et al. 2003*)* that the JGS did not incorporate: the need to target maximum power supply during periods of peak irrigation demand. The IWMI proposal argued that the farmers' derived demand for power is unlike that of domestic or

industrial users who need 24x7 power supply. Farmers need power mostly on 30-40 days of the year when their irrigation need peaks. A farm power regime that supplies maximum power to agriculture on those carefully selected 30-40 days and reduces daily power supply during the rest of the year to a maintenance ration of 3-4 hours would help farmers more than a uniform 8 hours/day of power supply would.

Under JGS, the government has committed itself to supplying 2,880 hours of farm power/year. There are a number of ways this same quota can be delivered to maximize its beneficial impact on the agrarian poor and on agriculture as a whole. In order to surface farmers' preferred season-adjusted power supply schedules, in our second round of enquiry, we asked our respondents to allocate an annual ration of 3,000 hours of farm power (@ 8.30 hours/day) over the 12 months. The responses we received (see figure 4) showed considerable variations across districts. However, everywhere, farmers allocated more hours of farm power to November-March months than the rest of the year. Aggregating the preferred schedules provided by all the respondents suggested two distinct patterns, which are displayed in figure 5: (a) in a year of normal or good monsoon, farmers would like power-hours reduced during kharif and increased to 11-12 hours/day during the rabi season and 8-9 hours/day during summer; (b) during a drought year, however, farmers would like 12-14 hours/day during kharif, 10-11 hours/day during rabi and a smaller ration of 5-6 hours/day during the summer months.

Another way a power supply regime can be fine-tuned to create value for farmers is to adjust it to regional hydrogeological specifics. . True, matching rationed power supply to each individual farmer's need is impossible; but it is possible to make adjustments according to broad regional parameters. In hard-rock areas, where wells run out of water after a few hours of pumping, it would help farmers a great deal to provide their power rations in two daily shifts, as is already being done in some parts of Sabarkantha.

Figure 4. Farmers' preferred distribution of 3,000 hours of electricity: 150 tubewell owners sampled in eight districts of Gujarat.

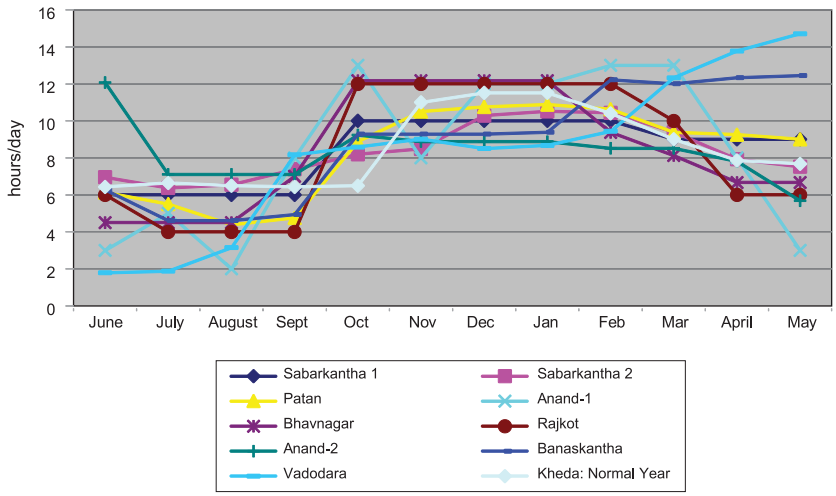
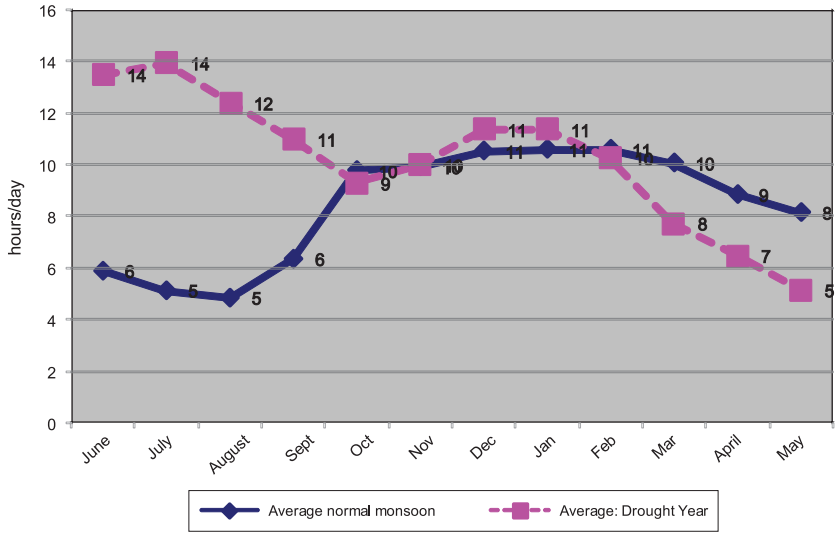


Figure 5. Aggregated preference of farmers about daily power supply during different months.



The Grand Promise of Jyotirgram

In our assessment, JGS has pioneered the real-time co-management of electricity and groundwater irrigation. It has unshackled domestic and non-farm rural electricity supply from the clutches of an invidious political economy of farm power subsidies. Its highly beneficial and liberating impacts on rural women, school children, village institutions and the quality of rural life are all too evident; its impact on spurring the non-farm rural economy are incipient but all indicators suggest that this will be significant and deepen over time. Post JGS, Gujarat is well on its way to putting its electricity industry on a sound footing in just over 5 years. Gujarat now has a kind of switch-on/off groundwater irrigation economy in which the administration has a powerful handle for groundwater demand management, which is another benefit of JGS. Elsewhere, governments have tried, mostly in vain, to manage groundwater by making laws that are unenforceable, or by vague notions like tradable groundwater rights. In comparison, Gujarat under JGS has shown that the effective rationing of power supply can indeed act as an all powerful tool for groundwater demand management. It can be used to reduce groundwater draft in resource-stressed areas and to stimulate it in water-abundant or waterlogged areas; it can be used to stimulate the conjunctive use of ground and surface water; it can be used to reward 'feeder communities' that invest in groundwater recharge and penalize villages that overdraw groundwater as if there is no tomorrow. A big breakthrough is the control the government now has on the size of the farm power subsidy: pre-JGS, *tota*-using tubewell owners subject to flat-tariff availed themselves of all the power they wanted with the government and electricity board being reduced to helpless bystanders. Now, tables are turned; tubewell owners have to manage with the power they are provided. In this sense, JGS has transformed what was a highly degenerate power-pricing-cum-supply regime into a rational one.

The JGS, however, has a big downside too, the brunt of which is borne largely by marginal farmers, and the landless, because of the shrinking of water markets and of groundwater irrigation itself. There is no way of eliminating this completely except by increasing hours of power supply – and subsidy – that tubewell owners everywhere are crying for. However, JGS can significantly reduce the misery of the agrarian poor by adjusting the schedule of power supply to match peak irrigation periods, especially for the rabi season. Providing the daily power supply in two or more installments to respond to the behavior of wells in hard-rock areas can further help the poor. Charging a common flat tariff to all tubewells regardless of whether metered or not can also stimulate metered tubewell owners to share irrigation with the poor.

The JGS has lessons of enormous significance for eastern Indian states - that, under the degenerate flat tariff regime, rural electrification is held hostage to farm power subsidy is nowhere more evident than in eastern India, where the country-side has got all but 'de-electrified' (Shah 2001), holding up rural development in that entire region. Orissa has tried to reverse this retrogression by metering tubewells; and West Bengal too is preparing to take that route, but this runs the risk of throwing the baby with the bathwater. Gujarat's JGS experience offers an important alternate model, which we consider is superior in many respects.

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