With talks about a second Green Revolution in eastern India high up in policy agenda, this article explores the role of access to affordable energy in such a revolution. It draws on recent research in West Bengal to underscore the point that farmers face acute energy constraints to pump groundwater in a region that is otherwise flush with both surface and groundwater resources. A large part of the solution, therefore, lies in the domain of rural electrification and more specifically electrification of tube wells and removal of administrative hurdles in the connecting tube wells to the grid. The government of West Bengal has taken two steps in the right direction and we posit that if implemented well, it will unleash another round of Green Revolution in the state.

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2012

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Water Policy Program

Water Policy Research

HIGHLIGHT

Rural Electrification for a Second Green Revolution in West Bengal

Aditi Mukherji

Rural Electrification for a Second Green Revolution in West Bengal[1]

Research highlight based on a paper with same title[2]

Story of agricultural growth and stagnation in Bengal

The story of agrarian growth in Bengal and its slowdown is well documented and may be captured in three distinct phases – the first from 1900 to 1980 tells a sad tale of "hunger in a fertile land" (Boyce 1987:1), the second (1981 - early 1990s) a triumphant account of a rate of foodgrain production that was "highest among 17 major states of the Indian union" (Saha and Swaminathan 1994:A2) and the third of agricultural growth that "significantly slowed down in the 1990s" (Sarkar 2006:342). Boyce (1987) captured the dynamics of the first phase and explained it in terms of regressive agrarian structure and high rural inequality. Just as Boyce's book was published in 1987, there were telltale signs of a quiet Green Revolution going on in rural Bengal (Saha and Swaminathan 1994). Agricultural growth and productivity in West Bengal in 1980s was sought to be explained in terms of two very opposing arguments – that of "agrarian structure" (Lieten 1992; Dasgupta 1995; Sen and Sengupta 1995; Ghatak 1995; Banerjee et al. 2002; Saha and Swaminathan 1994; Mishra and Rawal 2002; GoWB 1995-96, 2004) and "market and technology" (Harriss 1993; Palmer-Jones 1992). Harriss (1993) found that in his study villages in Bankura and Bardhaman, agricultural growth was better explained by development of groundwater irrigation rather by agrarian reforms. Expansion in area under boro cultivation, which is entirely an irrigated crop and increase in yield of all paddy crops *(aman, aus and boro)* due to assured groundwater irrigation from tube wells, resulted in high growth rates. However, since mid-1990s, agricultural growth in West Bengal slowed down and this also coincided with a slowdown in groundwater economy in the state.

Role of groundwater in agrarian growth story of West Bengal

bWest Bengal has 30.36 billion cubic meters (BCM) of annual renewable groundwater, receives high rainfall of 1500 mm to 2000 mm in a year and is underlain by alluvial aquifers with high recharge capacity (CGWB 2011). Only 43 percent of the state's groundwater resources have been used and this is much lower than groundwater use in other agriculturally prosperous states like Punjab, Haryana and Gujarat, while recharge potential in Bengal is much higher than all those arid and semi-arid states. According to the 4th and latest round of Minor Irrigation Census (GoI, 2011), the state has a total of 5.19 lakh[3] wells and tube wells and this has come down from a previous 6.48 lakhs in 2001. Almost 2/3rd of the rural households also access irrigation through informal irrigation services markets (Mukherji 2008). Bengal and Bihar are the only two states in India where number of wells and tube wells have declined in absolute numbers. This, I argue, is a result of inappropriate policies and elsewhere I discuss the political reasons for such decisions (Mukherji 2006).

Groundwater and electricity policies in West Bengal

Groundwater Act of 2005

West Bengal is among the very few states in India that has a Groundwater Act and one whose provisions were being implemented because it was tied to electrification process. Of direct interest to us in this Highlight, is the provision of the Act related to issue of permits (for wells and tube wells constructed after 2005) and registrations (for those constructed before 2005). These permits and registrations are mandatory for electricity connection. The State Water

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[1]This IWMI-Tata Highlight is based on research carried out with support from the International Water Management Institute (IWMI), Colombo. It is not externally peer-reviewed and the views expressed are of the authors alone and not of IWMI or its funding partners.

[2]TThis paper is available on request from p.reghu@cgiar.org

[3]One lakh = 0.1 million

Investigation Directorate's (SWID) district level SWID hydrogeologists were empowered to either accept or reject any applications. Guidelines were often indicative and the final decision was at the professional discretion of the hydrogeologist. Data shows that permits and registration applications were routinely rejected even in districts and blocks where groundwater development was as low as 20-25 percent (Table 1).

Table 1 Progress in implementation of GW Act of 2005 from 2007 till September 2010

Districts	Permits for new tube wells		Registration for tube wells constructed before 2005		Level of groundwater development
	Applications received	Percentage of permits rejected	Applications received	Percentage of registration rejected	
Bankura	2038	48.6	4215	26.9	28.7
Bardhaman	890	73.6	5911	73.5	43.1
Birbhum	2406	70.6	6448	47.4	23.9
Coochbehar	0		0		16.8
Dakshin Dinajpur	1856	81.5	153	90.8	45.7
Darjeeling	63	98.4	0	-	5.0
Hooghly	1361	43.6	2812	47.1	40.9
Howrah	136	25	15	46.7	21.6
Jalpaiguri	264	96.6	39	71.8	4.8
Malda	1038	92	2541	88.6	54.2
Murshidabad	1953	79.7	9657	76.9	83.6
Nadia	263	27	1943	2	84.6
North 24 Parganas	439	41.5	367	40.3	70.9
Paschim Medinipur	6036	76.7	6708	40.9	35.2
Purba Medinipur	1116	53.7	2487	34	38.3
Purulia	35	62.9	7	42.9	14.5
South 24 Parganas	125	56	110	80.9	NA
Uttar Dinajpur	2878	27.1	4	50	45.4
West Bengal	22897	64.1	43417	54.3	41.3

Source: SWID November 2010

Table 1 shows that since 2007, some 66000 farmers' in the state have approached SWID for either new permits to dig a well (22897) or registration for an existing well (43417). This is less than roughly 10-15 percent of existing wells in the state. Therefore, apart from high rejection rates, another implementation draw back has been that not many farmers knew about the Act or its provision. Given that level of groundwater is within 10 m in 80 percent of villages, farmers, if refused a permit by the SWID and hence denied electricity connection could always irrigate with a diesel pump. However, in the next section, we will see that high diesel prices and low crop prices meant that this is no longer a profitable or even viable option.

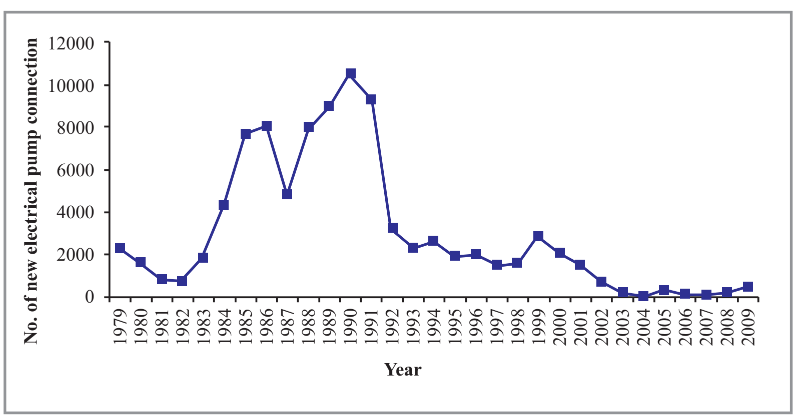
Tube well electrification procedures

Figure 1 show that pace of electrification of agricultural tube wells has slowed down in the last 10 years. Virtually, since 2003, the West Bengal State Electricity Board (WBSEB) and its new incarnation the WBSEDCL have stopped sanctioning new electricity connections for agricultural tube wells. There are both demand and supply side reasons to it.

Since 2000, the state electricity utility has been demanding full cost of electricity connection from the farmers – something that even relatively well-off urban customers are not asked to pay. This includes the costs of wires, poles and transformers, if needed, and may range from Rs. 1 to 2 lakhs per tube well. Such high capital costs for tube well electrification have depressed demand for new connections. Is the slow pace of pump electrification a response to dwindling groundwater resources in the state?

It does not seem to be so as seen from estimates of the Central Electricity Authority (CEA 2010). CEA gives the actual number of pumps energized as against the estimated groundwater potential in terms of number electrical pump sets that can be installed in the state. It shows that while most major states have exceeded their potential in terms of electric pump sets, West Bengal has electrified only 1.16 lakh of the potential 6.50 lakh that can be electrified. Low rates of pump electrification means that majority of farmers depend on diesel pumps for irrigation.

Figure 1 Number of new electrical pump connections given to farmers in West Bengal, 1979 to 2009



Source: WBSEB (now WBSEDCL)

Impact of restrictive groundwater policies on cost of cultivation and farm profits

Diesel prices have gone up sharply since mid-1990s. For instance, in real terms, price of diesel has gone up from Rs. 7.7/litre in 1995 to Rs. 26.1 in 2009, an increase of 3.5 times over a period of 15 years. This by itself would not have mattered as much if the value of output too had increased by similar proportion. But as Table 2 shows that price to cost ratio of *boro* paddy cultivation has declined in real terms from 1999 to 2007, thereby squeezing farmer's profit margins. While cost of all inputs such as fertilizer, seeds, manual and machine labor have increased, that of irrigation has increased by the largest quantity in West Bengal as shown in Table 3. Thus, as a result of increased diesel prices, electricity tariffs and cost of other inputs and more or less stagnant output prices, profit margins of the farmers have decreased.

Given that almost 80- 85 percent of all water extraction devices in West Bengal are diesel operated (GoI 2001), this has had serious repercussions on water intensive, but profitable, *boro* paddy cultivation in the state. According to the Director of Agriculture, Government of West Bengal, area under *boro* paddy has declined from 1.5-1.6 million ha around mid-2000s to 1.2 million in 2011, mostly due to unavailability of surface and groundwater (Farmers Forum 2012). We posit that unavailability of groundwater is not a function of physical scarcity of groundwater, but it is a function of high diesel costs and low rates of rural electrification.

Groundwater quantity and quality concerns

What may have propelled the state to follow such restrictive groundwater policies? Discussions with state level officials shows that the Groundwater Act of 2005 was a partly a response to the central government's policy directive to legislate on groundwater and partly a response to their own risk perception vis-à-vis groundwater quantity and quality, especially arsenic related concerns. How valid are these concerns?

Are groundwater levels declining over time?

Data from SWID (see last column of Table 1) shows that overall level of groundwater

Table 2 Price to cost ratio of *boro* paddy, 1998 to 2007

Year	Cost of cultivation of paddy (C2) at 2004-05 constant prices (Rs/100 kilos)	Farm harvest prices of boro paddy 2004-05 constant prices (Rs/ 100 kilos)	Price to cost ratio
1998	605.4	1513.4	2.5
1999	652.9	1361.8	2.1
2000	632.0	1214.3	1.9
2001	597.9	1030.9	1.7
2002	580.2	1012.6	1.7
2003	616.5	1101.6	1.8
2004	581.1	1096.8	1.9
2005	568.2	1129.0	2.0
2006	597.3	1092.2	1.8
2007	601.1	1236.7	2.1

Source: indiastat.org downloaded on 15 March 2011, compiled based on statistics released by Ministry of Agriculture, Government of India; C2 cost of cultivation includes: All actual expenses in cash and kind incurred in production by owner + rent paid for leased in land+ imputed value of family labor.

development in the state is 42 percent and that none of the districts use more groundwater than annual renewable recharge. At block level, only 38 out of 310 blocks have reached what is called a semi-critical stage of groundwater development and these numbers have remained constant since 2000. Table 4 shows majority of wells (70.5 percent in pre-monsoon and 81.1 percent) have a constant trend, while 25.2 percent and 16.7 percent of all observation wells experience a declining trend in pre and post monsoon respectively.

The next step is to understand how the water level trend behaves for each well across the seasons. In Table 5 below, we tabulate this behavior and see that majority of wells maintain same trends across seasons. Of concern to us is the category of wells which show a significantly declining trend in both pre and post monsoon seasons. We see that there are some 67, or 13.2 percent of wells that show this trend and these are the blocks that have been mostly categorized as semi-critical blocks.

These are the wells of concern because here water levels do not recover sufficiently after the monsoon rains to be able to reverse the declining trend. An analysis of depth to water table of these 67 wells with a falling trend shows that, some 31 (or 46 percent) of wells have a depth to water table of less than 9 m, 26 (or 39 percent) of wells have depth to water table between 9-12 m, while the rest 10 (15 percent) have depths of more than 12m. So overall, declining trend notwithstanding, depth to water table is still relatively shallow. Why is this so? Our hypothesis is that high rainfall and the nature of the alluvial aquifer and its inter-connectedness with the Ganges river systems ensures that there is high recharge in the post monsoon season and whatever decline happens in the pre-monsoon season gets adequately recharged in post monsoon season (Figure 2).

Arsenic contamination of groundwater and its policy implications

Threat of arsenic contamination of groundwater is often cited as the most important reason for restrictive groundwater policies in West Bengal. However, there are many dimensions to the arsenic problem and all dimensions must be carefully thought through before embarking on policies that deny access of irrigation water to the poor. First, transfer of arsenic into human chain is very ill-understood. However, there is a lot of ongoing research on mitigation options, research that needs to inform our policies. Second, and very fortunately, various low cost techniques exits for effective removal of arsenic from drinking water (Jakariya et al. 2005) and some of these are now being widely adopted in the affected regions in West Bengal and Bangladesh. Third, another body of literature linking nutrition level with arsenic poisoning finds that there is a negative co-relation between socio-economic status, education, level of nutrition and symptoms of arsenic poisoning (Mitra et al. 2004, Rahman et al. 2006 and Maharajan et al. 2007). Fourth, another body of literature shows that in the context of India, states with high agricultural growth rates also achieved high levels of poverty reduction (Dutt and Ravallion 1998; Palmer-Jones and Sen 2003) and that groundwater irrigation has played a crucial role in agricultural growth in those states (Daines and Pawar 1987; Repetto 1994). Linking these four arguments together tells us that restricting groundwater irrigation for containing arsenic contamination is likely to be counter-productive because in the absence of any other alternate sources of irrigation and livelihoods, the farmers would become nutritionally poorer and hence all the more susceptible to arsenic poisoning than ever before.

Recent groundwater and electricity related reforms in Bengal

In 2011, the government of West Bengal has taken two policy decisions, which if implemented well, will improve farmers' access to groundwater. First, the Water Resources Investigation and Development Department (WRIDD)

Table 3 Variable Input Price Index of paddy in West Bengal at 1999-2000 constant prices

Year	Human labor	Bullock labor	Machine labor	Seeds	Fertilizer	Manure	Insecticide	Irrigation
1999-00	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2003-04	114.0	110.5	139.2	108.2	115.2	112.6	107.0	153.5
2004-05	111.9	114.4	152.2	110.6	120.4	115.9	108.5	133.9
2005-06	122.1	116.1	172.4	112.6	115.2	119.4	116.8	208.2
2006-07	136.4	119.0	187.5	116.6	115.2	123.0	124.3	223.8

Source: Ministry of Agriculture, Govt. of India; downloaded from indiastat.com on 15th March 2011

Table 4 Groundwater level trend in 508 observation wells in West Bengal, 1999-2009

	Number of observation wells (Percent to total)			
	Constant (+-20cm)	**Falling (+20cm and more)**	**Rising (-20 cm and less)**	**Total**
Pre-monsoon	358 (70.5)	128 (25.2)	22 (4.3)	508 (100)
Post-monsoon	412 (81.1)	85 (16.7)	11 (2.2)	508 (100)

Source: SWID, 2010, Figures in parentheses shows percentage to total of 508 wells

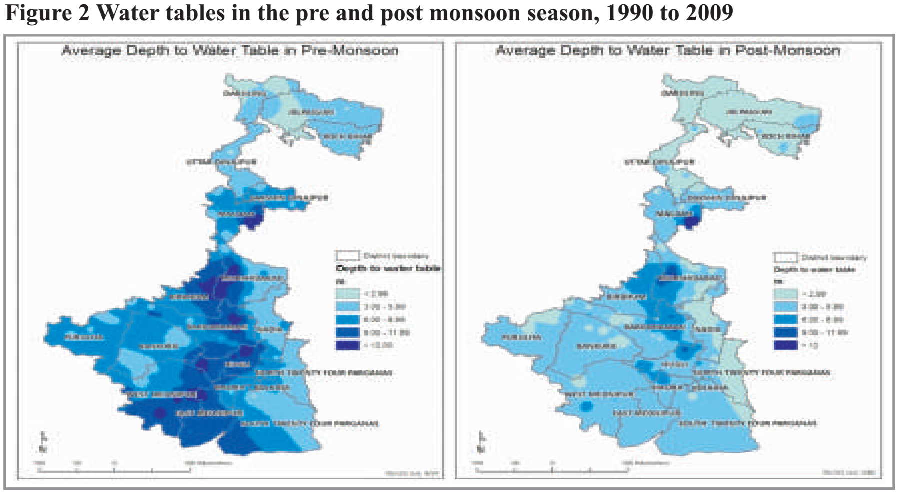
Table 5 Comparison of trend between pre-monsoon and post-monsoon season, 1990-2009

	Trends	Pre-monsoon			
		Constant	**Falling**	**Rising**	**Total**
Post-monsoon	Constant	335(65.9)	61 (12.0)	16 (3.1)	412 (81.1)
	Falling	*18 (3.5)*	***67 (13.2)***	*0 (0)*	*85 (16.7)*
	Rising	5 (1.0)	0 (0)	6 (1.2)	*11 (2.2)*
	Total	358 (70.5)	128 (25.2)	22 (4.3)	508 (100)

Source: SWID, 2010, Figures in parentheses shows percentage to total of 508 wells

vide a memo dated November 2011, has changed a provision of West Bengal Groundwater Resources (Management, Control and Regulation) Act 2005, such that, farmers located in 'safe' groundwater blocks and owning pumps of less than 5 HP and tube wells with discharge less than 30m^3/hour will no longer need permits from SWID. This will effectively put all farmers except those located in 37 semi-critical blocks outside the purview of the Act. Second, the WBSEDCL on its part has also passed a policy resolution by which it will give new electricity connections to farmers against a payment of a fixed connection fee depending on the connected load. However, farmers will continue to pay a metered tariff for their electricity consumption – a tariff that is entirely unsubsidized and reflects full cost of supply. We hypothesize that, if implemented well, these new policies may trigger another round of agricultural growth in the future.

Figure 2 Water tables in the pre and post monsoon season, 1990 to 2009



Source: SWID 2010

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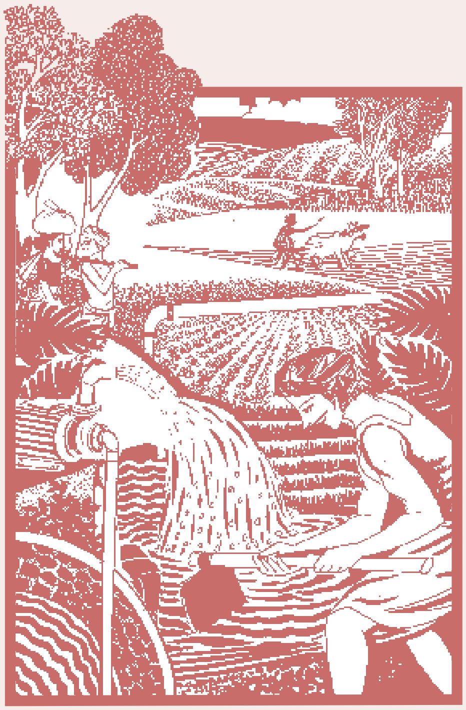

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The IWMI-Tata Water Policy Program (ITP) was launched in 2000 as a co-equal partnership between the International Water Management Institute (IWMI), Colombo and Sir Ratan Tata Trust (SRTT), Mumbai. The program presents new perspectives and practical 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, analyze and document relevant water-management approaches and current practices. These practices are assessed and synthesized for maximum policy impact in the series on Water Policy Highlights and IWMI-Tata Comments.

Water Policy Highlights are pre-publication discussion papers developed primarily as the basis for discussion during ITP's Annual Partners' Meet. The research underlying these Highlights was funded with support from IWMI, Colombo and SRTT, Mumbai. However, the Highlights are not externally peer-reviewed and the views expressed are of the author/s alone and not of ITP or either of its funding partners.

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