Managing externalities of groundwater use through electricity reforms

Evidence from three Indian states of West Bengal, Gujarat and Uttarakhand

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Groundwater irrigation in India

- **Rapid increase in area under groundwater irrigation due to**
  - High population density & small land holdings
  - Demand for assured supply of irrigation
  - Subsidized electricity

- **This led to**
  - Increase in electric pumps in 1980s and 1990s
  - Increasing contribution of GW to agriculture
  - Benefited millions of poor farmers
But multiple benefits came at a cost

- Unsustainable use of groundwater in some pockets and under use in others

- Quality deterioration either due to over use or natural causes (arsenic and fluoride)

- Twin concerns of
  - Groundwater resource sustainability
  - Livelihoods and Equity
Direct management of GW is not an option in South Asia

- Huge number of small users (25 millions wells and tubewells)
- No clear demarcation of property rights
- Exigencies of securing a livelihood
- Politically sensitive
Indirect GW management through electricity pricing and subsidy

- Pumping behavior of tubewell owners is influenced by:
  - Type of electricity tariff (flat rate vs. metered rate)
  - Hours of electricity supply

- Examples from three Indian states: West Bengal, Gujarat and Uttarakhand
Location of the study states

- Uttarakhand
- Gujarat
- West Bengal
## GW and electricity in 3 states

<table>
<thead>
<tr>
<th></th>
<th>Gujarat</th>
<th>West Bengal</th>
<th>Uttarakhand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rainfall</td>
<td>700-1000 mm</td>
<td>1500-2000 mm</td>
<td>1200 mm</td>
</tr>
<tr>
<td>GW potential</td>
<td>16 BCM</td>
<td>31 BCM</td>
<td>2 BCM</td>
</tr>
<tr>
<td>GW depth</td>
<td>&gt;100 feet</td>
<td>Less than 15 feet</td>
<td>30-50 feet</td>
</tr>
<tr>
<td>Electricity tariff</td>
<td>USD 16/HP/year</td>
<td>USD 50/HP/year</td>
<td>USD 25/HP/year</td>
</tr>
<tr>
<td>Agri. electricity consumption</td>
<td>&gt; 40%</td>
<td>6%</td>
<td>12%</td>
</tr>
<tr>
<td>Elec. Subsidy</td>
<td>&gt; 50-70%</td>
<td>Less than 5%</td>
<td>Medium 25%</td>
</tr>
<tr>
<td>Main irrigated crops</td>
<td>Cotton, high value</td>
<td>Summer paddy</td>
<td>Wheat</td>
</tr>
<tr>
<td>Hours of pumping</td>
<td>500-1500</td>
<td>1500-2100</td>
<td>500-800</td>
</tr>
<tr>
<td>GW markets</td>
<td>Highly developed</td>
<td>Highly developed</td>
<td>Thin</td>
</tr>
</tbody>
</table>
Gujarat: *Jyotirgram* experiment

- Gujarat: water scarce & intensive GW use
- Flat tariff promoted GW use
- GW markets flourished
- However, these tariffs remained low
- Leading to losses of electricity sector
- Over-exploitation of GW resources
In 2003, Gujarat launched Jyotirgram Yojana

- Separated agricultural feeders from rural domestic and commercial feeders
- Provided 24 hours of high quality electricity to domestic and commercial sector
- But rationed electricity to agricultural sector to only 8 hours
Electricity Network Before JGY

All-Uses 11 KV Feeder

Village 1
A1 D1 C1

Village 2
A2 D2 C2

Village 3
A3 D3 C3

Before JGY

Electricity Network after JGY

11 KV Agri. Feeder

Village 1
A1 Village 2
A2 Village 3
A3 Village 4
A4 Village 5
A5

D1 D2 D3 D4 D5

11 KV Non-Agri. Feeder

C1 C2 C3 C4 C5

After JGY
Outcomes of Gujarat experiment

- Over all quality of life improved due to 24 hours electricity
- Subsidy given by electricity utility for agriculture declined remarkably
- Some reported that GW levels recovered in some pockets
- However, small and marginal farmers suffered as they no longer got access to GW
Electricity reforms and metering in West Bengal

- Universal metering of tubewells
- Introduction of Time of the Day (TOD) meters
- Tamper proof meter with automatic meter reading instrument
- GSM and GIS technology for monitoring
Hi-Tech Metering Technology

- Sub-Transmission and Transmission (> 11 kV)
- Substation
- Uplink
- Data Center
- Distribution Transformer (pole or ground)
- LV Concentrator
- Secondary Distribution Voltage
- Smart Meter (Can be off-site outside user control, is partly a modem)
- Users
- Last Few Hundred Meters
- Access (440 or 220 V)
- Low Voltage
- Distribution (~11 kV)
- Medium Voltage
Winners and Losers

Pump owners: 🎉
Largely winners

😊 Same hour of pumping
  – Less electricity bill
😊 Same hour of selling water – Higher revenue
😊 Higher bargaining power vis-à-vis water buyers
😊 Win – win situation
Water buyers: Losers

😊 Increase in water charges by 30-50%
😊 Adverse terms & condition of buying water
Groundwater use efficiency:

Winner

😊 Increased adoption of plastic pipes for conveyance
😊 Better maintenance of field channels
😊 Construction of underground pipelines
😊 But will it save water?
Electricity and metering in Uttarakhand

- Universal metering of all tubewells since 2006
- Electronic meters, but needs to be read manually
- During our fieldwork in 2008, less than 50% of the tubewells had been metered
- There is paucity of manpower in state electricity boards, no new recruitments in the offing
- Therefore, metering here would bring about the same old set of problems for which it was discarded in the first place
However, the meter tariffs are low here and tubewell owners would have benefitted

There would have been no impact on groundwater markets because the markets are rather thin anyway

Might have been a win-win option, if only it were implemented right.....
Conclusions

Examples from Gujarat and West Bengal show that

- Electricity policies lead to change in pumping behavior
- Limiting hours of pumping leads to lower GW pumping as in Gujarat
- Charging electricity on pro-rata rate leads to lower incentives for pumping as in WB

However, in both scenarios, small and marginal farmers lose access to GW
Then the key challenge is to...

- Manage externalities of GW use using economic incentives without significantly harming livelihood options of the poor people.
Based on..

- Mukherji et al. (2009), Metering of agricultural power supply in West Bengal: Who loses and who gains, accepted by Energy Policy.
- Umar A. et al. (2008), Metering of agricultural tubewells in Uttarakhand, unpublished report submitted to IWMI.
Thank You
Rapid increase in groundwater irrigation
Rising contribution of groundwater

1970-73

1990-93

% of Agricultural GDP

% contribution of SWI to Agricultural GDP

% contribution of GWI to Agricultural GDP

Districts

Percentage to Agricultural GDP

% contribution of SWI to Agricultural GDP

% contribution of GWI to Agricultural GDP

Districts
District-wise Stage of Groundwater Development (in %)

Legend
Percent of Groundwater Development
- 0 - 25
- 26 - 50
- 51 - 75
- 76 - 100
- > 100
- No Data

Source: CGWB, 2004