Can Electricity pricing be a tool for efficient, equitable & sustainable use of groundwater in Indian agriculture?

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Presented at the International Conference
Towards Sustainable Groundwater in Agriculture: Linking Science with Policy
San Francisco, California, USA
15-17 June, 2010

INSTITUTE FOR RESOURCE ANALYSIS AND POLICY

Scope of the Presentation

- Modes of electricity supply & pricing to agriculture in the past & present: objectives & outcomes
- Certain myths about metering & consumption based electricity tariff
- Objectives, approach & methods used in 3-location study
- Impacts of pro-rata pricing of electricity in farm sector
- Technological innovation for metering electricity use
- Metering & restricting energy supply for groundwater pumping: scenarios & outcomes
- Conclusions

Past Modes of Pricing Electricity in Farm Sector: Objectives & Outcomes

- Flat rate pricing was introduced to maximize welfare benefits; and reduce transaction costs of metering
- It creates incentive to use groundwater excessively
- Increase the monopoly power of large well owners; and does not reduce the selling price of water
- Increased inequity in distribution of subsidy benefits
- Lack of information about actual power thefts; transmission losses
- Reduced the sustainability of groundwater use
- Annual revenue loss of 7 billion dollars
- Even after rationing of power supply hours, energy use doesn't drop

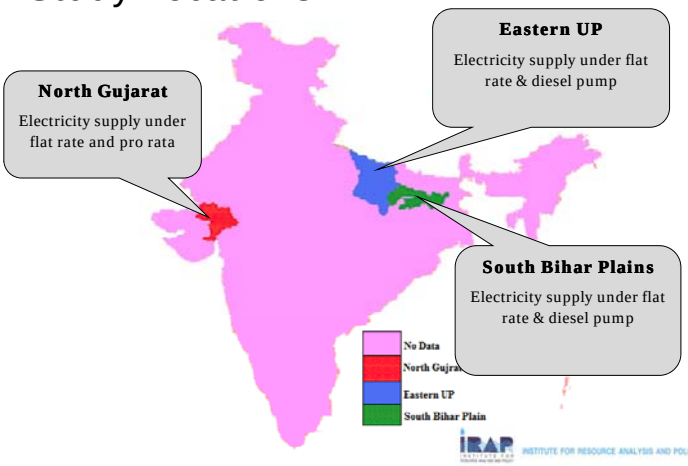
Why Metering?

- Farm level electricity metering generates information about the use of both energy and groundwater
- Farm level metering helps:
  - Detect electricity theft by individual farmers
  - Assess the actual energy requirements in farming different seasons; and
  - Assess technical losses separately
- Therefore, it is the first step towards managing both groundwater & energy economy

Myths about metering & pro rata pricing of electricity in farm sector

- That metering involves huge transaction costs
- That it reduces social welfare benefits
- Meters would be easily tampered with, and theft would increase, whereas the same would not happen with flat rates
- Farmers across classes resist metering
- With technological innovations, this can be drastically reduced
- It is the other way round; it increases the efficiency; improves welfare benefits, with pro rata charges
- Tendency would be more with flat rate, as the supply will have to be restricted
- Only large farmers are against metering

Study Locations



Approach and methodology

- Farmers who are using diesel wells for irrigation and water buyers are used as proxy cases for pro-rata tariff
- Impact of change in mode of pricing on economic viability of farming is examined by comparing the overall water productivity of the farming system, an indicator of the efficiency of both electricity & groundwater use, of electric well owners and water buyers of electric & diesel commands
- Sustainability impacts is analyzed by looking at the differences in water withdrawal per unit irrigated area
- Equity impact is analyzed by comparing the charges paid by the water buyers under these regimes against the cost (Rs/m^3) farmers have to incur for access groundwater if he would decides to have his own well

Methods

- Physical productivity of water for a given crop (kg/m^3) is estimated by using the data on crop yield and the estimated volume of water applied
- Water productivity in economic terms (Rs/m^3) is estimated by using net returns from crop production (Rs/ha) and estimated volume of water (m^3) used per unit area
- Physical productivity of water in milk production for livestock WP_{milk} (litres/m^3) is estimated as:

$$WP_{Milk} = Q_{MP} / \Delta_{milk}$$

- Δ_{milk} is the total volume of water used per animal per day, including the water embedded in feed and fodder inputs, used in dairying for an animal in a day, worked out for the entire animal life cycle (m^3/animal/day). It is estimated as:

$$\Delta_{milk} = (Q_{cf}/WP_{cf}) + (Q_{df}/WP_{df}) + (Q_{cf}/WP_{df}) + \Delta_{DW}$$

Methods

- Net water productivity in dairying WP_{Milk} (Rs/m^3) estimated as:

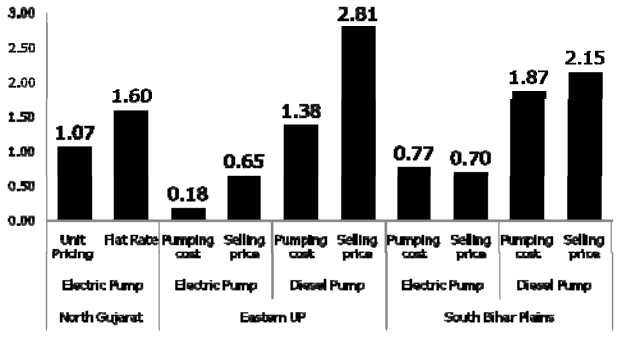
$$WP_{Dairy} = NR_{Milk} / \Delta_{milk}$$

- Water productivity of the farm WP_{farm} (Rs/m^3) is estimated as:

$$WP_{farm} = \frac{\sum_{i=1}^{m} WP_{crop,i} V_{crop,i} + \sum_{j=1}^{n} WP_{dairy} V_{dairy,j} N_j}{\sum_{i=1}^{m} V_{crop,i} + \sum_{j=1}^{n} V_{dairy,j} N_j}$$

- Here, $WP_{crop,i}$ *is water productivity of main product of crop i;* $V_{crop,i}$ *is total volume of water used for crop i;* $WP_{dairy,j}$ is the water productivity in dairying for livestock category j; $V_{dairy,j}$ *is the volume of water used for dairy production per animal for livestock category j; and* N_j *is the total number of livestock in that category*

Cost of groundwater irrigation



Efficiency impacts of pro-rata pricing

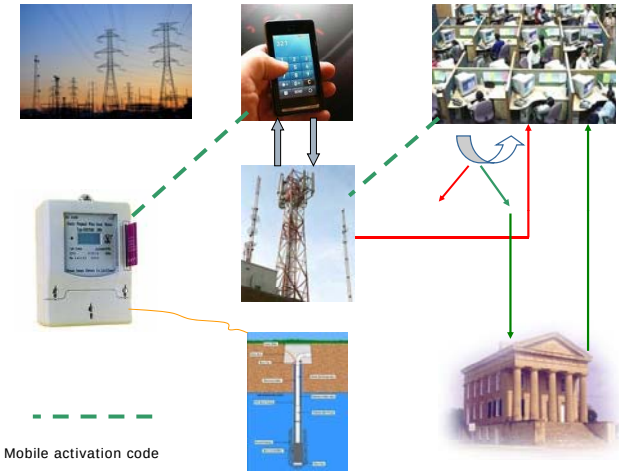
- Consumption based pricing creates incentives among farmers to obtain higher return from every unit of water
- When confronted with marginal cost, and under higher tariff, farmers use electricity & water more efficiently; select crops and farming systems that are more water-efficient
- Higher pro rata tariff does not lead to reduced income from crop production as farmers use water & other inputs judiciously
- They obtain higher returns from every unit of land also

Sustainability and equity impacts of pro rata pricing

- Farmers use less amount of groundwater per unit of land; improving sustainability of groundwater use
- Returns from farming are inelastic to tariff; but elastic to control over irrigation water
- The monopoly power of well owners is higher under flat rate pricing
- Pro rata pricing will have no adverse effects on access equity in groundwater; monopoly power of the sellers is driven more by other considerations (transferability of water; and difficulty in obtaining power connections)

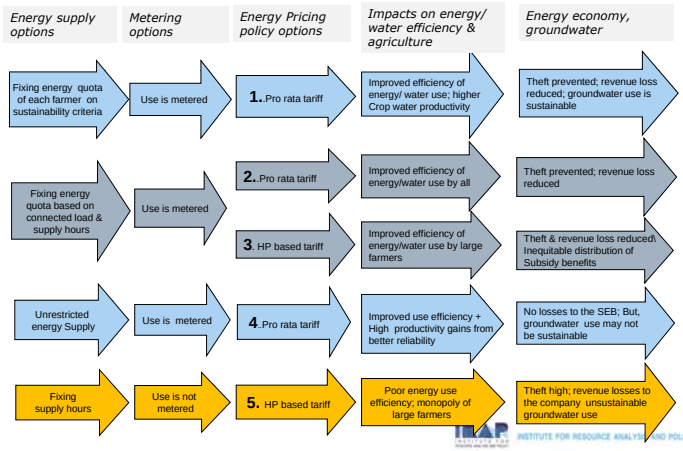
Pre paid meters: technological innovations for introducing pricing reforms

- It prevent electricity pilferage through manipulation of pump capacity
- Can be operated through tokens; scratch cards, magnetic cards or recharged digitally through internet & SMS.
- It helps electricity company restrict the use of electricity
- The company can decide on the "energy quota" for each farmer on the basis of either:
  - Reported connected load, and total hours of power supply
  - Sustainable abstraction levels per unit of irrigated land
- Database for every agricultural consumer of the connected load, location etc. is required
- Farmers pay & obtain activation code through mobile SMS



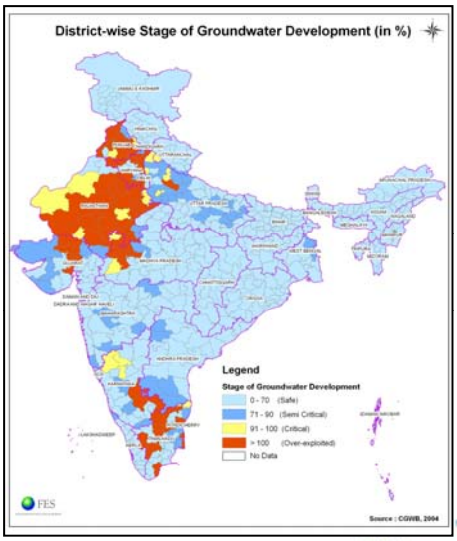
Source: Slim Zekri, 2008

Different modes of pricing & expected outcomes under different energy supply regimes

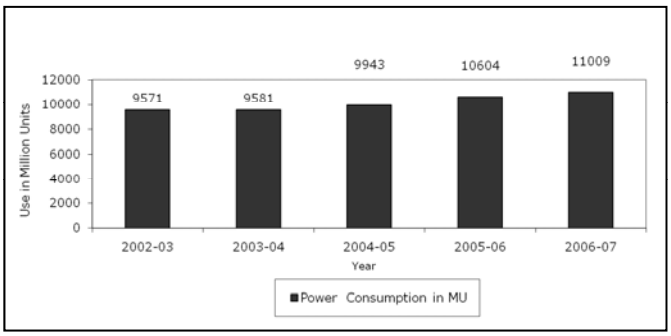


Conclusions

- Studies show metering & pro rata pricing of electricity improves efficiency, equity and sustainable of groundwater use in agriculture
- It is also socio-economically viable; orientation of farmer organizations and politicians is crucial to get wider acceptance of ideas
- **Option 3** is easily implementable to manage energy economy; **Option 2** is lightly difficult, but would conserve groundwater also; **Option 1** is best for co-management of groundwater and electricity; but needs political will
- Government can offer subsidies for meters if farmers are willing to go for **Option 1** and **2**
- SEBs to setup computerized database of all agro wells, comprising their latitude & longitude, physical characteristics and land use data



Increasing Electricity Use & Groundwater Withdrawal Under *Jyotigram*



Farming System Level Water Productivity (Rs/m^3) under Different Pricing Regimes

Name of the Regions	Name of the district	Electric Well Command		Diesel Well Command	
		Flat Rate	Unit Pricing	Well owner	Water buyers
North Gujarat	Banaskantha	6.20	7.90	NA	NA
		Well Owner	Water Buyer	Well Owner	Water Buyer
Eastern UP	Varanasi and Mirzapur	10.95	11.18	8.67	12.89
South Bihar Plains	Patna	9.28	10.13	11.97	12.43

Irrigation water use and crop water productivity

Name of the Crops	Electric Pump – Owner				Electric pump – water buyer			
	Depth of irrigation water (cm)	Water productivity (Kg/m^3)		Net water productivity (Rs/m^3)	Depth of irrigation water (cm)	Water productivity (Kg/m^3)		Net water productivity (Rs/m^3)
		Main Product	By-product			Main Product	By-product	
Kharif Season								
1. Paddy	7.1	1.9	8.47	3.4	3.61	2.3	10.59	3.6
2. Vegetable	3.3	6.0	-	26.3	1.73	10.7	-	26.6
3. Lady's Finger	3.2	2.3	-	10.8	2.33	3.9	-	21.2
4. Maize	2.4	2.9	19.4	9.4	1.17	5.7	18.79	18.8
5. Sesame	0.8	1.2	-	14.2	0.57	1.3	-	9.6
6. Sugarcane	1.1	12.4	-	6.7	0.57	10.6	-	8.1
7. Pearl millet	3.2	1.5	10.2	4.5	1.43	4.1	30.83	10.5
8. Black gram	2.7	1.9	-	39.1	1.14	2.4	-	46.3
9. Groundnut	3.3	2.6	-	31.7	-	-	-	-
10. Green gram	3.7	2.0	-	46.2	-	-	-	-
Rabi Season								
1. Wheat	6.7	2.4	11.3	7.8	2.93	2.6	12.36	7.6
2. Potato	5.0	5.7	-	8.6	2.91	6.0		9.6
3. Pea	2.3	1.9	-	13.5	1.33	2.1		15.0
4. *Barseem*	0.7	12.6	-	-	0.46	12.3		-
5. Gram	1.8	1.8	-	27.03	0.36	1.6		31.1
6. Mustard	1.6	1.4	-	10.8	1.20	1.4		11.4
7. Linseed	0.6	0.9	-	4.4	-	-	-	-
8. Barley	2.3	3.4	16.0	9.1	0.80	4.3	14.57	14.6

Net income from crop & milk production: three locations

Name of the Regions	Type of Well Command	Type of farmer	Gross cropped area (Ha)	Net income from crops (Rs)	Net income from dairying (Rs/day)	Total farm level income (Rs)	Farm level net income (Rs/Ha)
Eastern UP	Electric	Well owner	5.29	124587	7152	131740	24880
		Water buyer	2.21	54638	6165	60803	27570
	Diesel	Well owner	5.66	74765	7430	82194	14528
		Water buyer	3.79	62323	6261	68584	18075
North Gujarat	Electric	Flat Rate	13.35	369120	30048	768287	57531
		Metered	11.77	311807	45637	669250	56882
South Bihar Plains	Electric	Well owner	3.14	111737	10293	130770	210346
		Water buyer	1.70	61518	8131	76024	190031
	Diesel	Well owner	2.49	140106	9958	150064	191388
		Water buyer	1.60	71810	12232	84043	197896

Impact of pro-rata pricing on groundwater use

Name of the Regions	Name of the district	Groundwater Pumpage by Electric Pump Owners		Groundwater Pumpage by Diesel pump	
		Unit Pricing	Flat Rate	Well owner	Water buyers
North Gujarat	Banaskantha	303.88	443.88	NA	NA
		Groundwater Use in Electric Well Command by		Groundwater Use in Diesel Well Command by	
		Well Owner	Water Buyer	Well Owners	Water Buyers
Eastern UP	Varanasi & Mirzapur	175.38	183.93	222.23	148.00
South Bihar	Patna	329.97	249. 74	231.11	197.91

Monopoly power of well owners under different tariff regimes

Name of the Regions	Name of the district	Selling Price of Water and Monopoly Price Ratio in			
		Electric Well Command		Diesel Well Command	
		Selling Price	MPR	Selling Price	MPR
North Gujarat	Banaskantha	-	-	-	-
Eastern UP	Varanasi and Mirzapur	0.65	3.50	2.81	1.85
South Bihar Plains	Patna	0.70	0.90	2.15	1.15