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Solar Irrigation Pumps in India: Can Electricity Buy-Back Curb Groundwater Over-use?

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Session: What governance for groundwater and surface water use in agriculture?

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"India Plans to Install 26 Million Solar-powered Water Pumps"

Over € 1 billion German package for solar projects in India

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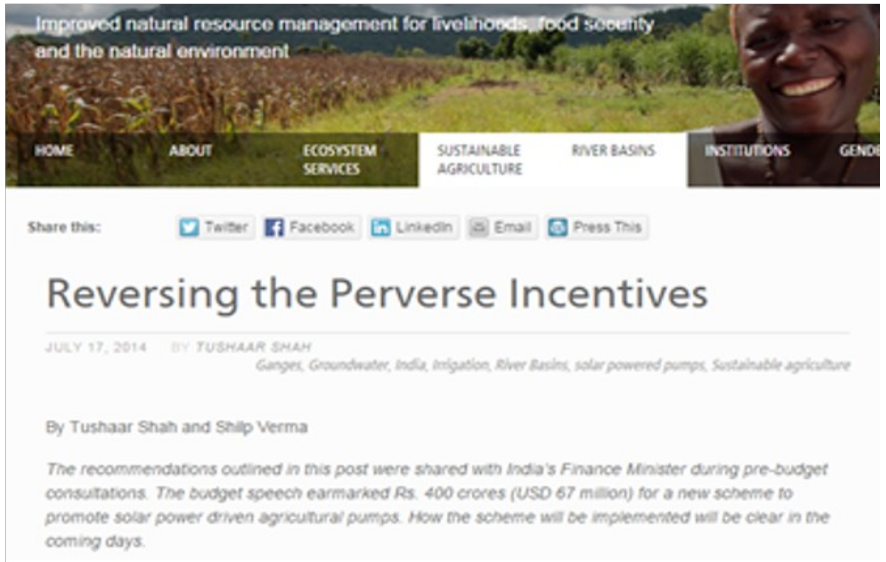

Will this spark excessive groundwater extraction?

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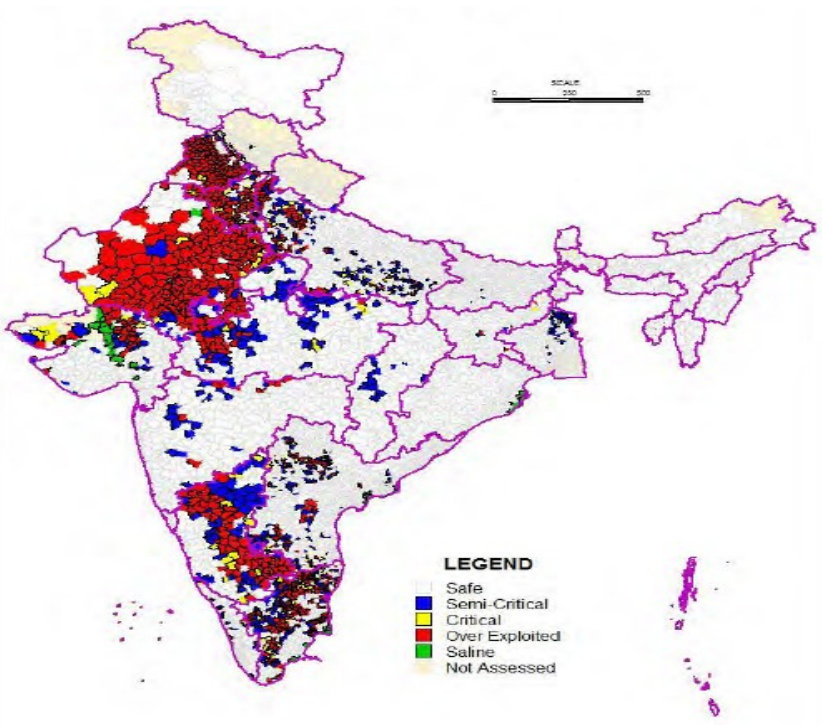
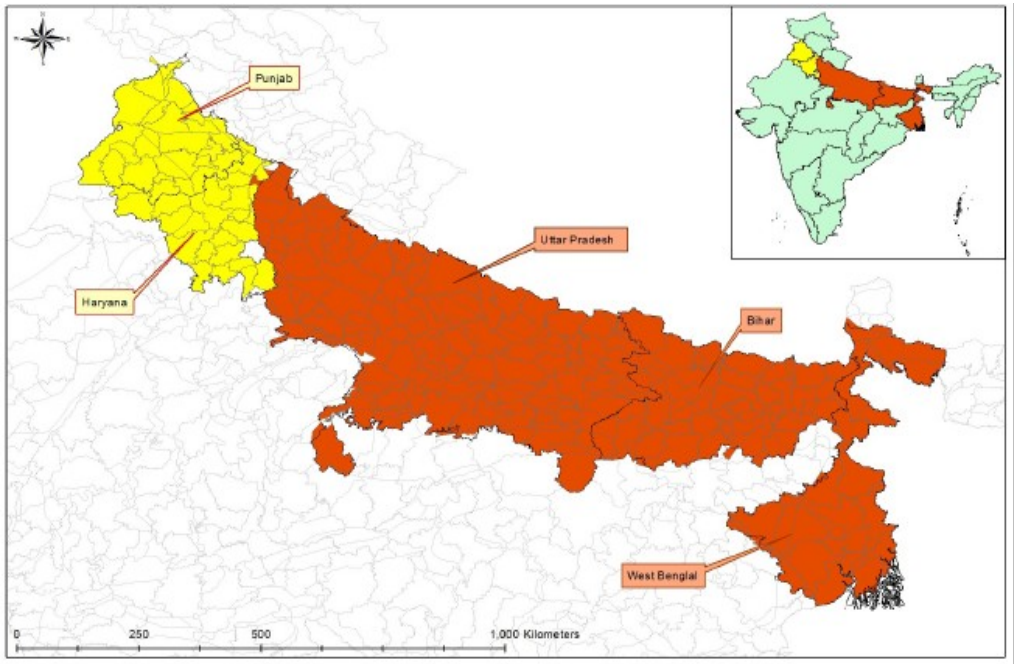
State of Indian Groundwater

- 221 BCM of water pumped per year.
- Over 20 Million irrigation wells – 14% over-exploited.
- Northwest and peninsular India – over-exploited.
- Northeast – under-exploited due to lack of electricity.





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Punjab State

Punjab Agriculture:

- Highly productive.
- Nearly 100% Irrigated.
- Very dependent on GW.
- At least 1.2 Million wells.
- Receives free electricity.

District	GW % Developed	% Irrigated area from GW	Depth MBGL
Amritsar	179	64	13.28
Bathinda	124	30	10.85
Faridkot	159	16	5.97
Fatehgarh Sahib	210	94	14.87
Firozpur	141	65	3.49
Gurdaspur	126	77	5.12
Hoshiarpur	104	89	9.05
Jalandhar	229	99	17.05
Kapurthala	235	100	17.57
Ludhiana	170	95	12.66
Mansa	214	41	9.72
Moga	203	81	14.76
Muktsar	70	8	1.365
Nawan Shehar	112	99	17.52
Patiala	195	98	13.61
Rupnagar	110	93	4.59
Sangrur	264	88	22.23
State Average	**172**	**67**	**11.4**

Table 1: Punjab state's reliance on groundwater irrigation

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Economics of Solar Pumps

- Economics of groundwater management (Gisser & Sanchez onward) typically assumes farmers pay energy cost of pumping.
- This is not the case for many areas in India – market distortion.
- World-wide, solar pumps rapidly becoming economically viable and may not require subsidies in near future.
- Question: How to manage groundwater use when irrigators face zero marginal pumping costs? (The whole world will look more like India.)
- One answer: Solar buy-back schemes.
  Farmers sell back to the grid instead of over-pumping.

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Research Questions

1. What is the “correct” buy-back price?

2. Is it affordable?

3. How do you structure a buy-back scheme?

4. What technical issues have to be dealt with?

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What is the right price?

Correct price (P) depends on value to farmer (VF).

No-Arbitrage:
VF < P < Rate paid by farmers

But in Punjab farmers get free electricity →
VF < P < 0!

If possible to ensure no electricity arbitrage, then consider:
VF < P < Rate affordable to electric utility

In Punjab, subsidy to farmers is approx 3-4 Rs per kWh.
Therefore, we look for: VF < P < 4

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How do estimate the value of water and electricity to farmers?

Assuming farmers are profit maximizers, value of groundwater depends on:

- Crops grown and yields
- Prices and costs
- Water demand (PET) and and other water supplies (rain, surface water, ponds, tanks).

Value of electricity for pumping depends on:

- Value of groundwater
- Depth of groundwater, electricity required for pumping each unit of water.

Optimization model – Maximize farm profits given contrained land, water.

- District-level data for 2008-09.
- Surface water use is estimated given other factors.
- GAMS NLP model.

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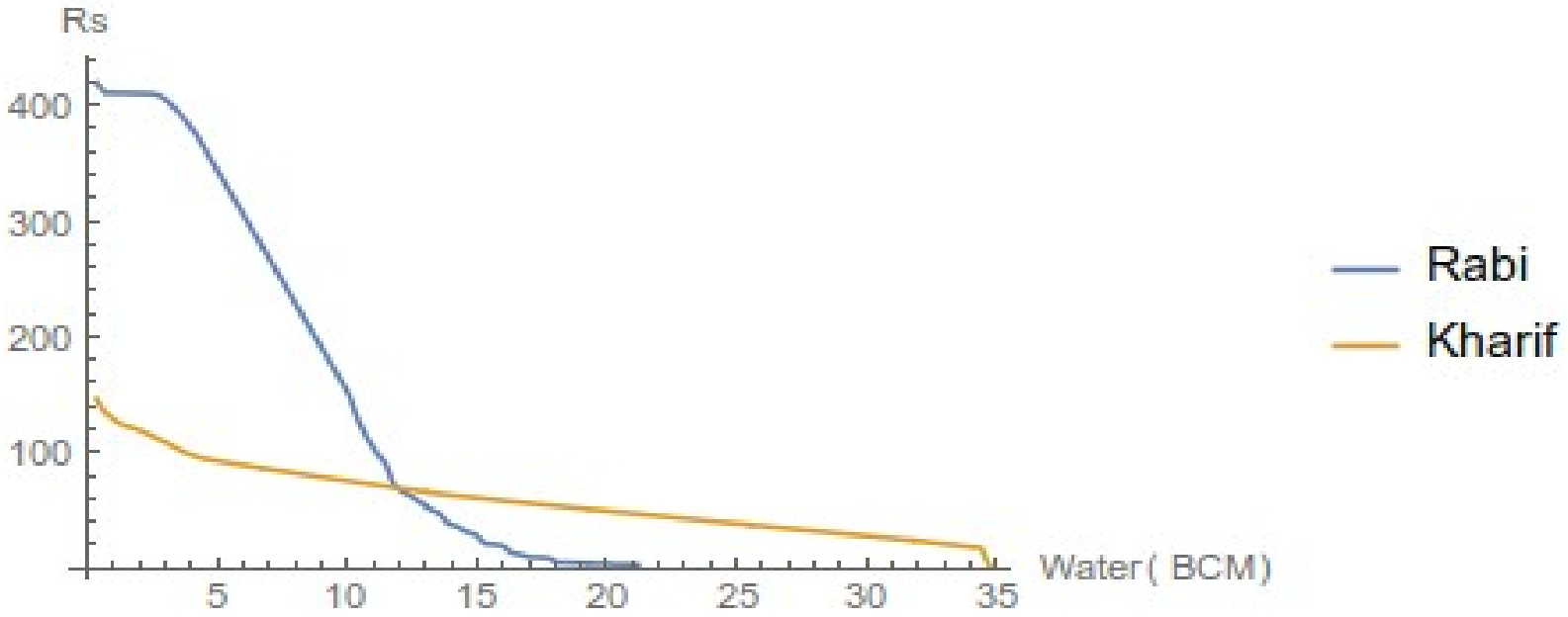
Value of Water by Season

- Kharif: June-Oct, Rice.
- Rabi: Nov-Mar, Wheat.
- Despite monsoon, most pumping during kharif season due to high crop water requirements.
- Rabi season water requirements lower but water more valuable.



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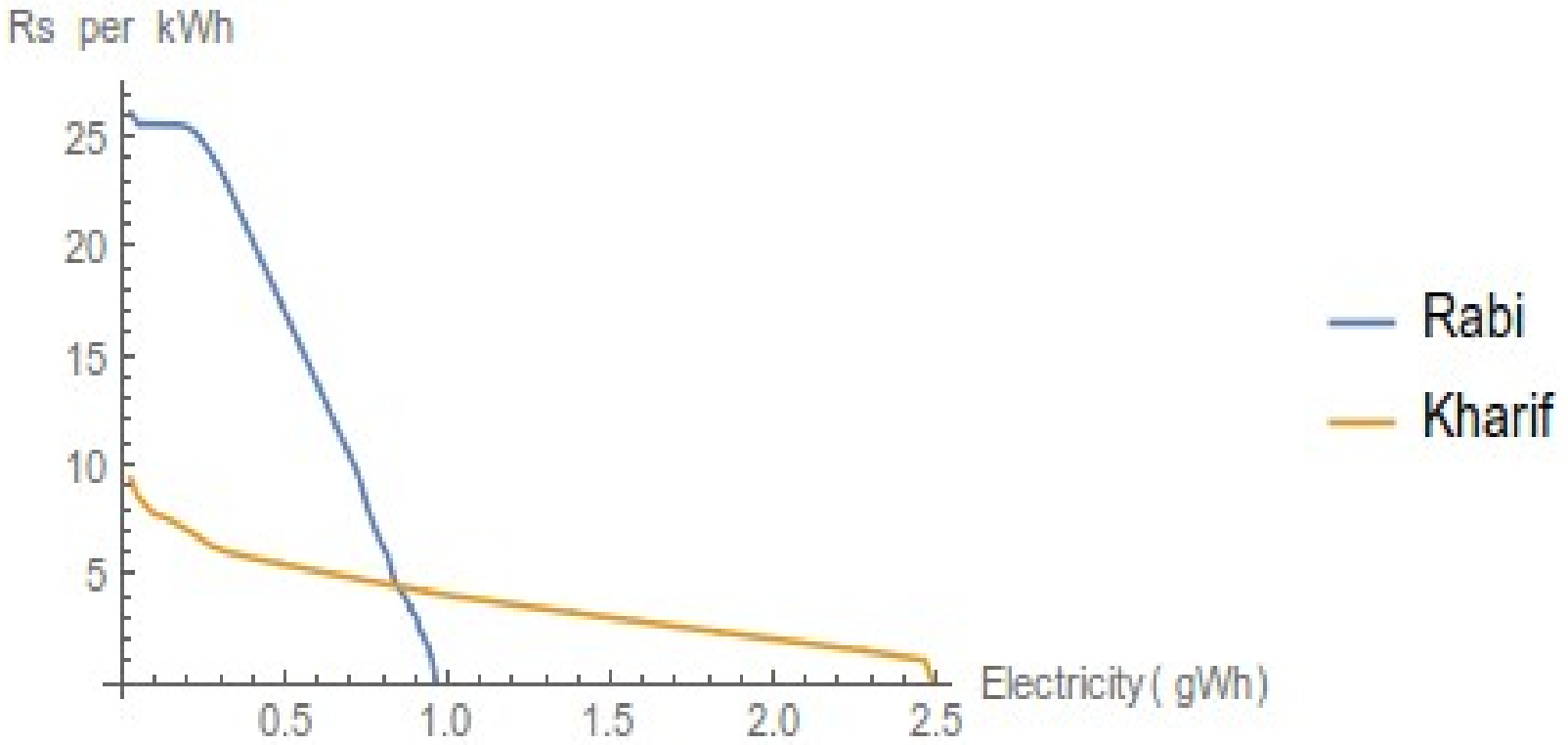
Value of Electricity for Pumping

Value of electricity for pumping is derived from value of water and amt of electricity required for pumping given depth of aquifer.



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Annual Average Electricity Value

2 Scenarios

- Baseline – observed use in base year.
- CGWB – annual replenishable amount as calculated by *Central Groundwater Board* of India.

Annual Value for whole state

- Baseline – 2.2 Rs per kWh
- CGWB – 5.2 Rs per kWh

Current Subsidy is 3-4 Rs per kWh →
Sustainability target not affordable but buy-back could prevent worsening the problem of over-use.

However, average value obscures heterogeneity, degree to which actual water savings would occur.

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Differentiated Electricity Value

- Large amount of variation by district and season.
- Kharif values range from 0 to 5.3 Rs per kWh.
- Rabi range from 2.3 to 26.6 Rs per kWh.

	Baseline		CGWB	
District	Kharif	Rabi	Kharif	Rabi
Amritsar	2.7	9.0	3.2	15.9
Barnala	1.7	9.6	5.3	26.6
Bathinda	0.8	3.8	0.9	5.4
Faridkot	0.0	3.3	1.0	5.9
FatehgarhSahib	0.6	4.9	2.9	13.9
Firozpur	1.4	5.5	2.1	12.6
Gurdaspur	3.9	14.4	4.9	20.6
Hoshiarpur	3.5	16.1	3.7	16.8
Jalandhar	0.0	6.9	4.1	17.0
Kapurthala	0.0	8.4	4.1	23.7
Ludhiana	0.0	5.4	2.5	15.1
Mansa	1.0	3.9	1.5	9.6
Moga	0.0	2.9	2.1	12.2
Mohali	2.3	9.6	2.5	10.3
NawanShehar	0.0	7.8	1.2	9.5
Patiala	0.0	3.0	3.3	13.7
Rupnagar	0.0	16.9	2.8	18.2
Sangrur	0.0	2.3	2.3	11.6

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Affordability of Buy-Back

- Kharif season:
  Baseline is affordable.
  CGWB is mostly so (14 of 18).

- Rabi season:
  Baseline - Only 6 of 18.
  CGWB – **None**.

- Caveat:
  Buy-back in kharif season may make more pumping possible in rabi season with same amount of electricity.

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Conclusions

- Value of electricity for pumping is determined by economic and technical factors.
- Cost of additional pumping is zero with solar pumps. →
  Need to give farmers incentive for limited pumping.
- Value of electricity varies by season and location. →
  Mitigation of groundwater over-use requires targeted policy.
- Possible that no feasible buy-back price exists.
- For Punjab state, evidence indicates buy-back would fail to achieve sustainable use of groundwater in most districts. But could be effective in avoiding additional over-use of water.
- Profit-maximizing behavior may not be good assumption in some areas.

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THANK YOU

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ERS ECONOMIC RESEARCH SERVICE United States Department of Agriculture