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Social dimensions of agricultural technology adoption

Research and action for energy-efficient irrigation in Andhra Pradesh

Christian Kimmich

11/06/12 India Science Day

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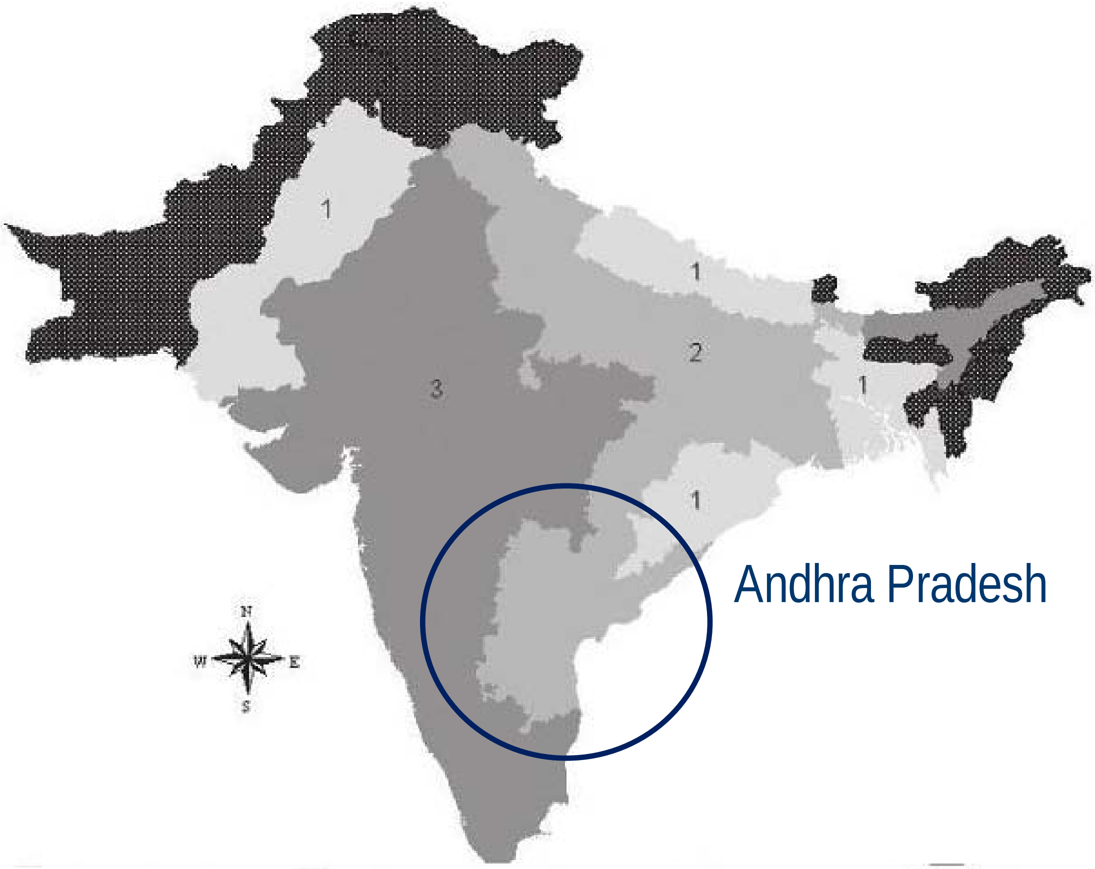
Introduction: electricity policies



- Zone 1 (Pakistan Punjab, Sind, Nepal terai, Orissa, Bangladesh): metering, leading to dieselization
- Zone 2 (eastern India): de-electrification, leading to dieselization
- Zone 3 (western and peninsular India): subsidization
- No data

Source: Shah (2009: 154)

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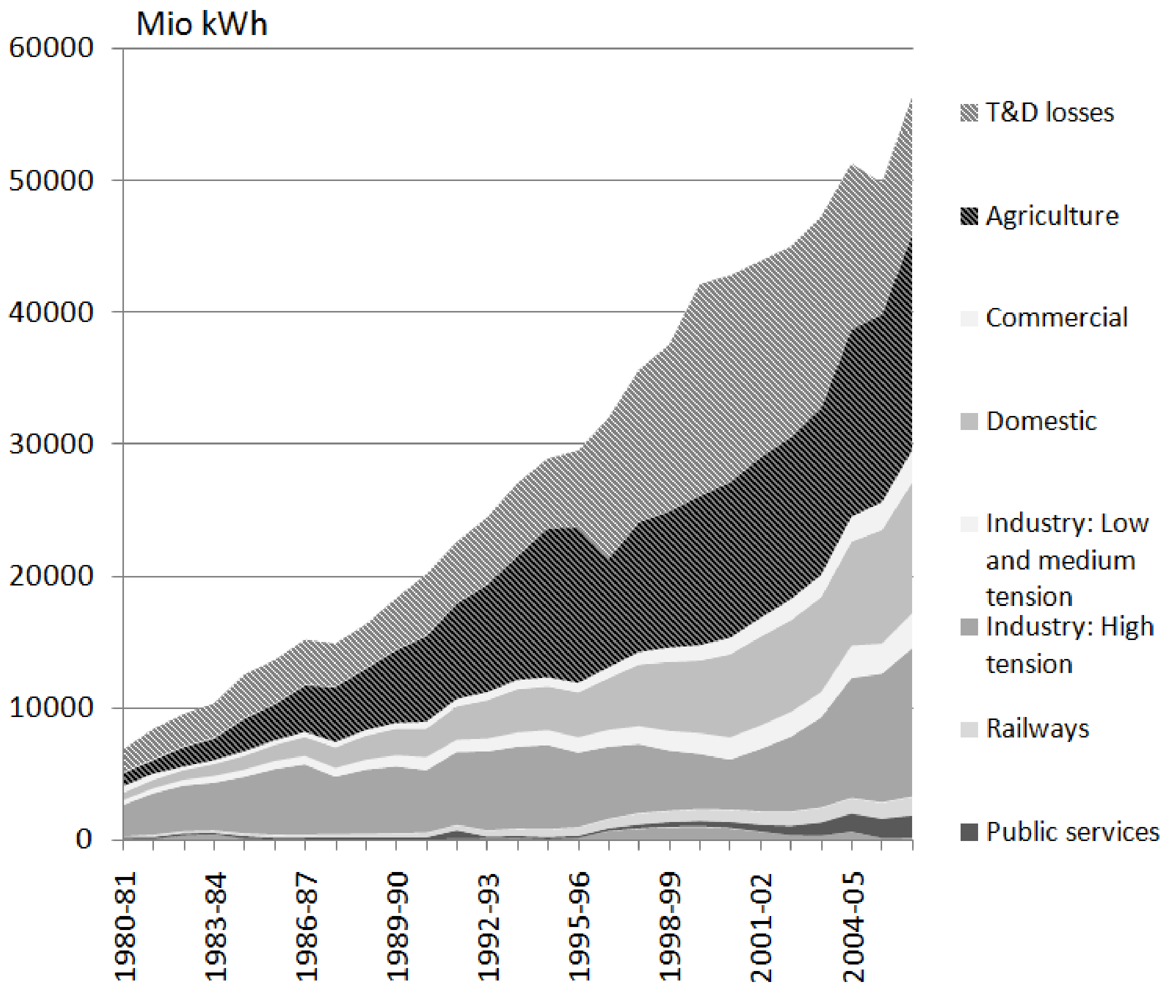
Electric power utilization in Andhra Pradesh

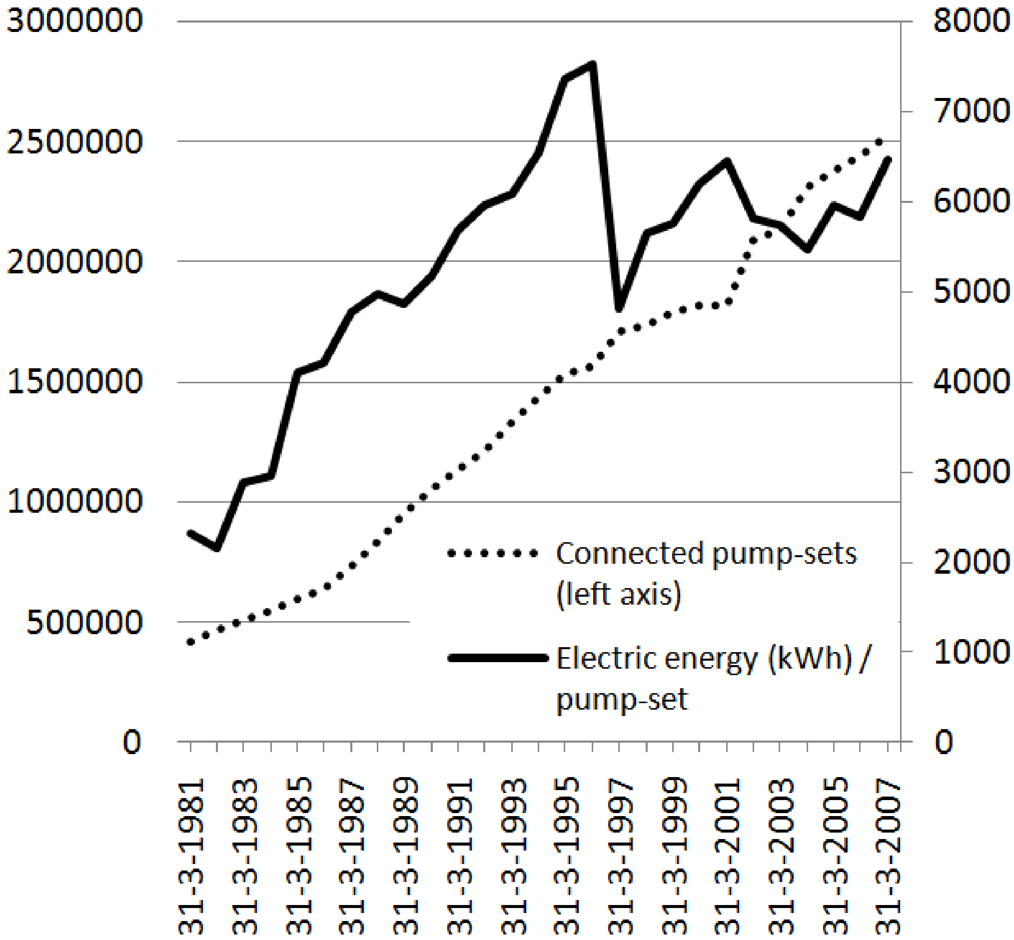
Figure 1: Electric energy consumed in AP, sector-wise



Source: based on data from CMIE (2008)

Electric power for irrigation in Andhra Pradesh

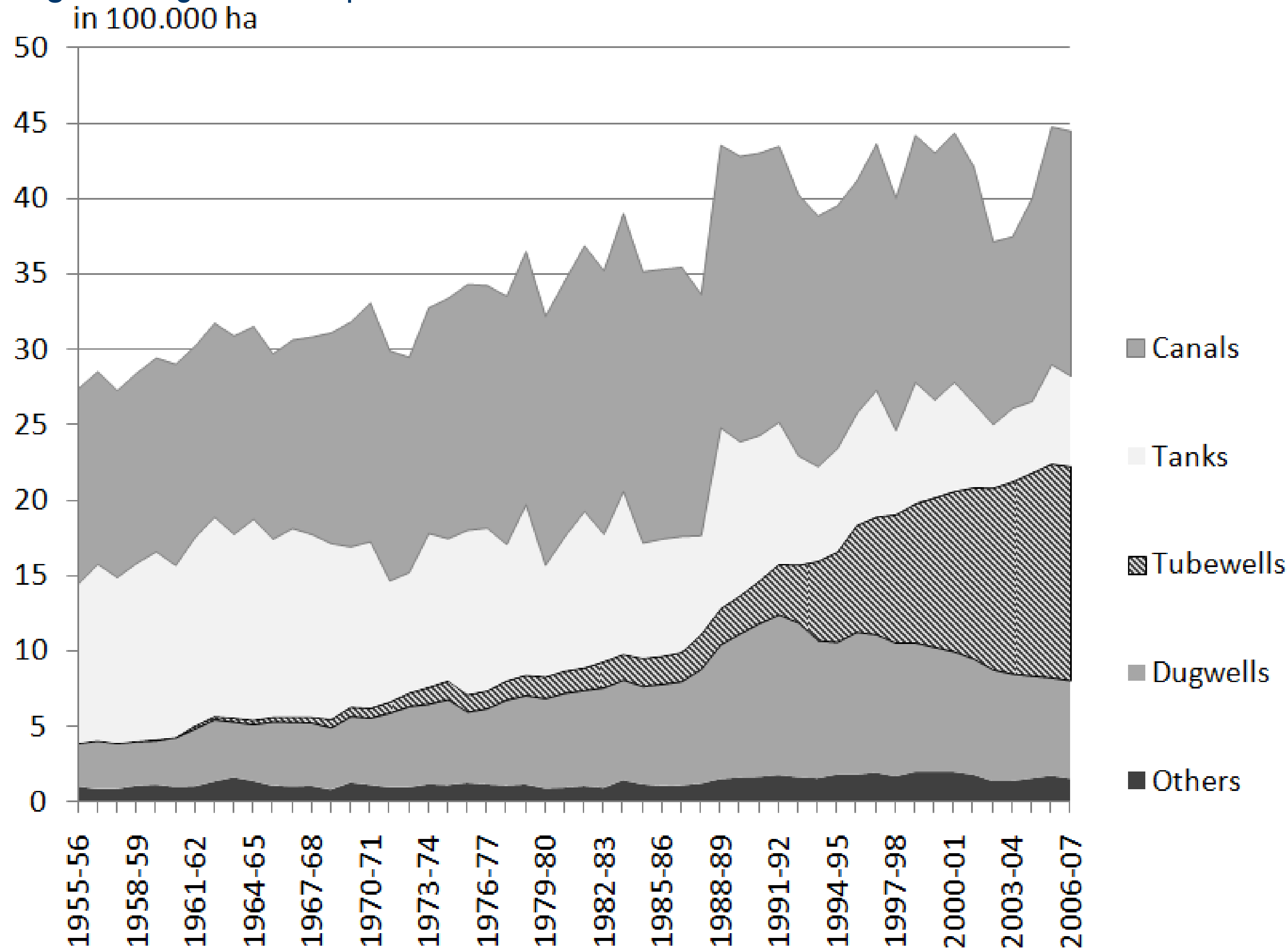
Figure: Connected pump-sets and consumption per pump-set in Andhra Pradesh



Source: based on data from APTRANSCO (2008) and CMIE (2008)

Context: irrigation sources and precipitation

Figure: irrigated area per source in Andhra Pradesh



Source: composed on the basis of data from the Directorate of Economics and Statistics, Andhra Pradesh

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Outline

- Research objective:
  Energy efficiency through power quality
- Methods
- Electric power quality:
  An assurance/coordination problem
- Power quality: An econometric analysis
- Networks of action situations
- Implications for practice:
  Pilot Project and Capacity Building

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Electric power quality

- Average Repair Costs (RC) / farmer / year: 5400 Rs. for motors and 600 Rs. for distribution transformers (DTRs)
  (1/3 of the seed costs / fertilizer&pesticide costs or 2/3 of the expenditure for the education of children)

- Measures to improve power quality also improve energy efficiency. All demand side measures (DSM), including pump-set rectification, can improve energy efficiency by up to 50% (Sant and Disxit 1996, Reidhead 2001)

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Electric power quality

- Investments in prevention measures seem feasible and affordable
  - capacitors against voltage fluctuations
    (10% use one)
  - ISI-marked and BEE-rated pump-sets
    (37% use ISI-marked, and 6% use BEE-rated motors)

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Research objective:

A marginal pricing scheme being absent, farmers have no incentive to improve energy efficiency. But: Some demand-side measures (DSMs) can improve power quality AND improve energy efficiency

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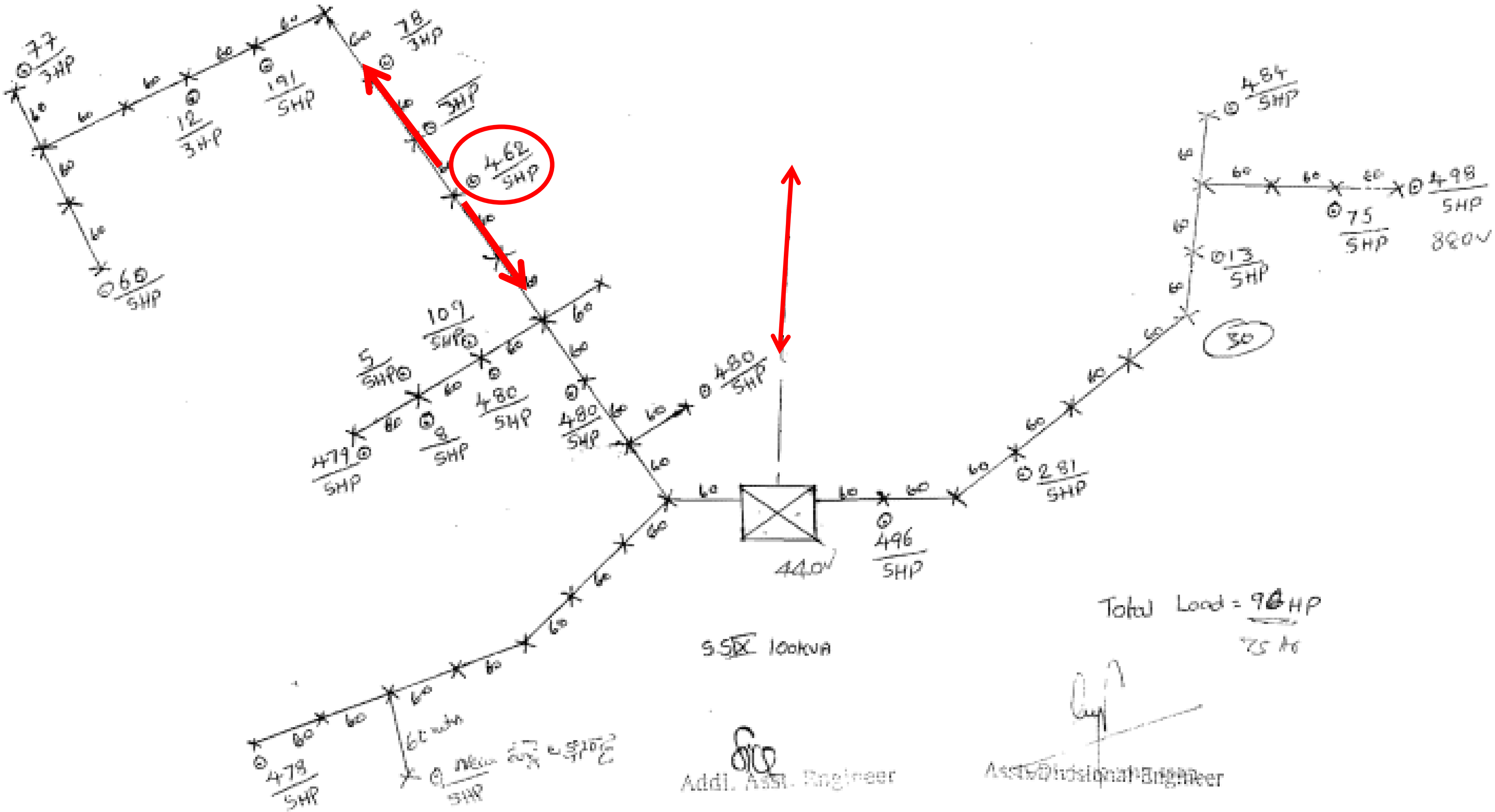
Methods

- Semi-structured interviews with farmers, utilities staff/ electrical engineers, pump-set workshops, manufacturers, pump-set retailers, electricity regulator, NGOs, local scientists

- Farm-level survey (N=305) and village-level survey (N=18)
  - Selection of 18 villages in 4 districts based on the Census 2001 according to irrigation conditions (groundwater/surface) and average holding size
  - Stratified random sample according to holding size, gender, caste

Electric power quality: interdependence



Source: Provided by the Cooperative Electricity Supply Society Ltd. Sircilla

Electric power quality: a coordination problem

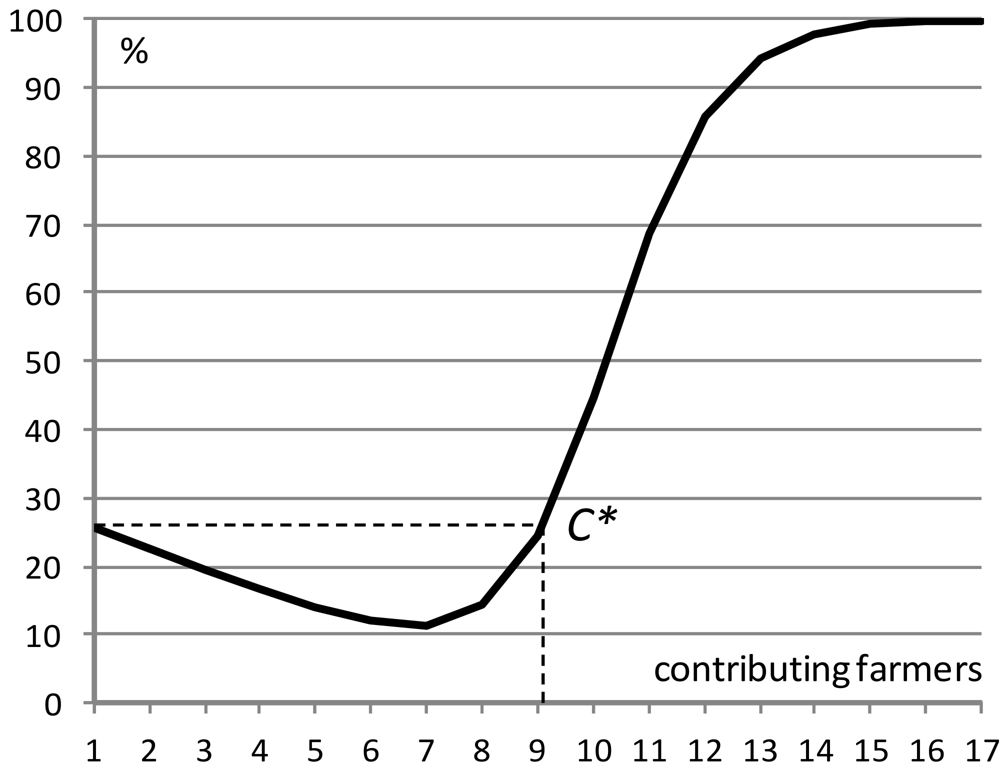


Figure 1: aggregate. power quality vs. contribution

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- The individual change to a better pump-set quality or capacitor use currently increases the frequency of motor burn-outs.

Electric power quality: a coordination problem

		Farmer 2	
		invest	*~invest*
Farmer 1	*invest*	*<<6000* *<<6000*	*6000* *>6300*
	~invest	*>6300* *6000*	*6000* *6000*

Figure 2: the coordination problem – repair costs (INR)

-> Only a concerted investment in electric power quality (e.g. simultaneous use of capacitors) will yield positive results!

"the capacitor (..) has been the biggest techno operational problem encountered in the power sector", and *"the consumers have not been made party to the scheme"* (APERC 2005: 74)

Econometric analysis: Results

Table: Regression results for DTR (1) and motor (2) burn-out frequencies

Frequency Independent variable	of DTR burn-outs per year *(1) Interval regression*		of motor burn-outs per year *(2) Ordered logit, odds-ratios*	
ISI-marked (1=y)	0.60***	(0.14)	0.90**	(0.41)
BEE-rated (1=y)	-0.78***	(0.13)	-0.88	(0.82)
Capacitor installed (1=y)	-0.27**	(0.12)	0.58*	(0.31)
Automatic starter (1=y)	0.15	(0.17)	0.38	(0.39)
Age of the pump-set			0.04	(0.04)
Pump- set cost (1000Rs)			-0.05***	(0.02)
Repair costs (1000Rs)			0.28***	(0.09)
ln (farmers per DTR)	0.39***	(0.12)	0.77	(0.60)
ln (DTR capacity/farmer)	0.11	(0.12)	0.52	(0.67)
DTR head/tail (1=head)	-0.20**	(0.09)		
Well depth (100 feet)	-0.15**	(0.07)		
Months without water			0.37***	(0.13)
…			…	…

H1 H2 (ISI-marked, BEE-rated, Capacitor installed)

H3 (ln (farmers per DTR), ln (DTR capacity/farmer), DTR head/tail)

H4 (Well depth, Months without water, …)

Standard errors in parentheses; * p<0.10, ** p<0.05, *** p<0.01

Linked action situations

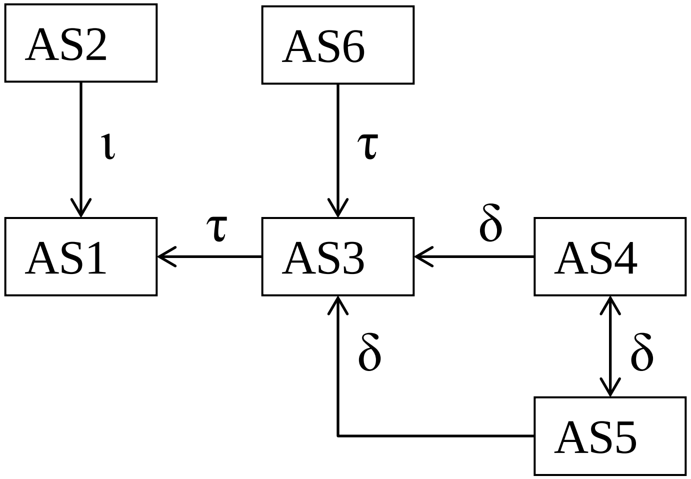


Figure: the network of action situations in the electricity-irrigation nexus

AS1: The coordination problem

AS2: Social learning and technology adoption

AS3: The dilemma of capacity appropriation

AS4: Collusion and solidarity

AS5: Infrastructure provision by the utility

AS6: The dilemma of groundwater exploitation

Theory:

- Networks of adjacent action situations (McGinnis 2011)
- Levels of operational, collective, constitutional choice (Kiser and Ostrom 2000)
- Economic network analysis (Goyal 2007), Ecology of games (Long 1958; Dutton 1995; Bauer, Lang and Schneider 2012), two-level games (Shubik 1986; Putnam 1988)

The energy-water nexus

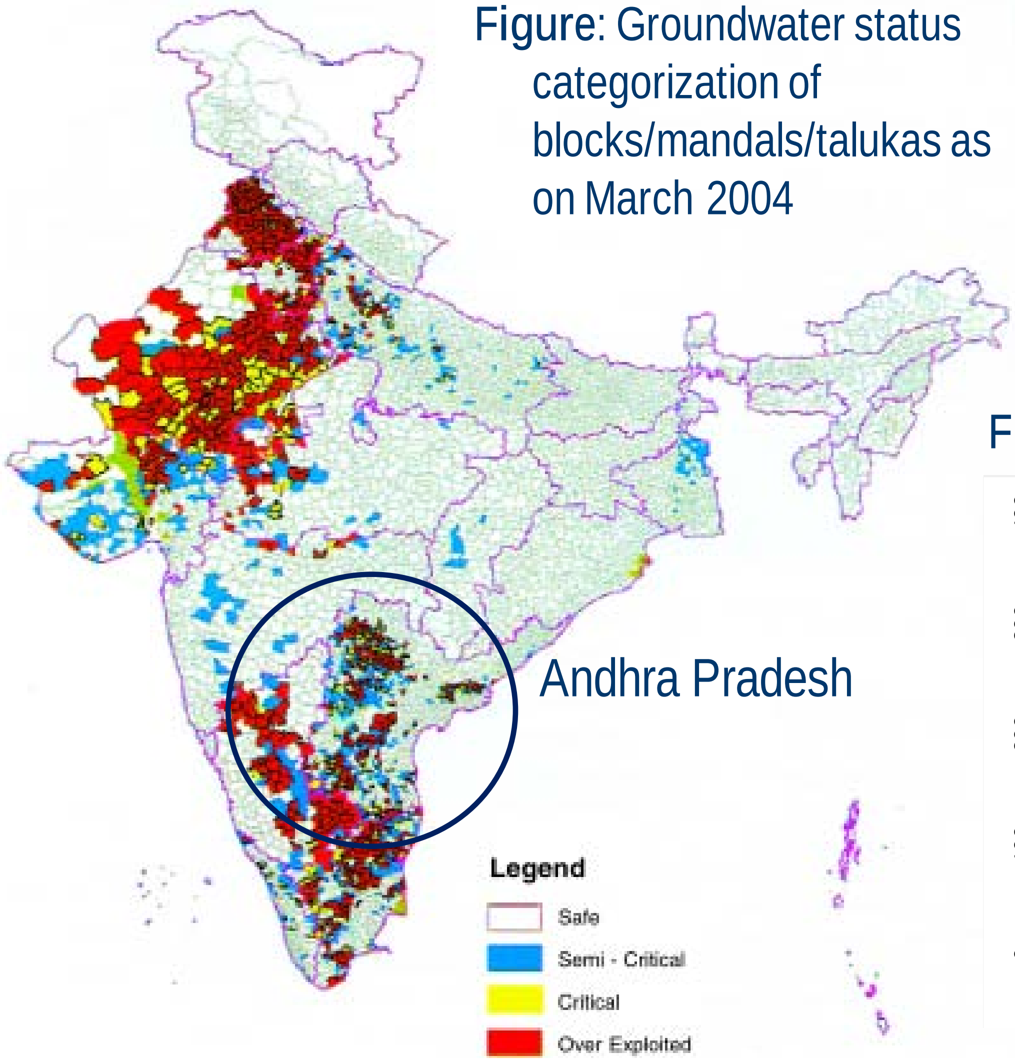
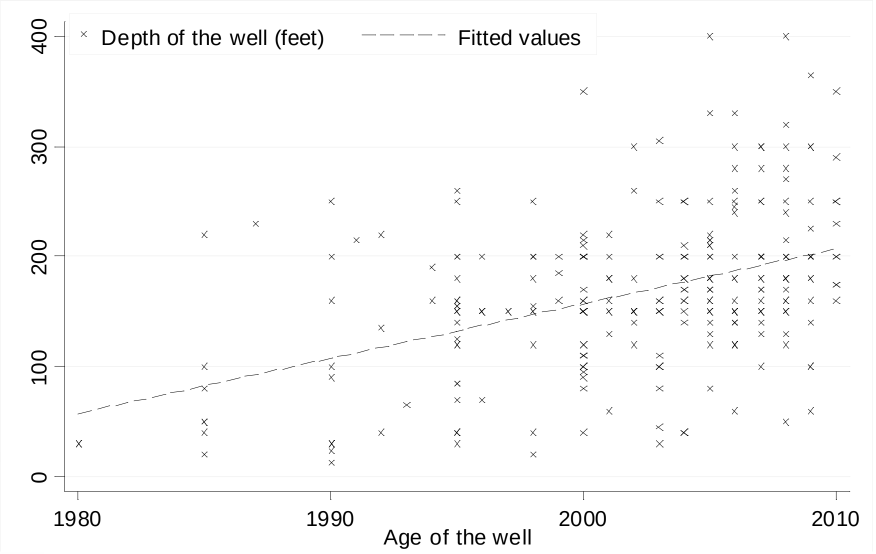


Figure: Groundwater status categorization of blocks/mandals/talukas as on March 2004

Source: *Dynamic Groundwater Resources of India (as on March 2004), Central Ground Water Board, Ministry of Water Resources, 2006.*

Figure: Depth vs. age of well



Implications for practice

- **Pilot Project** and Capacity Building Measures, led by HU Berlin
- **Partners**: Centre for World Solidarity (CWS), Hyderabad and Prayas Energy Group Pune, Rural Electricity Supply Cooperative in Andhra Pradesh, IIIT-Hyderabad, Steinbeis Technology Transfer India

IIIT-H

Steinbeis

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Thank you!

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