An aerial photograph of a rural landscape. The foreground shows a large, rectangular, muddy area, possibly a flooded field or a construction site. The middle ground is dominated by lush green fields and clusters of trees. In the background, more green fields stretch towards a distant horizon under a clear sky. The overall scene is a mix of natural and agricultural elements.

Beliefs, expectations, and assurance in SES dynamics of CPR regimes

WINS Seminar, 14.07.2016
*Christian Kimmich**

*: Masaryk University Brno, Czech Republic

Outline

1. IF common-pool resource provision & use can be represented by models with multiple equilibria (e.g. assurance model), **Yes or No?**
2. THEN beliefs about cooperation, expectations about outcomes, and resource system dynamics matter for cooperation, **How? (3 Cases) Why?**
3. with implications for sustainability transformations. **So what?**

Outline

1. IF common-pool resource provision & use can be represented by models with multiple equilibria (e.g. assurance model),

Yes or No?

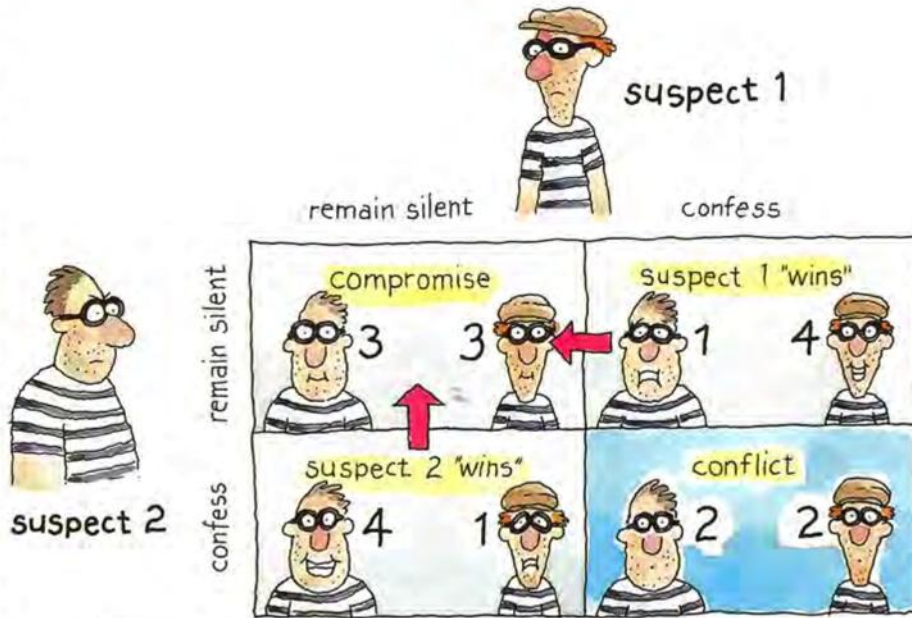
2. THEN beliefs about cooperation, expectations about outcomes, and resource system dynamics matter for cooperation,

**How?
(3 Cases)
Why?**

3. with implications for sustainability transformations.

So what?

Prisoners' Dilemma (PD)



(Brams, 1993)

=

- Widely used to study cooperation in biology, ecology, philosophy, law, social sciences

resource user 2

resource user 1

		resource user 1	
		use sustainably	exploit egoistically
resource user 2	use sust.	3	4
	exploit ego.	4	2

Research objective

“The two-person iterated PD is the E. coli of the social sciences”

(Axelrod 1997)

PD mentioned in >3000 law review articles,
other models virtually ignored

(McAdams 2008)

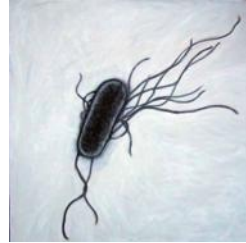
Common-pool resource management is not a PD

(Runge 1981, Cole and Grossman 2014)


➤ **Research question:**

Is CPR use best represented by PD models?

➤ If not, what are the implications for social-ecological systems research?



Assurance Problem (AP)







hunter 2

hunter 1

hunt stag together

hunt hare alone

hunt stag tog.		
hunt hare al.		

“Stag Hunt”

(Rousseau 1755, game-theoretic interpretation by Lewis 1969)

Differences between PD and AP

Prisoners' Dilemma (PD)

		RU_1	
		<i>C oop</i>	<i>D efect</i>
RU_2	<i>C</i>	3, 3	1, 4
	<i>D</i>	4, 1	2, 2

(Dresher, Flood, Tucker 1950)

Assurance Problem (AP)





		RU_1	
		<i>C</i>	<i>D</i>
RU_2	<i>C</i>	4, 4	1, 3
	<i>D</i>	3, 1	2, 2

(Sen 1967)

- Independent decisions (in one-stage models)
- Repeated games: TIT-for-TAT, Grimm, Trigger, etc.

- Interdependent decisions, payoff sizes matter
- Outcome depends on beliefs, expectations and resource dynamics

Assurance Problem (AP)

		hunter 1	
		hunt stag together	hunt hare alone
hunter 2	hunt stag tog.		
	hunt hare al.		

“Stag Hunt”

(Rousseau 1755, game-theoretic interpretation by Lewis 1969)

- Strategies depend on **beliefs** about the likely choices of others
- **Expectations** matter and can create self-fulfilling outcomes
- Expectations depend on beliefs and resource **system dynamics**

Repeated PDs: APs?

		<i>RU 1</i>	
		<i>use sustainably</i>	<i>exploit egoistically / trigger</i>
<i>RU 2</i>	<i>use sust.</i>	<i>Infinite discounted sum of 3</i> 1	4 1
	<i>exploit ego. / trigger</i>	4 1	<i>Infinite discounted sum of 2</i>

- NPV of infinite series:
 $3+3d+3d^2+.. = 3*1/(1-d)$
- IF “trigger” is played, AND
- IF $3/(1-d) > 4 \Leftrightarrow d > 1/4$,
- THEN cooperation is supported as an equilibrium (folk theorems for infinite games)
- THEN the game is an AP (Medina 2007)

Outline

1. IF common-pool resource provision & use can be represented by models with multiple equilibria (e.g. assurance model),
2. THEN beliefs about cooperation, expectations about outcomes, and resource system dynamics matter for cooperation,
3. with implications for sustainability transformations.

Yes or No?

How?
(3 Cases)
Why?

So what?

Case I: village heating networks in DE

with Philipp Grundmann

Wood chips
Biogas CHP



- Minimum participation rate and long-term supply contracts necessary for viable infrastructure investment
- Comparison with expected price of heating oil became central to the discourse in one sub-case (participant observation)

Case II: Wood provision in CH

with Urs Fischbacher

Wood market governance
and
fibre vs. fuel resource conflicts

➤ Trust, Expectations & Cooperation



Case II: Wood provision

Price expectations experiment with public forest managers of the cantons Grisons and Aargau in 2014

(Population: $N_{GR} = 86$, $N_{AG} = 63$; Response:

Survey: $n_{S,GR} = 70$, $n_{S,AG} = 48$; Experiments: $n_{E,GR} = 64$, $n_{E,AG} = 55$)

- Econometric model of institutional choice for selling wood:
Those who expected low future wood prices were more likely to use a marketing cooperative.

Case II: Wood provision

Sawmill Domat/Ems in 2007:



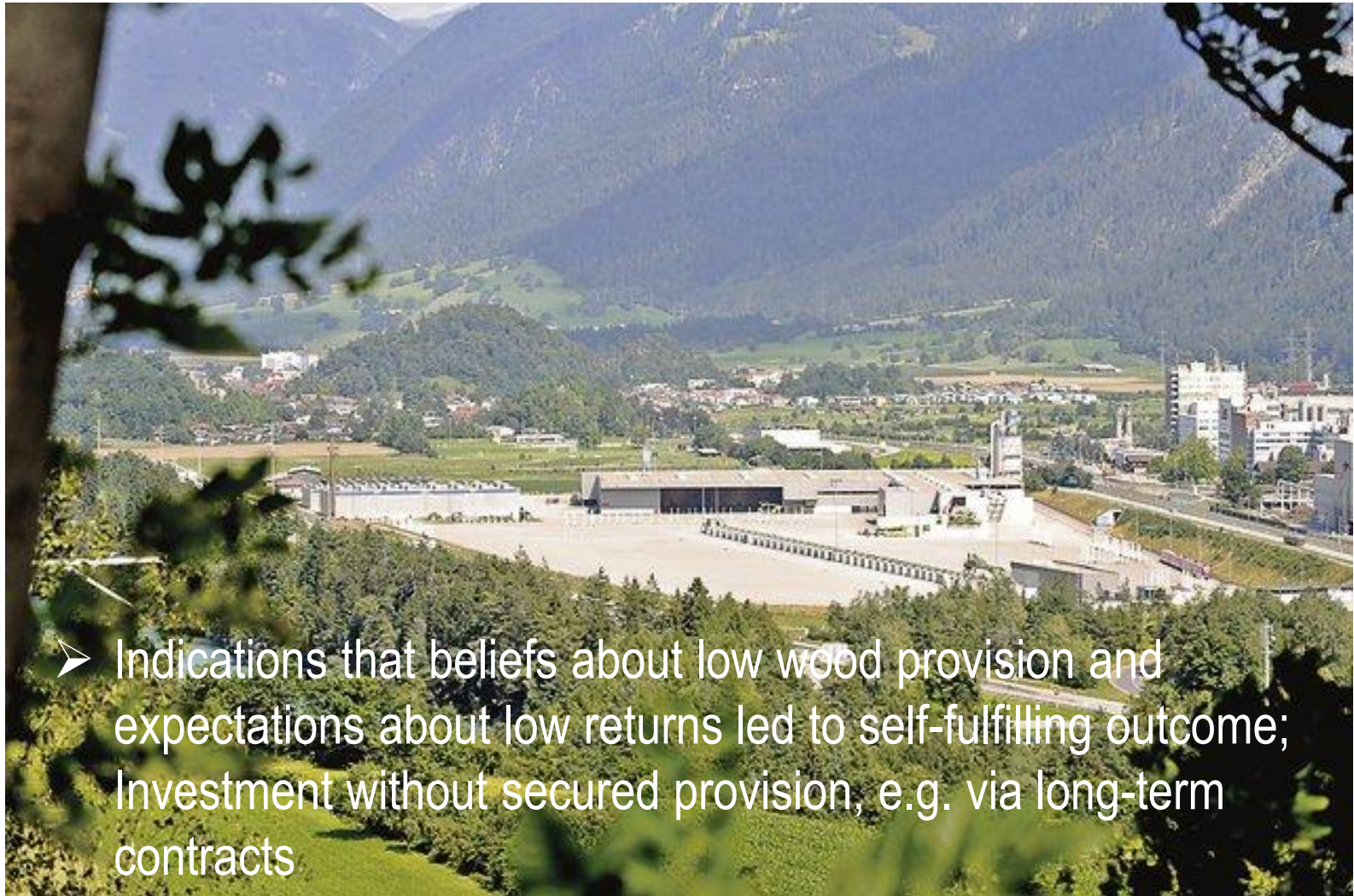
Annual capacity: 1 mio m³

- Investment grant: 7.5 mio CHF (GR)
- Loan: 10 mio CHF (GR)
- Support with rail infrastructure:
5 mio CHF (GR) + 10 mio CHF (CH)

(Photo: A. Badrutt)

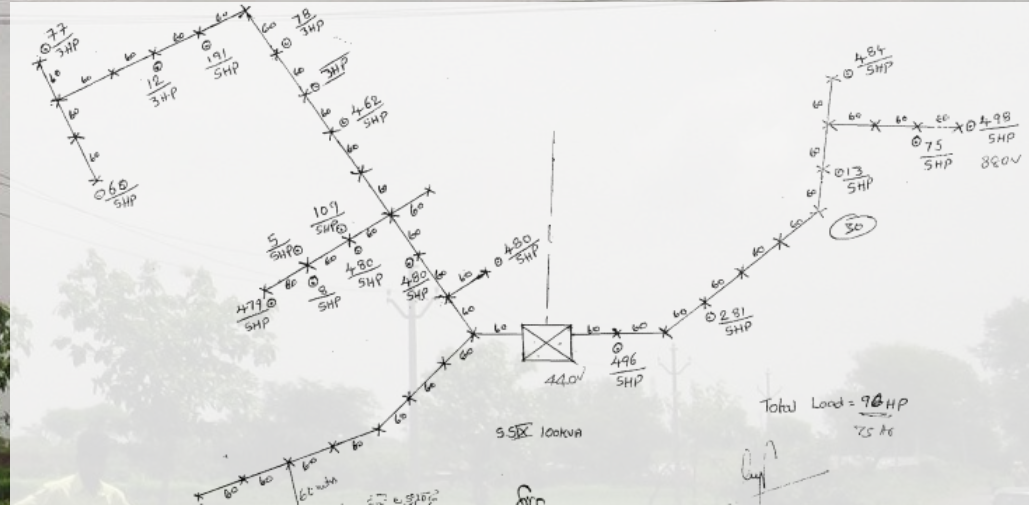
Case II: Wood provision

Sawmill Domat/Ems in 2010:



- Indications that beliefs about low wood provision and expectations about low returns led to self-fulfilling outcome; Investment without secured provision, e.g. via long-term contracts

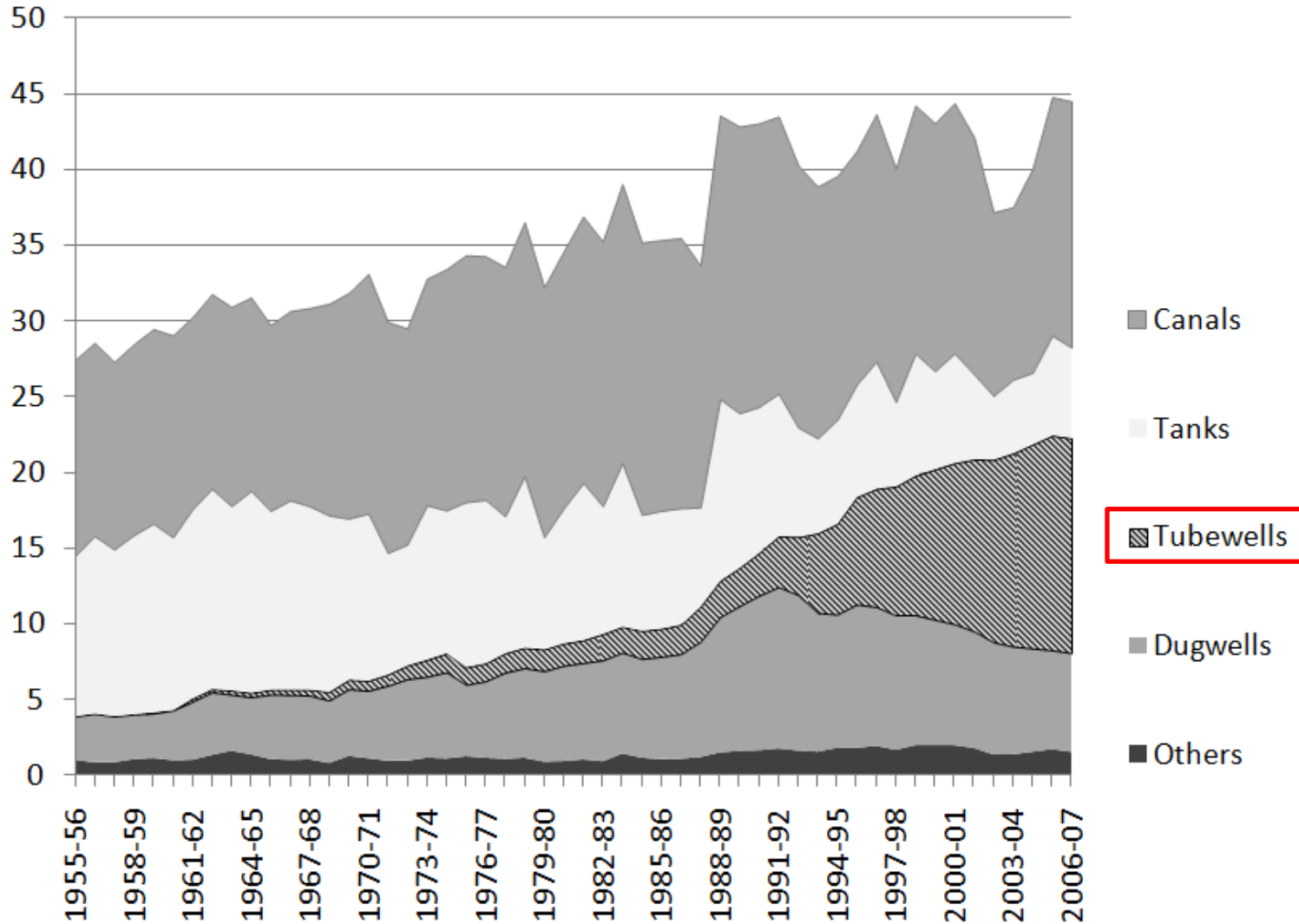
Case III: Water-energy-food nexus



Case III: Water–energy–food nexus

Figure: irrigated area per source in Andhra Pradesh

in 100.000 ha



Case III: Water–energy–food nexus

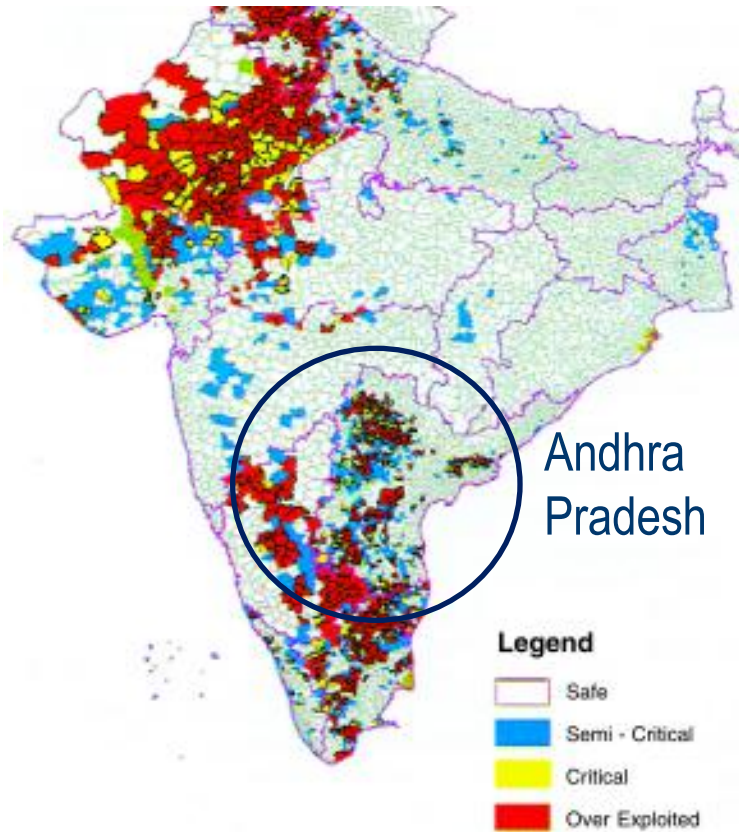
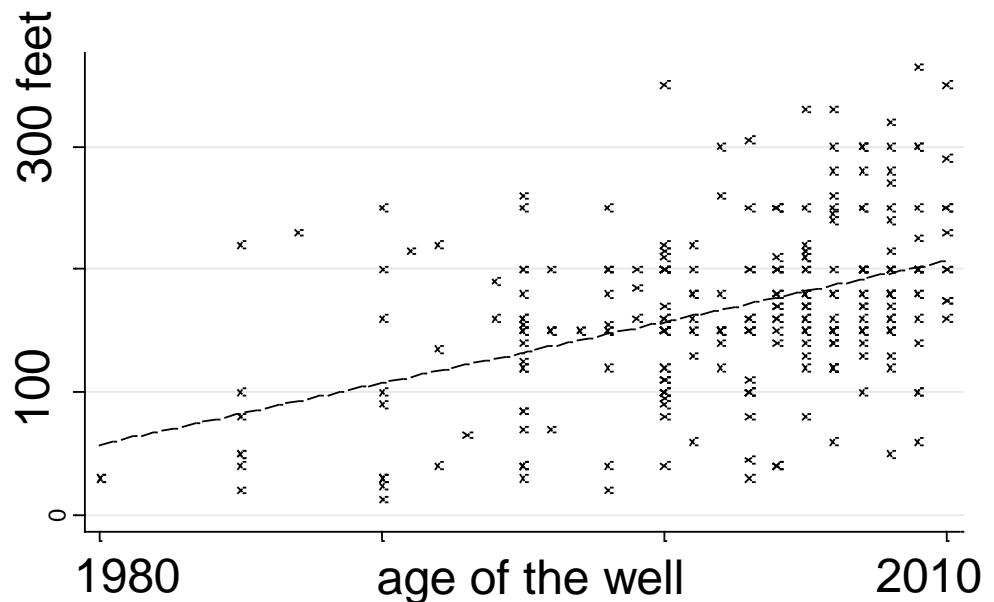


Figure: Groundwater status categorization

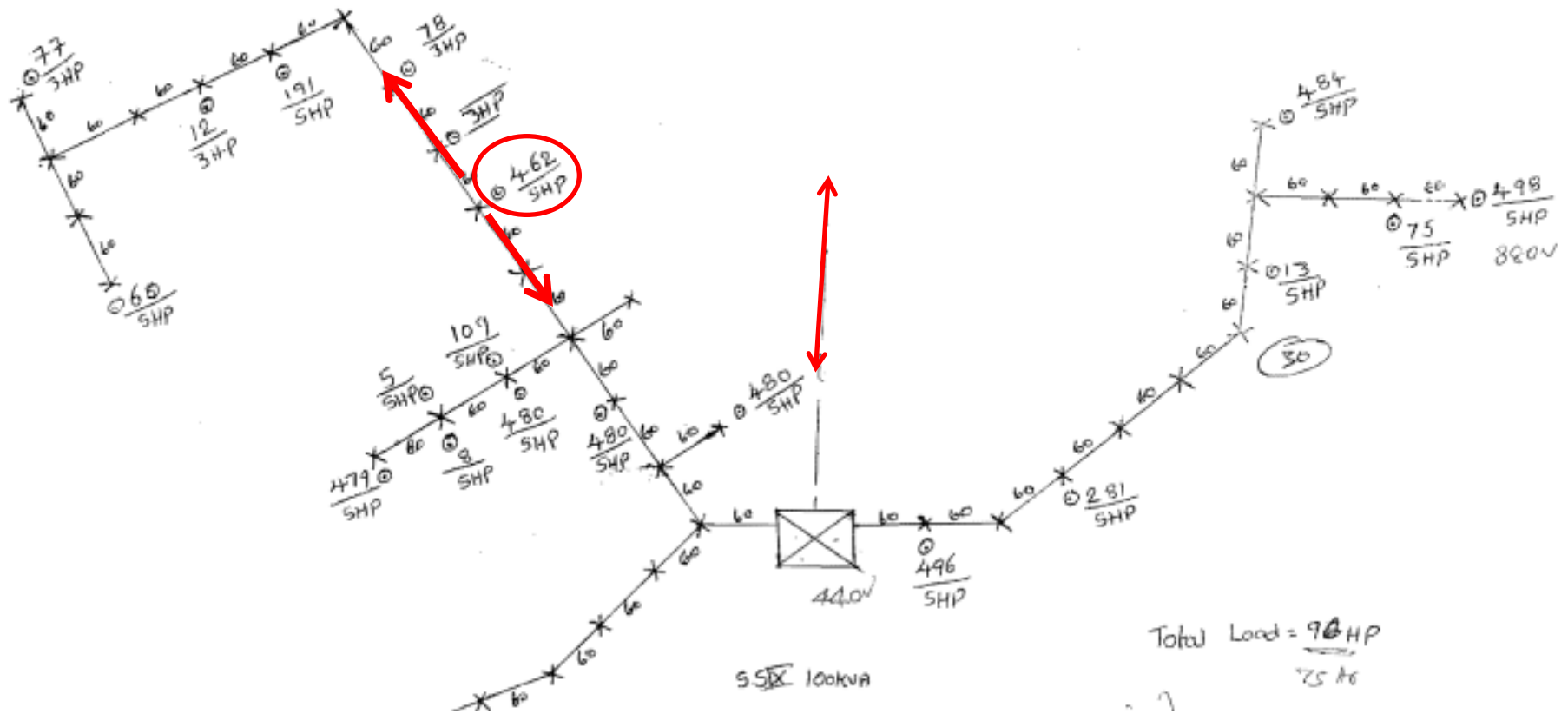
Source: Central Groundwater Board, Ministry of Water Resources, 2006

Figure: Depth vs. age of well



- The deeper the tube well, the more electric load on the grid

Case III: Water-energy-food nexus



- Low voltage and poor power quality due to inefficient pumps

Multiple equilibria in APs

with Hannu Autto and Luis Fernando Medina

- With multiple pure strategy equilibria, also Mixed-strategy Nash Equilibria (MSNE) exist
- MSNE are unstable and separate stable pure strategy equilibria
- A measure for the “probability of cooperating”
- Areas I and II belong to the stability sets of the two pure equilibria (Harsanyi & Selten 1988)
- MSNE is a “tipping point”, helps to analyse which outcome is more likely
- Equilibrium outcome depends on beliefs and expectations (Medina 2007)

➤ AP provides solutions for transformations..

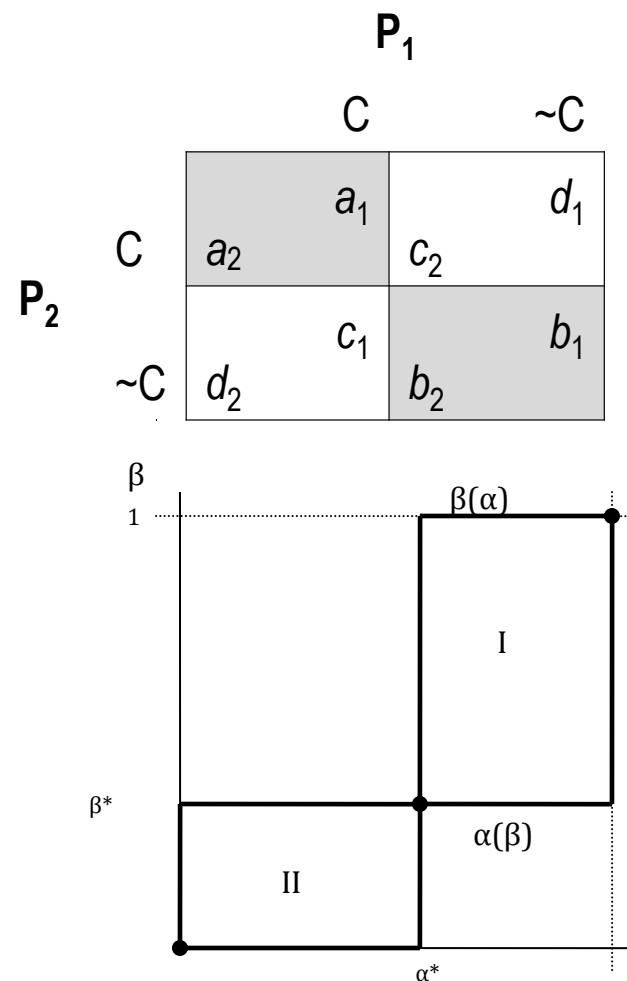


Figure: Best reply correspondences

Outline

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Yes or No?

**How?
(3 Cases)
Why?**

So what?

Assurance policies

1. **Demonstration pilot project:**

What payoff can be expected from cooperation?
(update expectations, which may change beliefs)

2. **Outcome-contingent incentives (“insurance”):**

Compensate cooperators, if common-pool is not provided
(reduce risk dominance and change beliefs about coop.)

3. **Discourse on expectations and beliefs:**

Communicative rather than strategic rationality in CPR
governance (e.g. Rist et al. 2007) to increase assurance

4. **Institutions as assurance:**

Crafting rules by discourse (Hagedorn & Reusswig 2011)

Conclusions

Research question:

Is CPR management best represented by PD models?

- Model type depends on resource user characteristics and resource system properties
- In Assurance Problems, beliefs, expectations, and resource system properties become crucial for cooperation
- Expectations matter in empirical cases
- Indicating solutions that would have remained neglected within the PD model perspective

Implications

- Detailed, case-specific social-ecological systems knowledge becomes necessary -> Applied research!
- Temptation of the PD (e.g. in law):
“Everyone can be made better off by legal sanctions”, but “unlike the PD, coordination games describe situations involving inequality, reveal how culture and history powerfully affect behavior, and demonstrate how law works expressively” (McAdams 2008)
- Game theory is pushed towards interdisciplinary research



Thank you!

PD models – a dominant narrative

1950

First mentioning of the PD model
(Dresher and Flood 1950, Tucker 1950)

“Tragedy of the Commons”
(Hardin 1968)

Common-pool resource = PD
(Dawes 1973)

➤ Privatization or State

“Cooperation among egoists”:
Repeated PDs, TIT-for-TAT
(Axelrod 1981)

Governing the Commons
(Ostrom 1990)

➤ Beyond market vs. state

- Reciprocity, Fairness, and Folk Theorems of repeated PDs
- Widely used in biology, ecology, philosophy, law, social sciences

2010

PD models – a dominant narrative

1950

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“Tragedy of the Commons”
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Assurance Problem
(Sen 1967)

Common-pool resource = PD
(Dawes 1973)

“Cooperation among egoists”:
Repeated PDs, TIT-for-TAT
(Axelrod 1981)

Isolation Paradox,
Assurance in CPRs
(Runge 1981)

Governing the Commons
(Ostrom 1990)

2010

- Reciprocity, Fairness, and Folk Theorems of repeated PDs
- Widely used in biology, ecology, philosophy, law, social sciences

Herder Problem = Assurance Problem
(Cole and Grossman 2010)

➤ Axelrod (1981) cited 30.000 times!

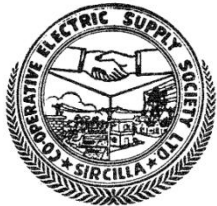
➤ Runge (1981) cited 420 times

Dynamic games as APs

1. Combine ecological system dynamics models
AND
2. dynamic (differential) game theory
(Clemhout and Wan 1979, Clark 1980, Levhari and Mirman 1980, Dutta and Sundaram 1993, Dockner and Sorger 1996)
3. to determine combined social-ecological conditions for an Assurance Problem to emerge.

Implications for practice

- **Pilot Project** and Capacity Building Measures with 800 farmers
- **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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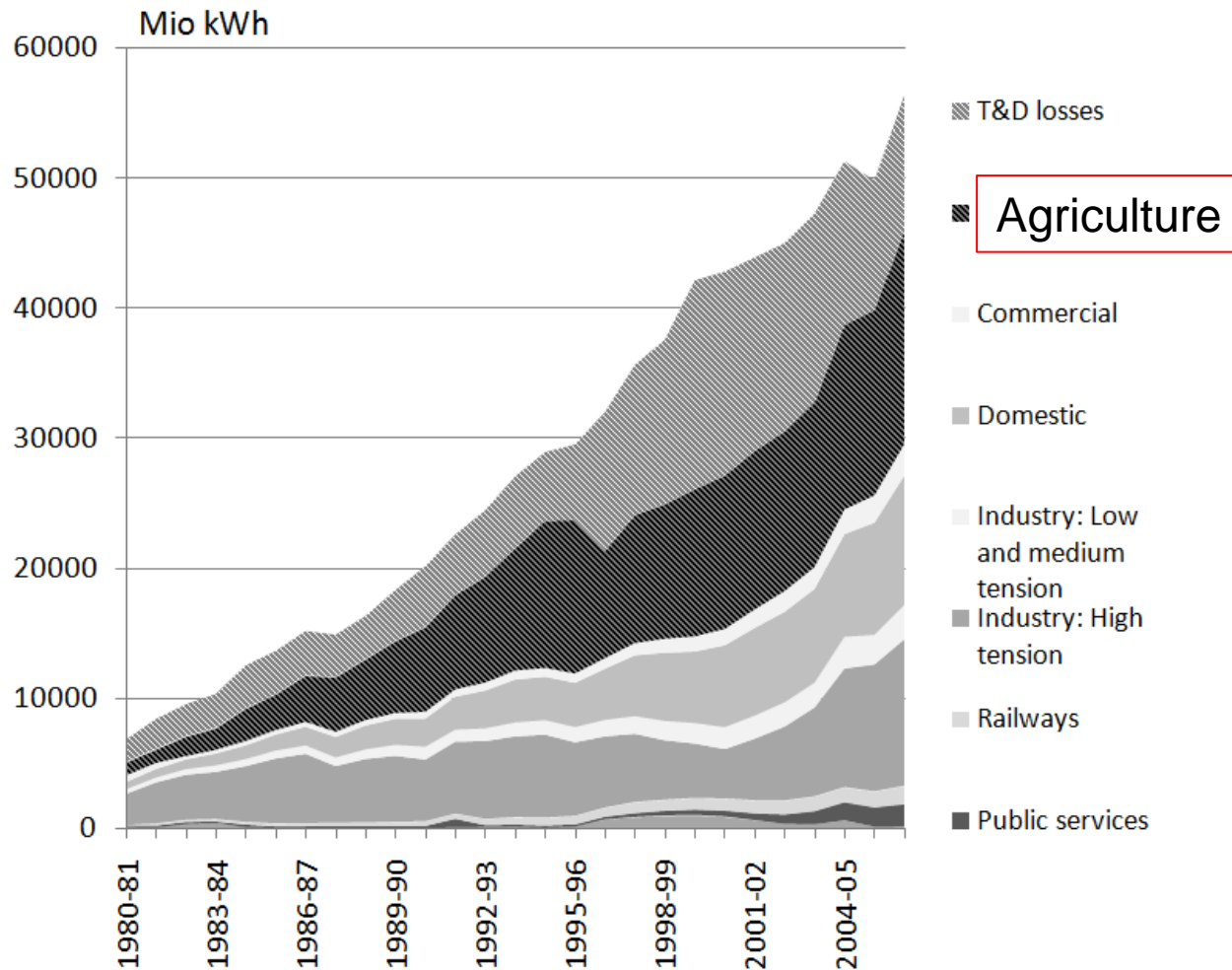
SUSTAINABLE HYDERABAD PROJECT



Federal Ministry
of Education
and Research

Electric power utilization in Andhra Pr.

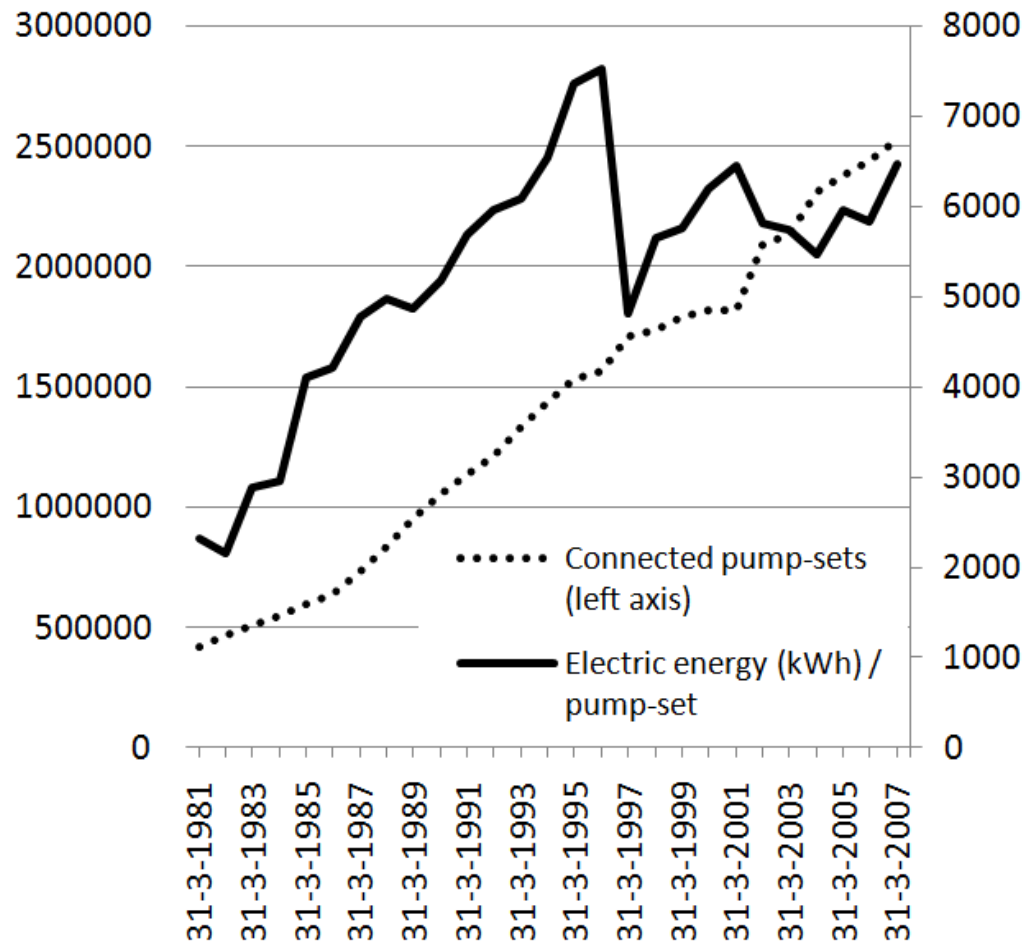
Figure: Electric energy consumed in AP, sector-wise



Source: based on data from CMIE (2008)

Electric power for irrigation in AP

Figure: Connected pump-sets and consumption per pump-set in AP



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