

Counter-intuitive impact of a policy for climate resilience in agriculture

The case of groundwater filled farm-ponds

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System Dynamics Workshop



My Inspiration: Thinking in Systems

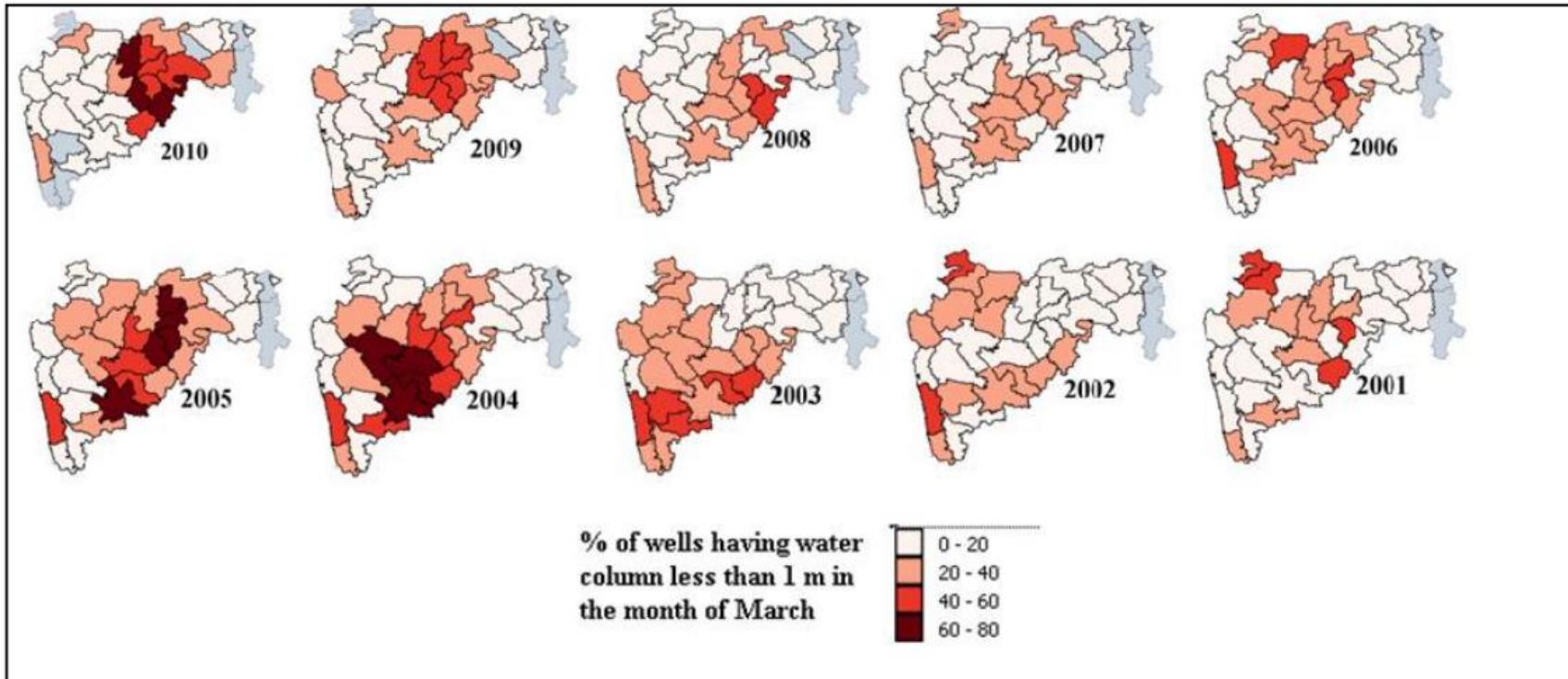
What is sustainability?

Source: Donella Meadows, Lecture on Sustainable Systems (inspired by Herman Daly) [You tube Link](#)

- Every **renewable resource** must be used at or below the rate at which it can regenerate itself
- Every **non-renewable resource** must be used at or below the rate at which a renewable substitute can be developed
- Every **pollution stream** must be emitted at or below the rate at which it can be absorbed or made harmless
- To be **socially sustainable**, resource stocks and flows must be **equitably distributed** and sufficient to provide a good life for everyone

The Emerging Situation Facing Agriculture

- Climate change
 - Longer, frequent monsoon dry spells and intense wet spells
- Over-exploitation of groundwater
 - Seasonal water scarcity, competitive extraction



State Response: *Build more Grow more*

- ‘Double farmers’ incomes’ by growing more high-value crops
 - Programs: National Horticulture Mission (NHM), PMKSY
 - Claims: *1 ha shift from staples to horticulture can increase gross returns by more than Rs. 1 lakh per ha* (Niti Ayog, 2017)
- ‘Drought-proof’ by building more water storage infrastructure
 - Programs: *Jal-yukta shivar, Mangel tyala shettale, Galmukta dharan*
- Plastic-lined farm-pond technology: 100% state subsidy
 - Variation of the traditional ponds, ~2TCM capacity elevated ponds
 - Groundwater storage structures
 - Enable dry season irrigation
 - Large evaporation loss
 - Farm energy subsidy further supports the practice

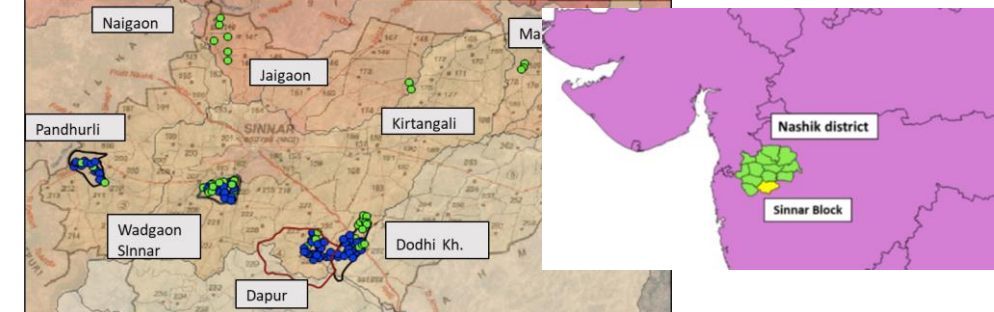
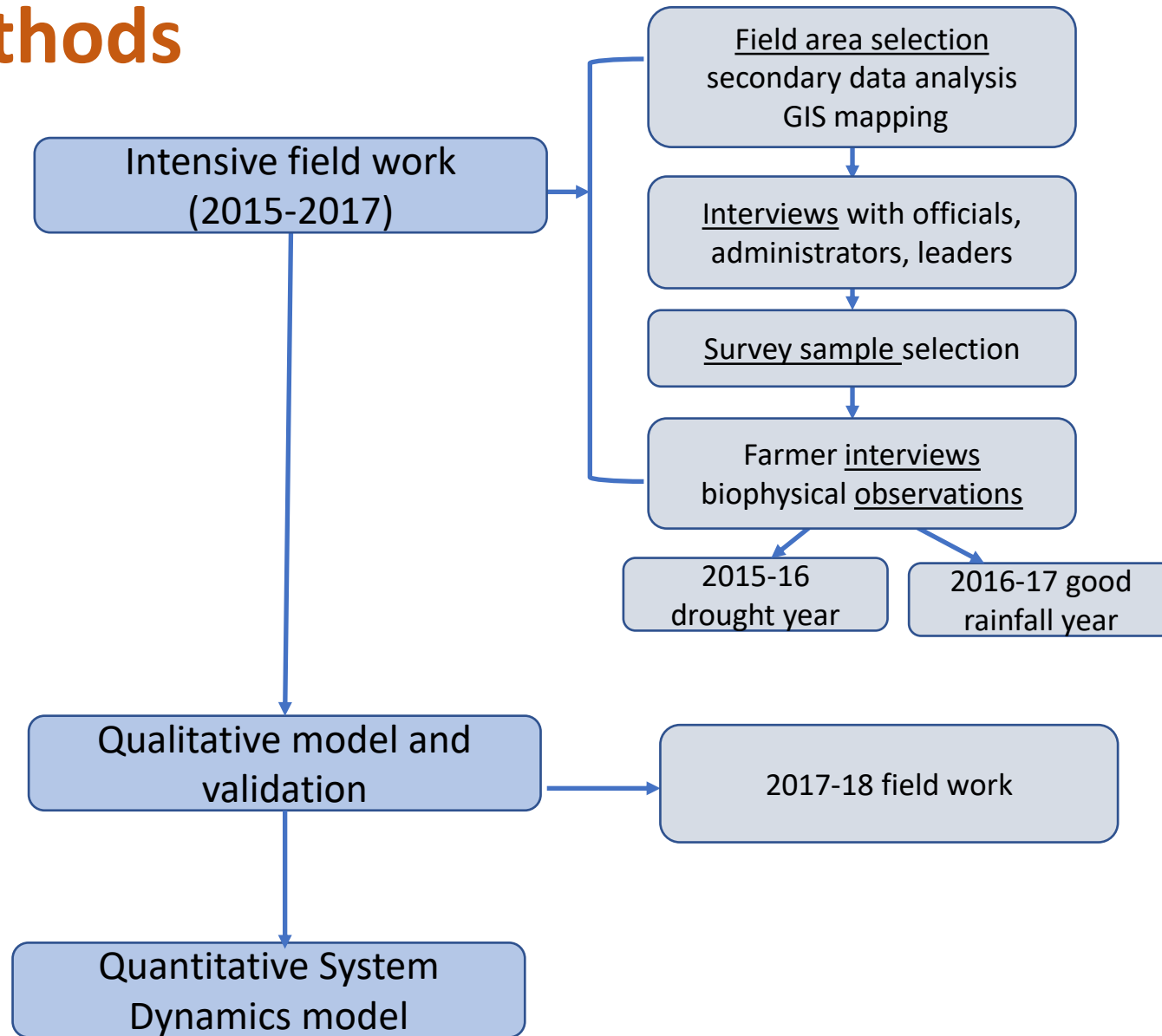


Does *build more grow more* solve the problem of water scarcity and farmer income?

Contradictory view-points

- *Farmpond as **response to climate change** – Tribune*
- ***Drought proofing**: Farm ponds turn out to be game changer – Indian express*
- *Farm ponds play a big role in tiding over **droughts** – The Hindu*
- *Why and how farm ponds can **save Indian farmers**- yourstory.com*
- *Maharashtra Farm Ponds: accelerating **groundwater exploitation** rather than harvesting rain? – SANDRP*
- *The great **farm pond chase** (center expects to see two million FPs in the year): Down to earth*
- *Ponds **need pondering** – India water portal*
- *Adaptation or maladaptation: case of farm ponds converted into **storage ponds** - WOTR*

Methods



Data collection:

- Social and hydrological drivers of farmer decisions
- Cross scale attributes (farm <--> village)
- Bad rainfall and good rainfall years

Qualitative model:

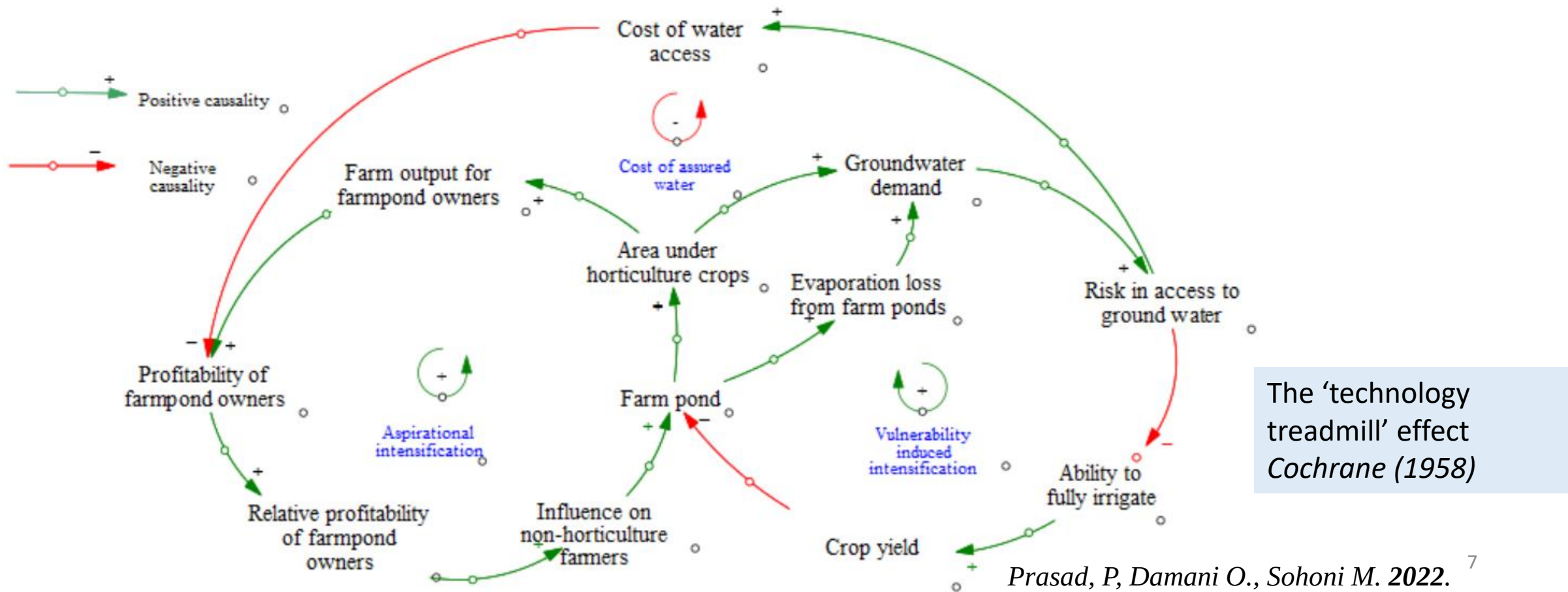
System structure driving field observations, leverage points

Quantitative model:

Simulation of system behaviour over long term, scenarios

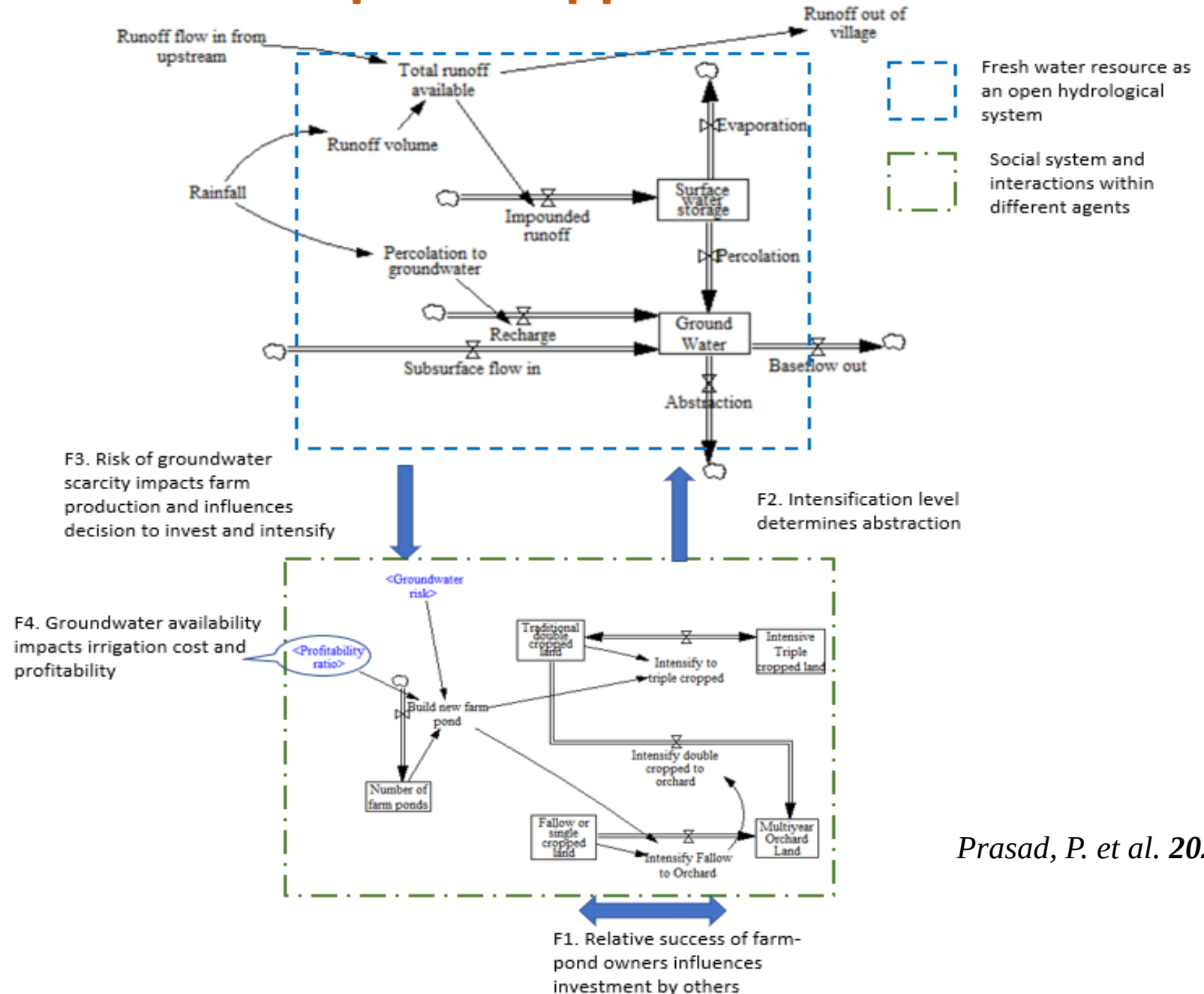
A Qualitative Model Based on Field learnings

- Structure of the system driving farm-ponds supported intensification
- Feedbacks and interactions: social-hydrological and cross-scale
- Tool: Causal-loop diagram
- Allows analysis of leverage points for changing the dynamics



System Dynamic Model of Farm-pond Supported Intensification

- A stylized model
- Biophysical parameters based on a specific village
- Social groupings based on cropping intensity



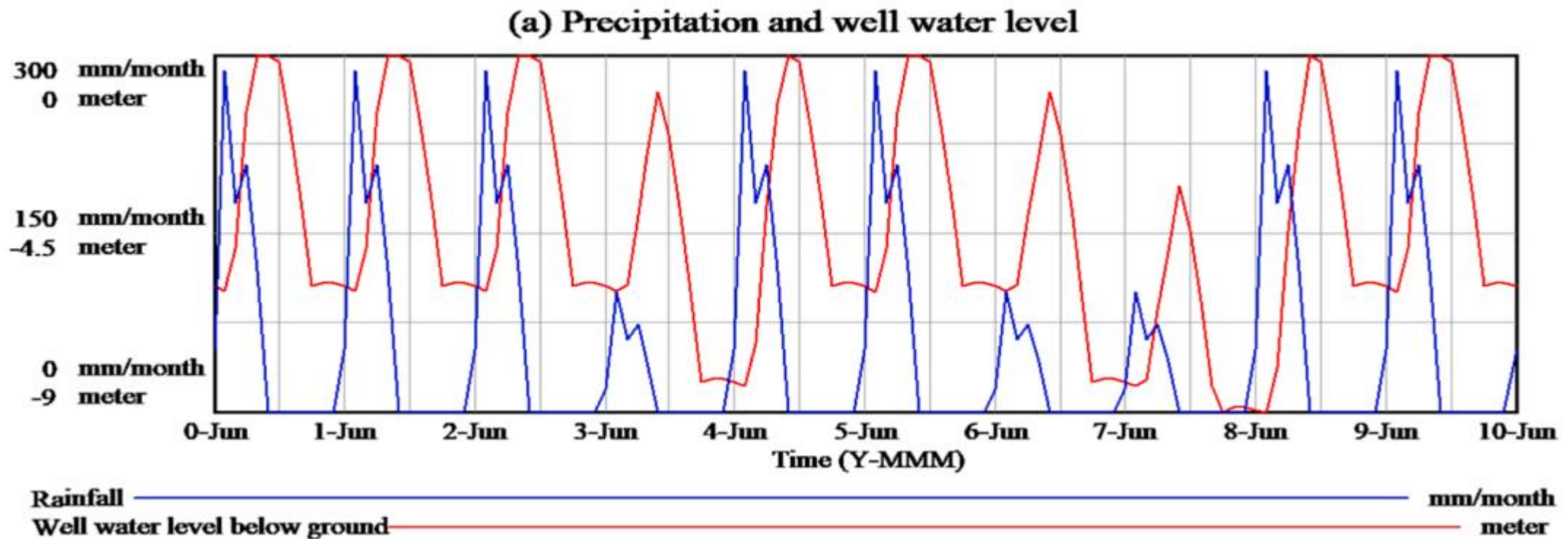
Prasad, P. et al. 2022.

System Dynamic Model: Scenario Design

No.	Scenario	Objective
1	Baseline (no farmponds - static)	Validating baseline groundwater behaviour
2	Farm-level view of farmponds (static)	Understand farm-level impact of farmpond use in average and poor rainfall years
3	Multi-year dynamics (no droughts)	Analyse impact of intensification on system (assuming no collective action)
4	Multi-year dynamics with droughts	Analyse impact of intensification in drought years (assuming no collective action)

1. Baseline (static) scenario

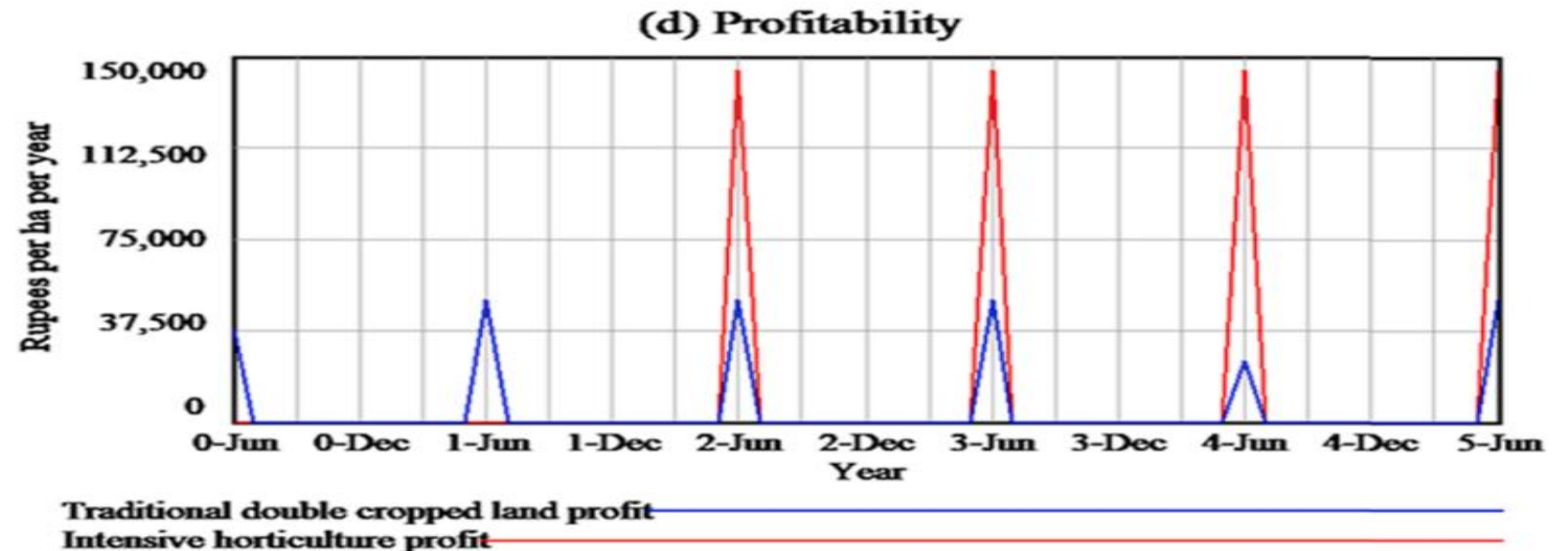
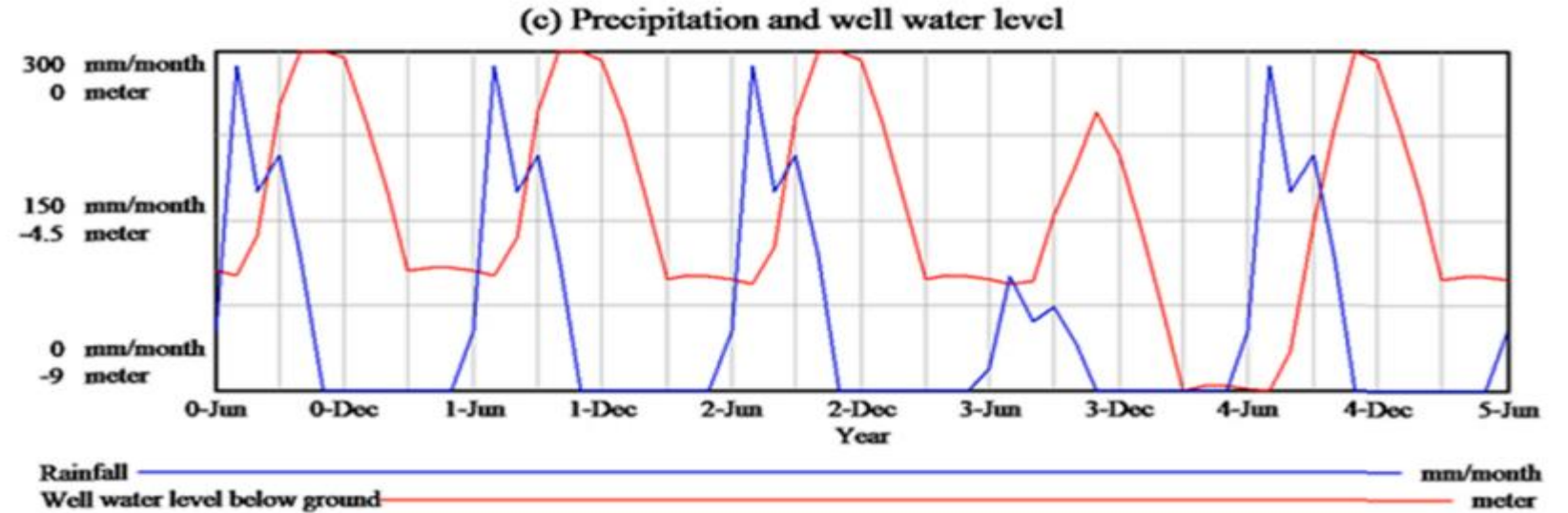
- No farm-pond or water-intensive farming
- Droughts in year 3, 6 and 7



Groundwater behaviour does not allow year-round irrigation: motivation for farmpond

2. Farm-level view of farm-ponds (static scenario)

- 10 farm-ponds in year 2 with horticulture
- Drought in year 3

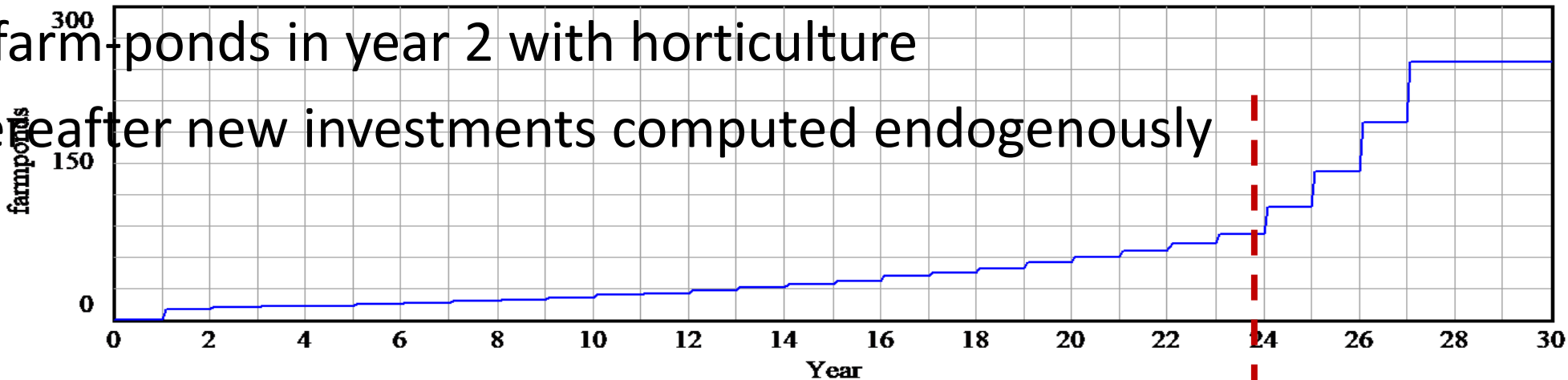


At farm-level, in the short-term, farm-ponds drought-proof farmers, help raise incomes

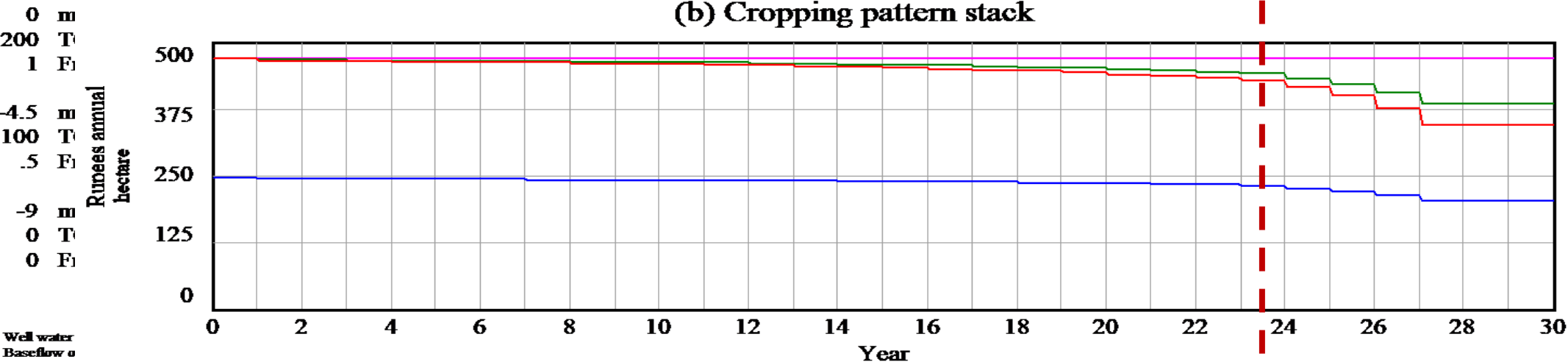
3. Multi-year dynamics (no drought) scenario

- 10 farm-ponds in year 2 with horticulture
- Thereafter new investments computed endogenously

(a) Number of farmponds



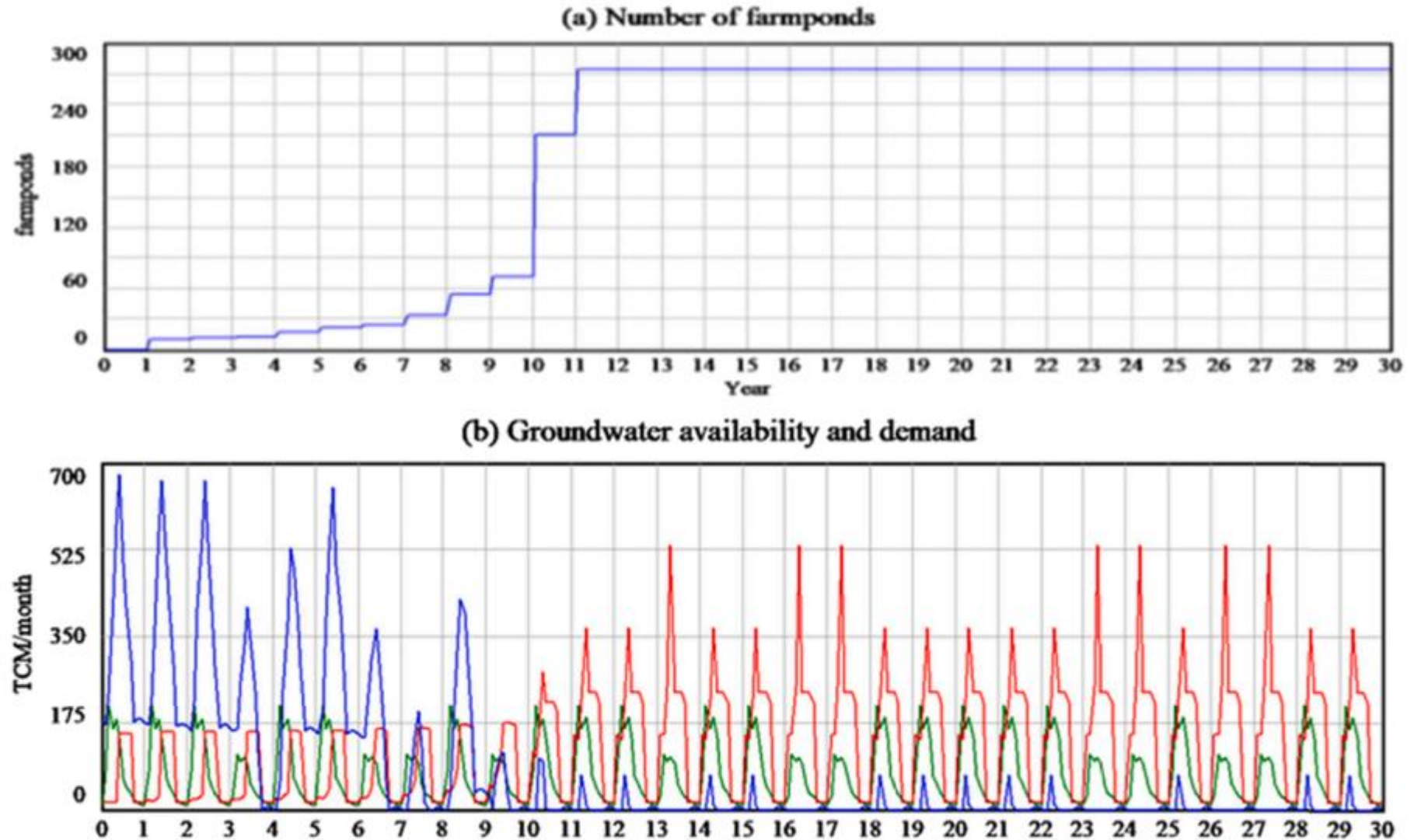
(b) Cropping pattern stack



The threshold breach leads to a system collapse, in which everyone is worse off

4. Multi-year dynamics: impact of droughts

- Droughts in year 3,6,7 of every decade
- Rapid escalation in farm-pond investments



Droughts lower the resource threshold, tipping the system even at low level of intensification

What are the implications?

- In the short term, farm-ponds shield early-adopters from droughts
- But, trigger a vicious cycle of new farm-ponds and ground water stress *increasing* drought-risk for all, *including horticulture farmers*
- What is the sustainable limit for intensification and farm-ponds?
 - Sustainable intensification => always staying below the resource threshold
 - Threshold is not fixed! Highly variable across good vs. bad rainfall years
 - *Not possible to have a “fixed” sustainable number of farm-ponds*
- Instead, an adaptive strategy based on seasonal carrying capacity
 - *Fill farm-ponds only in good rainfall years* (contradictory to current use and market incentives!)
 - Seasonally adaptive intensification: *seasonal horticulture in good rainfall years, drought resilient crops in others*
 - Avoid locking in irrigation demand: No multi-year orchards

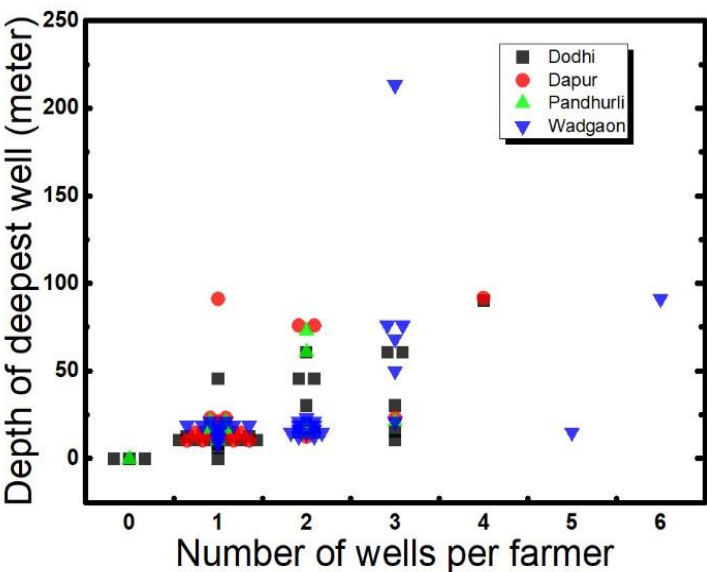
Thank you



Field-Work Findings

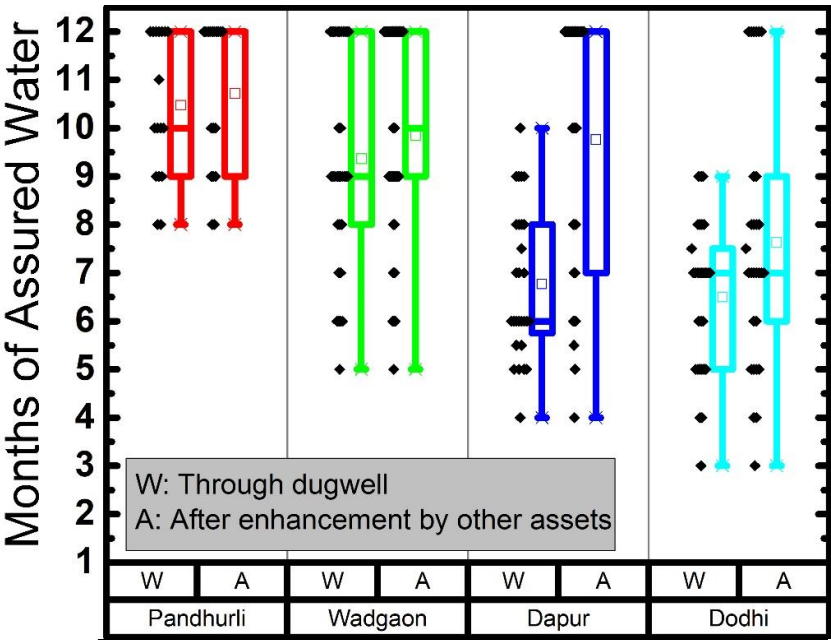
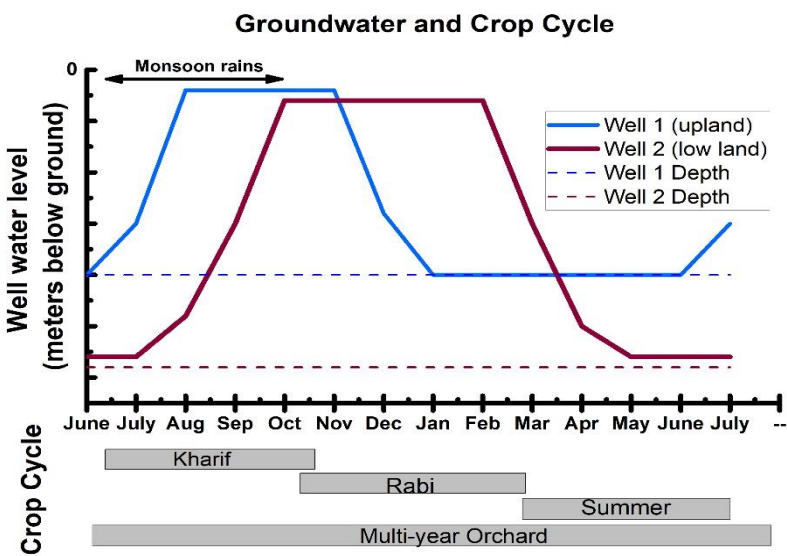
1. Access to water

- Primarily through dugwells
- *Months of water available* as a measure of access
- Large variability

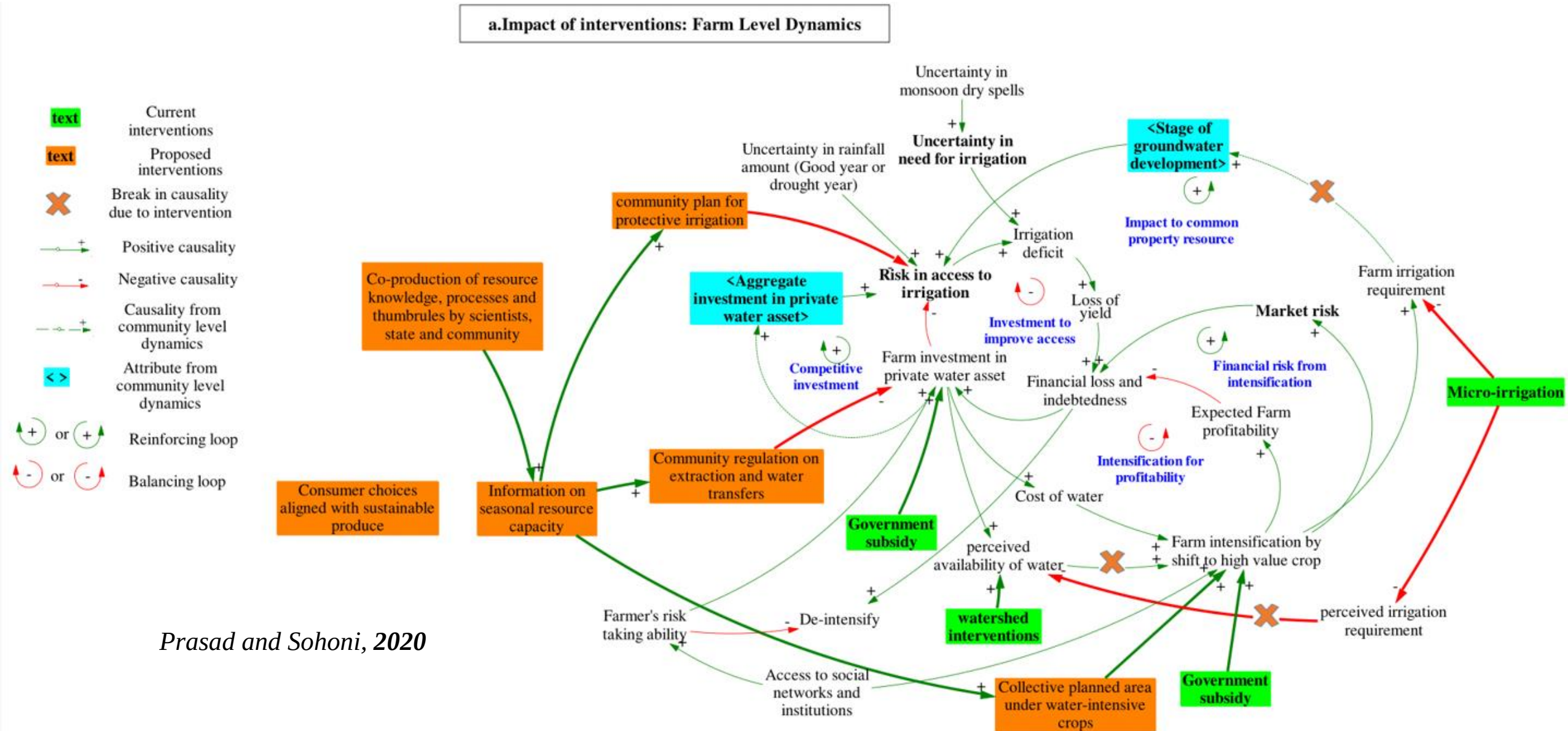


2. Farmer decisions

- Crop choice based on estimated water
- Estimates go wrong => crop loss
- Investments to enhance water access
 - Lateral bores, pipe network, illegal lifts, farm-ponds, tankers
- Simultaneously, cropping intensification to recoup investment



Leverage Point Analysis



Prasad and Sohoni, 2020