Groundwater and Society: Multi-Stakeholder Engagement for Collective Action

30 JULY 2026

the international water association

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WEBINAR INFORMATION – HOUSEKEEPING RULES

the international water association

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- **'Chat' box**: please use this for general requests and for interactive activities.
- **'Q&A' box**: please use this to send questions to the panelists.
  (We will answer these during the discussions)

Please Note: *Attendees' microphones are muted. We cannot respond to 'Raise Hand'.*

AGENDA

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- **Welcome and Introduction to the webinar**

  Dr. Prasanna Jogdeo, South Asia Engagement Manager, IWA

- **Speaker Presentation**

  Dr. Veena Srinivasan, Founder and Executive Director, WELL Labs, India

- **Panel Discussion and Audience Q&A**

  Speaker and Moderator

- **Closing Remarks**

  Dr. Prasanna Jogdeo, South Asia Engagement Manager, IWA

INTRODUCTION

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- The proposed webinar series 'Groundwater - The Invisible Lifeline' seeks to shift how **groundwater is perceived—from an unseen, extractive resource to a dynamic, living system** embedded within the hydrological cycle, ecosystems, and society.

- The second session will explore **groundwater as a common pool resource, the behavioural drivers of groundwater use and conservation, citizen science approaches** for monitoring water levels, quality and rainfall, and participatory practices for recharge, rejuvenation and watershed management.

WELL LABS

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Re-examining the Water-Energy Nexus in Peninsular India

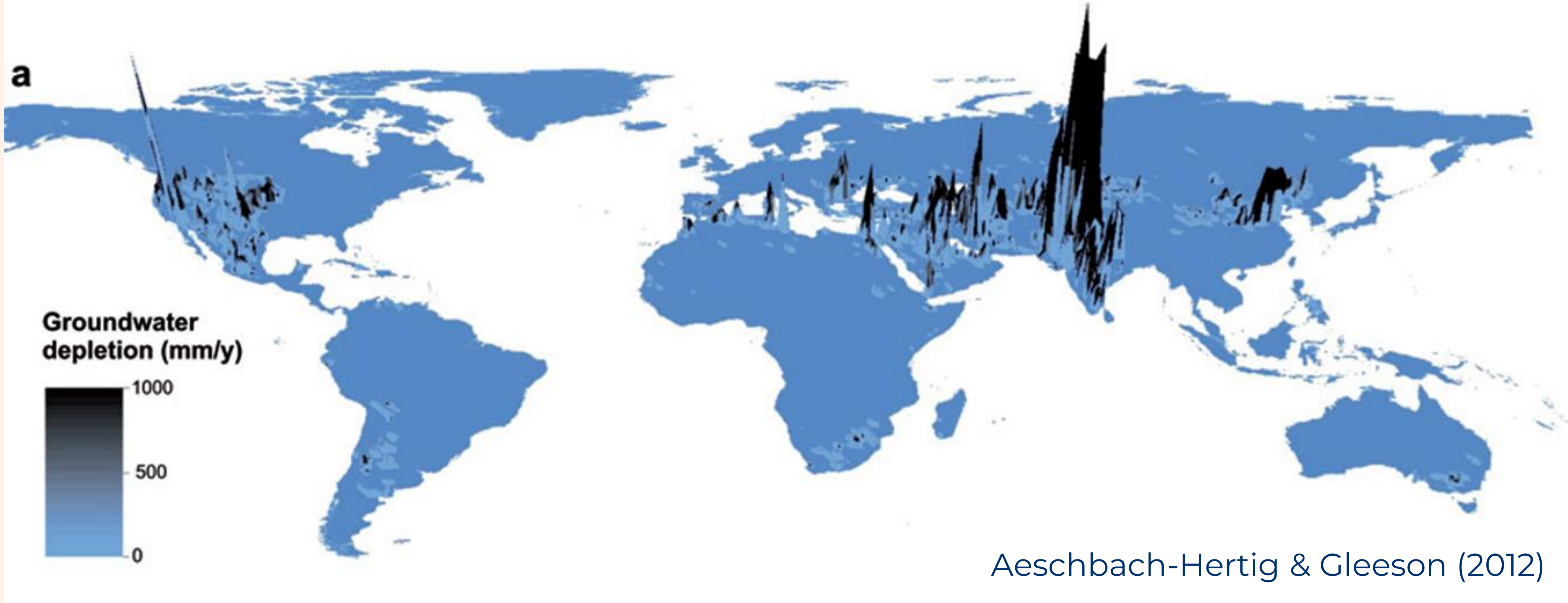
IWA Webinar, July 30

Veena Srinivasan

1

India has a groundwater problem!

India extracts a 25% of global groundwater withdrawals.

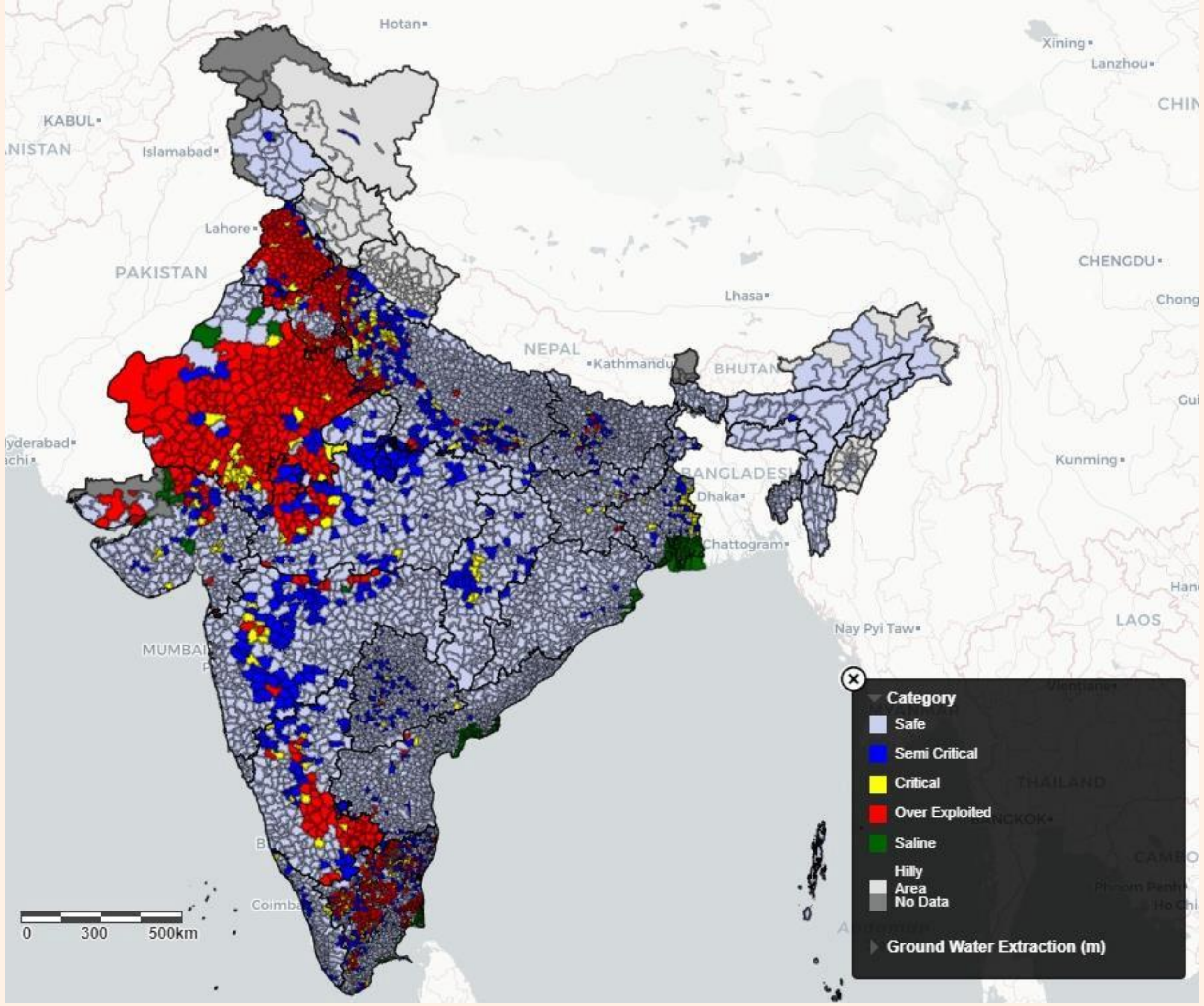


GW supplies 62% of irrigation demand, 85% of rural drinking water, and 50% of urban supply (CGWB, 2022).

18% of GW assessment units were stressed in 2022

The Central Ground Water Board classified 18% of assessment units as water-stressed (Over-Exploited and Critical) in 2022, concentrating over-exploitation in the northwest, west, and southern peninsula.

The drivers: subsidised electricity, lack of regulation, cropping systems.



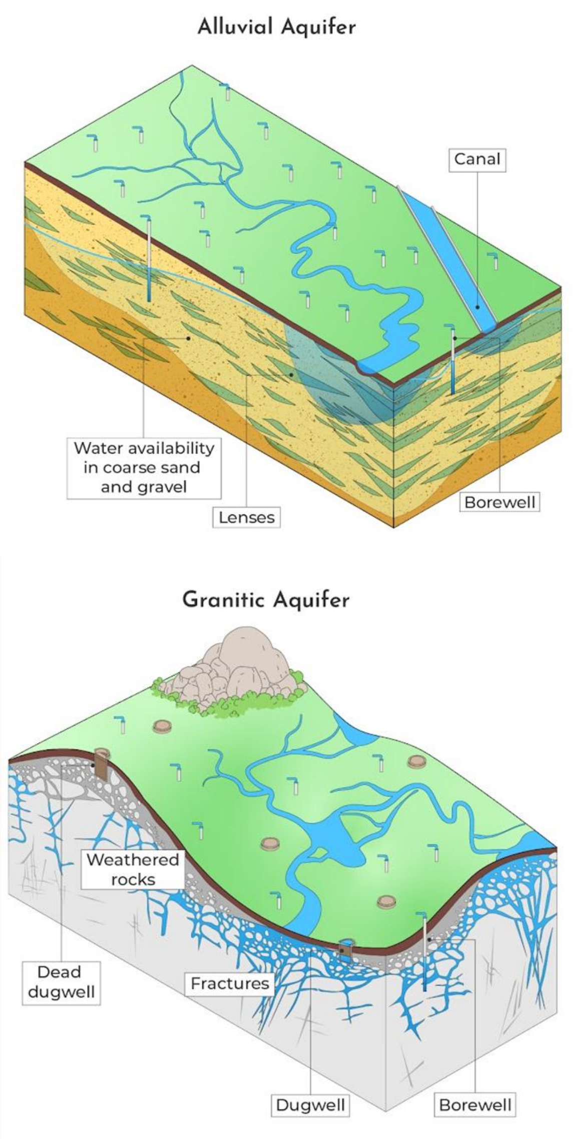
CGWB (2022). Dynamic Ground Water Resources of India, 2022.

2

Why this is a particularly thorny problem in peninsular India.

Aquifers in peninsular India are "low storage" "egg carton" aquifers.

Hard-rock aquifers in the peninsula have low capacity and annual recharge discharge cycles.

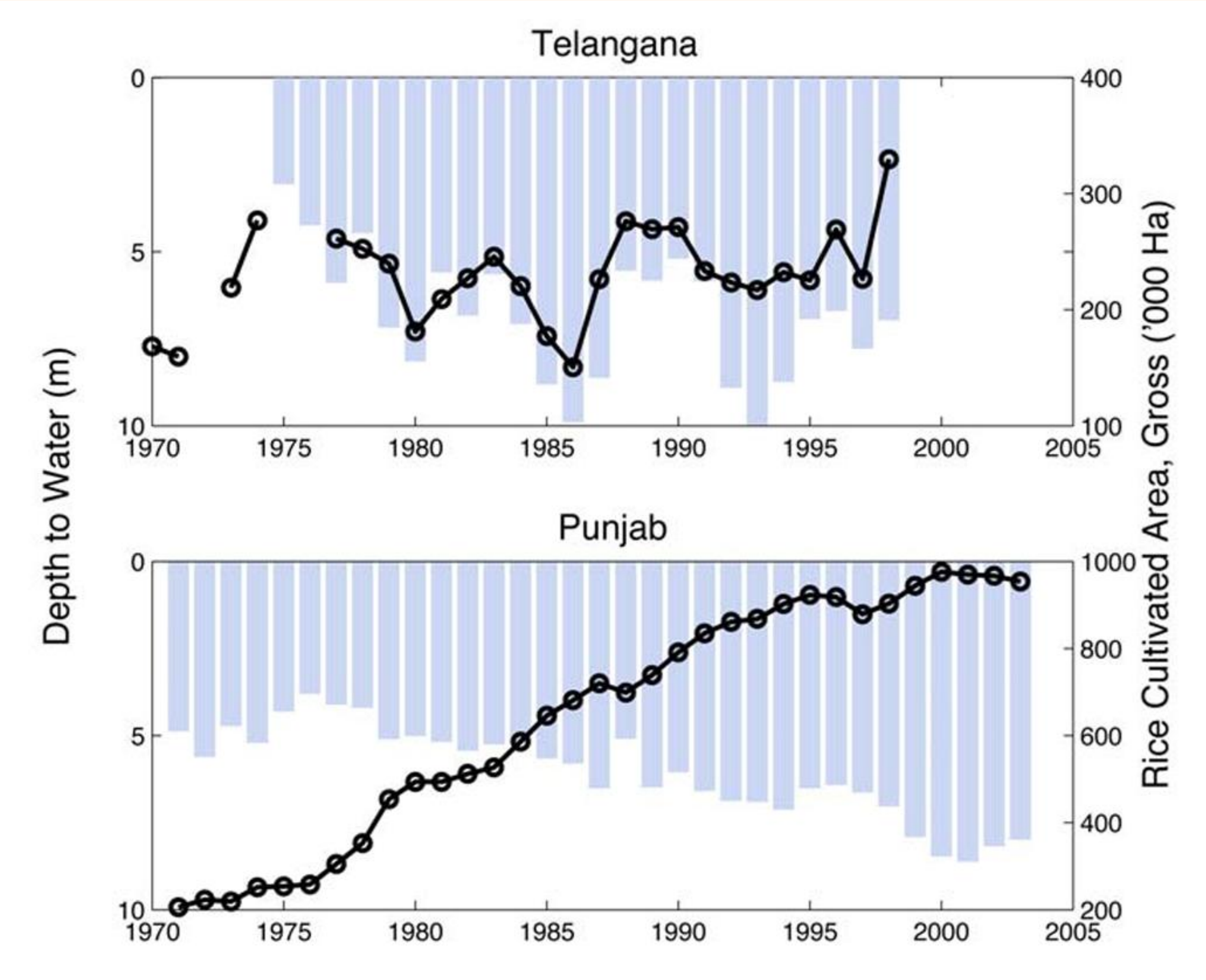


USGS

Rainfall, Groundwater, and Cropping Patterns are closely coupled

In Alluvial systems aquifer storage is large and groundwater levels are not greatly influenced by recharge

In Hard rock systems most extracted water derives from recent seasonal recharge, so the system responds quickly to changes in pumping behaviour across a single monsoon cycle



Fishman et al. (2011)

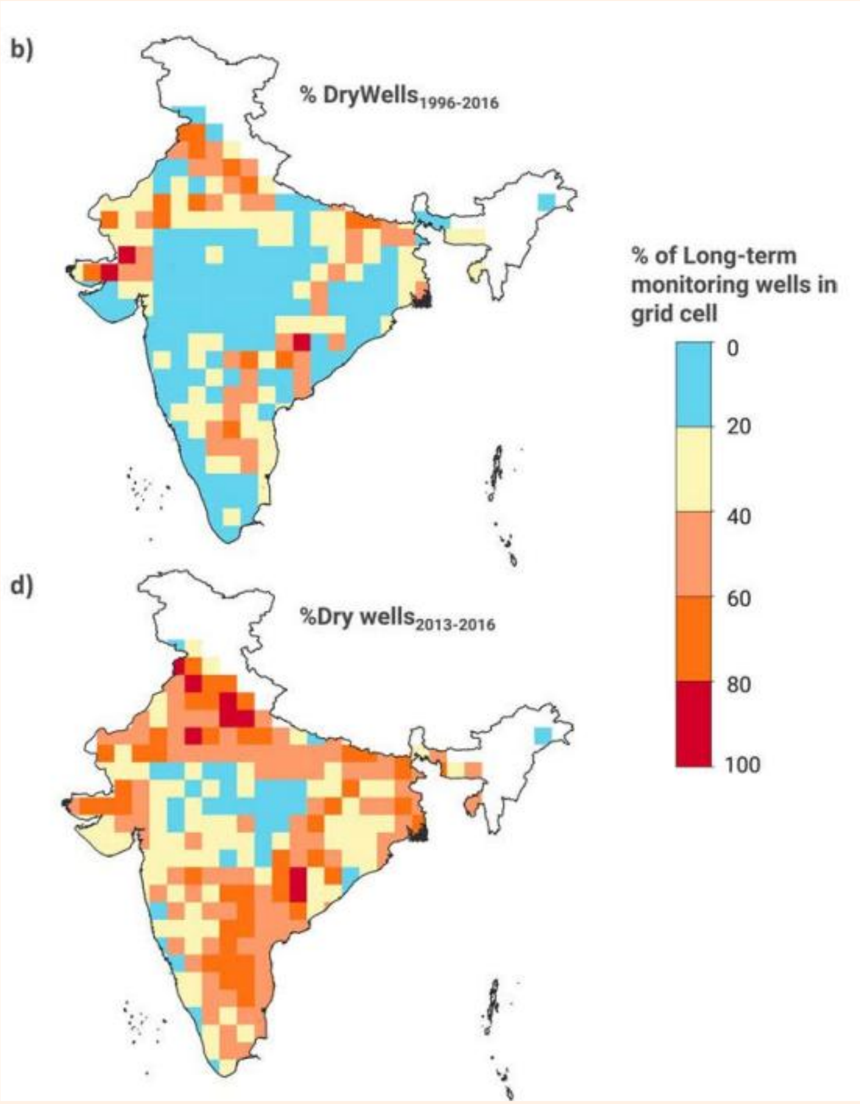
Static water levels are poor indicators of sustainable pumping rate.

When you look at the monitoring well data, they look very shallow for South India.

And the monitoring well records show very high rates of “dry and defunct wells”.

Many monitoring wells drop out of the dataset. Therefore, only looking at wells with continuous records reveals a “survivor bias” problem.

How do we then reconcile the relatively shallow static water levels with the 1000 ft borewells farmers are pumping from?



Hora, Srinivasan & Basu (2019)

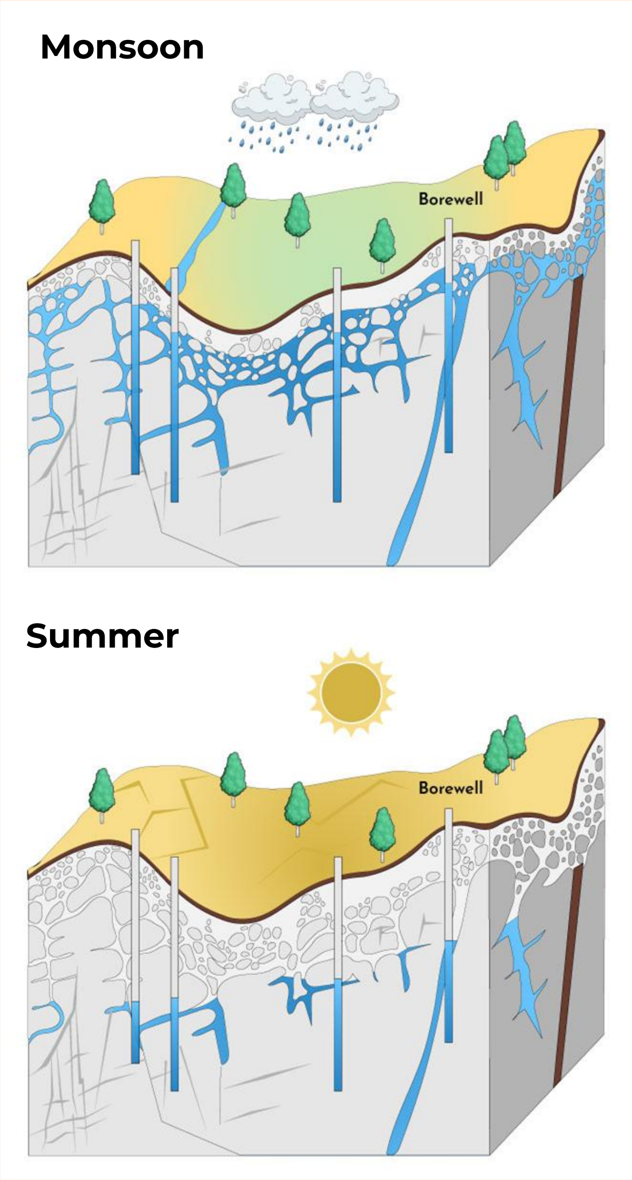
Farmers are competing for the last few drops of groundwater.

The answer lies in the nature of hard-rock systems.

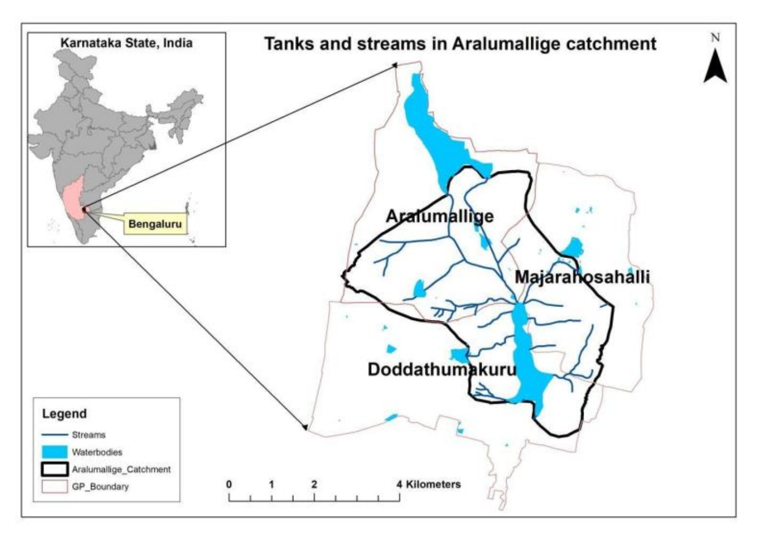
Water flows through disconnected fractures in ways we still don't completely understand at the well level.

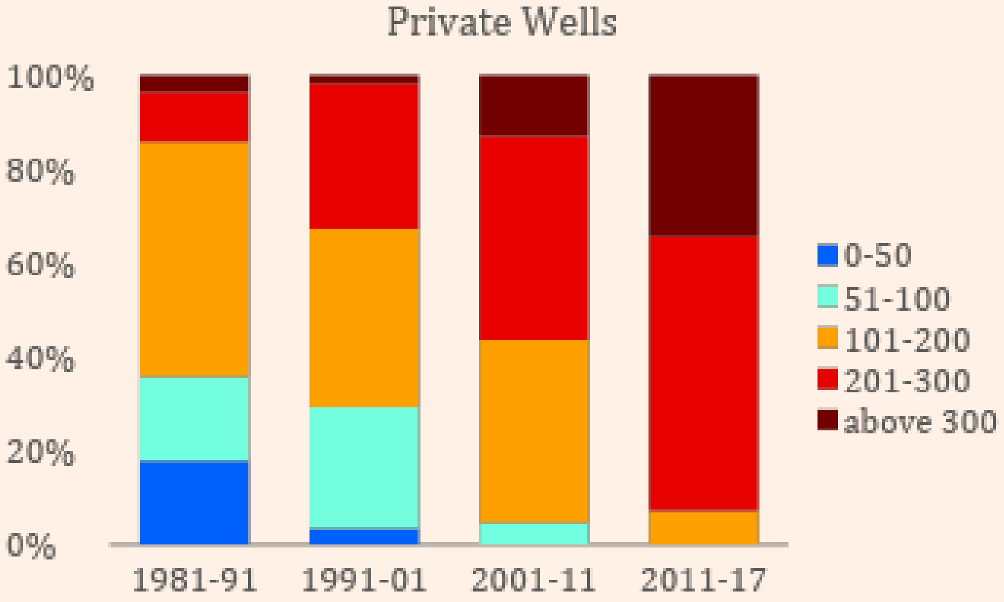
But we do know is that storage is extremely low. Essentially farmers are chasing the same few drops of water each year.

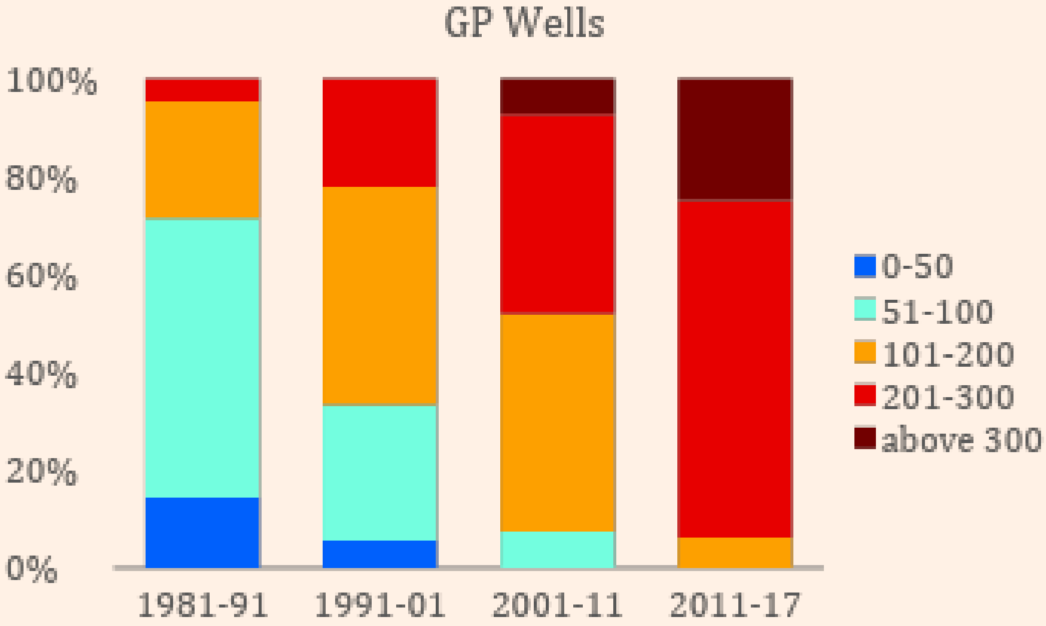
In peninsular India, depletion does not fully capture the problems with over exploitation.



Farmers are competing for the last few drops of groundwater.







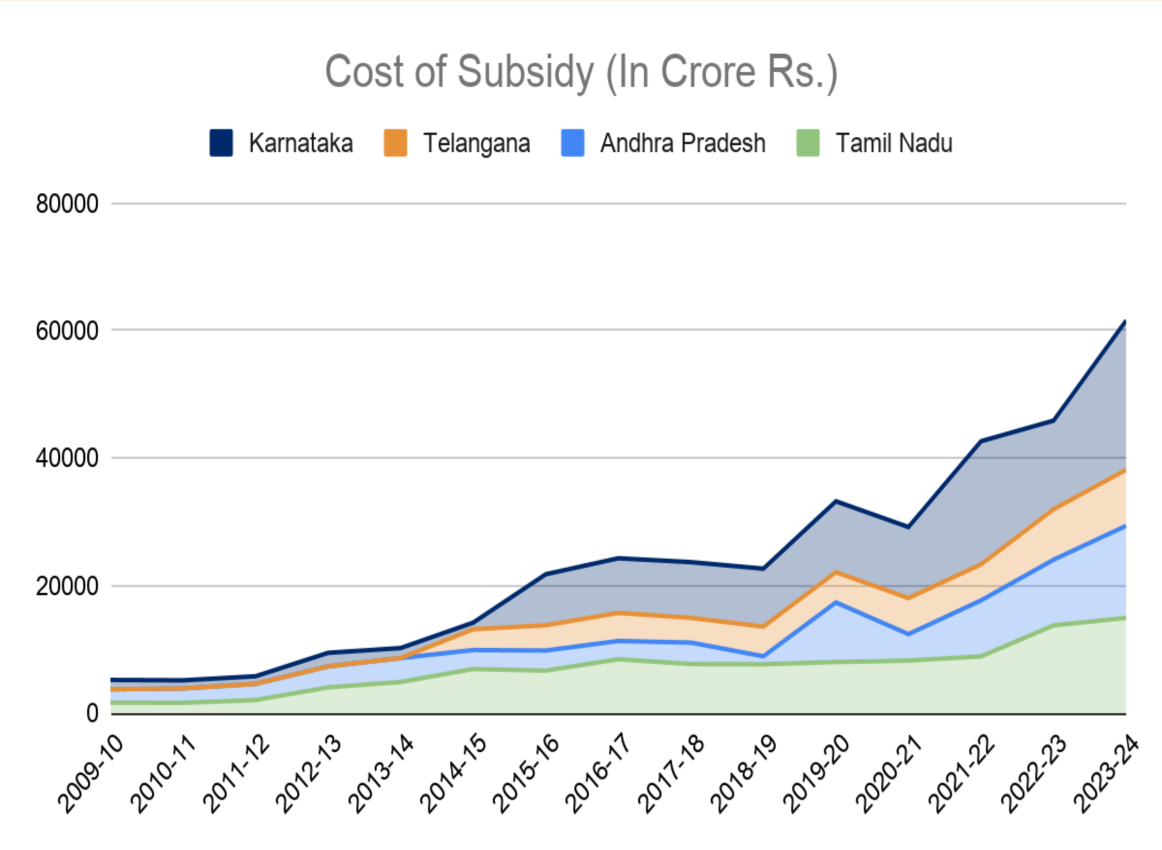
Both farmer and GP borewell depths got deeper over time.

This suggests that agricultural subsidies impose an "externality" on drinking water wells.

Electricity subsidy for the 4 southern states exceeded $ 6 Bn in FY 2023-24

Subsidies amount to more than Rs 80,000 per registered pumpset.

Despite well-documented costs no policy or program systematically incentivises aquifer recovery.



Source: https://iced.niti.gov.in/

BESCOM and KERC have struggled to forecast agricultural electricity demand

Discoms use Business as usual forecasts to anticipate demand

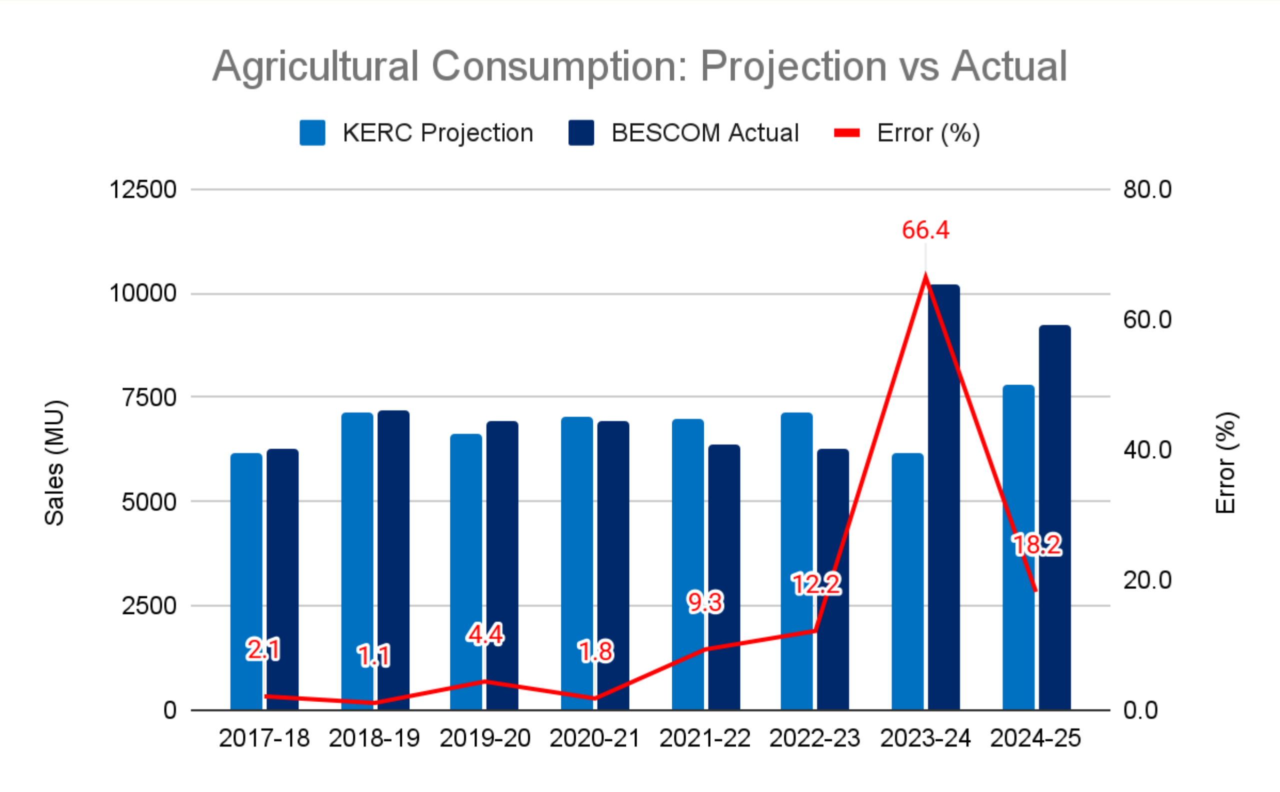
Unanticipated growth in Agricultural Consumption

- BESCOM's sales in 2023-24 increased by 23% over 2022-23 (6828 MU) to 36000 MU.

- 30% of the total and 57% of this increase was driven by IP Sets

Drought explains some of this.

- In 2023-24 rainfall in Karnataka was ~25% its long period average.



Drought Year

Source: Compiled for from BESCOM submissions at the KERC

GW Over-Exploitation becomes a lose-lose-lose-lose proposition

	Farmers (In Rs. Cr)	GP (In Rs. Cr)	Taxpayers (In Rs. Cr)	Planet (In Rs. Cr)
Electricity	-	123*	**729#**	-
Well Drilling	22-75^	12^	**-**	-
CO2 Emissions	-	-	**-**	*9.5^^

The irony is everyone loses even though the total amount of water available is fixed!

Source: *70% of the total real cost under the LT6a calculated using average cost of supply (Low Tension Drinking water supply connections for GPs and Municipalities). Assuming that 70% of population of Chikkaballapur lives in Gram Panchayats, compiled from KERC submissions; # Based on Average Total Annual Cost of Supply for consumption for agriculture from 2020-2024,from KERC submission; ^ Extrapolated from information from a comprehensive well census conducted in the Aralumallige Watershed. (Srinivasan et al. 2025); ^^Assuming voluntary market rate of Rs 200/ C-Tonne and 4.76 Lakh Metric Tonnes/year

3 Evidence on how past solutions have fared

Four approaches to groundwater governance have been attempted.

A. **Supply-side:** watershed development, rainwater harvesting, and increasingly capital-intensive managed aquifer recharge.

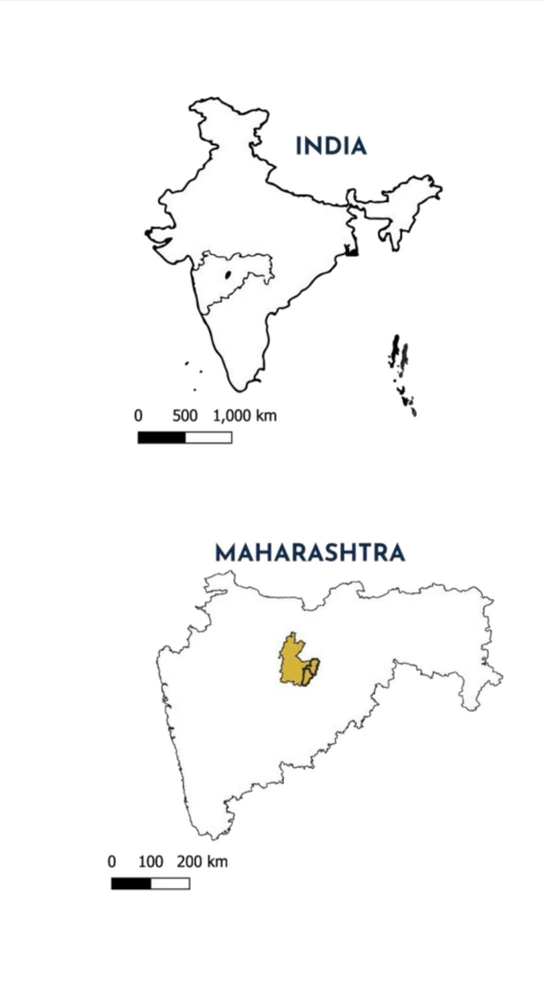
A. **Demand-side:** micro-irrigation and energy rationing.

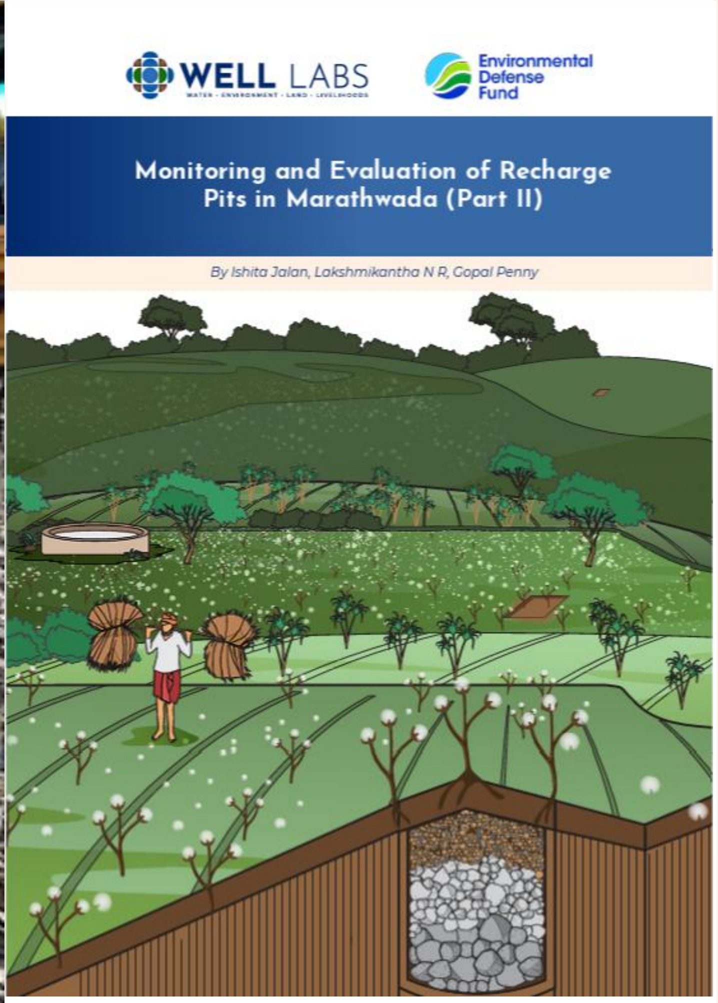
A. **Participatory governance:** groundwater managed as a common-pool resource requiring collective action.

3A

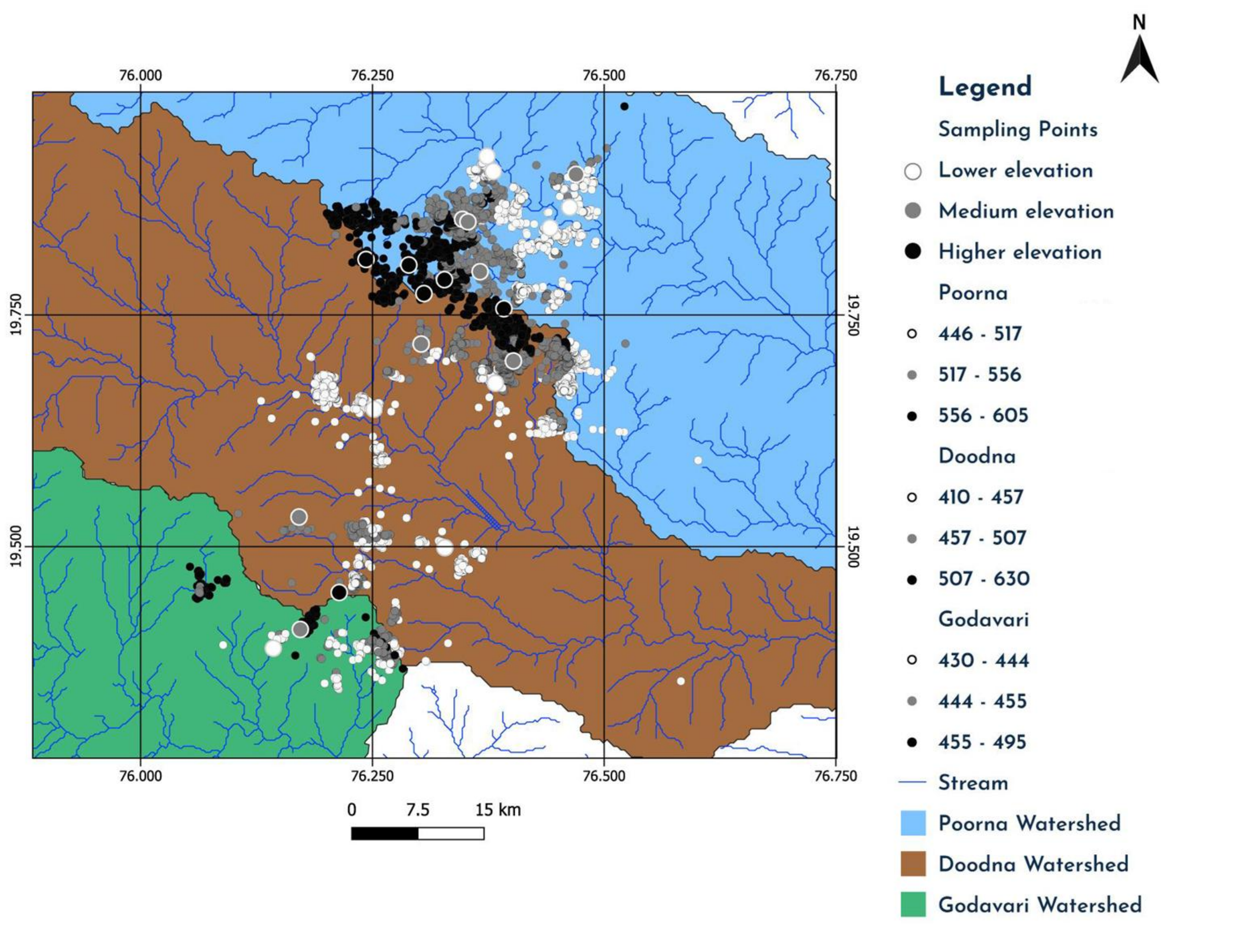
Supply side approaches are saturated, but sometimes misdirected.

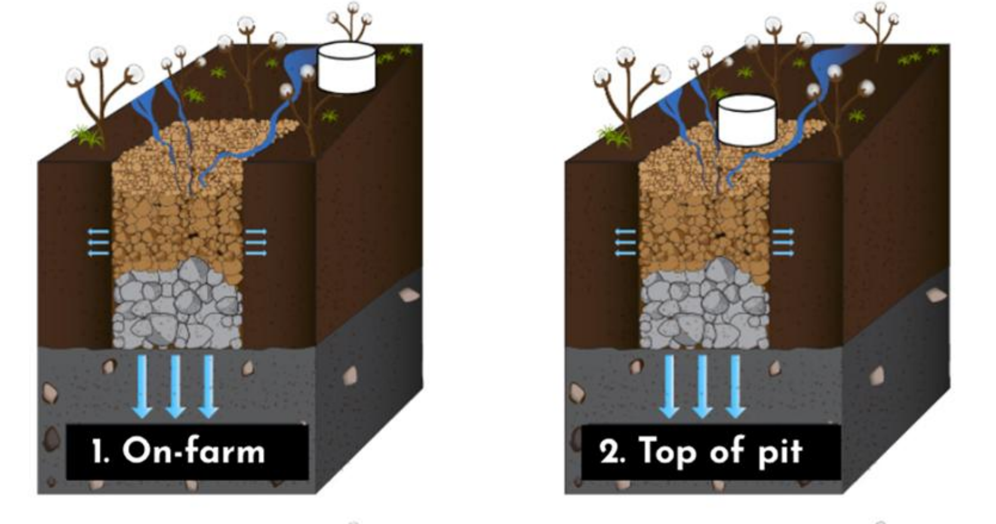
Consider the case of recharge pits in Jalna, a classic supply side intervention

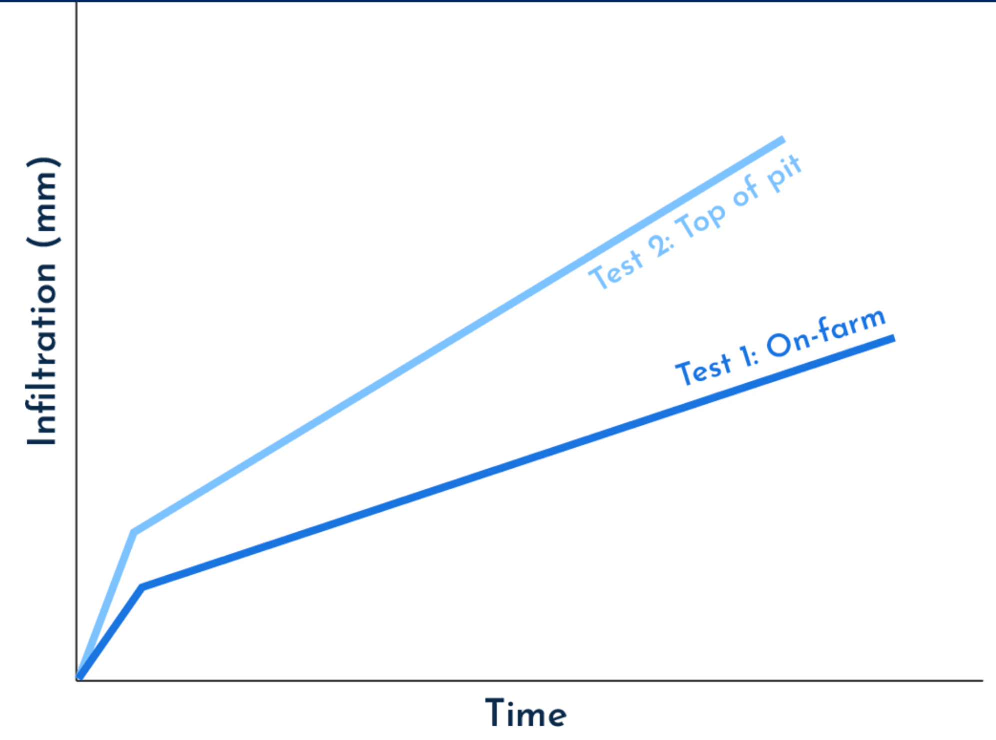




We systematically tested the hypothesis via infiltration tests





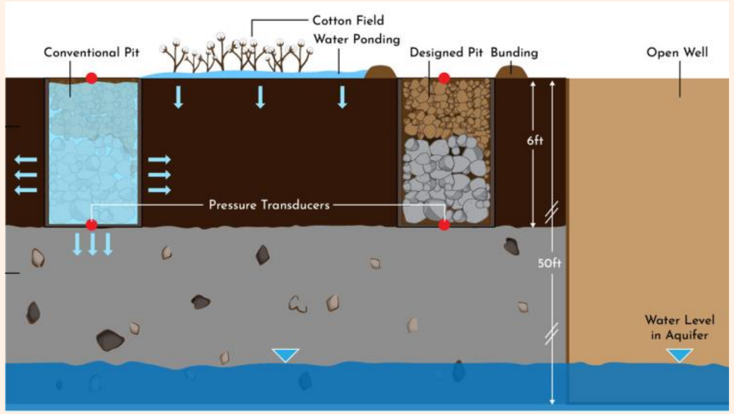


A total of 22 pairs of infiltration tests were conducted.

3A

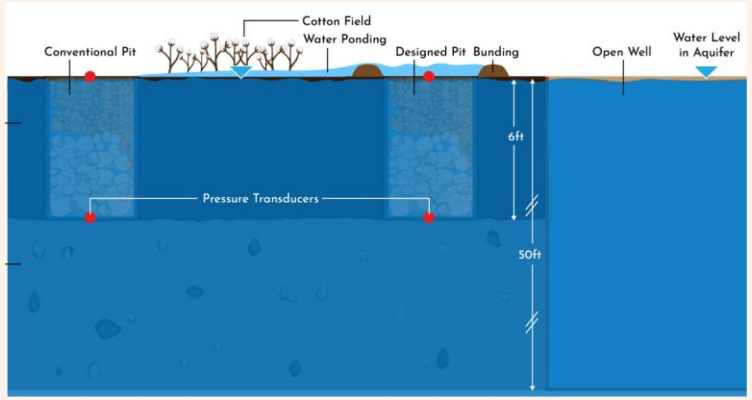
We found no difference to GW levels. On closer examination we sound GW levels

T1

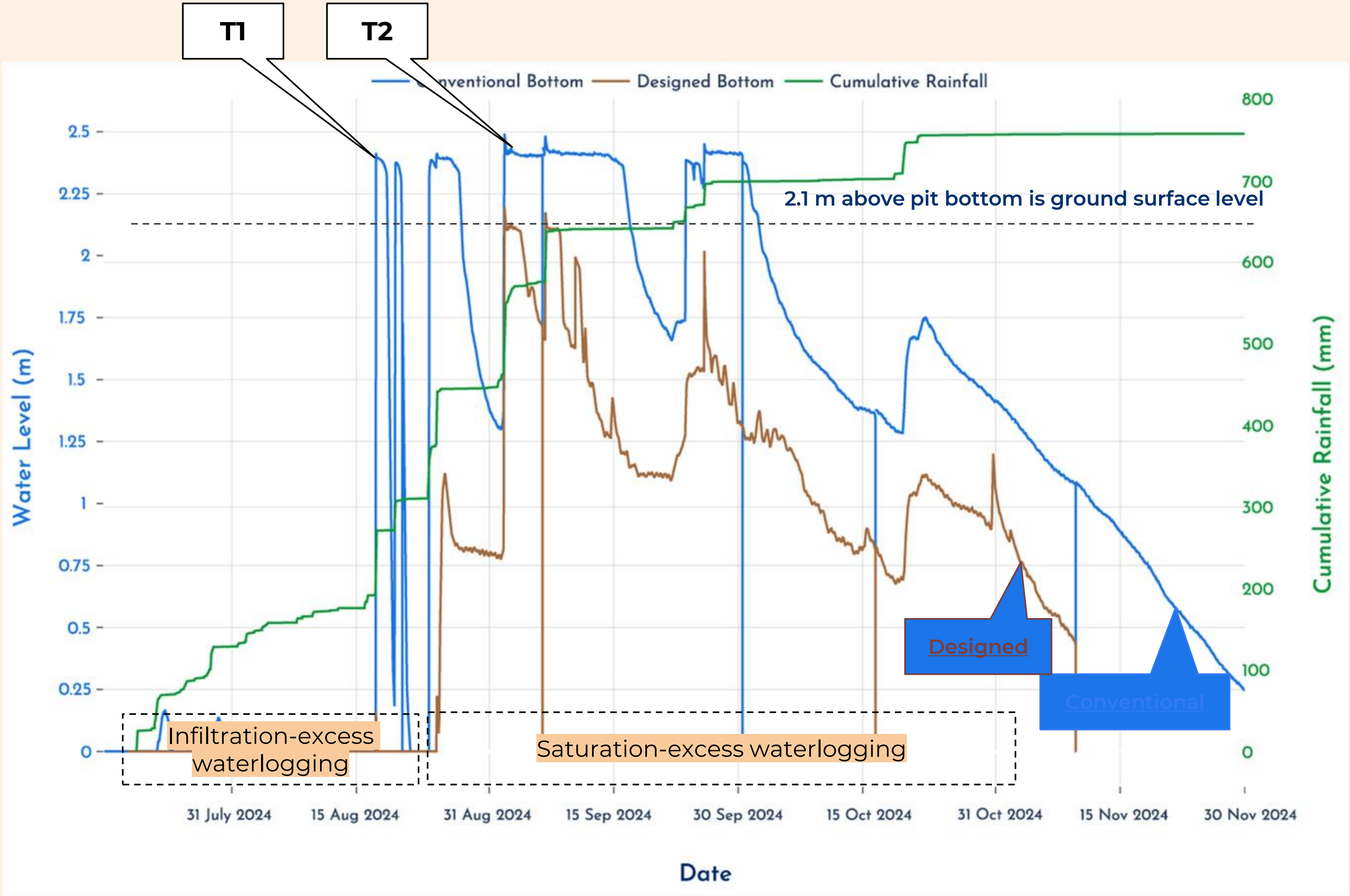


Infiltration-excess waterlogging

T2



Saturation-excess waterlogging

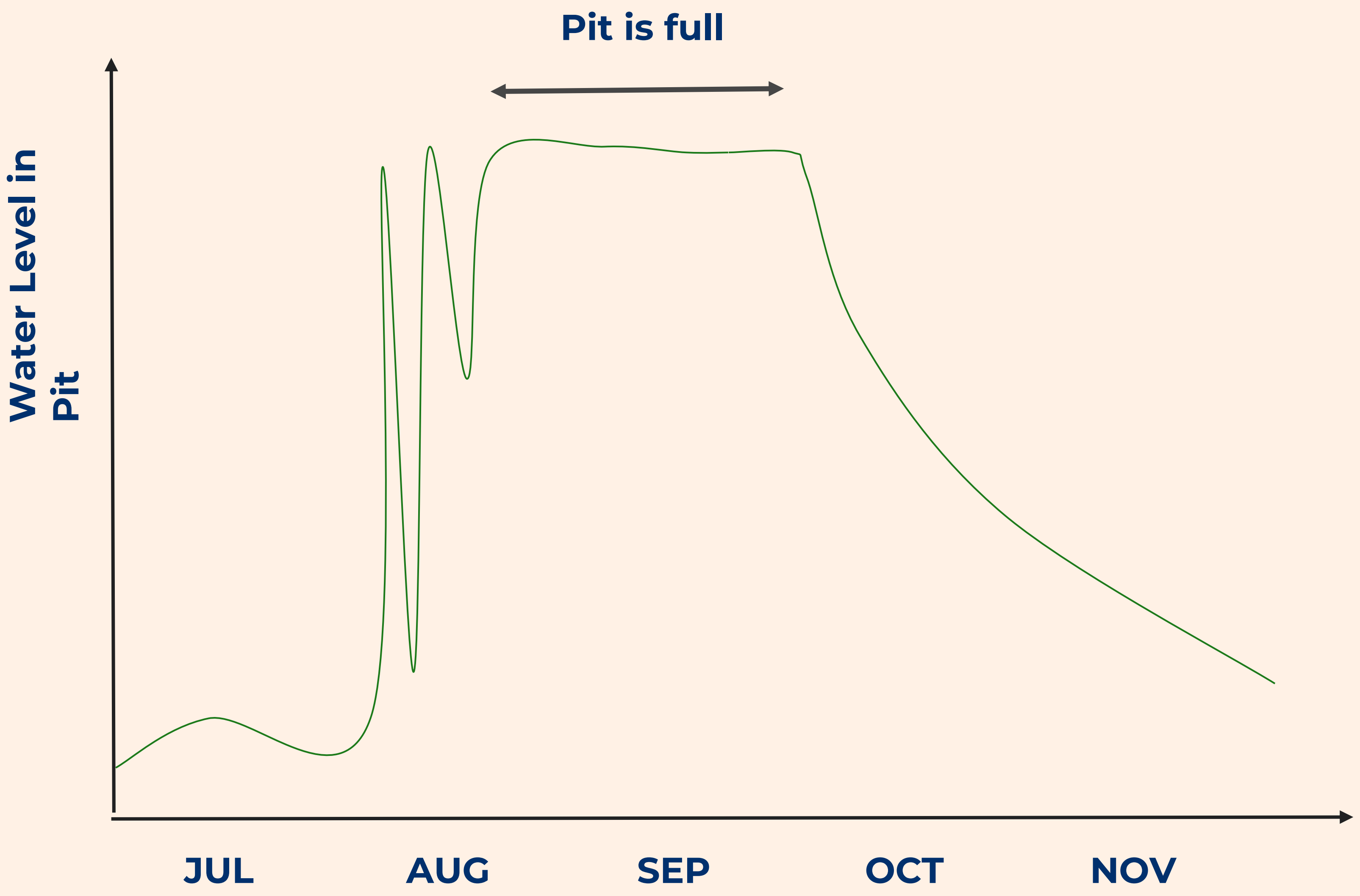


We found recharge in this landscape is not a meaningful goal.

Basically the pit initially empties and fills, but mid-way through the monsoon stops emptying.

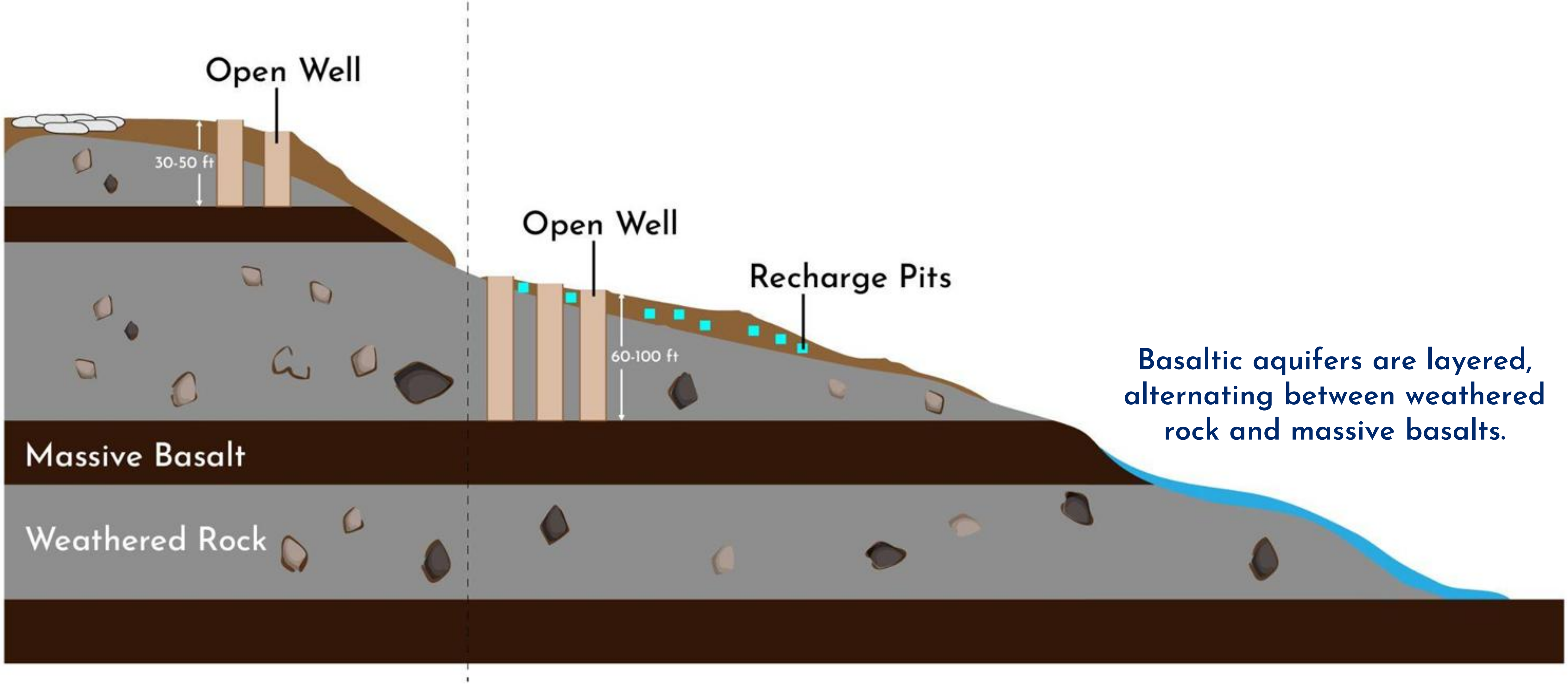
This is because the aquifer itself is saturated in this thin basalt aquifers.

Groundwater levels are literally at the surface.



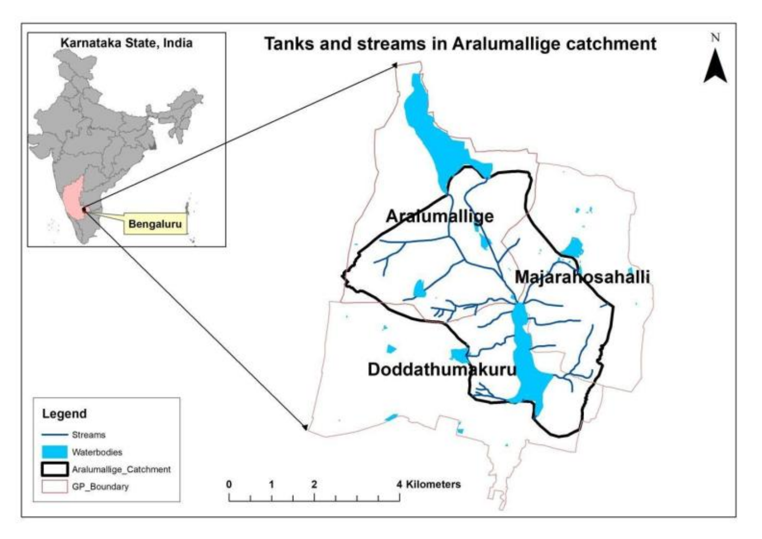
The problem was not lack of recharge, but short residence time.

Aquifers lack storage and seasonal decline occurs because groundwater doesn't stay put in the ridges.

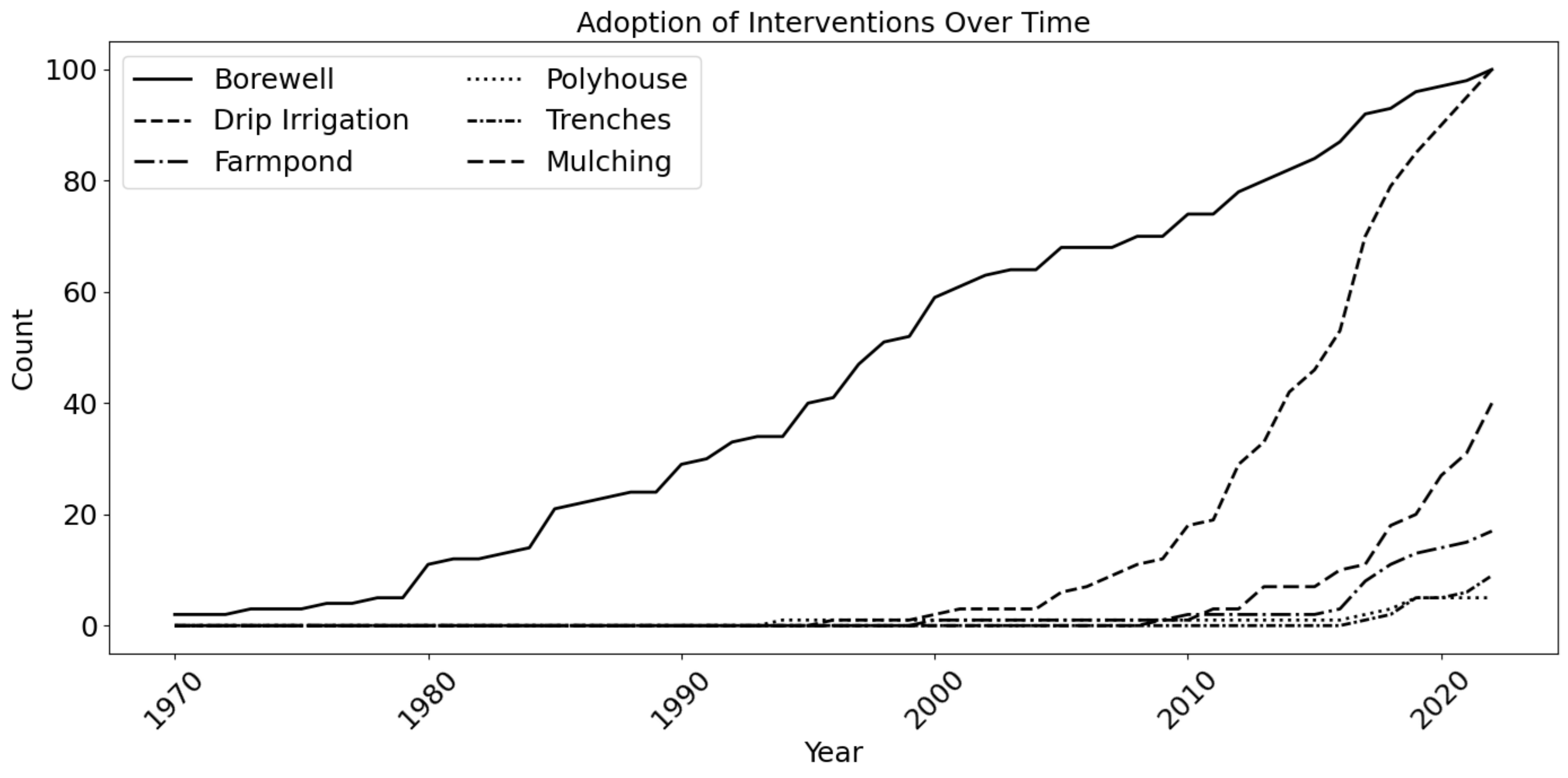


Basaltic aquifers are layered, alternating between weathered rock and massive basalts.

Demand side management through efficiency has reached its limits



In many parts of Peninsular India, on-farm efficiency improvements are saturated. Yet groundwater continues to decline.



Source: N R Lakshmikantha PhD Thesis

Experiments with Incentive Based Systems have been limited

Paani Bachao Paisa Kamao (Punjab) was the first systematic attempts to pay farmers directly for reducing groundwater-intensive cultivation or electricity consumption.

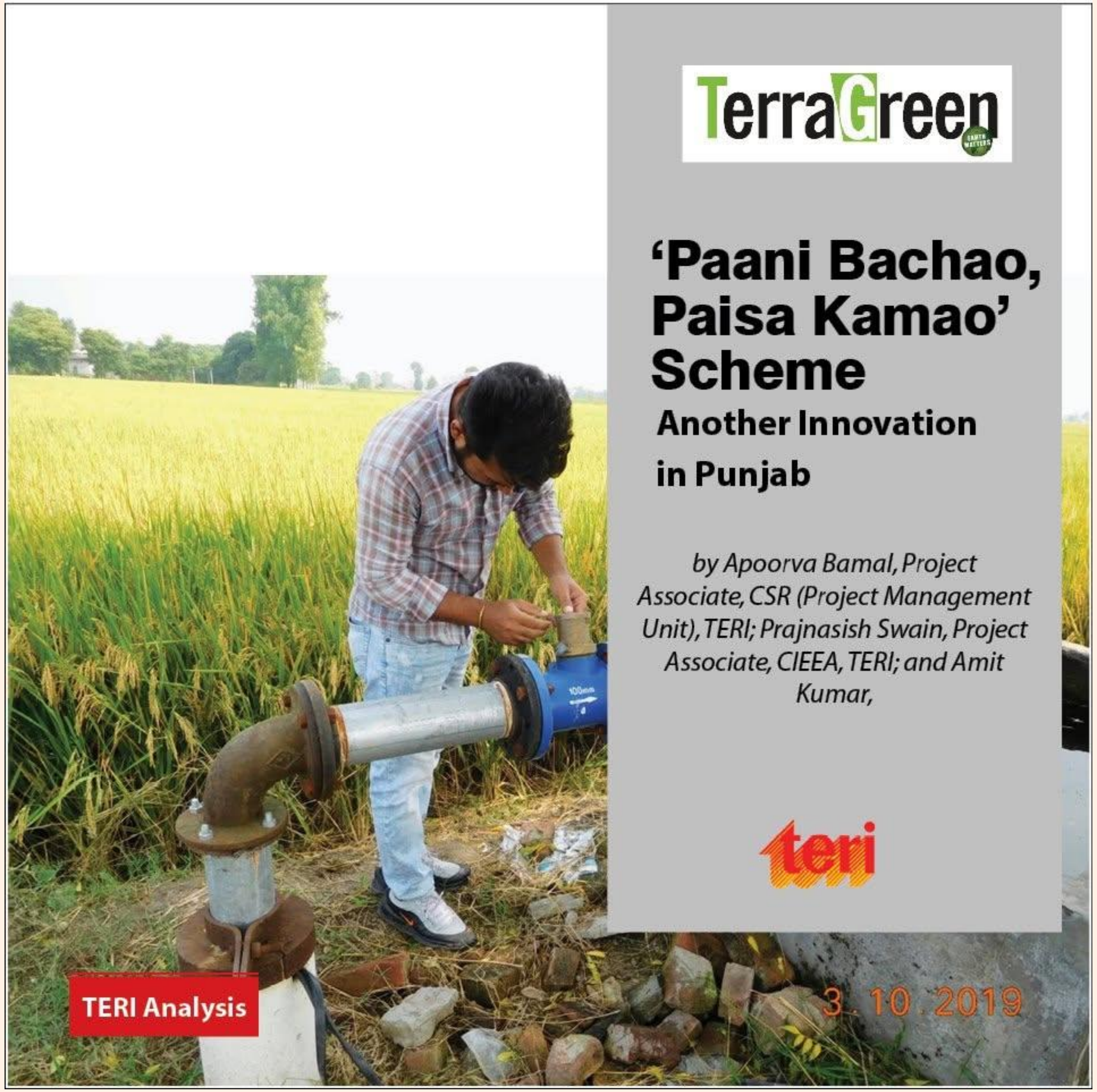
Operates in alluvial settings —

- Large, slowly-declining aquifers,
- 100% of cropped area is irrigated.

Offers between 3-7 Rs/per Unit saved

Incentives are targeted towards individual farmers

Attempts to transfer cash-for-power-saving to peninsular have been limited.



3C Participatory Groundwater Management hasn't worked either.

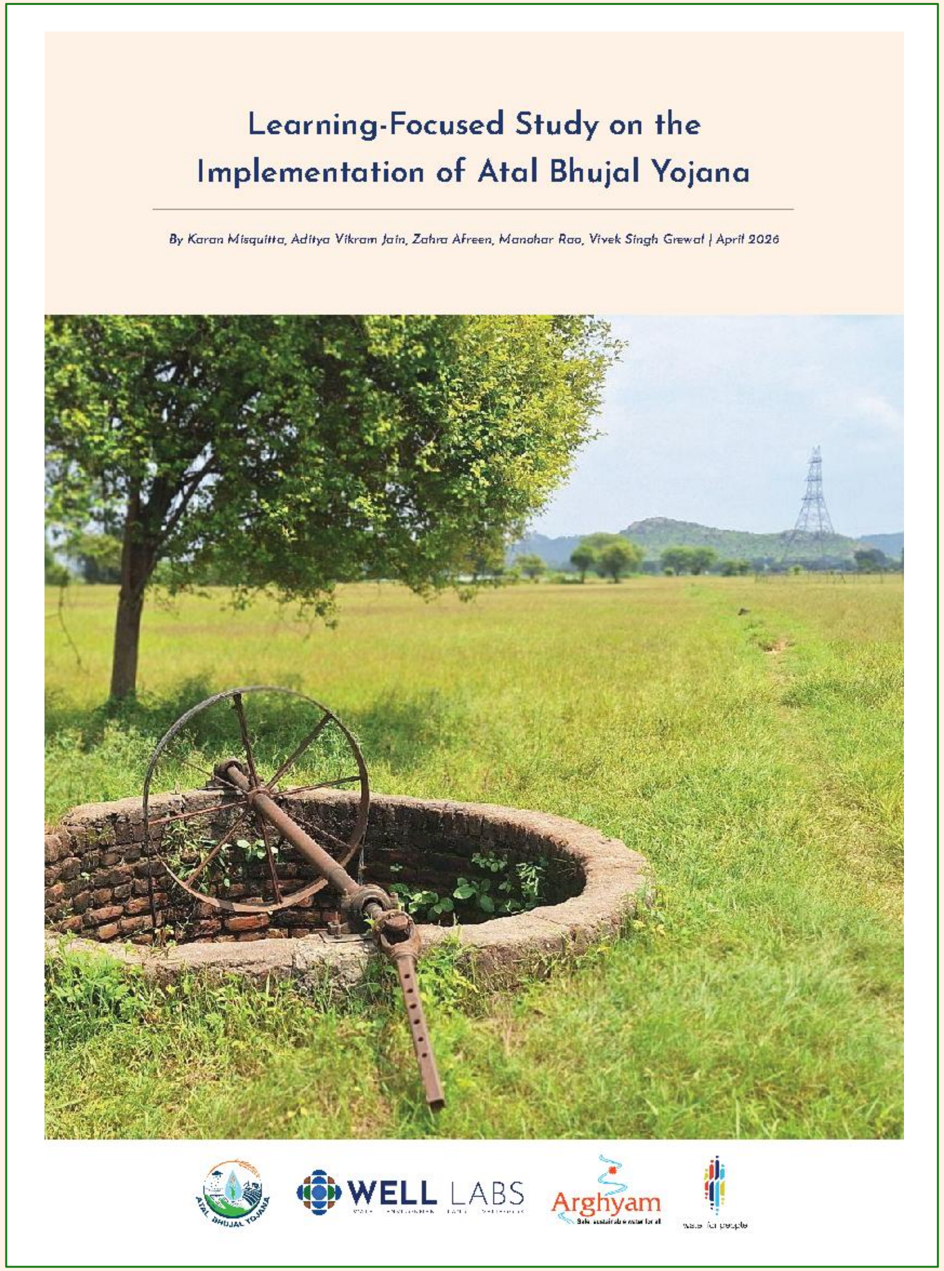
India's most integrated attempt at groundwater governance.

The programme **centred the participatory paradigm** in its approach and made demand management an explicit objective.

It **sidestepped direct regulation,** focusing instead on knowledge, water budgeting, and information as levers for behaviour change.

Incentive based design under the World Bank's Programme for Results framework — with **disbursements tied to programmatic milestones.**

The programme ended in 2025; the Government of India decided against a Phase II.



Participatory Groundwater Management hasn't worked either.

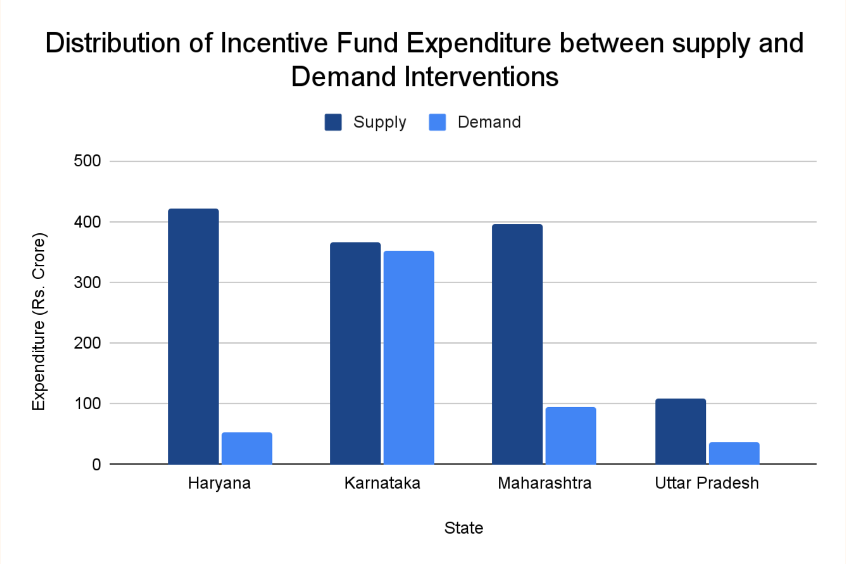
Created an extensive groundwater monitoring network.

- But the **data-to-planning link never materialised**

Officially prioritised demand management

- **Funds gravitated toward supply-side works**, despite the design's demand-management priorities

Incentives went to government agencies rather than to the farmers whose behaviour the programme sought to change.



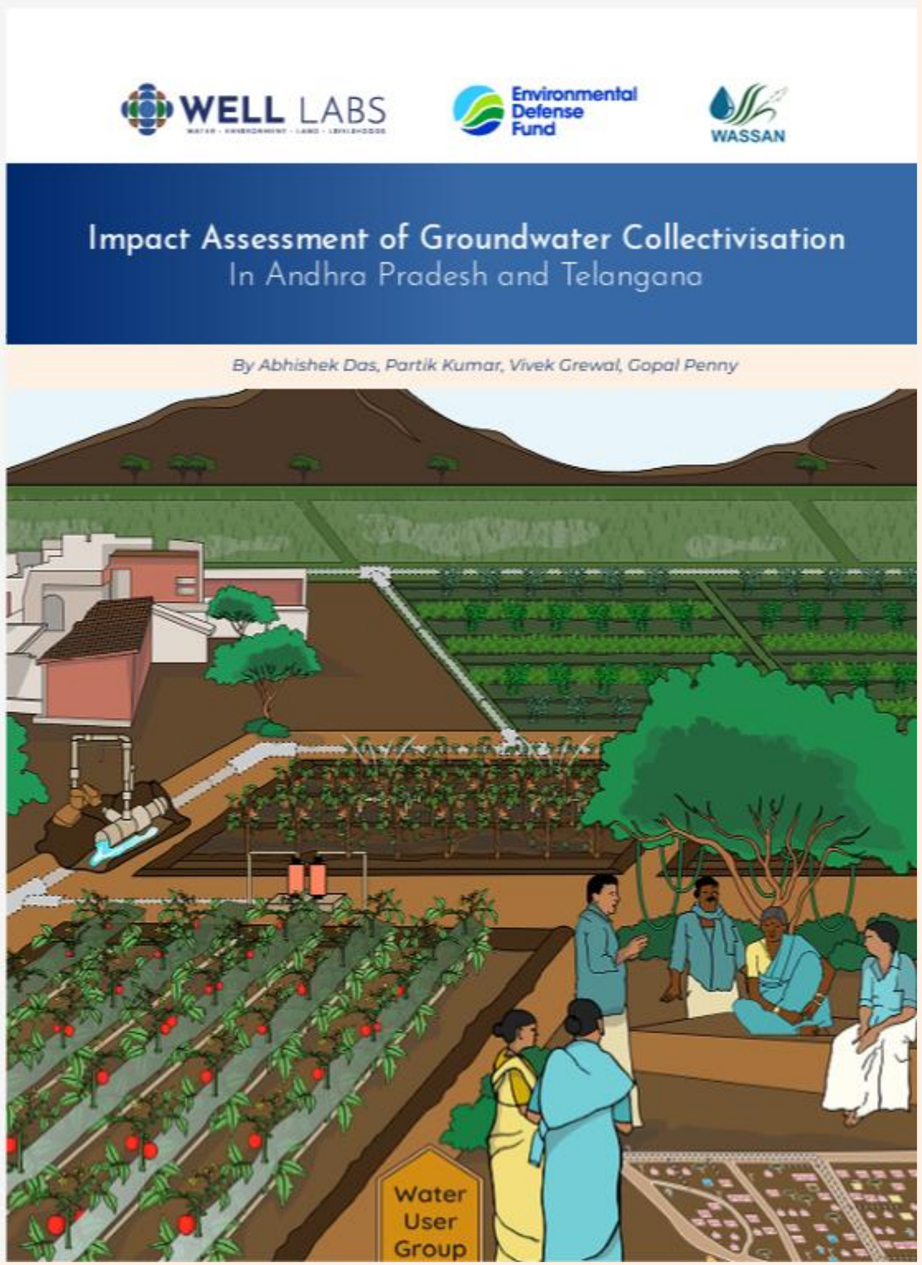
Source: Learning Focused study on Atal Bhujal Yojana

Participatory Groundwater Management hasn't worked either.

We also evaluated WASSAN's Borewell Collectivisation efforts in Andhra Pradesh and Telangana.

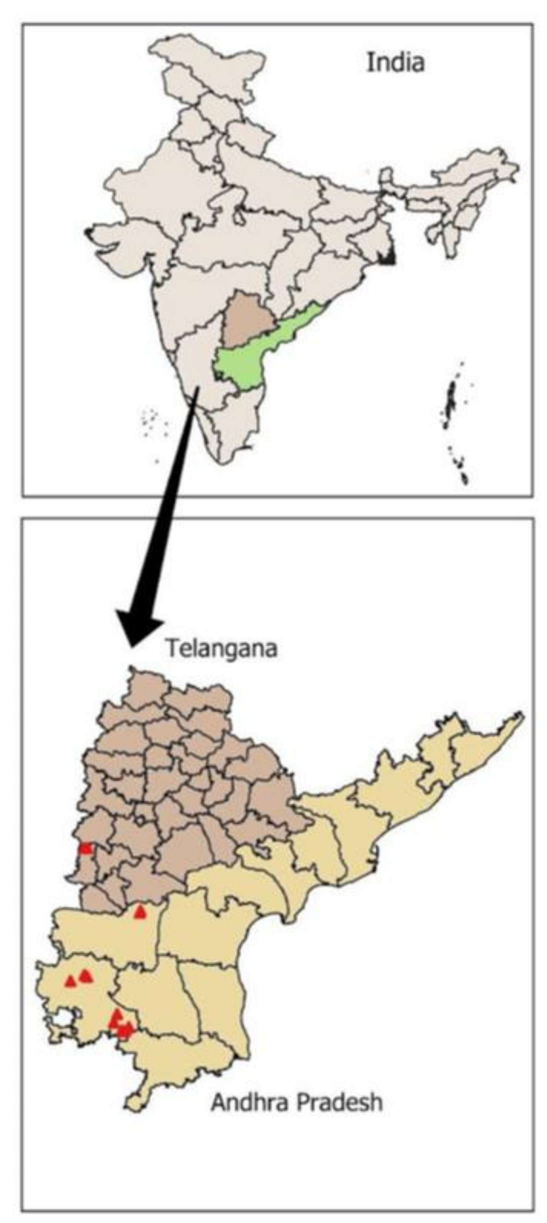
WASSAN made a bold move of creating Borewell User Associations.

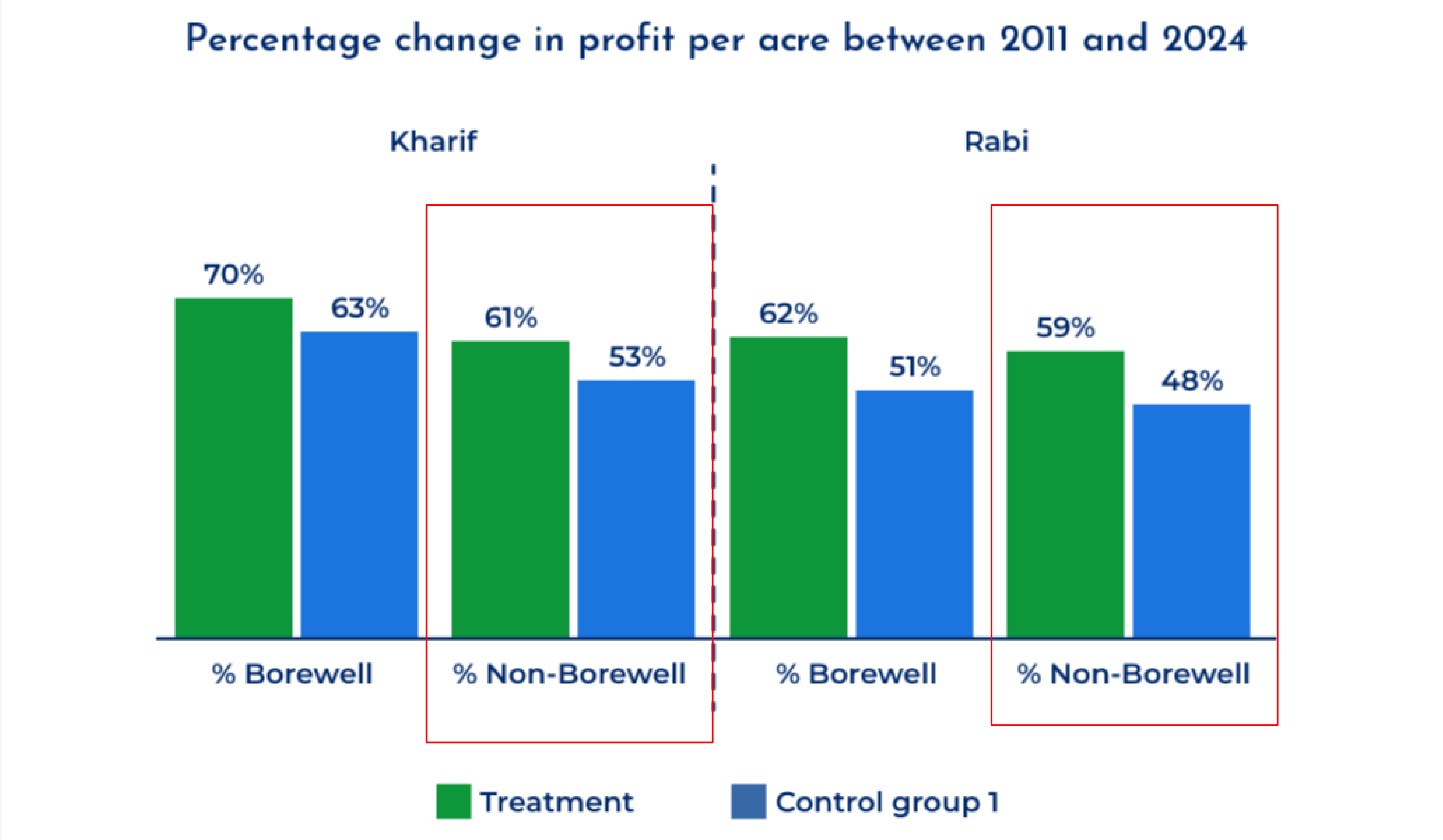
They persuaded borewell owners to share groundwater (for free) with rainfed farmers in exchange for a commitment that rainfed farmers would not drill wells for 10 years.



3B

Participatory Groundwater Management hasn't worked either.





Four approaches to groundwater governance have been attempted.

A. **Supply-side:** watershed development, rainwater harvesting, and increasingly capital-intensive managed aquifer recharge.

A. **Interventions are contextual**

A. **Demand-side:** micro-irrigation and energy rationing.

A. **Micro-irrigation gets more crop per drop but does not reduce overall pumping. (Jevon's Paradox)**

A. **Participatory governance:** groundwater managed as a common-pool resource requiring collective action.

A. **Groundwater needs to be managed collectively, incentives are key**


4
If we have tried everything, what could work?

Drawdown in wells is well

The average efficiency of existing IP sets is less than 30%.

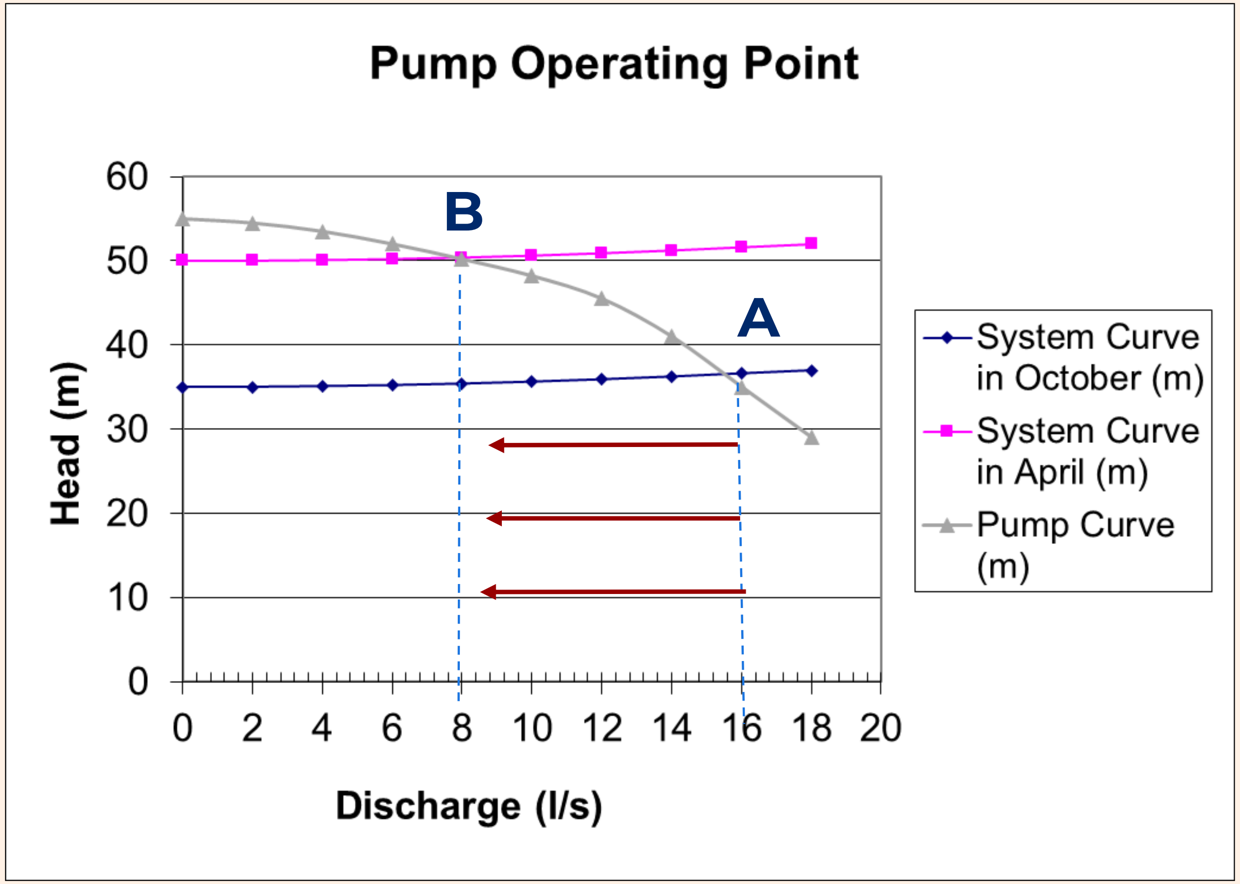
Drivers of inefficiency:

Competition and Seasonal Variations: farmers size pumps for peak drawdown and the deepest yielding fracture in the well.

Electricity rationing: limited daily hours drive farmers toward higher-HP pumps that extract more per hour.

Subsidies remove the cost signal that would incentivise investment in efficient equipment.

Voltage fluctuations cause frequent burnout and disincentivise purchase of efficient, voltage-sensitive pumpsets.



Source: WELL Labs

Energy consumption is driven by three processes

Precipitation:

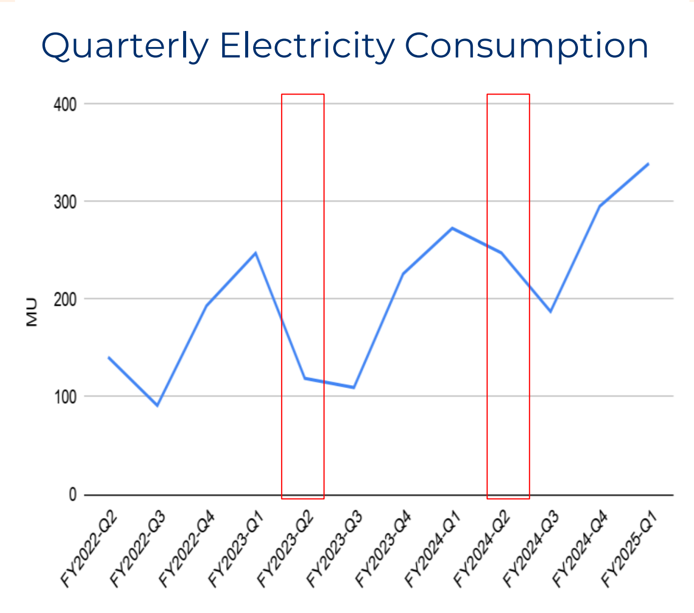
Farmers pumps more in drought years to make up for the shortfall in precipitation

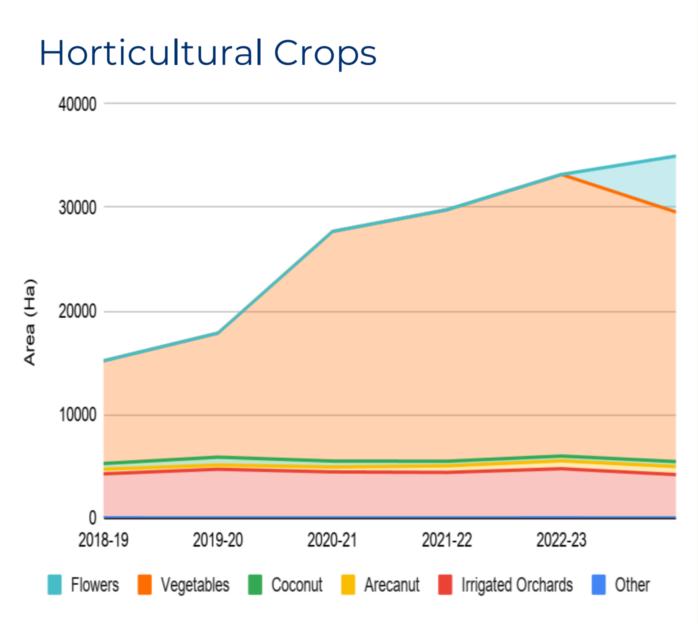
Cropping Patterns:

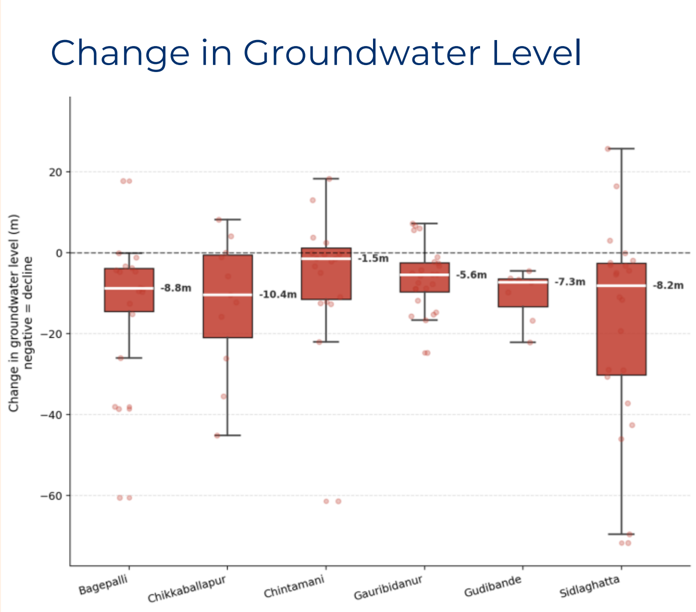
More water intensive crops result in more irrigation

Groundwater Levels:

As groundwater levels deepen pumps work harder







Examining the relationship between these three components and the role that pumping efficiency plays will help better anticipate shift in agricultural energy demand?

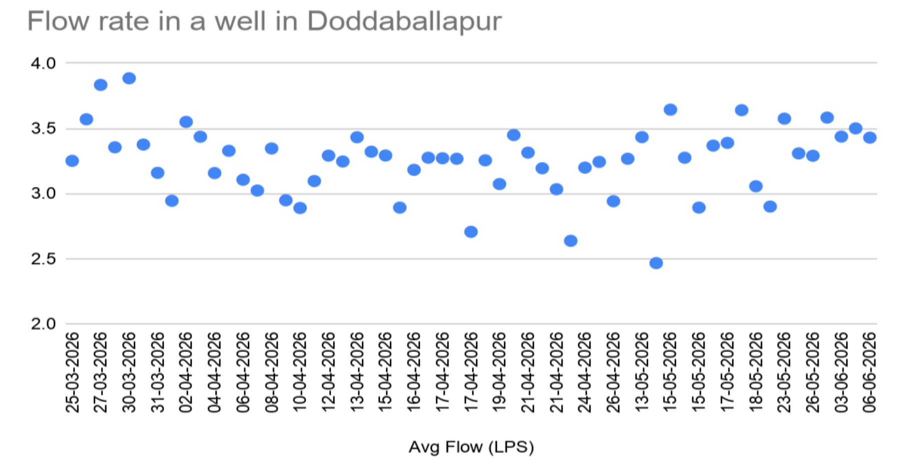
Source: WELL Labs compiled from BESCOM quarterly energy audits, Karnataka State Department of Horticulture, Atal Bhujal Yojana

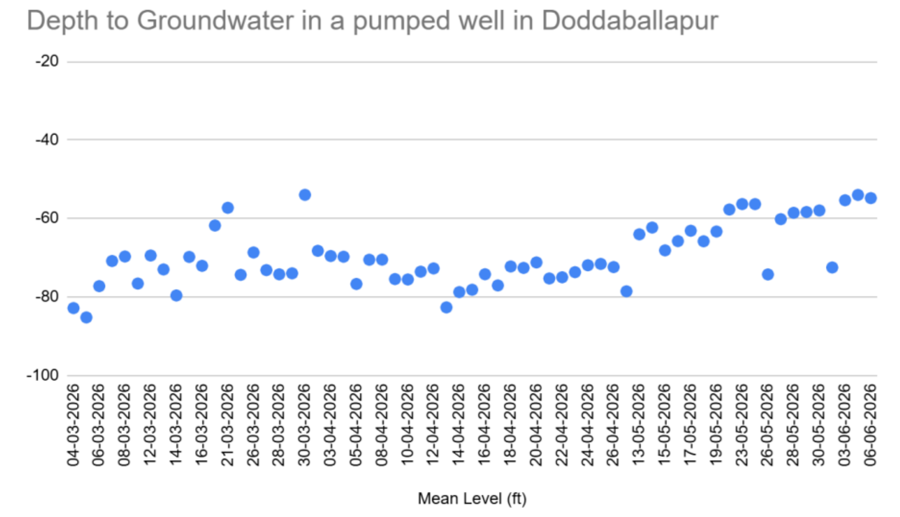
Designing an outcome-based incentive requires evidence on three distinct problems.

Measurement	Delivering an outcome-based incentive requires a reliable measure of the outcome variable. More accurate estimates of extraction and recharge are a precondition for incentive design.
Agency	Farmers must retain the capacity to change their behaviour. Understanding what pumping technologies and practices available determines the incentive can target.
Incentive	The incentive must compensate farmers for real transition costs. What crop-change, fallowing, recharge, and demand-management combinations would meaningfully restore the water balance, and at what cost?

Can we Measure groundwater levels extraction in pumped borewells?

Traditionally measuring groundwater levels in pumped wells has required interfering with a farmers operations





Source: WELL Labs, measurements from a irrigation borewell in Doddaballapura

Can we give farmers more Agency over pumping?

Can give farmers a way to use less electricity when pumping?

We are testing two things

1. Variable Frequency Drive Pumps.
2. Changing Pump-Rest cycles.

Incentive: What shape should Incentive mechanism take?

- Electricity payments
- Commercial Banks
- Carbon Credits
- Gram Panchayats

Can we make any of the four parties who suffer from externalities pay to change farmer behaviour?

5

We need MUCH more empirical research!

Measurement: accurate water-balance estimates require integrating model outputs with field-level observations

Recharge

- Recharge estimates for crystalline aquifers vary from 2% to 30%.
- The relationship between rainfall and recharge, with high rainfall year contributing significantly more to recharge.

Building a viable incentive requires more accurate and empirically validated estimates of recharge and extraction.

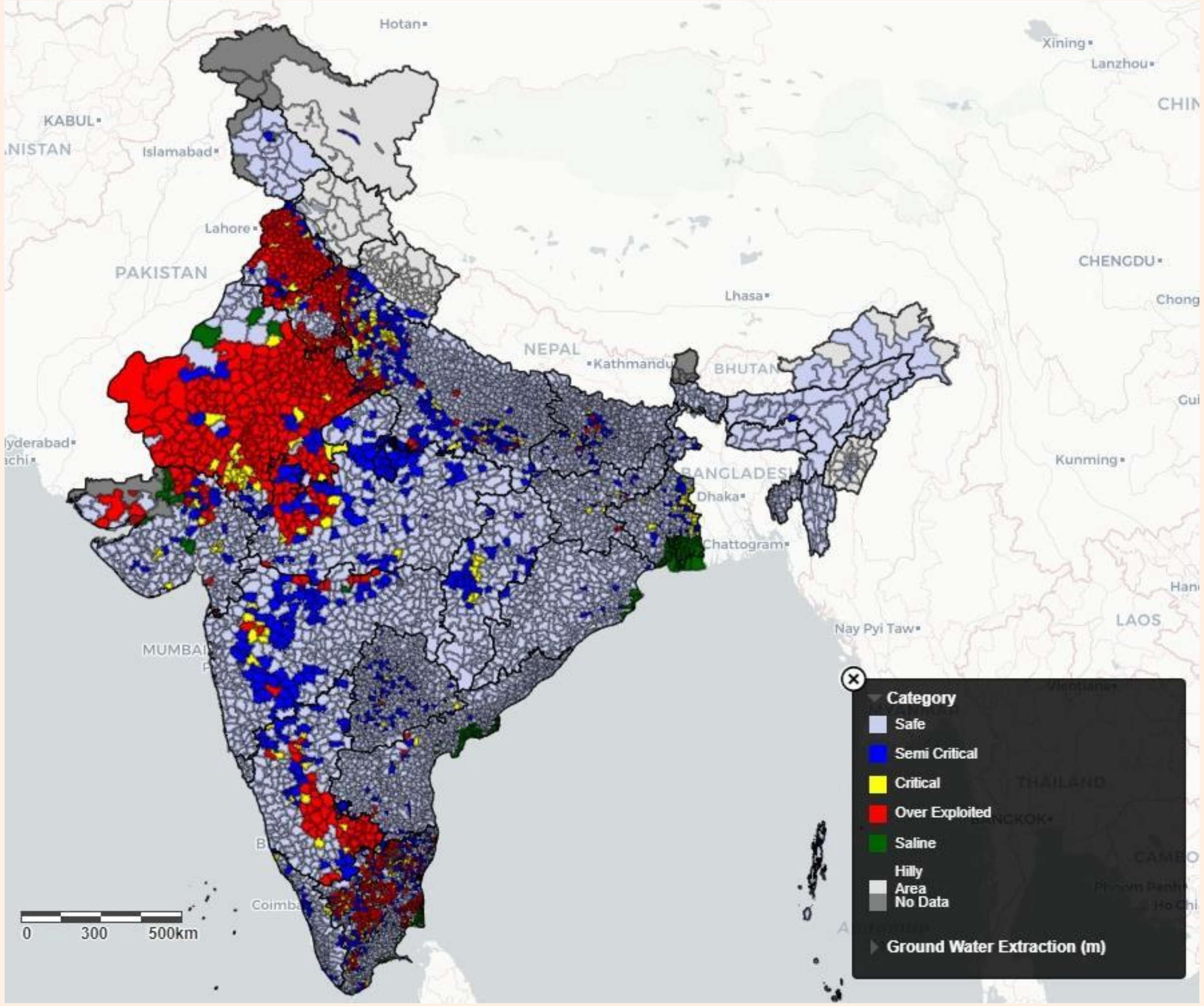
Reference (Method)	Hydro-geologic setting	Recharge (mm / year)	Recharge (% of rainfall)
Rohde et al., 2015 (Chloride Mass Balance and WTF)	Fractured granite (semi-arid)	20–31	**4–6 %**
Bhanja et al., 2019 (National WTF)	Crystalline fractured aquifers (central & south India)	40–120	**5–12 %**
Bhanja et al., 2019 Tritium tracer studies (granite)	Granite terrains	22–179	**2–10 %**
Bhanja et al., 2019 Tritium tracer studies (basalt)	Basalt terrains	46–171	**3–12 %**
Garg et al., 2012 (Kothapally, Modelled)	Hard-rock watershed (granite, with interventions)	70–300 (avg 174; wet years 300)	**9–30 % (avg 20 %; wet years 25–30 %)**

Estimating Groundwater Extraction is also

- Irrigated areas in hard rock areas are small and dispersed making crop mapping difficult.
- Extraction estimates, for most part, are based on the FAO method. But these can vary quite significant.
- We believe Existing estimates such as those of the FAO tend to overestimate extraction

Estimating Groundwater Extraction is also

- The GW overexploitation status



Karnataka

Thank You!

Reach us at

- https://welllabs.org
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- WELL Labs

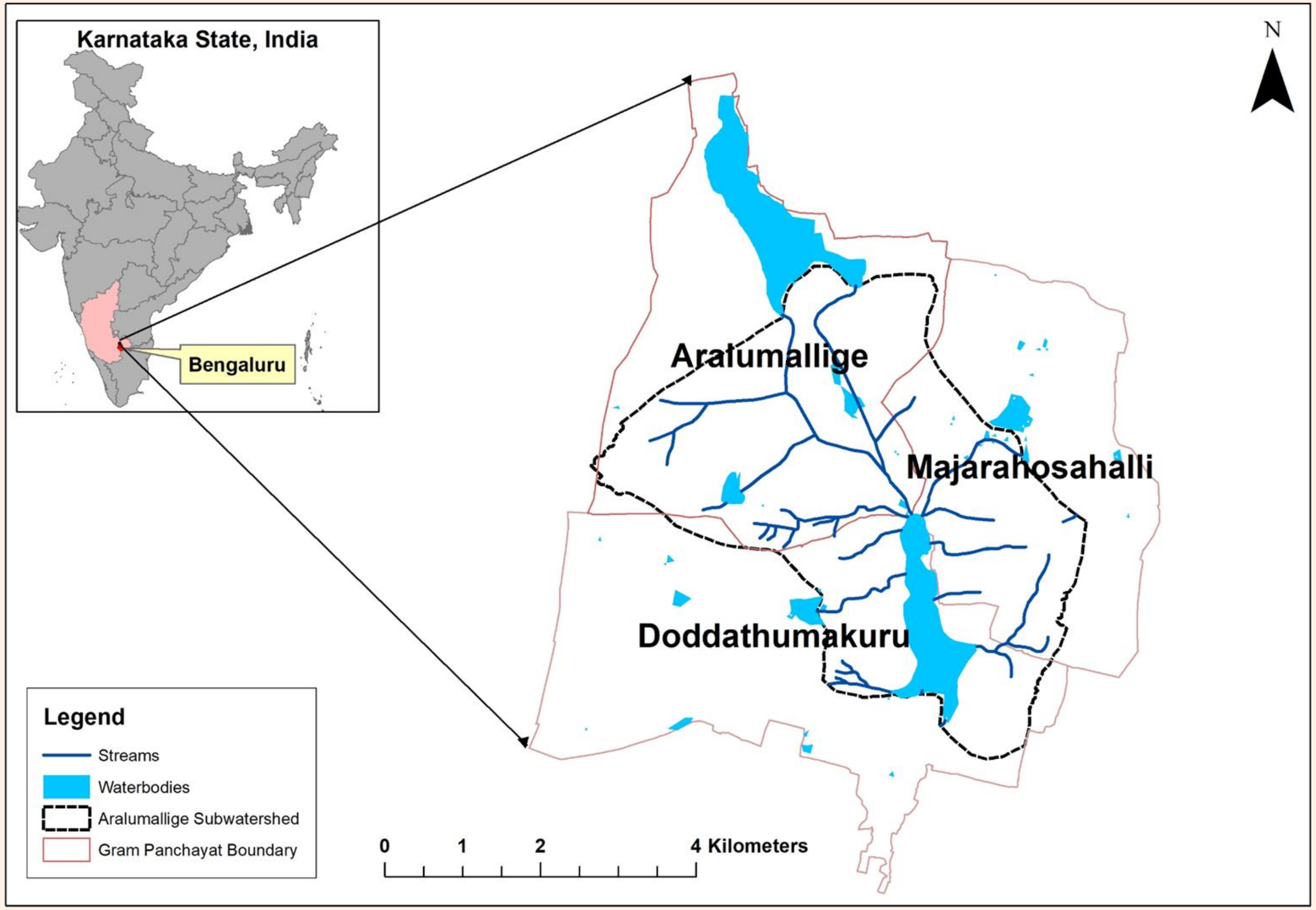
The Aralumallige Study Site

Location & size: Aralumallige watershed (~20 sq km) in Karnataka, northwest of Bengaluru, within the Upper Arkavathy catchment.

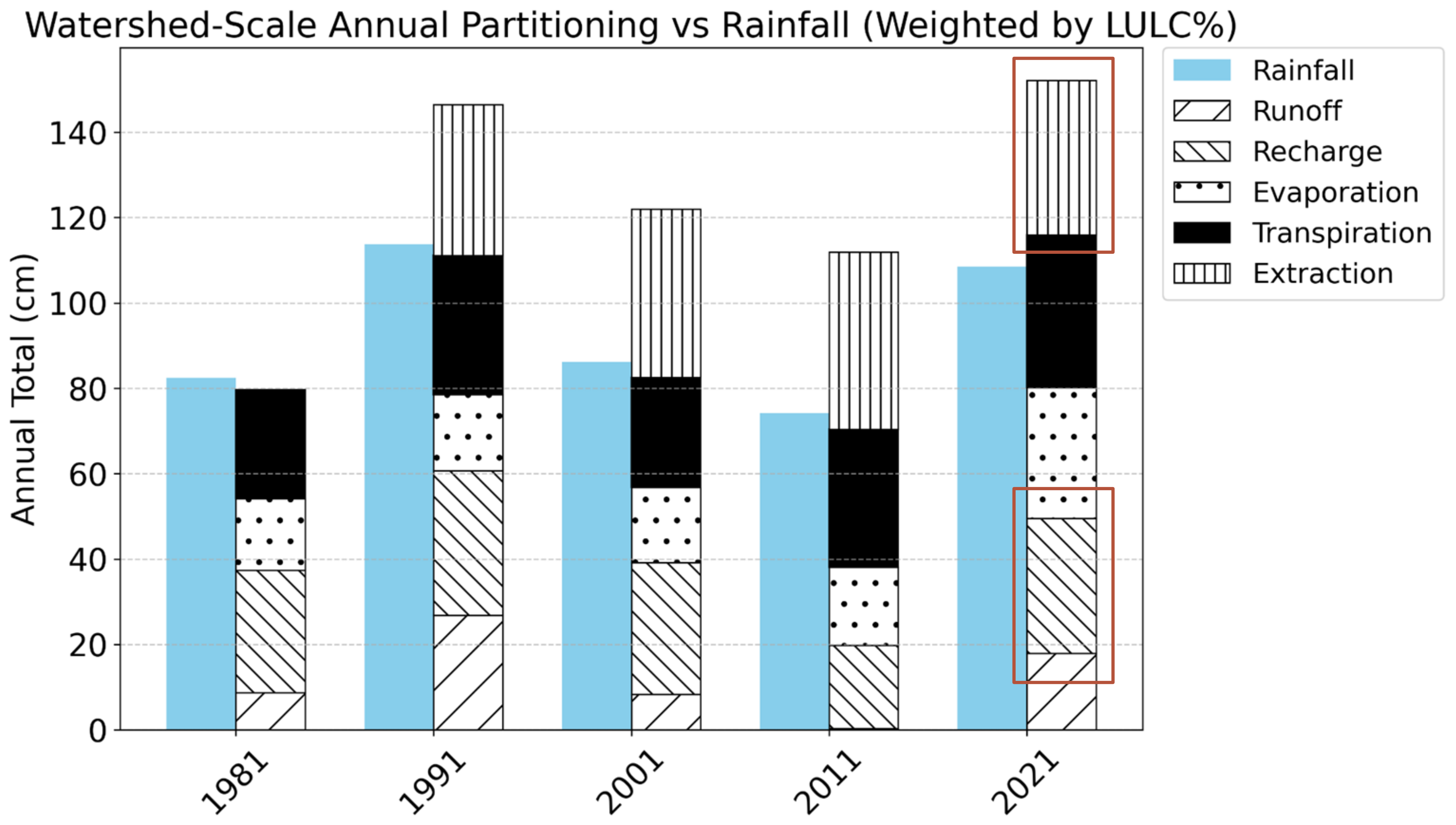
Climate: ~750 mm annually, concentrated in the monsoon season. ~1700 mm annual PET

Land use: Predominantly agriculture with rainfed millets, irrigated vegetables, eucalyptus, and horticultural crops.

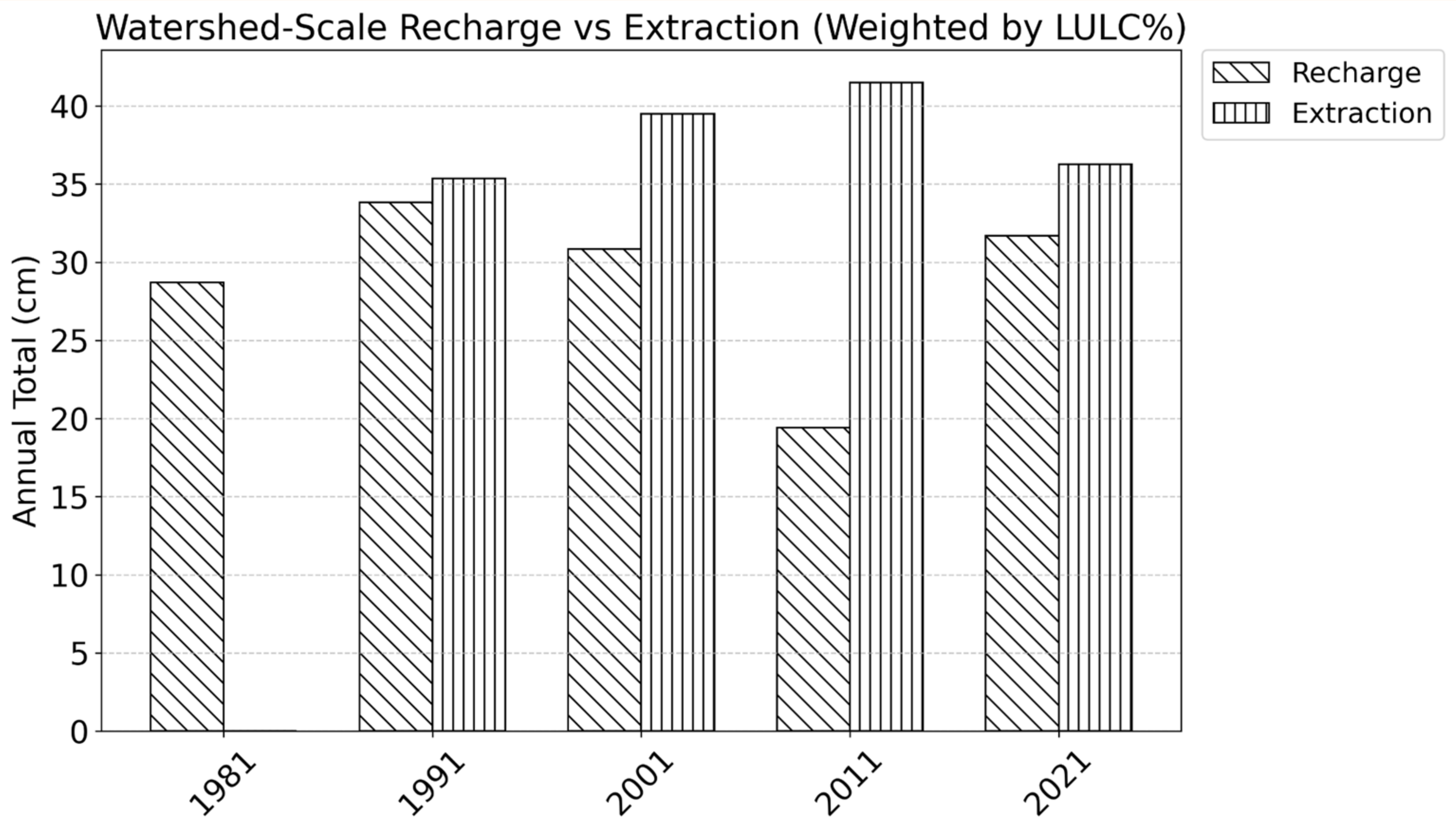
Water resources: Irrigation relies on deep fractured-rock aquifers; traditional tanks persist but function only partially to store monsoon runoff.



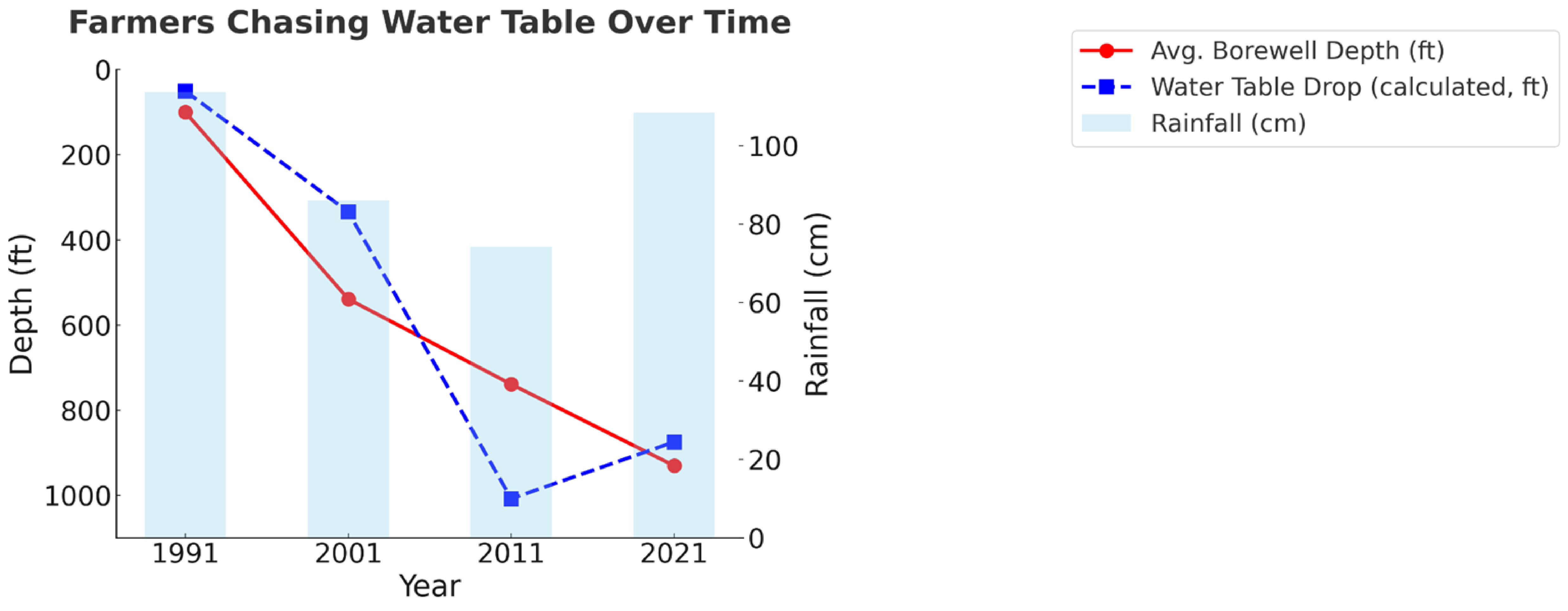
At the watershed scale, recharge, runoff has decreased, extraction is surprisingly stable.



Sustainability: Negative, but a decrease in the deficit due to rainfall.



Sustainability: Negative, farmers chasing the water table



How much additional investment is incurred each year due to GW depletion?

Gram Panchayat	Pumping Cost	15th FC Allocation (Central)	SBA Fund (State)	Tax Revenues	Arrears to electricity board
Aralumallige	71	25	9	22	192
Doddatumakuru	38	30	10	16	142

All costs in Rs lakh/ year, rounded. Arrears are total accumulated Rs lakh.
Capital cost of ~15 lakh/year for borewells is from other funds like JJM.

Panel Discussion and Q&A

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