How do we solve India's groundwater problem?

Mapping Problem Typologies and Solutions

IWMI Webinar on

Will solar irrigation deepen the groundwater crisis in South Asia?

Veena Srinivasan, Anjali Neelakantan and Shilpa Swaraj

February 5, 2021

MAIN ARGUMENT

India faces a looming groundwater crisis.

To address the looming crisis we need to:

- Define (and quantify) sustainable abstraction level.
- Identify policy approaches to move towards it.
  - Setting limits + licensing
  - Solar Irrigation
- Describe where Solar Irrigation will work, and under what conditions

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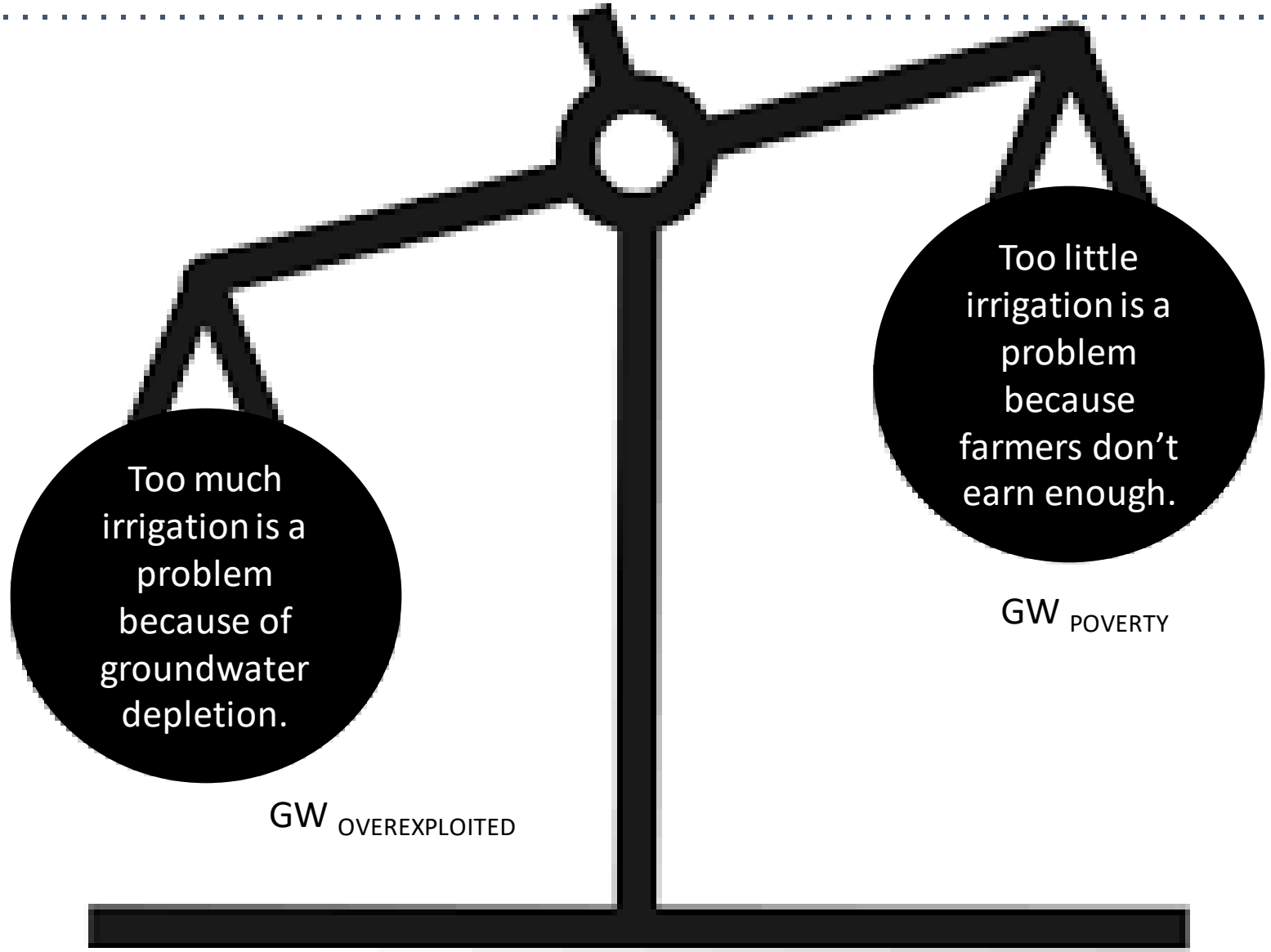
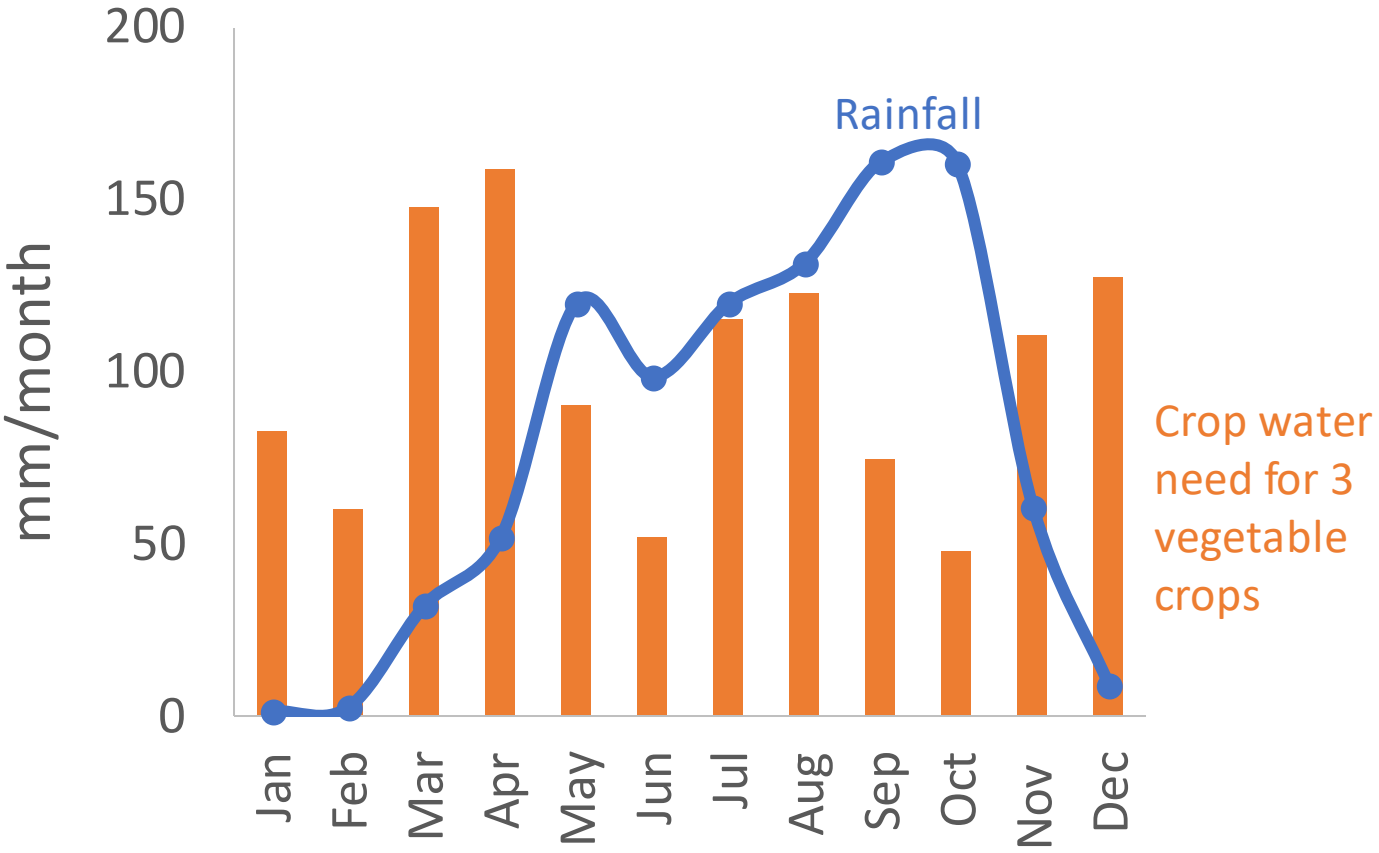
GROUNDWATER AND THE GOLDILOCKS PROBLEM



GROUNDWATER AND THE GOLDILOCKS PROBLEM

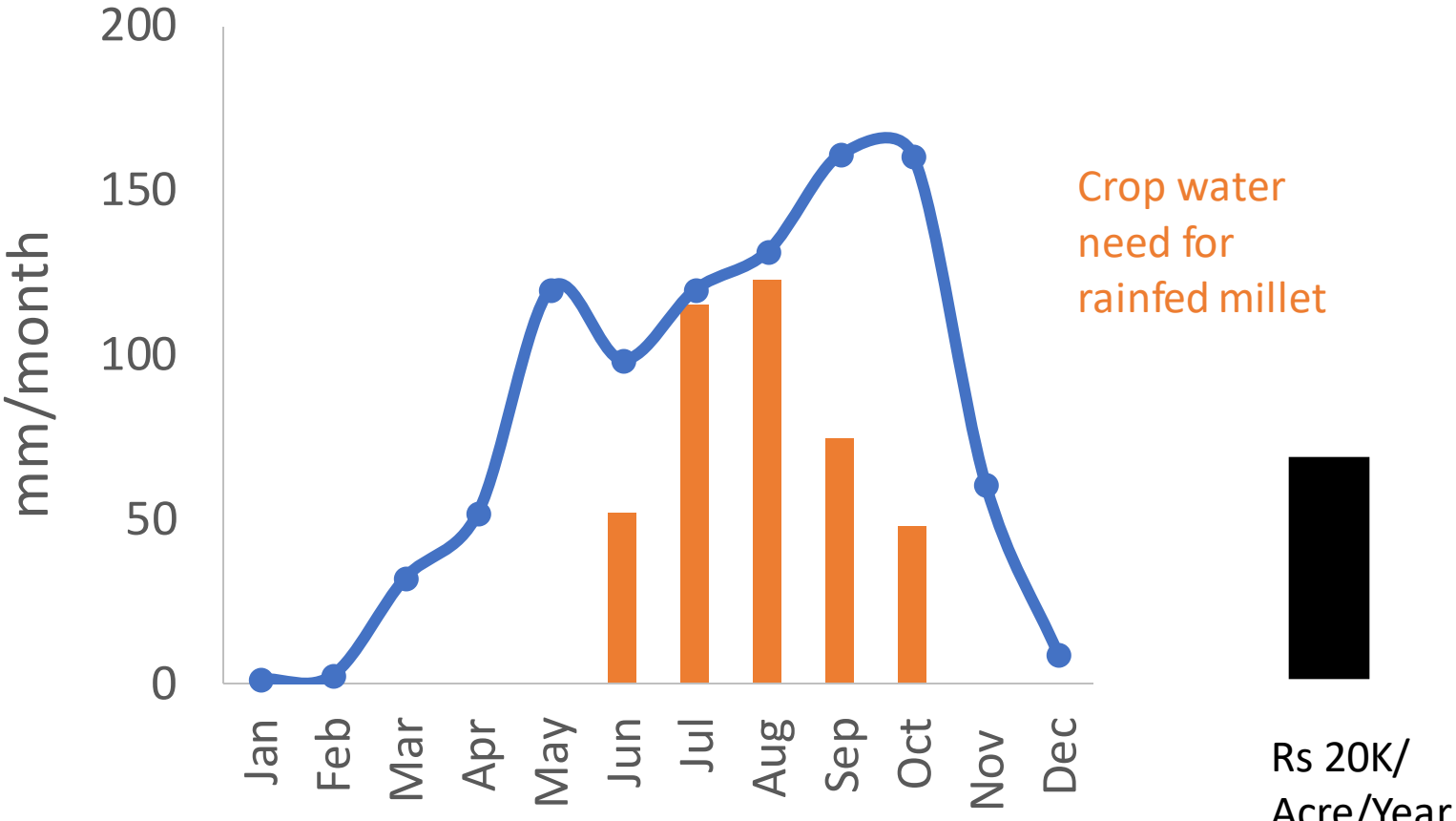
Seasonal rainfall => long dry season, low cropping intensities



* Data for Bangalore Rural District

GROUNDWATER AND THE GOLDILOCKS PROBLEM

Rainfed Agriculture: “Too little groundwater”



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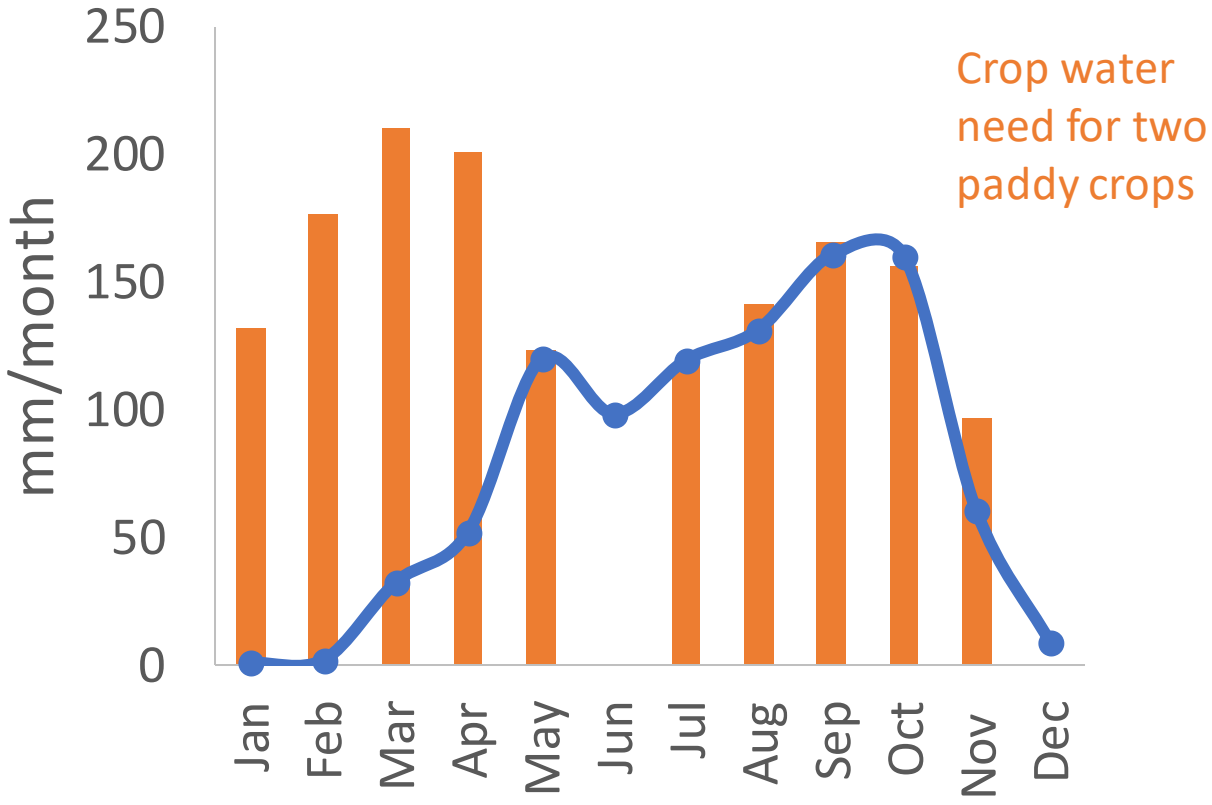
GROUNDWATER AND THE GOLDILOCKS PROBLEM

Irrigated Double Paddy: “Too much groundwater”



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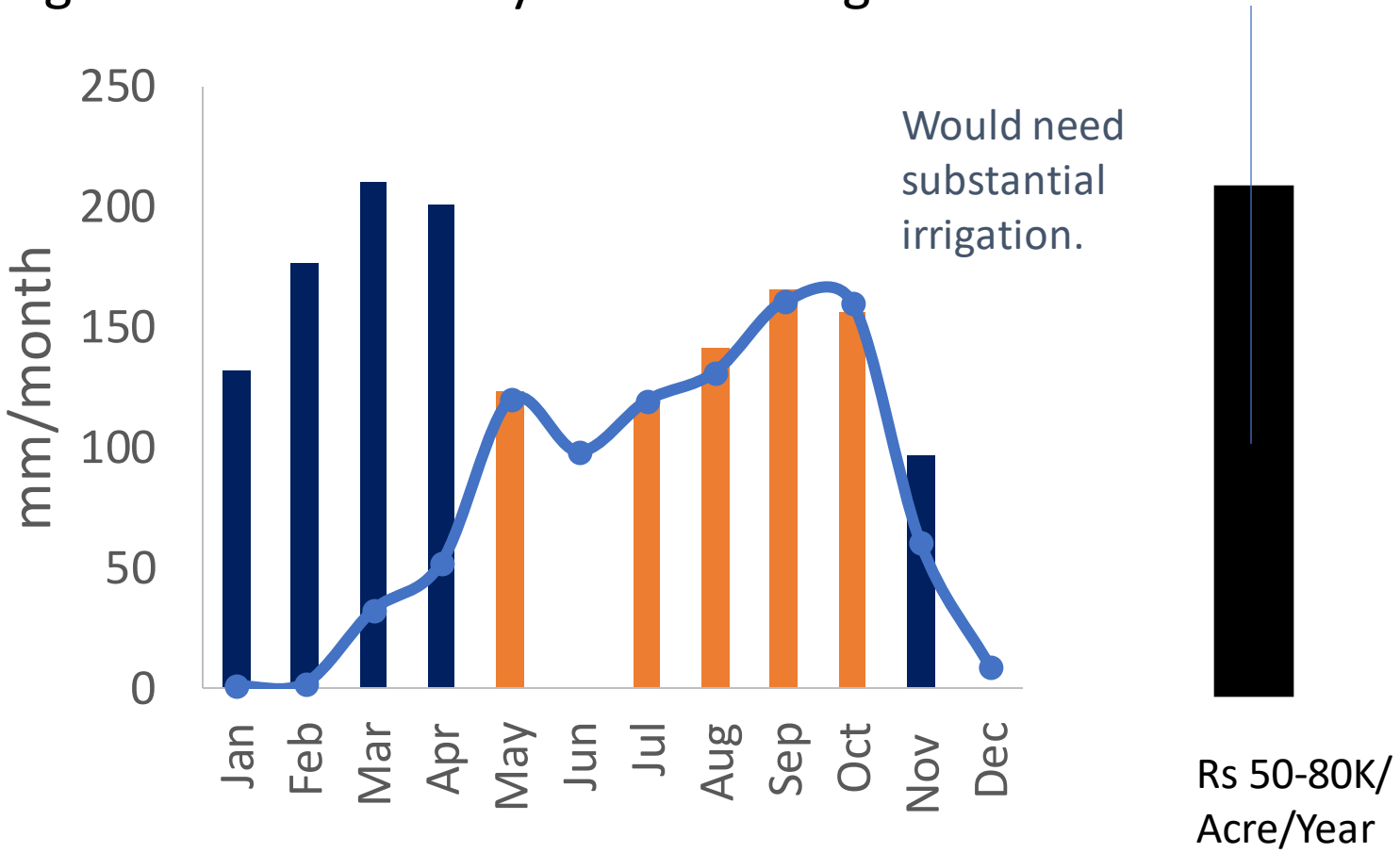

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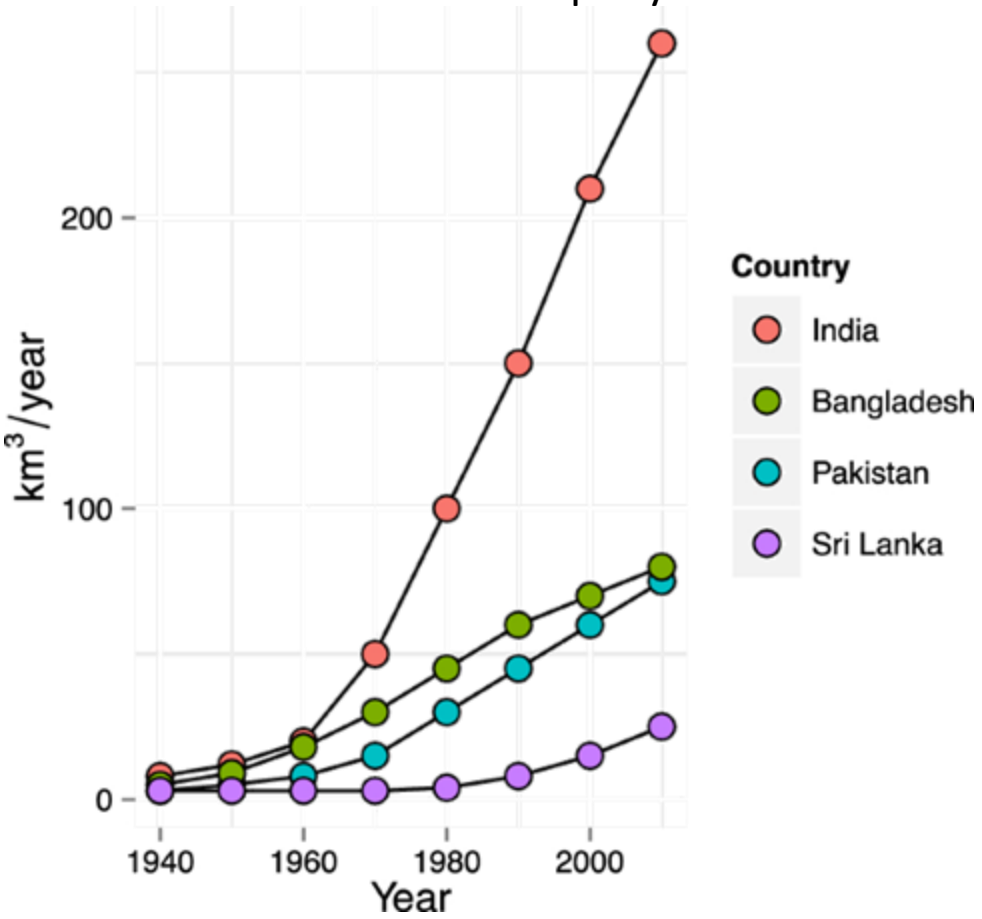
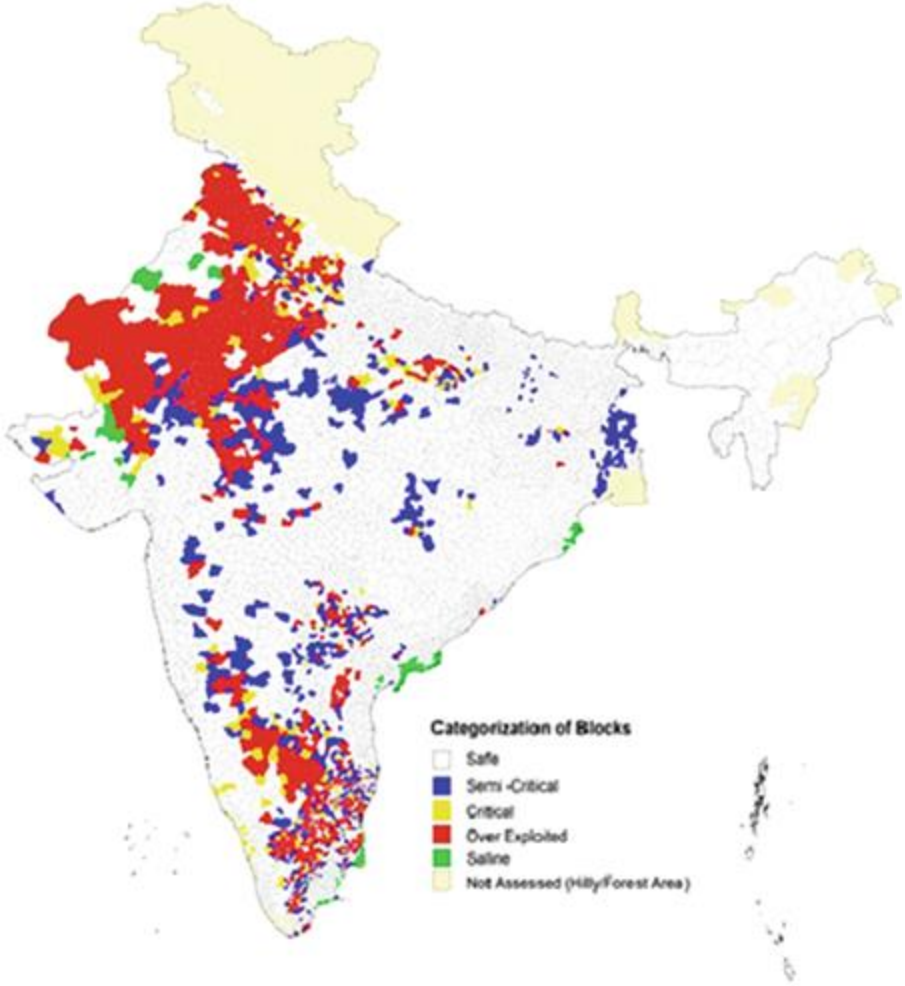
INDIA's GROUNDWATER CRISIS

As India has developed and with free electricity, groundwater abstraction has risen rapidly since the 1970s



INDIA'S GROUNDWATER CRISIS

Even as half the farmers lack access to irrigation, groundwater is already severely overexploited in parts of India



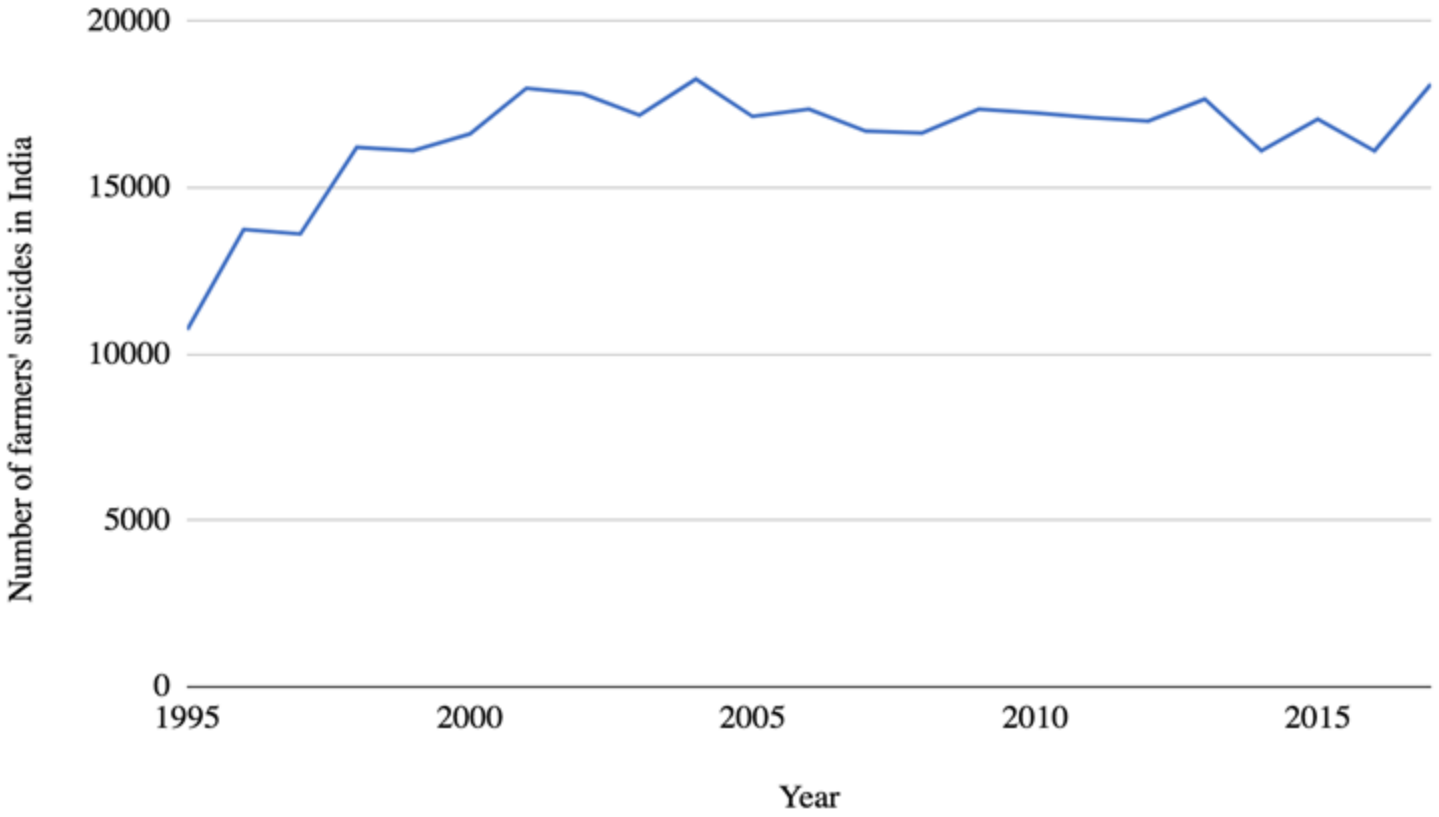
Source: CGWB

INDIA'S GROUNDWATER CRISIS

Source: Morgan Stanley

INDIA'S GROUNDWATER CRISIS

Increase in farmers' suicides over the last 25 years



Source: National Crime Records Bureau, 2015

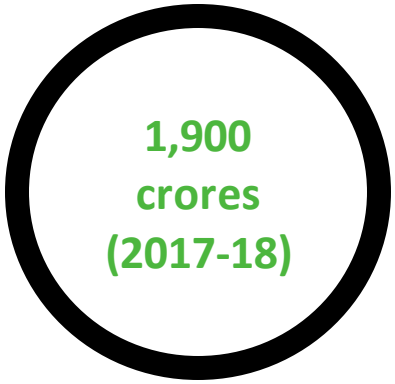
SECTOR INVESTMENTS DON'T SEEM TO BE PAYING OFF

A lot of money is being spent, but aggregate indicators are going in the wrong direction. Either we are not putting enough money in the right solutions, we are scaling the wrong things, or a combination of both.

Natural Resource Management expenditure under MNREGA

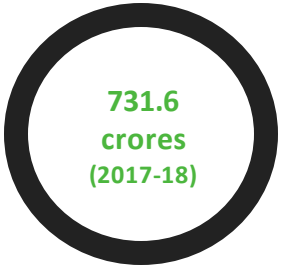
Source: Ministry of rural development, 2018

Har khet ko pani (Jal Shakti)



Source: Ministry of Water Resources, 2018

Total CSR spend on water



Source: Samhita, 2018

This is not accounting for state funding and other foundation and bilateral funding.

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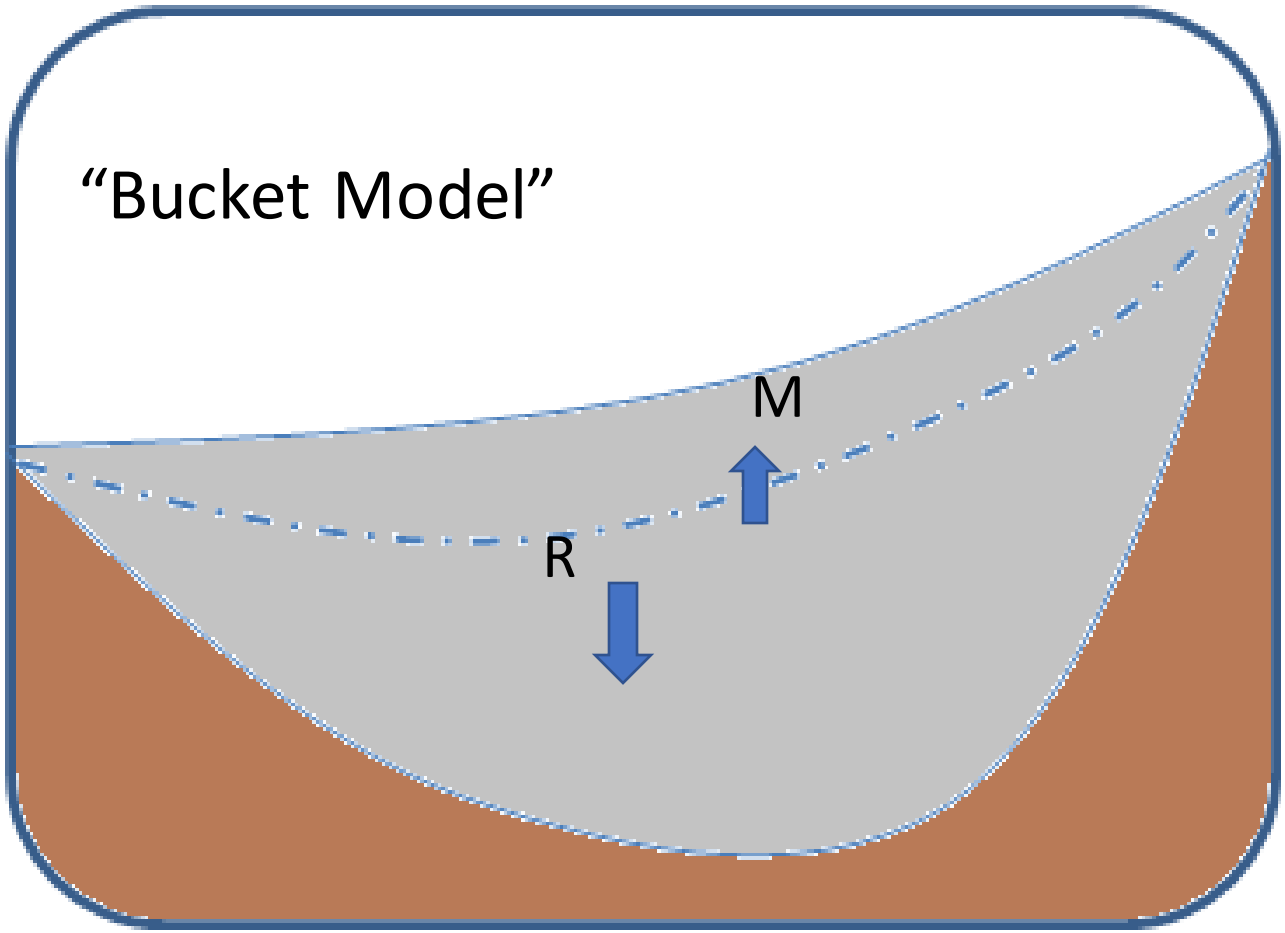
WHAT IS SUSTAINABLE GROUNDWATER?

The stated goal of regulation is “sustainable management”

- “development of groundwater must be ‘on a sustainable basis’ (Groundwater Resources Estimation Committee 1997, p.1).
- “promote sustainable groundwater use in the public interest” (Planning Commission 2011a).
- “to control indiscriminatory exploitation of ground water” (GoK 2011).

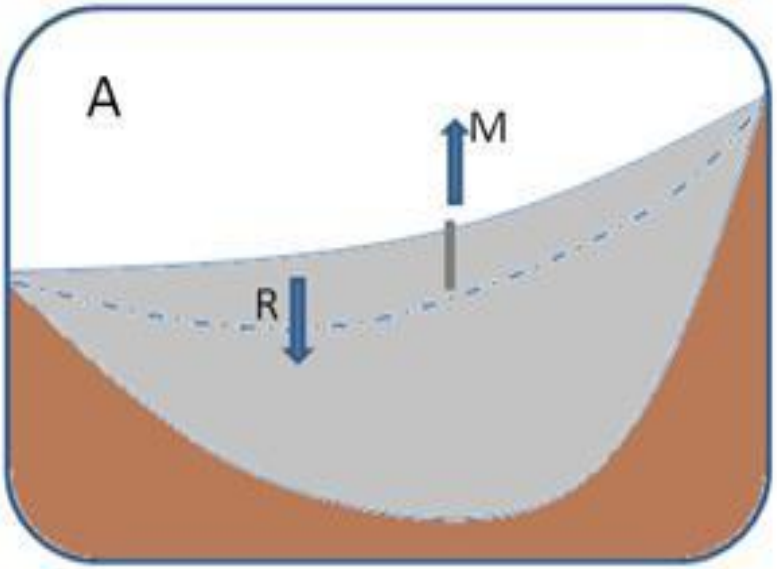
But what does sustainable management really mean?

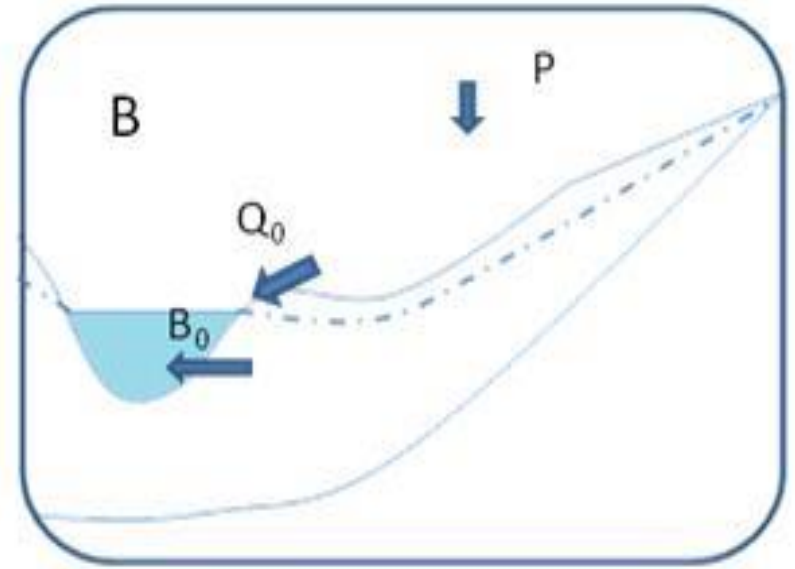
Traditional approach => Safe Yield: R=M



Srinivasan and Lele, 2017

But treats groundwater as distinct from surface water

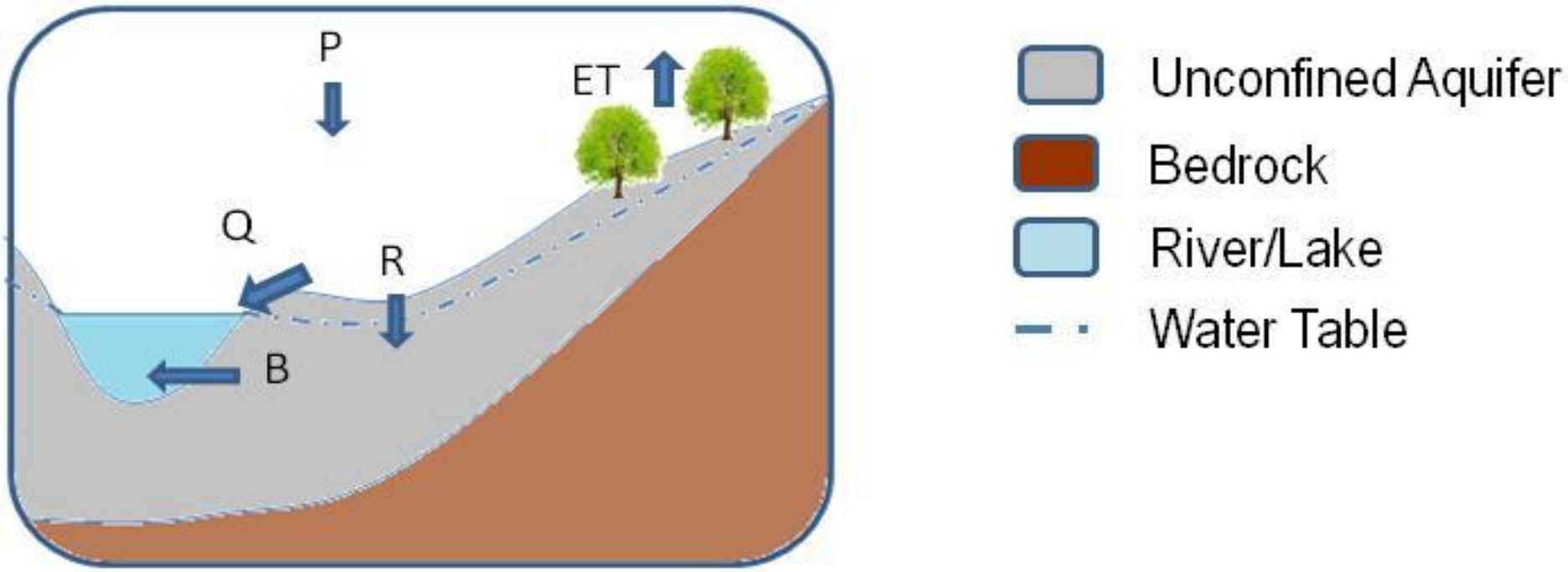




Groundwater **Surface Water**

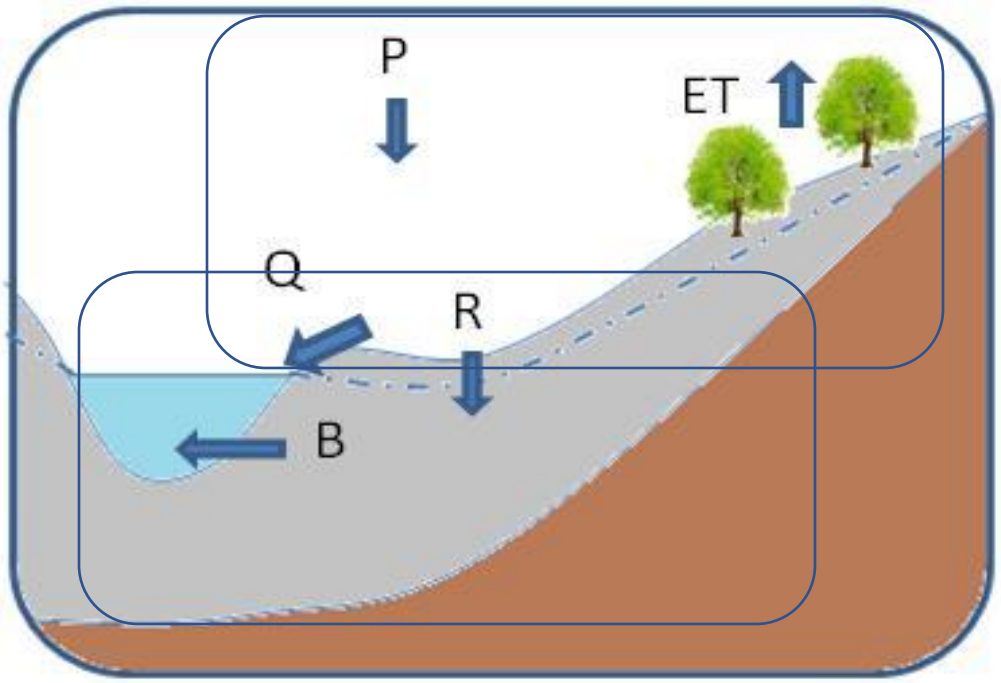
Srinivasan and Lele, 2017

Obviously, we all understand these are interconnected resources.



This poses a problem in being able to define groundwater sustainability.

In a pristine watershed, all recharge ended up as baseflow.



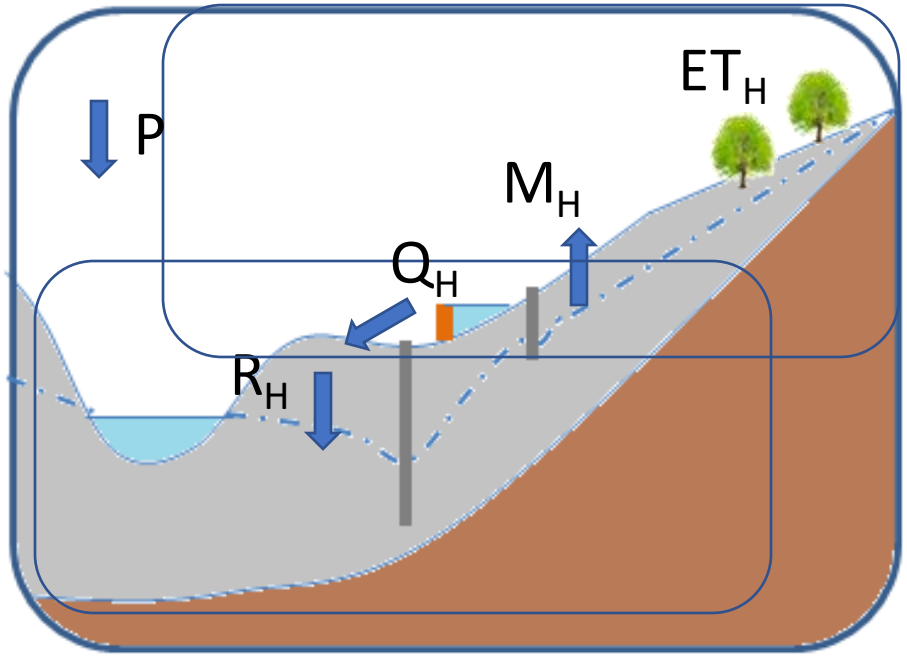
$$P = ET_0 + R_0 + Q_0$$

$$R_0 = B_0$$

$$P = ET_0 + B_0 + Q_0$$

All rainfall must end up as precipitation or streamflow or sub-marine discharge

In a human dominated watershed, some recharge ends up as evapotranspiration.



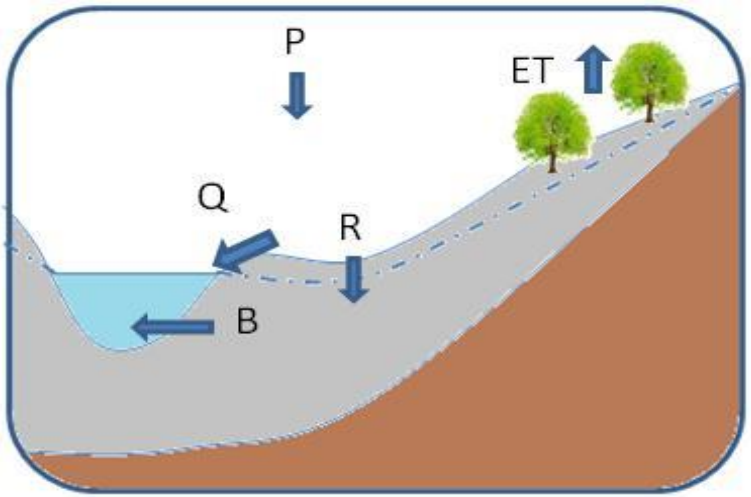
$$P = ET_H + R_H + Q_H$$

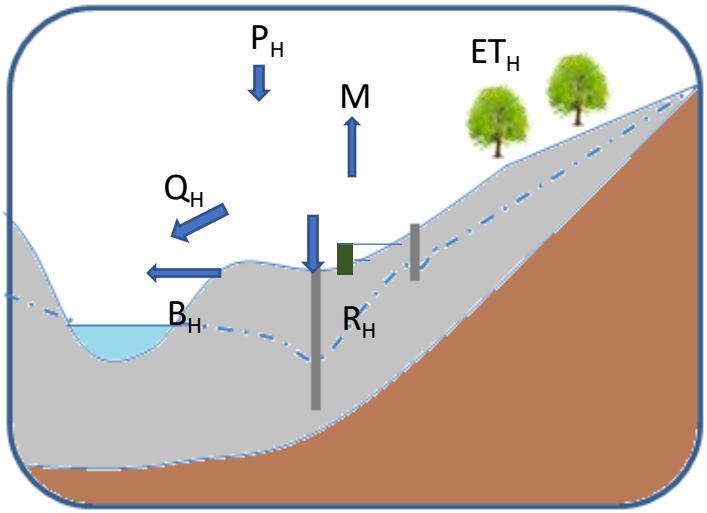
$$\Delta V = R_H - B_H - M$$

$$P - \Delta V = ET_H + (Q_H - B_H) + M$$

All rainfall must end up as precipitation or streamflow or sub-marine discharge or irrigated ET but some of this can come from storage

But all pumping must come at the expense of something.





If Sustainability means $\Delta V = 0$ then,

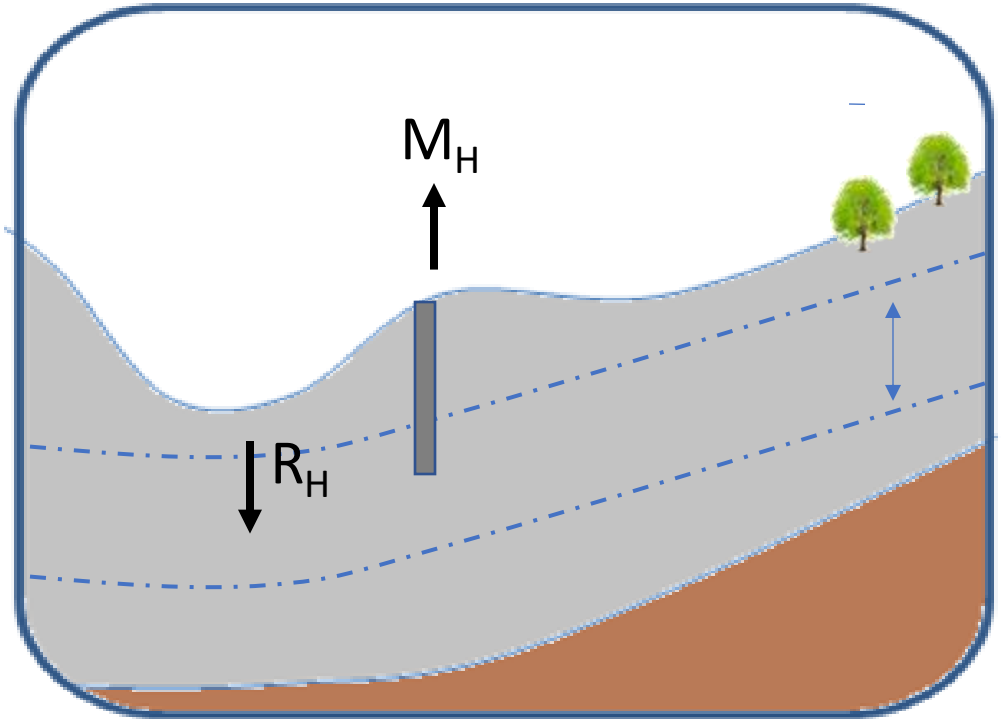
$0 = (ET_0 - ET_H) + (Q_0 - Q_H) + (B_0 - B_H) - M$

That is,

$M = \Delta ET + \Delta Q + \Delta B$

All pumping must come at the expense of ET or streamfllow

Caveat: If we assume no links to surface water, the condition for GW Sustainability is Extraction ≤ Recharge



Many aquifers in India are in this state, but this implies no base flows.

If wetlands, environmental flows matter the sustainability condition has to account for impact on those.

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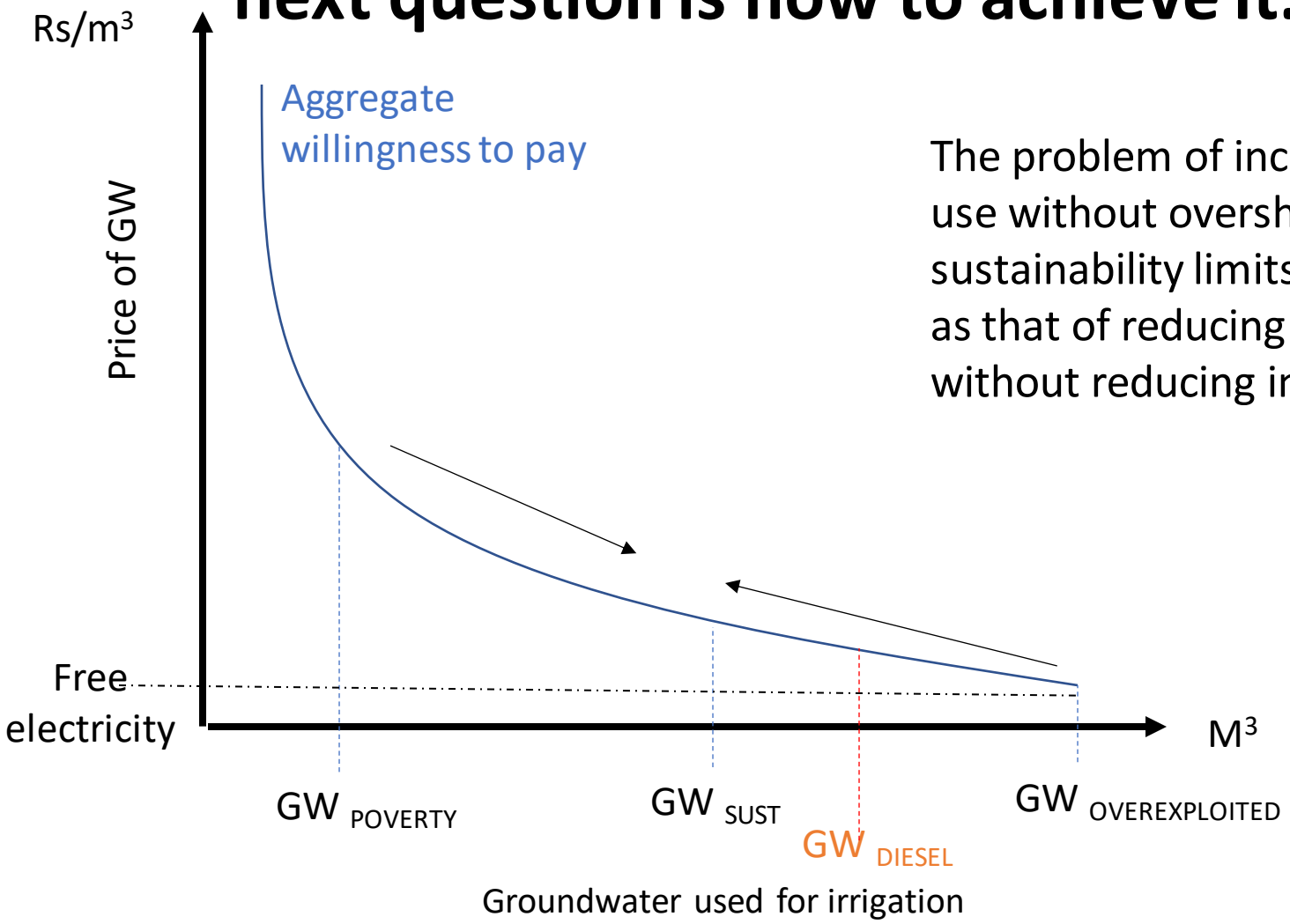
Once we have set a limit on what the acceptable maximum abstraction is the next question is how to achieve it.



The problem of increasing GW use without overshooting sustainability limits, is as vexing as that of reducing GW use without reducing incomes.

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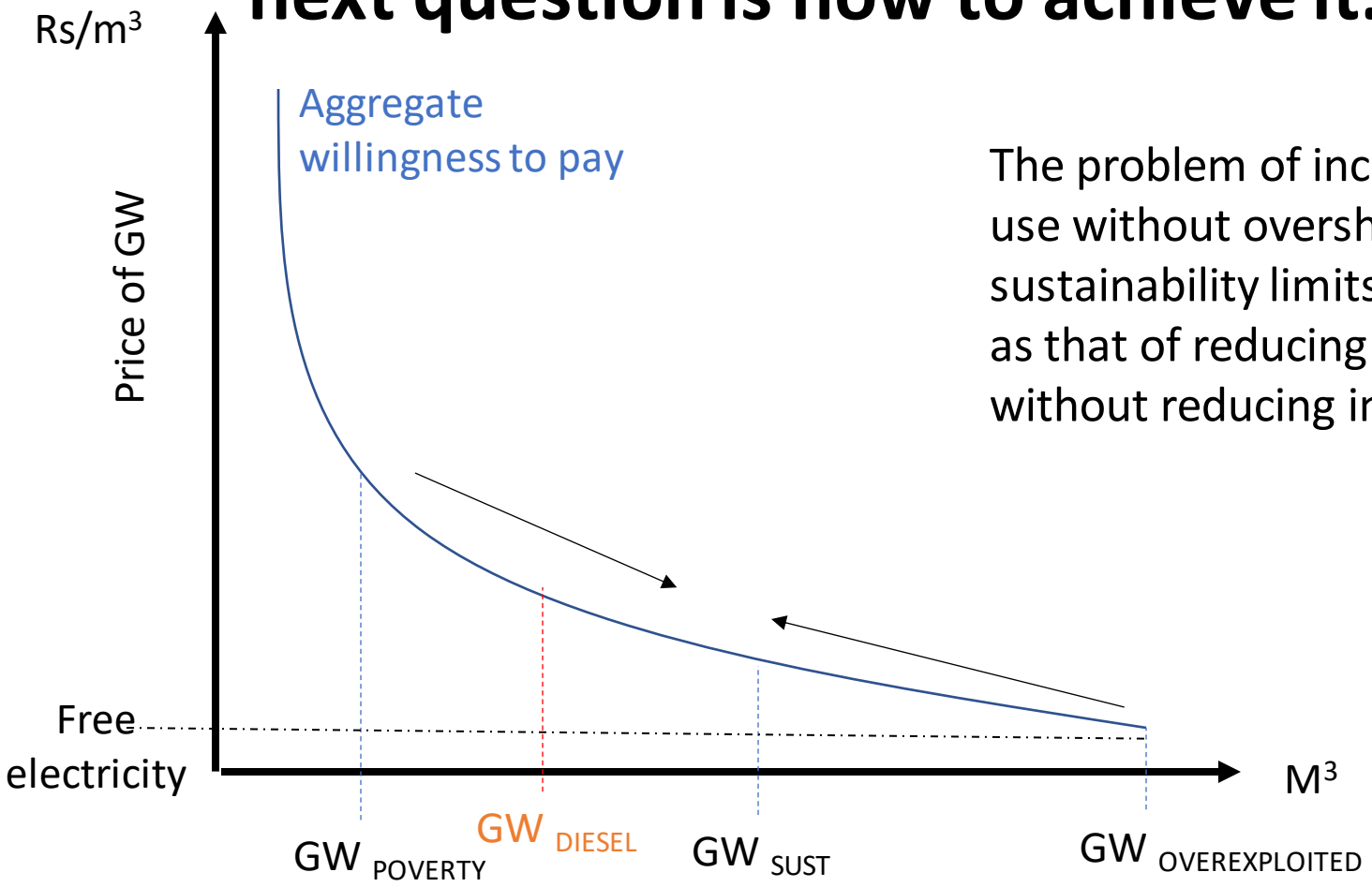
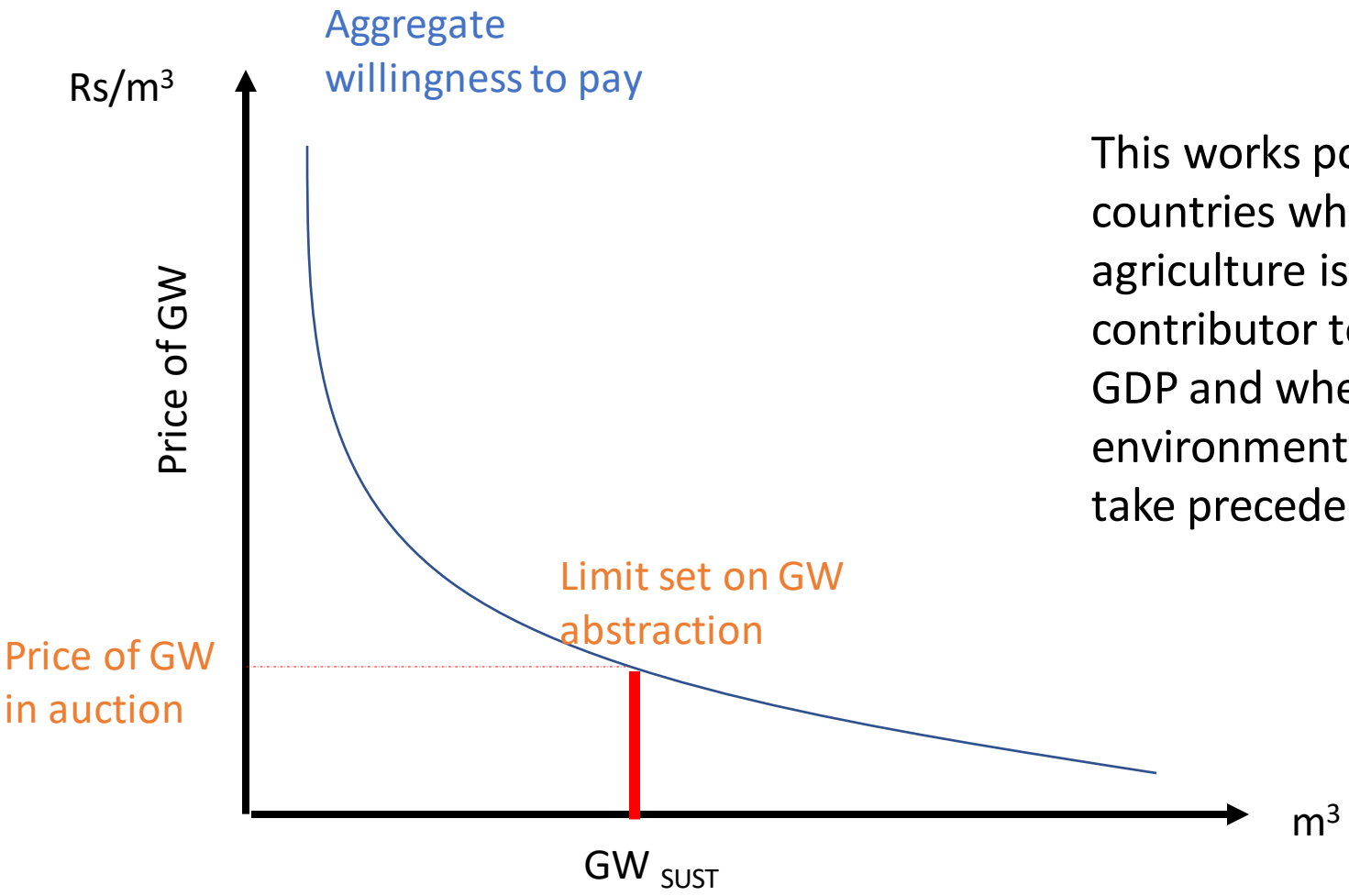


The problem of increasing GW use without overshooting sustainability limits, is as vexing as that of reducing GW use without reducing incomes.

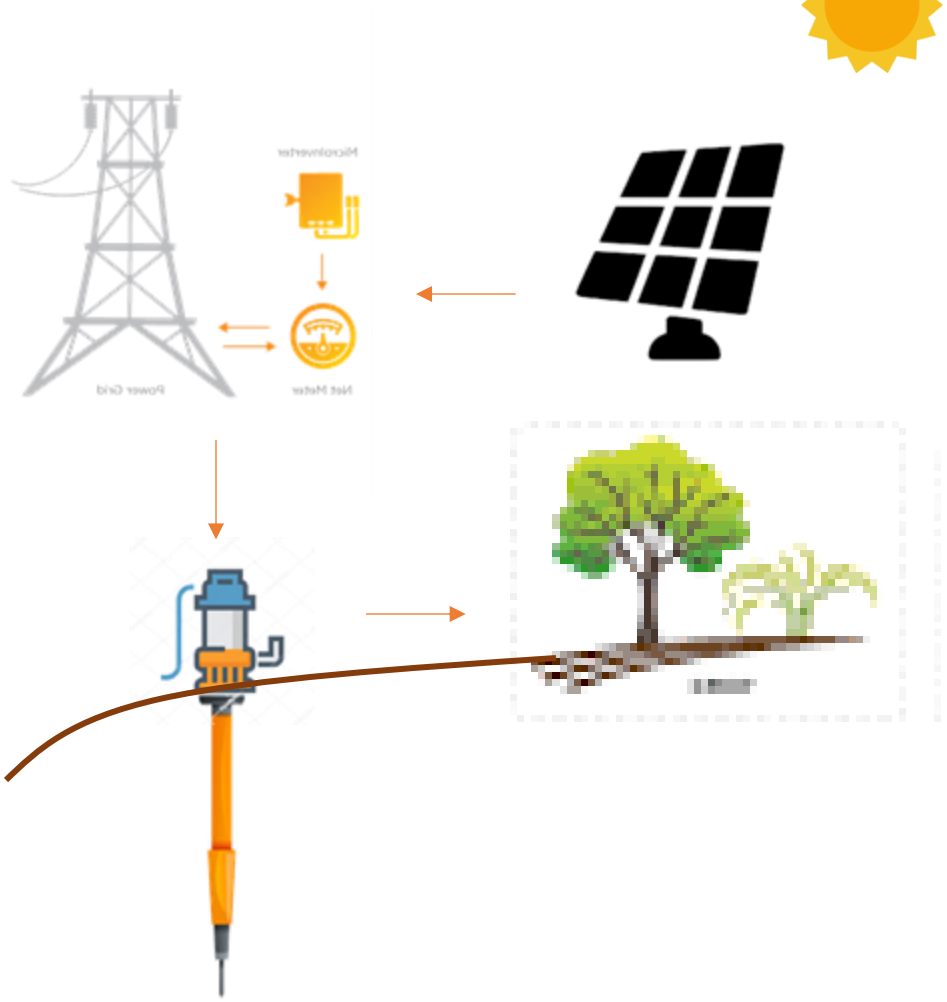
Developed countries have auctioned licenses thus setting a hard limit on GW but letting the price of GW remain uncertain.



This works politically in countries where agriculture is a small contributor to jobs and GDP and where environmental concerns take precedence.

Solar irrigation with feed-in-tariffs is nicely designed to address the Goldilocks problem

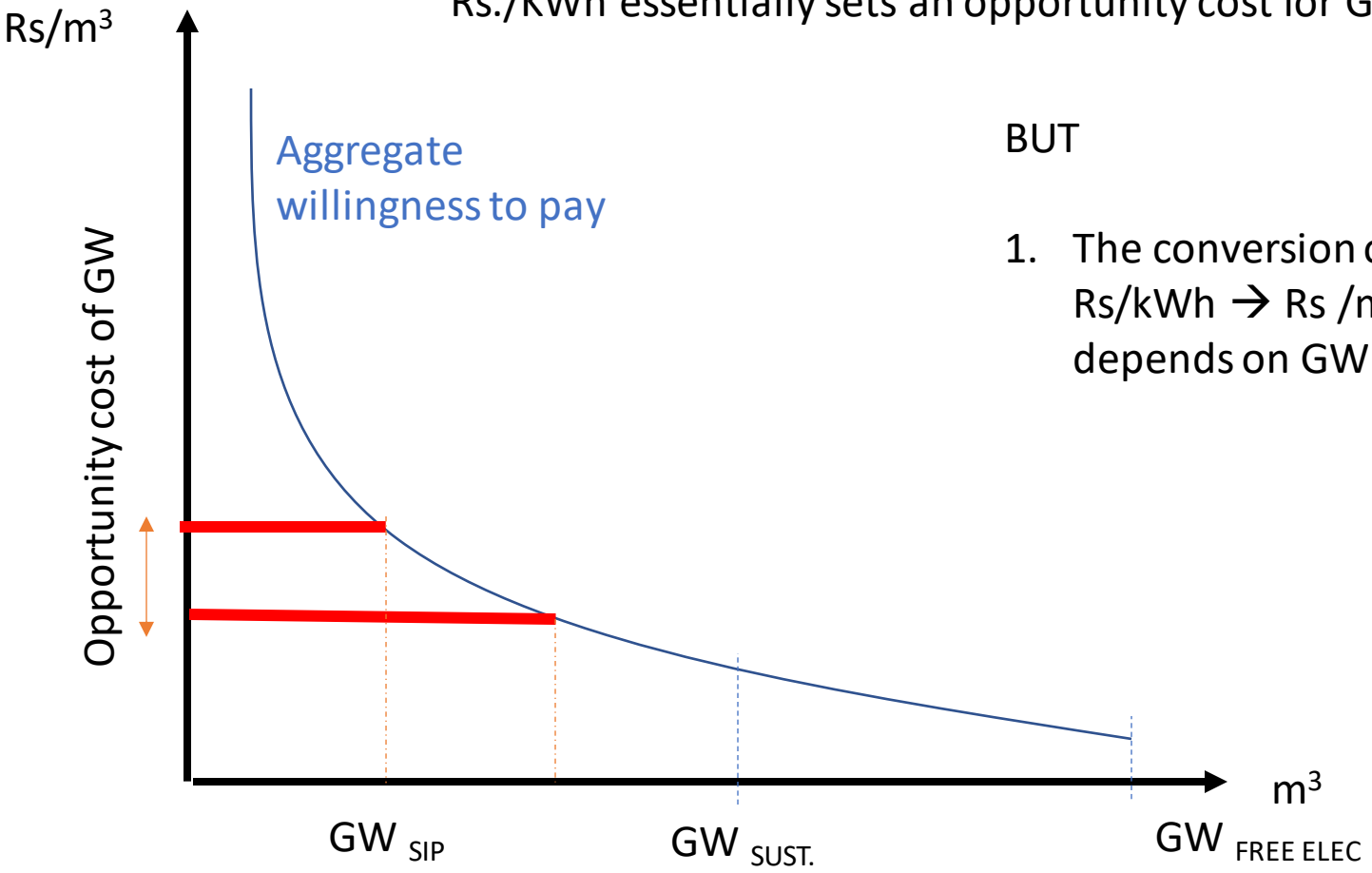
Source: IWMI



The feed in tariff with net metering forces farmers to choose between selling the electricity to the grid or pumping groundwater.

The feed in tariff approach in solar irrigation sets a price for groundwater, which constrains demand, while enabling irrigation.

Revenue earned from selling electricity to the grid, Rs./KWh essentially sets an opportunity cost for GW

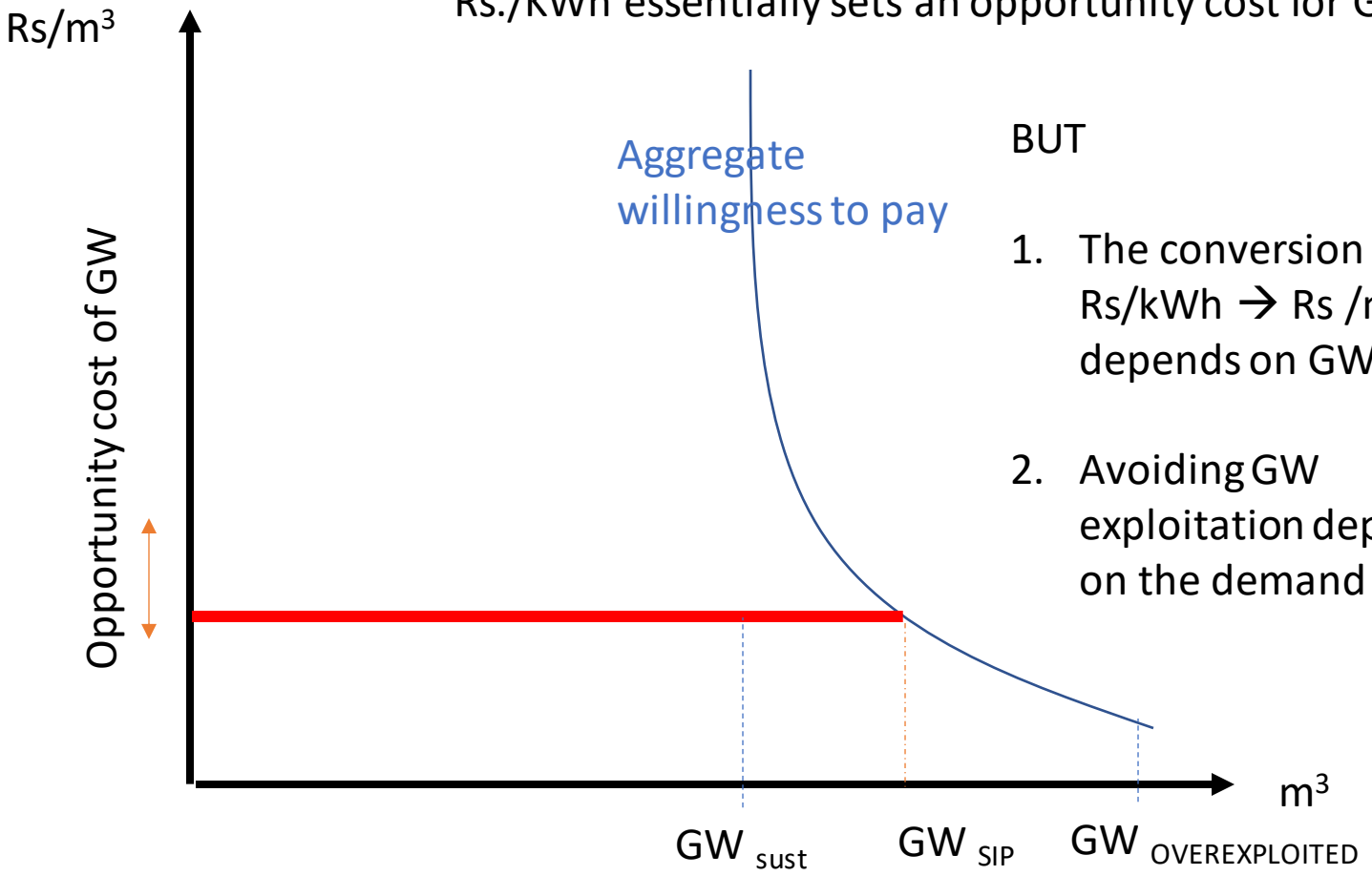


BUT

1. The conversion of Rs/kWh → Rs /m^3 depends on GW depth

But the feed in tariff approach is not designed to guarantee GW sustainability.

Revenue earned from selling electricity to the grid, Rs./KWh essentially sets an opportunity cost for GW



BUT

1. The conversion of Rs/kWh → Rs /m^3 depends on GW depth
2. Avoiding GW exploitation depends on the demand curve.

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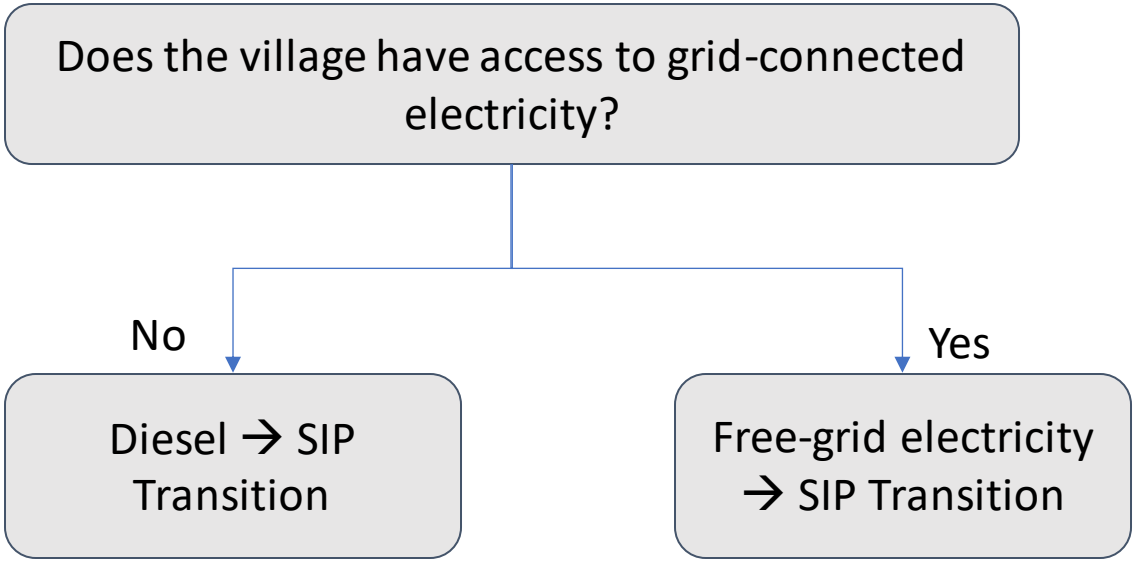
FRAMEWORK FOR SIP IMPACT: TYPOLOGY DEVELOPMENT

Irradiance | Shallow GW | Non-Canal

For any given location -- Is solar irrigation likely to
1. Improve farmer incomes? 2. Allow GW sustainability?



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Free-grid electricity → SIP Transition

IWR Eff: Ha /m^3

Yield: kg/Ha

Price: Rs/kg

GW Demand Curve

GW Budget

Feed in Tariff

Other Recharge

Rainfall Recharge

Where a given region will end up under SIP

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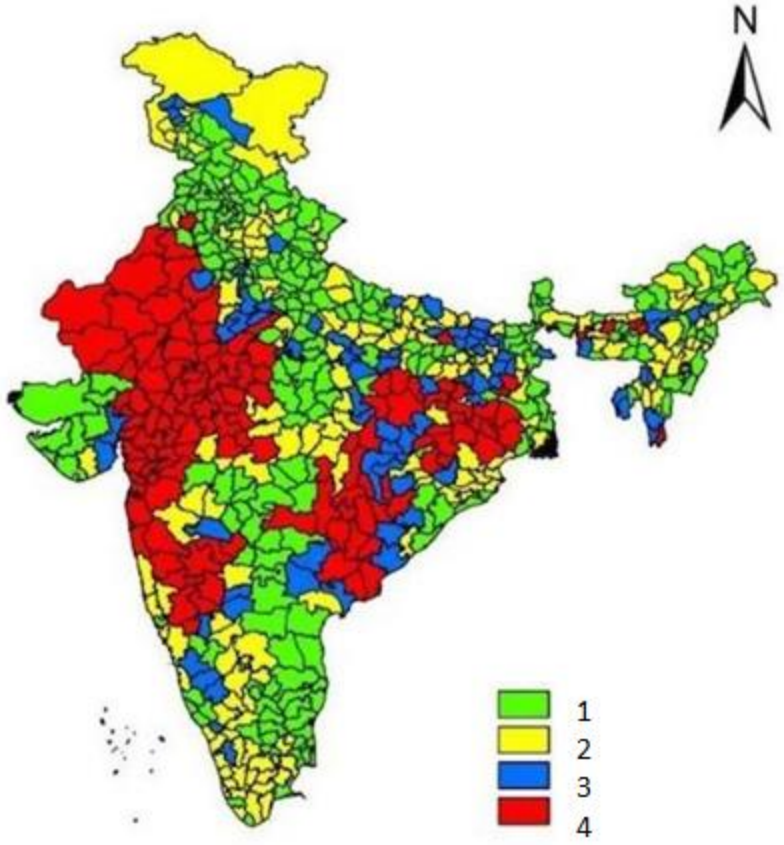

Where we hope to get in a few weeks.

THANK YOU!

Funding from India Climate Collaborative towards development of water typologies is gratefully acknowledged.

This is work in progress and we will be repeating this exercise for three rural water security interventions.

Please contact Anjali.neelakantan@atree.org if you have comments or want to collaborate.