IWMI International Water Management Institute

CGIAR

# Groundwater and resilience to climate change

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# Key message

Groundwater, if managed well, will be critical for climate resilient agriculture in the future.

Managing GW requires a WEF nexus approach

# Groundwater and climate change- Observed

- Global groundwater abstraction (~1,500 $km^3$ $year^{-1}$) is just about $1/8^{th}$ of the annual recharge (~12,600 $km^3$) (Aeschbach-Hertig and Gleeson, 2012)
- However, groundwater depletion occurs at local to regional scales.
- Human-induced groundwater depletion at rates exceeding 20 mm $year^{-1}$ (2001–2010) is occurring in the major aquifers systems:
  - The High Plains and California Central Valley aquifers (USA),
  - Arabian aquifer (Middle East),
  - North Western Sahara aquifer (North Africa),
  - Indo-Gangetic Basin (India),
  - North China Plain (China).

- In humid regions, linear associations between precipitation and recharge are often observed (e.g. Kotchoni et al., 2019).
- As the aridity increases, diffuse or focused recharge dominates, leading to non-linear relationship between precipitation and recharge
- Observed episodic recharge in India and USA, or higher recharge during more intense rainfall events, is likely to make groundwater more resilient to CC in dry land regions (Asoka et al., 2018; Thomas et al. 2016).

# Groundwater and climate change- Projected

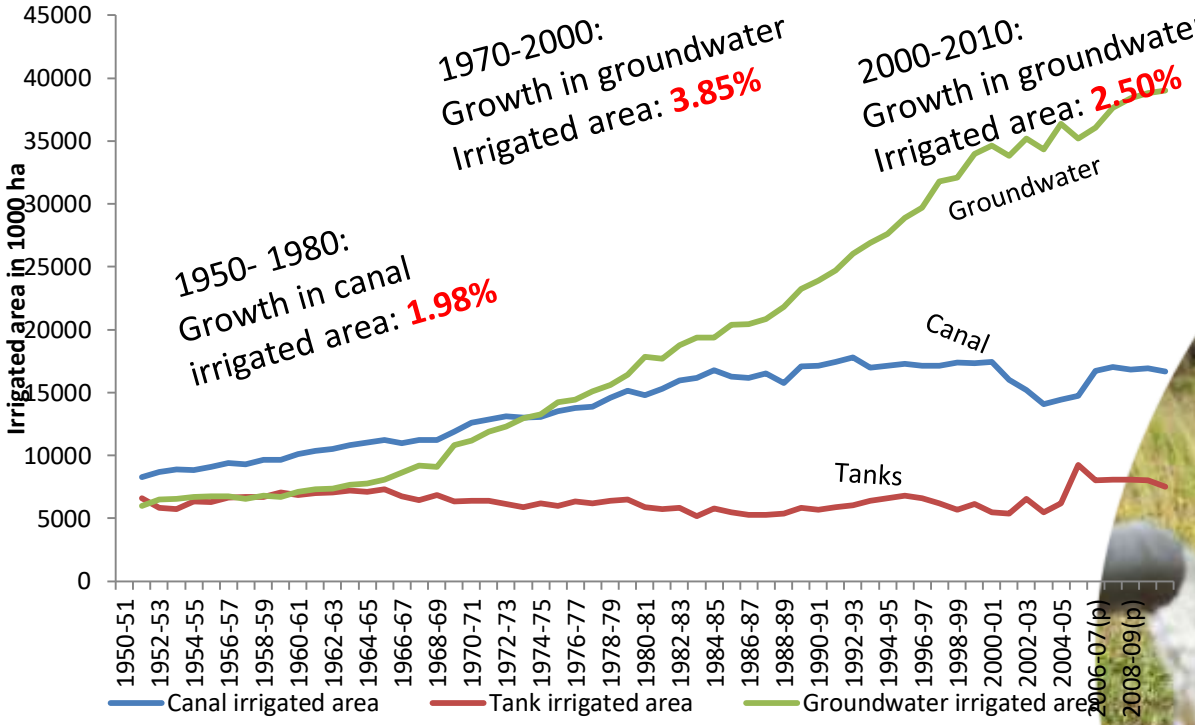
- A synthesis of 40 modelling studies suggests that projected changes in groundwater storage due to climate change will lead to a general decrease in recharge in aquifers located in arid/semi-arid tropics and humid tropics (Amanambu et al., 2020).
- Groundwater recharge will increase in northwest of India and the North China Plain (Wu et al. 2020)
- In semi-arid India, the projected increase in future rainfall will increase groundwater recharge, though the expected irrigation expansion is likely to negate this positive gain (Sishodia et al., 2018).
- However, large uncertainties remain in these groundwater models.

# Role of groundwater in water and food security in India

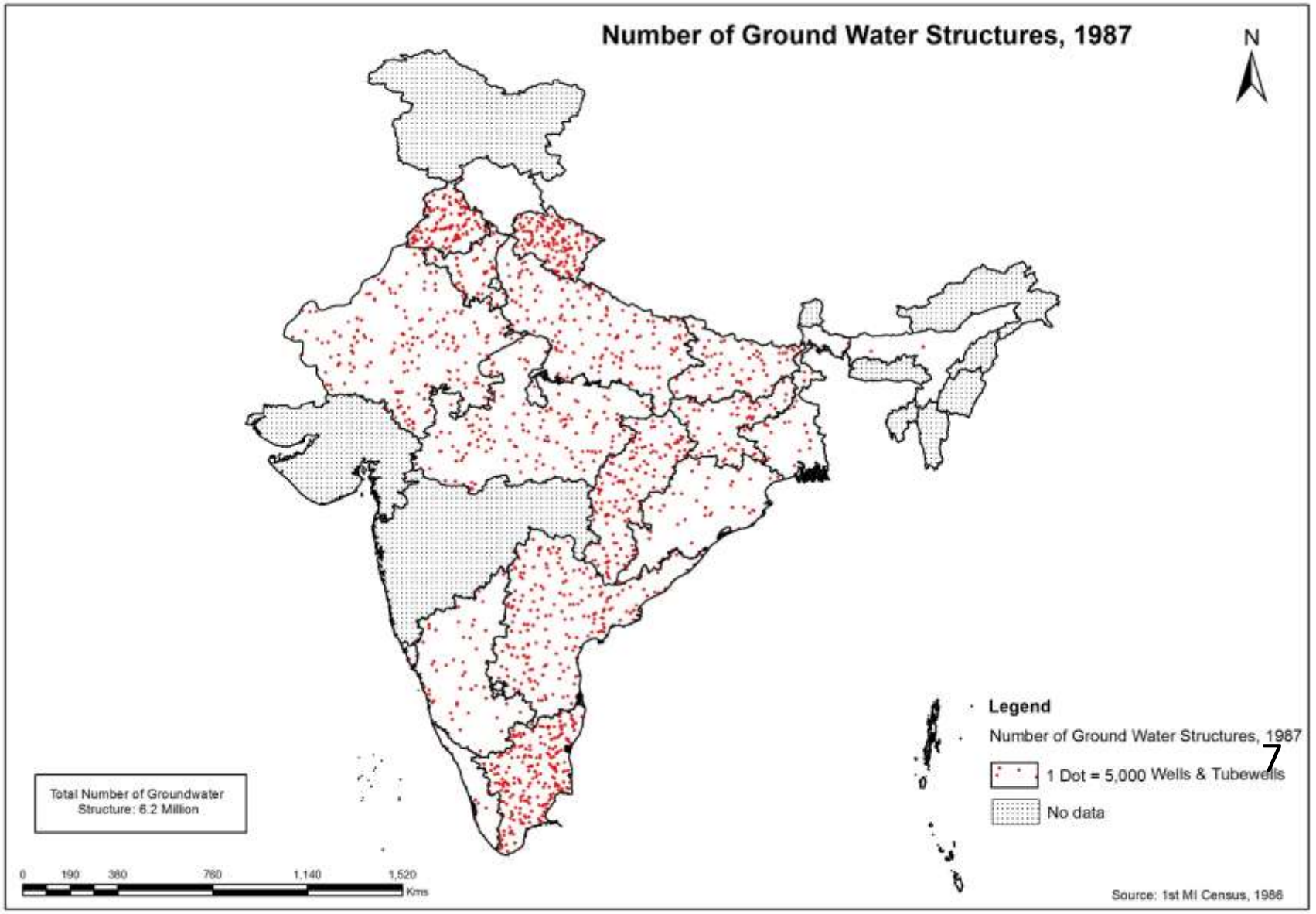
- ~60% of India's irrigated area gets irrigation from 20.5 million groundwater wells
- 50% of rice and 70% of wheat are grown with groundwater irrigation;
- ~88% of all water extracted from groundwater wells is used for irrigation (IDFC, 2013)
- 700 million rural India depend on groundwater for meeting all their needs (Kulkarni et al. 2015)
- Nearly 48% of the urban water share is derived from groundwater (Centre for Science and Environment, 2012)

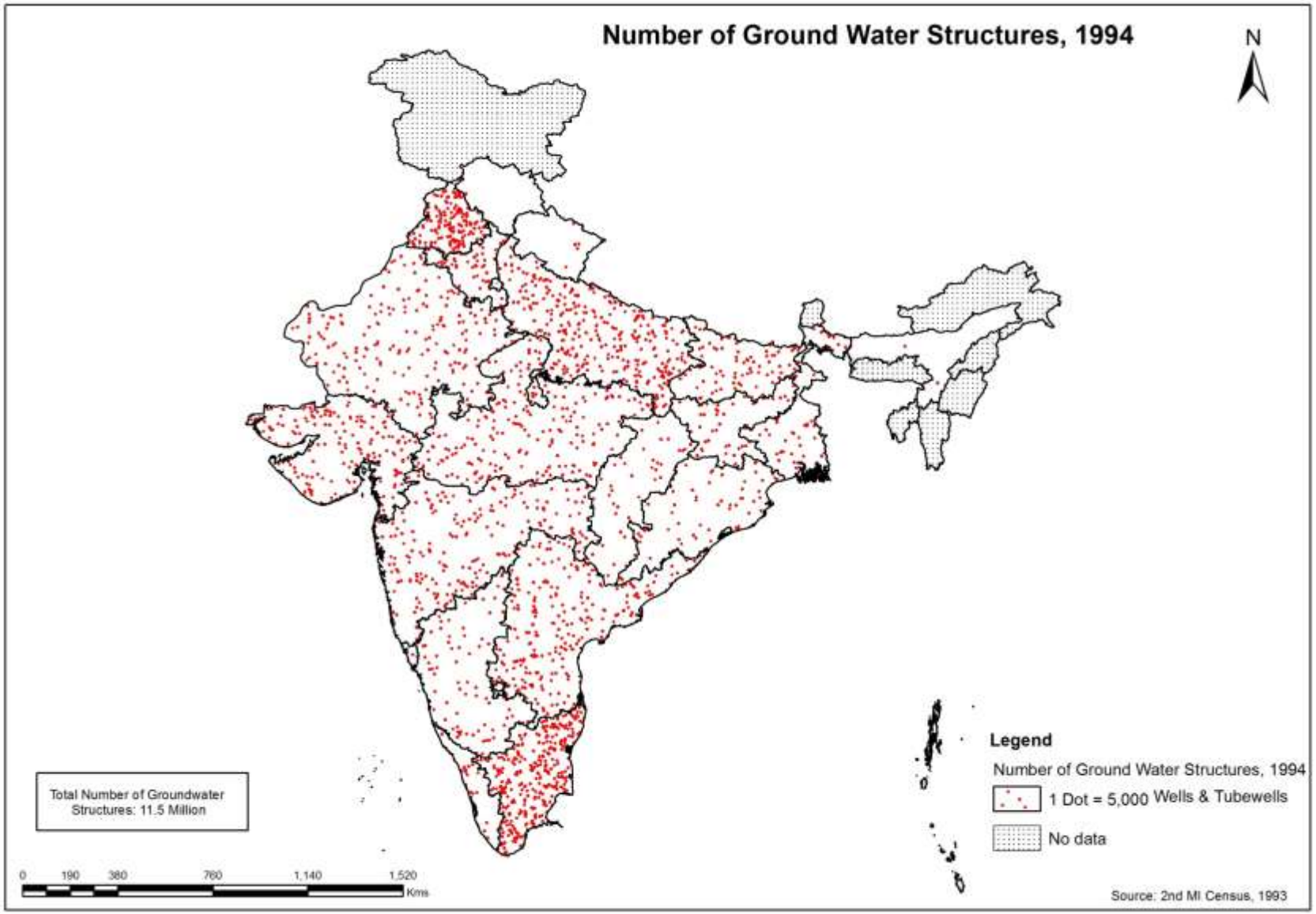
# Unsustainable Groundwater Use – A legacy of Green Revolution

Since 1970s, groundwater irrigated area has increased, as has number of wells and tubewells….




**Mukherji, A.**, S. Rawat and T. Shah. 2013. Major insights from India's Minor Irrigation Censuses: 1986-87 to 2006-07. *Economic and Political Weekly*, Vol 48(26 & 27): 115-124


Number of Ground Water Structures, 1987
N
Legend
Number of Ground Water Structures, 1987
1 Dot = 5,000 Wells & Tubewells
No data
Total Number of Groundwater Structure: 6.2 Million
0 190 380 760 1,140 1,520
Kms
Source: 1st MI Census, 1986


Number of Ground Water Structures, 1994
N
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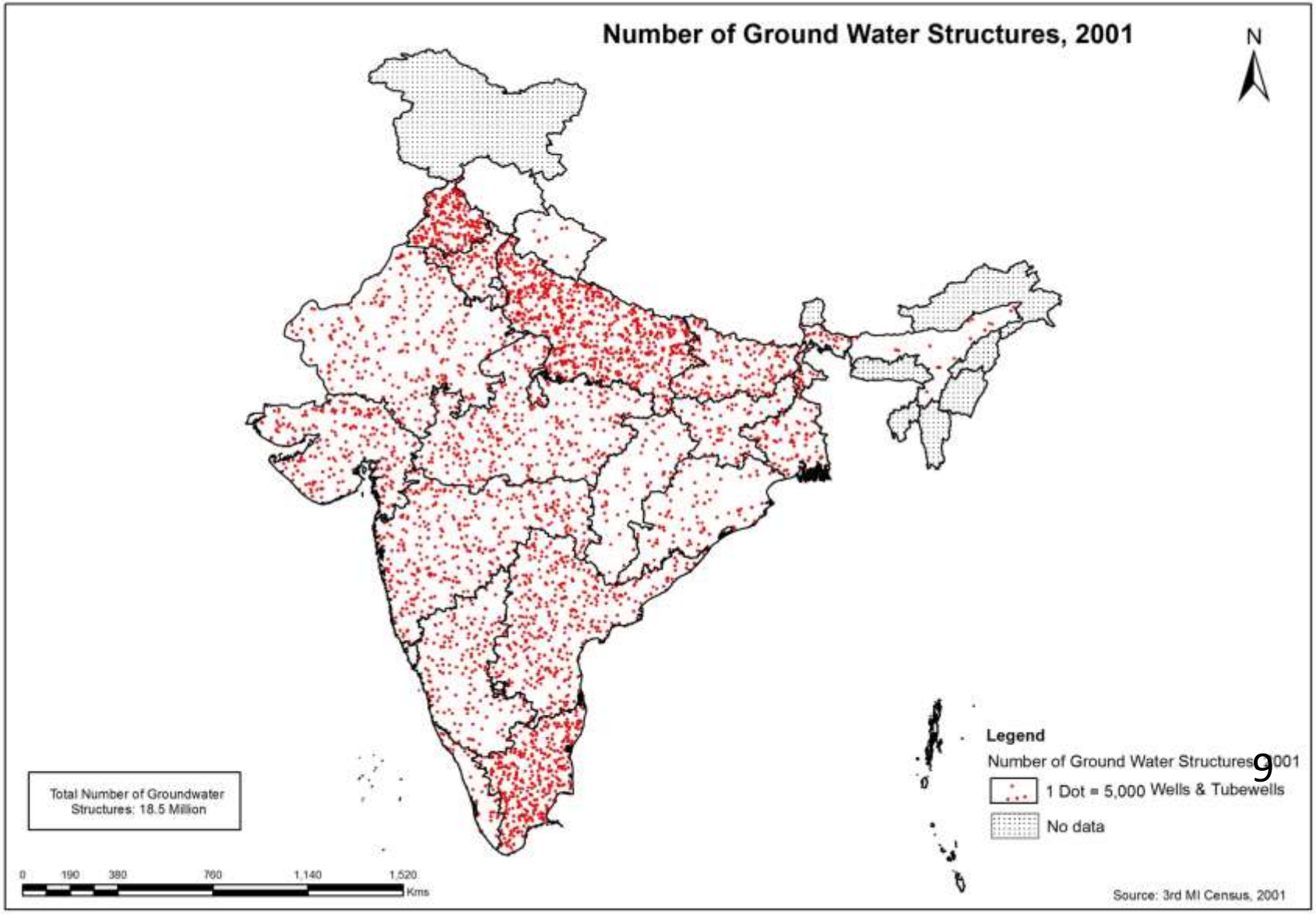
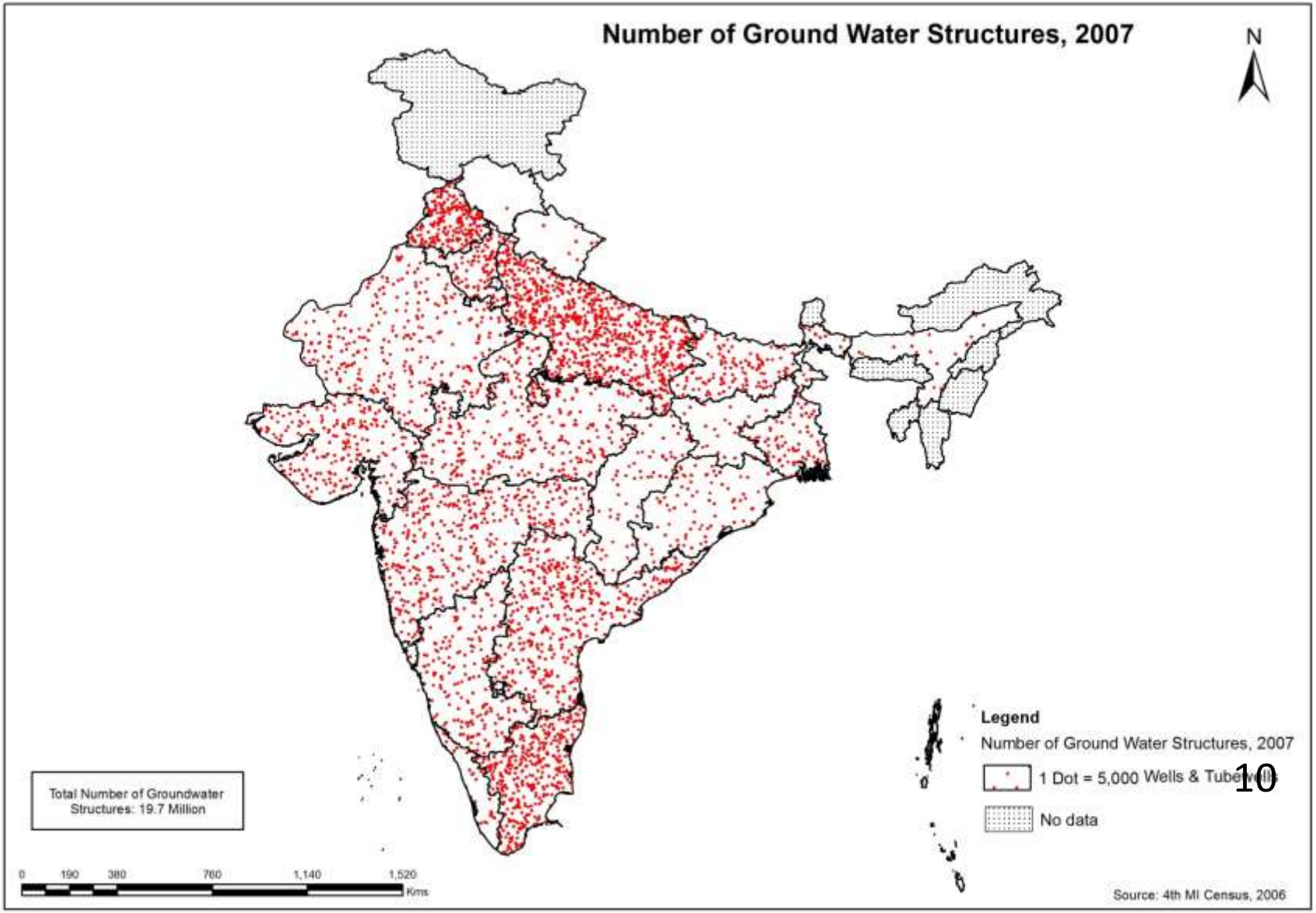
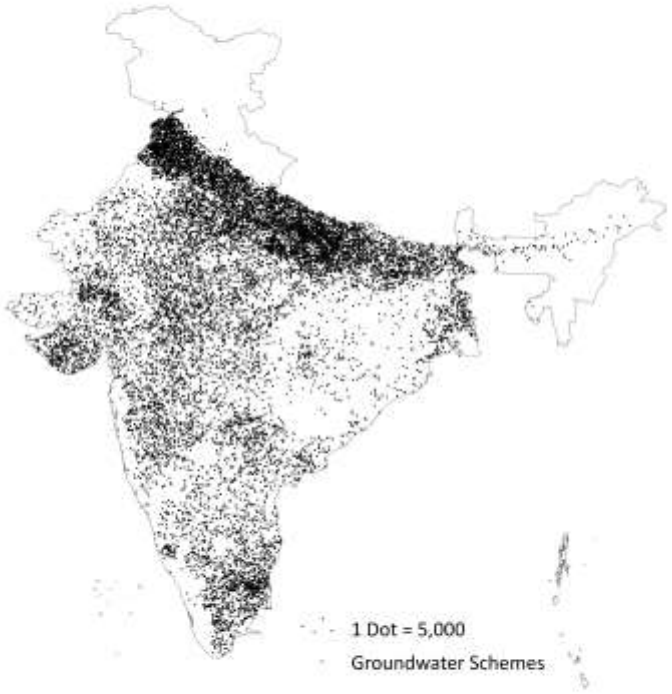
Number of Ground Water Structures, 1994
1 Dot = 5,000 Wells & Tubewells
No data
Total Number of Groundwater Structures: 11.5 Million
0 190 380 760 1,140 1,520
Kms
Source: 2nd MI Census, 1993


Number of Ground Water Structures, 2001
N
Legend
Number of Ground Water Structures, 2001
1 Dot = 5,000 Wells & Tubewells
No data
Total Number of Groundwater Structures: 18.5 Million
0 190 380 760 1,140 1,520
Kms
Source: 3rd MI Census, 2001

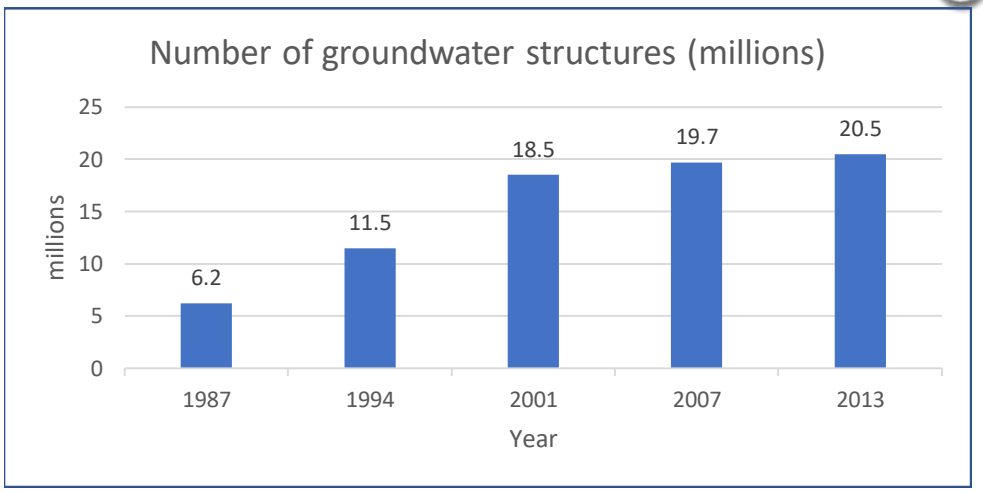

Number of Ground Water Structures, 2007
N
Legend
Number of Ground Water Structures, 2007
1 Dot = 5,000 Wells & Tubewells
No data
Total Number of Groundwater Structures: 19.7 Million
0 190 380 760 1,140 1,520
Kms
Source: 4th MI Census, 2006

## Number of groundwater structures, 2013




Total number of GW structures: 20.5 million

Source: 5th MI Census, 2013

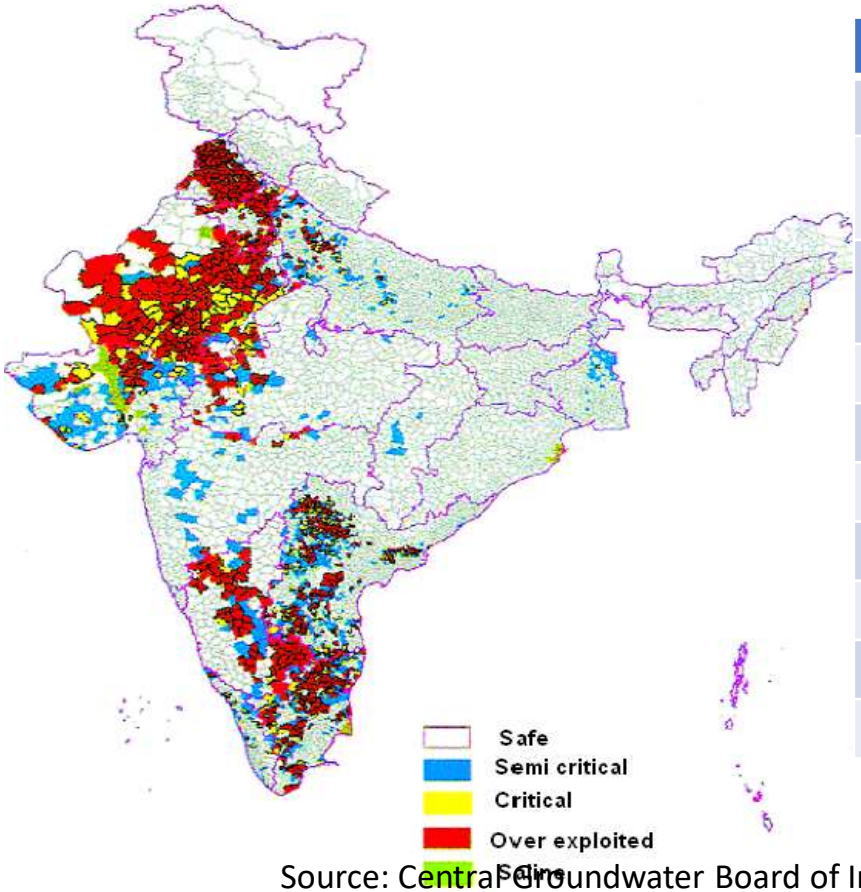



- Pace of growth in India's groundwater structure is slowing down.
- But number of deep wells is on the rise
- There are deep regional divides



**Mukherji, A**. 2016. Evolution of irrigation sector, *Economic and Political Weekly*, Vol 51(52): 44-47

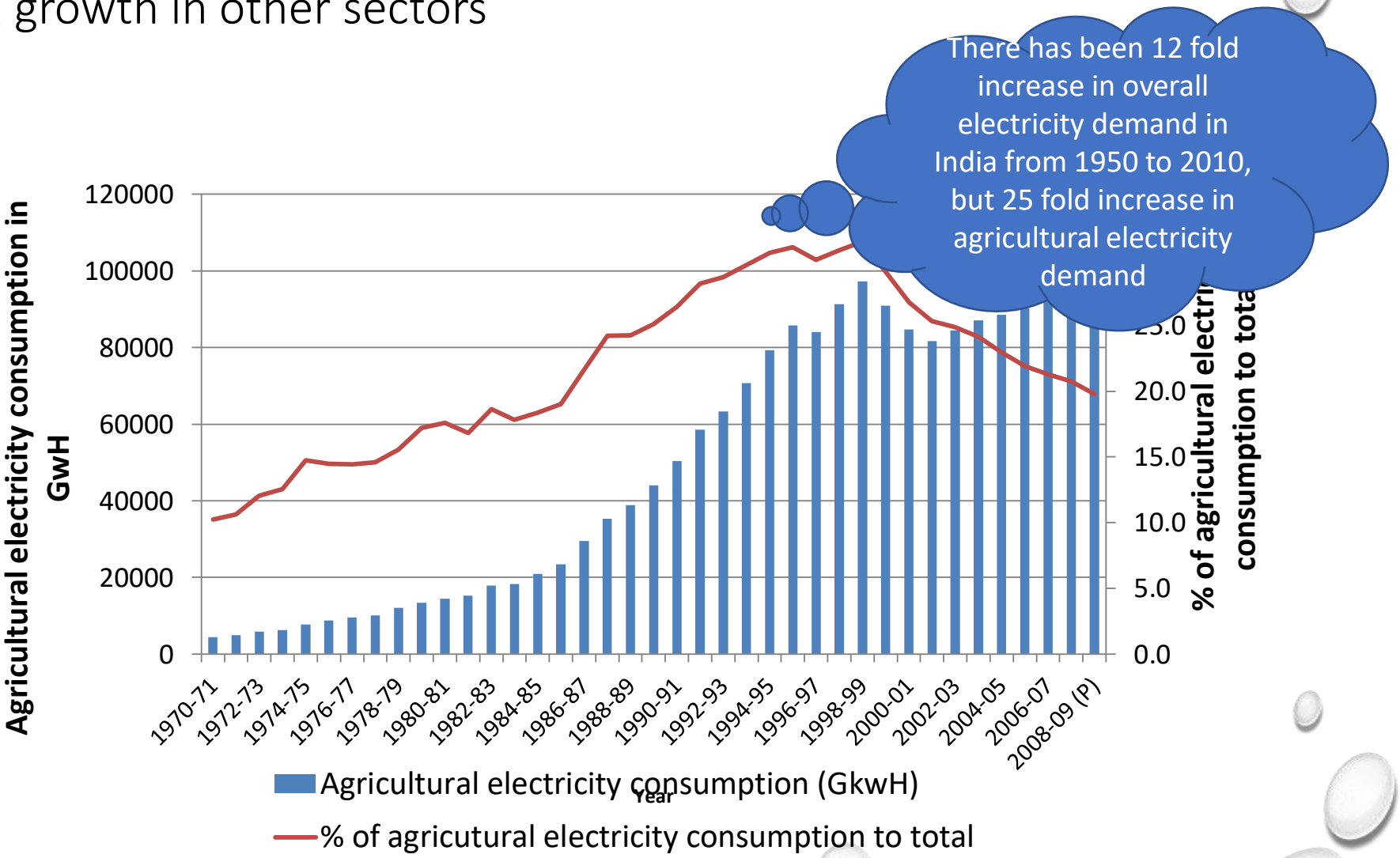
However, groundwater over-exploitation in India has clear regional dimensions: Eastern India has ‘under-developed’ groundwater resources



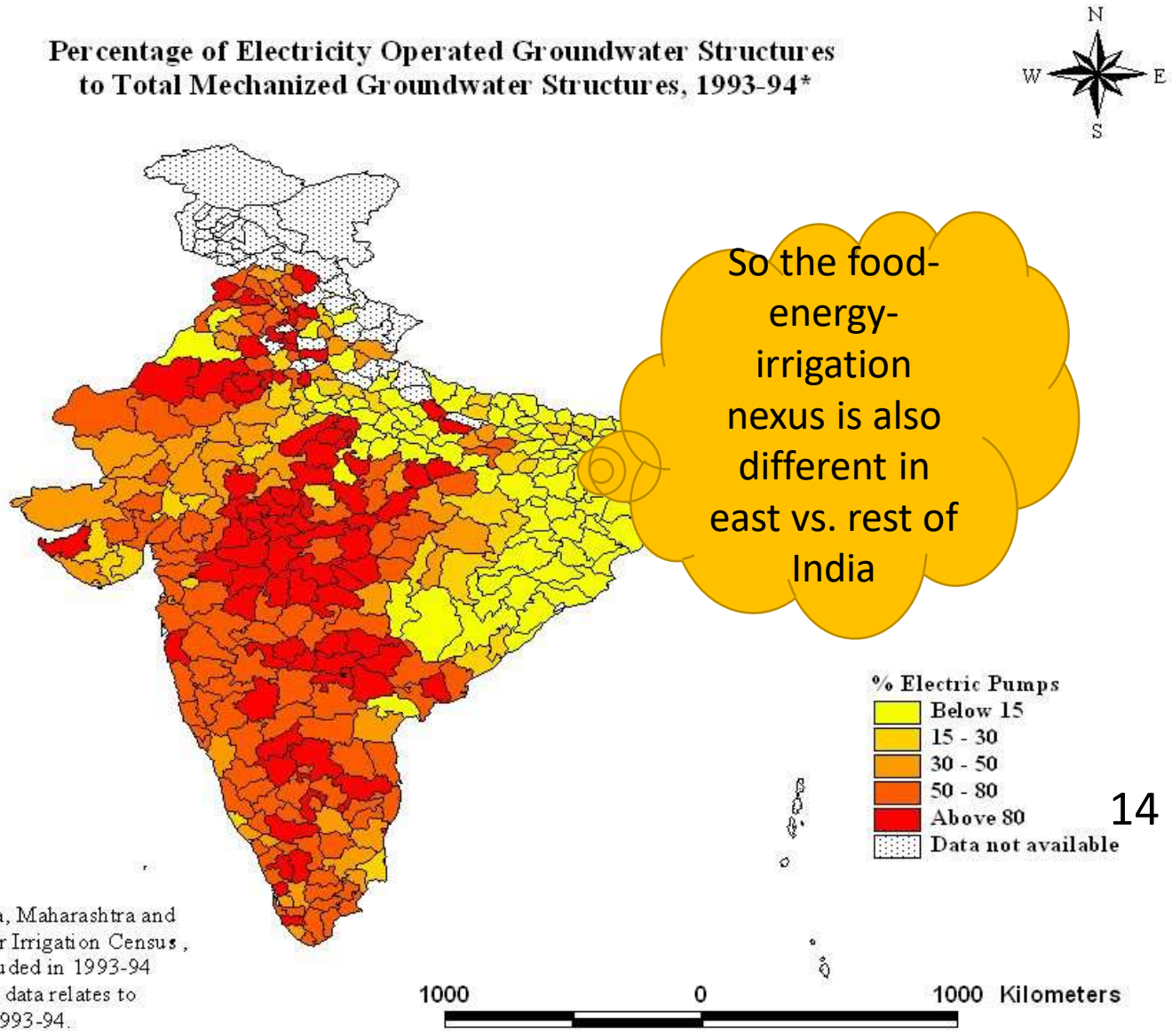

Source: Central Groundwater Board of India

| Sl. No | Item | 2017 |
|---|---|---|
| 1. | Annual Resources | 431.8 |
| 2. | Annual groundwater draft | 248.7 |
| 3. | Stage of groundwater development | 63.3% |
| 4. Categorization | | |
| | Total assessment units | 6881 |
| | Safe | 63% |
| | Semi-critical | 14% |
| | Critical | 5% |
| | Over-exploited | 17% |
| | Saline | 1% |

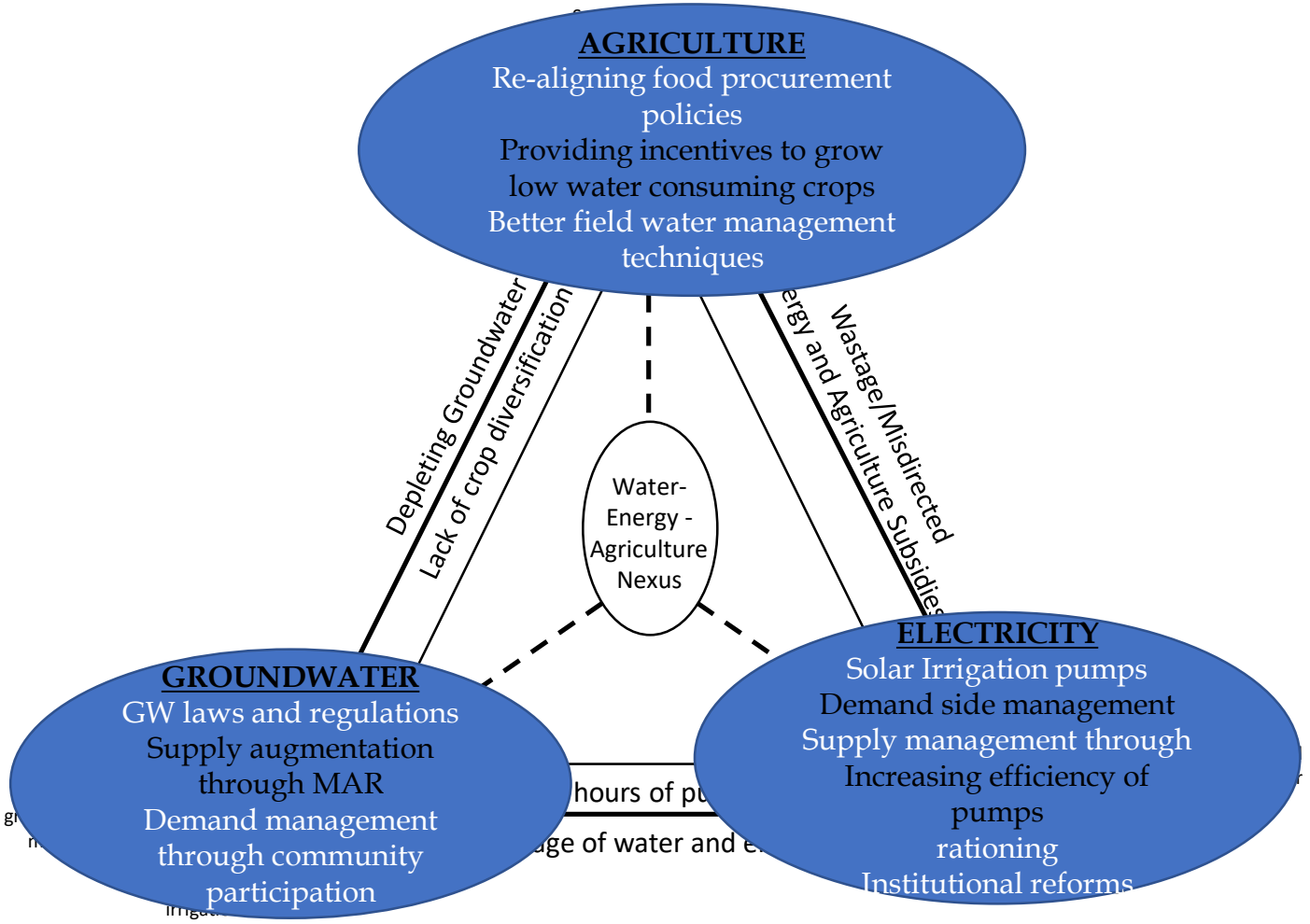
# Growth in electricity consumption in agriculture has outpaced growth in other sectors



But then, there is the energy divide: Farmers in eastern India depend pre-dominantly on diesel pumps, while rest of India has electric pumps



# Using Water Energy Food (WEF) nexus to improve groundwater sustainability






Adapted from Sinha, Sharma and Scott, 2006

# Groundwater management needs WEF approach

**Water**

Water policies needs to incorporate groundwater explicitly

**Electricity**

Electricity policies impacts groundwater use

**Food**

Food policies determines groundwater use

# Look for solutions outside the water sector

## Solutions in the electricity sector

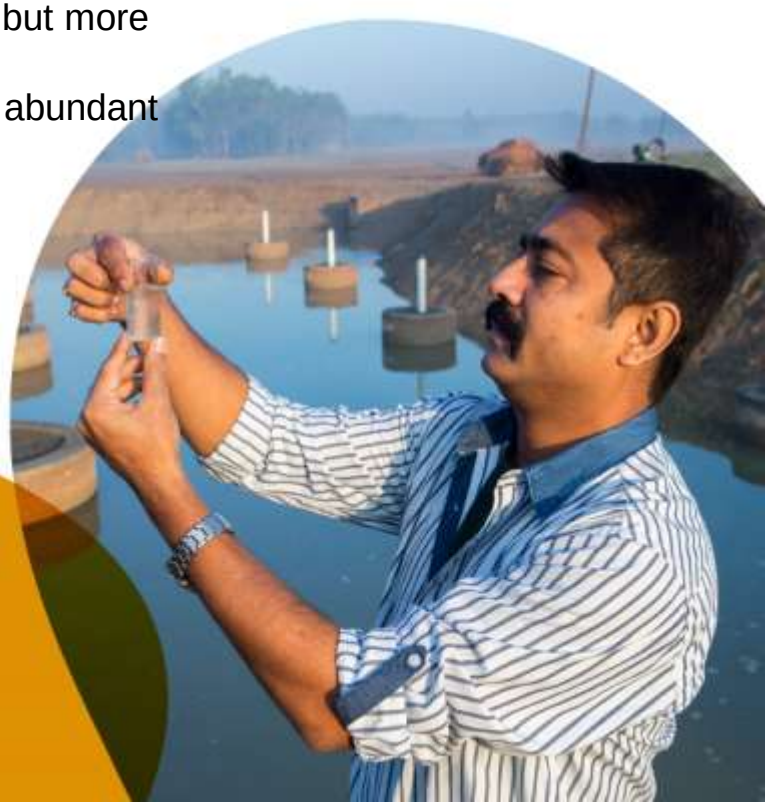
- Metering of agricultural electricity, e.g. West Bengal
- Feeder segregation in several states, e.g. Gujarat, Punjab, etc.
- Grid connected solar pumps

## Solutions in the food sector

- Higher prices for less water intensive, but more nutritious crops, like coarse cereals
- Growing water intensive crop in water abundant areas

## Solutions in water sector

- Implementable GW laws



Look for solutions beyond the water sector. Food and energy sectors are key for GW management in South Asia

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# Thank you