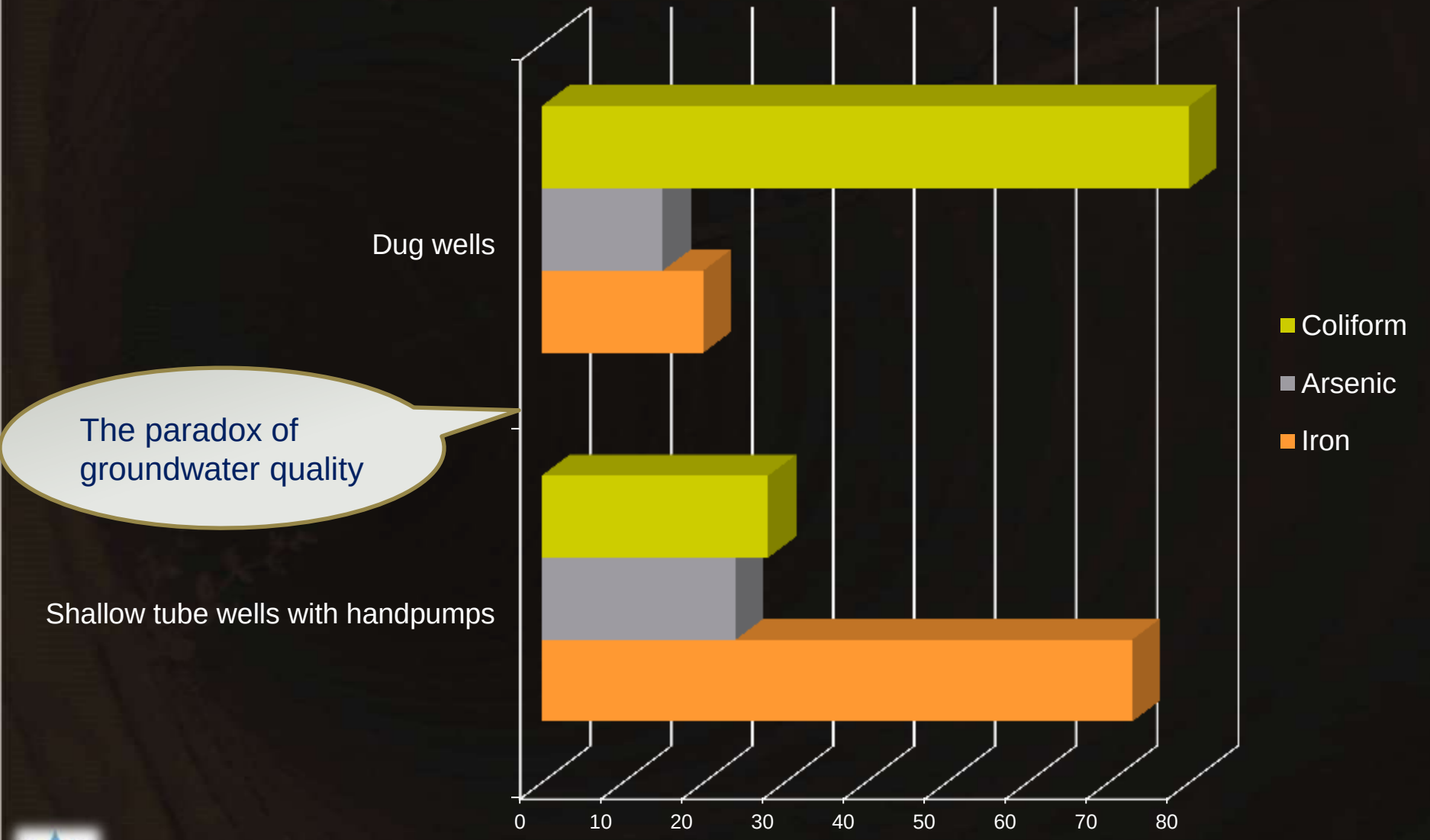
GROUNDWATER

Understanding Competition & Conflict

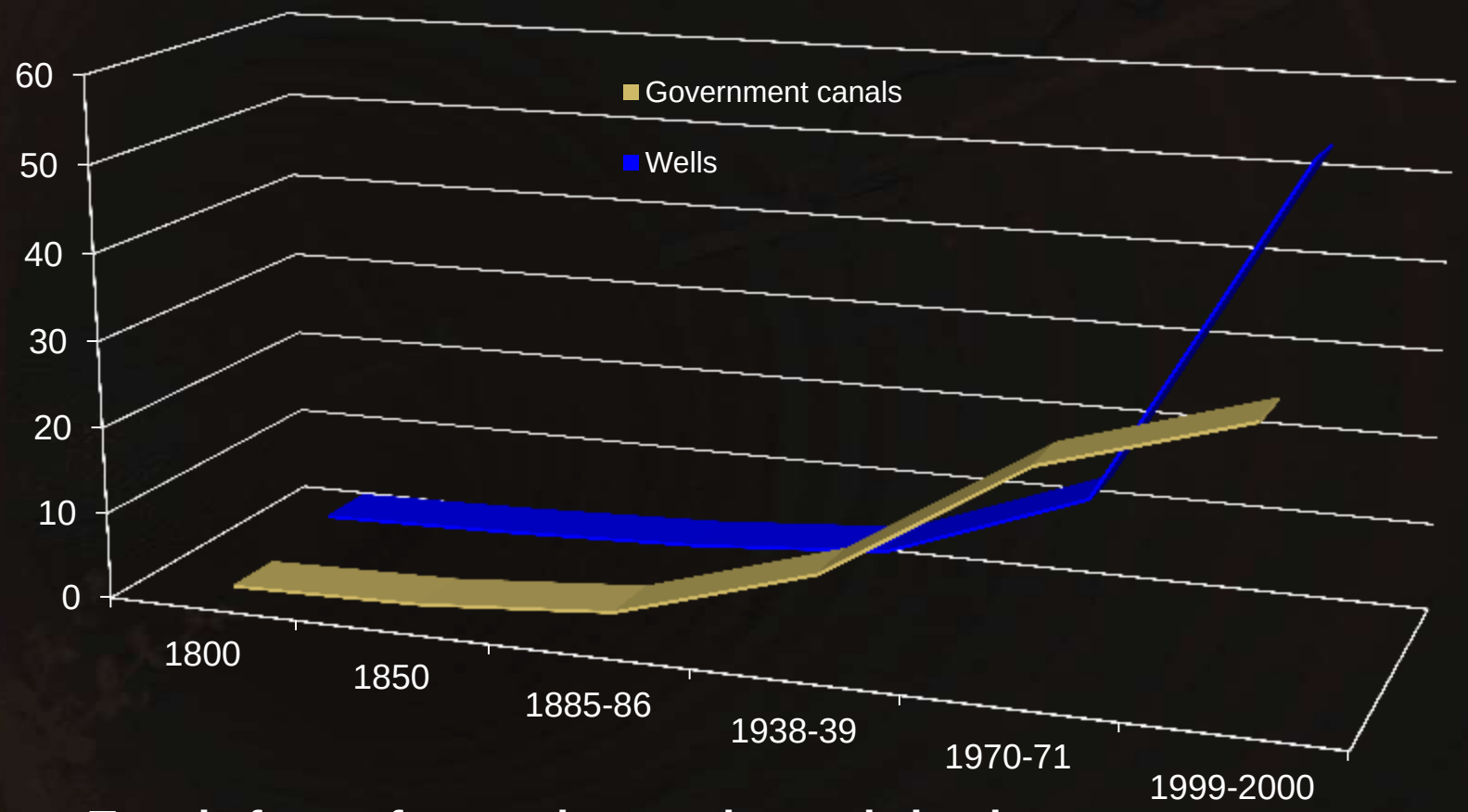
Five districts of North Bihar flood plain: competing sources??



The paradox of groundwater quality

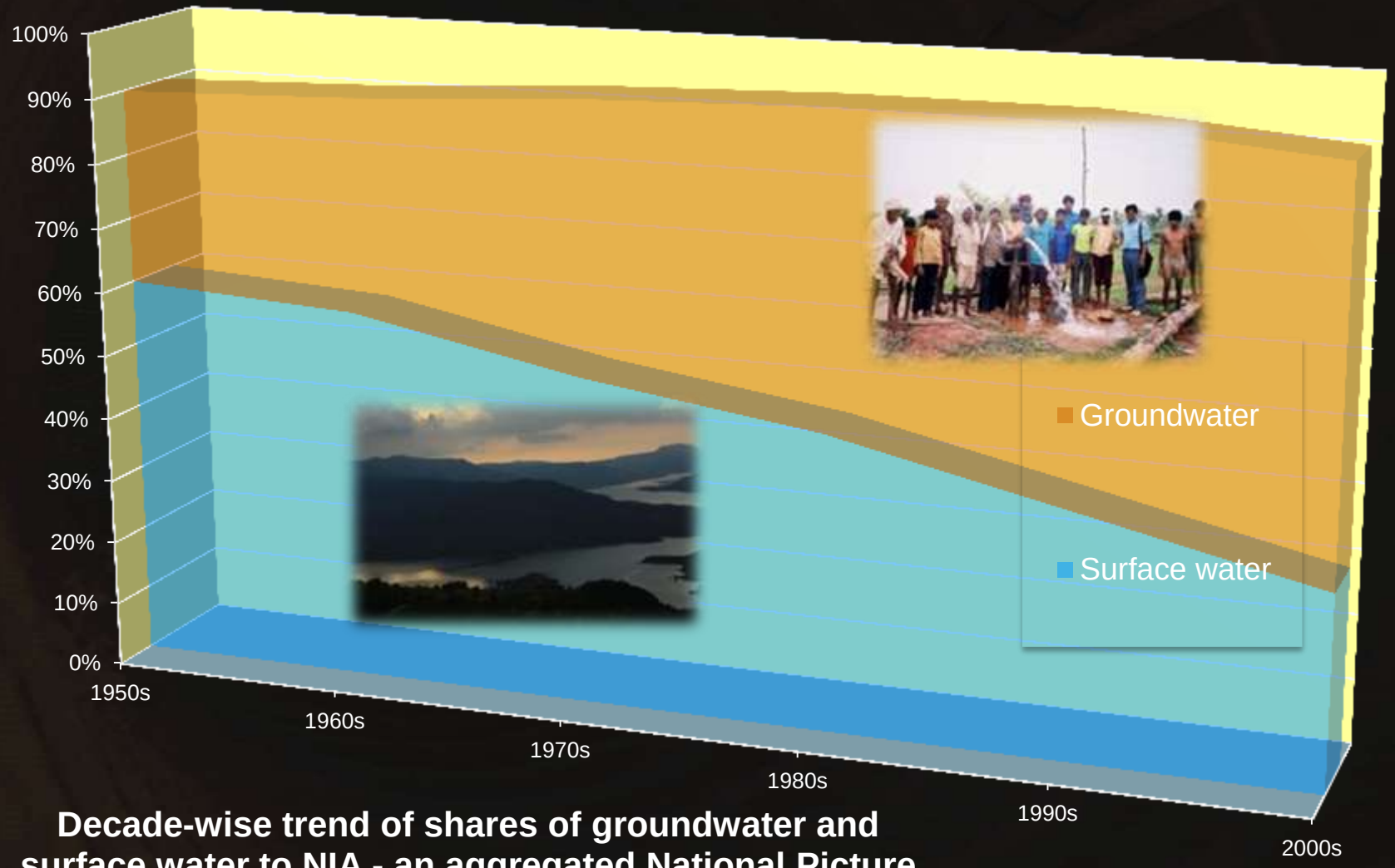
PGWM Programme – MPA & ACWADAM – (ongoing)

Trends: dug wells *vs* tube wells



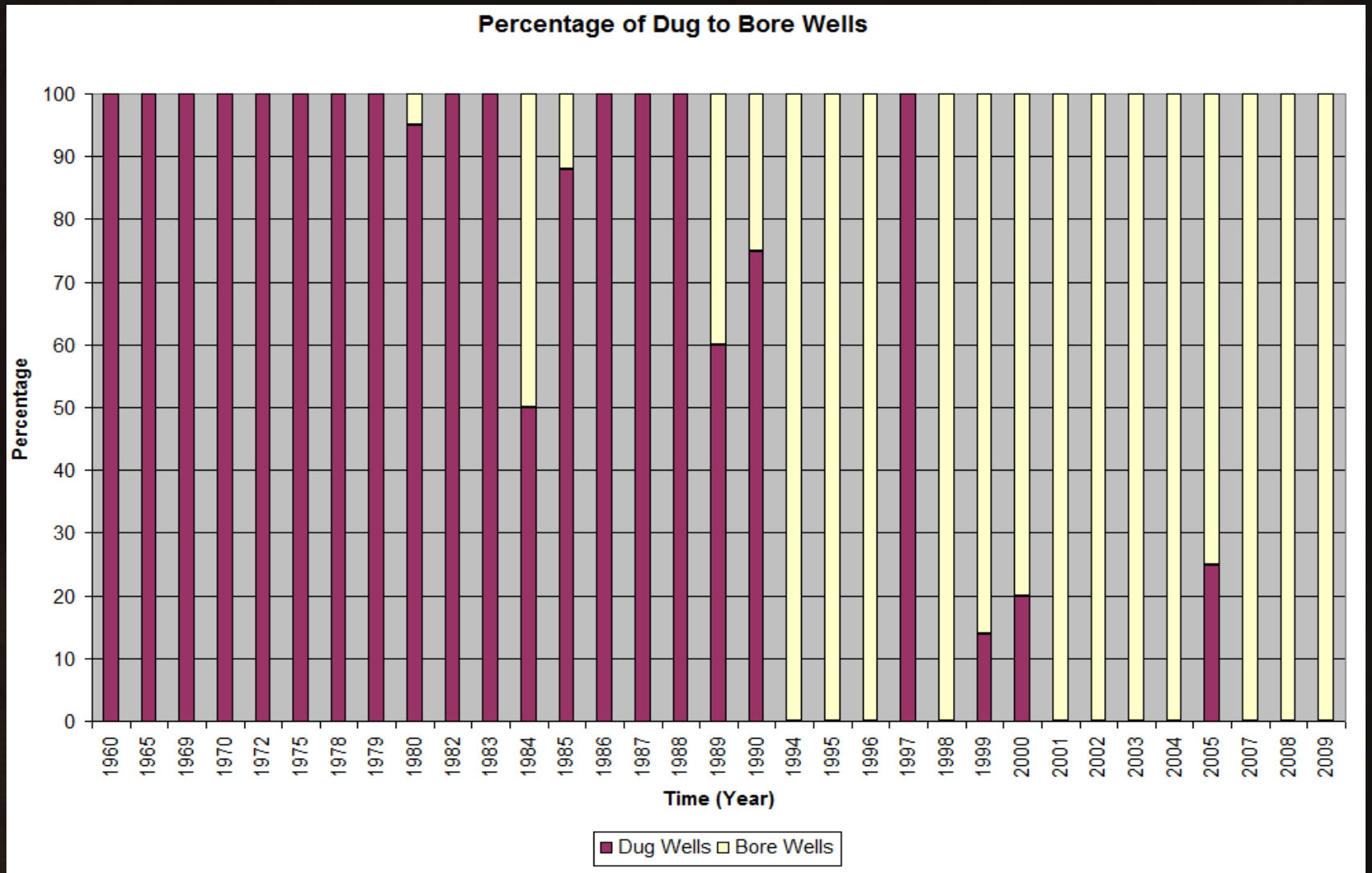
Trends for surface and groundwater irrigation
plotted from Shah (2009)

NIA, surface water & groundwater



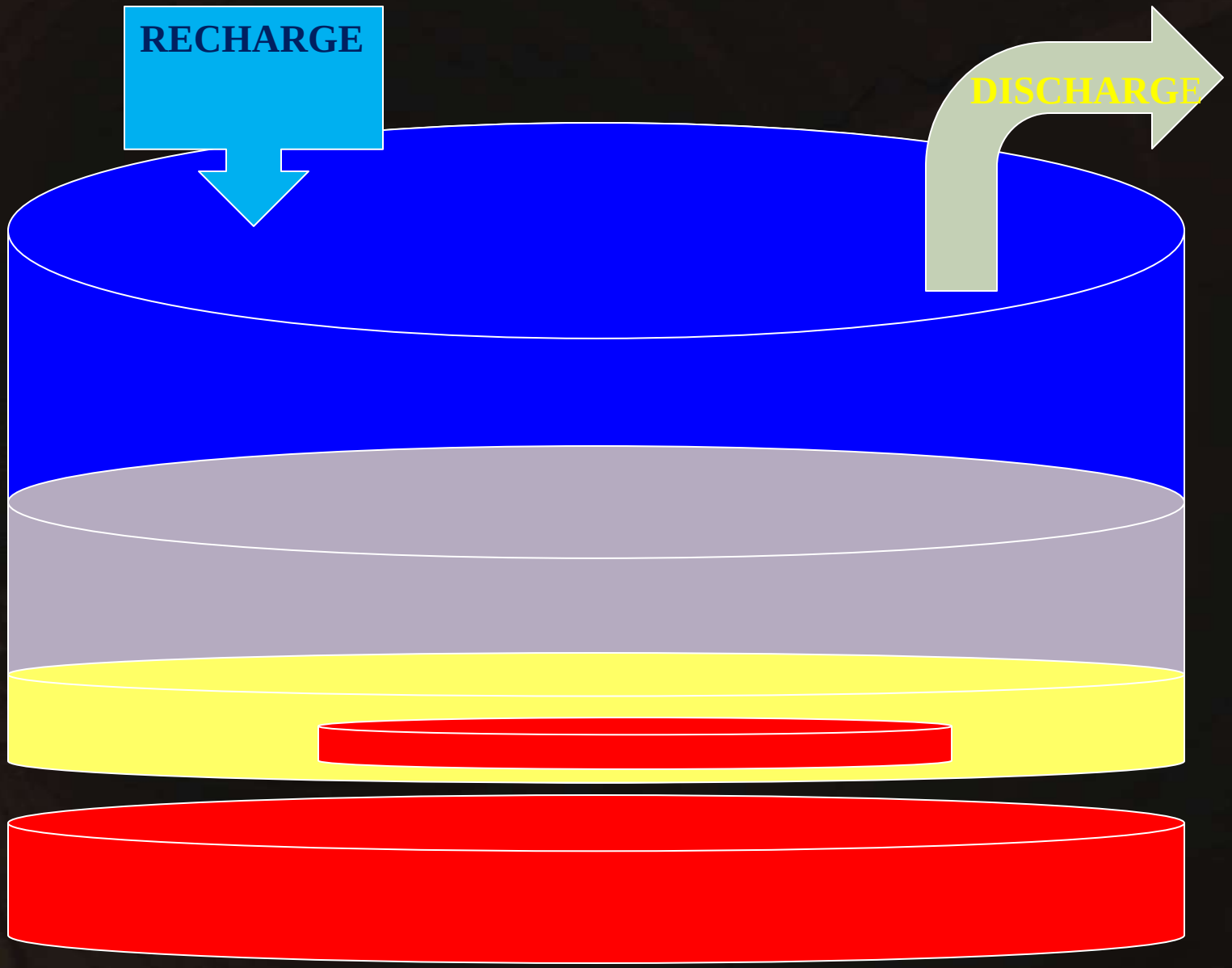
Decade-wise trend of shares of groundwater and surface water to NIA - an aggregated National Picture

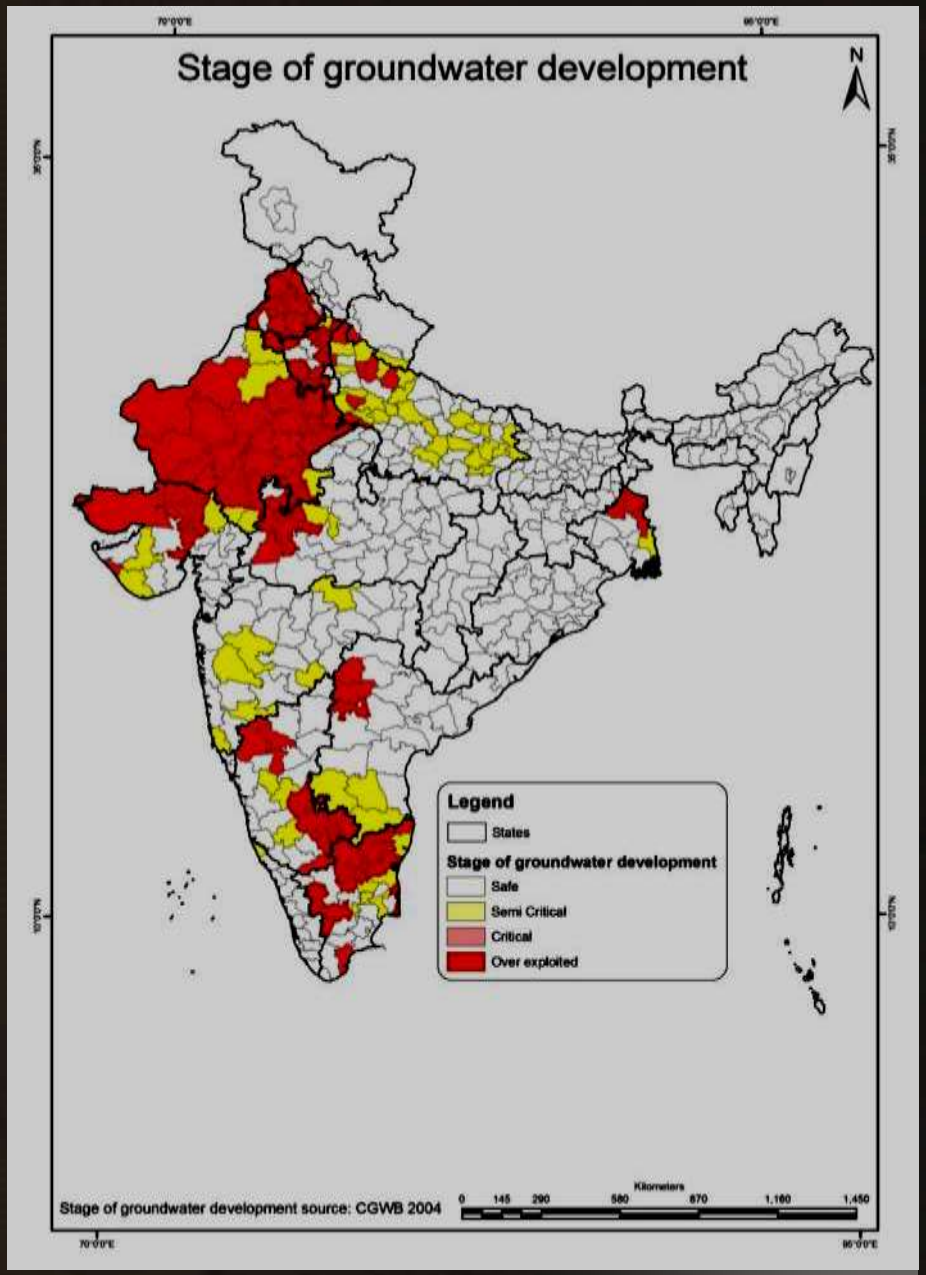
Source: Indian Agricultural Statistics, 2008

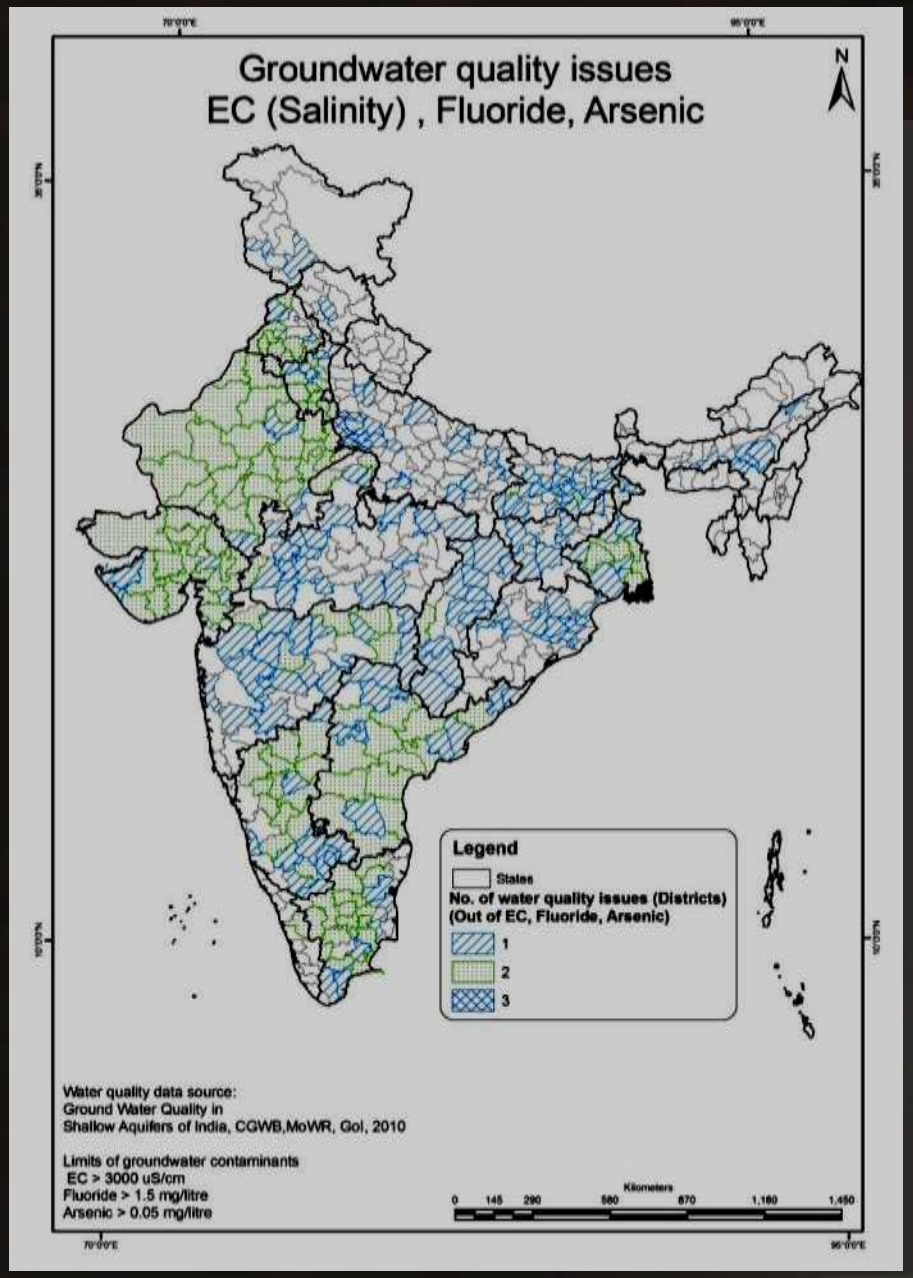


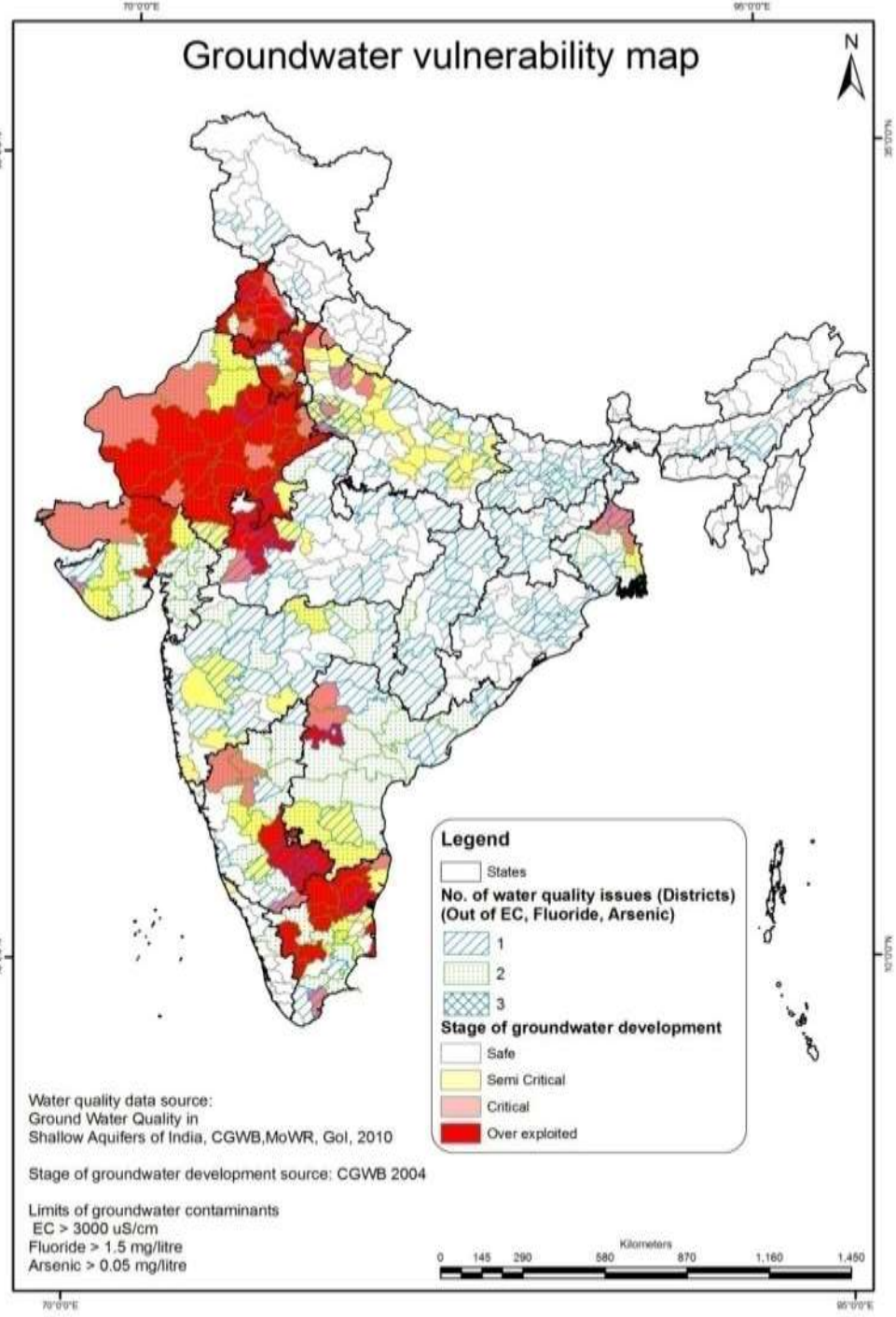
Kaushal (2010), WASSAN (2010)

Groundwater development..index




Stage of groundwater development
N
Legend
States
Stage of groundwater development
Safe
Semi Critical
Critical
Over exploited
Kilometers
0 145 290 580 870 1,160 1,450
Stage of groundwater development source: CGWB 2004


Groundwater quality issues
EC (Salinity) , Fluoride, Arsenic
N
Legend
States
No. of water quality issues (Districts)
(Out of EC, Fluoride, Arsenic)
1
2
3
Water quality data source:
Ground Water Quality in
Shallow Aquifers of India, CGWB,MoWR, GoI, 2010
Limits of groundwater contaminants
EC > 3000 uS/cm
Fluoride > 1.5 mg/litre
Arsenic > 0.05 mg/litre
Kilometers
0 145 290 580 870 1,160 1,450


Groundwater vulnerability map
N
Legend
States
No. of water quality issues (Districts)
(Out of EC, Fluoride, Arsenic)
1
2
3
Stage of groundwater development
Safe
Semi Critical
Critical
Over exploited
Water quality data source:
Ground Water Quality in
Shallow Aquifers of India, CGWB,MoWR, GoI, 2010
Stage of groundwater development source: CGWB 2004
Limits of groundwater contaminants
EC > 3000 uS/cm
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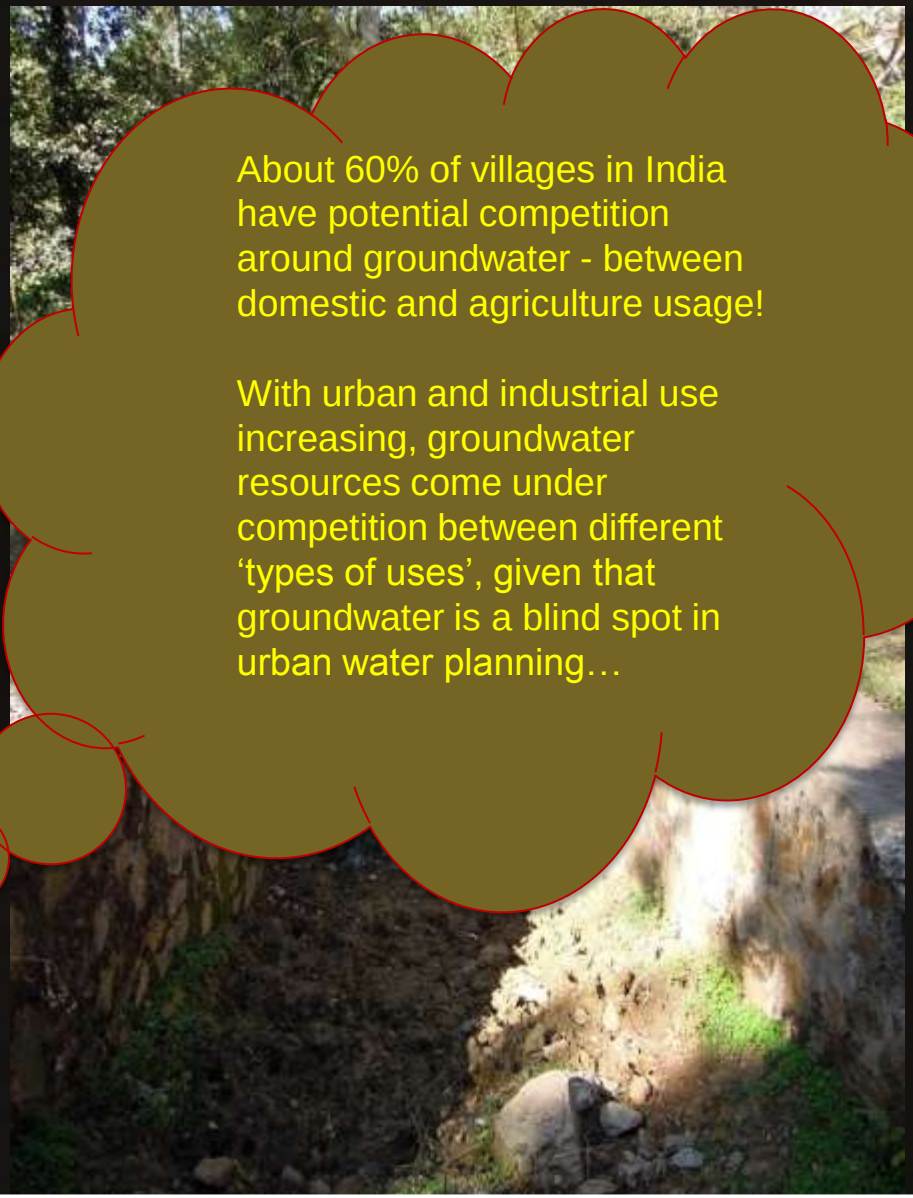
Kilometers
0 145 290 580 870 1,160 1,450

India's oft-unfathomed groundwater dependence

- Use & users
  - 30 million wells, at least every fourth farmer has a well
  - Used for drinking water, agriculture and industry

- Dependence
  - Rural drinking water: almost entirely groundwater – 80 to 95%
  - Agriculture: ???60-70%??? of total use
  - Urban: 48% of total use

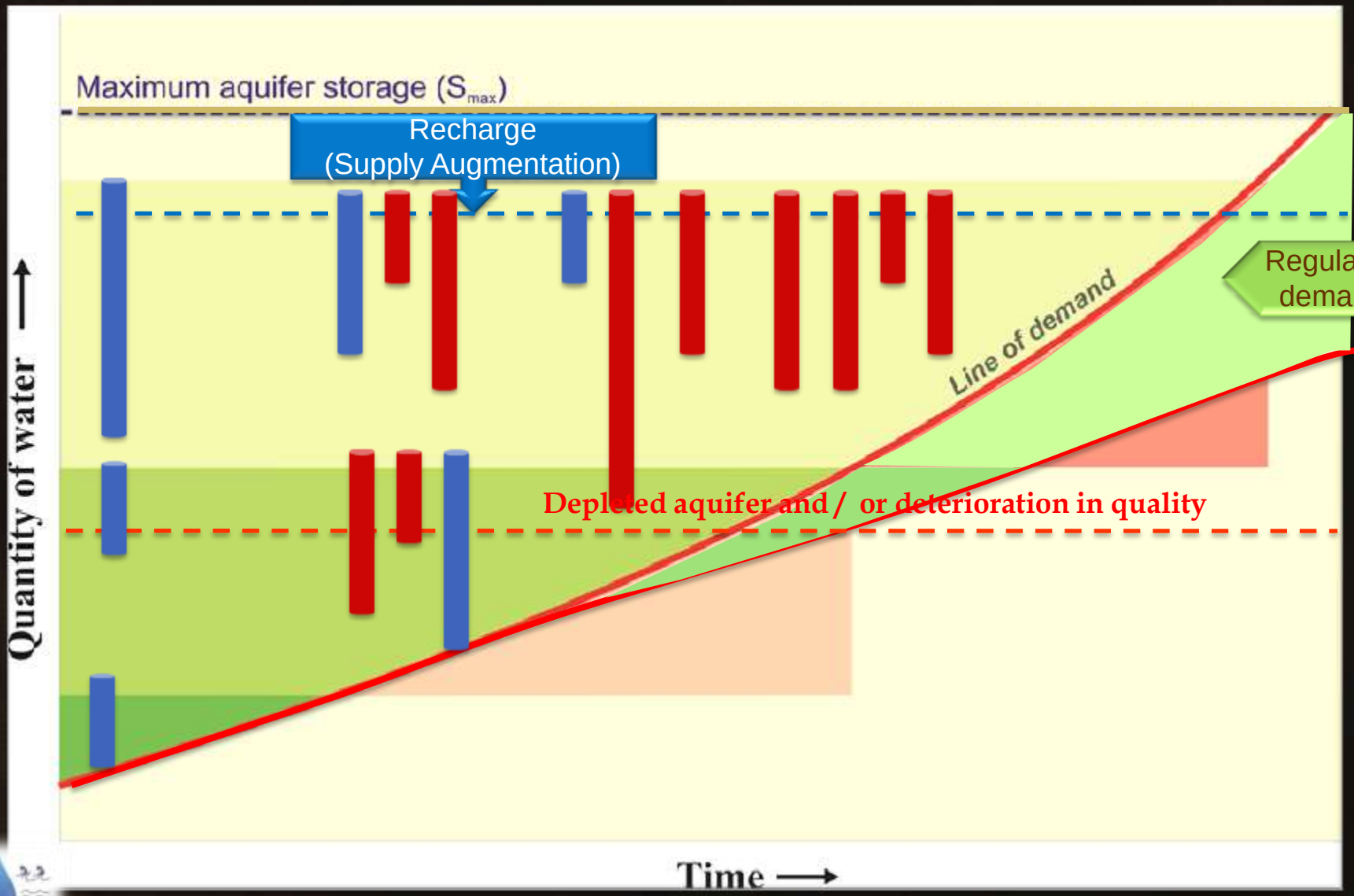


About 60% of villages in India have potential competition around groundwater - between domestic and agriculture usage!

With urban and industrial use increasing, groundwater resources come under competition between different 'types of uses', given that groundwater is a blind spot in urban water planning…

Shah (2009), Agriculture Statistics, various years; DDWS (2009); CSE (2012)

Supply, to meet a growing & competitive demand…



Various publications by Kulkarni, H.

Competition - conflicts

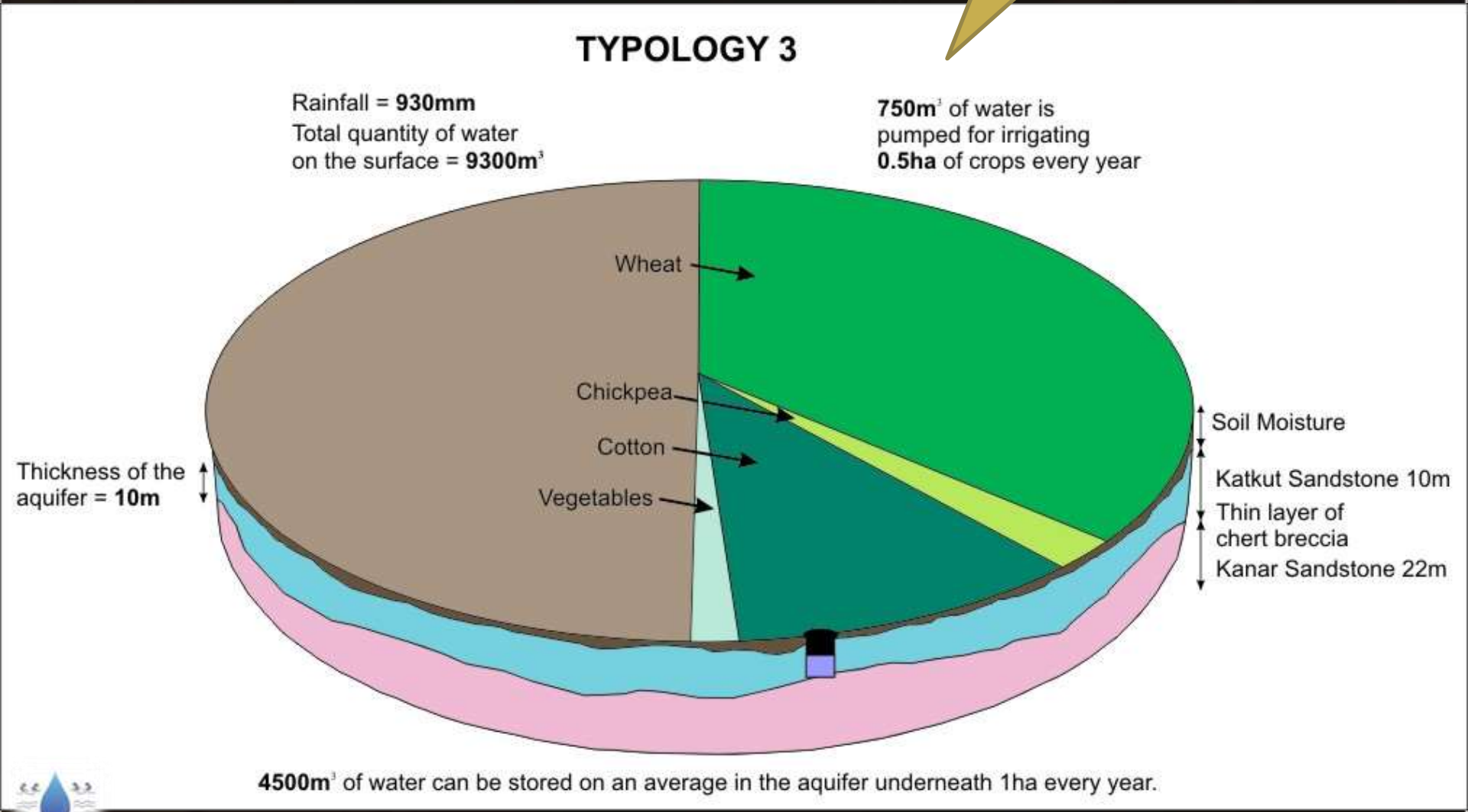
- Intense competition before conflicts
  - partial visibility and complexity surrounding resource and a perception that usage by a user can lead to reduced availability for others.
- Competition between users (same purpose) and between different types of uses
  - Largely individualistic development of the resource and the linkage of land ownership and access to groundwater.
- Competition depends upon nature of the resource.
  - A poor understanding of the aquifers.
  - Lack of data at the appropriate scale.

Competition before conflict

- Partial visibility
- Complexity surrounding the resource
- Subtractibility - usage by a user leads to reduced availability for others

Typology 3 dug well
One ha model: land and aquifer

Pumping from well affects aquifer under 1 ha only.



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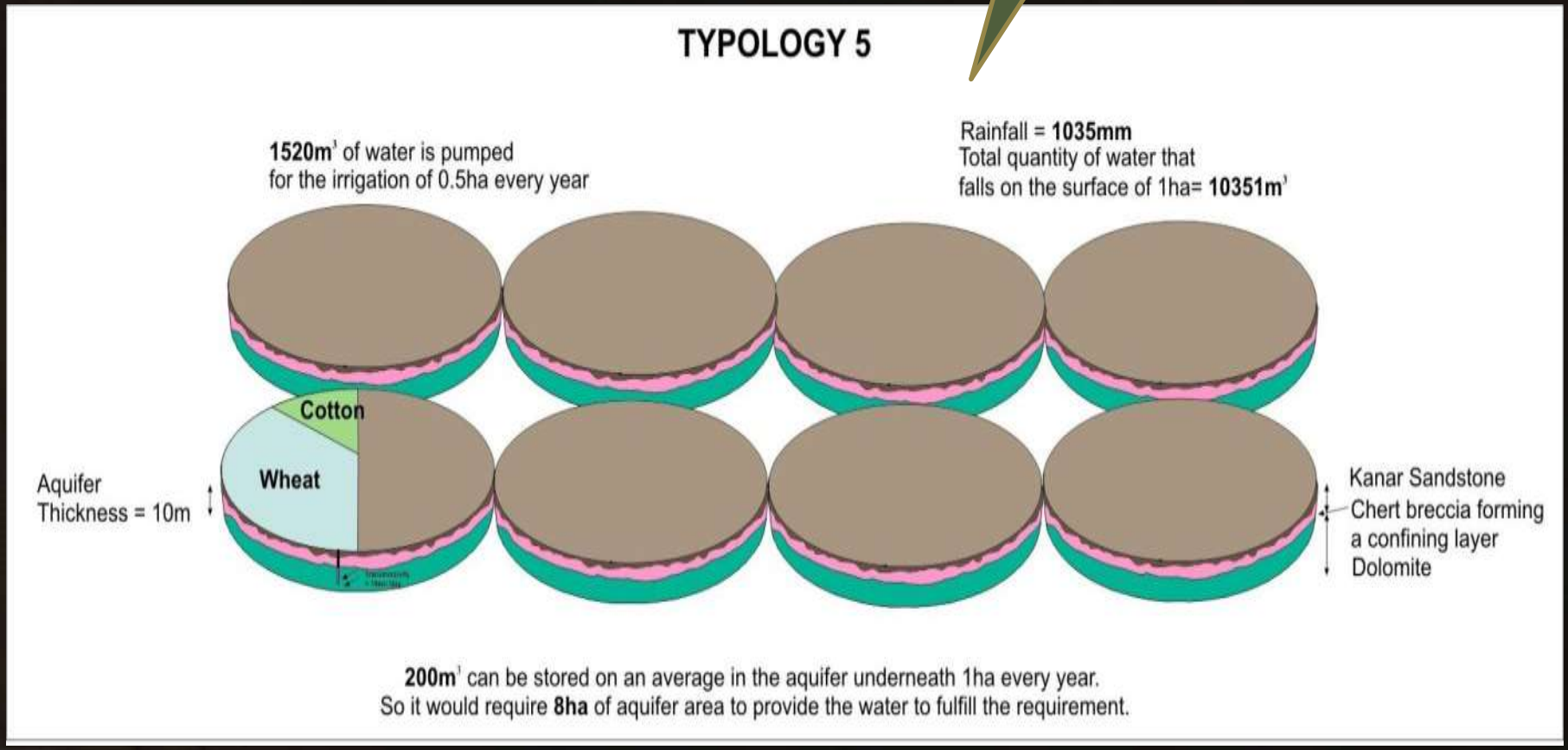
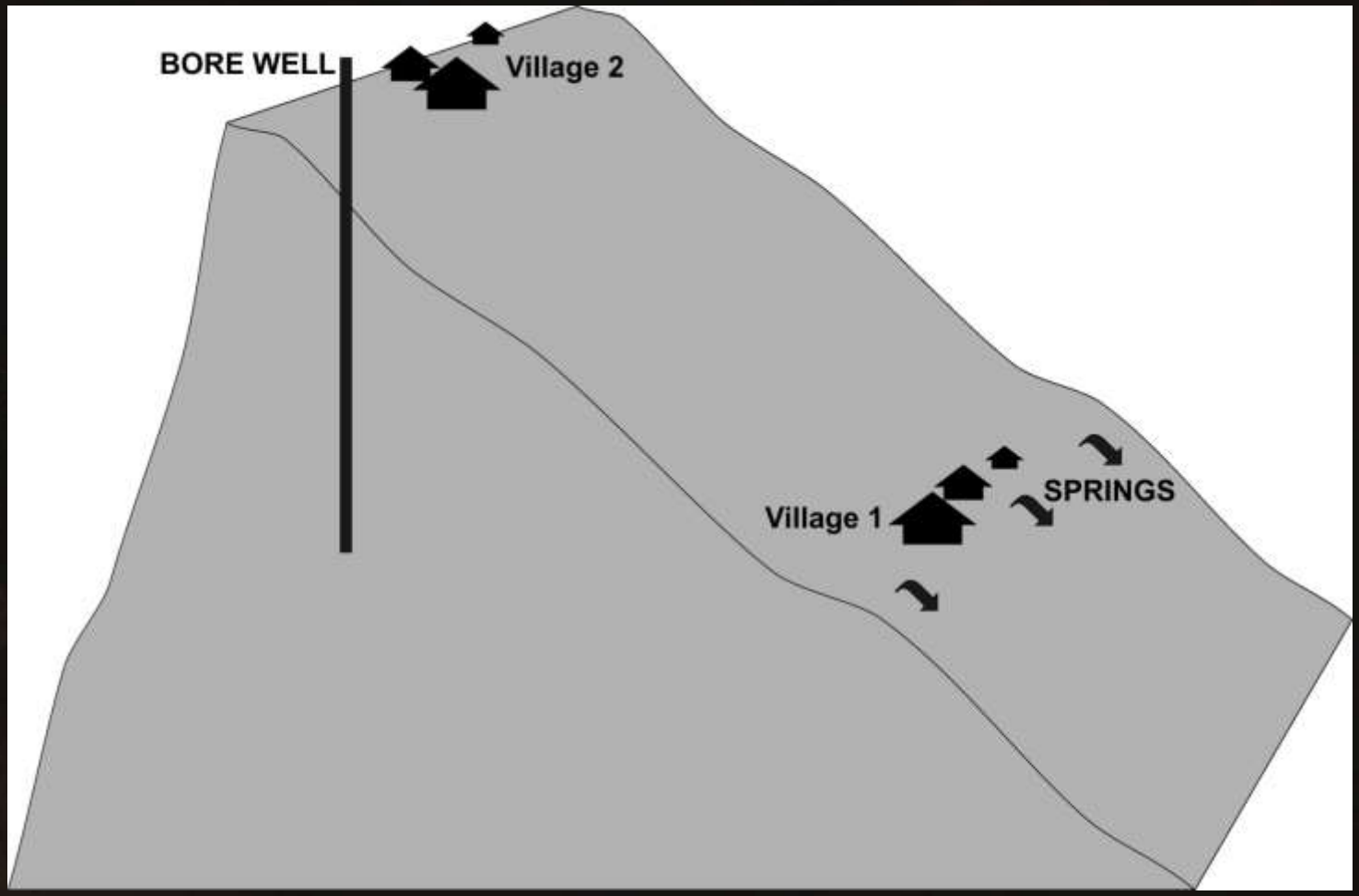
Typology 5
1 Hectare Borewell Model

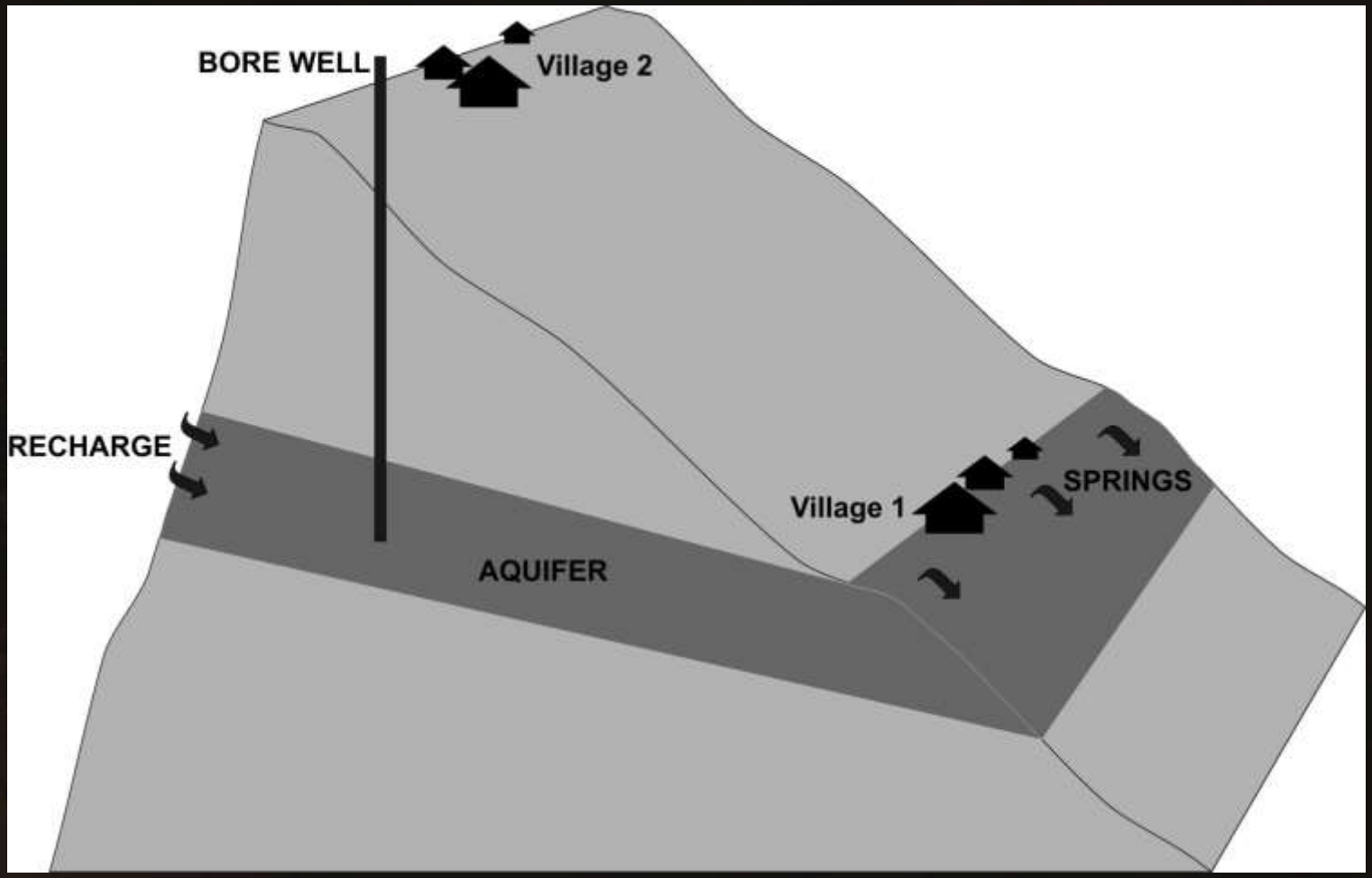
Pumping from well affects aquifer under 8 ha of land today



Groundwater: shift in focus needed – from *sources*...

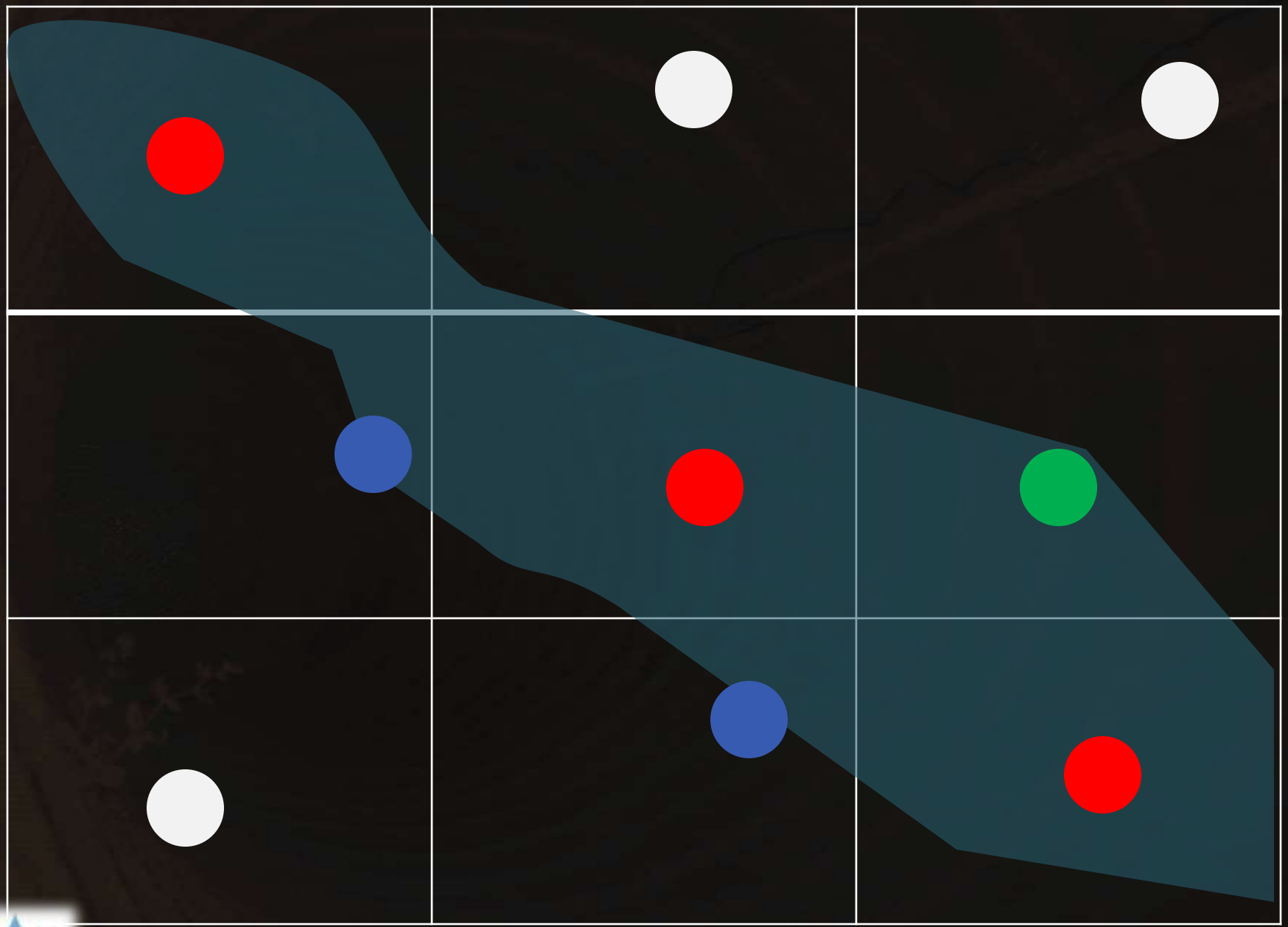


...to a ‘resource’, i.e. aquifers



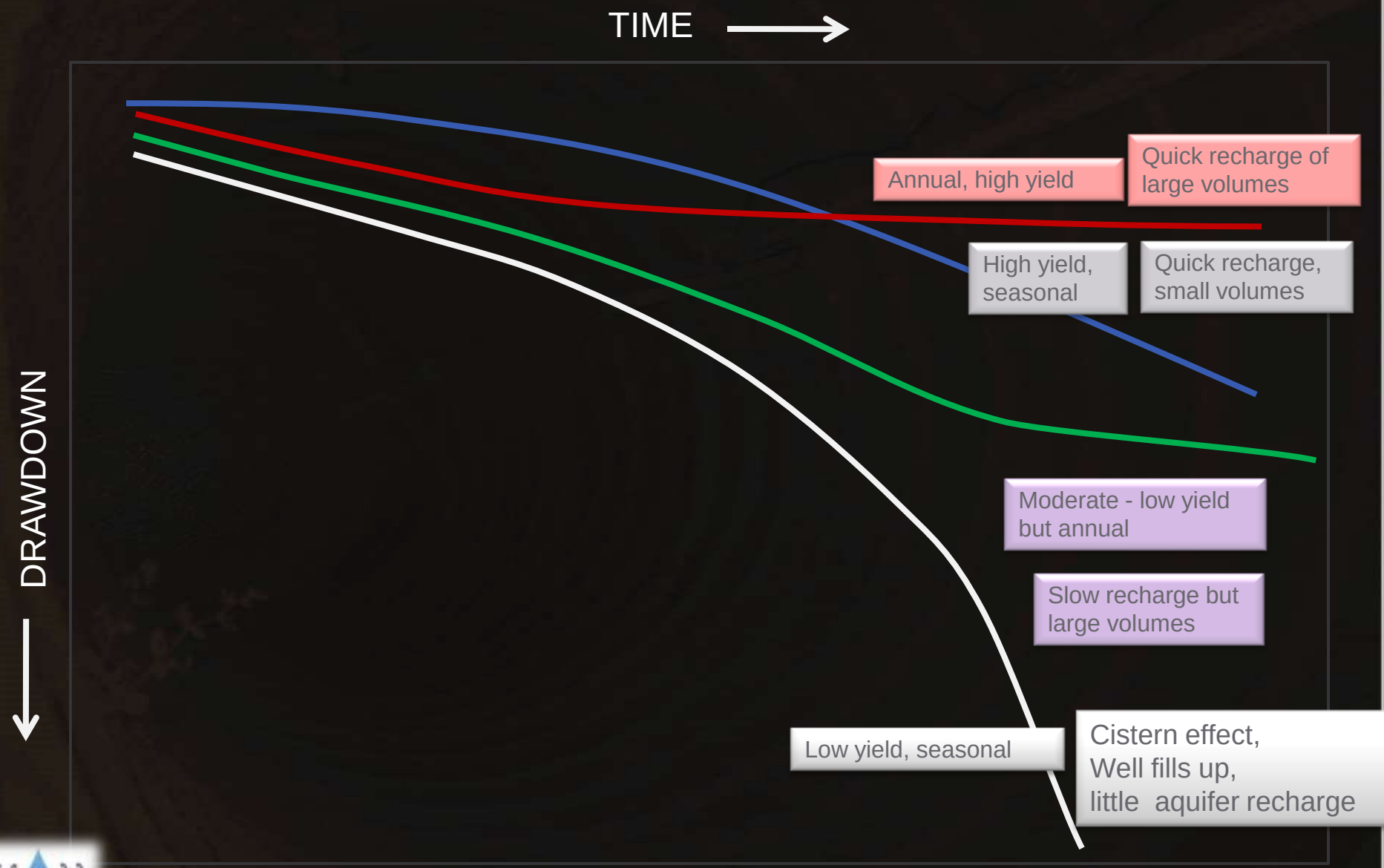
Competition: users & uses

- Users compete for the same use
  - *Farmer versus farmer*
  - *Industry versus another industry*
  - *One village versus another village*
  - *One town versus another town*
  - *Village versus township*
- Users compete for different uses
  - *Drinking water need versus irrigation needs*
  - *Irrigation versus industry*
  - *Drinking water versus industry*
  - *Irrigation versus domestic demand by a town / city*
- Largely individualistic development of the resource and the linkage of land ownership and access to groundwater.



Kulkarni and Vijay Shankar, *2014*

Each well is different: even in a single aquifer…



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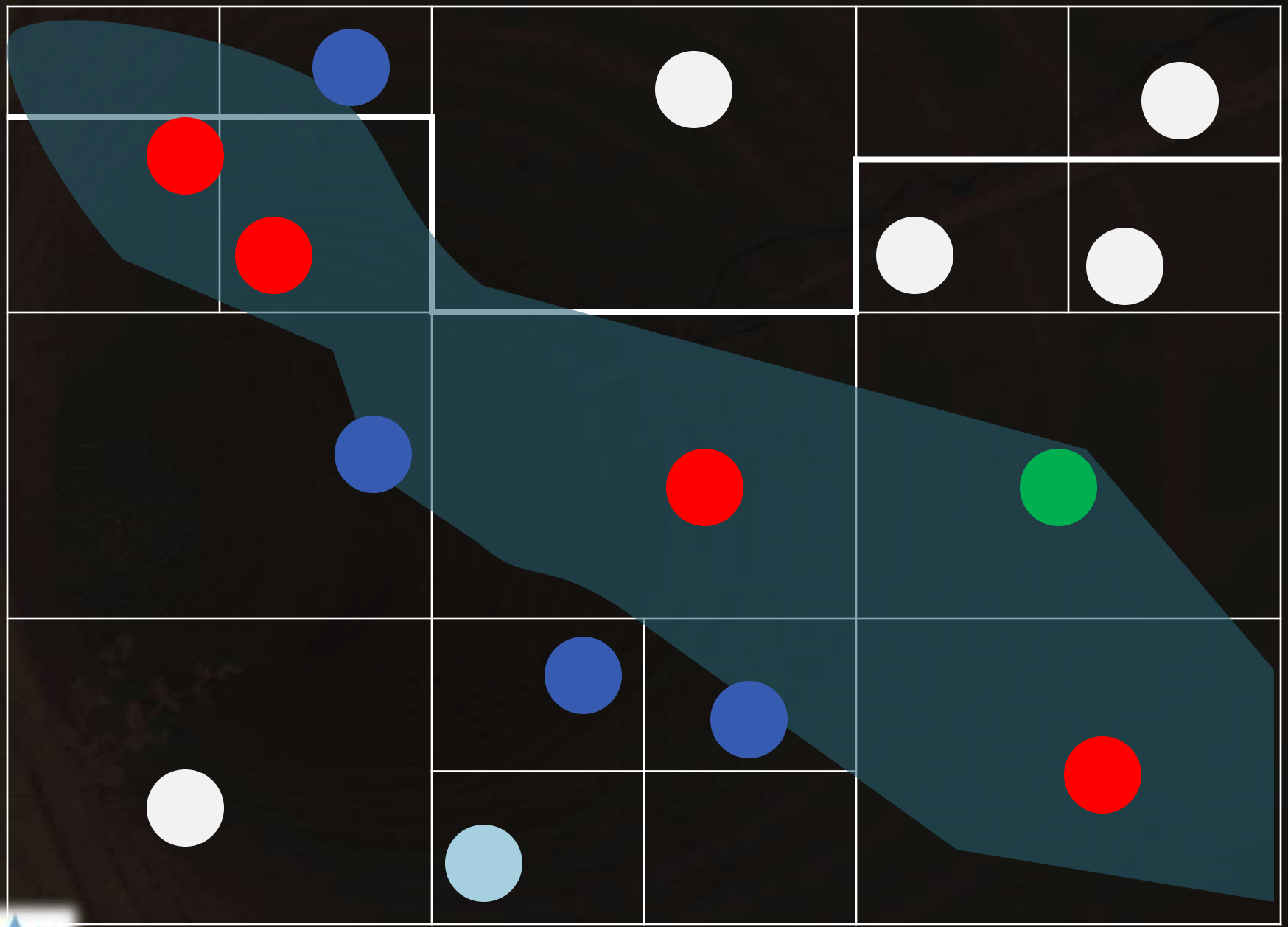
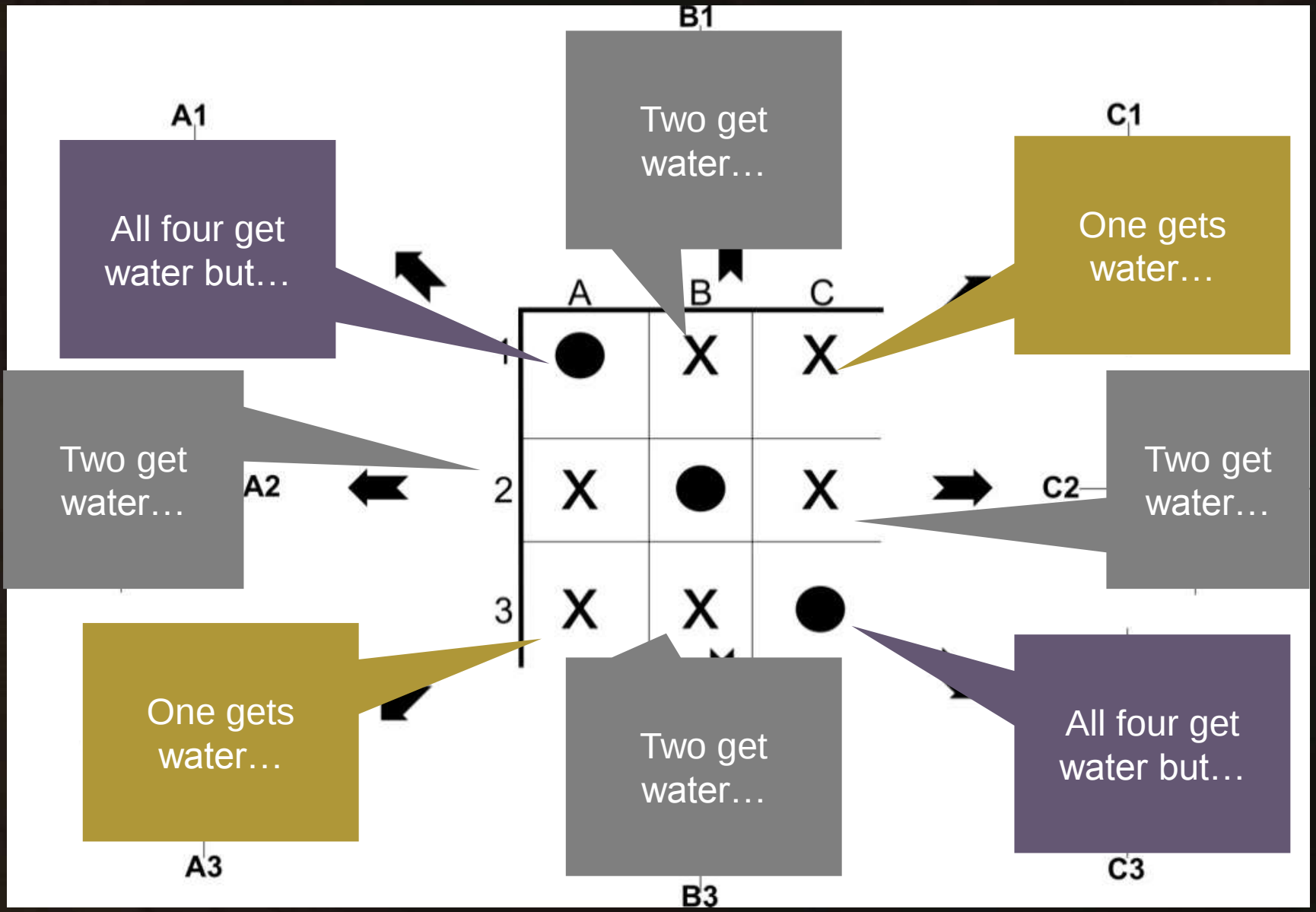


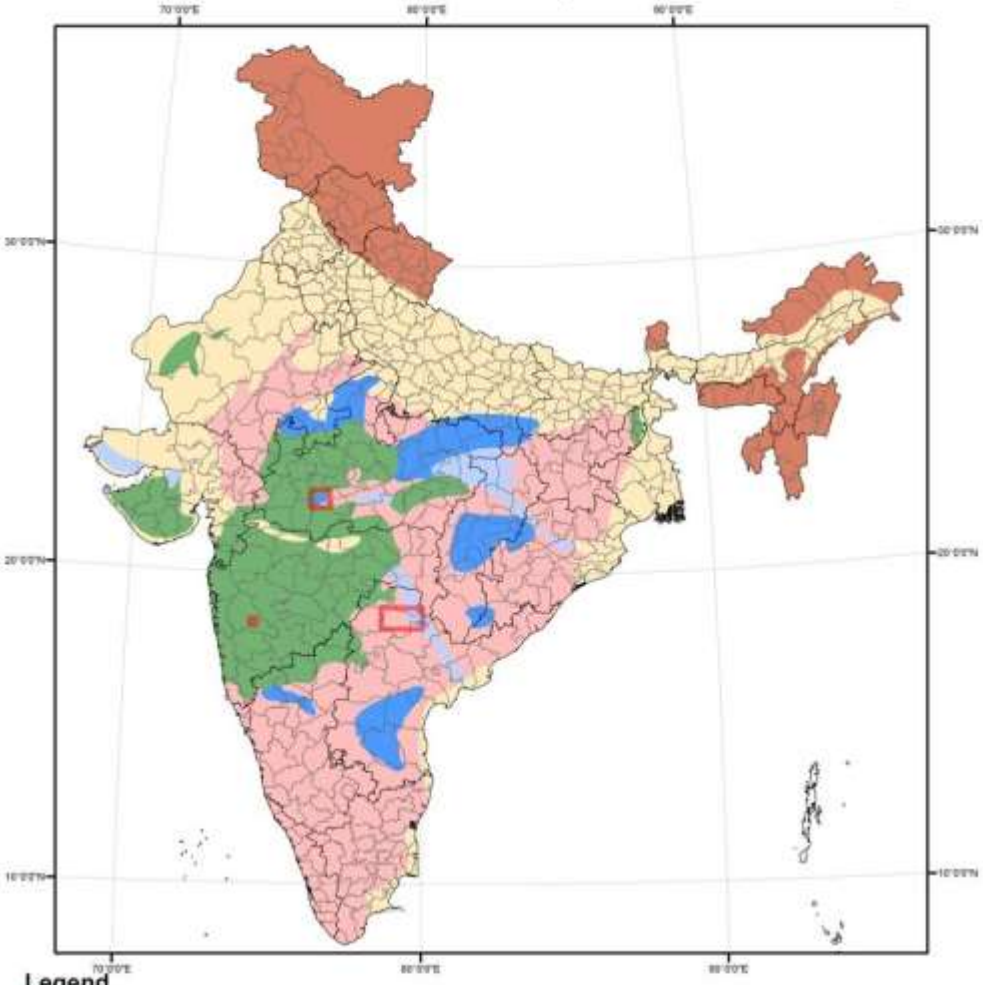

B1
A1
C1
All four get water but…
Two get water…
One gets water…
A
B
C
1
X
X
Two get water…
A2
2
X
X
C2
Two get water…
3
X
X
One gets water…
Two get water…
All four get water but…
A3
B3
C3

Competition: nature of resource

- A poor understanding of the aquifers has limited the understanding of competition and conflicts

- Lack of data at the appropriate scale has also led to speculations and confusion on groundwater conflicts

Overlay of generalised hydrogeological settings on administrative boundaries (Districts and States)



Legend

- Sample areas exhibiting groundwater diversity

Formations

- Alluvial (Unconsolidated) Systems
- Crystalline (Basement) Systems
- Mountain Systems
- Sedimentary (Hard Rock) Systems
- Sedimentary (Soft Rock) Systems
- Volcanic Systems

N

Kilometers

0 165 330 660 990 1,320

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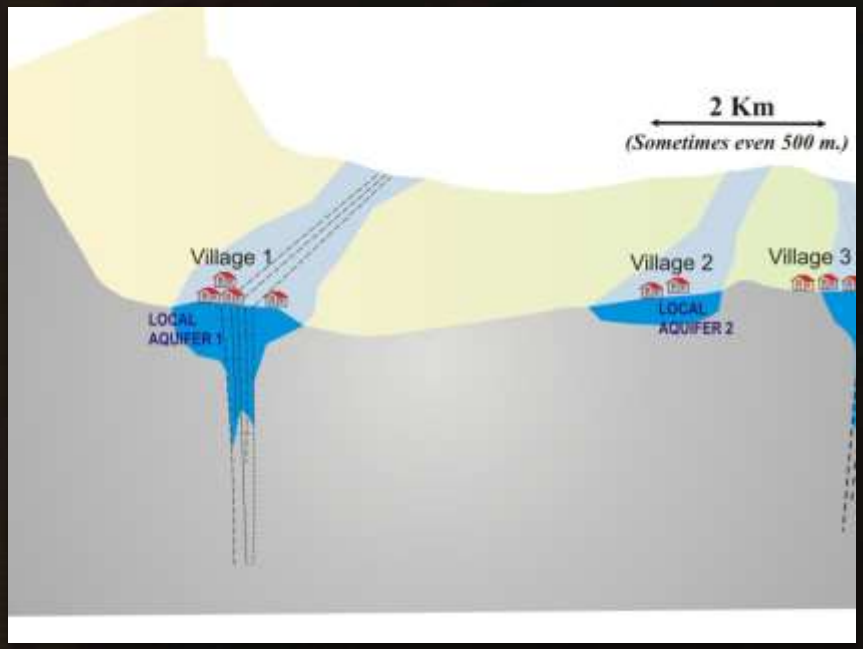
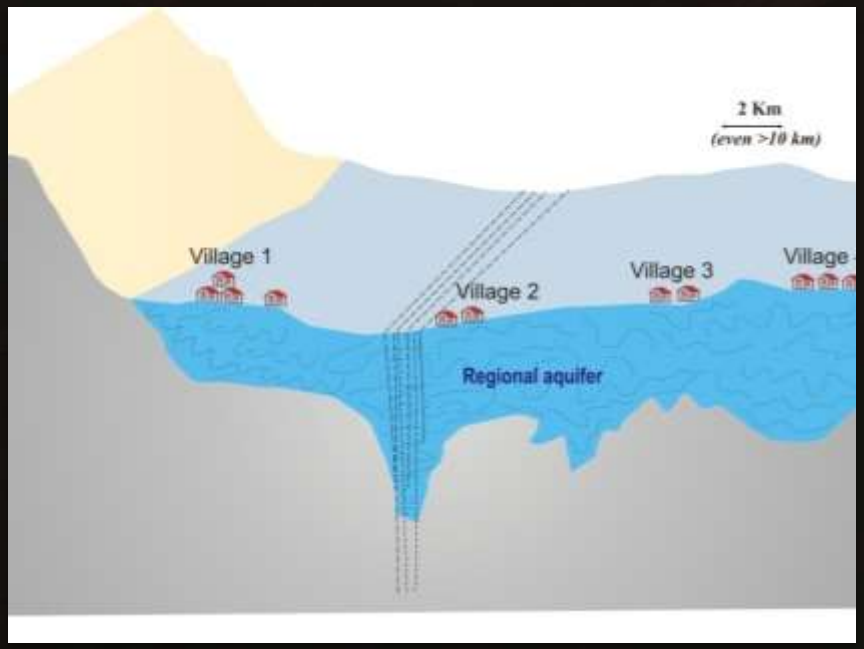
GROUNDWATER MANAGEMENT: Alluvial aquifers





Village 1: Taps a shallow aquifer

Village 2: Taps a separate shallow aquifer

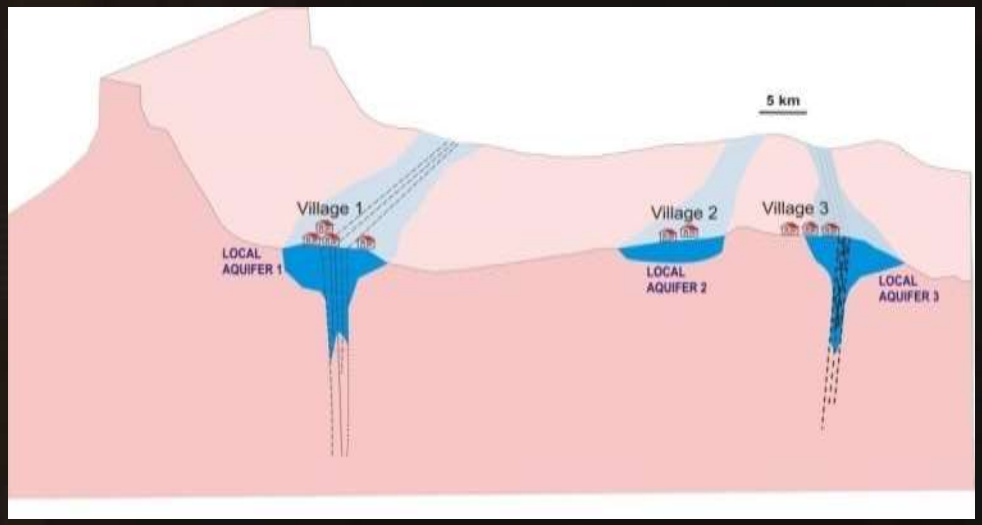
Village 3: Taps a third, separate shallow aquifer

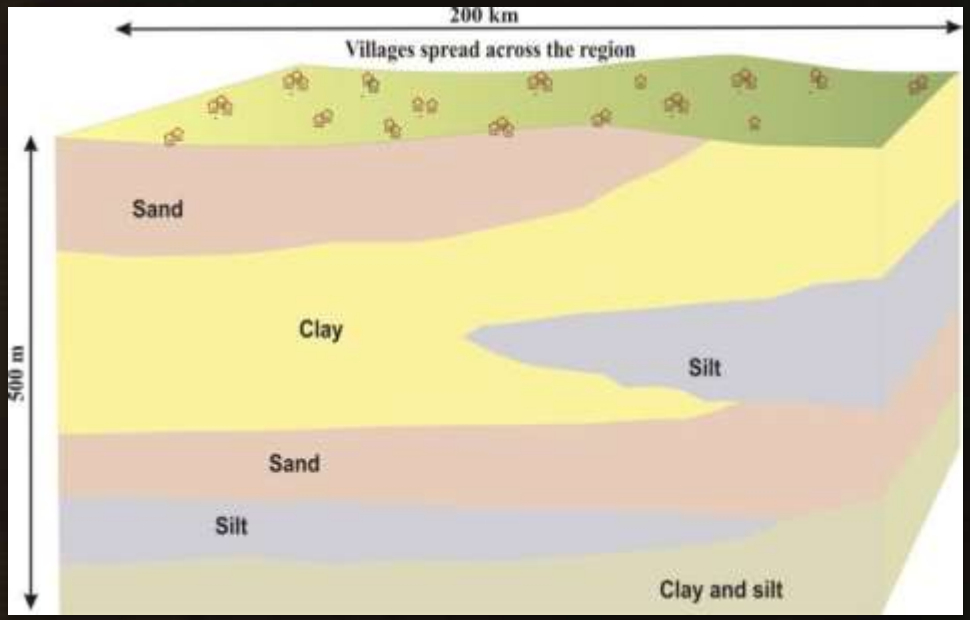
Recharge is greater for aquifer in village 1 than for the other aquifers.

Four villages share one single aquifer

The main recharge zone for the single aquifer is the fracture zone passing through village 2.

GROUNDWATER AS A COMMON POOL RESOURCE



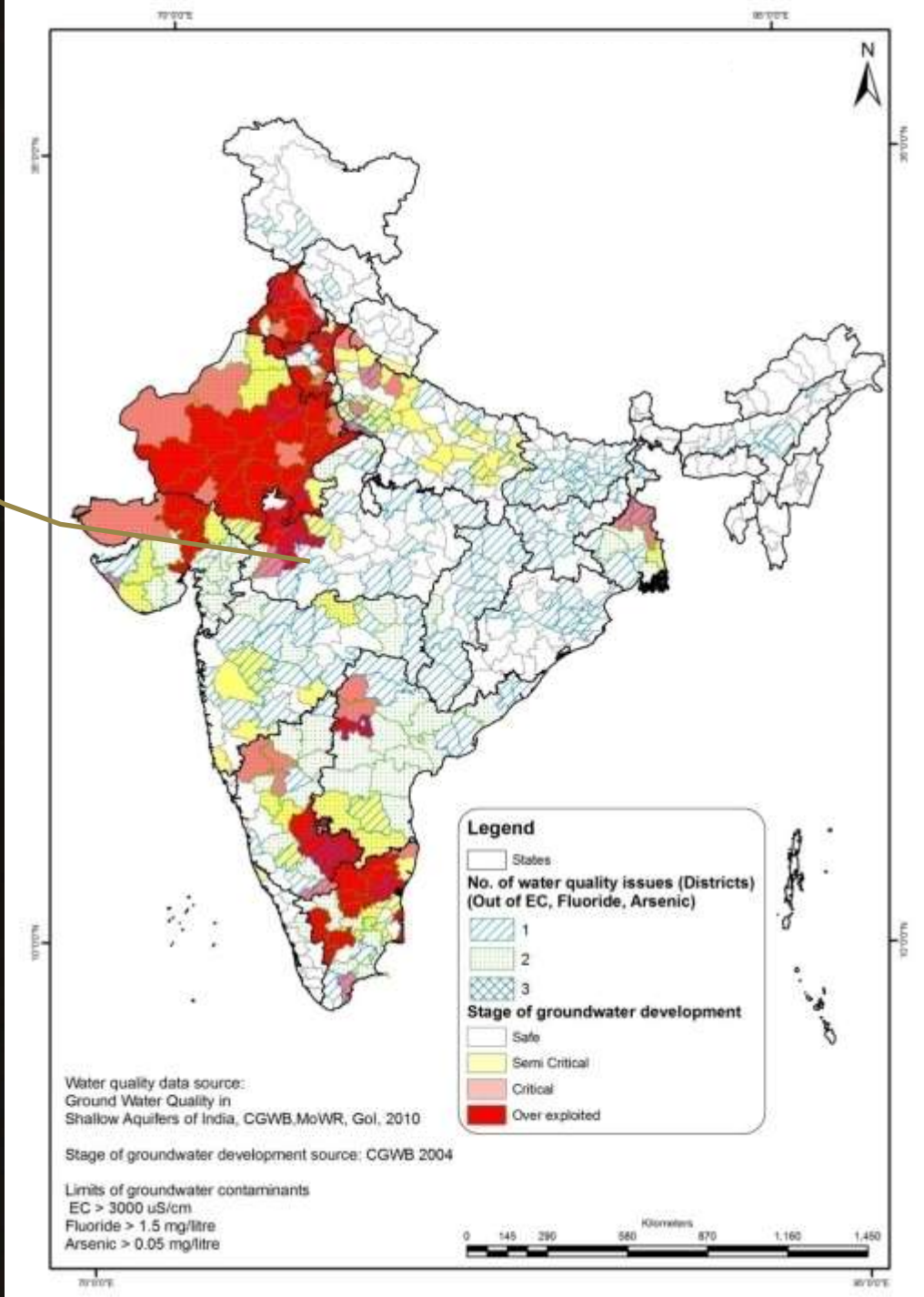


Starting point: 'Fragility' of groundwater resources – quantity and quality.

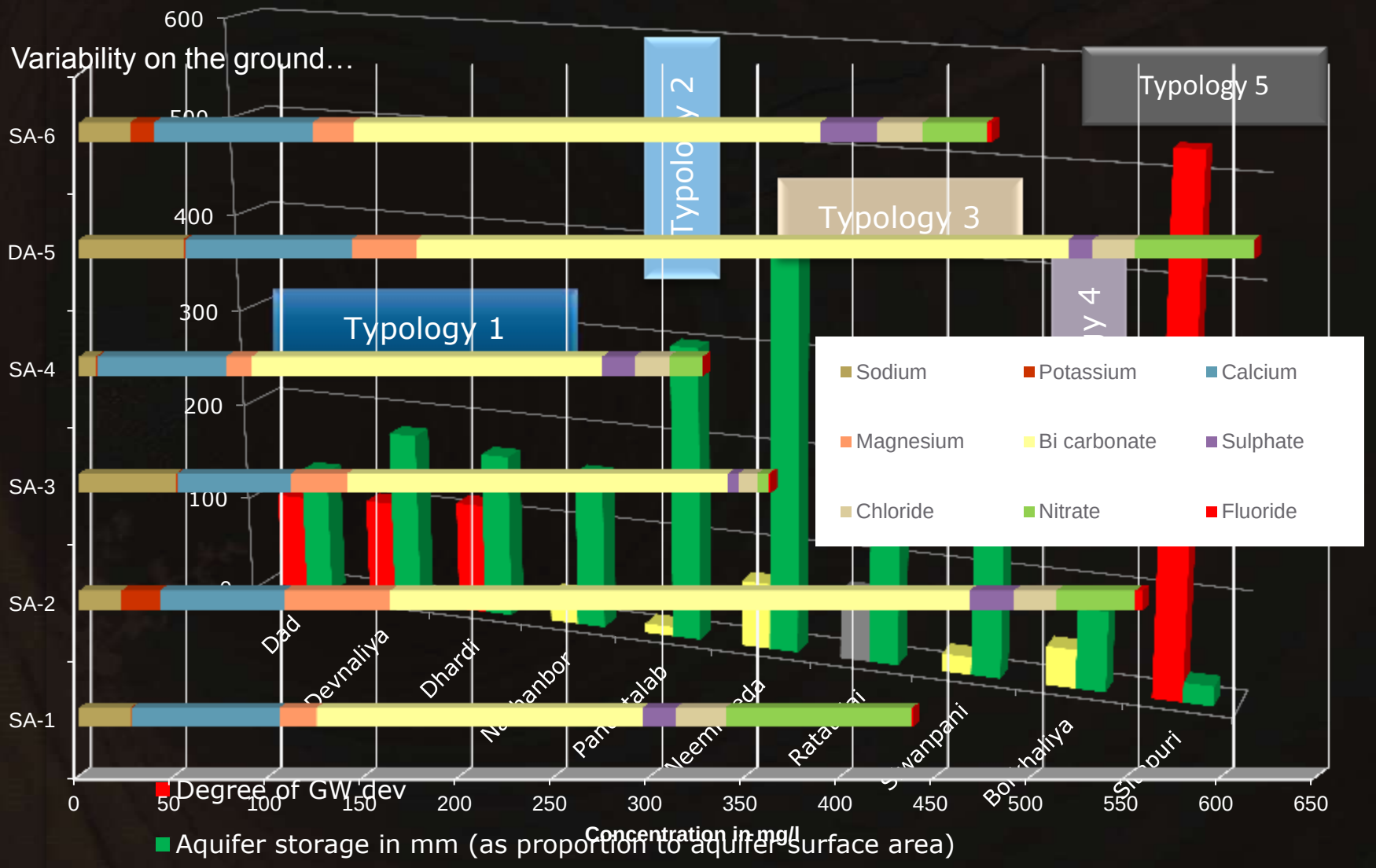
- Diversity in groundwater conditions – geology and hydrogeology
- Groundwater as a CPR – issue of equity, e.g. delinking of land and water rights.
- Efficiency of use – what is possible at the farm level, without disturbing equity and sustainability.
- Sustainability – long term trends – balance between resource condition and resource use

Exploitation and contamination

What does this mean on the ground?



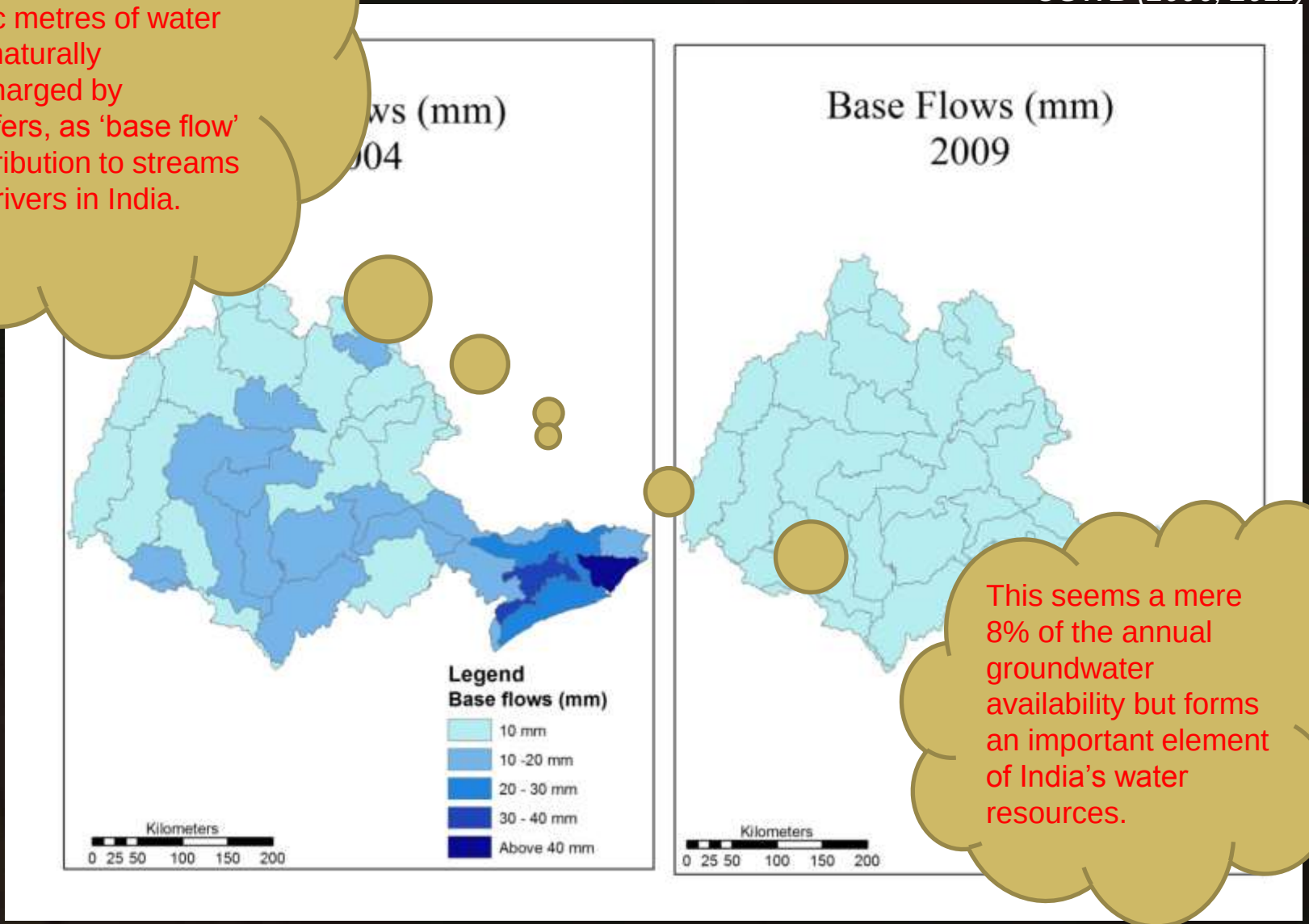
Aquifer typology within a block…



Base flow in India's groundwater assessment...

CGWB (2006; 2011)

Some 34-35 billion cubic metres of water are naturally discharged by aquifers, as 'base flow' contribution to streams and rivers in India.



This seems a mere 8% of the annual groundwater availability but forms an important element of India's water resources.

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Groundwater: “lender of the last resort”

- More than 30 million wells, with twice that number accessing groundwater
- Uncertain civic water supply offset by dependence on groundwater – *springs, tube wells, bore wells and tankers*
- One of the largest supplementary sources of industrial water supply

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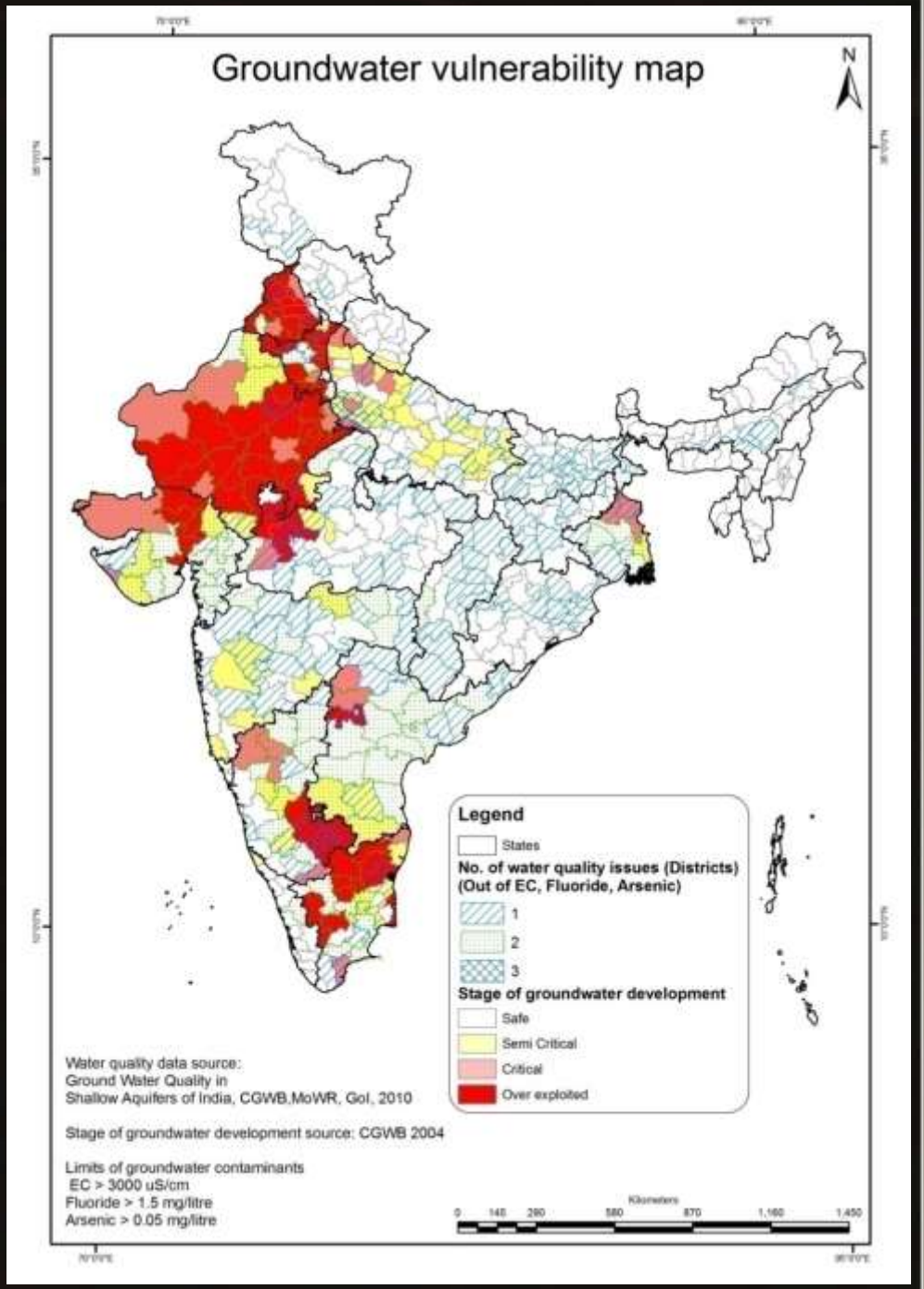
Groundwater: vulnerability to exploitation and contamination

- 60% districts vulnerable to exploitation and/or contamination
- “Slipback” habitations / villages...drinking water supply
- **Unhealthy competition, potential conflicts...**
- Health-related hazards: arsenicosis, fluorosis, selenicosis, Uranium-poisoning and temporary morbidity



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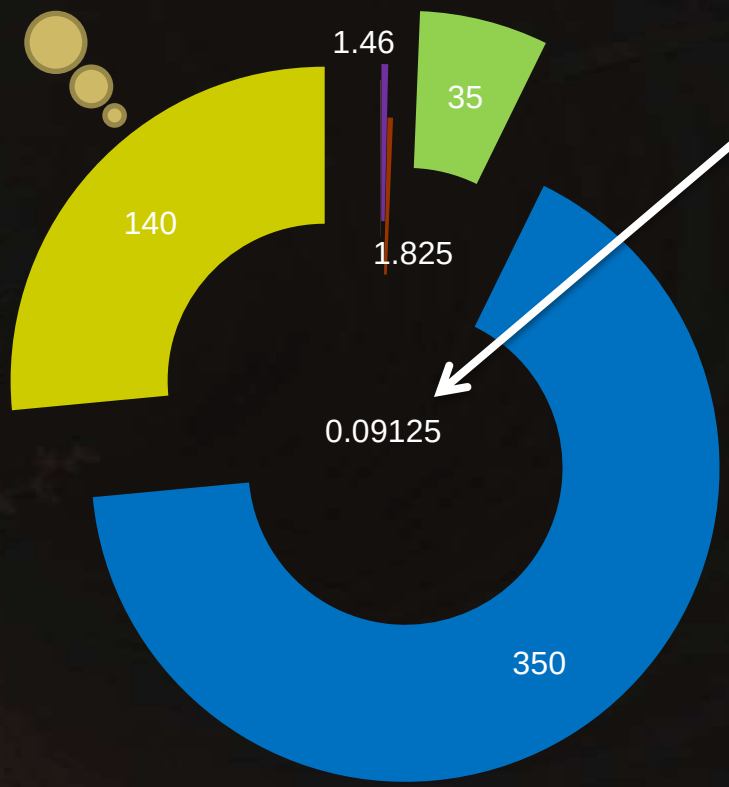
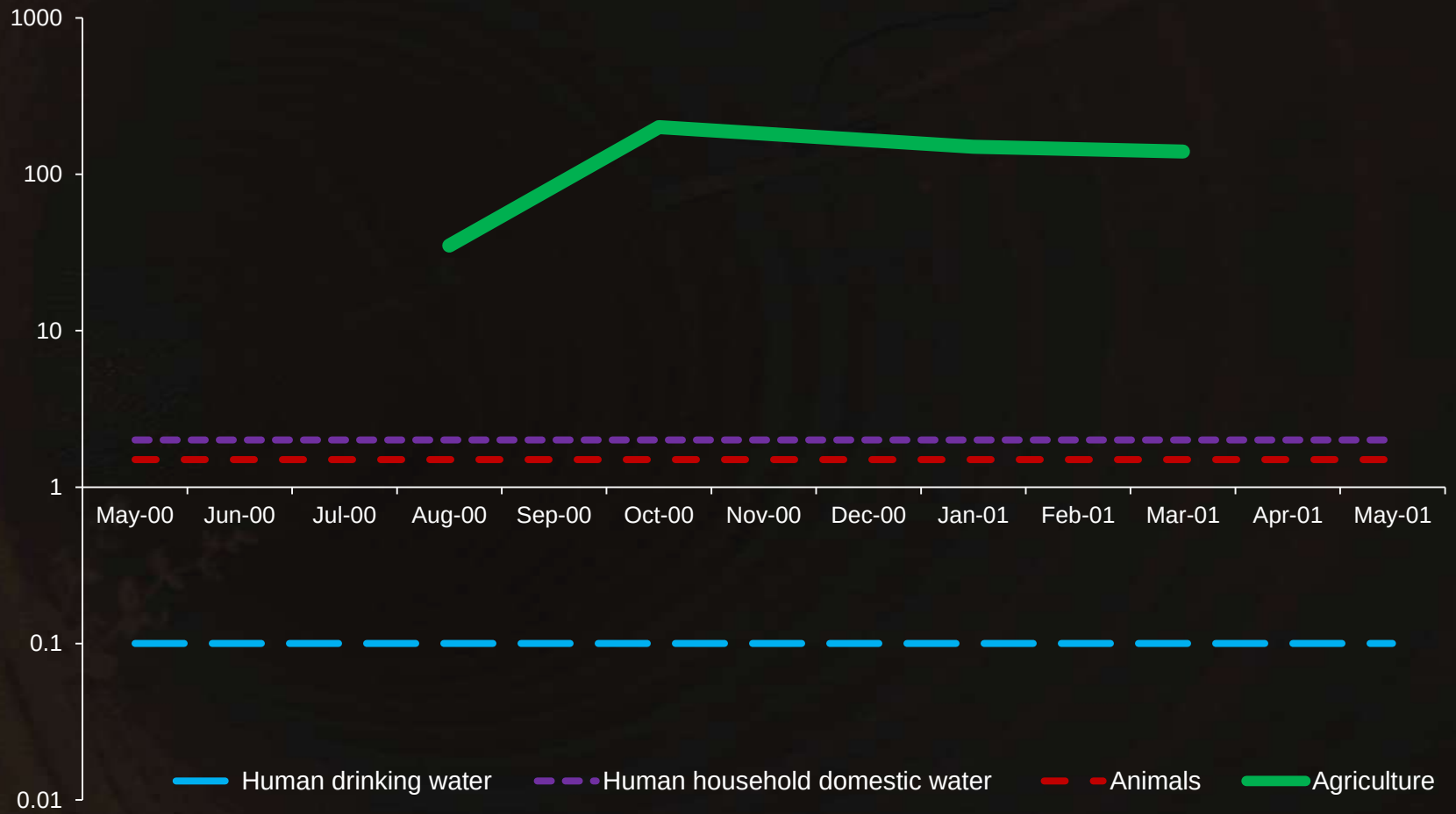
Annual demand in a typical Indian village

1 village, 1000 ha;
500 ha (agriculture);
100 hhs; 500 popn

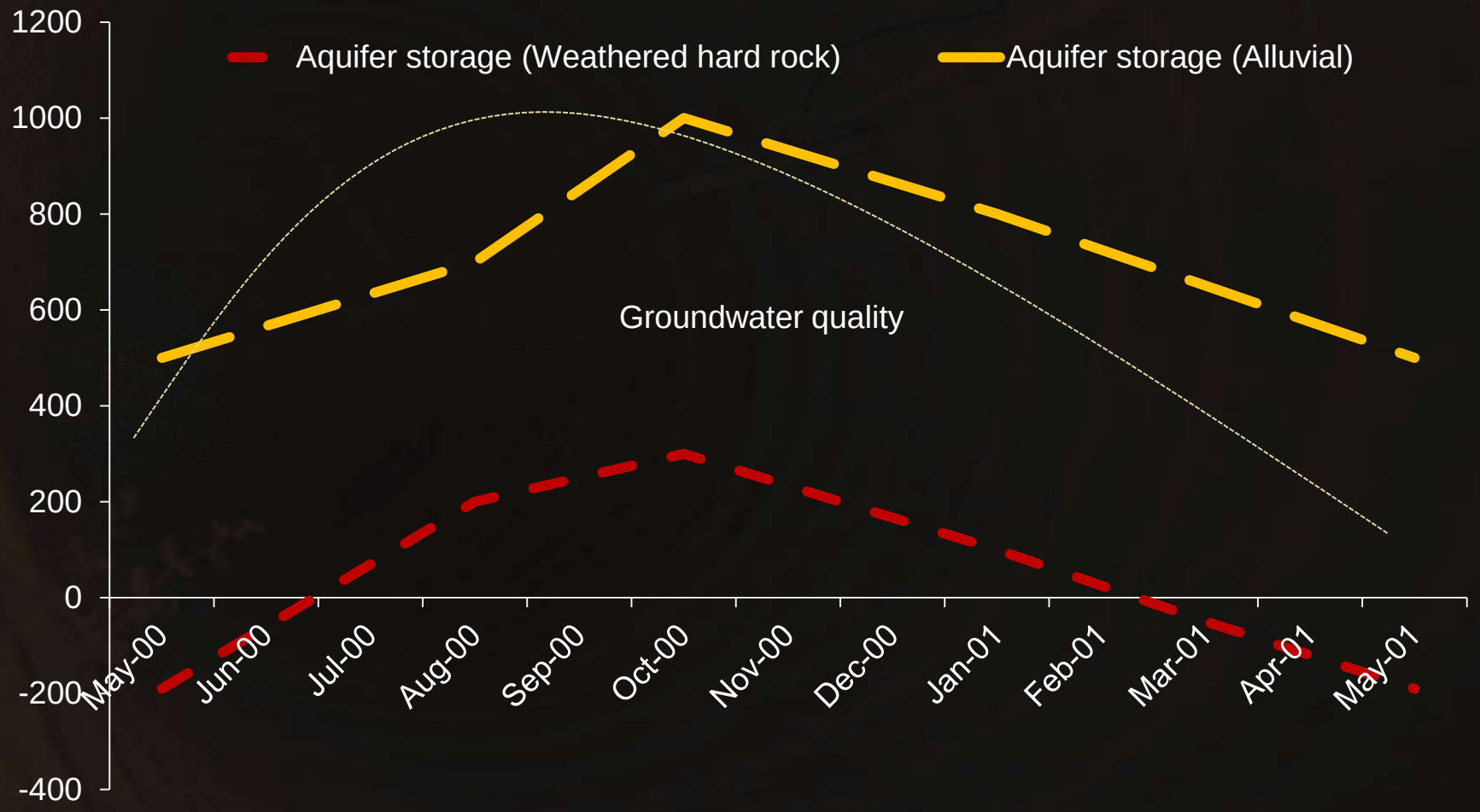


- Human drinking water
- Human household domestic water
- Animals
- Rainfed agriculture - kharif
- Irrigated agriculture - rabi
- Irrigated agriculture - summer

Seasonality of demand

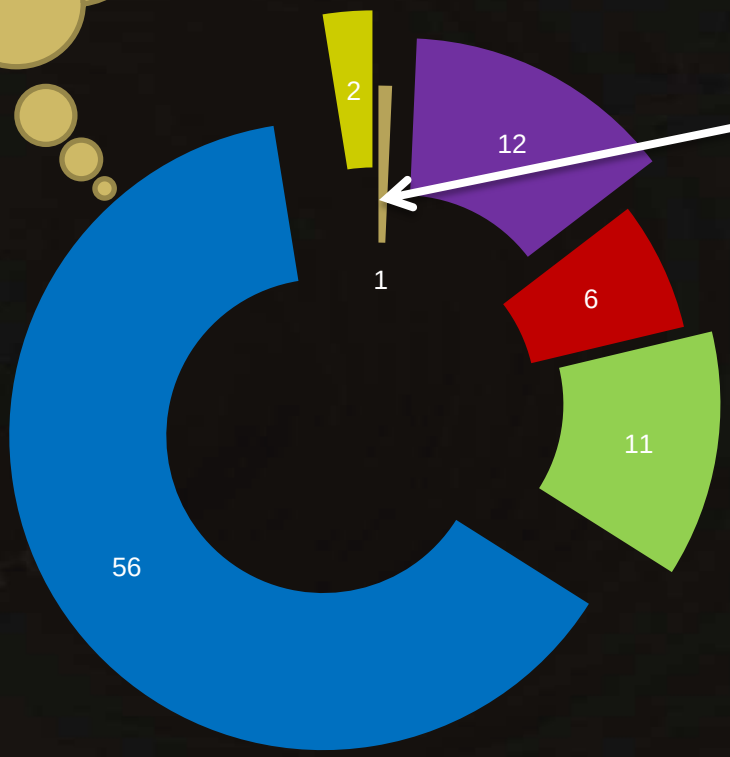


Changes in aquifer storage (wells)



Annual demand in a typical Indian (mountain) village

1 village, 300 ha;
100 ha (agriculture);
100 hhs; 500 popn

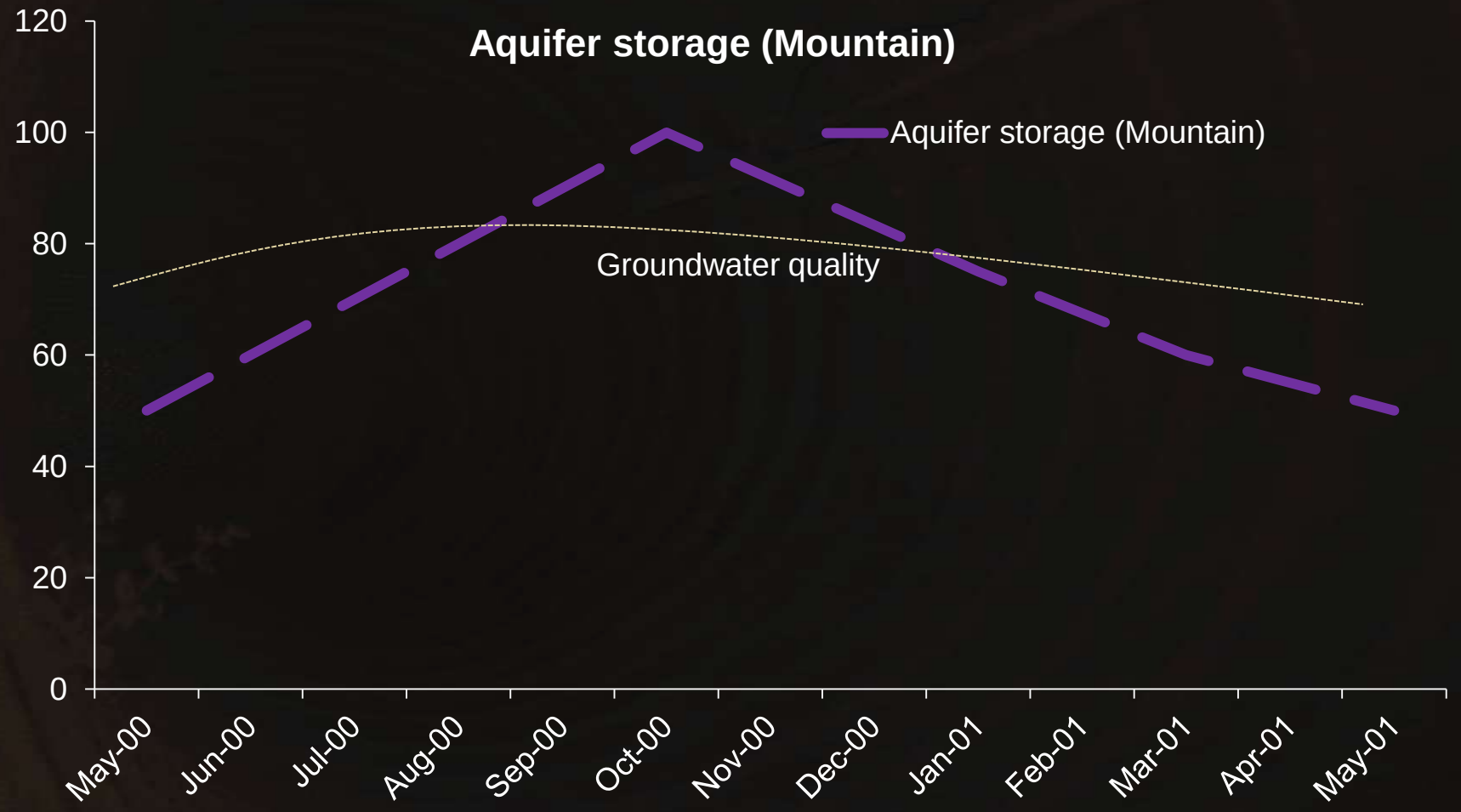


ANNUAL QUANTITIES IN mm

- Human drinking water
- Human household domestic water
- Animals
- Rainfed agriculture - kharif
- Irrigated agriculture - rabi
- Irrigated agriculture - summer

Seasonality of demand - springs

Changes in aquifer storage (springs)



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