INTERNATIONAL ASSOCIATION OF HYDROGEOLOGISTS
Australian National Chapter
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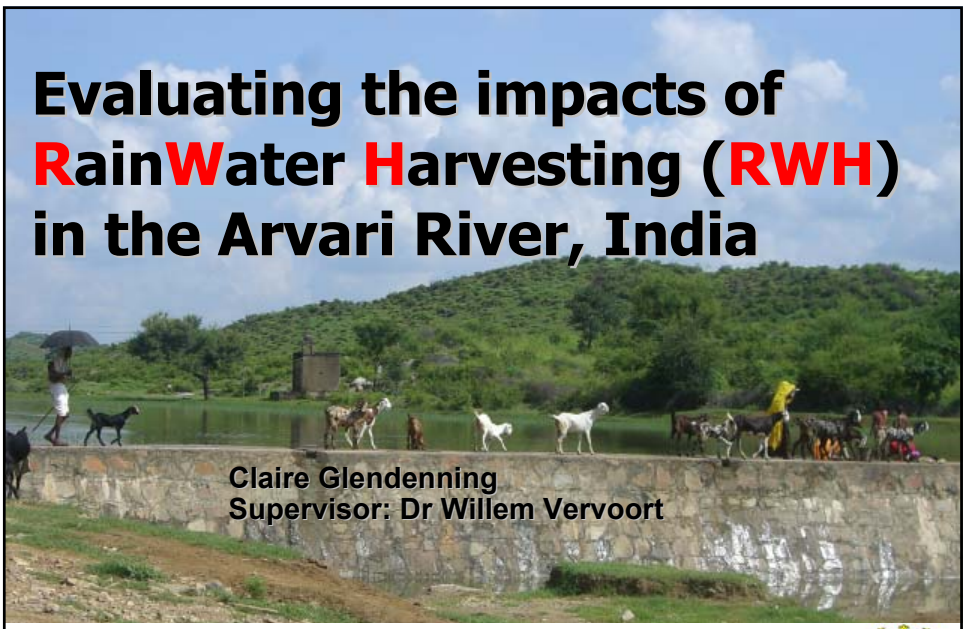
Evaluating the impacts of RainWater Harvesting (RWH) in the Arvari River, India



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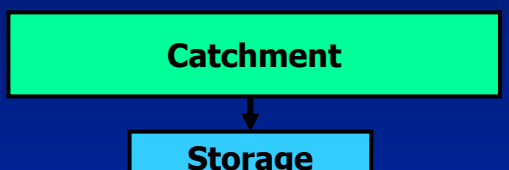
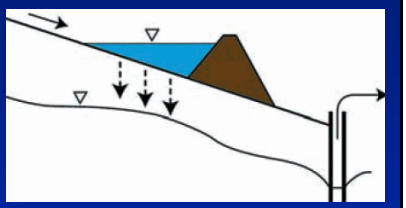
Groundwater in India

- World's largest user
- ~ 80% rural domestic use
  ~ 45% for irrigation
- <1 million tubewells (1960)
  to 20 million (2000)
- Common resource = Decline
- Management option:
  Rainwater Harvesting (RWH)?

What is Rainwater Harvesting?

- collect/store RUNOFF for DIRECT USE or RECHARGE



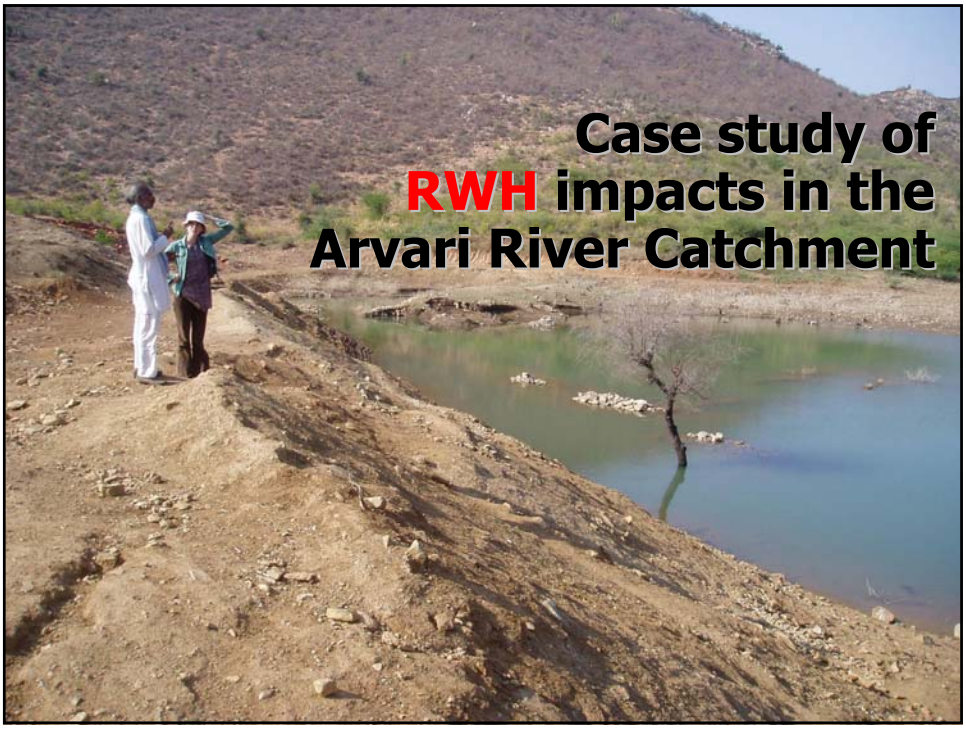


RWH in India

- > 1000 years in India
- Monsoon: 100 hr rainfall (80 days)/yr
  RWH=more time for recharge
- past neglect, now large reinvestment
- Impacts?

Quantified field studies of RWH

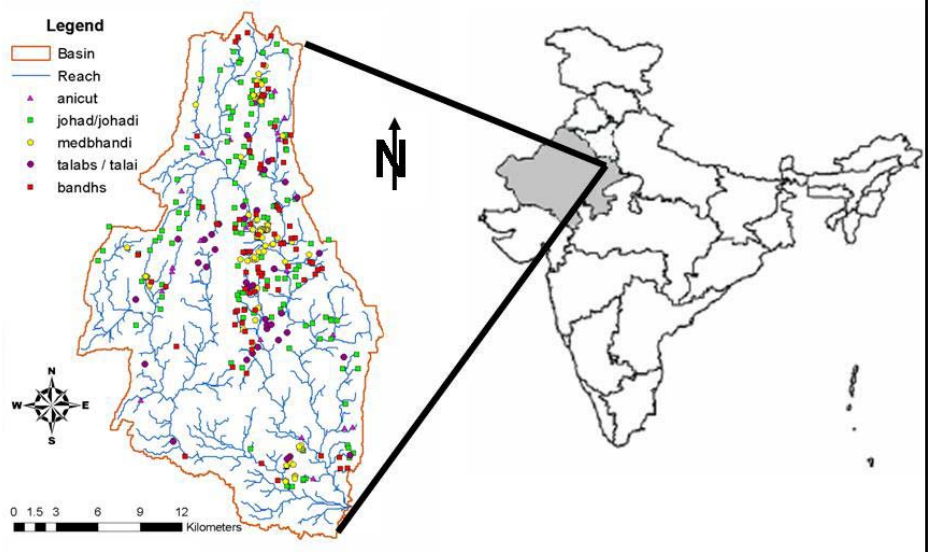
- Recharge = 3 – 8 % P: WTF
  (Badiger et al. 2002)
- Local impact on groundwater levels:
  1 structure (Neumann et al. 2004, 2005)
- Limiting capacity to induce recharge
  WTF / water balance in 812 ha
  (Sharda et al. 2006)
- Hydrological catchment impacts not known
  (Calder et al. 2006, Kumar et al. 2006)



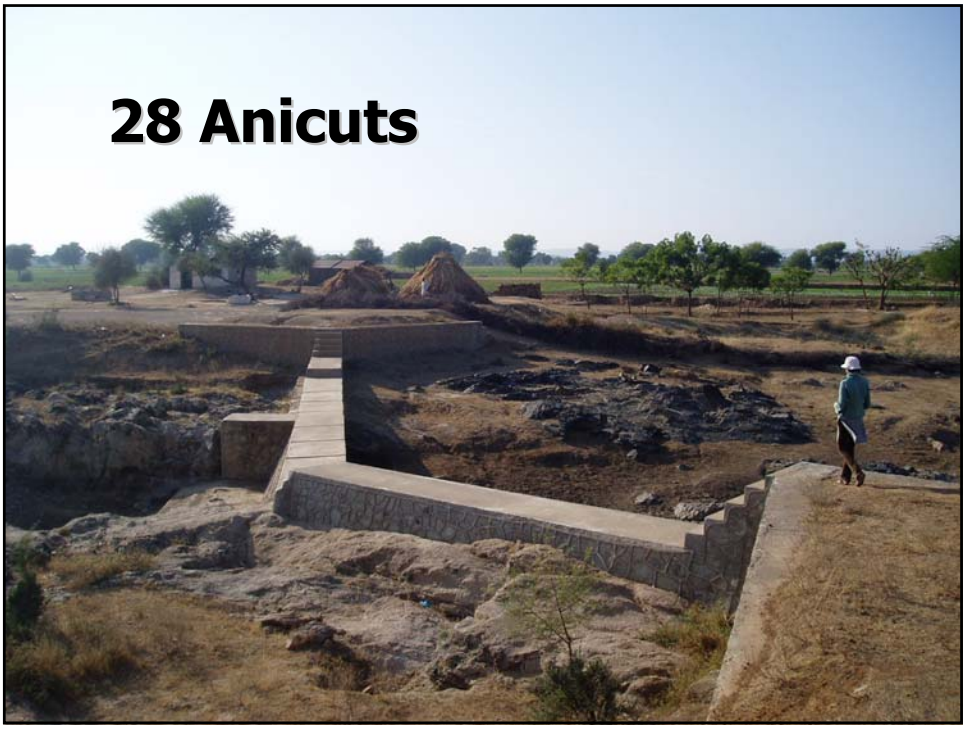
How to evaluate RWH impacts?

1. Field-scale impacts of RWH
2. Catchment-scale impacts of RWH
   - *a.* Build a conceptual water balance model
   - *b.* Run scenarios to investigate RWH impacts

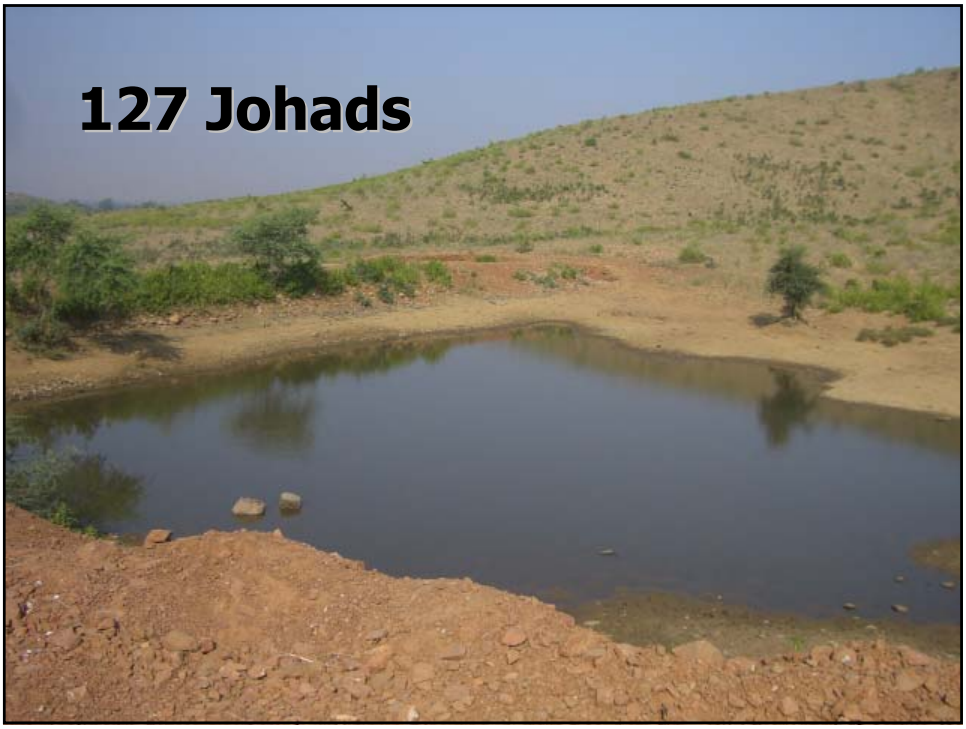
Case Study Location



458km² (45,800 ha)


28 Anicuts

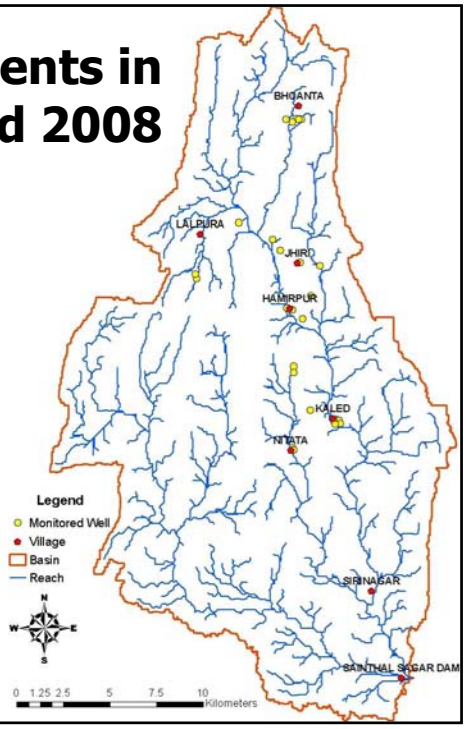
84 Bandhs


127 Johads

88 Medbandhi

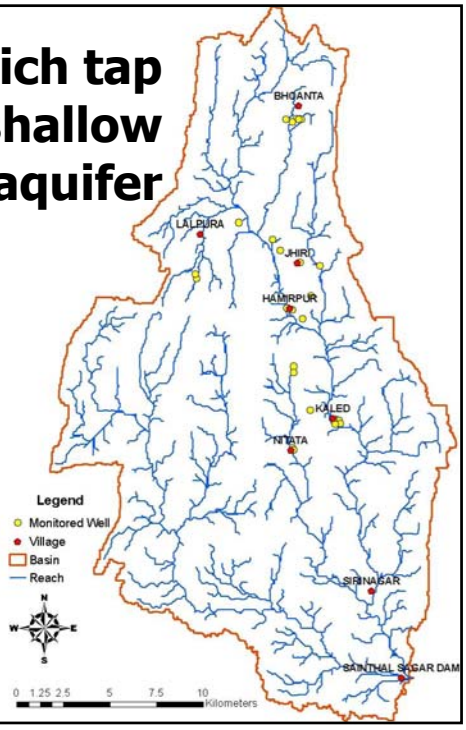
Daily measurements in monsoon 2007 and 2008

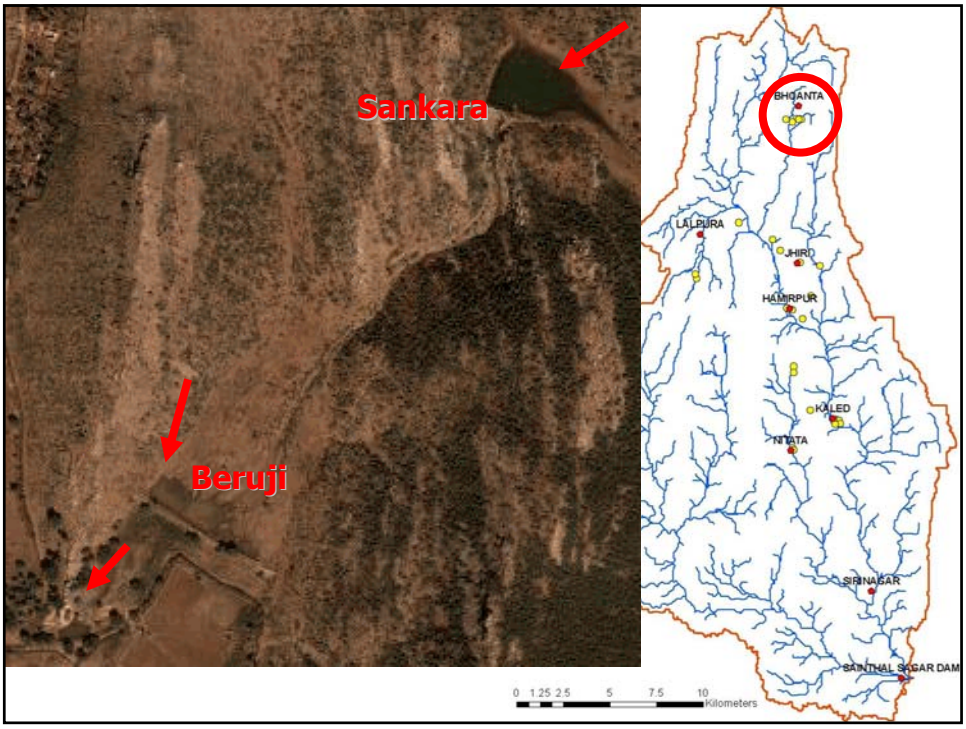
Monitoring Network

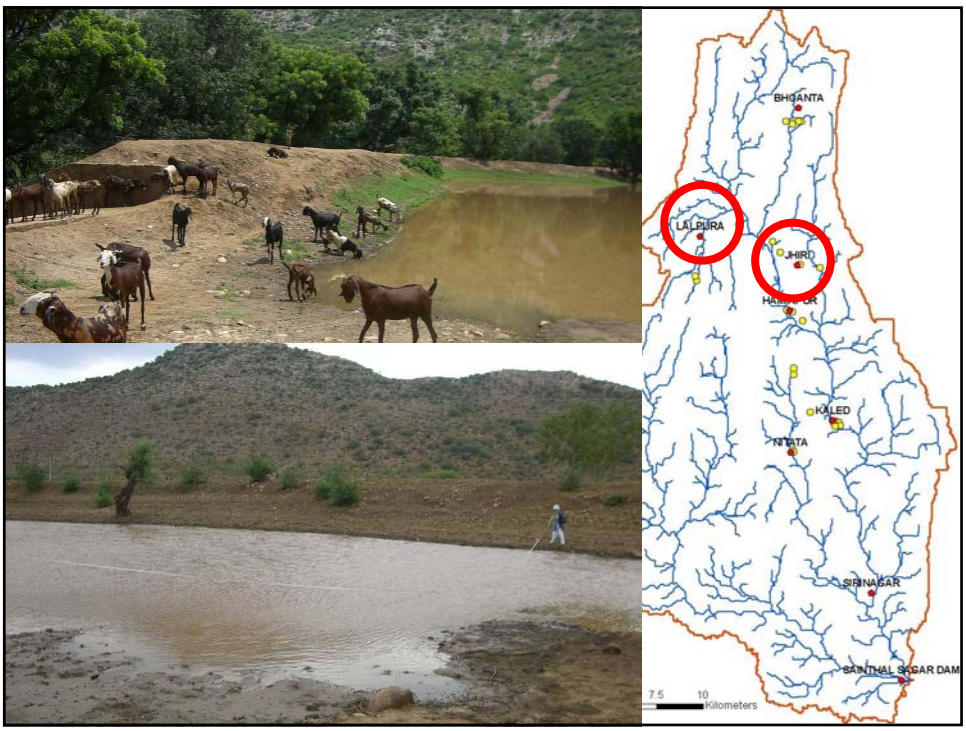


29 dug wells which tap unconfined/shallow aquifer

Monitoring Network




Sankara
Beruji
BHOANTA
LALPURA
JHIRI
HAMIRPUR
KALED
NIMATA
SIRINAGAR
SARDAR SAGAR DAM
0 1.25 2.5 5 7.5 10
Kilometers


BHOANTA
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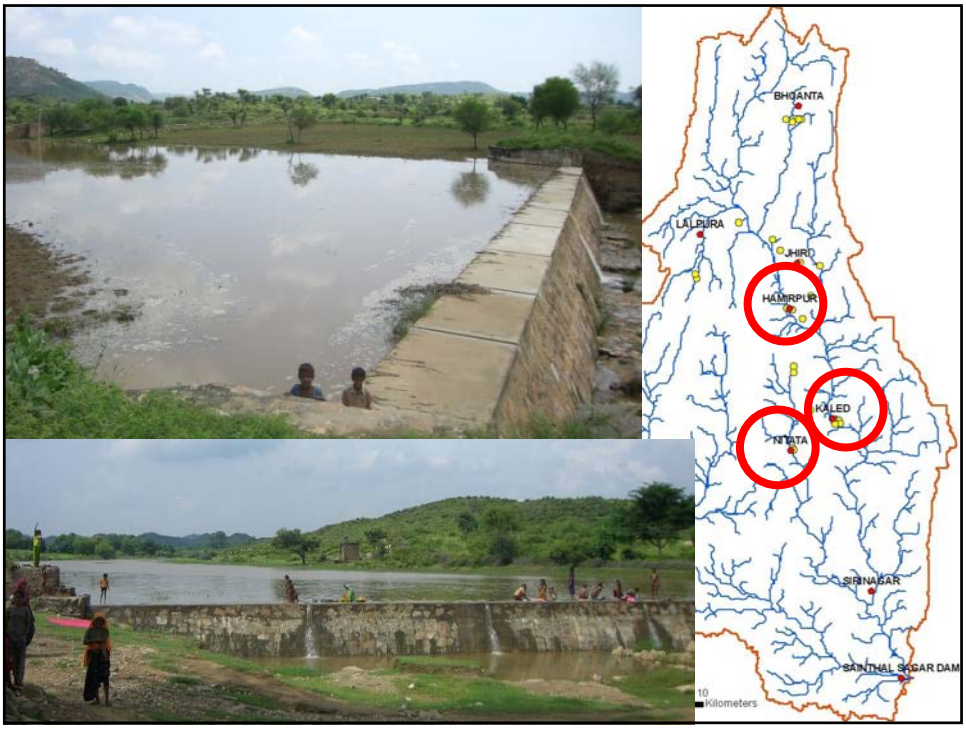
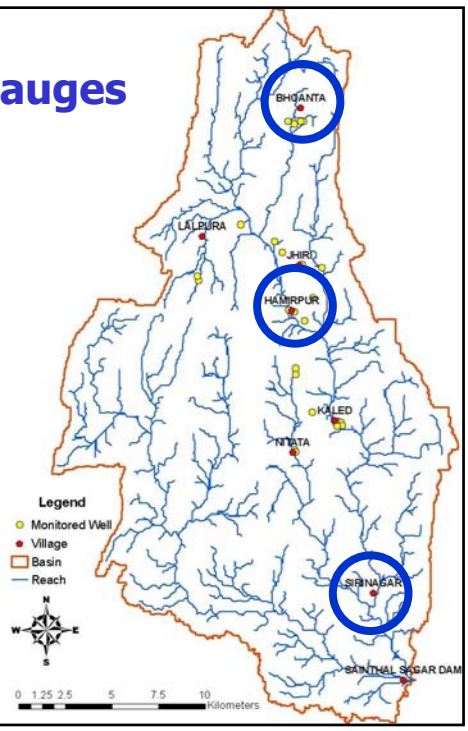
SIRINAGAR
SARDAR SAGAR DAM
7.5 10
Kilometers

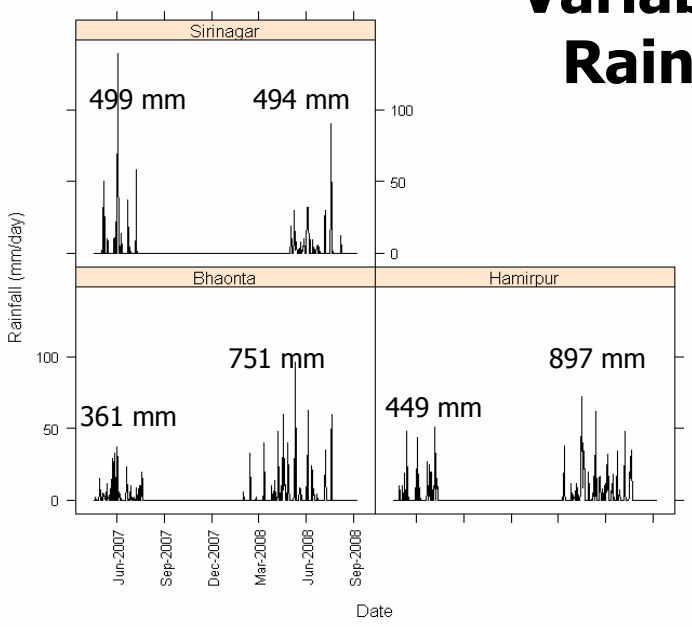


Rain Gauges

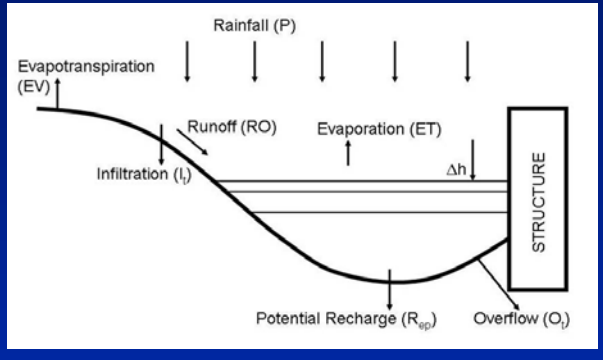
Monitoring Network



Variability of Rainfall (P)



Potential Recharge (R_{ep}) estimates

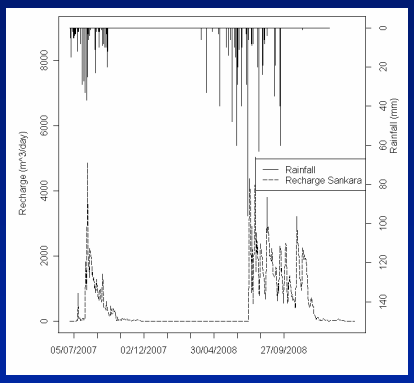


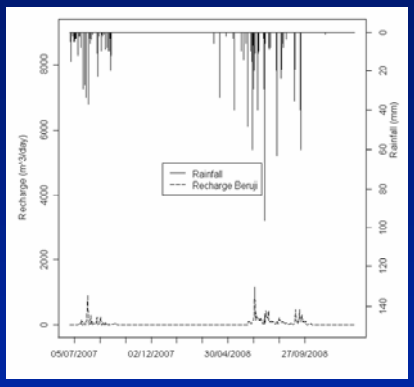
$$R_{ep} = -A_s.\Delta h - ET - O_t$$ non-rainy days

$$R_{ep} = a h_{av}^{b}$$ rainy days

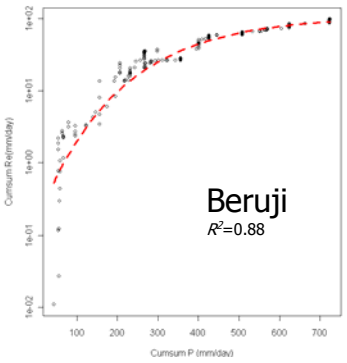
(Sharda et al. 2006)

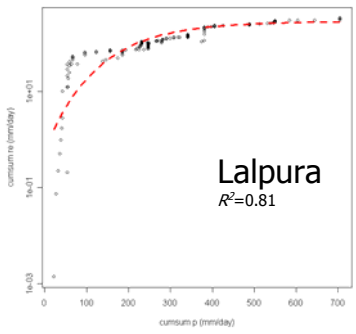
R_{ep} estimates (m^3/day)





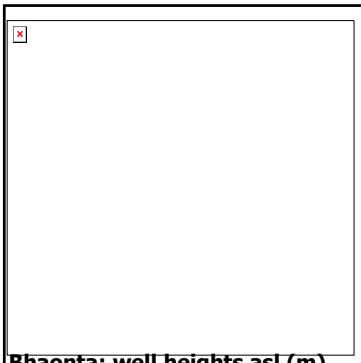
RWH Structure	R_{ep} mm/day		Days Storage		% P -> R_{ep}	
	2007	2008	2007	2008	2007	2008
Sankara Bandh	45	55	169	260	14	22
Beruji Bandh	20	27	138	201	8	10
Jhiri Johad	12	19	273	+270	6	8
Lalpura Johad	15	23	240	+270	6	8



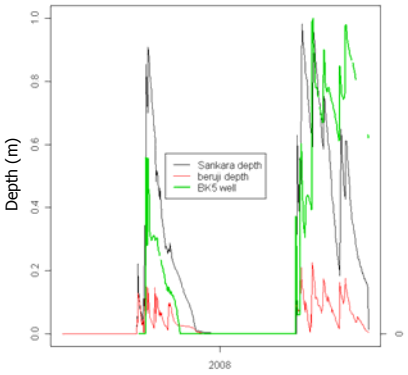


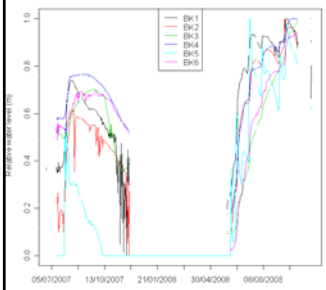
Cumulative sum R_{ep} and Cumulative sum Rainfall relationship

= RWH limited capacity to induce more recharge



Bhaonta: well heights asl (m)



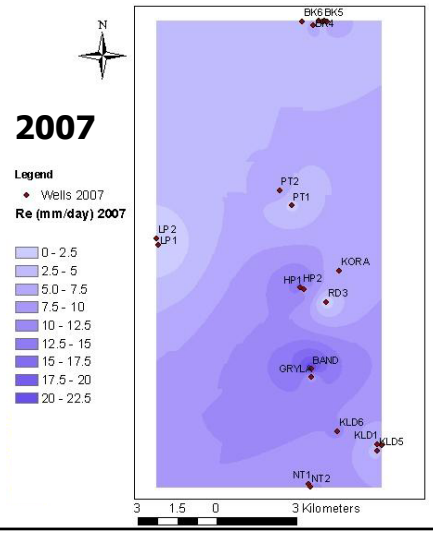


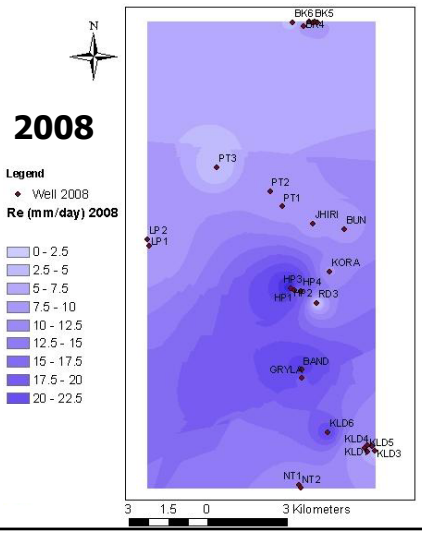
Bhaonta: relative well heights

Well Response

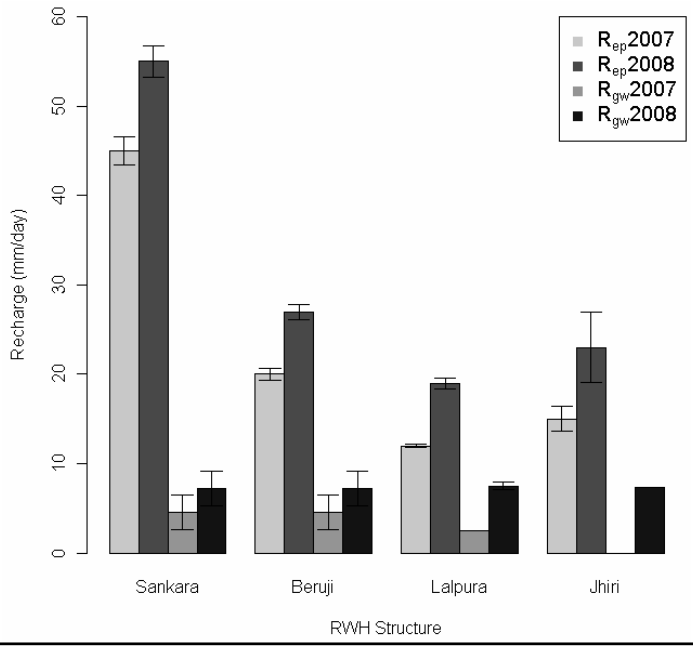
Water Table Fluctuation Method Recharge Estimation

$$\mathrm{Re} = Sy.\frac{\Delta h}{\Delta t}$$

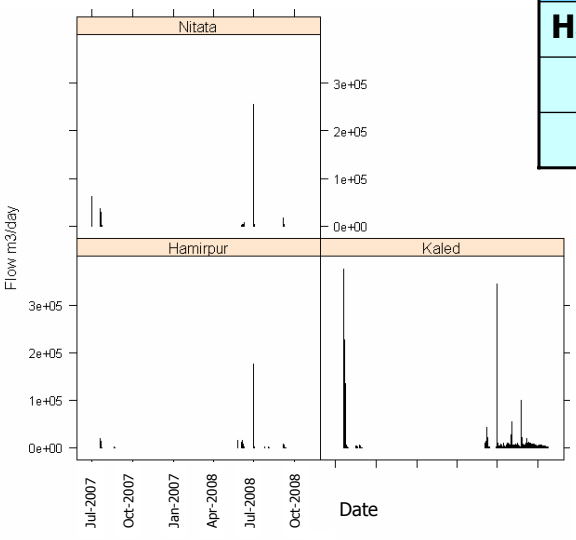




Comparison of recharge estimates



River flow



Anicut	Average Re mm/day
Hamirpur	44
Kaled	25
Nitata	42

Recharge from Anicuts on River

Field-Scale Characteristics

- High inter/intra-annual P variability
- RWH
  - 12-55 mm/day ~ 170-260 storage days
  - Dependent on P, but limiting capacity
  - Difference btw *Johad* / *Bandh*
  - ~ 7% P -> R_{ep}
- Wells and Groundwater
  - No baseflow, high lateral flow
  - Annual fluctuation

Acknowledgements

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- **Arvari River Community**
- **Willem Vervoort**