



A century of groundwater levels in India and Pakistan

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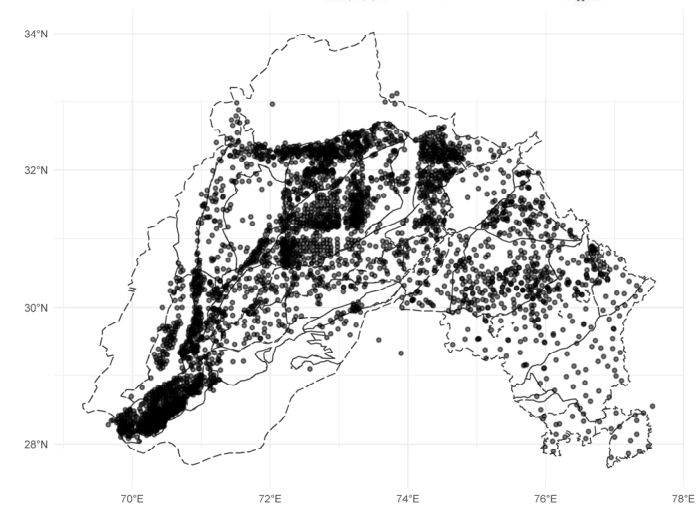
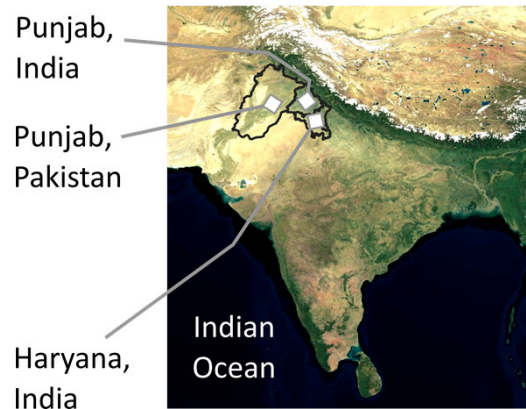


British
Geological
Survey



Project background

- Groundwater depletion is a major concern.
- Groundwater used for > 100 years.
- Groundwater level change since 1900?
- 4028 observation wells from 1900 - 2010



Pre1857

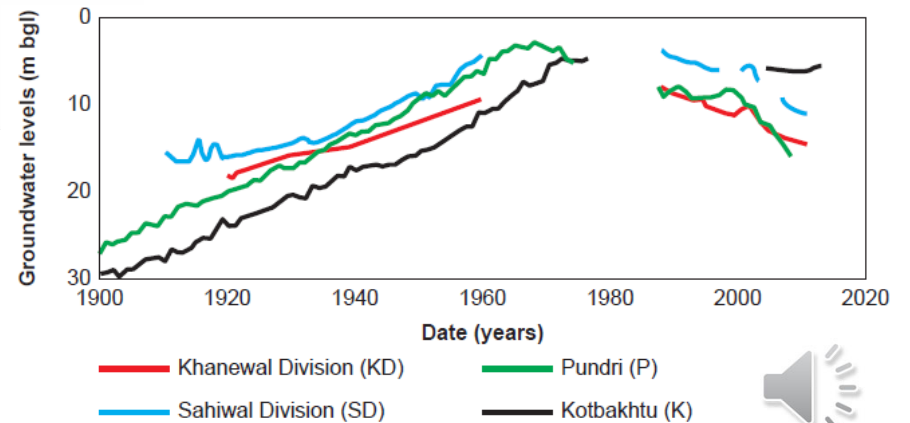
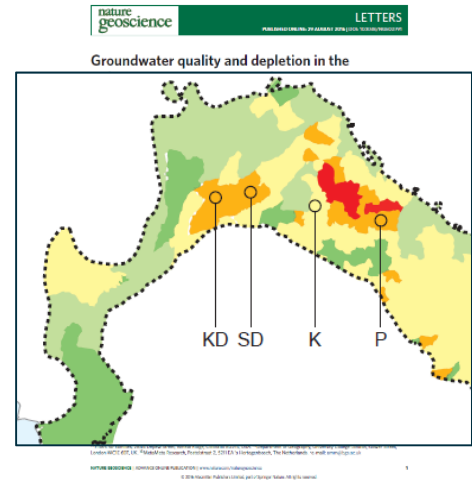
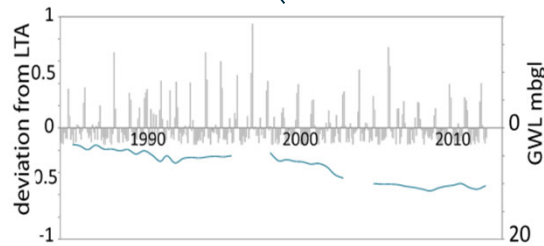
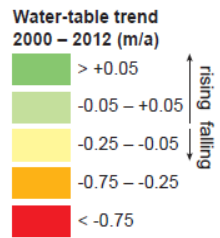
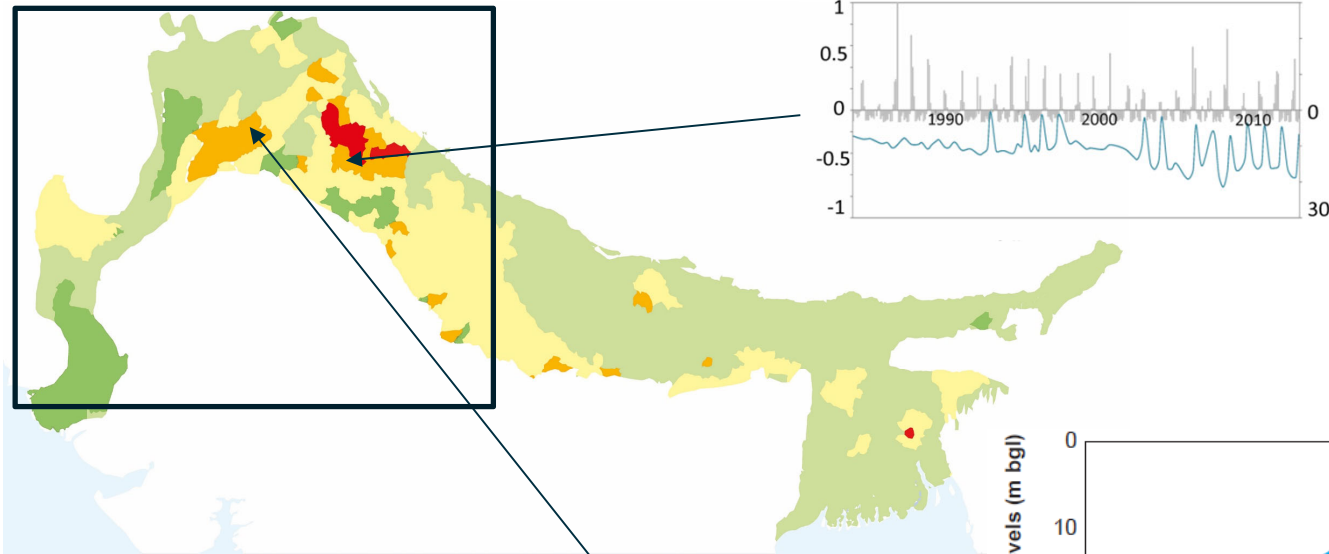


1800s - 1947



Post 1947

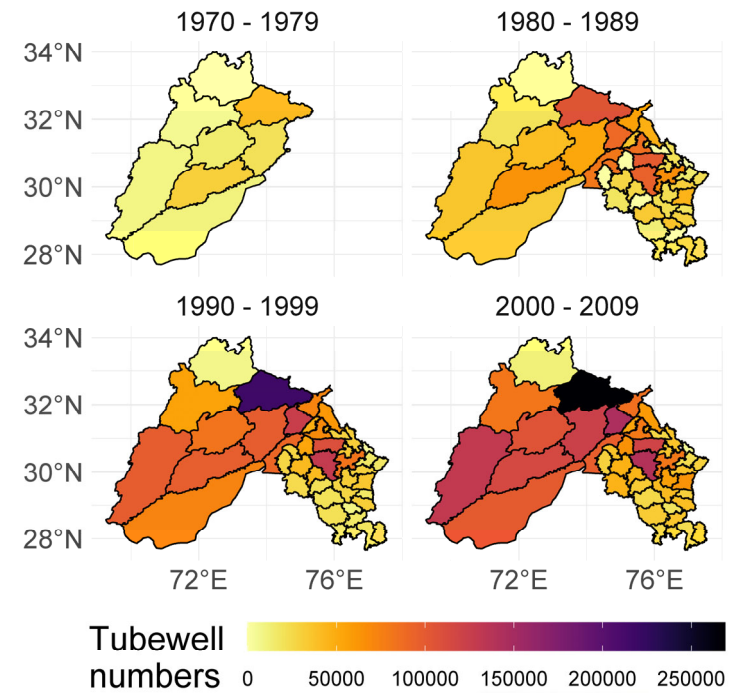
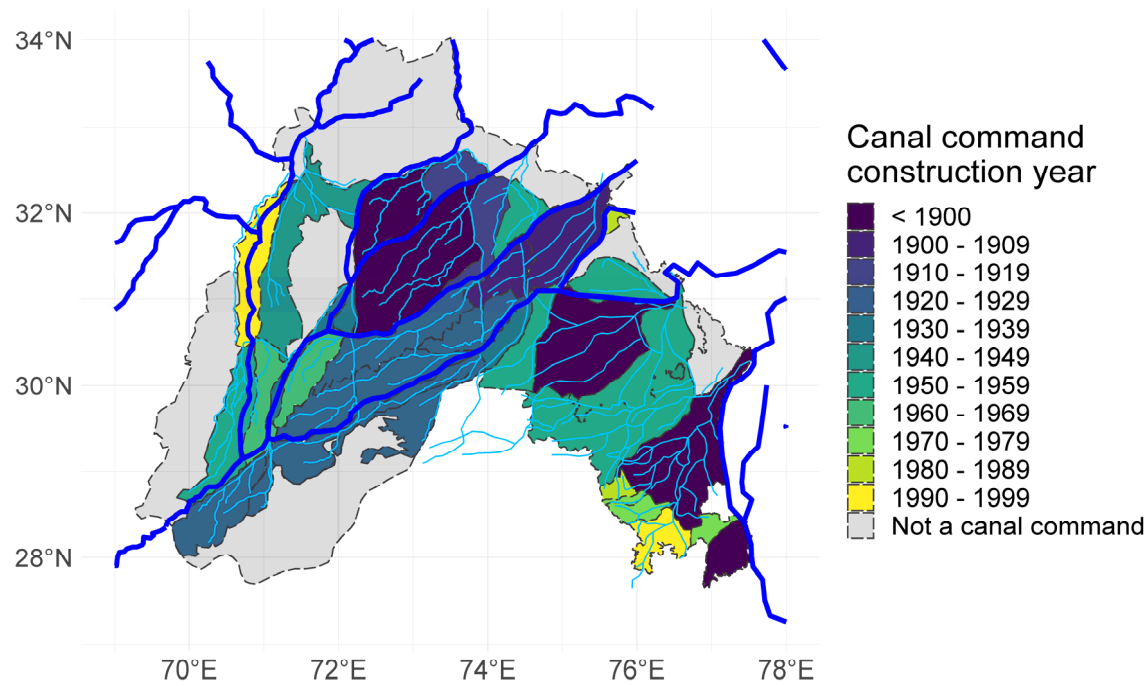
Motivation



MacDonald et. al. 2016, Nat Geoscience



A century of water resource development



Compilation of historic groundwater data

- > 100 hydrographs scans:

 - old reports
 - books
 - government archives
 - digital and hard copy

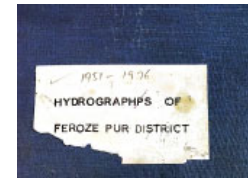
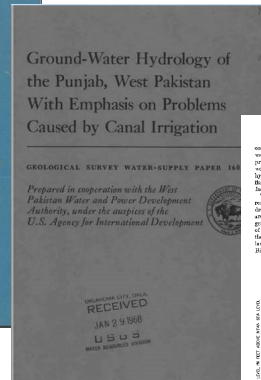
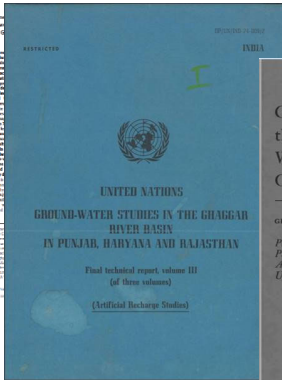
Environ Monit Assess (2015) 187:111–121
 DOI 10.1007/s10661-014-4111-1
 LETTERS

Groundwater quality and depletion in the Indo-Gangetic Basin mapped from *in situ* observations

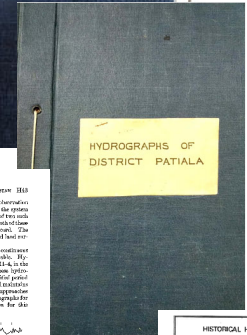
A. M. MacDonald¹, H. C. Boman², K. M. Alam³, A. Shah⁴, S. S. Foster⁵, K. Goyal⁶, S. J. Langan⁷, M. S. Rao⁸, M. Shamsuddin⁹, L. Smith¹⁰, R. G. Wells¹¹, K. S. Yeh¹²

Groundwater depletion from the Indo-Gangetic Basin, which supports the largest population in the world, has not been fully understood. This paper presents a comprehensive review of the literature on groundwater depletion in the Indo-Gangetic Basin, with a focus on the Indo-Gangetic Basin. The review covers the period from 1950 to 2010, and includes a synthesis of the available data on groundwater depletion in the Indo-Gangetic Basin. The review identifies the major factors contributing to groundwater depletion in the Indo-Gangetic Basin, and discusses the implications of these factors for the future of the basin. The review also identifies the major gaps in our knowledge of groundwater depletion in the Indo-Gangetic Basin, and suggests areas for future research.

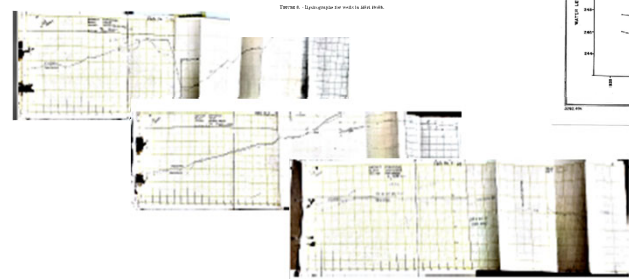
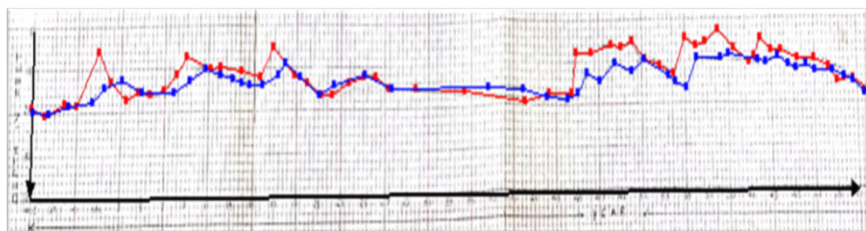
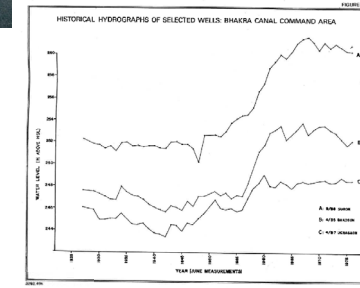
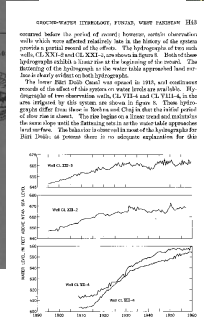
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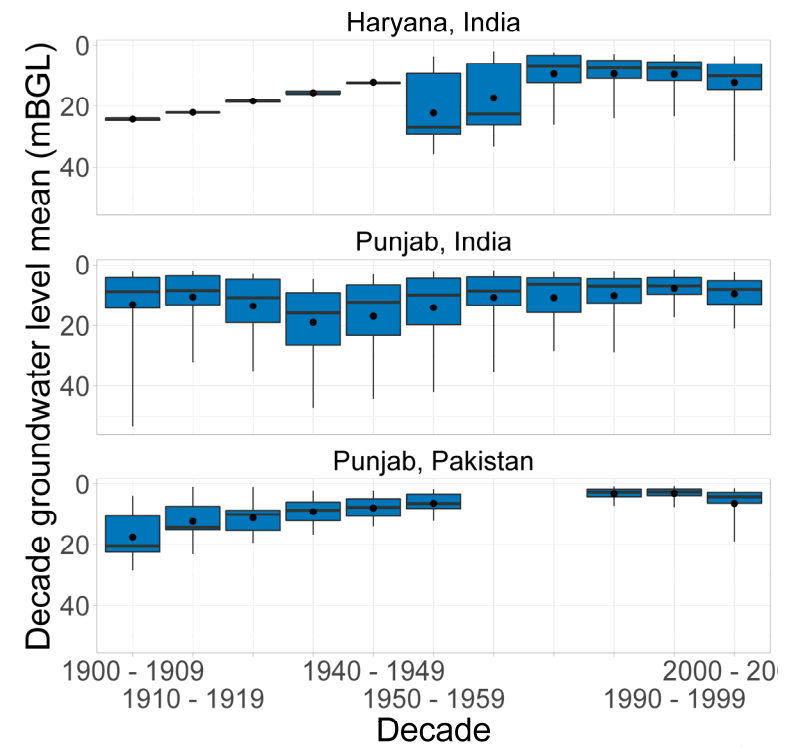
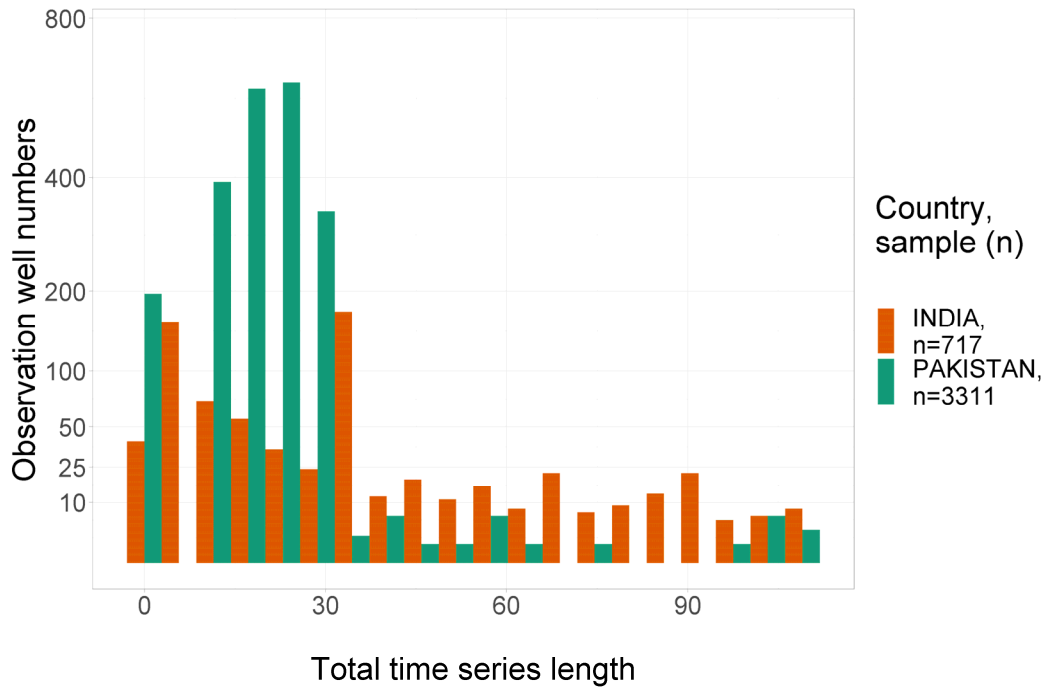
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2
3
4
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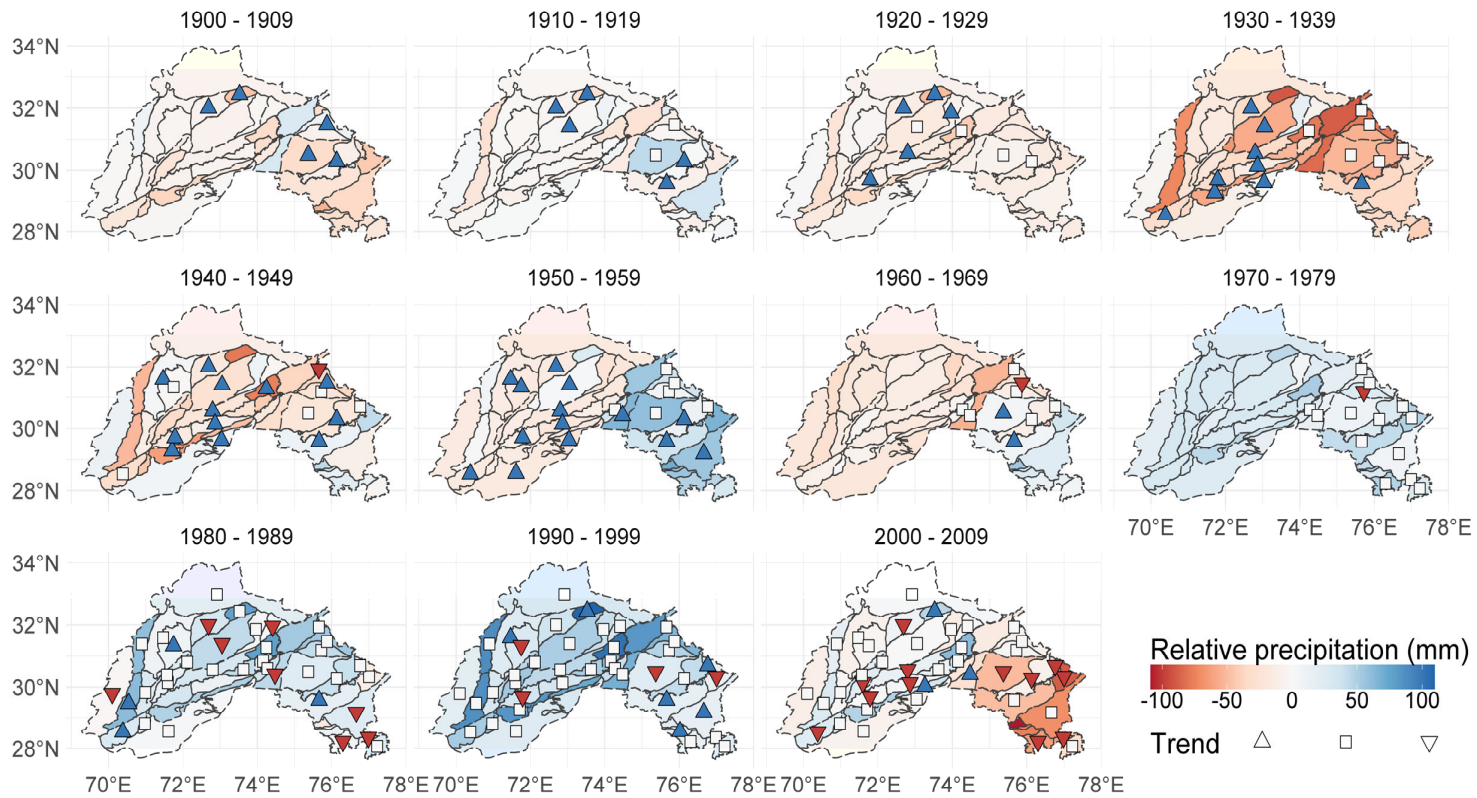
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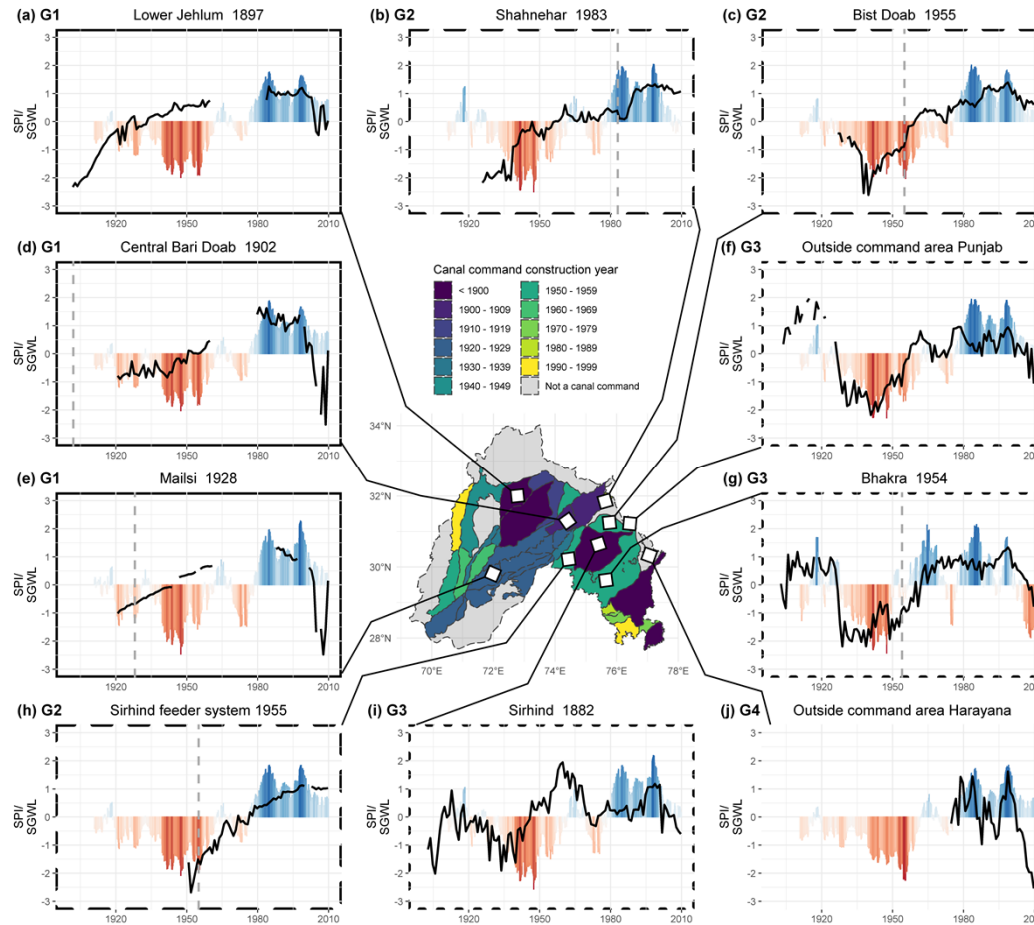
Tubewell numbers and groundwater levels



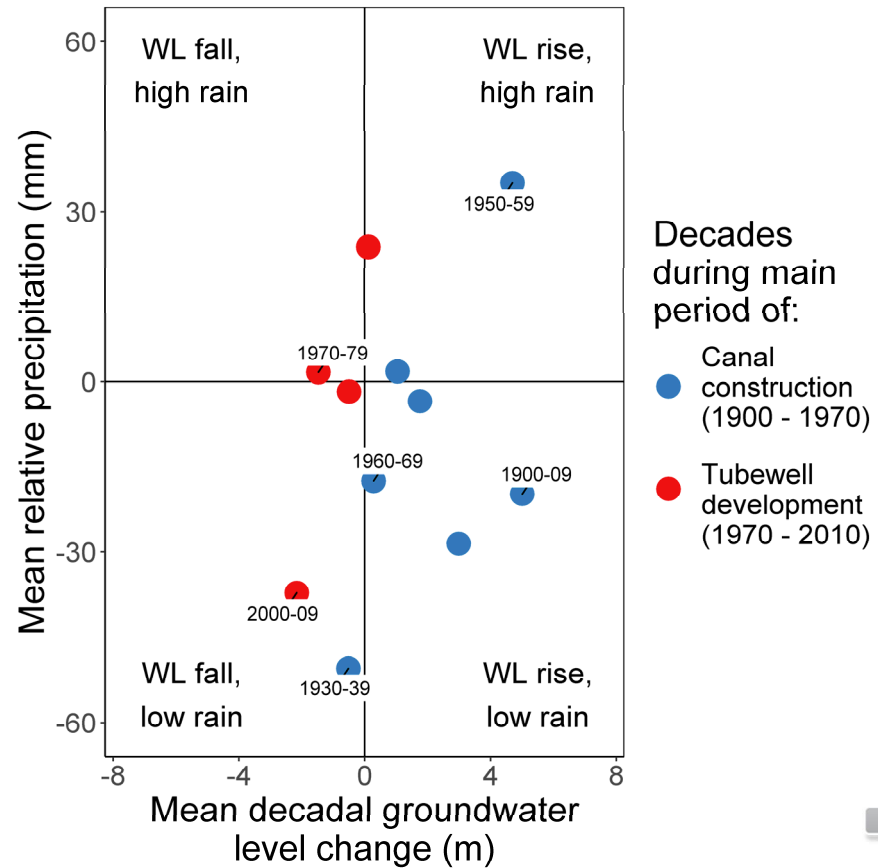
Groundwater level and precipitation trend



Regional groundwater level trends

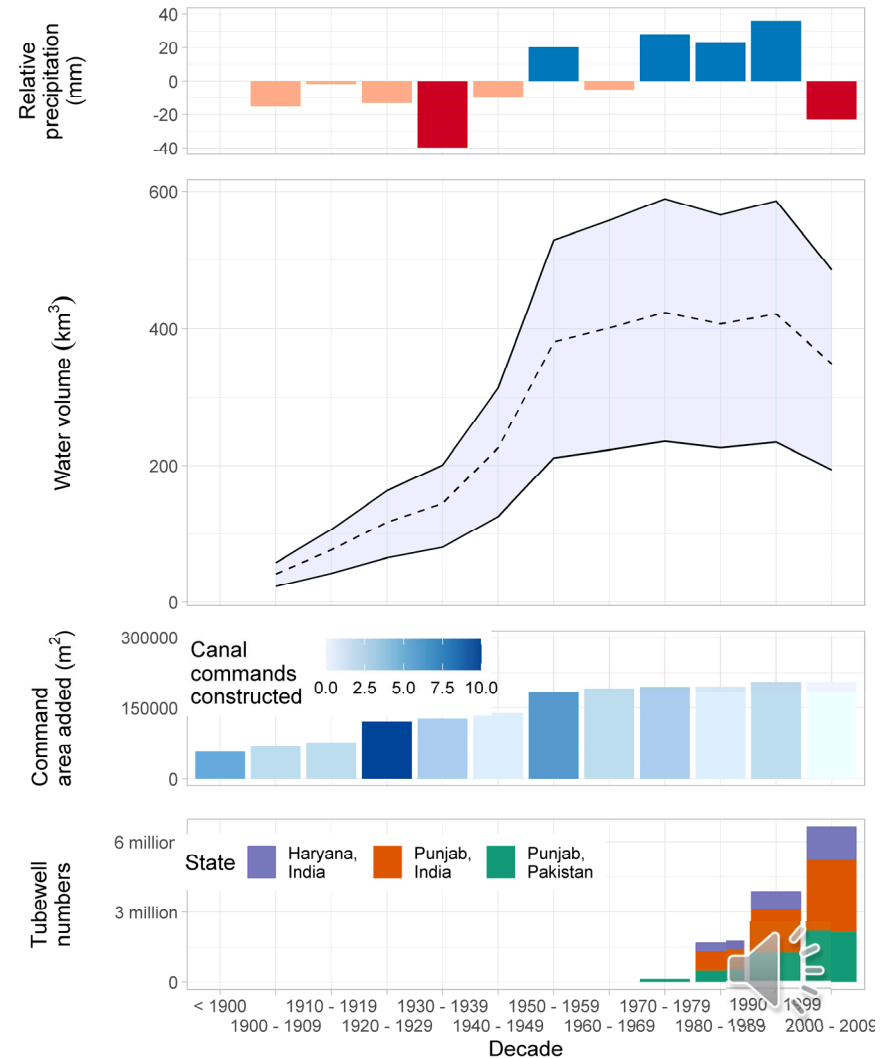


Influence of canals and tubewells on decadal trend



A century of accumulation

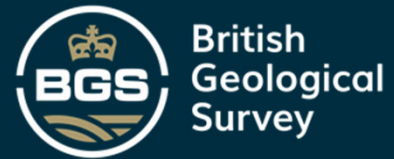
- 1900 – 1960:
 - Rainfall below period mean.
 - **125,000 km²** of canal area added.
 - Net groundwater accumulation: **350 km³** (range: 150-450 km³)
- 1960 – 1990:
 - Rainfall above period mean.
 - Little additional canal area added.
 - Tubewell development began.
 - Groundwater stabilised.
- 1990 – 2010:
 - Rainfall below period mean.
 - Groundwater depletion **75 km³** (range: 25-100 km³)



Summary and conclusions

- For the majority of the last century groundwater levels were rising, net groundwater accumulation was c.350 km³.
- Large scale irrigation development via canal construction played a defining role in groundwater accumulation.
- More recent groundwater depletion was driven by the superimposed effects of low average rainfall and large scale tubewell development.
- **Human activity in the early 20th century increased the total volume of groundwater available prior to large scale exploitation in the late 20th century.**





THANK YOU

Any questions?

