ALAN MACDONALD, DONALD JOHN MACALLISTER, GOPAL KRISHAN.
MUHAMMAD BASHARAT, **DAN LAPWORTH**, MATT ARRAN

Long term evolution of groundwater / surface water interactions in the Indus and Upper Ganges

British Geological Survey

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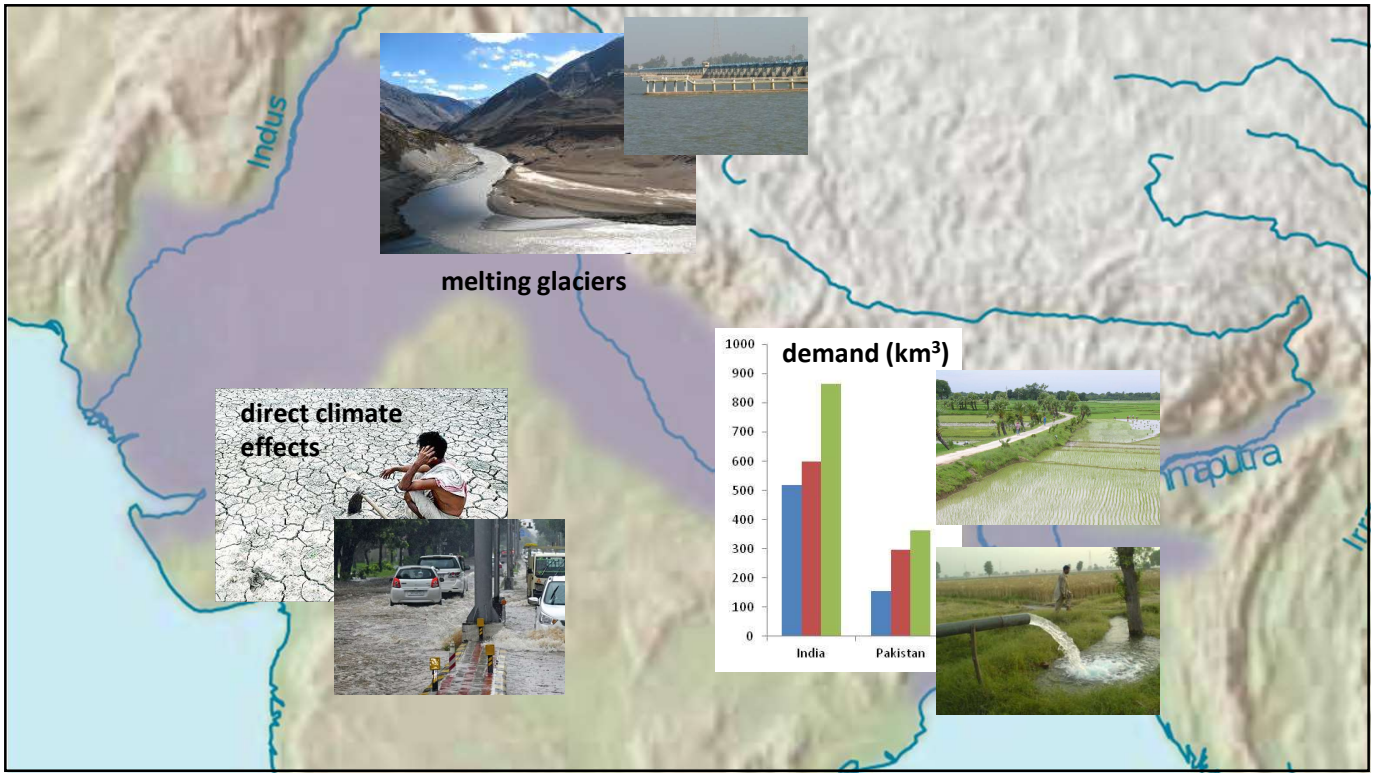

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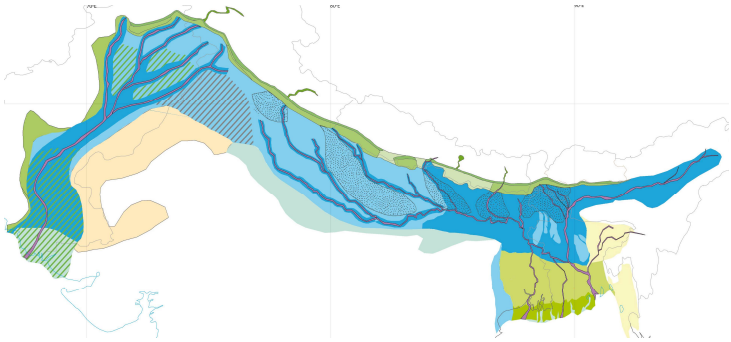
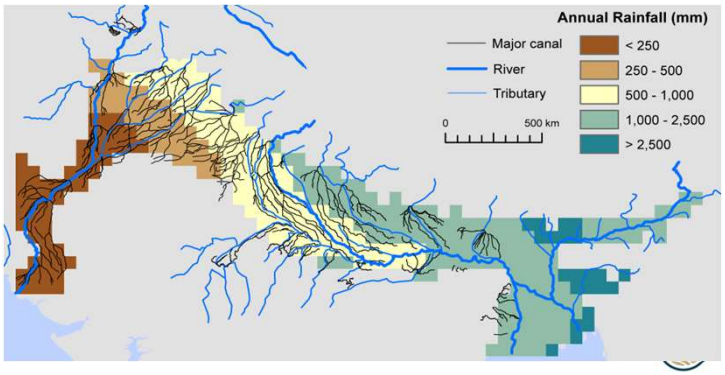
Hydrogeology

1. Highly prolific unconsolidated aquifer, high storage, yields > 20 l/s
2. Large systematic variations in aquifer properties: permeability, storage and anisotropy
3. High flow rivers: Indus, Ganges, Brahmaputra
4. Significant rainfall gradient
5. largest canal network in the world
6. Chemistry issues: salinity, arsenic, uranium, contamination





Bonsor et al. 2017 *Hydrogeol J.*

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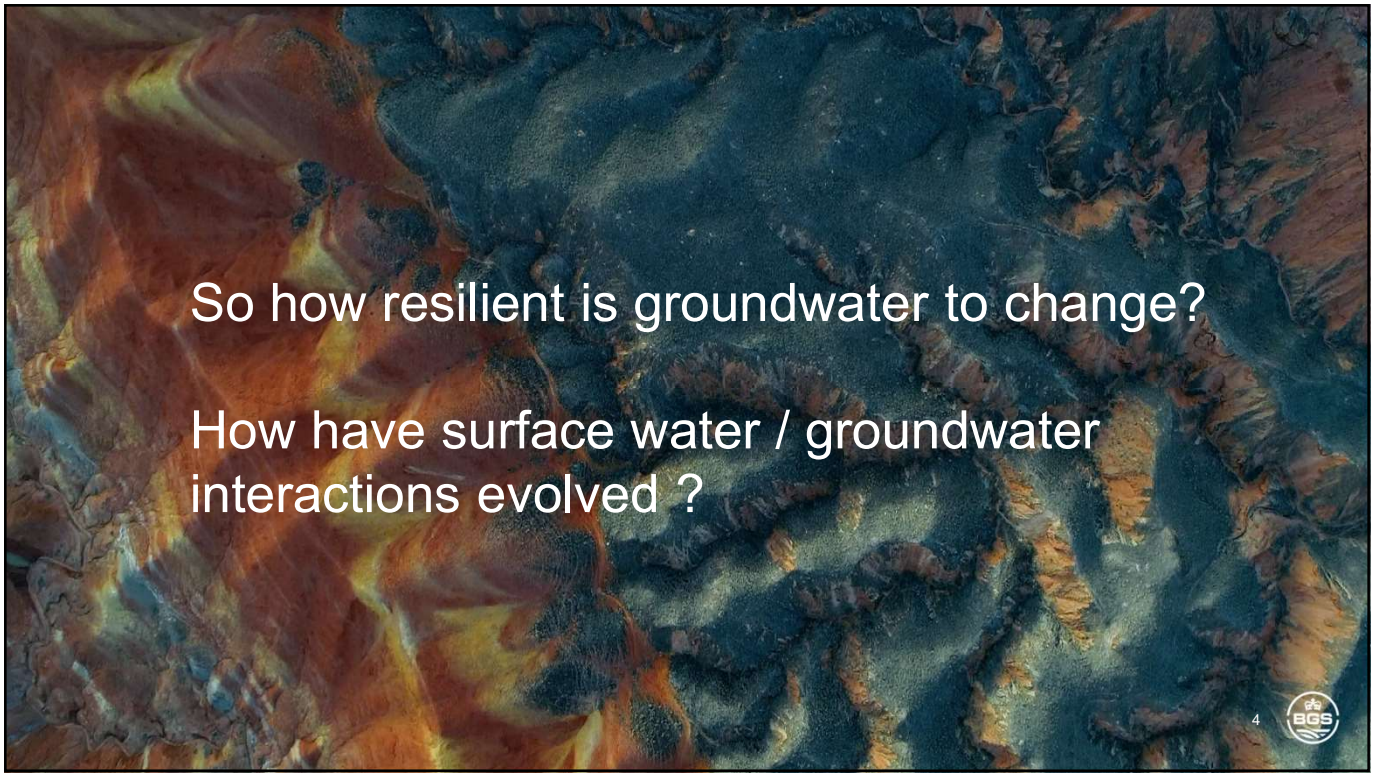

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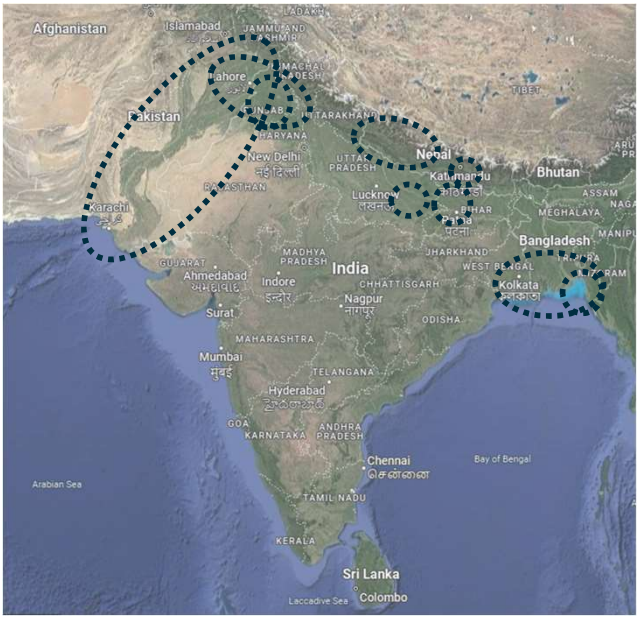
Studies

- Recharge and residence times using stable isotopes and environmental tracers
- Analysis of groundwater level data
- Water quality and salinity
- Groundwater modelling



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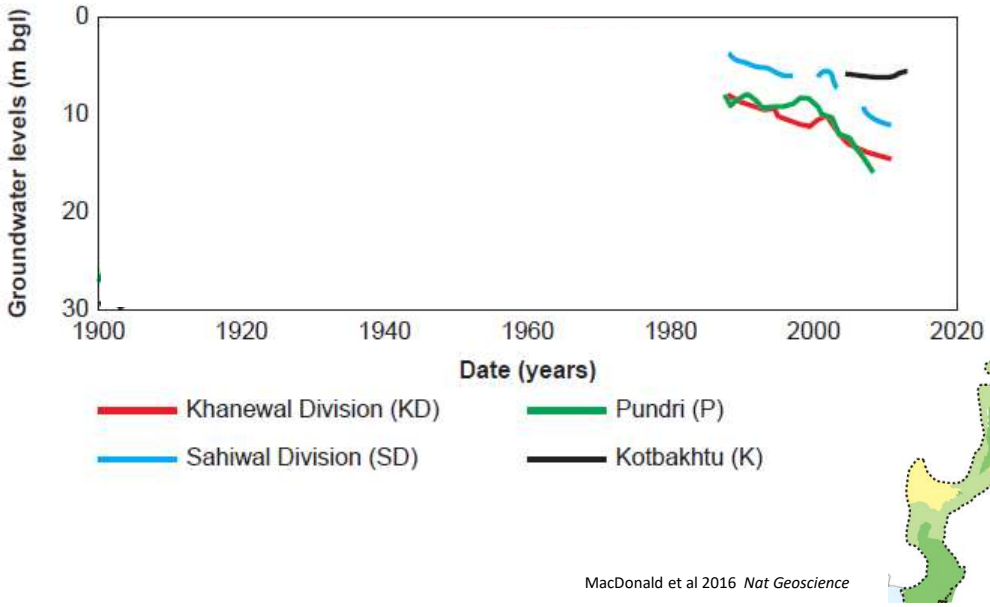
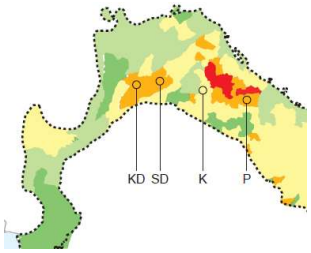
Long term hydrographs





MacDonald et al 2016 *Nat Geoscience*

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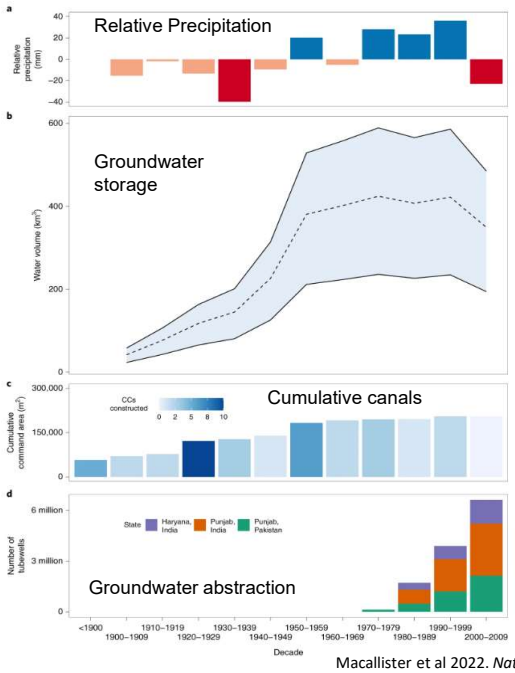

Macallister et al 2022. *Nat Geoscience*

Long term hydrographs

Digitised 4000 hydrographs – India and Pakistan

Groundwater accumulated during the 20th century

Influence of climate, canals and abstraction

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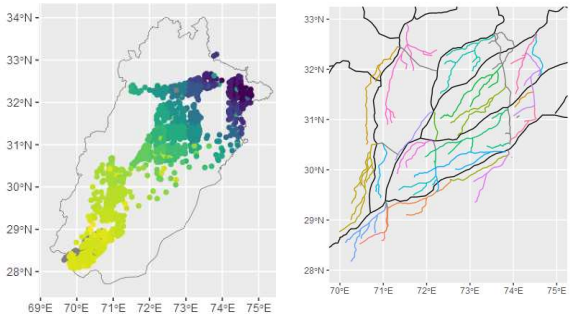
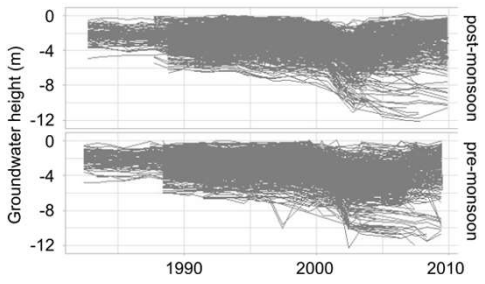
A closer look at canals





- 78,878 digitised groundwater records at 2,968 wells, 1979 – 2009
- Digitised abstraction tubewell numbers, at 5-year intervals and by district
- Spatial networks of rivers and canals, with associated canal inflow data
- Data on precipitation and potential evapotranspiration

BGS, IWASRI in prep ..

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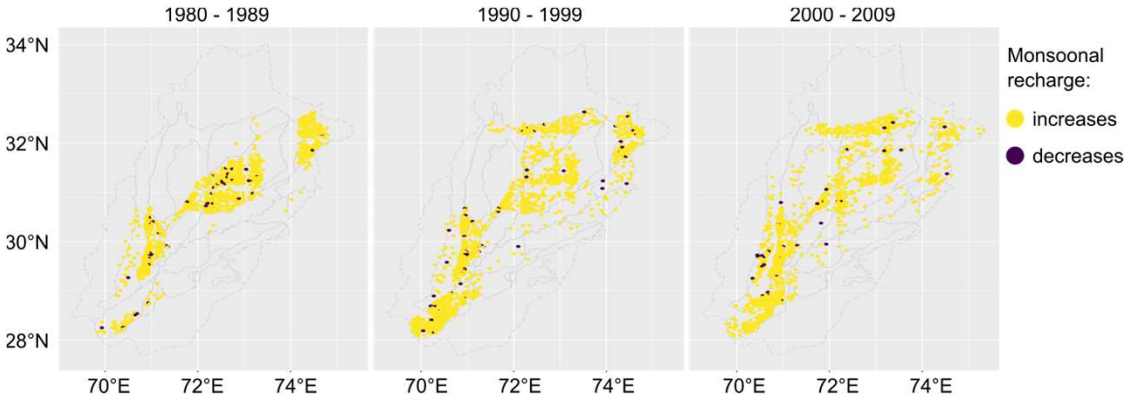
A closer look at canals

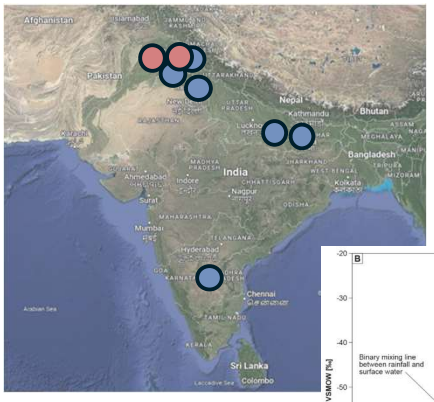


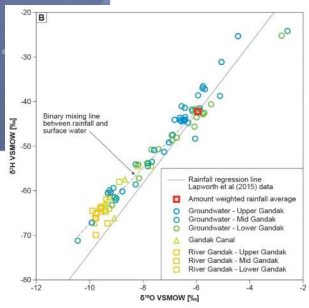
Lowering water levels BUT …. increases in monsoonal recharge

Related to depth of water table, rainfall and distance from canals

BGS, IWASRI in prep ..

Stable isotopes studies

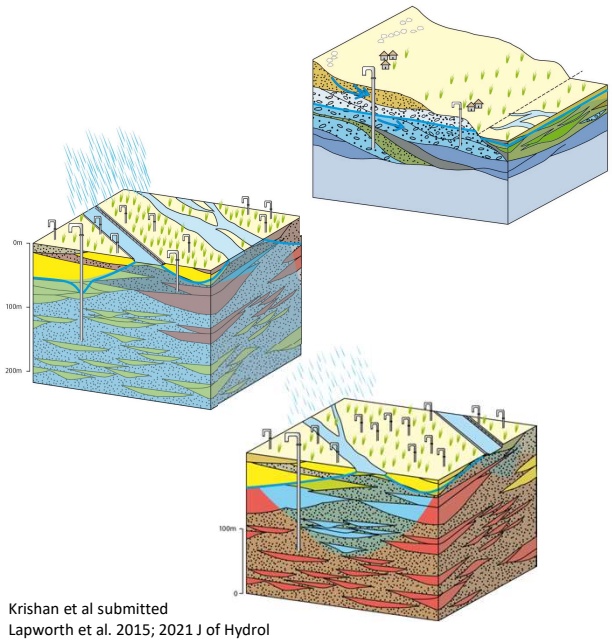




- Env tracers
- Water levels

- Using water stable isotopes of groundwater, rainfall, rivers and canals.
- Also inorganic chemistry and emerging organic chemistry
- Dissolved gases – SF6 and CFC
- Supplemented by Water level variations

Canals and rivers



Krishan et al submitted
Lapworth et al. 2015; 2021 J of Hydrol

- There is much variability in relationship
- In upper Ganges – baseflow from rivers shown to be important for environmental flows
- In Upper Indus, rivers and canals recharge, but rainfall dominates
- In drier parts of the Indus canal flow dominates for 10s of kilometers
- Stable isotopes indicate connection between shallow and deep in upper Ganges and Indus

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Summary

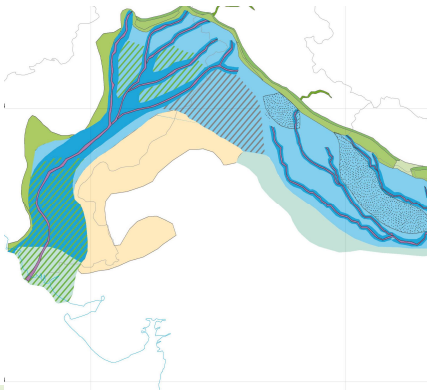
Groundwater / surface water interaction has been evolving for > 150 years

Interactions vary spatially due to:

- distance down catchment, related to the prevailing rainfall gradient;
- position in the canal command

Interactions vary with time due to:

- the historical evolution of the canal network;
- patterns in precipitation over the past 120 years;
- increased pumping, which has also led to increased capture of surface water



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