



A tale of two groundwaters

Contrasting resource development and trajectories of change across two continents
(and two countries)

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DONALD JOHN MACALLISTER

DONMAC@BGS.AC.UK

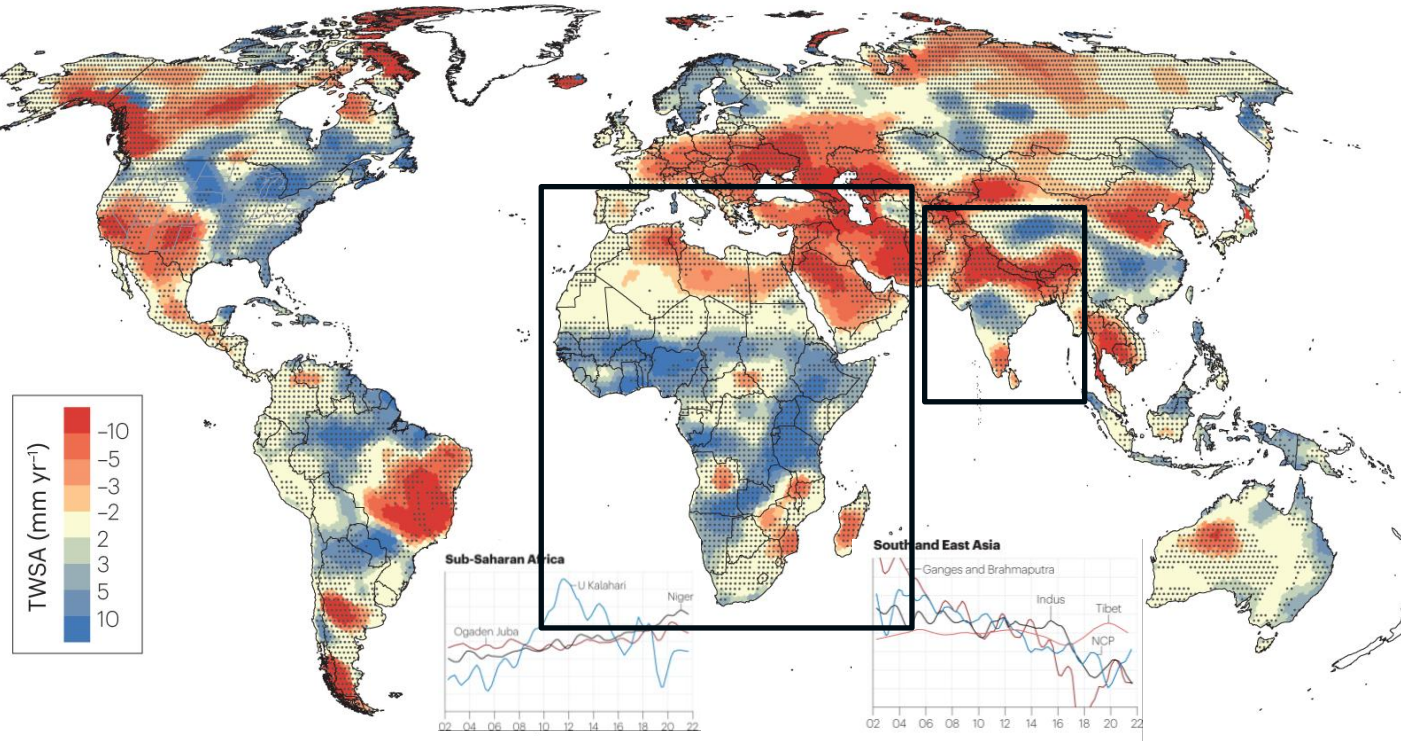


British
Geological
Survey

Introduction: Global Groundwater Trajectories

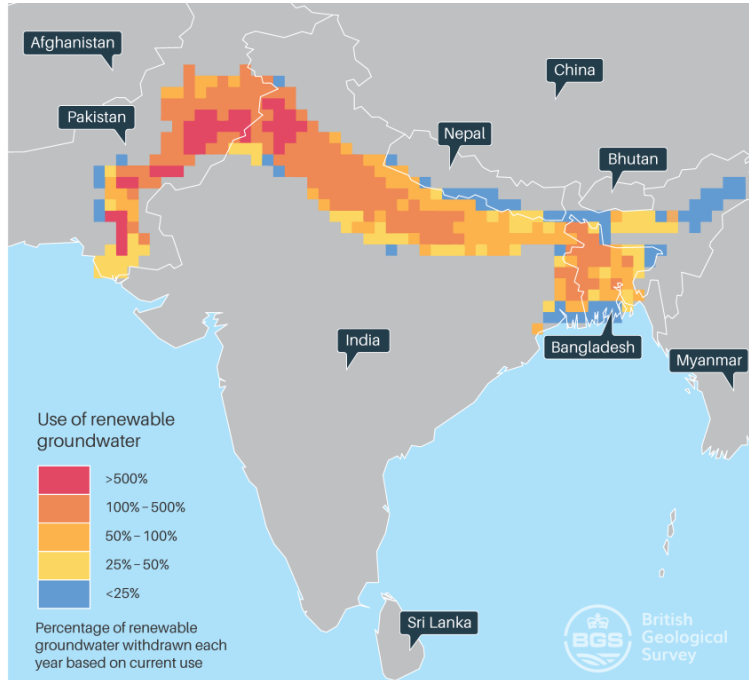
Scanlon, Bridget R., et al.
"Global water resources and
the role of groundwater in a
resilient water future." *Nature
Reviews Earth &
Environment* 4.2 (2023): 87-
101.

- In-situ data reveals trends where abstraction highest (75% global withdrawal)
- GRACE provides insight in data scarce regions.
- India and Africa, contrasting case studies.

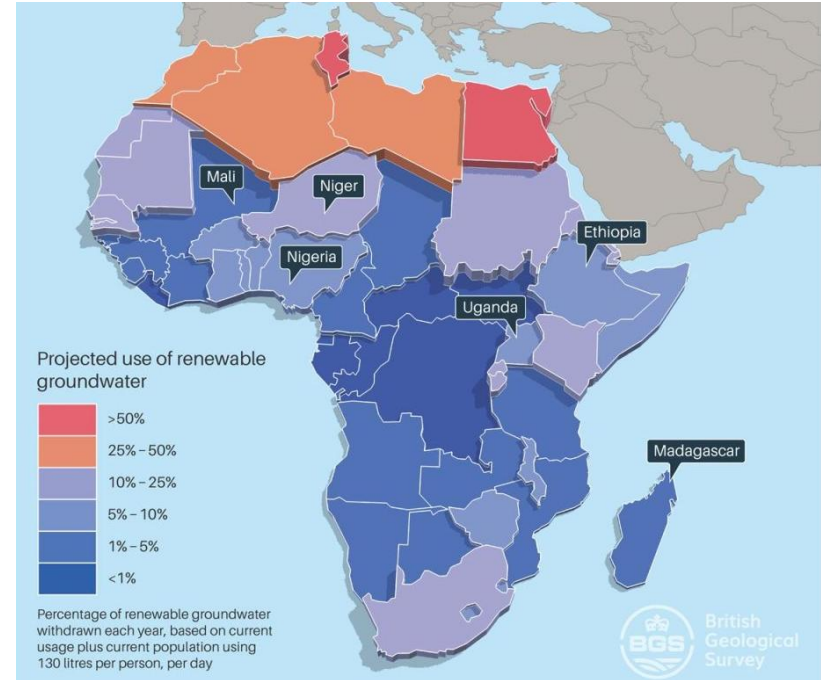


A TALE OF TWO GROUNDWATERS

Introduction: Over and under-development



Groundwater is over-exploited and under threat

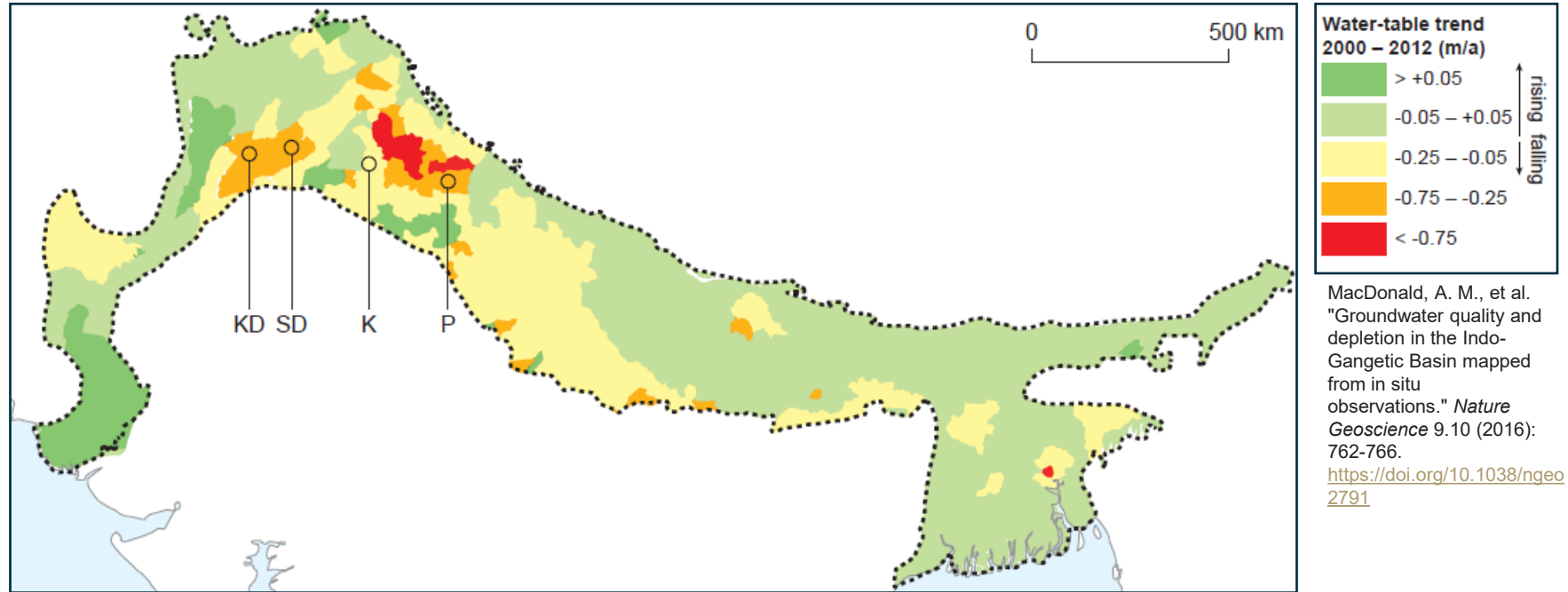


Groundwater is underutilised offering great potential

CHAPTER 1

India – an over exploited resource?

Chapter 1: Groundwater depletion

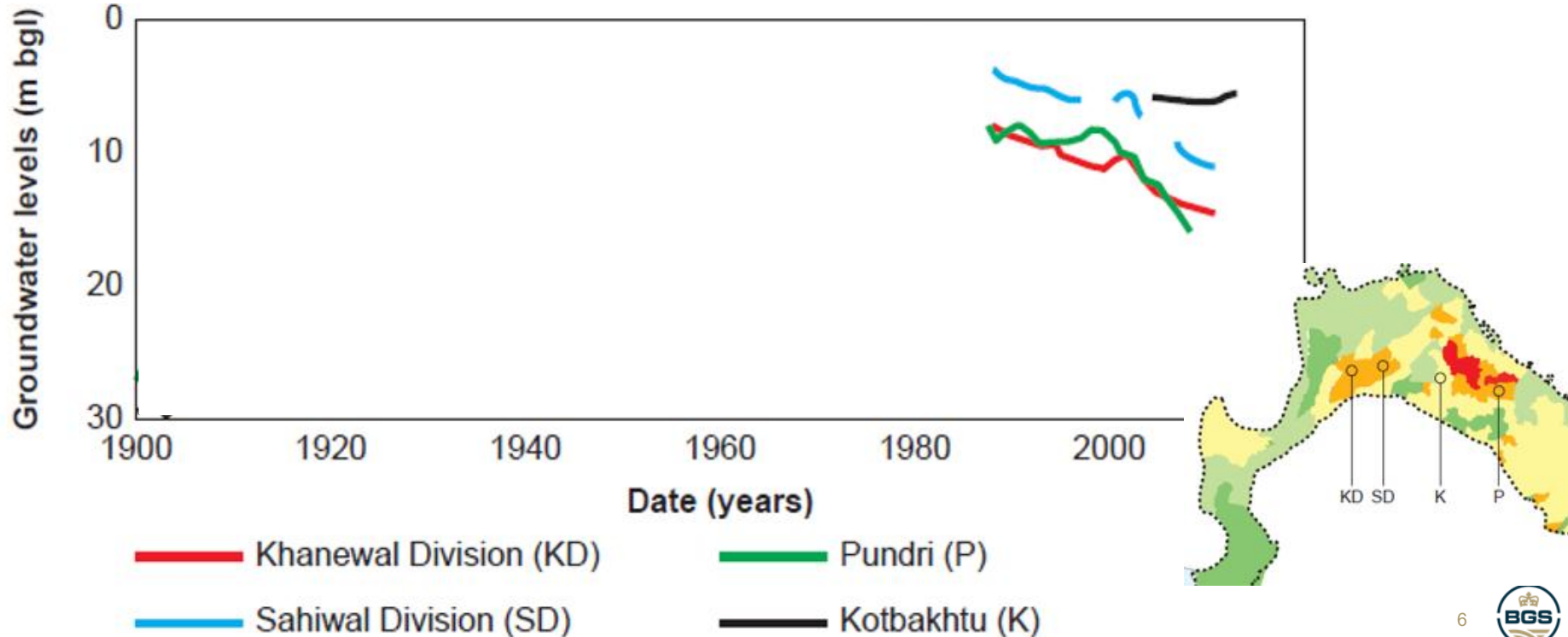


GW storage $30,000 \text{ km}^3 > 20 \times$ annual flow in the IGB $> 100 \times$ dam storage

Yields $> 20 \text{ l/s}$

Chapter 1: The long-term perspective

MACDONALD, A. M., et al. 2016.
Groundwater quality and depletion in
the Indo-Gangetic Basin mapped from
in situ observations. *Nature
Geoscience*, 9, 762 - 766.

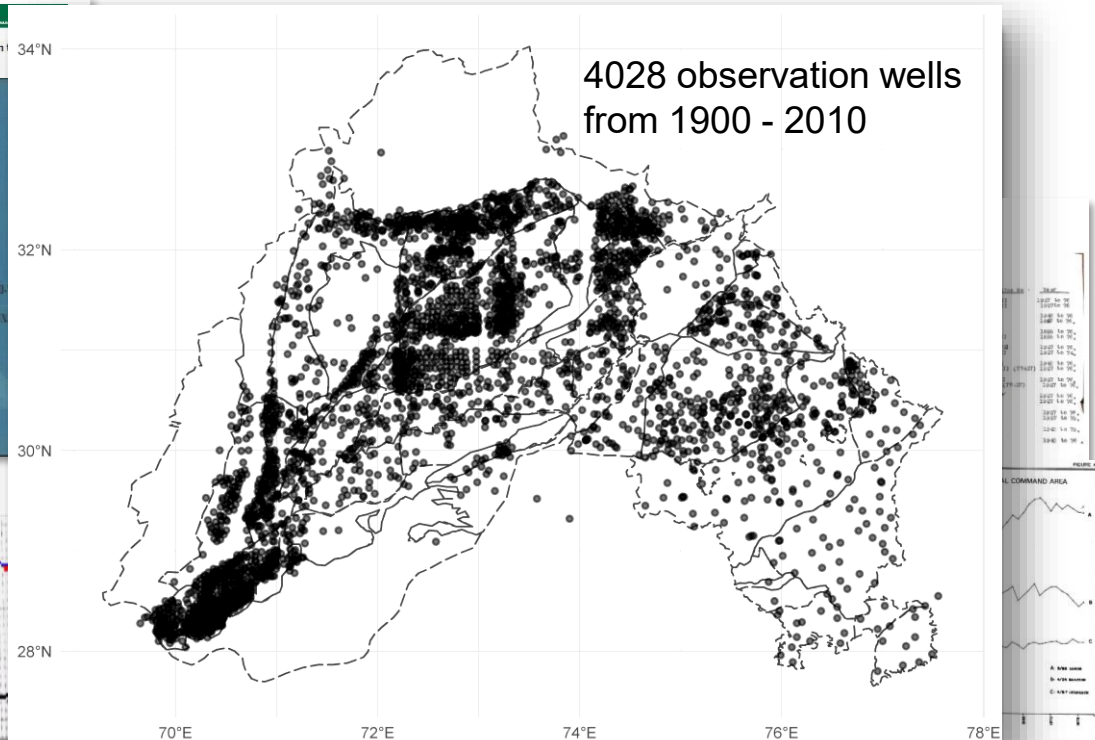
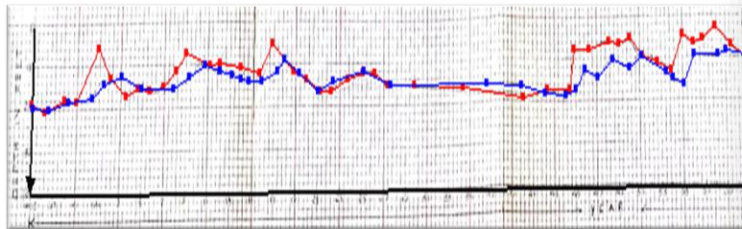


Chapter 1: Compiling historic groundwater data

MACALLISTER, D. J., et al. 2022.
A century of groundwater
accumulation in Pakistan and
northwest India. *Nature
Geoscience*, 15, 390-396.

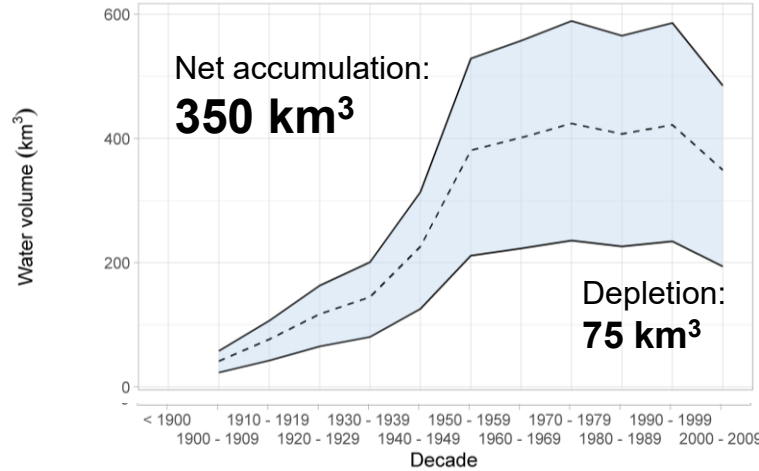
> 100 scans:

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

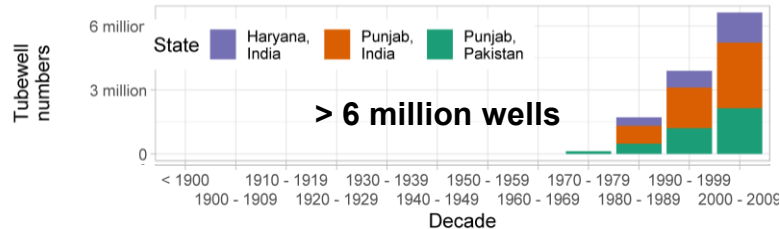


Chapter 1: The long-term perspective

MACALLISTER, D. J., et al. 2022.
A century of groundwater
accumulation in Pakistan and
northwest India. *Nature
Geoscience*, 15, 390-396.



Groundwater accumulation
in Pakistan and north-west India



Long history of large-scale water resources
developments with unintended consequences



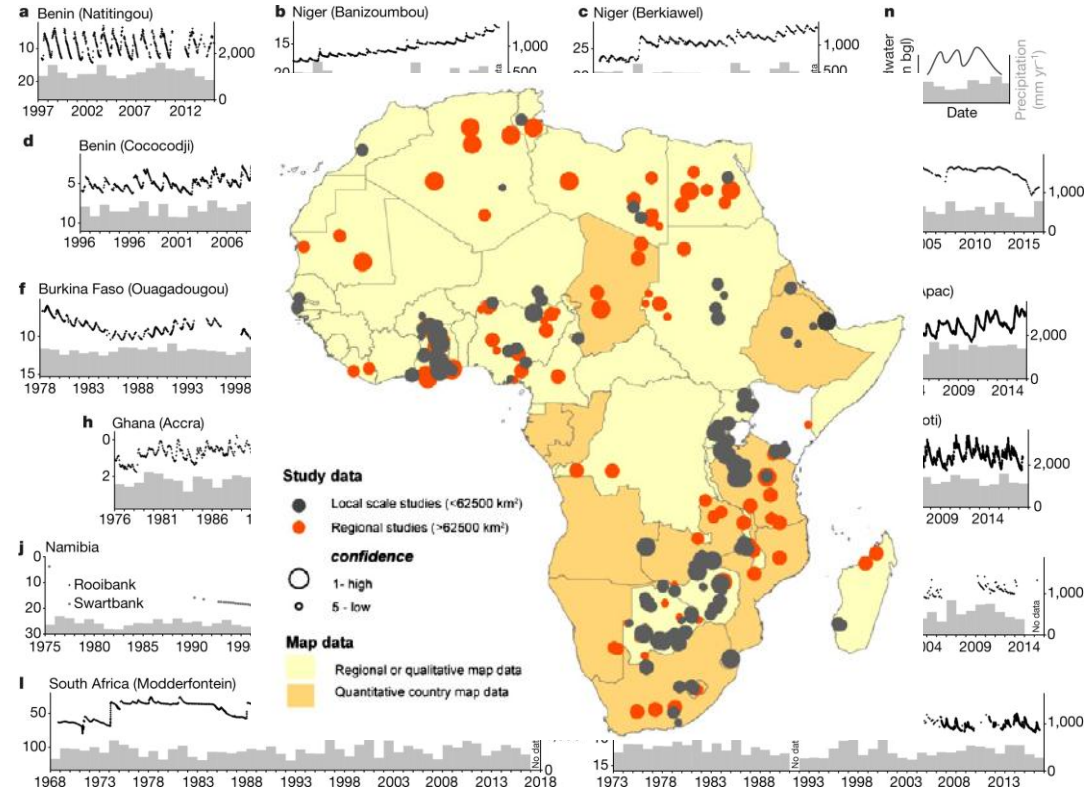
CHAPTER 2

Africa – an underdeveloped resource?

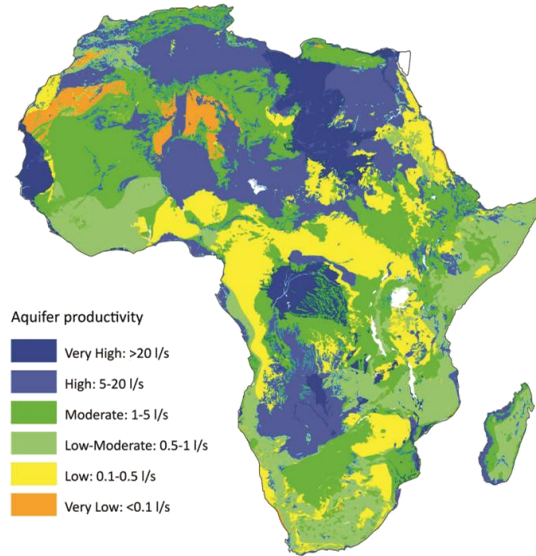
Chapter 2: Groundwater in Africa

Cuthbert, Mark O., et al.
"Observed controls on
resilience of groundwater
to climate variability in
sub-Saharan
Africa." *Nature* 572.7768
(2019): 230-234.

- Groundwater data is scarce across Africa.
- Scarce data can:
 - be used to characterise groundwater systems.
 - develop quantitative mapping at continental scale.
- Quantitative maps can help anticipate future development pathways.

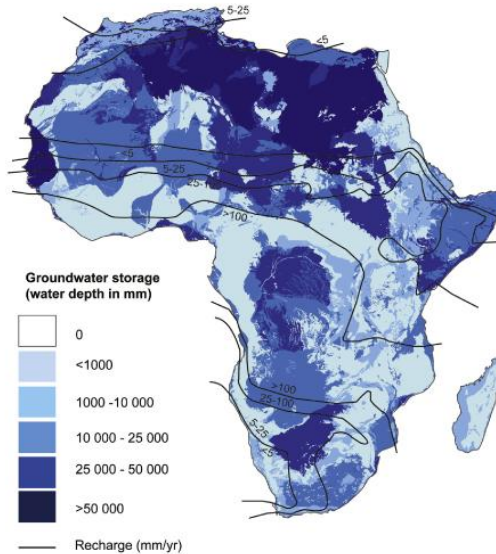


Chapter 2: Quantitative maps of groundwater resources

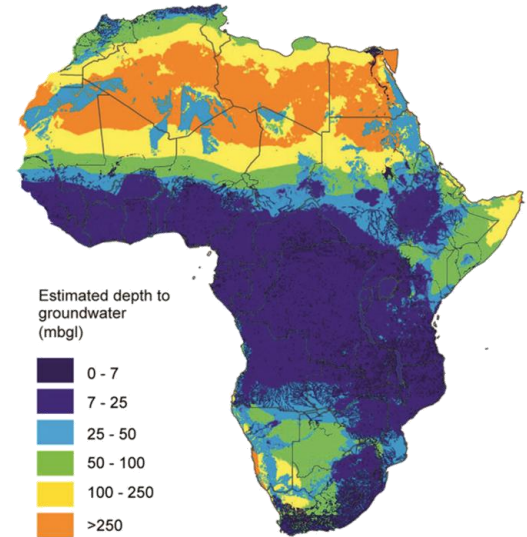


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Boundaries of surficial geology of Africa, courtesy of the U.S. Geological Survey.
Country boundaries sourced from ArcWorld © 1995-2011 ESRI. All rights Reserved

Aquifer productivity



Aquifer storage

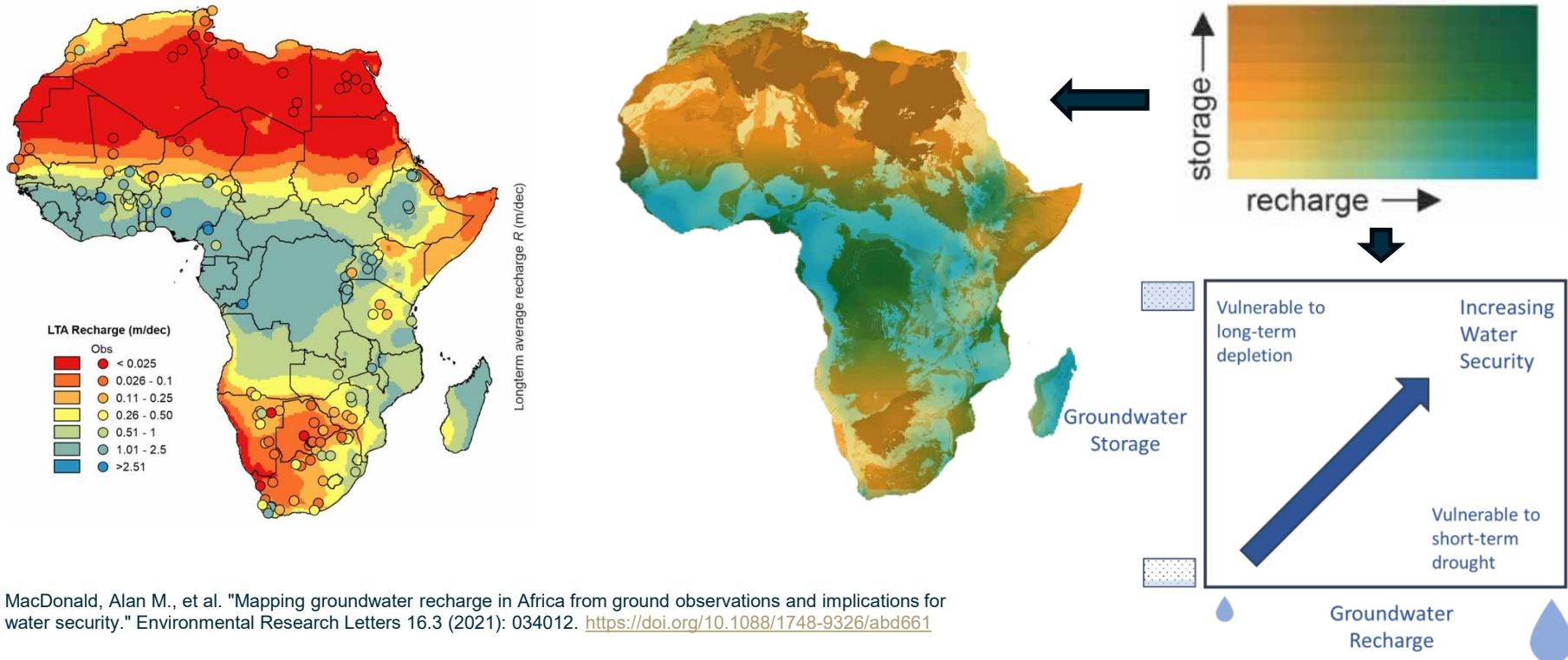


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Boundaries of surficial geology of Africa, courtesy of the U.S. Geological Survey.
Country boundaries sourced from ArcWorld © 1995-2011 ESRI. All rights Reserved.

Depth to GW

GW storage 600,000 km³ > 30x annual rainfall > 20 x SW storage

Chapter 2: Groundwater recharge and groundwater security



MacDonald, Alan M., et al. "Mapping groundwater recharge in Africa from ground observations and implications for water security." *Environmental Research Letters* 16.3 (2021): 034012. <https://doi.org/10.1088/1748-9326/abd661>

Chapter 2: Managing water security

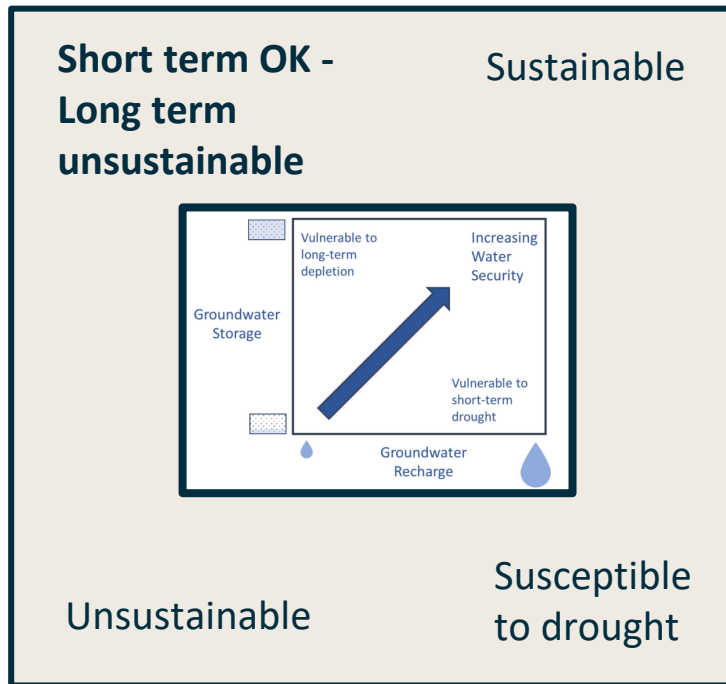
High recharge and storage:
high abstraction from multiple users possible

Low recharge and storage:
groundwater scarce

Low recharge, high storage:
high groundwater abstraction possible - but
long-term decline should be managed – a
policy choice?

High recharge, low storage:
groundwater users stressed by drought

Aquifer
Storage



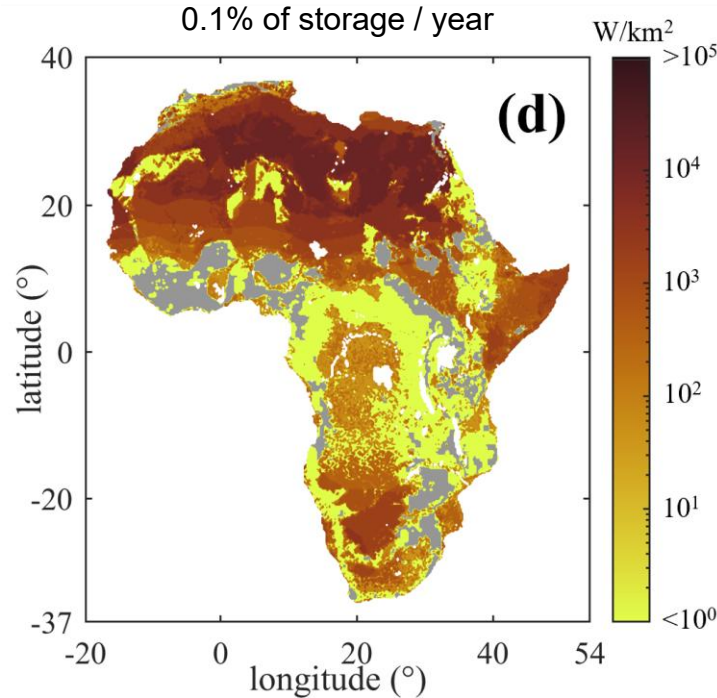
Long term recharge →

CHAPTER 3

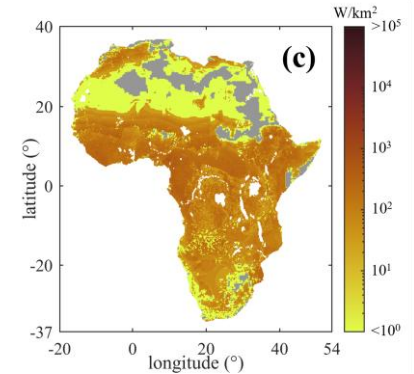
What does this
mean for future
use?

Chapter 3: How much can be pumped?

Zuffinetti, Guillaume, et al.
"A method for estimating
maximum safe installable
power for groundwater
extraction with application
to Africa." *Science of The
Total Environment* 955
(2024): 177062.



25% of annual recharge / year



Estimate of the maximum remaining installable power for groundwater development in Africa.

Chapter 3: Changing trajectories and enhancing recharge?



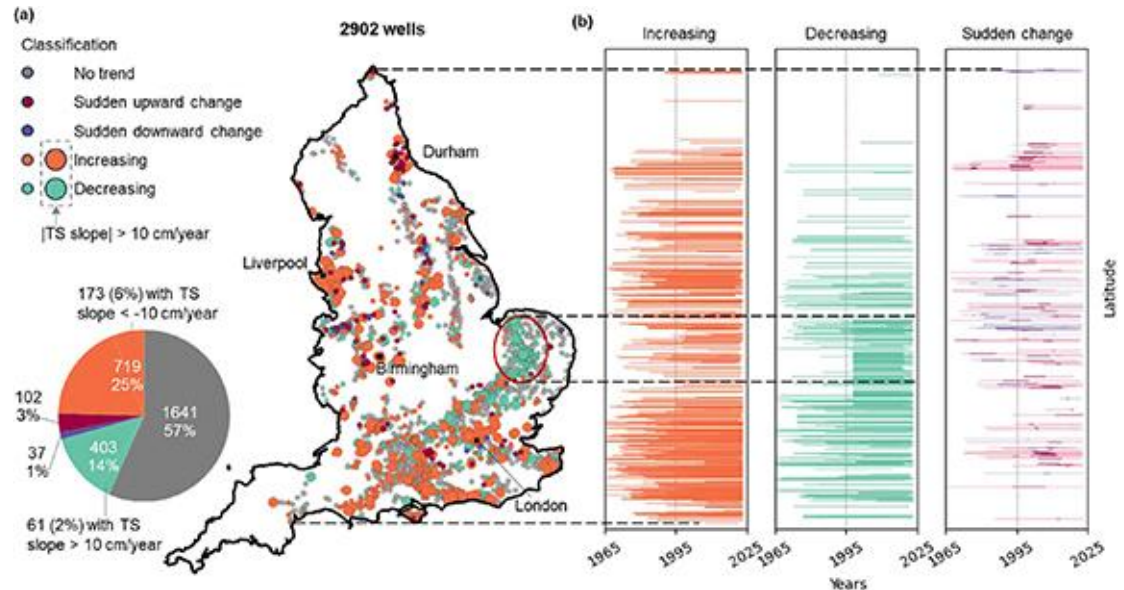
EPILOGUE

What about
closer to (my)
home?

Epilogue: A parallel closer to home?

Fang, Qidong, et al.
"Widespread human
footprints on groundwater
trends across
England." *Environmental
Research: Water* 2.2
(2026): 021001.

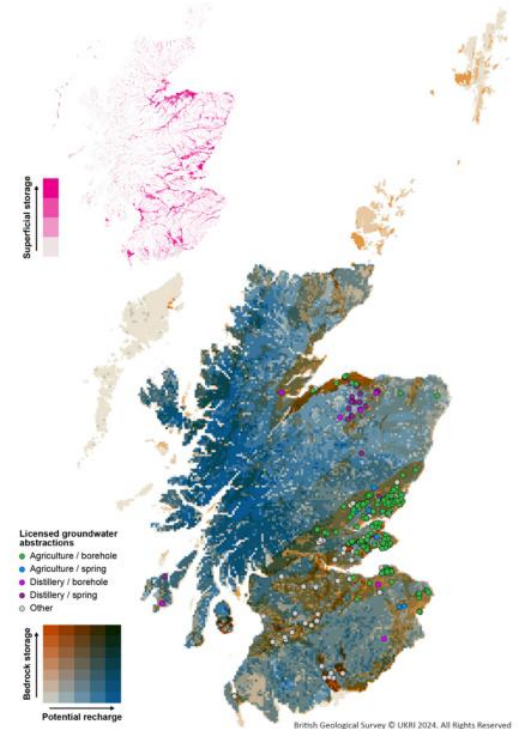
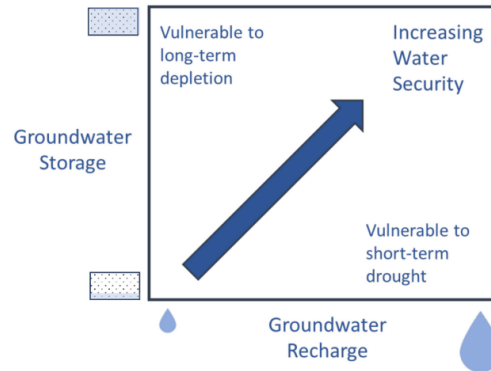
- Striking parallels between stage of groundwater development:
 - England and South Asia
 - Scotland and Africa.
- In England major aquifers:
 - long-history of groundwater use
 - supply large parts of the population including London.



Epilogue: A parallel closer to home?

Glendell, Miriam, et al.
"Future predictions of water scarcity in Scotland: impact on distilleries and agricultural abstractors."
(2024).

- In Scotland, much more complex hydrogeology makes groundwater development harder.
- However, groundwater underpins agriculture in the drier eastern parts of the country.
- Groundwater has potential to increase water security in a changing climate.

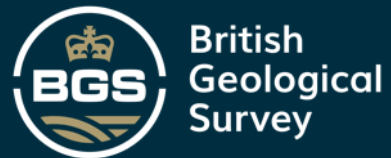


Summary and conclusions

Summary and conclusions

- A continent and a sub-continent (and two countries) with very different historical groundwater development pathways.
- In South Asia human impact exceeds climate impact, defining groundwater trajectories of change for more than a century.
- In Africa there is considerable potential for well managed expansion of groundwater use, supported by quality data.
- Future groundwater development pathways depend on:
 - Hydrogeology
 - Climate change
 - Socio-economic factors (i.e. what we decide to do with it)





Thank you
donmac@bgs.ac.uk