Groundwater in a Changing World - Buffer or Burnout?”

WRA Online Conference
Addressing Groundwater Resilience under Climate Change
28-30 October 2020

Karen G. Villholth
IWMI – International Water Management Institute
Outline

1. Groundwater – moving towards a buffer or burnout?
2. The quadrant of Climate Change impacts on groundwater
3. Adaptation – groundwater-based solutions
4. Some ways forward
The world on its edge
The world on its edge
Renewable fresh groundwater resources

van der Gun (2012)
Global freshwater availability
Global groundwater abstraction

Wada and Bierkens (2014)
Drivers of groundwater development

- GW provides a reliable and suitable water source:
  - Often widely present
  - In-built distribution and storage
  - All-year availability and drought resilience
  - Individual access and management possible
  - Little loss from evaporation
  - Normally a safe source of drinking water

- Increasing demand for drinking water and food
- Better low-cost efficient pumps and wells
- Better knowledge on GW resources
- Increasing attention from governments, private sector and donors
Climate change impacts on groundwater

- Groundwater provides resilience and a critical adaptation mechanism if well-managed
- In arid areas, GW recharge will be increasingly episodic and focused (Cuthbert et al, 2019)
- Most vulnerable areas: large coastal cities, tropical deltas, and small islands (due to seawater intrusion, subsidence and dense populations)
- In humid areas, like Denmark, groundwater levels are rising
- Groundwater depletion and flooding will co-exist
Challenges

- Exact impacts are still not well understood
- Impacts on both quantity and quality important
- Groundwater is the ‘memory’ of climate, and so understanding groundwater in the context of climate (historic and future) is key
- Climate footprint on groundwater is increasingly confounded/overshadowed by human impact
The quadrant of GW and Climate Change impacts

Water quantity

Direct
Indirect

Water quality

Direct
Indirect
Direct impact on GW quantity

Water quantity
- Direct
- Indirect

Water quality
- Direct
- Indirect
Research in Sub-Saharan Africa

Cuthbert et al., 2019
Anomalies during El Niño event 2015-2016

Large-scale climate anomalies over the study region for Oct-Apr 2015–2016. (a) SPEI-7. (b) Anomalies of the 80th percentile of daily TRMM rainfall (mm day$^{-1}$).
Indirect impact on GW quantity

Water quantity
- Direct
- Indirect

Water quality
- Direct
- Indirect
Indirect impact on GW quantity

Water quantity
- Direct
- Indirect

Water quality
- Direct
- Indirect
Indirect impact on GW quantity

Scanlon et al., 2016
Direct impact on GW quality

Water quantity
- Direct
- Indirect

Water quality
- Direct
- Indirect
Direct impact on GW quality

Water quantity
- Direct
- Indirect

Water quality
- Direct
- Indirect
Contamination impacts from flooding in Botswana

<table>
<thead>
<tr>
<th></th>
<th>Flood</th>
<th>Flood Recession</th>
<th>Wet Season</th>
<th>Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dolomite</td>
<td><img src="#" alt="Diagram" /></td>
<td><img src="#" alt="Diagram" /></td>
<td><img src="#" alt="Diagram" /></td>
<td><img src="#" alt="Diagram" /></td>
</tr>
<tr>
<td>Basement</td>
<td><img src="#" alt="Diagram" /></td>
<td><img src="#" alt="Diagram" /></td>
<td><img src="#" alt="Diagram" /></td>
<td><img src="#" alt="Diagram" /></td>
</tr>
<tr>
<td>Alluvium on Basement</td>
<td><img src="#" alt="Diagram" /></td>
<td><img src="#" alt="Diagram" /></td>
<td><img src="#" alt="Diagram" /></td>
<td><img src="#" alt="Diagram" /></td>
</tr>
</tbody>
</table>

**Water quality key**
- High
- Medium
- Low

**Contaminants**
- SW Sampling (Reservoir)
- SW Sampling (Stream)
- GW Sampling
- Borehole (logger)
- Borehole (monthly level)
- Groundwater Level

**Interpreted Flow Direction**

*Geris et al., 2020*
Indirect impact on GW quality

Water quantity
- Direct
- Indirect

Water quality
- Direct
- Indirect
Indirect impact on GW quality

Water quantity
- Direct
- Indirect

Water quality
- Direct
- Indirect
Climate change impacts on GW quality
Botswana case
Ramotswa water supply system

Legend
- Water Works
- Wellfield
- Population
- Blending Station
- Types of water
  - Untreated
  - Treated
  - Blended
- Water restriction point during drought

Types of water
- Untreated
- Treated
- Blended

Pit latrines affect groundwater quality?

Boatle

Water restrictions => no water to flush toilets

McGill et al., 2019
Human health risk propagation through food trade of arsenic in GW-irrigated crops

Alam et al., 2020
Human health risk propagation through food trade of arsenic in GW-irrigated crops

Currently, 4.7 MMT/yr of contaminated rice is traded globally, ~10.4% of global rice trade.

In future scenarios, the area grown under GW-irrigation in hazard areas may expand from 10.6 to 23.2 Mha.

Alam et al., 2020
Groundwater and climate change adaptation

http://gripp.iwmi.org/natural-infrastructure/
Underground transfer of floods

Pavelic et al., 2020
Time to GW depletion reversal

Jaipur:

Recharge: 100 mm/year (Bhanja et al., 2019)

GW level decline (1995-2010): 21.6 m

Average porosity: 0.4

Time to recover depleted aquifer: 86.4 years

At India scale (Sutanudjaja, 2019):

Recovery time: 9.6 years

Bhanja et al., 2019
Possible ways forward

https://cgspace.cgiar.org/handle/10568/103496

Possible ways forward
Possible ways forward
Possible ways forward
GRIPP objective

*Sustainable groundwater management for livelihoods, food security, climate resilience and economic growth*
References


Thank You

Karen Villholth

k.villholth@cigar.org
http://gripp.iwmi.org/
https://www.groundwaterstatement.org/

Innovative water solutions for sustainable development
Food · Climate · Growth