Future Water: Hotspots, Brightspots and Blind spots

Proclias/ISIMIP webinar

Prof Carolien Kroeze, Wageningen University, The Netherlands
Take home messages

- Worldwide, clean water availability is at stake
- In the future, this may be worse
- Hotspots – most pollution from a few sources – targeted policies
- Brightspots – optimistic scenarios show that clean water availability can be secured worldwide, but may be a challenge in Africa
- Blindspots – we need to avoid tradeoffs and pollution swapping
- Need for multi-pollutant, multi-impact approach
Sustainable Development Goals

1. No Poverty
2. Zero Hunger
3. Good Health and Well-being
4. Quality Education
5. Gender Equality
6. Clean Water and Sanitation
7. Affordable and Clean Energy
8. Decent Work and Economic Growth
9. Industry, Innovation and Infrastructure
10. Reduced Inequalities
11. Sustainable Cities and Communities
12. Responsible Consumption and Production
13. Climate Action
14. Life Below Water
15. Life on Land
16. Peace, Justice and Strong Institutions
17. Partnerships for the Goals
Future Water Challenges

Too much
Too little
Too dirty
Too much (flooding) – Germany

Germany, July 2021. Photo: Stadt Erftstadt
Too much (flooding) – Pakistan
Where flood risk is projected to rise fastest in the US

A new analysis projects changes in flood risk between 2020 and 2050 by zooming in on every neighborhood across the U.S. The map shows county-level data on the average annual loss due to flood damage.

Percentage rise, 2020-2050

Flood damage measured in 2020 U.S. dollars.

Map: The Conversation/CC-BY-ND • Source: Wing, et al. 2022 • Get the data • Download image
Too little (droughts) – Europe

Europe faces a future of extreme droughts

Mitigation and adaptation measures are going to be crucial for future farming on the continent.

- Summer 2018
- 80% less rainfall across central Europe

A parched section of the Wayoh Reservoir in August 2018. Photograph: Paul Ellis/AFP/Getty Images
Too little (droughts) – Europe 2022 may be worse

Loire, France

https://nos.nl/artikel/2440817-europa-s-droogvallende-rivieren-in-beeld
Too little (droughts) – Europe 2022 may be worse

Savoureuse, France

https://nos.nl/artikel/2440817-europa-s-droogvallende-rivieren-in-beeld
Too little (droughts) – Europe 2022 may be worse

https://nos.nl/artikel/2440817-europa-s-droogvallende-rivieren-in-beeld

Rhine, Germany
Too little (droughts) – Europe 2022 may be worse

Dreisam, Germany

https://nos.nl/artikel/2440817-europa-s-droogvallende-rivieren-in-beeld
Too little (droughts) – Europe 2022 may be worse

Waal, The Netherlands

https://nos.nl/artikel/2440817-europa-s-droogvallende-rivieren-in-beeld
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Future Water Challenges

Too much
Too little
Too dirty
Too dirty:
Nitrogen and Phosphorus (Nutrients)
Too dirty – Dutch Texel Reserve

Water in the Dutch Texel nature reserve suddenly turns pink again after five years

By taketonews

June 2022

“Severe drought on the Wadden Island. As a result, the salt content in the water is high and the oxygen content is low.” (https://taketonews.com/)
Too dirty: Pharmaceuticals

This lake was once a thriving waterbody, it now receives pharmaceutical waste flowing in through open nallahs. Photo: Shailendra Yashwant
Too dirty: Pathogens

Children fetch water as the cows also take from the same point in Amudat district (PHOTO/File).
Too dirty: Plastic
Future Water – The need for clean water

- Drinking water
- Irrigation water
- Industrial water
- Water for nature
Future Water – Demand for water is increasing

Based on data of Gleick et al. (2003) Science
Future Water – Climate change impacts on streamflow

van Vliet et al (2016), nature cc
Future: More water stress worldwide

- Increasing water demand
- Changing water availability
- Increasing water pollution
Water security at risk for 80% of the world population

Future Water - Pollution

- **Hotspots** of pollution
- **Bright spots** of transitions in society
- **Blind spots** in environmental policy
Future Water

- Hotspots of pollution
- Bright spots of transitions in society
- Blind spots in environmental policy
Hotspots of pollution

- 80% of water pollution from 20% of the sources
  - Hotspots: urbanization and food production
- Water pollution hotspots overlap for many pollutants
- Opportunity for focused pollution control
- In the future: more and more an urban problem
  - over two-thirds of the world population is urban in 2050
Multi-pollutant assessment of river pollution from livestock production worldwide

Yanan Li\textsuperscript{a,b,\textordmasculine}, Mengru Wang\textsuperscript{b}, Xuanjing Chen\textsuperscript{c}, Shilei Cui\textsuperscript{a}, Nynke Hofstra\textsuperscript{b}, Carolien Kroeze\textsuperscript{b}, Lin Ma\textsuperscript{d}, Wen Xu\textsuperscript{a,\textordmasculine}, Qi Zhang\textsuperscript{a,b}, Fusuo Zhang\textsuperscript{a}, Maryna Strokal\textsuperscript{b}

Urbanization: an increasing source of multiple pollutants to rivers in the 21st century

Maryna Strokal\textsuperscript{a,\textordmasculine}, Zhaohai Bai\textsuperscript{c\textordmasculine}, Wietse Franssen\textsuperscript{1}, Nynke Hofstra\textsuperscript{1}, Albert A. Koelmans\textsuperscript{3}, Fulco Ludwig\textsuperscript{1}, Lin Ma\textsuperscript{d}, Peter van Puijenbroek\textsuperscript{d}, J. Emiel Spanier\textsuperscript{1}, Lucie C. Vermeulen\textsuperscript{1}, Michelle T. H. van Vliet\textsuperscript{1}, Jikke van Wijnen\textsuperscript{7} and Carolien Kroeze\textsuperscript{1}
Hotspots of river pollution by N, P and a pathogen from livestock in 2010 (MARINA model)
Hotspots of river pollution by N, P and a pathogen from livestock in 2010 (MARINA model)

Li et al., (2022)
Hotspots of river pollution by N, P and a pathogen from livestock in 2010 (MARINA model)

Li et al., (2022)
Hotspots of water pollution from cities in 2050 (MARINA model)

Strokal et al. (2021)
Hotspots of water pollution from cities in 2050 (MARINA model)

Strokal et al. (2021)
Future water pollution (N, P, pathogen) from cities 2010-2050 Business-as-Usual scenario

More pollutants in rivers

Less pollutants in rivers

Strokal et al. (2021)
Future hotspots of nitrogen-related water scarcity 2010-2050 (Wang et al. unpublished)

- **No hotspot**
- **Scarcity hotspot since 2010**
- **Recovered**
- **New pollution hotspot in 2050**
- **New quantity hotspot in 2050**
- **New scarcity hotspot in 2050**
Future Water

- Hotspots of pollution
- **Bright spots of transitions in society**
- Blind spots in environmental policy
What challenges are for optimistic futures with clean water?

- www.menti.com
- 7513 1476
Future Water

- Hotspots of pollution
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Future hotspots of nitrogen-related water scarcity 2010-2050 (Wang et al. unpublished)
Future hotspots of nitrogen-related water scarcity 2010-2050 (Wang et al. unpublished)

**Business-as-Usual Scenario**
- No hotspot
- Scarcity hotspot since 2010
- Recovered
- New pollution hotspot in 2050
- New quantity hotspot in 2050
- New scarcity hotspot in 2050

**More Sustainable Scenario**
Future water pollution (N, P, pathogen) from cities 2010-2050

Strokal et al. (2021)
Future water pollution (N, P, pathogen) from cities 2010-2050

Optimistic Scenario

Less pollutants in rivers

More pollutants in rivers

Business-as-Usual Scenario

Less pollutants in rivers

More pollutants in rivers

Strokal et al. (2021)
Bright spots

- Promising examples of transition in society
- However, not enough to reach SDG6 (clean water for all) worldwide
- Optimistic futures
- Backcasting
  - what future do we want, and how do we get there?
Backcasting: how to reach environmental targets? (Li et al. 2019)
Backcasting: how to reach environmental targets

Options to reach the environmental target:
- Manure recycling
- Improved animal feed
- Improved treatment

River export of nitrogen
- Projection for 2050
  - Huang: 300 Gg
  - Huai: 150 Gg
  - Hai: 80 Gg

River export of phosphorus
- Projection for 2050
  - Huang: 40 Gg
  - Huai: 35 Gg
  - Hai: 15 Gg

Target
Long term targets call for short term actions
Optimistic versus Optimal Solutions

Optimistic
• Maximum feasible pollution control

Optimal
• Minimizing tradeoffs, costs
• Fair allocation of the burden

Li et al. (2019)
Optimal allocation of pollution rights
(Li et al. 2019)
Future Water

- Hotspots of pollution
- Bright spots of transitions in society
- **Blind spots in environmental policy**
  - Trade-offs and pollution swapping
“Climate change alone may increase river export of nutrients considerably: we calculate 24% higher river export of nitrogen and 16% higher phosphorus for a scenario assuming severe climate change compared to the same scenario with low climate change.”
Blind spot – Effects of COVID-19 control on the environment?

- **Worldwide**
  - More use of plastic (masks, protection materials)
  - More use of soap (hand washing)
  - More use of pain killers

- Implications for water quality?
Blind spot – COVID-19 control resulted in more water pollution (plastic, soap, pain killers)

Zhang et al., (under review)
Accounting for interactions between Sustainable Development Goals is essential for water pollution control in China

Mengru Wang, Annette B. G. Janssen, Jeanne Bazin, Maryna Strokal, Lin Ma & Carolien Kroeze
319 interactions between Sustainable Development Goals for water sustainability

- **286 synergies** (e.g., water - climate – food)
- **33 trade-offs** (e.g., water – urbanization)

Wang et al., (2022)
A new science agenda

- Multiple sources
- Multiple pollutants
- Multiple impacts

- Need for creative, inclusive and bright solutions
We need a multi-pollutant approach

- Common sources
- Diverse interactions
- Diverse impacts

Strokal et al., (2021)
MARINA: Model to Assess River Inputs of pollutants to seas (Strokal et al. 2021)

- Multiple pollutants
- Climate-water-land-society interactions
- Pollution sources
- Effective solutions

The MARINA models

MARINA Family

In short, MARINA is a Model to Assess River Inputs of pollutants to seas.
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- Need for multi-pollutant, multi-impact approach
Challenges for optimistic futures

- Grand challenges (climate, biodiversity, water, food)
- Need for transitions in society
- Natural and social sciences
- Involvement of society
- From mono- to multi- to inter- to transdisciplinarity
- Beyond Earth & Environmental Science
Thank you for your attention

The MARINA Team