Introduction:
Pollution-driven water scarcity for ecosystems and human uses worldwide

Michelle van Vliet - *Wageningen University (Netherlands)*

Simon Langan, Yoshihide Wada – *IIASA (Austria)*

Stockholm World Water Week, 26 August 2018

WAGENINGEN UNIVERSITY & RESEARCH

NWO Veni, Vidi, Vici

IIASA International Institute for Applied Systems Analysis www.iiasa.ac.at

Programme

Introduction: pollution-driven water scarcity for human uses and ecosystems - *Dr. Michelle van Vliet (Wageningen University)*

1. **Urbanization: an increasing source of river pollution in the 21st century?** - *Dr. Maryna Strokal (Wageningen University)*

2. **Global water quality modelling assessments and the SDGs**
Dr. Martina Flörke (CESR, University of Kassel)

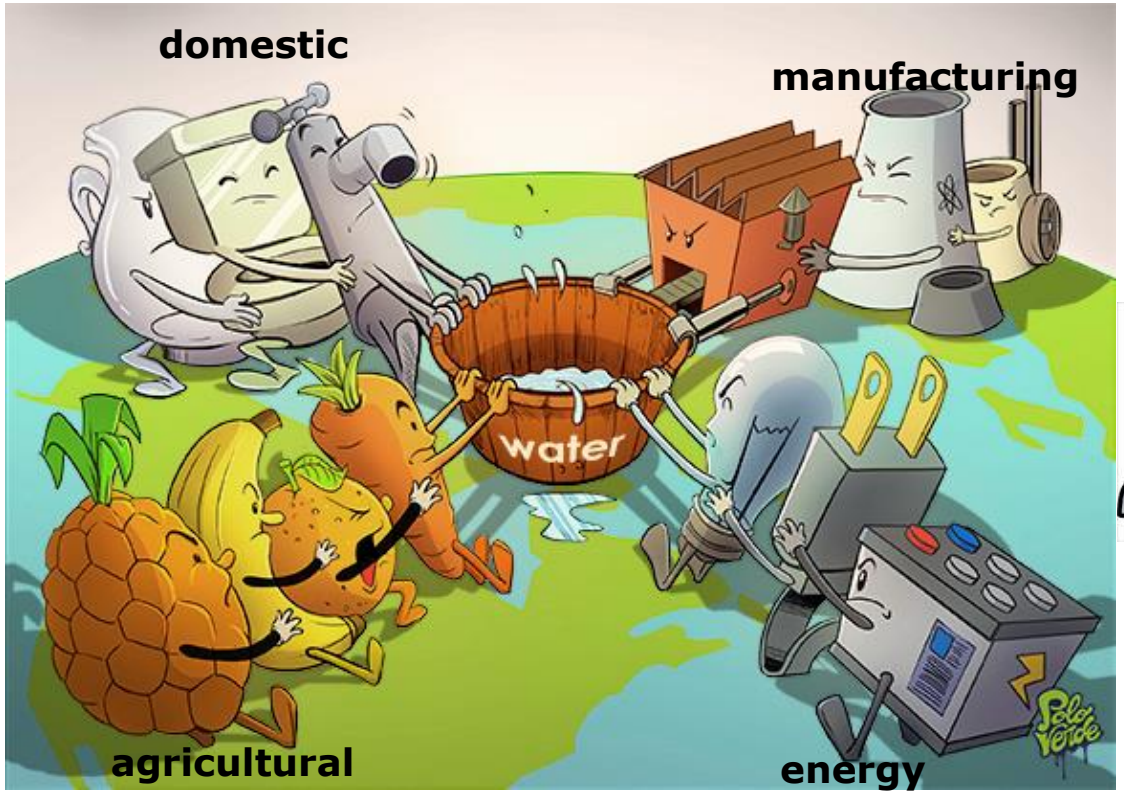
3. **Global water quality challenges and grey-green solutions**
Prof. Dr. Charles Vörösmarty (City University of New York)

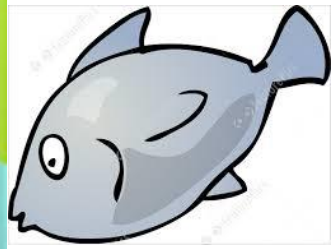
Q & A

Interactive discussion and wrap-up - *Dr. Simon Langan (IIASA)*

What is water scarcity?

Water scarcity: *demand for water by all sectors and the environment cannot be fully satisfied due to the impact of water use on supply or quality of water (Liu et al, 2017)*





Source: Water and sanitation program, 2016

Rethinking water scarcity

- Previous studies focussed on **water quantity**

$$\textbf{Water scarcity (criticality ratio)} = \frac{\text{water use}}{\text{water availability}}$$

- **Usability of water** depends on:

1) Sufficient water quantity

2) Suitable water quality:

  - Water temperature → cooling of power plants
  - Salinity, nutrients → irrigation and drinking water

- **<u>Pollution-driven water scarcity</u>**

→ New water scarcity-indicators and assessments including water quality

Rethinking water scarcity – new indicators

commentary

Quality matters for water scarcity

Michelle T.H. van Vliet, Martina Flörke and Yoshihide Wada

Quality requirements for water differ by intended use. Sustai
different uses will not only need to account for demand in wa
and salinity, nutrient levels and other pollutants.

http://www.nature.com/articles/ngeo3047

Box 1 | Water scarcity by sector including water quality.

We propose to assess water scarcity as the ratio of sectoral water withdrawals of acceptable water quality to the overall water availability (equation (1)). Our index considers, in addition to the required sectoral water withdrawals, also the extra water withdrawal required to obtain water of acceptable quality for each sector by dilution. In case water quality requirements are not met for a certain sector, we estimate the extra amount of water to dilute and lower concentrations below the threshold of a relevant water quality parameter according to sectoral guidelines. A water quality dimension for freshwater ecosystems can be added to the environmental flow requirements by including the relevant water quality parameters and their thresholds for freshwater ecosystems.

$$WSq = \frac{\Sigma_{j=1}^{n}(D_j + dq_{i,j})}{Q - (EFR + dq_{i_{eco}})} \qquad (1)$$

with:

$$dq_{i,j} = \begin{cases} 0, & C_i \le Cmax_{i,j} \\ \left(\frac{Q \cdot C_i}{Cmax_{i,j}} - Q\right), & C_i > Cmax_{i,j} \end{cases}$$

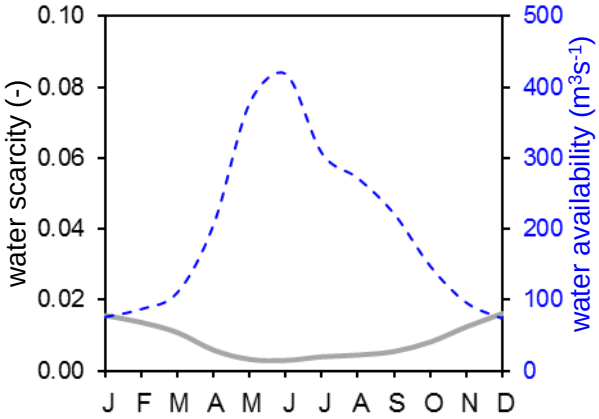
Where WSq is the water scarcity including water quality (-); D is water withdrawal for sector j ($m^3 s^{-1}$); Q is water availability ($m^3 s^{-1}$); EFR is the environmental flow (quantity) requirements ($m^3 s^{-1}$); dq is extra water withdrawals for dilution to obtain acceptable quality for sector j and water quality parameter i ($m^3 s^{-1}$); C_i is actual water quality level of water quality parameter i (unit depends on water quality parameter considered; for example, mg l^{-1} for concentrations, °C for water temperature); and $Cmax_{i,j}$ is the maximum water quality threshold for water quality parameter i for water use sector j (for example, mg l^{-1}, °C).

WAGENINGEN
UNIVERSITY & RESEARCH

Quality matters for water scarcity

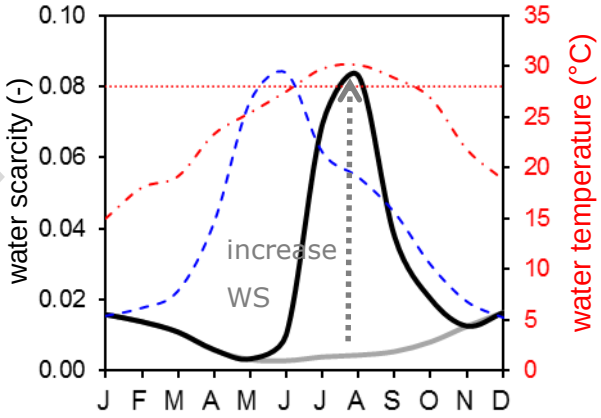
energy sector
water temperature
(Pearl river)

energy water scarcity
only water quantity



water scarcity(only water quantity)
water availability

energy water scarcity
including water quality

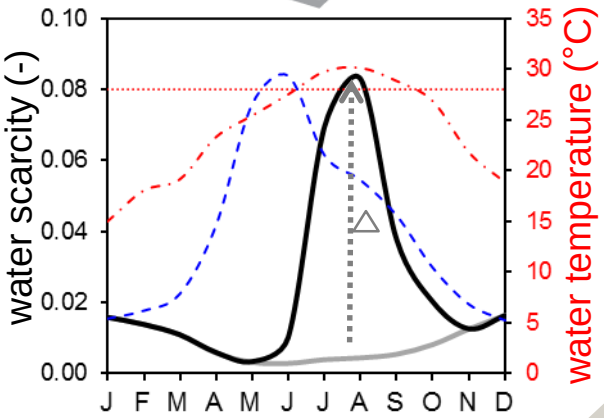


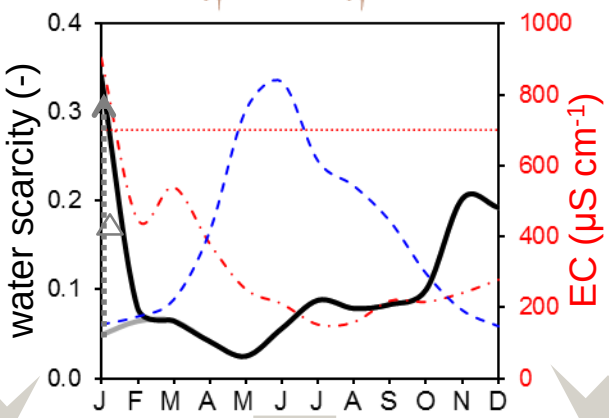
water scarcity (incl. water quality)
water temperature
water temperature threshold for cooling water use

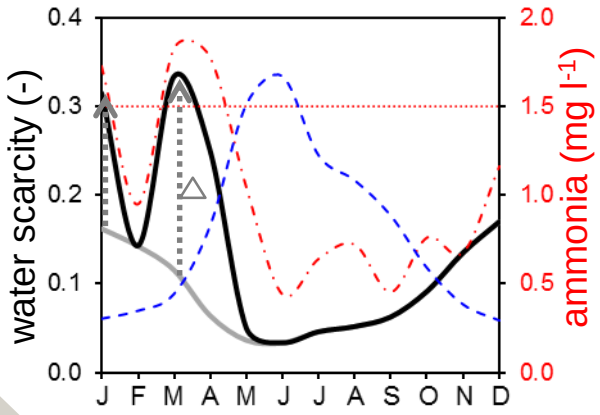
van Vliet et al (2017), nature geoscience

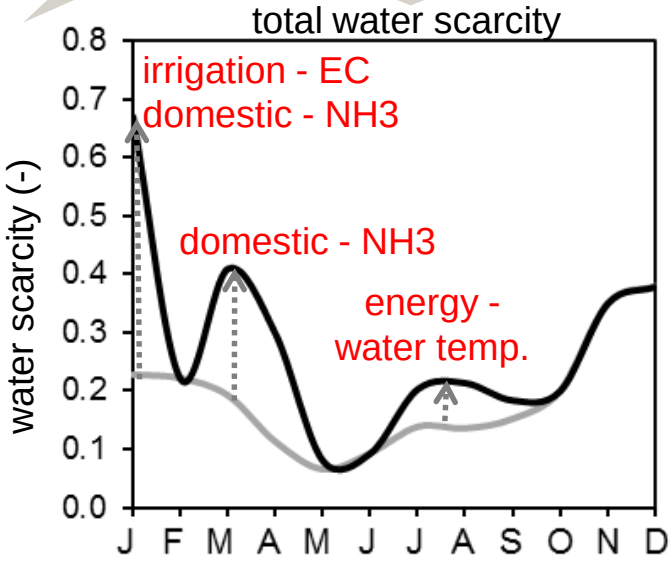
WAGENINGEN
UNIVERSITY & RESEARCH

Quality matters for water scarcity









van Vliet et al (2017), nature geoscience

water availability
water quality
water quality threshold for sector
water scarcity (only water quantity)
water scarcity (incl. water quality)

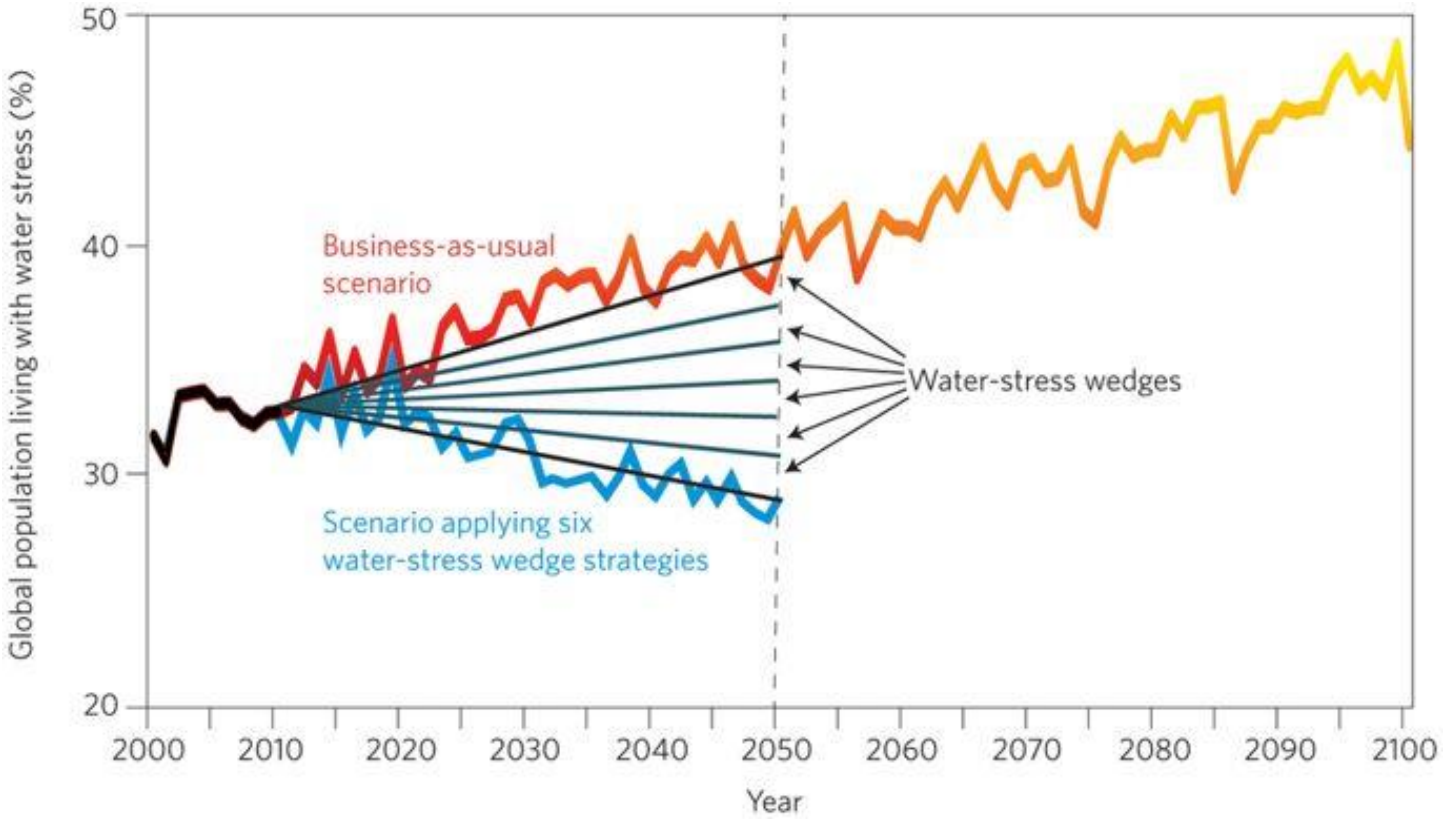
WAGENINGEN UNIVERSITY & RESEARCH

Solution options to reduce pollution-driven water scarcity

‘Grey’ options

‘Green’ options

‘Wedge approach’ to reduce water scarcity



Wada et al (2014), nature geoscience

- Approach to evaluate solutions/strategies for reduction of future water scarcity

Conclusions

1. *Water quality matters* for estimating **water scarcity** to **ecosystems** and **human uses**

→ **pollution-driven water scarcity**

2. Need for improved understanding of **causes**, **impacts** and **solutions** to reduce the **gap** between the **supply** vs. **demand** of **clean water**

Programme

Introduction: pollution-driven water scarcity for human uses and ecosystems - *Dr. Michelle van Vliet (Wageningen University)*

1. **Urbanization: an increasing source of river pollution in the 21st century?** - *Dr. Maryna Strokal (Wageningen University)*

2. **Global water quality modelling assessments and the SDGs**
Dr. Martina Flörke (CESR, University of Kassel)

3. **Global water quality challenges and grey-green solutions**
Prof. Dr. Charles Vörösmarty (City University of New York)

Q & A

Interactive discussion and wrap-up - *Dr. Simon Langan (IIASA)*

Discussion goals

1. To set an **agenda** for **future (modelling) assessments** that integrate our knowledge on **water quality** and **quantity**, with sustainable requirements for **ecosystem** and **human water use** sectors.

2. To assess how to develop **investment-relevant pathways** that meet **clean water requirements** of society and the environment in a more sustainable manner that contribute to achieving **policy targets** such as - **Agenda 2030-SDG's**

Thank you very much

Contact:

- Dr. Michelle van Vliet (Wageningen University)
  michelle.vanvliet@wur.nl
- Dr. Simon Langan (IIASA)
  langan@iiasa.ac.at

Acknowledgement:

This event was financially supported by a Veni-grant (project no. 863.14.008) of NWO Earth and Life Sciences (ALW) - '*Quality matters: Including water quality in global water stress projections*'

Veni, Vidi, Vici