Global water scarcity reduction requires water quality solutions

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What is 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, Earth’s Future)

- Previous studies focussed on water quantity

\[
\text{Water scarcity} = \frac{\text{water use}}{\text{water availability}}
\]

Water scarcity = ‘criticality ratio’ SDG6.4.2

World Resources Institute (2019)
**Usability of water** depends on:

1) Sufficient water *quantity*

2) Suitable water *quality*:
   - Water temperature $\rightarrow$ cooling of power plants
   - Salinity, nutrients $\rightarrow$ irrigation and domestic water

**Objective of NWO-VENI project:**
To develop a new concept and indicators of **water scarcity** including water quality
Rethinking water scarcity

Quality matters for water scarcity

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

Quality requirements for water differ by intended use. Sustainability considerations will only need to account for demand in water and salinity, nutrient levels and other pollutants.

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.

\[
WSq = \frac{\sum_{j=1}^{n} (D_j + d_{q,i,j})}{Q - (EFR + d_{q,\text{req}})}
\]

with:

\[
d_{q,i,j} = \begin{cases} 0, & C_i \leq C_{\text{max}_i,j} \\ \frac{Q \cdot C_i}{C_{\text{max}_i,j} - Q}, & C_i > C_{\text{max}_i,j} \end{cases}
\]

Where \(WSq\) is the water scarcity including water quality (\(\sim\)); \(D\) is water withdrawal for sector \(j\) (\(m^3/s\)); \(Q\) is water availability (\(m^3/s\)); \(EFR\) is the environmental flow (quantity) requirements (\(m^3/s\)); \(d_q\) is extra water withdrawals for dilution to obtain acceptable quality for sector \(j\) and water quality parameter \(i\) (\(m^3/s\)); \(C_i\) 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 \(C_{\text{max}_i,j}\) is the maximum water quality threshold for water quality parameter \(i\) for water use sector \(j\) (for example, mg l\(^{-1}\), °C).
Quality matters for water scarcity

van Vliet et al. (2017), Nature Geoscience
Sectoral water scarcity

van Vliet et al (2017), Nature Geoscience
Water scarcity concept

**Water quantity**
- global hydrological model output (0.5°)

**Water quality**
- water temperature
- salinity (TDS)
- organic pollution (BOD)
- nutrients (TN, TP)

**Water supply**

**Water demands**
- withdrawal, consumption
  - irrigation
  - domestic
  - energy
  - manufacturing
- environmental flow requirements

**Sector water uses**

**Sector water quality requirements**
- water quality standards per sector and for ecosystem health
Global surface water quality modelling

Average concentrations for 2000-2010

**Salinity (TDS)**
- TDS conc. [mg/l]
- 0 - 10
- 10 - 50
- 50 - 100
- 100 - 500
- 500 - 1,000
- > 1,000

**Organic Pollution (BOD)**
- BOD conc [mg/l]
- < 0.1
- 0.1 - 1
- 1 - 10
- 10 - 15
- 15 - 30
- > 30

Validation BOD
- Normalized RMSE [-]
- < 0.5
- 0.5 - 1.0
- 1.0 - 5.0
- 5.0 - 10.0
- > 10.0

Rangitaiki (New Zealand) 1980-2010

van Vliet et al. (2019), COSUST; van Vliet et al. (submitted)
Surface water quality impacts on global water scarcity

- Increases in world's population under severe water scarcity from 30% (only water quantity) to 40% (both water quantity and quality)
- Water scarcity driven by both water quantity and quality issues in hotspots regions of the world
Technological solutions to reduce water scarcity

- Expansion in desalination (inland/sea water) for domestic, manufacturing and energy uses
- Expansion in treated waste water reuse for irrigation

Jones et al. (2019) Science of the Total Environment

n= 15,906 present-day desalination capacity

Feedwater
- New
- Existing

Sector Use
- Municipal
- Industry
- Irrigation
- Power

Capacity (m³/s)
- 0.1 – 0.25
- 0.25 – 0.5
- 0.5 – 1.0
- 1.0 – 2.5
- 2.5 – 5.0
- > 5.0
Conclusions

- **Quality** matters for **water scarcity**
- **New water scarcity concept and indicators** including **water quality** and **water scarcity mitigation options** (desalination, treated waste water reuse)

  → **Regional hotspots** of **water scarcity**, both in terms of **water quantity** and **quality**.

  → **Causes, impacts** and **solutions** to reduce the gap between supply and demand of water of a suitable quality

**Questions?**
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