Water Footprint

from virtual water to local impacts

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GRoW cross-cutting topic „Water Footprint“

21 March 2018

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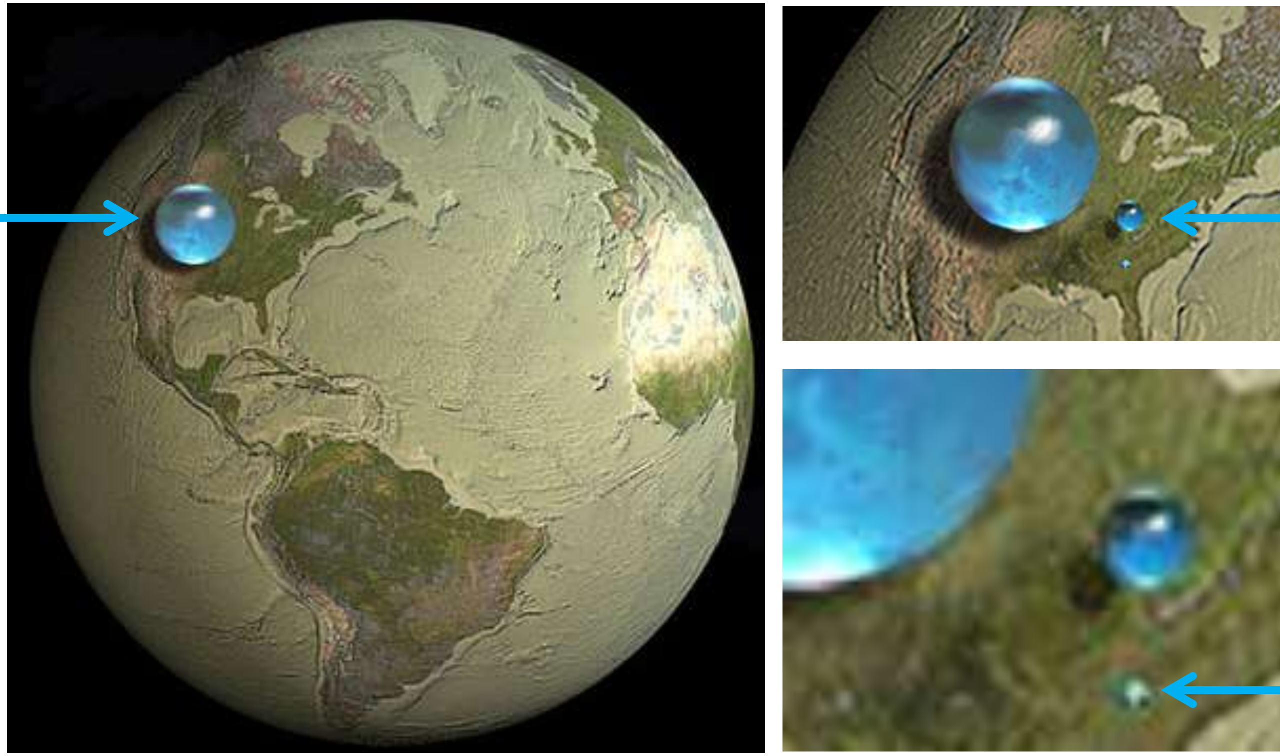
Water Footprint

- Introduction
- From Virtual Water…
- …to Local Impacts
- Decision Support

Total amount of water on the planet: 1,400,000,000 km³

Global
Water
reserves



Freshwater

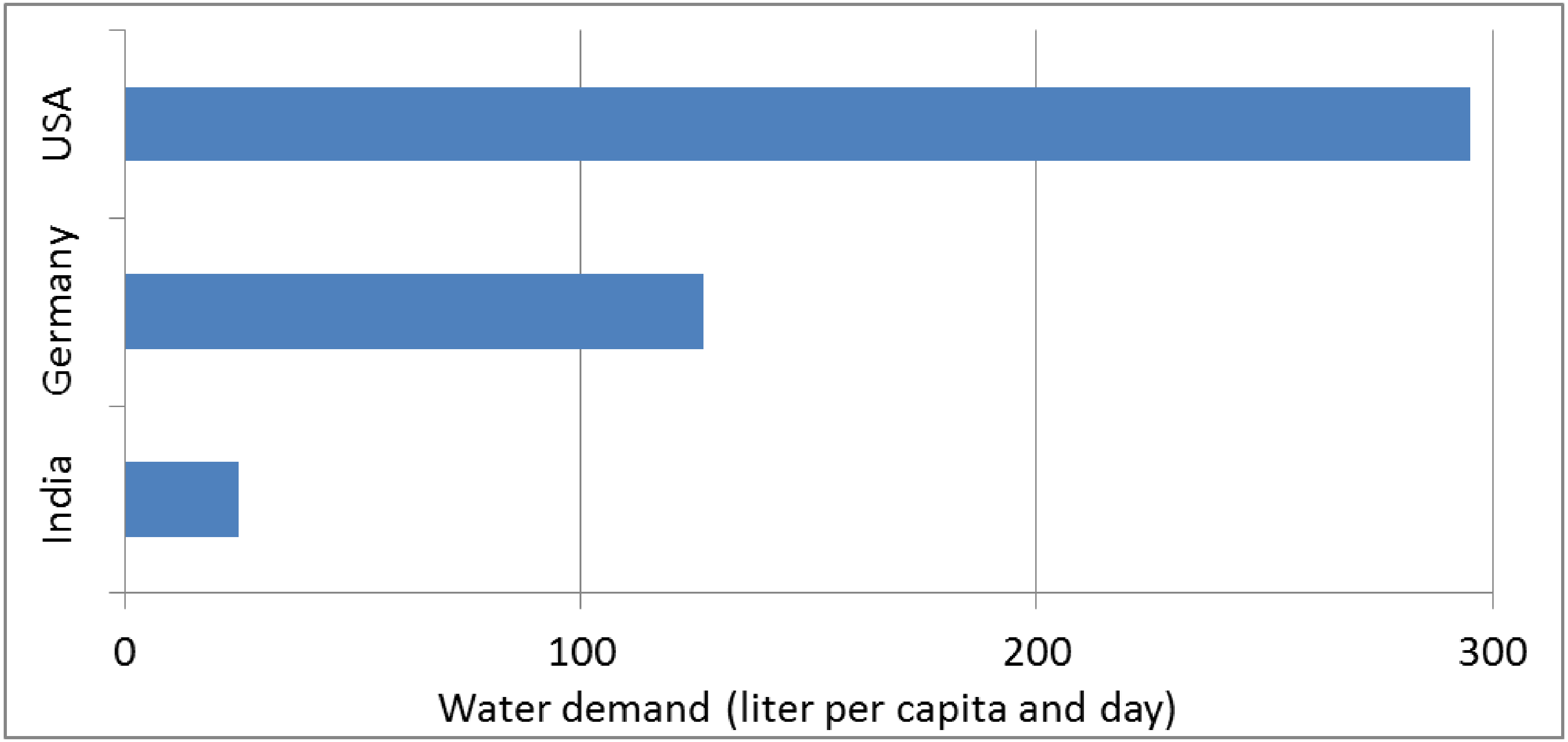
Available
freshwater

(USGS 2013)

- Only 1% of the global water reserves are useable freshwater and there are huge differences in the regional distribution

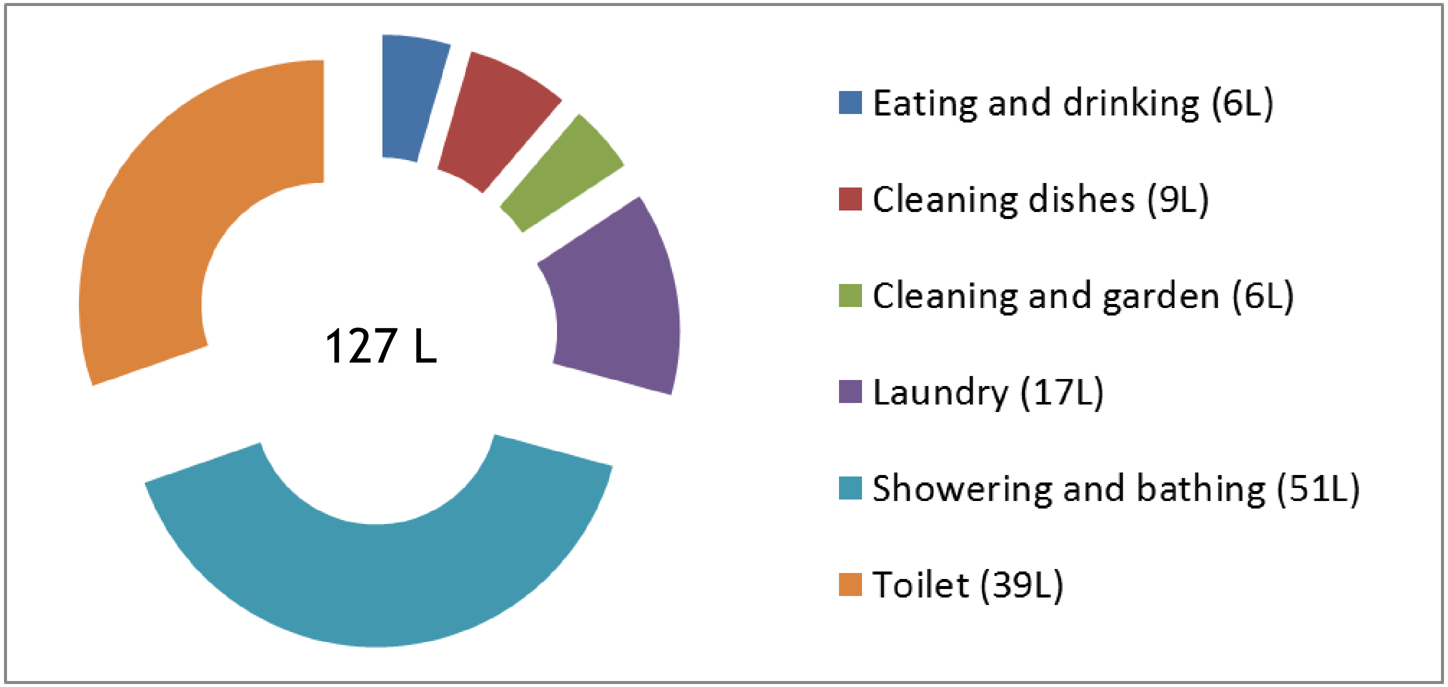
SUSTAINABLE ENGINEERING

- How much water do we need every day?



SUSTAINABLE ENGINEERING

- For what is the water needed?



→ Figures reflect DIRECT water use only!

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Virtual water

- Total amount of water consumed/polluted in the production of goods:

Blue water: ground- and surface water
- Blue water consumption:
  Evaporation of ground- and surface water

Green water: soil moisture available for plants

- Green water consumption:
  Evapotranspiration of rain water by plants

Gray water: polluted freshwater

→ Gray water footprint: water polluted by waste water, measured by the volume of water required to dilute waste water until quality standards are reached

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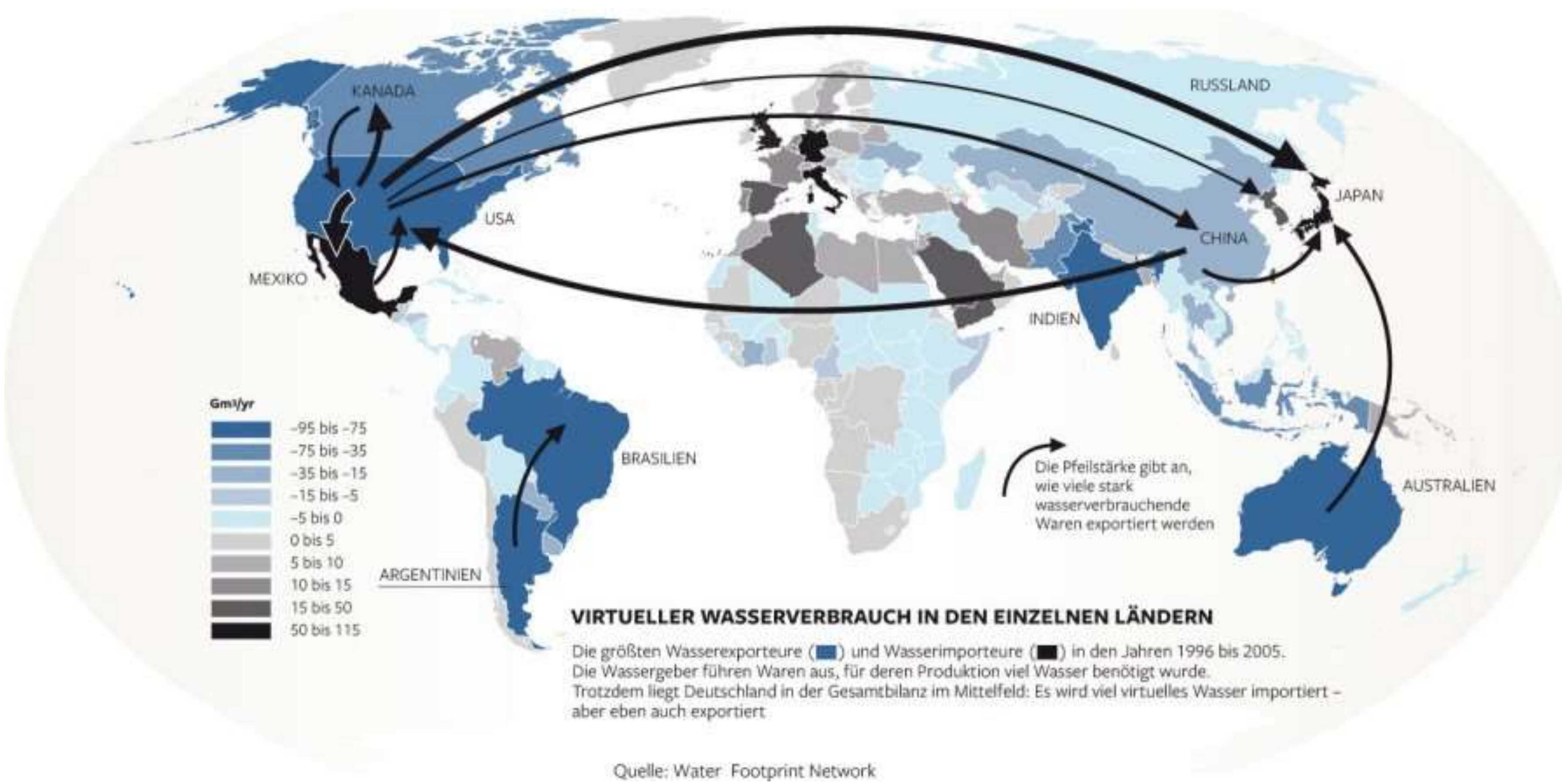
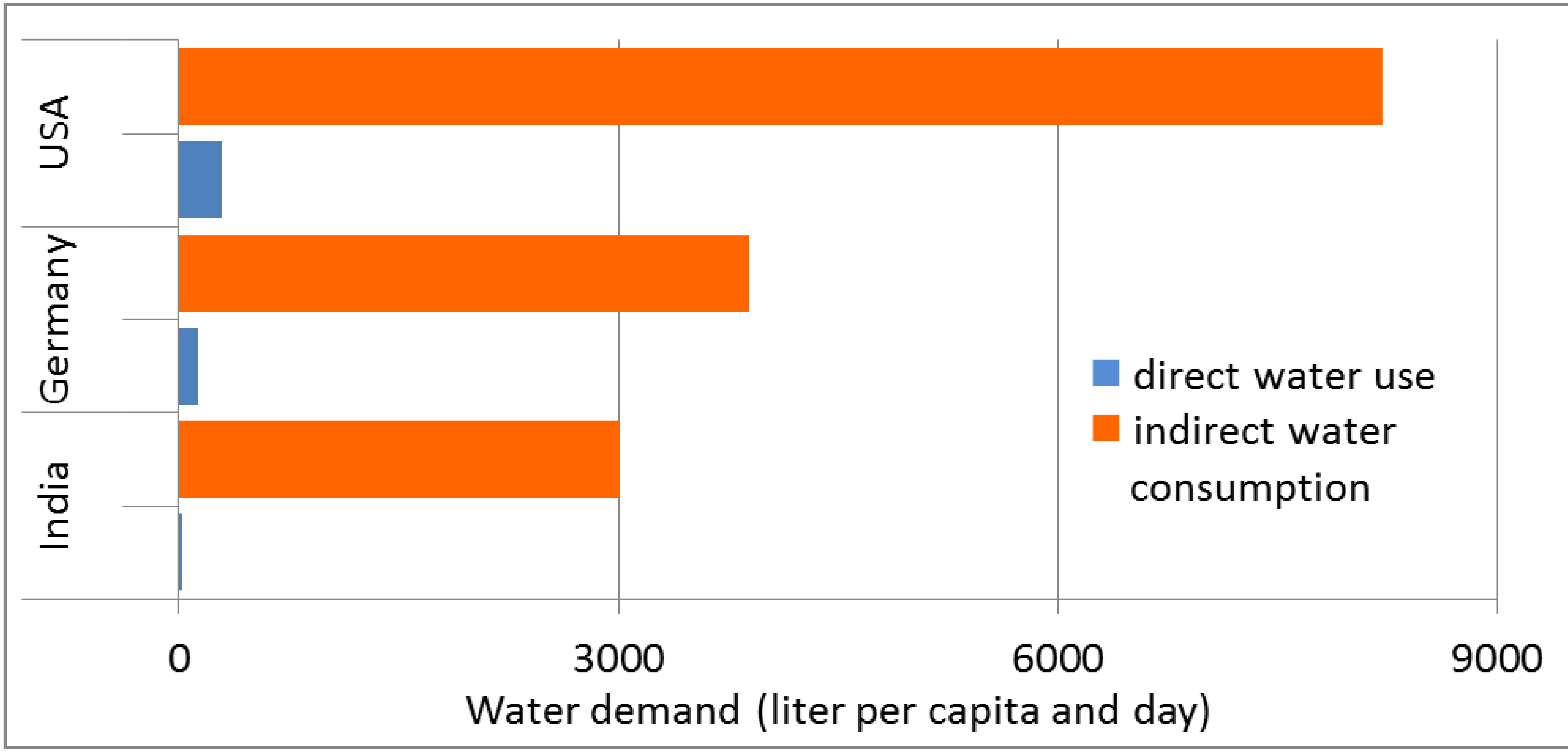
Quelle: http://www.waterfootprint.org

- Due to global trade of products, water is virtually im- and exported



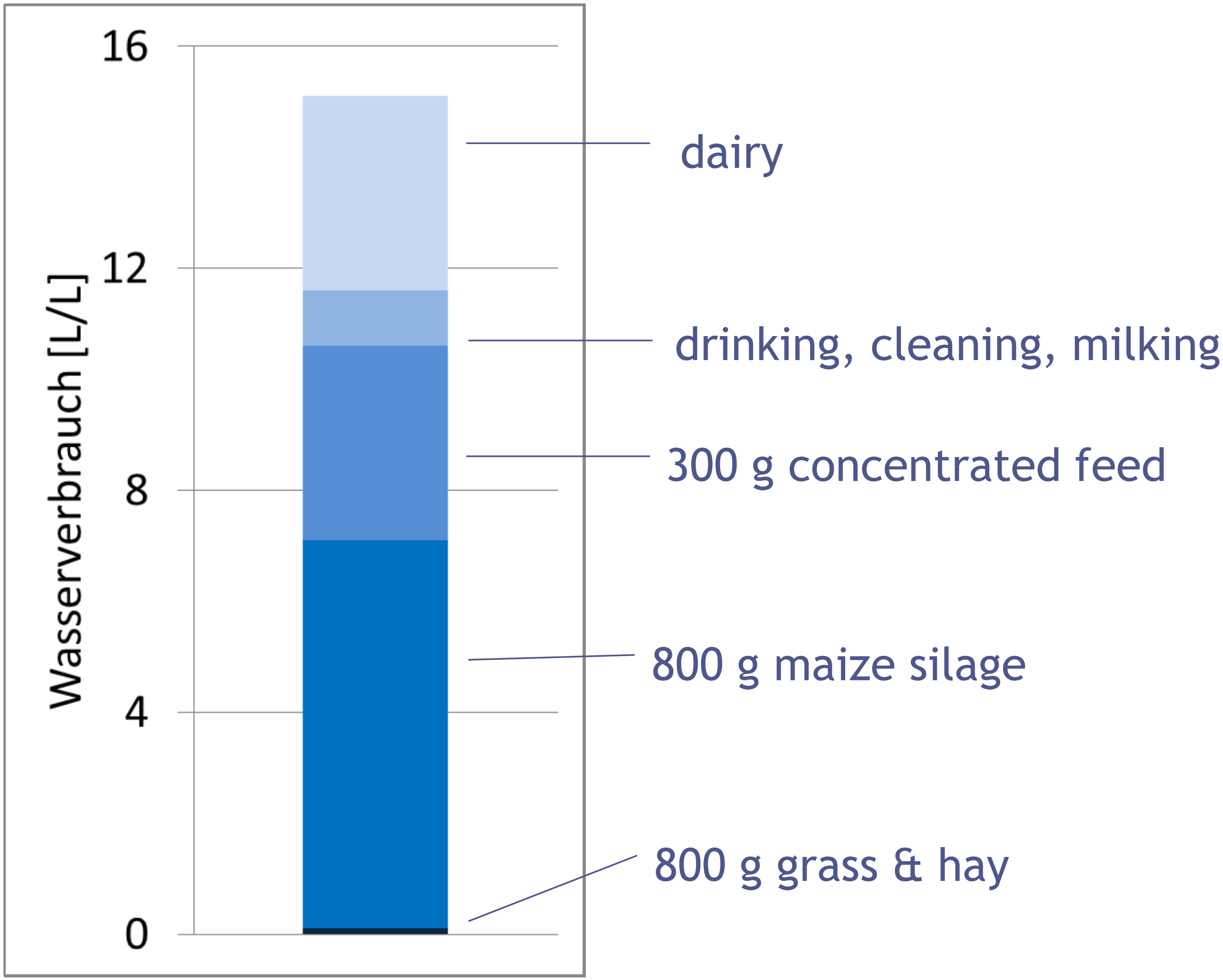
Quelle: http://www.welt.de/wissenschaft/umwelt/article13870606/Die-grosse-Bilanz-des-globalen-Wasserverbrauchs.html

- How much water do we need every day?

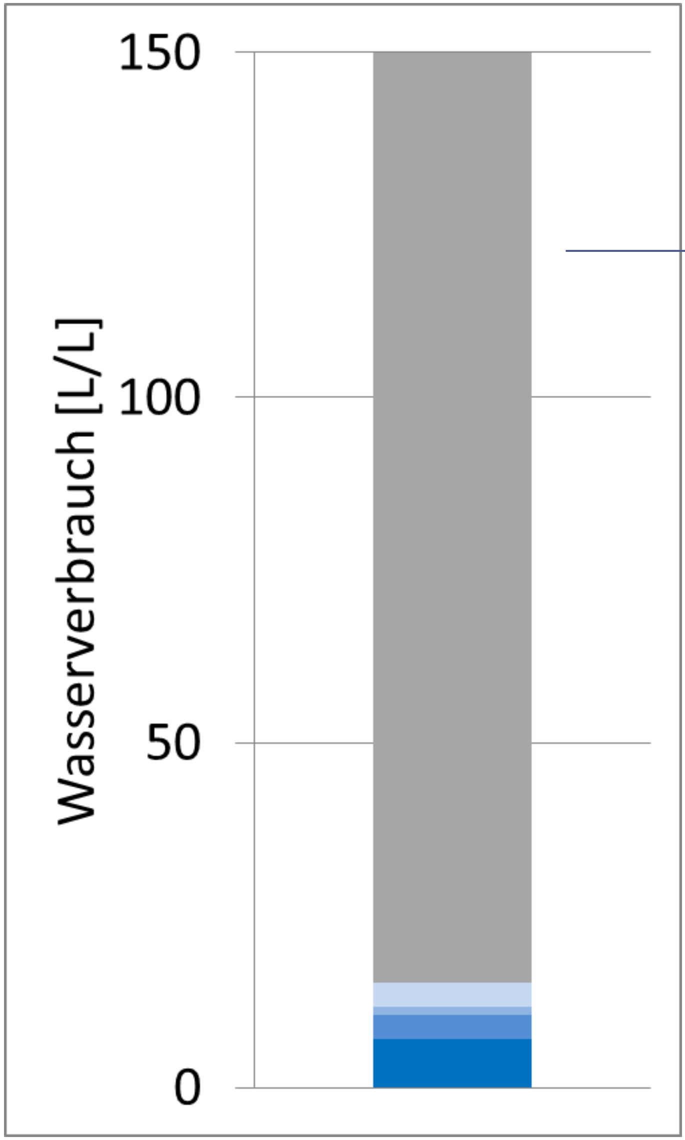


Virtual water milk

What does a cow need to give 1 liter of milk?

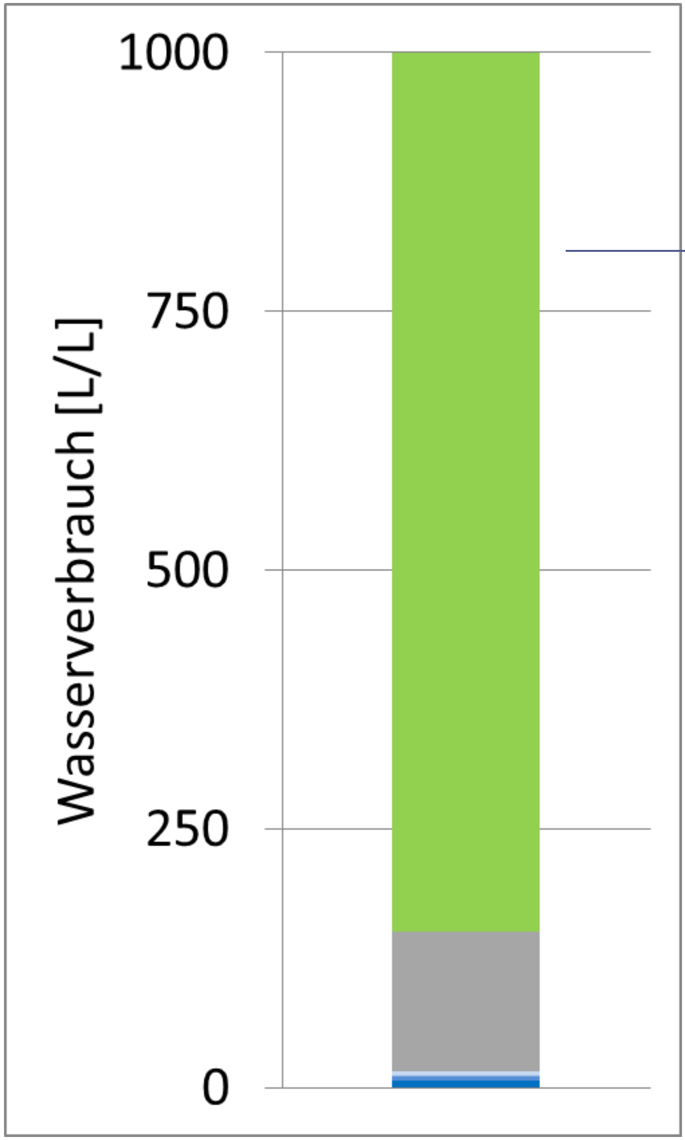


What does a cow need to give 1 liter of milk?



Water pollution due to leaching of fertilizers (gray water)

What does a cow need to give 1 liter of milk?



Evapotranspiration of rain water and soil moisture of forage crops (green water)

Virtual water – criticism

- Relevance of green water is controversial:
  - Only locally available for plants, not for surrounding ecosystems or humans
  - Green water consumption should be seen in comparison to evapotranspiration of natural land → net green water footprint
  - Actual question: How does the green water footprints influence the blue water availability?
- Grey water (dilution water) is dependent on quality standards chosen
- Amounts of blue, green and grey water consumption are usually added

  → Implication of equality for which a scientific rationale is lacking
- Volume of water consumption does not allow for any statement regarding impacts on human health and ecosystems

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Water footprint according to ISO

Water footprint = „water shoe size“ x weight

Impacts of water use along a product life cycle

Volume of water used/consumed

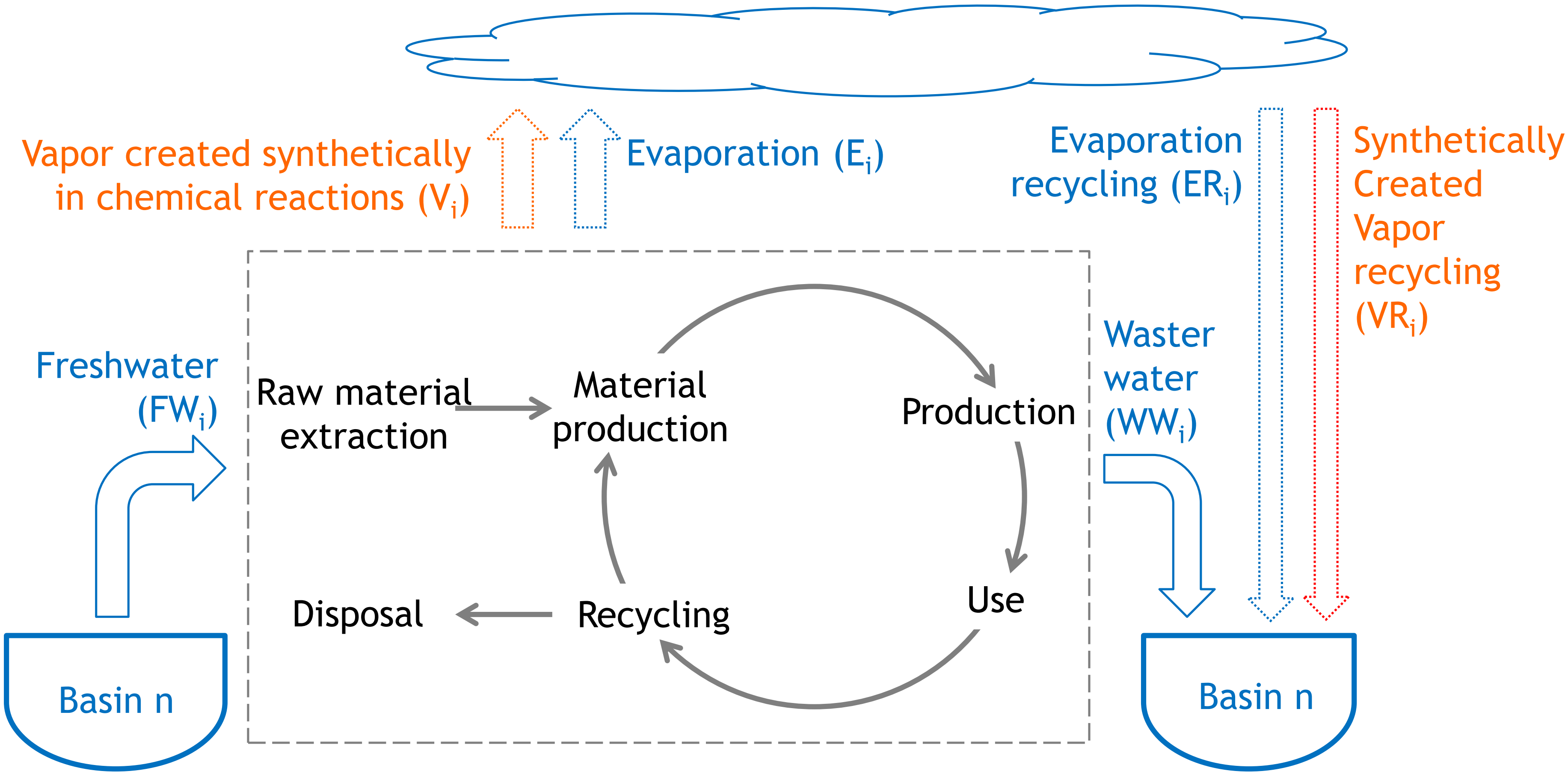
- Lokal water scarcity
- Lokal sensitivity of population (wealth, medical care, etc.)
- Lokal sensitivity of ecosystems
- Type of watercourse
- Water quality
- Time of water use (dry/wet season)

- Method for accounting and assessing water consumption

  – Water accounting: consideration of atmospheric evaporation recycling
  – Vulnerability evaluation: Consideration of water scarcity

Berger, M., R. van der Ent, S. Eisner, V. Bach, and M. Finkbeiner (2014). **Water accounting and vulnerability evaluation (WAVE) – considering atmospheric evaporation recycling and the risk of freshwater depletion in water footprinting.** *Environmental Science and Technology, 2014, 48(8), 4521-4528.*

WAVE - Inventory



$$Water\ consumption = \sum_i FW_i - WW_i - ER_i\ - VR_i$$

Basin Internal Evaporation Recycling (BIER)

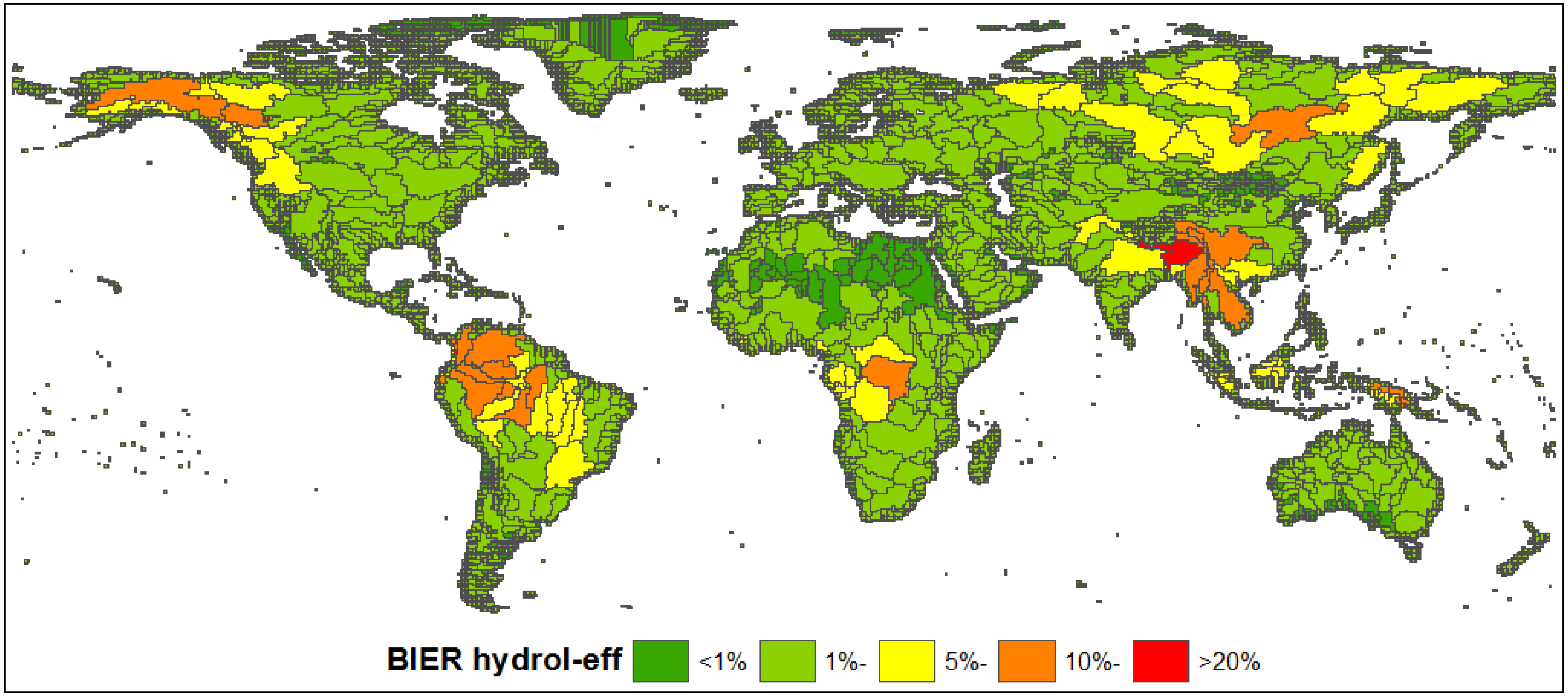
- Evaporation recycling: $ER_i = E_i \cdot BIER_n \cdot \alpha$

$$BIER = \frac{-x - \lambda \cdot exp\left(\frac{-x}{\lambda}\right) + \lambda}{-x}$$

λ - Ø lenght scale of evaporation recycling (van der Ent und Savenjie 2011)

x - Size of drainage basin, assumed to be quadratic

$$\alpha = hydrologically\ effective\ run\ off / precipitation$$



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Step 1: Ratio of water consumption (C) to water availability (A)

$$CTA = \frac{C}{A}$$

Step 2: Consideration of surface water stocks (SWS)

$$CTA^{*} = \frac{C}{A + SWS}$$

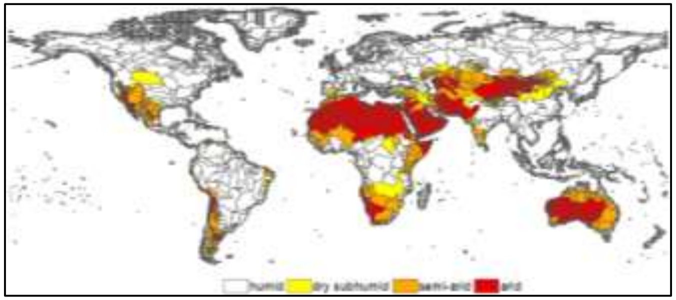
Step 3: Consideration of groundwater stocks (GWS)

$$CTA^{**} = \frac{C}{A + SWS} \cdot AF_{GWS}$$

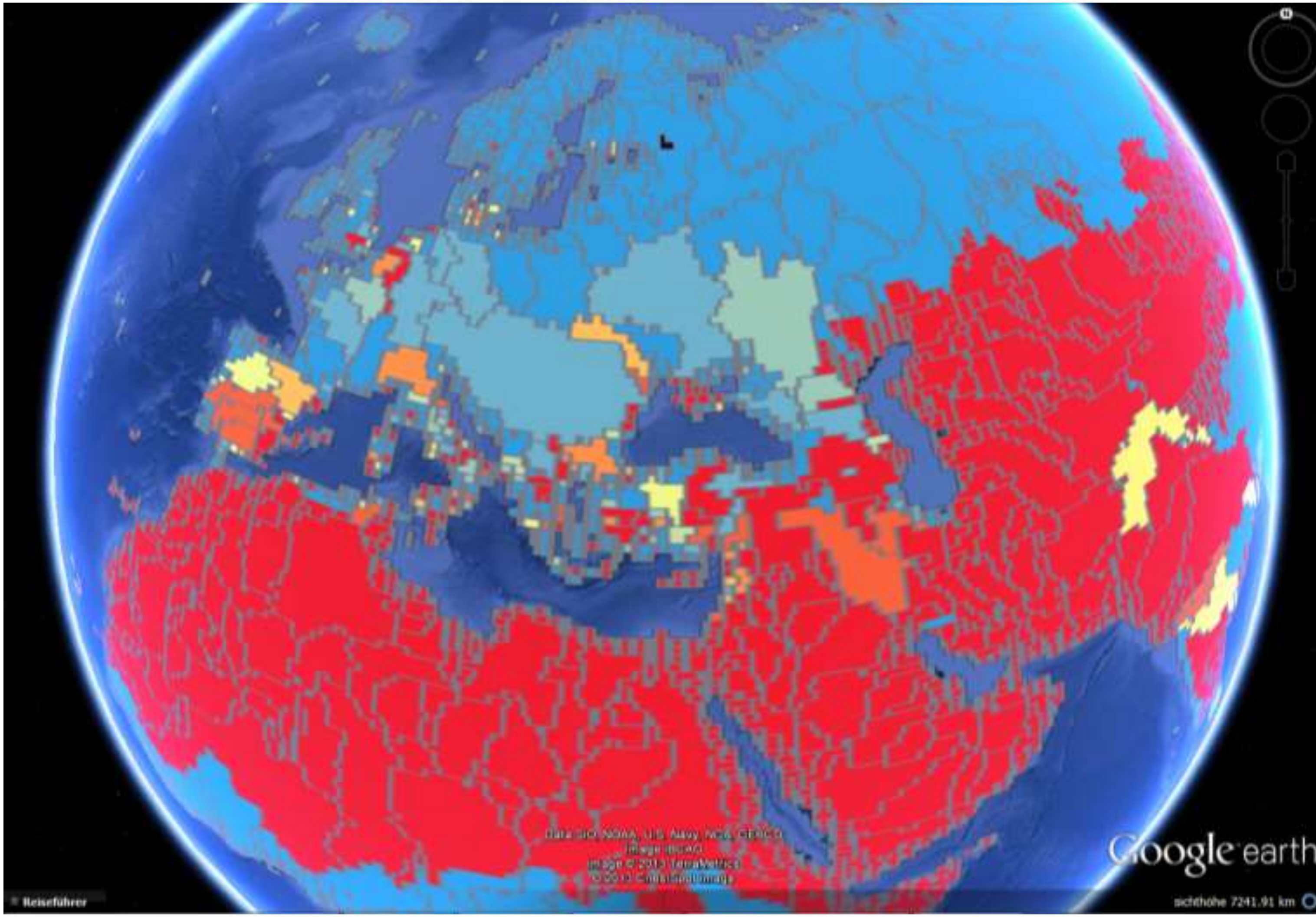
Step 4: "Translation" of water scarcity into vulnerability of basins

$$WDI = \frac{1}{1 + e^{-40 \cdot CTA^{**}} \left(\frac{1}{0.01} - 1\right)}$$

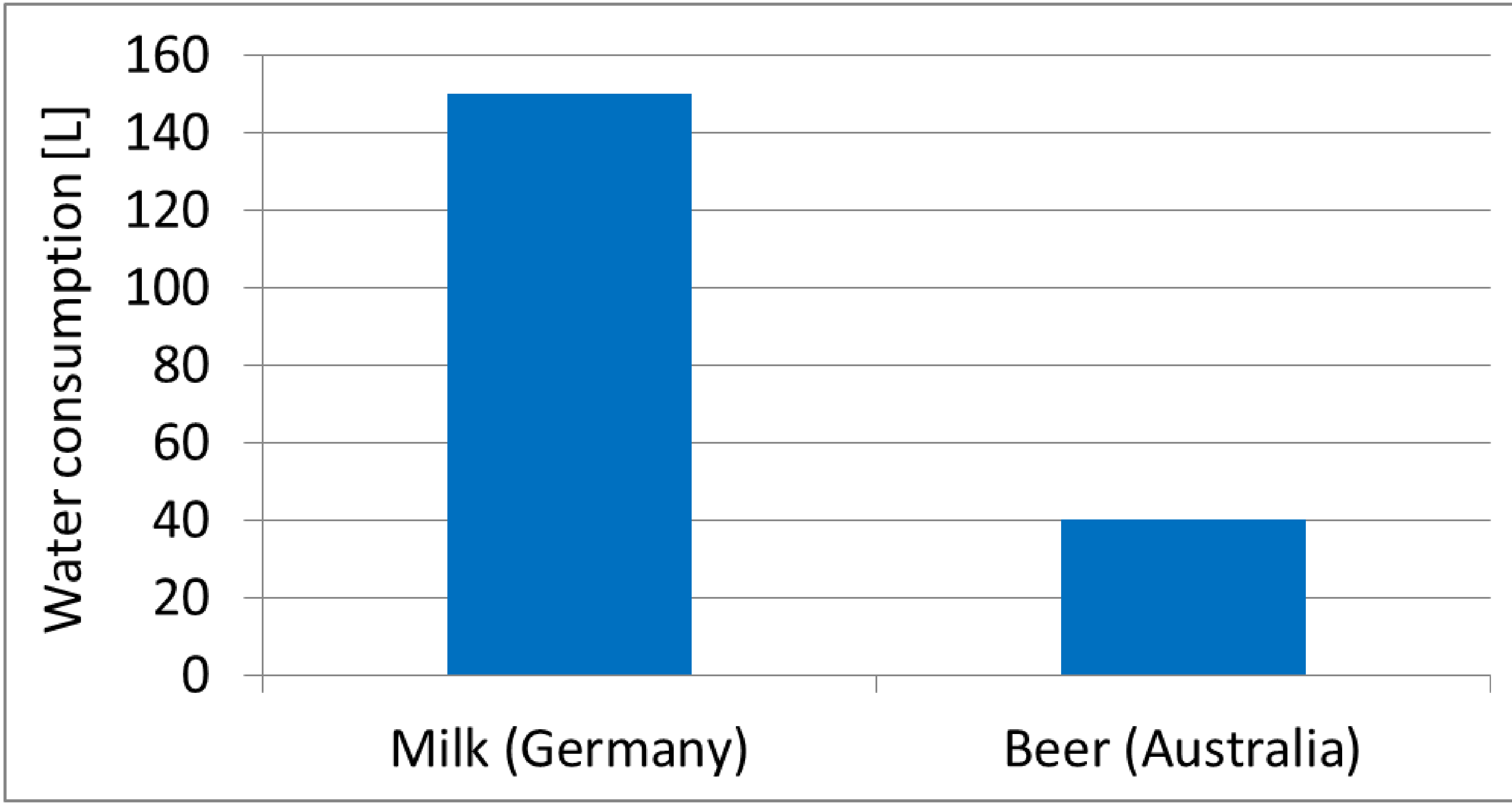
Step 5: Set WDI=1 if basin arid to consider absolute shortage in addition to relative scarcity



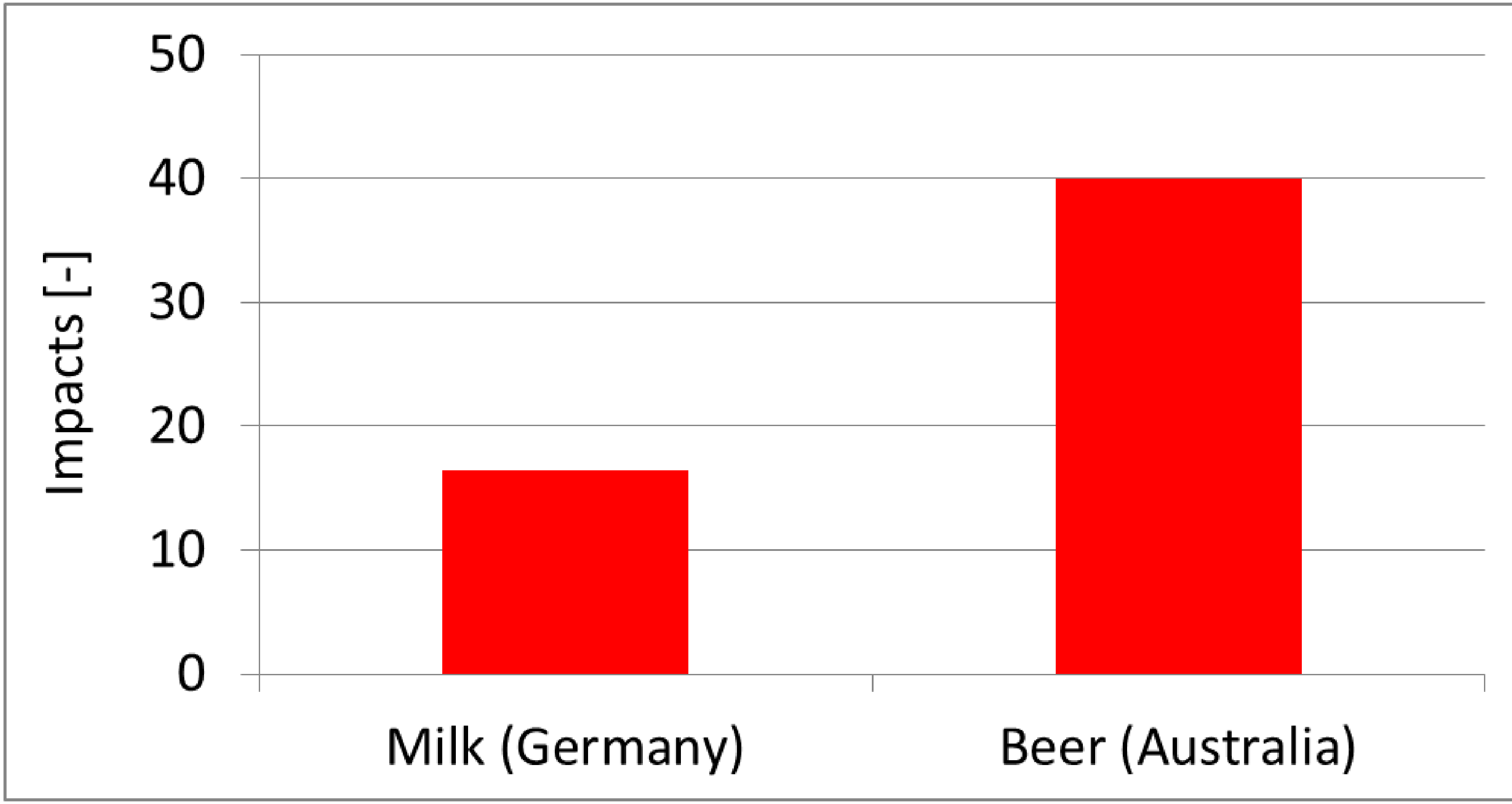
Water deprivation index



Download: http://www.see.tu-berlin.de/WAVE



Water consumption lower



Impacts higher

From WAVE to WAVE+

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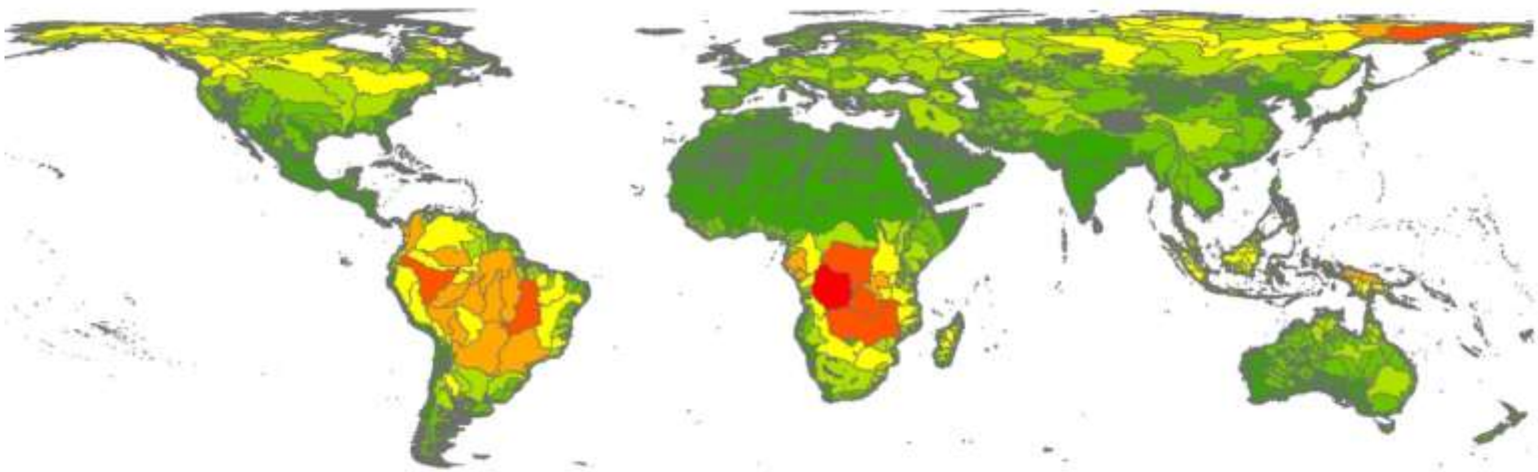
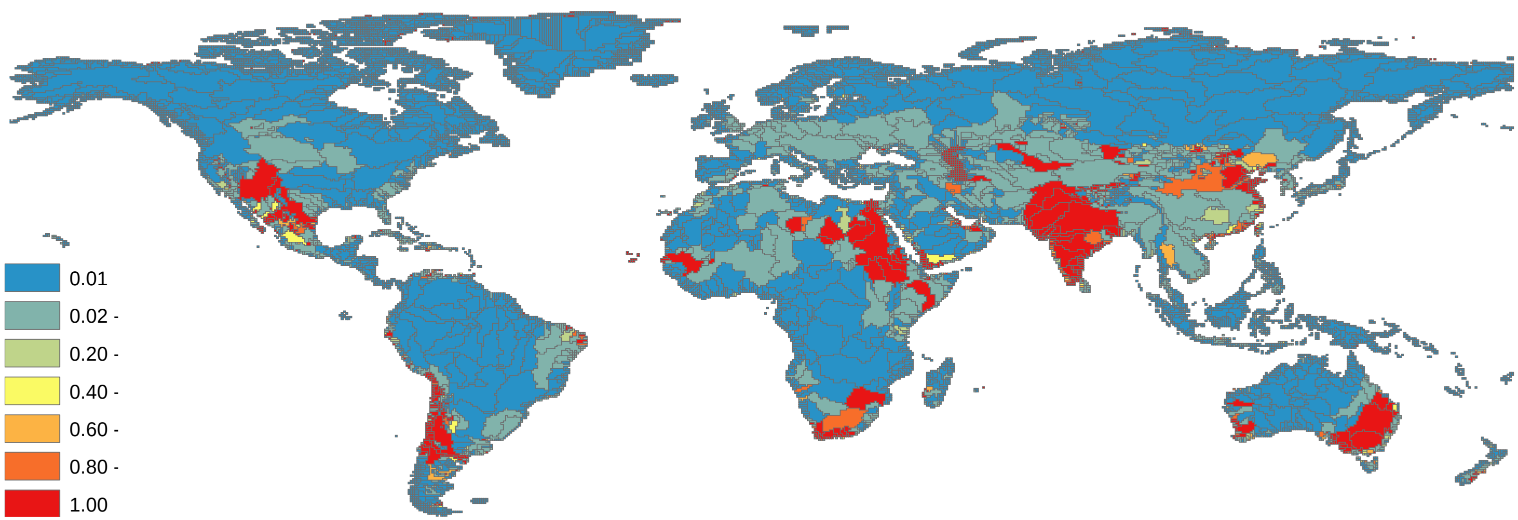
BIER [%]



Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | **Dec**

WDI [m^3depr./m^3cons.]



Modelling impact pathways

Virtual Water

AWARE, etc.

Pfister et al. (2009), Boulay et al. (2011), Motoshita et al. (2015)

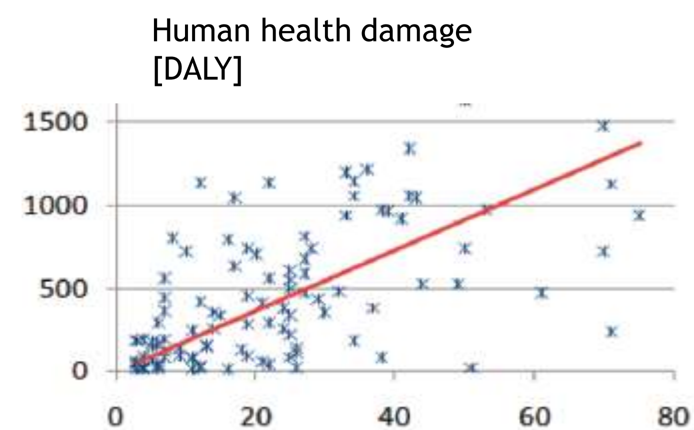
Water consumption → Water deprivation → Deficit in irrigation → Reduced yield → Mal-nutrition → Health damage [DALY]

1 $m^3_{Germany}$ → 0.09 $m^3_{depr.}/m^3$ → 0 DALY

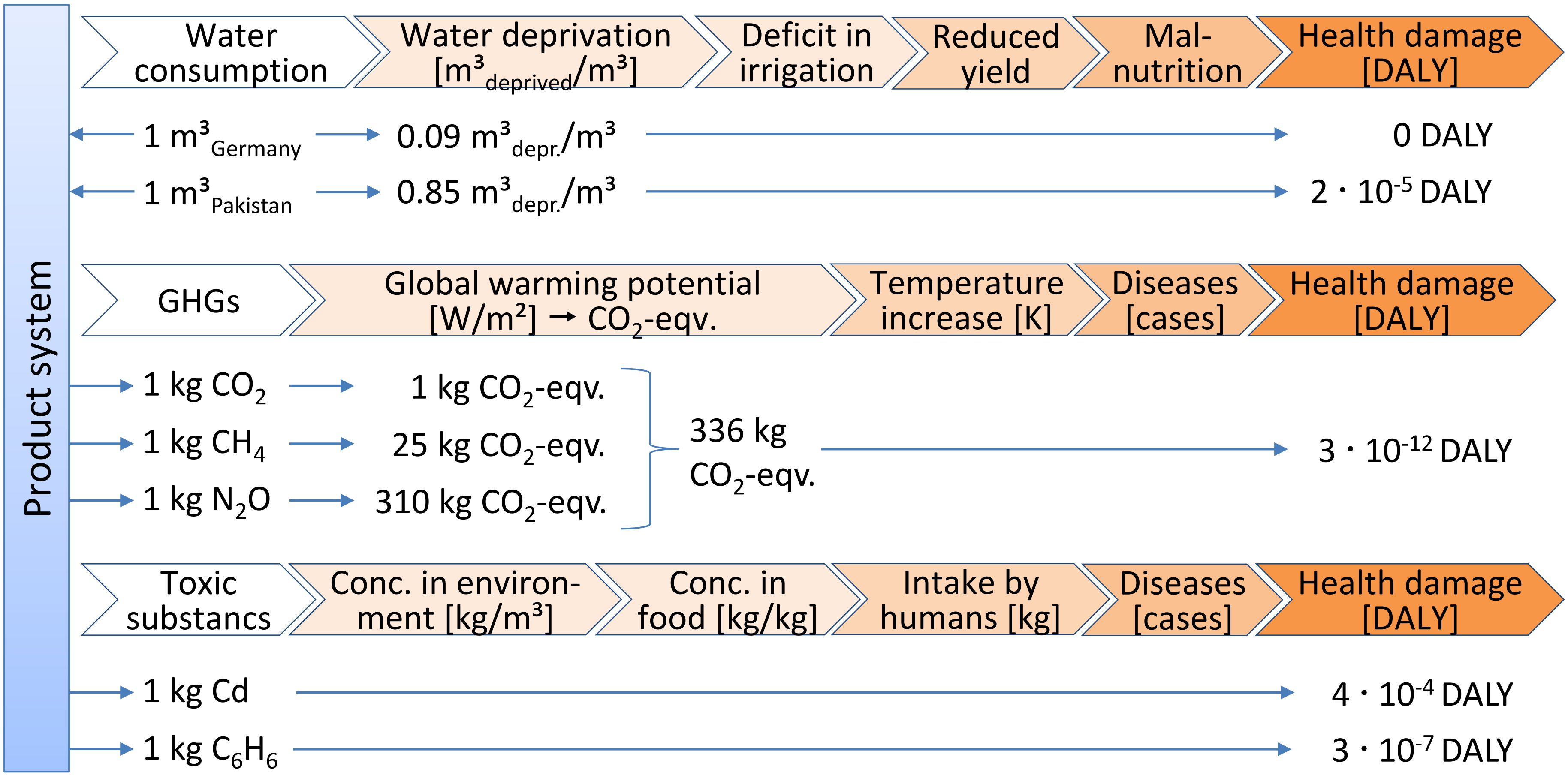
1 $m^3_{Pakistan}$ → 0.85 $m^3_{depr.}/m^3$ → $2 \cdot 10^{-5}$ DALY

Reliability — Relevance

Modelling impact pathways relies on assumptions and statistics…



Modelling impact pathways



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Water footprint case studies

• Daimler:	Water footprint of production site Sindelfingen
• EuroCopper:	Water footprint of copper sheet and tube
• Siemens:	Water footprint of seawater desalination plants
• Volkswagen:	Water footprint of passenger cars
• Research:	Water footprint of biofuels
• Neoperl:	Water footprint of flow regulator
• German EPA:	Water footprint of milk production
• BMBF:	Water footprint of cotton (InoCottonGrow)
• BMBF:	Water footprint of organizations (WELLE)
• BfdW:	Water footprint of German and European agricultural imports

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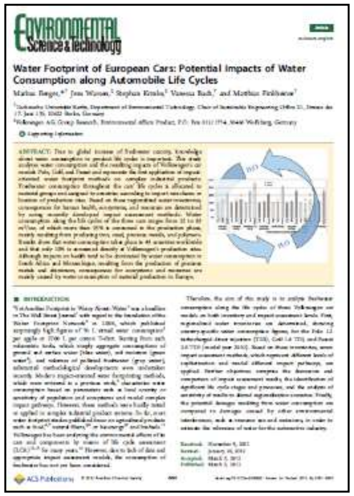
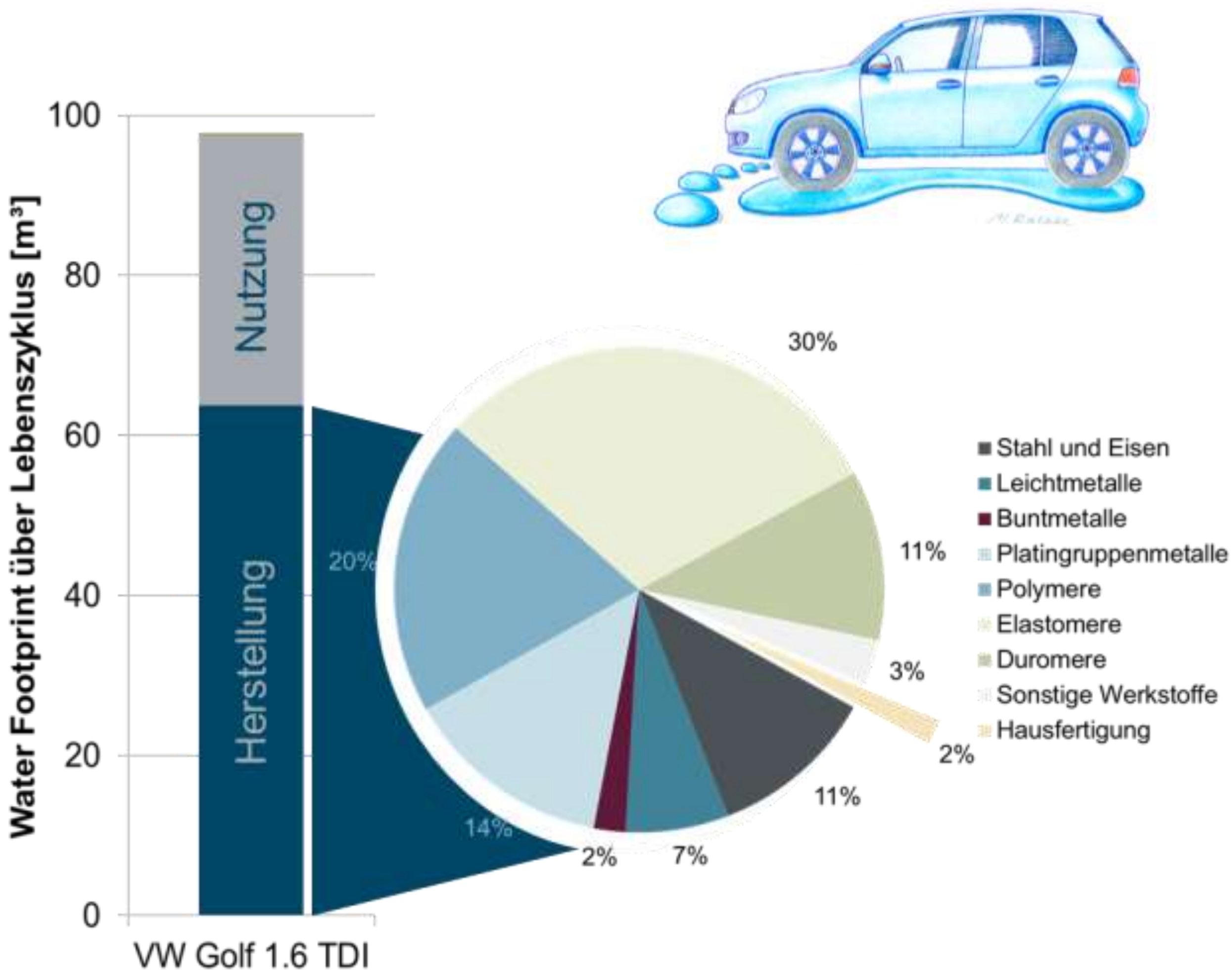
- Water Footprint Golf: 97 m³ of (blue) water consumption along life cycle

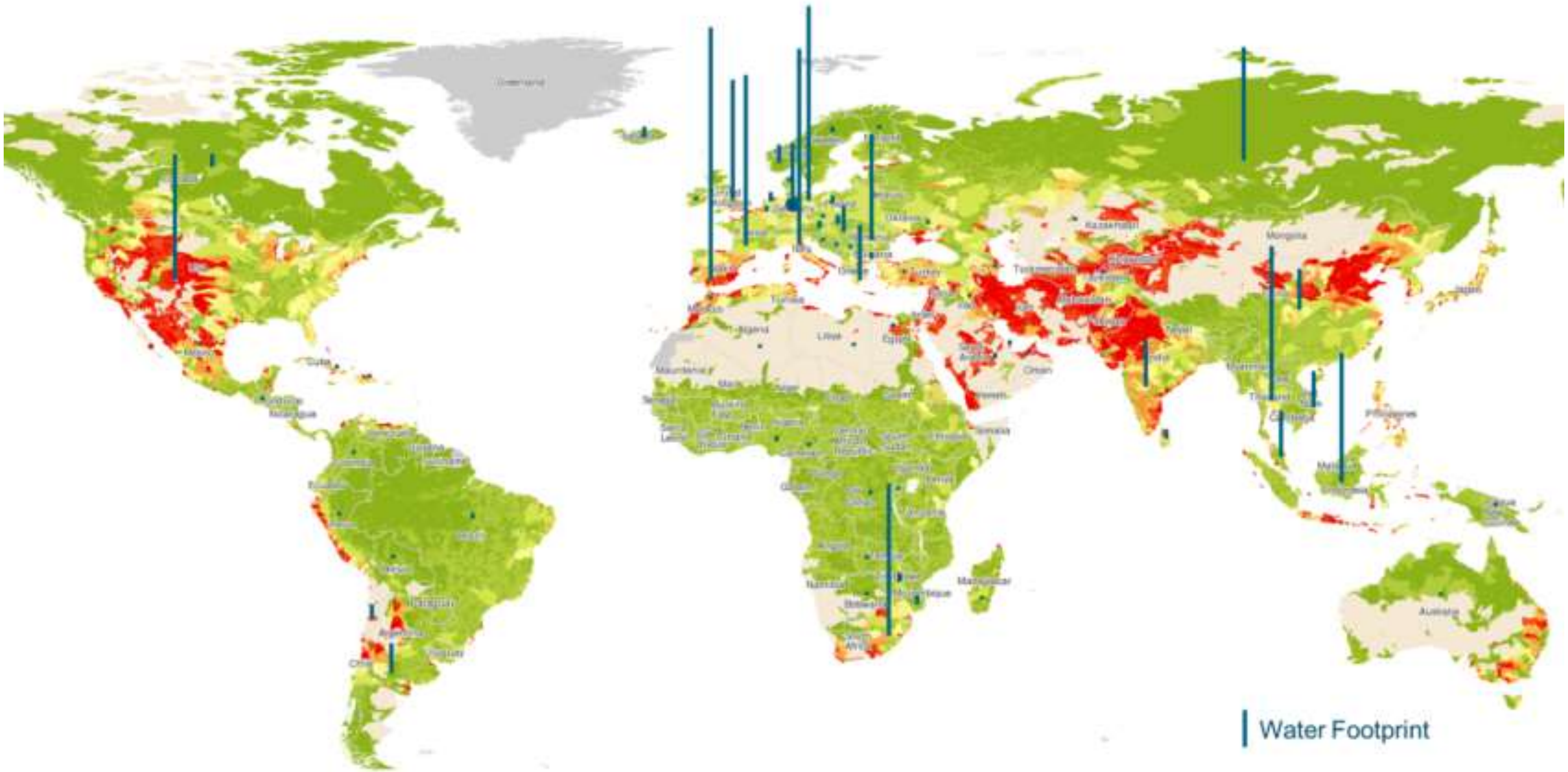

Environmental Science & Technology

Water Footprint of European Cars: Potential Impacts of Water Consumption along Automobile Life Cycles



Water Footprint Volkswagen

- Water consumption in 69 countries, only 2% at production site



Now hotspots are identified – what's next?

- Water Footprint of Organizations – Local Actions in Global Supply Chains
  – Develop a method, database, and tool for organizational water footprints
  – Initiate a water stewardship process at hotspots in supply chains, e.g. Lonmin (Platinum supplier in South Africa)

GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung

Thank you very much for your attention!

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