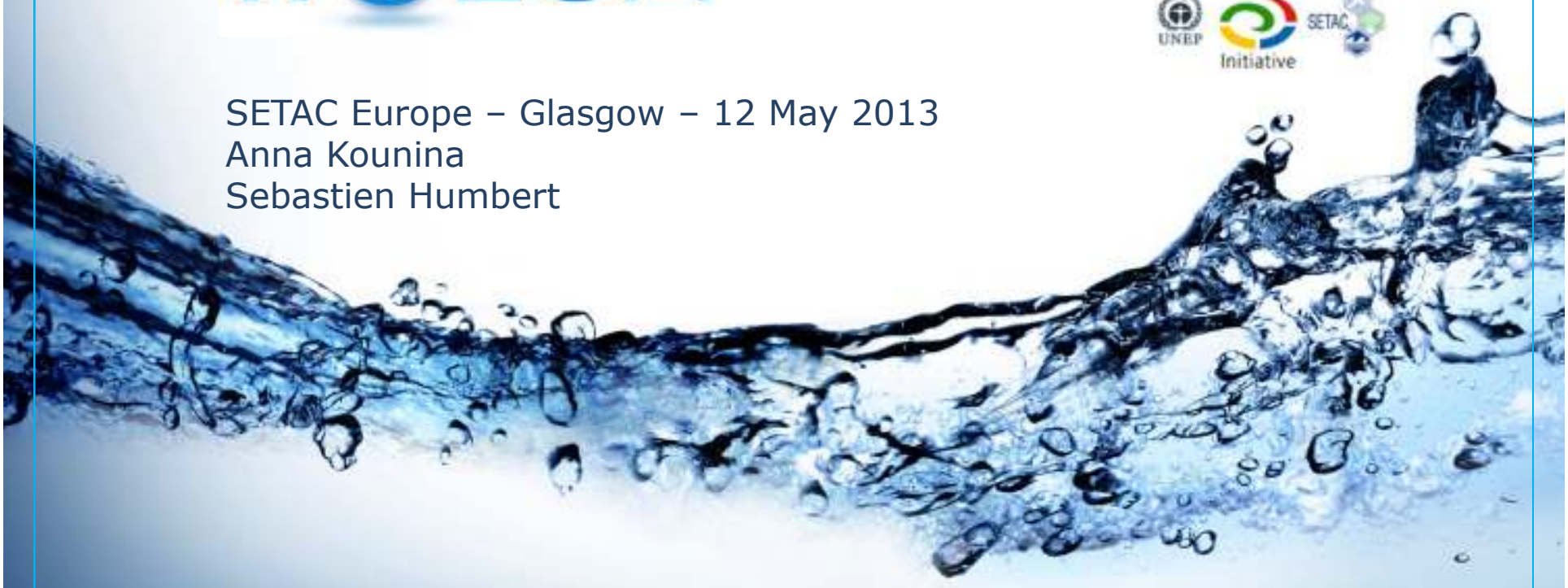
WULCA

A LIFE CYCLE INITIATIVE PROJECT



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Review of methods addressing freshwater use in life cycle inventory and impact assessment

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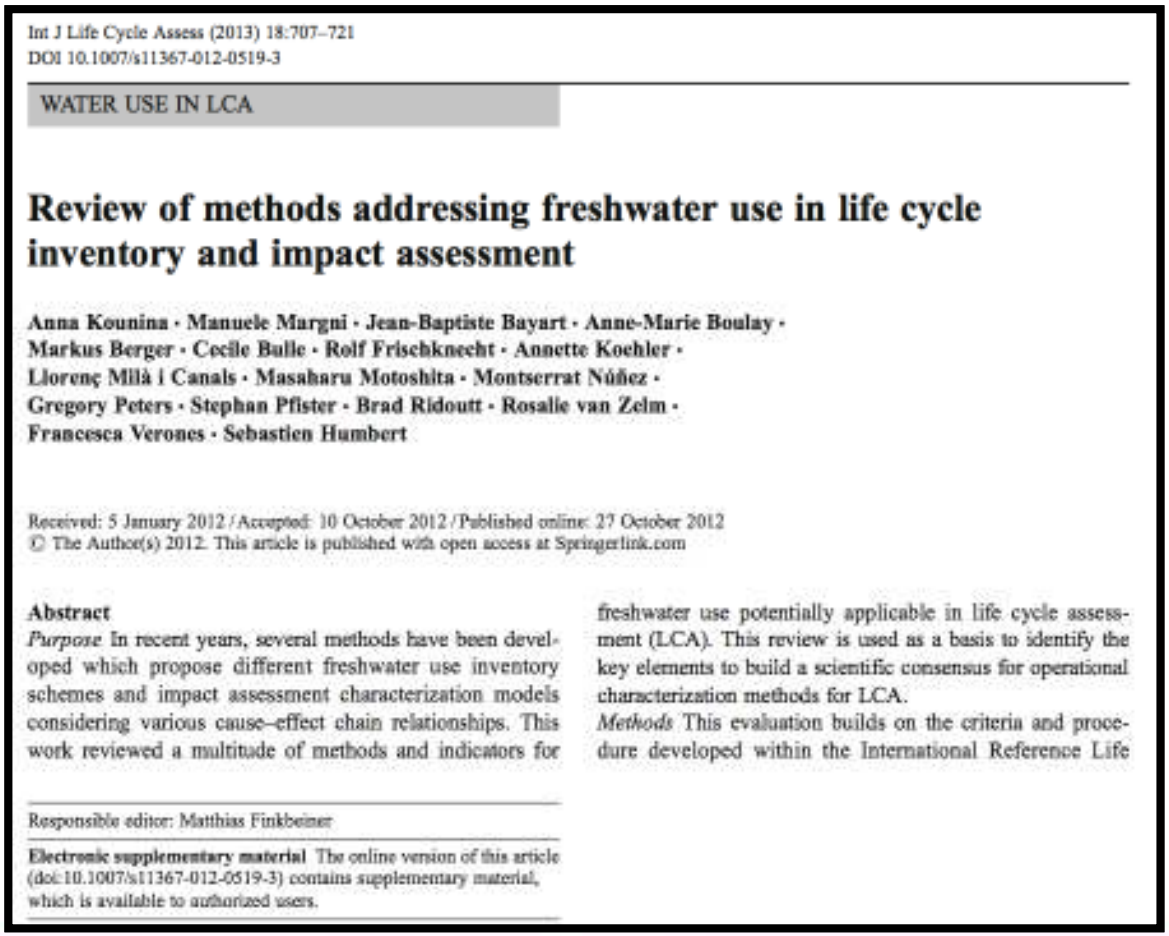

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WATER USE IN LCA

Review of methods addressing freshwater use in life cycle inventory and impact assessment

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Abstract
Purpose In recent years, several methods have been developed which propose different freshwater use inventory schemes and impact assessment characterization models considering various cause–effect chain relationships. This work reviewed a multitude of methods and indicators for freshwater use potentially applicable in life cycle assessment (LCA). This review is used as a basis to identify the key elements to build a scientific consensus for operational characterization methods for LCA.
Methods This evaluation builds on the criteria and procedure developed within the International Reference Life

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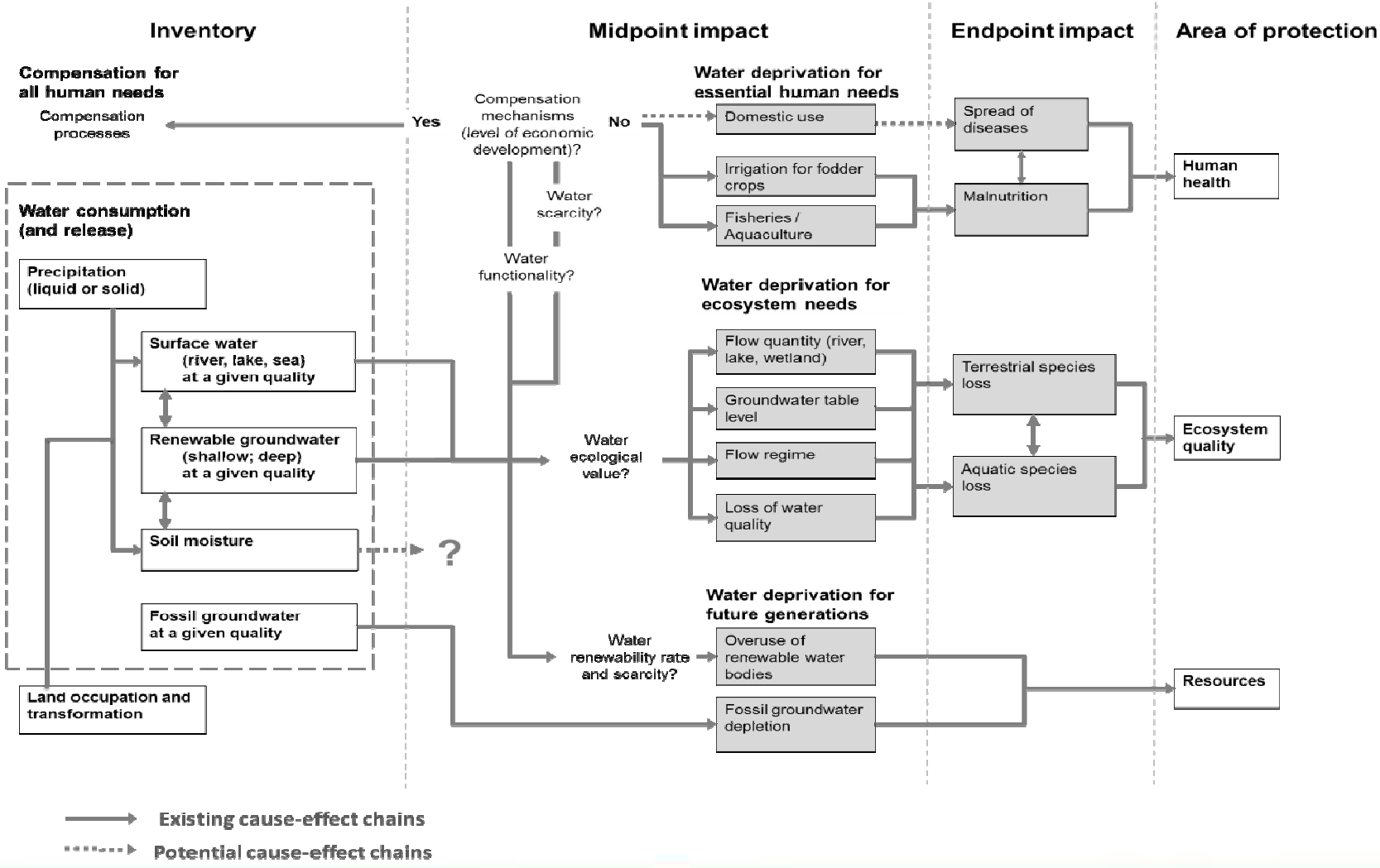
WORK SUMMARY

Cause-effect chains leading from the inventory to the areas of protection human health, ecosystem quality and resources (adapted from Bayart et al. (2010))



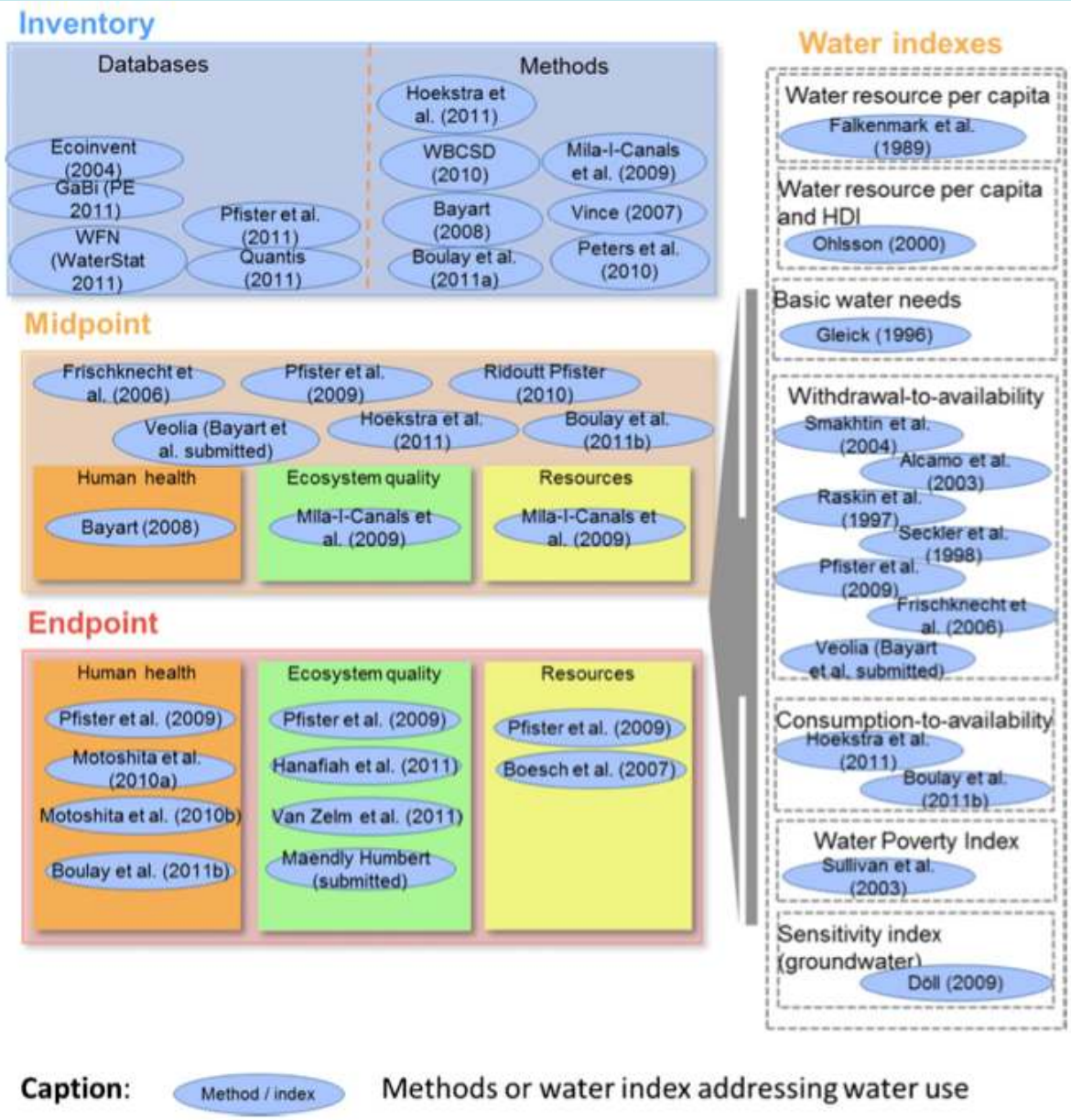
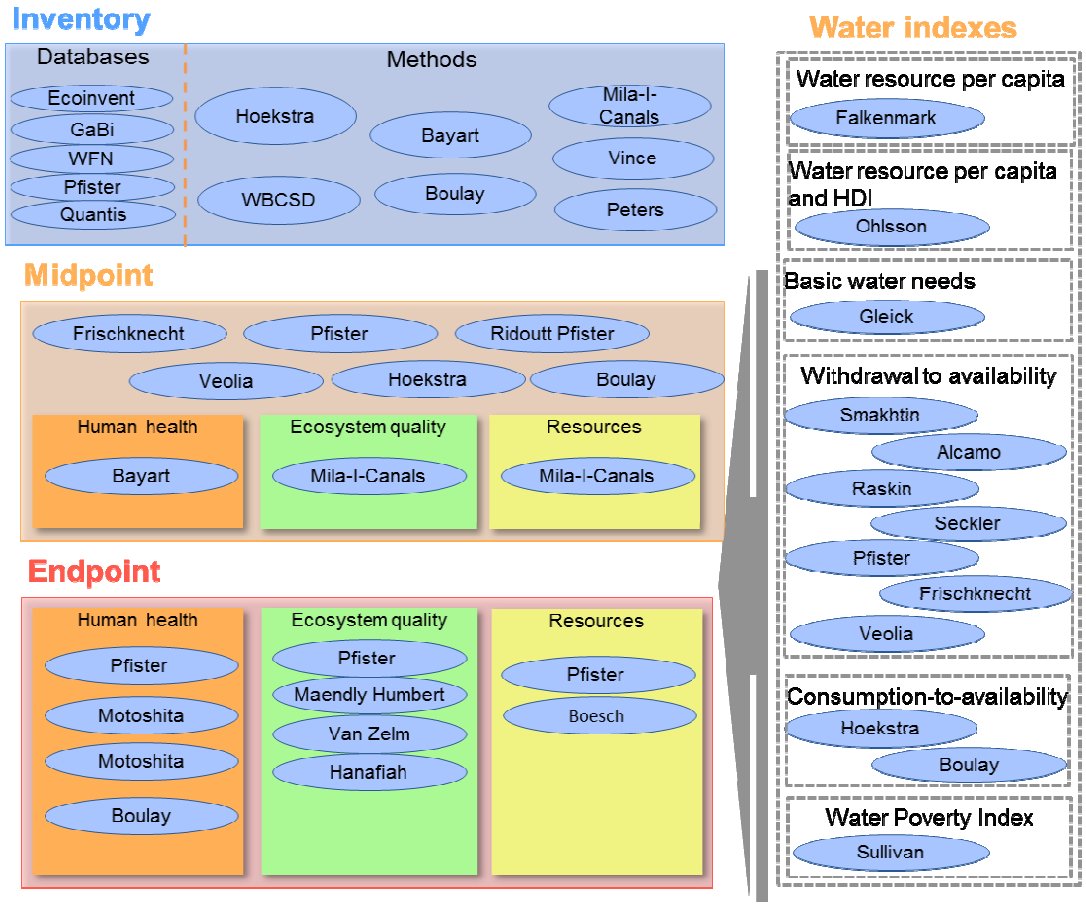


Fig. 2 Scope of and relationship between the available freshwater use inventory and impact assessment methods with classification for the three areas of protection

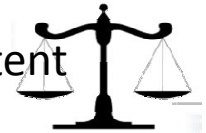
Scope of and relationship among the available freshwater use inventories, and impact assessment methods with classification for the three areas of protection



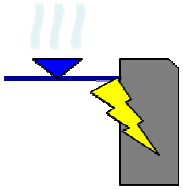
Caption: Method / index — Methods or water index addressing water use

Model components to build a scientific consensus for method developers (1)

Inventory databases



- Differentiate **consumptive** freshwater use from **withdrawal** through consistent water balances for foreground and background processes
- Do not mix physical flows with assessment of polluted water (such as m^3-eq.)
- **Distinguish** among different water types based on **origin** (surface freshwater, including river, lake and sea, groundwater, including renewable, shallow and deep and precipitation freshwater stored as soil moisture and fossil groundwater) and freshwater **quality** (and thus functionality)
- Include freshwater **evaporation from water reservoirs** as consumptive use



Optionally:

- Differentiate **shallow** (<3.5) and **deep** groundwater (e.g., in order to apply Van Zelm et al. 2011) or estimate regional average fractions of areas of each type
- Differentiate withdrawal of **fossil** groundwater from **renewable groundwater** based on regionally available resources

Model components to build a scientific consensus for method developers (2)

Inventory methods

- Include only measurable freshwater types (or said it differently, calculated in a **transparent** way), e.g., surface water and groundwater, or a method to estimate those flows shall be provided
- Use water quality parameters to characterize freshwater flows that are available in existing databases

Midpoint methods addressing water scarcity

- Include **water storage** capacity in the modelling of total water availability within a geographical unit
- **Compare** quantitatively more comprehensive midpoint indicators (e.g., including water functionality) with other indicators based solely on water scarcity
- Provide further empirical evidence of the **link** among **water scarcity, water deprivation, and impact** on different areas of protection to evaluate the relevance of midpoint versus endpoint indicators

Model components to build a scientific consensus for method developers (3)

Endpoint method for the area of protection human health

- Provide a **quantitative comparison** of existing methods as well as an evaluation against empirical figures
- Assess the relevance and uncertainty of modelling indirect impacts related to **water deprivation**
- Develop new approaches for modelling of **compensation mechanisms** to prevent water loss in functionality throughout impact categories

Endpoint method for the area of protection ecosystem quality

- Identify extensively **missing cause-effect chain**
- Provide **global coverage** for methods developed for a single country or with partial basin coverage

Model components to build a scientific consensus for method developers (4)

Endpoint method for the area of protection resources

- Cover the cause-effect chain leading to impact of **fossil groundwater** exhaustion
- Distinguish impact related to **different freshwater types** consumption, given they have different renewability rates and functionalities
- Quantifying the link between **green water use** and resources
- Explore the possibility of considering freshwater issues in a global perspective by expressing water consumption and evapotranspiration in relation to global freshwater availability

All methods

- Evaluate uncertainties of input data as well as model **uncertainty**
- Provide characterization factors with **monthly differentiation** to reflect variability related to meteorological conditions and associated ecosystem changes

Application recommendations for practitioners given current state-of-the-art

Inventory

- Including freshwater withdrawal and release, water consumption and turbined water

Midpoint level assessment

- Use all existing midpoint methods and perform a sensitivity analysis to interpret results
- Interpret results in parallel with damage oriented impact assessment indicators

Endpoint level assessment

- **Human health:** combine indicators of all cause-effect chains, i.e., malnutrition or infectious diseases related to water deprivation of a defined quality class for agriculture, fisheries and domestic use for human health
- **Ecosystem quality:** use all ecosystem quality indicators simultaneously and summed up into a single metric
- **Resources:** not sufficiently developed to provide significant results

Complete the assessment with the impact of emission to all compartments ultimately affecting water (e.g., aquatic acidification, aquatic eutrophication, eutrophication, aquatic thermal impacts, human toxicity and ecotoxicity)

Thank you for your attention

Questions?

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