

## Complementarities of Water-Focused Life Cycle Assessment and Water Footprint Assessment

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The recent past has shown two parallel developments: the water resources community discovered the relevance of supply chain thinking for water resources management and freshwater allocation,<sup>1</sup> while the life cycle assessment (LCA) community recognized the importance of water use and included those related impacts in LCA studies.<sup>2</sup> The water footprint concept was introduced by Arjen Hoekstra as an indicator of freshwater appropriation, with the aim to quantify and map indirect water use and show the relevance of involving consumers and producers along supply chains in water resources management.<sup>1</sup> The Water Footprint Network (WFN) subsequently developed a methodology for water footprint assessment (WFA).<sup>3</sup> Simultaneously, the LCA community developed comprehensive methodologies<sup>4</sup> to include environmental impacts related to water in LCA studies and started to frame the main concepts in the forthcoming international standard on water footprint (ISO 14'046). In this text, WFA refers to the approach that emerged in the water resources management community, and LCA<sub>water</sub> to the approach that emerged from the LCA community and that focuses only on the assessment of impacts related to water.

The two different approaches have been somewhat in conflict in the past few years.<sup>5</sup> We shed light on this argument and clarify the objectives of both approaches, their strengths and complementarities, in the hope that less energy can be invested

in debating these approaches and more on applying and developing them further.

Both methodologies have the indirect goal to help their practitioners preserve water resources, however, the way they achieve this differs. The LCA methodology aims at quantifying potential environmental impacts generated by a human activity on a wide range of environmental issues (climate change, human respiratory impacts, land use, etc.). One of the potential causes of impact is water use. LCA therefore includes potential impacts from depriving human users and ecosystems of water resources, as well as specific potential impacts from the emitted contaminants affecting water, through different environmental impact pathways and indicators (mainly eutrophication, acidification and toxicity to human and ecosystems). The LCA methodology includes four phases: goal and scope, inventory accounting, impact assessment and interpretation. Quantitative impact indicators are at the core of the impact assessment phase.

The WFA methodology addresses freshwater resources appropriation in a four-step approach including setting goals and scope, water footprint accounting, sustainability assessment, and response formulation. The accounting phase includes the quantification and mapping of freshwater use with three distinct types of water use: the blue, gray and green water footprints. WFA is primarily designed to support better water management, including its use and allocation and has played an important role in the awareness raising of water issues in the past decade.

Both WFA and LCA use quantitative indicators, but in different phases of the assessment. This can be more easily understood when comparing the frameworks of both methodologies (see Figure 1). WFA particularly relies on water use indicators in the inventory phase, while LCA focuses on impact indicators in the impact phase. This is the primary source of confusion for practitioners as indicators are to be understood in the right context.

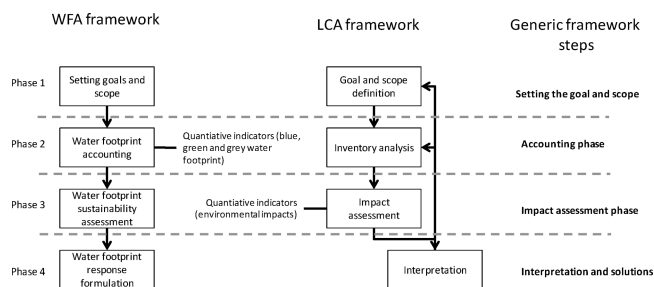
WFA defines the water footprint (WF) as a spatiotemporally explicit indicator of freshwater appropriation in the accounting phase. The "water footprint sustainability assessment" phase focuses on a multifaceted analysis of the environmental sustainability, economic efficiency and social equity of freshwater use and allocation. Here, WFs are put into context, for example by comparing WFs of activities or products to

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**Figure 1.** Comparison of LCA and WFA, illustrating the large similarity and the difference in quantitative indicators.

benchmarks and by comparing total WFs to water availability within catchments. Water scarcity, quantified as the ratio of water use to water availability, is one aspect of the assessment. LCA focuses on quantitative indicators, both in the accounting phase (the inventory), but more importantly in the regionalized impact assessment phase. This latter phase describes specific impact pathways and ultimately focuses on impact indicators in three main areas of protection: human health, ecosystems impacts and resources depletion. Water scarcity indexes are sometimes used as indicators along these impact pathways. The last step is similar for both frameworks as it allows for further interpretation to define solutions to reduce the anthropogenic intervention on the environment.

Probably the most important difference between both methods is the product-focus of  $LCA_{water}$  and the water management-focus of WFA. The LCA methodology focuses on the sustainability of products, with a comprehensive approach, whereby water ( $LCA_{water}$ ) is just one area of attention among others (e.g., carbon footprint, land use). WFA focuses on analyzing the sustainable, efficient and equitable allocation and use of freshwater in both local and global context with either a product, consumption pattern or geographic focus.

In terms of synergy, both methodologies could take advantage of the other. In particular for LCA:

- **Inventory:** The quantitative indicators used in WFA can be used within LCA as inventory flows, in particular the blue WF. The green WF can be used within the LCA inventory although at this point no specific methods exists assessing impacts from green water use. The gray WF represents a hypothetical quantification of water pollution and thus cannot be used as an inventory flow in LCA.
- **Impact Assessment:** The blue water scarcity indicator used in WFA compares well with other scarcity indicators used in LCA, and efforts could be joined to develop a consensual indicator emerging from the best practices suggested by each method.
- **Interpretation:** LCA methodology could take advantage of the sustainability assessment and response formulation to further develop the interpretation of LCA quantitative results.

In particular for WFA:

- **Accounting:** LCA inventory data relies usually on well-developed databases that could allow WFA accounting to be more comprehensive and precise, especially for industrial products.
- **Sustainability assessment:** WFA could benefit from considering the impact assessment methodologies evolving within the LCA community and joint efforts

could lead to some consensual metrics to better assess the sustainability of freshwater use.

In conclusion, the methodologies are fulfilling complementary goals. Practitioners could benefit from using these synergies in their studies. They should be cautious when comparing quantitative indicators from both methodologies, as they are not comparable.

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### Notes

The authors declare no competing financial interest.

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