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Editorial

Towards Sustainable Consumption and Production in a Thirsty World: Progress and Challenges in Water Footprint Assessment

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Humanity's need for freshwater has more than doubled since the 1960s, in line with population and economic growth [1]. Currently, the percentage of the world's population suffering from severe water scarcity ranges from 30% (considering only water quantity) to 40% (looking at both water quantity and quality) [2]. Global water demand is projected to increase by more than 55% by 2050 [3]. As water scarcity is primarily driven by human water demands and management, solutions should also come from anthropogenic actions [4]. However, moving towards more sustainable consumption and production economies entails addressing complex global supply chains, which can transfer water impacts, risks, and vulnerabilities between producer and consumer regions. Fortunately, achieving these more sustainable economies might also be a way to mitigate water impacts and build water resilience. Improving water resources management is, therefore, complex as it involves all sectors and actors of the economy, including governments, companies, farmers, investors, NGOs, consumers, and civil society.

In 2015, the United Nations Member States approved the 17 Sustainable Development Goals (SDGs). These include a sixth Goal focused on water that aims not only to attain access to safe drinking water and provision of sanitation but also to achieve sustainable water management worldwide, addressing the challenges of water quality, efficiency, integrated water resources management, and protection and restoration of water-related ecosystems [5]. In this context, determining the key indicators and tools for assessing water use in the economy that assure sustainable water management and water security for all uses and users is imperative. Since what cannot be measured cannot be managed and improved, the water footprint emerges as a key indicator for this purpose. Building on the advances in the water footprint field within the last 20 years, the water footprint assessment today can support different stakeholders in achieving the SDGs, particularly SDG 6, in the areas of policy and planning and production and consumption of goods and services [6,7]. The water footprint has been proven to be an effective method and tool to achieve a more water-circular economy [8].

The water footprint can support decision-making in different ways. Governments, businesses, and end-consumers alike usually turn a blind eye to supply chains and the impacts of imported goods. Water footprint assessments are a first step towards improving the sustainability of worldwide production because they provide objective data and perspectives on the big picture and on the drivers of water use and abuse [9,10]. A consideration of trade-related water concerns might also suggest new global water-governance solutions, which could be applied by introducing measures to ensure that existing food-trade

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frameworks of the European Single Market and the World Trade Organization are effective, sustainable, and equitable [9]. Decision-making could also be supported by assessing the water footprint in different scenarios. For instance, comparing the business-as-usual scenario with a more sustainable path. For example, the comparative analysis between the scenario with a Food Bank and the theoretical scenario without its action highlights the benefits associated with its activity, which avoids the waste of food suitable for consumption and the unnecessary consumption and pollution of freshwater resources [11]. The water footprint indicator can also be used to assess different production systems, which hide an enormous variability as regards the different productive and management aspects. For instance, there are important differences in the water footprints of beef fed on two different diets, with co-product and conventional feed, particularly when animal performance indicators differ [12]. On the other side, advanced grey water footprint assessments are useful for understanding the link between diffuse pollution pressures and their impacts on water resources, which are generally difficult to monitor and regulate [13]. This might help to elucidate the connections between consumption patterns and environmental consequences, provide insight into solutions, and help anticipate pollution hotspots [13].

However, the path to achieving sustainable consumption and production in terms of water is still long. The water footprints of production and consumption activities can be calculated using different methodological approaches, yielding different results for the same geographical region [14]. Moreover, specific calculation assumptions can yield very different results [14]. Adequate models and harmonized approaches are needed to track the water flows through the global trade network up to final consumption [14]. This could facilitate the assessment measures and predict what measures are more effective. New technologies, such as the application of Internet of Things-based monitoring systems, could help to perform measurements more efficiently along the value chain [15].

As regards the energy sector, most studies have traditionally addressed the consumptive (blue and green) water footprint of energy [16–19]. However, they have generally overlooked the grey water footprint, as there are missing data at regional [20] and global scales [21]. Unfortunately, the grey water footprint of certain power generation technologies might be significant, as indicated by previous researchers [22–25]. The international literature also still lacks rigorous studies on the water footprint of new energy alternatives, such as green hydrogen. Although green hydrogen is presented as a proper alternative for the reduction of greenhouse gas emissions, its impact in terms of water could not be negligible. Likewise, given their potential to reduce pollutant emissions, new electric and alternative fuel vehicles have been widely promoted by governments. As the transport sector uses multiple types of energy and is a major source of water consumption from a life-cycle perspective, the environmental water implications of these new types of vehicles should be enhanced [26–28]. Finally, over the last decade, artificial intelligence models have seen remarkable advances and successes in many areas of vital importance to our society, including tackling climate change. Data warehouse centers are known to be energy-intensive, collectively accounting for 2% of the world's electricity consumption and leaving a large carbon footprint [29]. However, much less is known about the unintended water externalities of these data centers. Some recent studies have tried to estimate the water footprint of artificial intelligence models or information retrieval systems, but efforts are still insufficient [30,31].

Lastly, the water footprint can be a useful tool not only to raise awareness and inform consumers about the hidden water use and resulting impacts of daily products and services but also as a tool for capacity building [32] and educating children to protect local and global water resources [33–37]. Education is crucial for achieving the water-related SDGs and is one of the most powerful vehicles for improving water management and governance [38]. While some progress has been made in water footprint educational materials over the past two decades, mainly at the secondary school level [33,35–37] and to a lesser extent at the primary school level [37], it is still scarce and fragmented. The potential of the water footprint for education remains an isolated area in general, and even more so when it comes to educational practices that integrate the acquisition of water footprint knowledge during curricular training. As a result, more educational developments and practices related to water footprint are urgently needed.

There is still much work to be performed to achieve more sustainable consumption and production patterns related to water. The water footprint is a useful instrument to support achieving this goal. Still, advances in the field are needed to fill the research gaps and better understand the inter-linkages and water flows in the economy. This Special Issue, titled "Water Use in a Thirsty World: Towards Sustainable Consumption and Production Using the Water Footprint", welcomes contributions that make progress in the field of green, blue, and grey water footprint assessment and virtual water trade in different contexts and scales that seek to achieve more effective, sustainable and equitable integrated water resources management.

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