

Beyond Litres per Kilogram: Rethinking the Water Footprint of Food

Iram Jamal¹

When we buy a kilogram of rice, we usually consider its price, quality and nutritional value. We rarely consider the water required to produce it. Even when that water is measured, however, an important question remains: Does the quantity of water used tell us whether the production is sustainable? Understanding the water footprint of food requires us to look beyond the volume consumed and examine where the water comes from and what its use means for the producing region.

The concept of virtual water helps reveal this connection between agricultural production and trade. Virtual water refers to the water consumed in producing a commodity. When rice or another agricultural product is traded, the water itself does not travel with the shipment. Instead, the importing region becomes indirectly dependent on the water resources used by the producer. This relationship matters because agricultural trade can distribute the benefits of production across regions while leaving its environmental pressures concentrated in particular locations.

The scale of this connection is significant. Mekonnen et al. (2024), in a review published in *Nature Reviews Earth & Environment*, estimated that approximately one-fifth of the water used in global food production is traded virtually rather than consumed domestically. Their study also documented a substantial expansion of virtual-water trade between 1986 and 2022. While this trade can help countries manage water scarcity and food insecurity, the authors warn that it is also associated with unsustainable water use and groundwater depletion.

The challenge, therefore, is not simply to calculate the water footprint of a commodity. It is to understand what that footprint represents in its local context.

Consider two regions producing the same quantity of rice. One relies mainly on rainfall, while the other depends heavily on irrigation from rivers or groundwater. Their total water footprints may appear comparable, yet their implications for water security can differ considerably. Rainwater stored in soil and used by plants is generally classified as **green water**, whereas water drawn from surface sources and aquifers is classified as **blue water**. Distinguishing between these sources helps explain why equal quantities of water use do not necessarily create equal environmental pressures.

India provides an important example of this distinction. Rice is essential to domestic food security and rural livelihoods, and it also contributes substantially to agricultural exports. Nishad and Kumar (2022), examining India's rice-related virtual-water trade, highlighted the scale of water associated with rice production and exports and raised concerns about the implications for long-term water sustainability. Their analysis reinforces the need to consider agricultural trade alongside the country's wider water-resource constraints.

This does not mean that rice exports are inherently undesirable. Export earnings, farm incomes and international markets are important to agricultural development. Nor does a large water

footprint automatically mean that a crop is environmentally harmful. The more relevant question is whether the water used can be replenished and whether its withdrawal compromises the needs of other users and ecosystems.

Research by SreeVidhya and Elango (2018) further illustrates why virtual-water trade deserves attention in India's resource planning. Their analysis of trade in selected crop and livestock products identified rice as an important contributor to India's virtual-water exports. Such findings demonstrate the value of looking beyond the monetary value and physical volume of agricultural exports to consider the natural resources supporting them.

Yet water availability alone cannot explain the pattern of agricultural trade. Countries and regions make production decisions under different economic, technological and institutional conditions. Access to irrigation, infrastructure, markets, finance and government support can influence which crops farmers grow and which products enter export markets. Consequently, a water-stressed region may continue exporting water-intensive commodities even when this raises questions about competing domestic needs.

Vallino, Ridolfi and Laio (2021), in *Scientific Reports*, examined virtual-water trade in relation to both physical and economic water scarcity. Their findings challenge the assumption that water-scarce countries will necessarily import water-intensive products while less-constrained countries export them. Trade flows do not always follow differences in water availability, and the consequences cannot be understood through a single national average.

These findings are particularly relevant to rice-growing regions around the Bay of Bengal, including eastern India, Bangladesh and Myanmar. Rice production is central to livelihoods and food systems across the region, but local rainfall, irrigation dependence, groundwater conditions and agricultural practices differ. A single water footprint estimate for rice cannot adequately represent these differences. The sustainability of production must be assessed in relation to the specific water system that supports it.

This distinction also matters when evaluating improvements in agricultural productivity. A reduction in water use per kilogram of rice may indicate greater efficiency. However, if improved efficiency encourages an expansion of cultivated area or more intensive production in a water-stressed location, total withdrawals may not decline. Water productivity and water sustainability are related, but they are not interchangeable.

For policymakers, the implication is straightforward: water-footprint assessment should move beyond reporting a single figure. Alongside the volume of water associated with a commodity, assessments should identify its green- and blue-water components and consider local water scarcity, groundwater conditions and seasonal availability. These indicators could be examined alongside crop yields, production costs, farmer incomes and export earnings.

Such an approach would not require governments to prohibit water-intensive crops or restrict trade solely because a commodity has a high-water footprint. Instead, it would provide a stronger evidence base for decisions about irrigation investment, crop planning, agricultural incentives and export strategies. It could also help distinguish between production systems that

use substantial amounts of water yet remain compatible with local conditions and those that place excessive pressure on already vulnerable resources.

For the Bay of Bengal region, a more contextual approach could support better-informed discussions about agricultural cooperation and water security. Shared research methods and comparable data would help policymakers understand how production and trade affect water resources across different locations. The objective should not be to treat the region as hydrologically uniform, but to recognise its differences when designing agricultural and trade policies.

Ultimately, a water footprint is more than a measurement of water consumption. It is a starting point for understanding the relationship between food production, trade and the resources on which livelihoods depend. A figure expressed in cubic metres per tonne cannot, by itself, tell us whether water use is sustainable. That judgement requires information about the source of the water, its availability and the competing demands placed upon it.

As agricultural trade expands and climate variability creates greater uncertainty, this distinction will become increasingly important. The task is not merely to measure how much water is associated with the food we trade, but to understand the conditions under which that water is used. **The same quantity of water can have very different consequences in different places.** Recognising this should be central to a more sustainable approach to agricultural production and trade.

References

- Mekonnen, M. M., et al. (2024). Trends and environmental impacts of virtual water trade. *Nature Reviews Earth & Environment*, 5, 890–905. <https://doi.org/10.1038/s43017-024-00605-2>
- Nishad, S. N., & Kumar, N. (2022). Virtual water trade and its implications on water sustainability. *Water Supply*, 22(2), 1704–1715. <https://doi.org/10.2166/WS.2021.322>
- SreeVidhya, P. K., & Elango, L. (2018). Temporal variation in export and import of virtual water through popular crop and livestock products by India. *Groundwater for Sustainable Development*, 7, 42–50. <https://www.sciencedirect.com/science/article/pii/S2352801X18301358>
- Vallino, E., Ridolfi, L., & Laio, F. (2021). Trade of economically and physically scarce virtual water in the global food network. *Scientific Reports*, 11, 22806. <https://doi.org/10.1038/s41598-021-01514-w>

¹Iram Jamal is a Senior Research Fellow and PhD Scholar at the Department of Business Management, University of Calcutta. Views are personal