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Water footprints: Path to enlightenment, or false trail?

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ABSTRACT

Virtual water and water footprints have gained recognition as indicators to guide action on issues related to water scarcity. I argue that water footprints are fundamentally different from carbon footprints, as local reductions in carbon emissions have global benefits, while global attempts to reduce water footprints will have neither necessary beneficial impacts in areas of local water scarcity, nor global impacts on atmospheric water content. In addition, water footprints have little or no meaning for purposes of setting policy regarding national water use or international trade. Furthermore, the calculation procedures adopted in most estimates of water footprints are flawed. Finally, I suggest that water footprints are incorrectly assessed on an absolute, rather than a relative basis. Water analysts are fortunate to have hydrology, a science with agreed procedures and standards, to use in describing the physical impacts of interventions in the hydrologic cycle. Generalised water footprints are neither accurate nor helpful indicators for gaining a better understanding of water resource management.

1. Introduction

Competition for water, unsustainable use of groundwater, polluted, and depleted lakes and rivers, damaged ecosystems and dried-up estuaries are recurrent themes of agency and donor reports, journal articles, and international conferences. Such problems are evident in many regions where precipitation is low or erratic, such that vegetative growth is limited by water availability. Population growth, changes in diet, increasing incomes, and climate change are generally expected to increase these pressures.

Trade offers a solution to differential resource endowments between regions and countries. Since some countries have inadequate land (e.g., Singapore) or water resources (e.g., Yemen) to be self-sufficient in agricultural commodities, importing food and fibre is an essential element of their economy. Some twenty years ago, Prof. Tony Allan (Allan, 1997) introduced the phrase “virtual water”, noting that many goods, especially agricultural products, require large quantities of water in their production: for example, producing a kilogram of wheat typically utilizes a tonne of water. Trade in agricultural products, he argued, can be viewed as trade in the water utilised in the production process.

According to the virtual water perspective, if a country has fully committed its water resources, importing a kilogram of wheat negates the need to import a tonne of water. Yet, the traded products actually contain very little water. Most of the water used to produce a crop is transpired through the leaves, or evaporated from wet leaves or soil. Both these processes—the first essential to crop growth, the second a non-productive consequence of making water available to the crop—convert locally available water into water vapour that contributes to the hydrologic cycle at uncertain future times and places. Thus, crops embody “virtual” water just as an industrial product might be said to embody “virtual” labour, capital, or intellectual property rights.

In the early 2000s, the virtual water perspective was extended to the idea of a “water footprint” (Hoekstra and Huynen, 2002). This involves two key additions to Allan’s original approach. First, the footprint of a product (e.g., a bottled drink) involves the water used to produce the agricultural ingredients, plus the water used to produce the container, the water required to generate power consumed in the production process, and the water used in other aspects of production and marketing. Second, water footprint analysis considers both ends of the trade in virtual water—where the water embodied in a product comes from, and where it goes (Hoekstra et al., 2012).

In parallel with the extension of virtual water into the notion of a water footprint, the insight provided by the concept has evolved from an idea of “economic efficiency” (whereby countries with very scarce water resources can redirect water to higher valued uses, while importing lower valued crops, or reducing consumption to more sustainable levels) to one of “fairness” (in which countries with very high per capita water footprints are seen as excessive consumers, while other countries remain “water poor”). For example, Lillywhite et al. (2010) write:

If the UK were to adopt an ethical policy on water, it should commit to assisting non-industrialised economies to increase their sustainable intensification of water use as a precautionary measure

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to reduce impacts on water resources, economies, and on farmers.

Such recommendations involve value judgements (ethical, sustainable, precautionary) that I do not address here. Rather, I focus on the meaning and measurement of a water footprint, and in particular the uncertainties in estimating the underlying virtual water content of agricultural crops, which is typically the largest component of an estimated water footprint. I consider also the partitioning of a water footprint into “green” and “blue” components.

2. Water and carbon footprints

Knowing the water footprints of the commodities we grow, manufacture, and consume provides an indicator of our dependence on water, and allows estimation of national, sectoral, and individual contributions to the global demand for water. In recent years, the water footprint perspective has attained rather similar status to that of a carbon footprint.

Ercin and Hoekstra (2012) present a detailed comparison of the similarities and differences between carbon and water footprints, noting:

Although there are similarities in the way both footprints are defined and calculated, they differ in important ways as well. **The location and timing within the year of [greenhouse gas] emissions, for example, are not relevant, whereas location and timing of water consumption and pollution matter critically.**

The highlighted comment is of considerable importance. Any (local) carbon dioxide emissions contribute to the (global) stock of carbon dioxide in the atmosphere. The location of the source is not relevant because our concern is with the global total. We expect that reducing the consumption by 1 kg of a commodity with a carbon footprint of 2 gm kg^{-1} will reduce global carbon emissions by 2 kg, with a corresponding impact on the amount of carbon in the atmosphere. Whether the commodity is produced in Iowa or Adelaide is irrelevant. We do not need to know the location of production to evaluate the global impact of carbon emissions.

Water footprints are in some ways the opposite. Emitting water vapour locally into the atmosphere is not a global concern, as the amount of water vapour in the atmosphere is a rather stable outcome of the earth’s energy balance. However, the local source of water vapour is a matter of concern, particularly in water-stressed areas. With carbon footprints, our concern is aggregate emissions and the source is irrelevant. With water footprints, aggregate “emissions” are irrelevant and the source is the critical issue.

The above quotation suggests that some water footprint proponents understand this important difference between carbon and water footprints. Yet many authors present estimates of water footprints without noting whether a producing area is water plentiful or water short. For example, statements such as the following appear on the Water Footprint Network website:

For drinking one standard cup of coffee in the Netherlands we need about 140 L of water, by far the largest part for growing the coffee plant.[1] Hoekstra and Mekonnen (2012a) write that “Understanding the water footprint of a nation is highly relevant for developing well-informed national policy.” Elsewhere in that article, as indeed in the two manuals published by the Water Footprint Network (Hoekstra et al., 2009; Hoekstra et al., 2011) there are caveats and cautions that estimated water footprints should be seen in context. Yet, as can be seen from the list of options described in the latter document, at Table 5.4 (p. 109), reductions in the capture and consumption of rainfall, and reductions in the consumption of irrigation water are advocated, and are presumed to be virtuous and desirable, given global concerns regarding water scarcity. Even where water is plentiful the recommendation is similar:

We acknowledge that reducing the aggregate [water footprint] in environmentally stressed catchments deserves priority, but given the competition over the globe’s freshwater resources, increasing water productivities (lowering product water footprints) in non-stressed basins can be an instrument to reach that goal. (Hoekstra and Mekonnen, 2012b)

Lowering product water footprints in such circumstances, thus allowing more water to run unproductively to the sea, has no economic or social merit[2]. This limited view of water use is evident in the body of publications on water footprints[3]. Many authors suggest that because human activities result in water scarcity, we must reduce the water footprints of our production and consumption activities.

Water and carbon footprints share a common weakness with respect to policy implications (Gawel and Bernsen, 2011a, 2011b, 2013). Both are essentially one dimensional estimates of impact. In the case of coffee noted above, we do not know whether, if the consumer gives up a daily cup of coffee:

a) Decreased coffee production will occur in a water-short or a water-plentiful country;
b) The water “saved” will be left in a river or aquifer, or reallocated to a lower (or higher) valued use; or
c) The coffee consumer will instead drink some other beverage with a lower (or higher) water footprint in a more (or less) water stressed area.

Procedures to recognise the significance of scarcity are yet to be agreed among proponents of water footprints. Ridoutt and Huang (2012) propose a method of computing “weighted” water footprints that evaluate the components of the footprint depending on whether the source of water has limited or abundant water supplies. However, Hoekstra and Mekonnen (2012b) reject this idea, writing:

A mere focus on reducing [water footprints] in water-stressed catchments displays a limited perspective on the question of what is globally sustainable and efficient water use.

According to Chenoweth et al. (2013) the Water Footprint Network opposes such adjustments because the volumes of water then reported would not represent “real” volumes, and also because “a weighted water footprint... may lead to an over-emphasis on reducing water use in water stressed catchments, thus preventing investment in improved efficiency in water-abundant areas.” In sum, there is no agreed approach to incorporating scarcity into the calculation of water footprints, other than the partition of water into “blue” and “green” components. The procedure for that analysis is assessed later in this paper, but here it can be noted that there is no necessary relationship between colour and scarcity (“blue” water in Canada is far more plentiful than “green” water in Egypt, for example).

While some authors are sceptical of the potential significance of the virtual water concept for addressing environmental issues (Meran, 2011), others have proposed “integrating” water, carbon,

[1] http://www.waterfootprint.org/?page=files/CoffeeTea, viewed October 17, 2013

[2] Admitting that such a policy might have a positive outcome would undermine the presumption that a reduced water footprint is desirable in the same, unqualified way that reducing a carbon footprint is desirable.

[3] Publications from the Water Footprint Network and independent scholars contribute to a substantial body of literature on the subject: Science Direct (searched December 11, 2012) finds more than 400 papers including “water footprint” in the title, and almost 13,000 web hits.