The water footprint of food

Professor Arjen Y. Hoekstra, Twente Water Centre, University of Twente, the Netherlands.

The international trade in agricultural commodities at the same time constitutes a trade with water in virtual form. Water in external areas has been used to produce the food and feed items that are imported. The water footprint of a good or a service is the total amount of water, external and internal, that is required to produce it. The concept can be used to calculate and compare the strain on water resources resulting from different options. It can also be extended to provide water budgets for whole nations or continents.

Water management is no longer an issue restricted to individual countries or river basins. Even a continental approach is not sufficient. The water footprint of Europe – the total volume of water used for producing all commodities consumed by European citizens – has been significantly externalised to other parts of the world. Europe is for example a large importer of sugar and cotton, two of the most thirsty crops. Coffee is imported from countries such as Colombia, soybean from Brazil, and rice from Thailand. European consumption strongly relies on water resources available outside Europe. How is Europe going to secure its future water supply? China and India are still largely water self-sufficient, but with rising food demand and growing water scarcity within these two major developing countries, one will have to expect a larger demand for food imports and thus external water demand. Water is increasingly becoming a global resource.

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Although in many countries most of the food still originates from the country itself, substantial volumes of food and feed are internationally traded. As a result, all countries import and export water in virtual form, i.e. in the form of agricultural commodities. Within Europe, France is the only country with a net export of virtual water. All other European countries have net virtual water import, i.e. they use some water for making export products but more water is used elsewhere to produce the commodities that are imported. Europe as a whole is a net importer of virtual water. Europe's water security thus strongly depends on external water resources. Related to this, a substantial proportion of existing problems of water depletion and pollution in the world relates to export to Europe.

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The 'water footprint' has been developed as an analytical tool to address policy issues of water security and sustainable water use. The water footprint shows the extent and locations of water use in relation to consumption by people. The water footprint of a community is defined as the volume of water used for the production of the goods and services consumed by the members of the community. The water footprint of a nation is an indicator of the effects of national consumption on both internal and external water resources. The ratio of internal to external water footprint is relevant, because externalising the water footprint means increasing the dependency on foreign water resources. It also results in externalising the environmental impacts. European countries such as Italy, Germany, the UK and the Netherlands have external water footprints contributing 50–80 % to the total water footprint.

The global water demand for production of food, feed, fibre and energy crops is rapidly increasing. A key question for regions that already now depend on external water resources is whether they can keep up their position as net virtual water importers. Another key question is which role businesses in the food sector can play in delivering products in a water-sustainable way. This chapter introduces a recently developed analytical framework to study the relation between globalisation of trade and water management for both governments and businesses.

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New concepts: virtual water trade and water footprints

The virtual-water concept was introduced by Tony Allan when he studied the possibility of importing virtual water (as opposed to real water) as a partial solution to problems of water scarcity in the Middle East. Allan elaborated the idea of using virtual-water import (coming along with food imports) as a tool to release the pressure on scarcely available domestic water resources. Virtual-water import thus becomes an alternative water source, alongside endogenous water sources.

The water footprint concept was introduced six years ago by Arjen Hoekstra. The concept is an analogue to the ecological footprint, but indicates water use instead of land use (see Box). The water footprint is an indicator of water use that looks at both the direct and indirect water use of a consumer or producer. The water footprint of an individual, community or business is defined as the total volume of freshwater that is used to produce the goods and services consumed by the individual or community or produced by the business. Water use is measured in terms of water volumes consumed (evaporated) and/or polluted per unit of time. The water footprint is a geographically explicit indicator that not only shows volumes of water use and pollution, but also the locations.

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Box: Three dimensions of the human footprint

The water-footprint concept is part of a larger family of concepts that have been developed in the environmental sciences over the past decade. A "footprint" in general has become known as a quantitative measure showing the appropriation of natural resources by human beings. The ecological footprint is a measure of the use of bio-productive space (hectares). The carbon footprint measures energy use in terms of the total volume of carbon dioxide emissions. The water footprint measures water use (in cubic metres per year).

In the mid-1990s, Wackernagel and Rees developed the concept of the 'ecological footprint'. They were worried about the amount of land required to supply the world population with what they consume, particularly if everybody in this world were to adopt a western lifestyle. People need land for living and moving, agricultural land (cropland and pasture) to produce the food required and forested land to supply things like wood and paper. Finally, there is forested land needed to transform the carbon dioxide emitted by human activities into organic matter. It has been argued that the total ecological footprint of all world inhabitants together can temporarily go beyond the available area, but only by exhausting the natural resource base, which is considered 'unsustainable'. Humanity has moved from using, in net terms, about half the planet's biocapacity in 1961 to over 1.2 times the biocapacity of the Earth in 2002. The global ecological deficit of 0.2 Earths is equal to the globe's ecological overshoot.

The carbon footprint is a measure of the impact that human activities have on the environment in terms of the amount of greenhouse gases produced, measured in units of carbon dioxide. It is an indicator for individuals and organizations to conceptualize their personal or organizational contribution to global warming. The carbon footprint can be seen as the total amount of carbon dioxide (CO_2) and other greenhouse gases emitted over the full life cycle of a product or service. A carbon footprint is usually expressed as a CO_2 equivalent (in kilograms or tonnes), in order to make the global warming effects of different greenhouse gases comparative and addable.

The total water footprint of an individual or community breaks down into three components: the blue, green and grey water footprint. The blue water footprint is the volume of freshwater that is evaporated from the global blue water resources (surface and ground water) to produce the goods and services consumed by the individual or community. The green water footprint is the volume of water evaporated from the global green water resources (rainwater stored in the soil). The grey water footprint is the volume of polluted water, which can be quantified as the volume of water that is required to dilute pollutants to such an extent that the quality of the ambient water remains above agreed water quality standards.

A water footprint can be calculated for any well-defined group of consumers (e.g. an individual, family, village, city, province, state or nation) or producers (e.g. a public organization, private enterprise or economic sector). One can also calculate the water footprint of a particular product. The water footprint of a product (a commodity, good or service) is the volume of freshwater used to produce the product, measured at the place where the product was actually produced. It refers to the sum of the water used in the various steps of the production chain. The 'water footprint' of a product is the same as what at other times is called its 'virtual water content'. Table 1 shows the water footprint for a number of common food items.

Consider the water footprint of beef. In an industrial beef production system, it takes on average three years before the animal is slaughtered to produce about 200 kg of boneless beef. The animal consumes nearly 1,300 kg of grains (wheat, oats, barley, corn, dry peas, soybean meal and other small grains), 7,200 kg of roughages (pasture, dry hay, silage and other roughages), 24 cubic metres of water for drinking and 7 cubic metres of water for servicing. This means that to produce one kilogram of boneless beef, we use about 6.5 kg of grain, 36 kg of roughages, and 155 litres of water (only for drinking and servicing). Producing the volume of feed requires about 15,300 litres of water on average. The water footprint of 1 kg of beef thus adds up to 15,500 litres of water. This still excludes the volume of polluted water that may result from leaching of fertilisers in the feed crop field or from surplus manure reaching the water system. The numbers provided are estimated global averages; the water footprint of beef will strongly vary depending on the production region, feed composition and origin of the feed ingredients.

Table 1. The water footprint of different food items.

Food item	Unit	Global average water footprint (litres)
Apple or pear	1 kg	700
Banana	1 kg	860
Beef	1 kg	15,500
Beer (from barley)	1 glass of 250 ml	75
Bread (from wheat)	1 kg	1,300
Cabbage	1 kg	200
Cheese	1 kg	5,000
Chicken	1 kg	3,900
Chocolate	1 kg	24,000
Coffee	1 cup of 125 ml	140
Cucumber or pumpkin	1 kg	240
Dates	1 kg	3,000
Groundnuts (in shell)	1 kg	3,100
Lettuce	1 kg	130
Maize	1 kg	900
Mango	1 kg	1,600
Milk	1 glass of 250 ml	250
Olives	1 kg	4,400
Orange	1 kg	460
Peach or nectarine	1 kg	1,200
Pork	1 kg	4,800
Potato	1 kg	250
Rice	1 kg	3,400
Sugar (from sugar cane)	1 kg	1,500
Tea	1 cup of 250 ml	30
Tomato	1 kg	180
Wine	1 glass of 125 ml	120

A new accounting framework

Traditional national water use accounts only refer to the water use within a country. In order to support a broader sort of analysis, the accounts need to be extended. This has resulted in an accounting framework as shown in Figure 1.

As can be seen in the figure, the water footprint of a nation has two components. The internal water footprint is defined as the water used within the country in so far as it is used to produce goods and services consumed by the national population. The external water footprint of a country is defined as the annual volume of water resources used in other countries to produce goods and services imported into and consumed in the country considered. It is equal to the virtual-water import into the country minus the volume of virtual-water exported to other countries as a result of re-export of imported products.

Figure 1. The new national water-accounting framework.

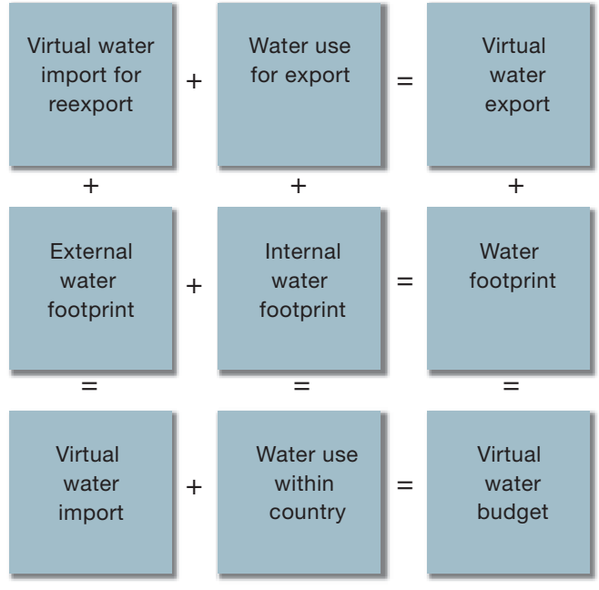
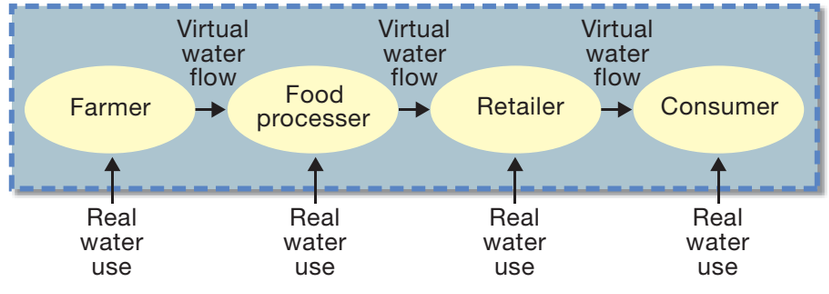


Figure 2. The virtual-water chain.



The virtual-water export consists of exported water of domestic origin and re-exported water of foreign origin. The virtual-water import will partly be consumed, thus constituting the external water footprint of the country, and partly re-exported. The sum of virtual water import and water use within a country is equal to the sum of the virtual water export and the country's water footprint. This sum is called the virtual-water budget of a country.

Not only national water use accounts need to be adjusted. Also business water accounts need to be extended in order to address issues of sustainability. Figure 2 shows the so-called

'virtual-water chain', which is the chain of production and consumption of water-intensive goods. A typical virtual-water chain consists of a farmer at the primary production end, a consumer at the consumption end and, depending on the commodity at stake, some intermediaries such as a food processor and a retailer.

The water footprint of a business is defined as the total volume of freshwater that is used, directly and indirectly, to produce the products and services of that business. The water footprint of a business consists of two parts: the operational water footprint and the supply-chain water footprint. The first refers to the amount of freshwater used within the business, i.e. the direct freshwater use for producing, manufacturing or supporting activities. The second refers to the amount of freshwater used to produce all the goods and services that form the input of the business, i.e. the indirect water use.

Reducing and offsetting the impacts of water footprints

The increasing focus on water footprints has led to the question of how humans can neutralise or offset their water footprint. The question is very general and interesting from the point of view of both individual consumers and larger communities, but also from the perspective of governments and companies.

The idea of the water-neutral concept is to stimulate individuals and corporations to make their activities 'water neutral' by investing in water saving technology, water conservation measures, wastewater treatment and water supply to the poor that do not have proper water supply. In other words, water-neutral means that the adverse environmental and social consequences of a water footprint are reduced and compensated for. The water-neutral concept was conceived by Pancho Ndebele at the 2002 Johannesburg World Summit for Sustainable Development. The idea at the time of the Summit was to quantify the water consumed during the conference by delegates and translate this into real money. Delegates, corporations and civil society groups were encouraged to make the summit water neutral by purchasing water-neutral certificates to offset their water consumption during the ten-day summit, with the offset investment being earmarked for improving water supply to the poor in South Africa and for water conservation initiatives. The water-neutral concept is currently being discussed within various communities, including academia, NGOs and businesses, as a potential tool to translate water footprints into modes of action.

Now that the water-neutral concept has been discussed in a bit wider audience it has become clear that the concept of water neutrality can be applied in a variety of contexts. Individual consumers or communities can try to become water neutral by reducing their water footprint and offsetting their residual water footprint. Rich travellers who visit a water-scarce country where many people do not even have basic water supply facilities can try to 'neutralise' their water use during their stay by investing in projects to enhance sustainable and equitable water use. Large events like the Johannesburg Conference or the Olympic Games, that generally have a significant additional impact on local water systems, can be organised in a water-neutral way by minimising water use and pollution by all possible means and by investing in local water projects aimed at improved management of the water system as a whole and for the benefits of society at large. Finally, businesses may like to become water neutral, be it from the perspective of minimising business risks (the risk of running out of water) or from the idea that it offers an attractive way of presenting the business to the consumer.

Water neutrality can be an instrument to raise awareness, stimulate measures that reduce water footprints and generate funds for the sustainable and fair use of freshwater resources. In a strict sense, however, the term 'water neutral' can be misleading. It is often possible to reduce a water footprint, but it is generally impossible to bring it down to zero. Water pollution can be largely prevented and much of the water used in various processes can be reused. However, some processes like growing crops and washing inherently need water. After having done everything that was technically possible and economically feasible, individuals, communities and businesses will always have a residual water footprint. In that sense, they can never become water neutral. The idea of 'water neutral' is different here from 'carbon neutral', because it is theoretically possible to generate energy without emitting carbon, but it is not possible to produce food without water. Water neutral is thus not about nullifying water use, but about water saving where possible and offsetting the negative environmental and social effects of water use.

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In order to become 'water neutral' there are at least two requirements:

1. all that is 'reasonably possible' should have been done to reduce the existing water footprint;

2. the residual water footprint is offset by making a 'reasonable investment' in establishing or supporting projects that aim at the sustainable and equitable use of water.

The investment can be made in the form of own effort, but it can also be in terms of providing funds to support projects run by others. The size of the investment (the offset or 'pay off' price) should probably be a function of the vulnerability of the region where the (residual) water footprint is located. A water footprint in a water-scarce area or period is worse and thus requires a larger offset effort than the same size water footprint in a water-abundant region or period. Besides, compensation is to be made in the same river basin as where the water footprint is located, which differs from the case of carbon offsetting, where the location of the offset does not make a difference from the viewpoint of its effect.

Discussion

For about a year there has been increasing interest in water footprint accounting, primarily from the international NGO and business community. Governments respond more slowly, but several governments at different levels have started to respond as well. Water footprint accounting is about extending the knowledge base in order to improve the base for decisions. Ideas about water neutrality are expected to receive more debate. The water-neutral concept includes a normative aspect in that consensus needs to be reached about what effort to reduce an existing water footprint can reasonably be expected and what effort (investment) is required to sufficiently offset the residual water footprint. The remaining key questions are:

1. How much reduction of a water footprint can reasonably be expected? Is this performance achieved by applying so-called Better Management Practices in agriculture, or Best Available Technologies in manufacturing? How does one deal with totally new products or activities?

2. What is an appropriate water-offset price? What type of efforts count as an offset?

3. Over what time span should mitigation activities be spread and how long should they last? If the footprint is measured at one period of time, when should the offset become effective?

4. What are the spatial constraints? When a water footprint has impacts in one place, should the offset activity take place in the same place or may it take place within a certain reasonable distance from there?

Finally, accounting systems need to be developed that prevent double offsetting. For example, a business can offset its supply-chain water footprint while the business in the supply chain offsets its own operational water footprint. How to share offsets? And where offsets are achieved in projects that are joint efforts, how much of any calculated water benefits can an individual entity claim?

Despite the possible pitfalls and yet unanswered questions, it seems that the water-neutral concept offers a useful tool to bring stakeholders in water management together in order to discuss water footprint reduction targets and mechanisms to offset the environmental and social impacts of residual water footprints. The concept will be most beneficial in actually contributing to wise management of the globe's water resources when clear definitions and guidelines will be developed. There will be a need for scientific rigour in accounting methods and for clear (negotiated) guidelines on the conditions that have to be met before one can talk about water neutrality.

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