Virtual Water as a Tool to Protect Water Resources at the Local and Global Level

Interview with Arjen Hoekstra

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The water used in the production process of a commodity is called the *virtual water* contained in the commodity. International trade in commodities implies long-distance transfers of water in virtual form. It is shown that import of water-intensive commodities reduces water demand at national level. Reversely, export of water-intensive commodities raises national water demand and thus enhances water scarcity at local level. While trade patterns influence patterns of water use and scarcity, spatial differences in water scarcity do not seem to have a strong influence on trade patterns. The reason is that water is generally underpriced, therefore water input does not contribute to the pricing of traded commodities. Consequently water cannot be a significant factor influencing trade patterns. Global water-use efficiency can be increased if countries include in the price of water its scarcity value.

Arjen Hoekstra - Professor in Multidisciplinary Water Management at the University of Twente - is one of the principal experts on the idea of virtual water and on the correlation between international trade and water resources endowments. He has introduced the water footprint concept (2002) and has established the interdisciplinary field of water footprint and virtual water trade analysis. His scientific publications cover a wide range of topics related to water manage-

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ment and include a large number of articles and book chapters. In particular he has published together with Ashok K. Chapagain the book *Globalization of Water: Sharing the Planet's Freshwater Resources* (2008). Globalization of Water is a review of the critical relationship between globalization and sustainable water management. In examining the correlation between water management and trade, the book seeks to answer fundamental questions such as whether international trade can actually lead to an efficient use of water globally or simply transfer the negative environmental impact from one to another area of the planet. Arjen Hoekstra has made fundamental contribution to research associated with the concepts of *virtual water trade* and *water footprints*.

Virtual water is a concept that was first used by J.A. Allan (1993) to show how, in arid and semi-arid regions such as North Africa and the Middle East, the growing pressures on a country's water resources has been partly offset by trade in agricultural products. Instead you have coined the term water footprint taking the cue from the broad concept of ecological footprint which is utilized as a measure of how much land and water area a human population requires to produce the resource it consumes and to absorb its wastes, using prevailing technology. Could you give me a definition of virtual water and of water footprint highlighting the difference between these two terms?

"Virtual water trade" is the trade of water in virtual form that occurs when a product is traded from one to another place. Import of virtual water can be regarded as a "source" of water for water-short countries. The water footprint of a product is the total volume of freshwater consumed or polluted over the various steps of the production chain. The aggregate water footprint of the consumers in a nation is defined as the total amount of freshwater that is used to produce the products consumed by the inhabitants of the nation. The water footprint of national consumption is calculated as the total use of domestic water resources plus the nation's gross virtual-water import minus the nation's gross virtual-water export.

How can "virtual water" embedded in an imported or exported good be estimated?

We look at three components: consumptive use of rainwater, consumptive use of ground- or surface water and volume of water polluted. Consumptive use refers to the part of the water that evaporates and is thus no longer available in the basin for other purposes. Water pollution is measured as the volume of freshwater that is required to assimilate the load of pollutants based on existing water quality standards. It is calculated as the volume of water that is required to dilute pollutants to such an extent that the quality of the water remains above agreed water quality standards.

According to the theory of comparative advantage a country will gain from trade if it concentrates in the production of those goods which it can produce with lower opportunity costs with respect to its competitors. Countries which have abundant supplies of particular resources will tend to have lower opportunity costs in the production of those goods which make use of such resources. According to this theory a country's factor endowment determines its comparative advantages: countries which have abundant supplies of some resources will tend to have a comparative advantage in the production of those goods which make heavy use of them and hence export them and will tend to have a comparative disadvantage in the production of those goods which make heavy use of factors of production which are scarce and hence are forced to import them. If the theory of comparative advantage is correct, water scarce countries could reduce national water demand by importing water-intensive commodities. Consequently, international trade has a positive impact not only economically, but also from an environmental point of view. As you have written, currently international trade reduces global water use in agriculture by 5 per cent, as a result of the fact that water-intensive commodities, such as agricultural products, are traded on average by countries with a high water productivity to countries with low water productivity. So trade patterns influence patterns of water use and scarcity. Reversely, spatial differences in water scarcity do not seem to have

a strong influence on trade patterns. Most international trade in the world, in fact, has little to do with international trade in water-intensive commodities from countries with higher water availability to countries with low water availability. Which are the driving forces of international trade and which are those factors able to increase water-intensive trade flows among countries?

Since users generally do not pay for the full economic cost of water, the scarcity cost of water is not factored into the price of traded commodities. Therefore, trade flows are mostly not influenced by water scarcity patterns. It also explains why some highly water-scarce regions, like the north of China and northwest of India, can have net virtual water export. The global picture, however, is that water-short regions generally import water in virtual form, not because water is so expensive but simply because it is not sufficiently available. When water runs short in absolute sense, trade patterns will thus be influenced such that water-intensive commodities like cereals are increasingly imported. Only when worldwide water will be priced according to its real economic cost, water scarcity may become a more important factor in determining trade flows. One should bear in mind however, that the agricultural sector in most countries is strongly influenced by governmental policies, so that international trade in agricultural products will remain partially dependent on domestic agricultural policies.

The estimation of virtual water flows among countries can help evaluate "water savings" made by importing countries. In other words, it's possible to quantify the amount of water that can be saved within countries importing water intensive products instead of producing them at national level. But are there other questions that can clear the concept of virtual water and how can they be of support to policy makers?

Considering trade there are two sides. The import of water-intensive products implies a water saving for the importing country. The consumers in the importing country, however, have a water footprint in the exporting country. Knowing the external water footprint of national consumption can help to create understanding on the sustainability of that water footprint. In Europe, for instance, many products are imported from water-scarce regions, contributing to water depletion and pollution. The consumers take the benefit without covering the cost, which remains in the exporting country. This sort of knowledge can help to formulate governmental policies to make supply chains sustainable.

The Mediterranean region has been, since 1990, a net virtual water importer, with respect to the rest of the world. All the Southern and Eastern Mediterranean countries are net virtual water importers, with Libya being the largest net importer per inhabitant (2800 m^3/inhabitant/year).

Due to water scarcity that characterizes these countries, therefore, governments have given up the objective of food self-sufficiency, by substituting it with that of food security. This has determined a strong dependency of the arid Mediterranean countries on the international market for primary food supplies. Consequently when the food crises broke out in 2007-2008 the Mediterranean Arab Countries experienced a strong socio-economic impact that brought about in some areas as in Egypt proper bread revolts. Is it somehow possible to reconcile a protection of water resources and a certain capacity of food self-sufficiency?

The dilemma for water-short nations is: allocate the scarce water resources to high-value products like dates, olives, grapes, citrus fruit and nuts for export or to low-value cereals to feed the own population? From an economic point of view, the first is more attractive, because the income can be used to import cereals. In this way one creates a positive virtual water trade balance (export of products with a low water footprint per dollar earned and import of products with a high water footprint per dollar spent). The more cereals are imported, however, the more food security depends on imports, which carries a certain risk. Whatever strategy is chosen, full food self-sufficiency is impossible for countries with too many people compared to their availability of freshwater.

Breakthroughs in molecular precision technologies during the late 1970s and early 1980s made it possible to intervene in microbiological processes and to alter the genetic set up of plants and organisms. The genetically modified organisms (GMOs) were characterized by new genetic traits and properties that could cross species barriers. In agriculture, GMO-crops were introduced in the mid 1990s with insect/herbicide, resistant/tolerant soybeans and maize, later cotton. The rapidly expanding use of GM seed has determined an intense debate about biosafety and seed monopolies. Questions arose over the impact on human health and on ecological effects, such as unintended outcrossing of GM traits to non GM crops and wild impacts on agro-biodiversity. On the other hand, GM crops offer new opportunities to match global challenges such as climate change and rapid population growth. Agro-biotechnology offers the possibility of developing, for example, salt-tolerant rice, drought-tolerant maize and wheat, and new disease-resistant varieties of major staple crops. In view of these facts, what role do agro-biotechnologies play in Mediterranean arid and semi-arid countries?

Humans will continue to optimize plants, undoubtedly. Optimizing plants, whether this is through genetic modification or traditional means, will however not solve water scarcity. It may help to relieve water use to some extent in some places, but we should not expect miracles, even more so if one takes into account possible downsides of the new crops. In both industries and agriculture we see a continued focus on *eco-efficiency* – producing more with less natural resources. Simultaneously, however, total volumes of production grow at a faster rate than can be offset by increased efficiency in production. Therefore, total production and consumption deserve much more attention than they currently receive. Finally: there isn't so much wrong with existing crops; it's the way people waste water when irrigating them and the way people pollute water by excessive use of fertilizers and environmentally unfriendly pesticides.

As you wrote in one of your articles (Hoekstra, 2008), although it is clear that global trade and water use efficien-

cy are connected issues, there is no international agency that has ever included this connection in either trade policy or water policy considerations. The growing scarcity of freshwater in the world and the fact that water could possibly be saved by producing water-intensive commodities in places where water is comparatively abundant to trade them to places where it is not, demand international research and policy coordination in this field. What kind of institutional arrangements could be set up to cope with the global dimension of water issues?

Freshwater should be properly priced, everywhere, in order to avoid unfair competition. This required some sort of international water pricing protocol. National governments should also collaborate on promoting product transparency, by requiring the business sector to report on the water footprints of some selected water-intensive products, specifying how much, where and in which period of the year water is being consumed or polluted. Global benchmarks can be developed so that companies can formulate appropriate water footprint reduction targets. Furthermore, the water footprint of humanity cannot exceed the carrying capacity of the earth, which means that internationally people will have to agree on a maximum sustainable global water footprint and on how to share it among nations.