The Theory of Virtual Water

Why It Can Help to Understand Local Water Scarcity

Reaction to Two Articles Regarding the Virtual Water Concept. D. Wichelns. 2011. GAIA 20/3: 171–175; E. Gawel, K. Bernsen. 2011. GAIA 20/4: 224–228

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There are regions in this world which are water-scarce, and where using water in the most profitable way with respect to local living conditions and the environment is compulsory. The international trade of water-consuming agricultural goods plays in this context a small, but decisive part. Import of water-intensive goods into water-scarce regions can alleviate water scarcity and free up water for other uses. Export of water-intensive goods from water-scarce regions, on the other hand, can lead to unsustainable exploitation of water resources. But in order to develop policies supporting water scarcity alleviating trade or policies reducing trade which worsens local water conditions, the invisible water in the trade flows has to become visible, and this is exactly what the theory of virtual water trade does. While Wichelns (2011) and Gawel and Bernsen (2011) doubt the usefulness of the virtual water theory, we want to defend the concept.

Biewald (2011) argued that using virtual water can indeed lead to wrong policy implications, but when used carefully, considering not only the consumption side of the virtual water, but the production side as well, it can help to develop water policies. It is important to know if the virtual water considered is "blue" (surface water and ground water) or "green" (rainwater stored in the soil), since "blue" water can serve many purposes, whereas "green" water cannot. Wichelns (2011) and Gawel with Bernsen (2011) criticized this argumentation as follows:

1. The distinction of blue and green water is not scientifically sound and justifiable. So it does not improve the virtual water theory to look at the green and blue parts of it more closely.
2. There is no reason to assume that saving blue water in water-scarce regions is more important than saving green water.
3. International trade cannot be made responsible for local water scarcity since most of the unsustainable use of water is caused by domestic agricultural production.
4. A better understanding of trade relations does not help to understand the causes of water scarcity nor can it help to alleviate them.
5. Refining the concept of virtual water is not turning it into a useful concept.

A Valid Definition

Both articles are critical of the distinction of green and blue water: "Green and blue water are not scientifically sound categories of water resources and they are not necessarily distinct" (Wichelns 2011). There is indeed no green water without blue water, as their processes of origin are closely related (Savenije 2000), and when looking at large time spans, green water will eventually turn into blue water. But considering periods of time relevant for plant growth and agricultural production, the distinction is measurable and clear. Not only is the definition of blue and green water widespread in literature (e.g., Falkenmark 2003, Falkenmark and Rockström 2006, Rockström and Gordon 2001, Gerten et al. 2005), it does also enhance the clarity of the virtual water theory. Only when we are able to identify and define the source of virtual water we can judge about merit or harm done by virtual water trade.

Why Rain Is Good, But Rivers Are Better

"No author in the virtual water and water footprint literature has demonstrated any conceptual (...) basis for the perspective they offer regarding the preference for saving blue water in favor of saving green water" (Wichelns 2011). Maybe there has been no concept, but we argue that there have been strong arguments in

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the literature which support the preference of saving blue over green water. Yang et al. (2006), for instance, argue that blue water has many uses (municipal, industrial, recreational), is highly mobile, but at the same time costly in storage and distribution, while green water has hardly any other uses than agriculture, is immobile, but at the same time basically for free. In addition, irrigation (which uses only blue water) can have negative external effects, such as salinization, water logging, or soil degradation. The authors conclude that trading green virtual water and saving blue is the most efficient solution – and this view is indeed supported in the literature (e. g., Aldaya et al. 2010).

As Gawel and Bernsen rightly point out, preference for blue over green water reveals an anthropocentric view, since "cultivated land might as well serve as habitat for other species and contribute to biodiversity" (Gawel and Bernsen 2011). But a preference for preserving habitats for other species is by no means less anthropocentric: the quest for biodiversity also serves the human desire to live in a world with a multitude of organisms. Therefore we might have to decide if we prefer green water contributing to biodiversity or blue water for drinking, but anthropocentrism cannot refute the preference for blue over green water per se.

Good or Bad, But Not Neutral: International Trade

International trade is indeed not responsible for regional water scarcity (Wichelns 2011), but it can help regions to save their blue water, as well as cause overusage of scarce water. Very dry countries in the Middle East and North Africa, for example, are able to reduce substantially blue water usage by importing food (Yang and Zehnder 2007, Yang et al. 2006). Mexico, another example, saves water by importing different agricultural goods from the USA and Canada (Chapagain et al. 2005). But there are also water-scarce countries exporting water-intensive agricultural products. A study by Dabrowski et al. (2009) on trade of maize in the SADC countries (Southern Africa Development Regions) showed that the water-scarce South Africa is a net exporter of blue water, which it exports to water-rich countries, such as Zimbabwe, where maize could be produced without any irrigation. Another country which exports blue water while overusing its blue water resources is Uzbekistan: Chapagain et al. (2006) indicate that each year Uzbekistan exports essentially the entire runoff of the Aral Sea basin in form of the virtual water embedded in cotton trade.

A study by Garrido et al. (2010) shows that virtual water trade in Spain has two sides: Spain is a net importer of cereals, while it exports high economic value crops. But the production of cereals for its own use still consumed 32 percent of the blue water resources, but generated only six percent of the gross value of irrigated agriculture in 2001. Because of the high water productivity of crops – such as citrus fruits, olive oil, and vegetables –, increasing the import of cereals (and decreasing the production), while at the same time exporting only slightly more high-value crops, would not change the gross value, but it would improve the water situation. Using grain imports in order to alleviate water scarcity has apparently already worked in Spain, as a study of Novo et al. (2009) shows that grain trade is consistent with relative water scarcity as net imports increase in dry years.

The reasons for local water scarcity are complex, but when we are able to identify one specific source for improving or worsening local water scarcity, it is also possible to determine specific policy measures.

Conclusion

We argue that understanding virtual water trade will improve the ability of policy makers to deal with regional water scarcity problems. While it is true that "a better understanding of mere trade relations provides (not) sufficient information for local water management" (Gawel and Bernsen 2011), it is not true that it provides no information.

The reasons for local water scarcity are complex, but when we are able to identify one specific source for improving or worsening local water scarcity (namely international trade), it is also possible to determine specific policy measures. These could be, e. g., for water-scarce regions importing virtual water to alleviate imports by scrapping import barriers, or for water-scarce regions exporting virtual water to limit production for the export or switch to crops for the export which use less water. We see the complexity of the reasons of local water scarcity as a puzzle, and international trade of virtual water as a small but decisive piece of it.

Gawel and Bernsen (2011) end their article by questioning "whether water footprint analysis will benefit from the various refinements and be turned into a meaningful concept which can support reasonable policy decisions". We believe that the concept is already meaningful and useful, and that it will indeed benefit from future refinements. Developments of the theory of virtual water do not confirm "that the concept in its current form is not useful in giving reasonable policy advice" (Gawel and Bernsen 2011), but only that an even better concept together with an increasing database of consistent information on water consumption of agricultural goods will be even more useful.

References

Aldaya, M. M., J. A. Allan, A. Y. Hoekstra. 2010. Strategic importance of green water in international crop trade. *Ecological Economics* 69/4: 887–894.

Biewald, A. 2011. Give virtual water a chance! An attempt to rehabilitate the concept. *GAIA* 20/3: 168–170.

Chapagain, A. K., A. Y. Hoekstra, H. H. G. Savenije. 2005. Water saving through international trade of agricultural products. *Hydrology and Earth System Sciences Discussions* 2/6: 2219–2251.

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Chapagain, A. K., A. Y. Hoekstra, H. H. G. Savenije, R. Gautam. 2006. The water footprint of cotton consumption: An assessment of the impact of worldwide consumption of cotton products on the water resources in the cotton producing countries. *Ecological Economics* 60/1: 186–203.

Dabrowski, J. M., K. Murray, P. J. Ashton, J. J. Leaner. 2009. Agricultural impacts on water quality and implications for virtual water trading decisions. *Ecological Economics* 68/4: 1074–1082.

Falkenmark, M. 2003. Freshwater as shared between society and ecosystems: From divided approaches to integrated challenges. *Philosophical Transactions of the Royal Society of London Series B – Biological Sciences* 358/1440: 2037–2049.

Falkenmark, M., J. Rockström. 2006. The new blue and green water paradigm: Breaking new ground for water resources planning and management. *Journal of Water Resources Planning and Management* 132/3: 129–132.

Garrido, A., M. Ramón Llamas, C. Varela-Ortega, P. Novo, R. Rodríguez-Casado, M. M. Aldaya. 2010. *Water footprint and virtual water trade in Spain: Policy implications.* New York, NY: Springer.

Gawel, E., K. Bernsen. 2011. The colour of water. What does it tell us about scarcity? *GAIA* 20/4: 224–228.

Gerten, D., H. Hoff, A. Bondeau, W. Lucht, P. Smith, S. Zaehle. 2005. Contemporary "green" water flows: Simulations with a dynamic global vegetation and water balance model. *Physics and Chemistry of the Earth, Parts A/B/C* 30/6–7: 334–338.

Novo, P., A. Garrido, C. Varela-Ortega. 2009. Are virtual water "flows" in Spanish grain trade consistent with relative water scarcity? *Ecological Economics* 68/5: 1454–1464.

Rockström, J., L. Gordon. 2001. Assessment of green water flows to sustain major biomes of the world: Implications for future ecohydrological landscape management. *Physics and Chemistry of the Earth, Part B: Hydrology, Oceans and Atmosphere* 26/11–12: 843–851.

Savenije, H. 2000. Water scarcity indicators; the deception of the numbers. *Physics and Chemistry of the Earth Part B: Hydrology Oceans and Atmosphere* 25/3: 199–204.

Wichelns, D. 2011. Virtual water and water footprints. Compelling notions, but notably flawed. *GAIA* 20/3: 171–175.

Yang, H., L. Wang, K. C. Abbaspour, A. J. B. Zehnder. 2006. Virtual water trade: An assessment of water use efficiency in the international food trade. *Hydrology and Earth System Sciences* 10/3: 443–454.

Yang, H., A. J. B. Zehnder. 2007. Virtual water: An unfolding concept in integrated water resources management. *Water Resources Research* 43/12: W12301–W12311.

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