Water Wars by Other Means: Virtual Water and Global Economic Restructuring

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In spite of relatively widespread predictions in the late twentieth century of coming "water wars," violent conflict between states over access to water resources has actually been quite rare.[1] One reason suggested for this is trade in "virtual water"—commodities requiring water for their production—which can and has alleviated national water scarcity more efficiently than armed conflict.[2] The conceptual innovation of seeing water "embedded" in products of various kinds means that even if the energy costs associated with moving large supplies of water over long distances are prohibitive, water-scarce countries can nevertheless purchase various commodities with water-intensive production processes on the global market, rather than expend precious domestic water supplies producing those goods for themselves. The virtual water thesis has thus been taken up not only as a theoretical innovation, but also as a policy prescription. As a policy tool, virtual water fits well with both the neoclassical economic framework that focuses on the advantages of trade and ecological modernization's emphasis on developing state policies to make efficient use of natural resources.

The confluence of market-oriented and conservationist views—what Karen Bakker calls "market environmentalism"[3]—has tended to produce *policy* prescriptions that assume away *politics.* Virtual water proponents rightly do shift attention away from global water scarcity to water scarcity manifesting itself at lower scales. Given water's density, its renewability, and the volumes needed for the daily reproduction of human life, it makes much more sense to speak of multiple local scarcities than global water scarcity. Nevertheless, the discourse still tends to present water scarcity as a technical problem: a situation where the definition of the problem itself is settled. "Virtual water" looks quite different,

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1. Wolf 2003, 2007.
2. Allan 1997, 2002.
3. Bakker 2010, 35–39.

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however, if we understand "water scarcity" to be an inherently political problem, or a term that is slippery and subject to multiple and even conflicting definitions.[4] In what follows I articulate such a view of virtual water; as a policy prescription that defines and solves particular problems in ways that have unequal effects, even as it is couched in the universalizing language of economic and ecological efficiency and administrative rationality. The remainder of this paper proceeds as follows. In the next section, I provide a brief overview of the virtual water discourse and its evolution over the last decade and a half, emphasizing the exemplarity of arid countries in framing the terms of the virtual water discourse. The third section provides an alternate account of the problem of "water scarcity" and its resolution—one that emphasizes the social production of scarcity via underdevelopment, rather than the problem of physical water scarcity emphasized in the virtual water discourse. The fourth and fifth sections focus on patterns of virtual water imports and exports, respectively, using contemporary and historical data to develop an understanding of virtual water trade that focuses on its role in reproducing an unequal global political economy. The sixth section and conclusion draw out some of the political-economic and ecological consequences of virtual water trade in the context of uneven development.

Virtual Water: An Overview of the Discourse

In the 1990s—just around the time that World Bank Vice-President Serageldin made his widely-cited prediction that "the wars of the [21st] century will be fought over water"—J. A. (Tony) Allan developed the term "virtual water" to describe international grain shipments.[5] Looking at the case of the Middle East and North Africa (MENA), and noticing a lack of "water wars" in an arid and fast-growing region, Allan suggested that regional water shortages were effectively being met not through the importation of water itself, but rather by grain imports. Water is a dense substance (one cubic meter, or 1000 liters, of water has a mass of one ton); large amounts of it are required (about 50–100 kilograms/person daily) for basic human functions, including drinking, cooking, cleaning, and sanitation needs; and it has a relatively low economic value. All of these factors conspire to make the transportation of large amounts of water across significant distances economically feasible only under exceptional circumstances; in most cases, international bulk water trade is highly impractical. But at the same time, water's fluid nature and its susceptibility to pollution often make waging war to secure water supplies an equally fraught proposition.[6] If neither buying water on a global market nor waging war to secure new supplies is feasible, what is a country facing water scarcity to do?

4. Graffy 2006; and Trottier 2008.
5. Allan 1996, 1997, 1998.
6. Wolf 2003.

Allan's insight begins with the fact that some 70 percent of human water withdrawals are for agricultural purposes. Far more water is required for food production than for household uses: "With prevailing land and water management practices, a balanced diet represents a depleting water use per capita of 1,300 m^3/p yr, which is 70 times more than the 50 l/p day used to indicate the basic household needs."[7] It is for this reason that water scarcity tends to manifest itself as food shortages—that is, drought leading to famine—rather than individual dehydration or a lack of water for domestic use. These last do occur, as we shall see, but generally for reasons other than large-scale scarcity of physical water resources. Thus, beyond the relatively small amount required for household consumption, Allan concludes, water scarce countries can efficiently make up for water deficits by purchasing staple agricultural goods on the global market. Given water's density, and the ability to effectively "compress" it at a ratio of about 1000:1 by using it to produce grain (i.e., approximately 1000 liters (kg) of water are required to produce 1 kg of grain), it seems to make far more economic sense to import grain directly than to import water to grow that grain.

Thus trade in virtual water—or to put it more prosaically, global agricultural trade—appears to provide a very elegant solution to the problem of potential water wars. In Allan's words: "Virtual water prevents water crises from becoming water wars. There is no need to resort to lethally expensive armed conflict when the remedy to a water deficit is so easily gained by importing wonderfully subsidized grain with inexpensive embedded water."[8] Indeed, the concept is increasingly popular in both academic and policy circles;[9] for his pioneering work in understanding virtual water, in 2008 Allan was awarded the prestigious Stockholm Water Prize.[10]

Furthermore, Allan sees virtual water trade as a source of political stability in domestic politics, as well. In an early article on virtual water imports in the MENA, Allan describes it as a "silent solution" to an increasing regional "water deficit." The mere admission that such a deficit exists could be seen as "tantamount to admitting unfitness to govern." Thus, Allan concludes: "The availability of a totally effective but nonevident solution in the form of virtual water could not be more timely."[11]

In sum, virtual water provides an example of neoclassical economic rationality, justifying increased global trade because of differing national conditions of natural resource endowments. This aligns with Hoekstra and Hung's more recent analysis of virtual water, which begins with the claim that "[w]ater should be considered an economic good."[12] Increased global trade is not only econom-

7. SIWI-IWMI 2004, 3. 50 liters per day is about 18 m^3 annually, but the widely accepted definition of national water scarcity is a renewable supply of less than 1000 m^3 per capita annually; a national renewable supply of 1000–1700 m^3 per capita annually is typically described as "water-stressed."
8. Allan 1998.
9. Mariss 2008; Roth and Warner 2008; Warner and Johnson 2007; and Wichelns 2005.
10. SIWI 2008.
11. Allan 1996.
12. Hoekstra and Hung 2004, 45.

ically efficient, but helps to avert localized ecological crises and enhances the prospects for peace, filling water deficits that might otherwise be filled by violent expropriation of neighboring water supplies. Even more, it seems a bargain for the leadership of arid, high-population-growth developing countries such as those in the MENA region, because grain often trades on the world market below its price of production. While empirically the virtual water concept has greater explanatory purchase on the demand side,[13] on the supply side, at least theoretically, agricultural exports can also be seen as a way for water-rich countries to extract economic value from soil water that would otherwise go unexploited.[14]

Since Allan's initial development of the concept, a considerable amount of research on the topic of virtual water has been undertaken. While some critiques of the concept have been advanced, much of the research has aimed at conceptual clarifications, refining the ways in which virtual water is measured, and developing a clearer picture of virtual water flows, at both global and lower scales of analysis.[15] For example, Yang and Zehnder's discussion of "Prospects of Future Virtual Water Studies" only covers "Data and Methodology Improvement" and rescaling analyses from the national and regional to the watershed level.[16] Perhaps the apotheosis of this effort is the Water Footprint Network (WFN), which began as a series of research reports done under the aegis of UNESCO ("Value of Water Research Report Series") and has flourished into an organization with nearly two dozen sponsoring partner organizations from every inhabited continent in the world.[17]

To see how far things have progressed in terms of empirical sophistication, one can consider that Allan's early accounts were based on a blanket global estimate that one kilogram of grain required 1000 liters of water.[18] Only a few years later, Chapagain and Hoekstra had developed highly complex formulas to ascertain national water footprints for all countries, with water footprints defined as "the volume of water needed for the production of the goods and services consumed by the inhabitants of the country."[19] Rather than estimating a standard conversion rate of water to generic grain, these formulas take into account, as precisely as possible, the specific amounts of water required for different species of agricultural goods, and attempt to account for cross-national differences in climatic conditions, such as daily mean temperature, vapor pressure, cloud cover, and average wind speed. This is consistent with a shift in the understanding of virtual water from a national policy option for dealing with incipient

13. Wichelns 2005.
14. Aldaya, Allan, and Hoekstra, 2009; Liu, Zehnder, and Yang, 2009; and Water Footprint Network, "Water Saving by Trade." http://www.waterfootprint.org/?page=files/Water-saving-by-trade, accessed 23 March 2011.
15. See the literature review in Kumar and Singh 2005, 761–763.
16. Yang and Zehnder 2007, 7–9.
17. Partner data collected from www.waterfootprint.org/?page=files/OverviewPartners, accessed 9 March 2011.
18. Allan 1998.
19. Chapagain and Hoekstra 2004, 11.

scarcity to a policy tool for *global environmental* management, "increasing the efficiency of water use in the world."[20] And rather than focus on, for example, the use of water-saving technologies, the focus on developing more detailed knowledge of climatic variables suggests that achieving global "efficiency" means growing particular crops where climatic conditions are optimal.[21] As one opinion piece in a leading Canadian newspaper synoptically asserts, citing the UNESCO project: "All factors considered, Canada helps to save the world's water supply by buying California lettuce and Florida oranges."[22]

Even more recently, the desire for policy uptake through the promise of increasingly precise measuring of how much water is being virtually traded, and how much actual water is being saved through virtual water trade, can be seen in the WFN's development of a "Global Water Footprint Standard" which, according to the accompanying press release, is "a scientifically credible methodology that will make all water footprints comparable, [and] has garnered international support from major companies, policy-makers, NGOs and scientists as an important step toward solving the world's ever increasing water problems."[23]

Whether this actually works is of course a matter of some debate. De Fraiture et al. argue, for example, that environmental benefits or "real" water savings are relatively small and that environmental considerations play a limited role, at best, in trade policy.[24] Even so, "global environmental management" can remain an important discursive frame in the dissemination of the virtual water concept. The effect of this frame is that "the world's ever increasing water problems" continue to be understood as problems of physical resource scarcity, ultimately, or at least ideally, amenable to rational management through the development and policy implementation of more precise accounting techniques.[25] Recall that Allan's original geographic focus was the MENA, understood as an arid region with rapidly growing rates of water use. The experience of "water problems" or incipient water crises (as they have actually developed or as they are imagined) in this particular region has shaped the understanding of the problem to be solved by the virtual water concept more globally. Increasing demand and limited physical supply become the defining features of "water problems," for which virtual water becomes a commonsensical solution. The next section briefly outlines an alternate view of "the world's water problems" in order to show that the problems can be differently defined, with quite different solutions emerging as commonsensical responses.

20. Chapagain, Hoekstra, and Savenije. 2005, 11; see also El-Sadek 2010, 2439; See also Water Footprint Network, "Water Saving by Trade." http://www.waterfootprint.org/?page=files/Water-saving-by-trade, accessed 23 March 2011.
21. Kumar and Singh 2005, 763.
22. Neil Reynolds, "Swap Water for Food? It's a good deal," *Globe & Mail,* 26 January 2007.
23. "International Leaders Support Global Water Footprint Standard." Media release, 28 February 2011. Available at http://www.waterfootprint.org/downloads/WFN-PressRelease-28Feb2011.doc, accessed 21 April 2011.
24. de Fraiture et al. 2004.
25. On "green governmentality" more generally, see Luke 1999.

Water Scarcity as a Problem of Underdevelopment

In his discussion of water-related conflicts, Aaron Wolf notes that in spite of the absence of water wars as the term is traditionally understood (i.e., armed conflict between nation-states), "there *is* a history of water-related violence—it is a history of incidents at the sub-national level, generally between ethnic, religious or tribal groups, water-use sectors, or states/ provinces."[26] If our definition of wars does not fetishize inter-*state* violence, then, we need not project into the future in order to see the existence of water wars. Instead, we can see violent conflict over water in the present. Furthermore, if we incorporate Michel Foucault's "inversion of Clausewitz's aphorism that war is politics continued by other means. It consists in seeing politics as sanctioning and upholding the disequilibrium of forces that was displayed in war,"[27] then we do not have to look far to find the "silent violence" (to borrow Michael Watts' term[28]) of dramatically unequal access to water resources, enforced variously by private property regimes and bureaucratic regulation.

As Julie Trottier notes, in spite of the fact that "'the water crisis' . . . is usually presented as an objective reality," it is in fact a term with multiple significations, each presenting a different interpretation of the nature of the crisis and posited solution.[29] Not only are there multiple meanings of "the water crisis," but insofar as "structures of signification" reinforce "structures of domination," interpretations of the crisis are framed within specific understandings of how the world does and should operate, and "this allows some to recommend a 'solution' that appears to be a disaster to others."[30]

The view that physical resource scarcity leads to international conflict uses a lens that defines security in state-centric terms. It is the state's interest in securing water supplies that is at stake, and states will ultimately resort to any means necessary to achieve their security goals. An alternate view, where water scarcity is a rationale for the establishment and tightening of markets within states, driving up prices and profits, and increasing inequality, might focus on a more individualized notion of water (in)security. On this view, global water crisis—or even water wars—might be presented as a crisis of built environments unable to deliver water to meet basic human needs, as a result of globalized pathologies (i.e., failed states) and practices (i.e., public service cuts in the wake of forced structural adjustment).[31] And rather than seeing this kind of water scarcity as the persistence of a chronic poverty that has characterized various non-Western and/or indigenous societies for millennia, we can instead see it as a result of the produced lack of state capacity in many parts of the world, grinding against the contemporary age's momentous structural socioeconomic transformations.

26. Wolf 2003, 165, emphasis in original.
27. Foucault 1980, 90.
28. Watts 1983.
29. Trottier 2008, 201.
30. Trottier 2008, 198.
31. Matz 2006; and Trottier 2008.

In 2004, over one billion people lacked access to an improved water supply. The Millennium Development Goals' (MDG) target with respect to water is to halve the proportion of people without secure access to safe drinking water between the baseline year of 1990 and 2015. In 2012, it was announced that this goal was met, although this still leaves 800 million people without access to an improved water supply.[32] Peter Gleick further estimates that even if targets are met, water-related diseases will be responsible for 34–76 million deaths between 2000 and 2020, and 135 million deaths if no action is taken.[33] For the most part this is not a consequence of local physical water scarcity; indeed, many people lacking a secure supply of clean water live in non-arid environments (e.g., Central and Sub-Saharan West Africa). Rather it is the result of a lack of water delivery infrastructure, caused by a constellation of factors including underdevelopment and massive rapid urbanization.

Virtual Water Imports

With this alternate view of water scarcity/crisis in mind, we can see more clearly how the fact that virtual water discourse begins with the MENA example provides a particular ideological frame to the water scarcity issue. Virtual water is constructed as a solution to a particular kind of problem, while closing off other ways of framing the issue.[34] If arid countries with rapidly growing populations are typical virtual water importers, then the arguments for virtual water to prevent interstate water wars and for achieving environmental efficiencies become more sensible. MENA examples, in other words, structure our perception of water scarcity in particular ways and with important political effects.

To be sure, MENA countries *are* virtual water importers. Taking the period 1995–1999, Hoekstra and Hung conclude that virtually all of the MENA nations are net virtual water importers for agricultural crops (recall that roughly 70 percent of human water use is for agriculture), and that among thirteen world regions, North Africa and the Middle East rank third and fourth respectively for virtual water imports and eleventh and tenth respectively for virtual water exports.[35] However, even MENA countries themselves do not necessarily conform to the virtual water discourse's theoretical ideal. For example, El-Sadek concedes that Egypt's status as a net virtual water importer has been driven by aridity combined with economic development and high rates of population growth. However, he also notes that domestic food production (and particularly low-value cereal crops such as wheat, corn, and rice) has continued to *increase*, driven partly by agricultural policies that are motivated by a concern for na-

32. Gleick 2009, ch.4; UNICEF and WHO 2012. See also WWAP 2003.
33. Gleick 2002.
34. This claim about its ideological function implies certain political effects of discourse, but does not necessarily imply the conscious intention to produce those effects on the part of the discourse's authors.
35. Hoekstra and Hung 2005.

tional food security: "it is perceived by Egypt that dependence on food imports will lead to giving in to foreign domination."[36] As Yang and Zehnder note, "virtual water studies so far have been mostly carried out by scholars outside of water scarce countries."[37] This may account for a downplaying of domestic "political" factors and also reflects the discursive preference for global-scale rationalization and efficient resource use.

But to what extent are the MENA countries typical of virtual water importers globally? In Hoekstra and Hung's ranking of the top ten net virtual water importing countries, which was calculated on the basis of net imports of all agricultural crops, only one MENA country makes the list (Egypt, ranked seventh). Japan, ranked first, has net virtual water imports almost four times that of Egypt's with about twice Egypt's population.[38] Similarly, Chapagain and Hoekstra's calculation of net virtual water imports by country for *all* traded goods—not just agricultural crops—for the period 1997–2001 has only two MENA countries in the top ten: Iran is ranked eighth and Saudi Arabia is tenth.[39] Other than these countries and Mexico (ranked sixth in Chapagain and Hoekstra), both lists of top ten net virtual water importers are comprised entirely of countries in Western Europe and East Asia. But few countries in either Western Europe or East Asia are considered "water-scarce" or even "water-stressed."[40]

What comprises a "typical" virtual water-importing nation may become clearer if we can assess how patterns of virtual water trade have changed over time. Here, one of the limits of existing studies becomes clear. Where empirical calculations of virtual water flows have been undertaken, they have generally been based on the most recent five-year window of data available.[41] Rather than examine historical dynamics, as noted above, a good deal of intellectual energy has focused on developing more precise metrics of contemporary flows, perhaps reflecting an assumption that the underlying theory is essentially ahistorical.

Using data from the UN Comtrade database to compare trade flows of particular agricultural commodities over approximately the past half-century provides some insights for understanding how patterns of virtual water trade have changed over time.[42] Comtrade provides records of international trade flows (exports and imports) broken down by commodity type. Discussion here will focus largely on traded volumes of four agricultural staple crops—wheat, rice, soybeans, and maize (corn). These four crops alone account for anywhere from just under one-half to nearly three-quarters of water used globally for crop

36. El-Sadek 2010, 2444.
37. Yang and Zehnder 2007, 7.
38. Hoekstra and Hung 2005.
39. Chapagain and Hoekstra 2004, 46.
40. Hinrichson, Robey, and Upadhyay 1997. China—a country that will be discussed in more detail below—has an annual renewable supply of 2138 m^3 per capita (Gleick 2009, 84).
41. One exception is Yang and Zehnder 2007.
42. Unless otherwise noted, statistical information on trade flows below is based on data from UN COMTRADE database, DESA/UNSD. The database is available at: http://comtrade.un.org/db/.

production.[43] Moreover, unlike some fruits and vegetables, these basic food staples have a relatively low economic value by volume. Thus for nations that seek virtual water imports, it is most rational in economic terms to import these kinds of goods, reserving domestic water supplies for higher-value uses, including municipal and household uses, industrial uses, and higher value-added agriculture. Levels of imports of these crops, then, can function as a kind of proxy for the employment of a virtual water policy whether consciously framed as such or not.[44]

In the early 1960s, the top importers of wheat, soybeans, rice, and corn were then-advanced capitalist countries in Western Europe and Japan; by contrast, contemporary imports are more skewed towards newly industrialized countries, largely though not exclusively in East Asia. Both historically and in the present, virtual water policies appear to underwrite the shift from an agricultural to a manufacturing economy—part of the process of industrialization and urbanization—to a greater extent than being a response to arid environmental conditions.

The case of Mexico illustrates this shift particularly dramatically. In the first decade for which Comtrade data is available (1962–71), Mexico was a net corn exporter for seven years. Overall, during that ten-year period, corn exports outweighed imports by about a half-million tons per year. Corn, furthermore, outweighed exports of other staple crops, generally by a significant margin, and given the centrality of corn in the Mexican diet, international trade figures very likely seriously understate the importance of corn to Mexico's agricultural sector. And yet, by the turn of the millennium, Mexico ranked among the world's top net virtual water importers in agricultural goods. The spike in food prices in 2006–2007 underlined the extent to which Mexicans have become dependent on imported corn. By the early 1990s, Mexican corn imports consistently outweighed exports, by an average of one to two million tons per annum. In every year since 1998, net corn imports have been greater than five million tons, and greater than seven million tons in every year since 2006.

Virtual Water Exports

One of the striking things about the development of the virtual water concept thus far has been the extent to which it has focused on *imports.* But of course, for one country to import virtual water, another country has to use its own domestic water supplies in the production of goods for *export.* As noted above, "water scarcity" is almost invariably a localized condition. "Global water scarcity" is a sort of category mistake, in the sense that global hydrological limits are approached with tremendous regional and local variation. Still, and notwith-

43. Chapagain and Hoekstra 2004, 40; and Hoekstra and Hung 2005, 51.
44. Aldaya, Allan, and Hoekstra 2009.

standing real global hydrological limits given the finite amount of water on the planet, it is as a discursive frame that "global water scarcity" has powerful effects. So, it seems at least worth looking into the circumstances under which virtual water trade is sustainable.

A neoclassical-oriented answer to that question would likely be structured around an accounting of global water supplies, with virtual water functioning to smooth out differences in water endowments. Allan initially portrays grain shipments from the US to the Middle East as trade "from comparatively advantaged regions, where there is a surplus of soil water in soil profiles, to comparatively disadvantaged regions."[45] More recently, Aldaya, Allan, and Hoekstra focus their analysis on virtual water exports, stating early on and citing a number of sources: "International trade can save water globally if a water-intensive commodity is traded from an area where it is produced with high water productivity (ton/m^3) to an area with lower water productivity."[46] And the WFN, admitting that "national policy makers [focus on] the status of national water resources" similarly sees global efficiencies in the aggregate of national savings. Drawing on the distinction between "blue" and "green" water (i.e., accessible groundwater and surface runoff, and water absorbed in soil and returned to the atmosphere through evapotranspiration, respectively), WFN further notes that "importing a product which has a relatively high ratio of green to blue virtual water content saves global blue water resources that generally have a higher opportunity cost than green water."[47]

But it is far from certain that global trade is designed to produce such an equalization, or even to maximize efficiencies based on differences in resource endowments. Instead, the increased economic globalization associated with neoliberalism, including but not limited to increased international trade, has produced a world of ever-starker inequalities. And because actors with particular interests structure the rules that govern the global political economy, there is little reason to believe that the general welfare, or even Pareto-optimality, should, in fact, be an actual outcome.

Indeed, the pattern of virtual water exports raises what must seem puzzling findings when compared to more traditional accounts of the global economy and of national economic development. In their study of virtual water exporters, Aldaya, Allan, and Hoekstra focus on what they identify as the major exporting countries of maize, soybeans, and wheat (those crops, as noted above, accounting for a significant proportion of global virtual water trade): US, Argentina, Canada, and (for wheat only) Australia. These three or four countries account for 58–69 percent of global exports of those three crops. By contrast,

45. Allan 1996.
46. Aldaya, Allan, and Hoekstra 2009, 887.
47. Water Footprint Network, "Water Saving by Trade." http://www.waterfootprint.org/?page=files/Water-saving-by-trade, accessed 23 March 2011. See also the Water Footprint Network glossary available at: http://www.waterfootprint.org/?page=files/Glossary.

Brazil, the country with the largest renewable freshwater supply in the world is identified as a major virtual water importer, with the third-highest volume of wheat imports (for the period 1999–2004).[48] One plausible explanation is that factors other than water use drive Brazil's lack of domestic wheat production, with water among other inputs such as arable land, labor, and capital investment being used for other purposes.[49]

Before we presume that water naturally migrates to higher-value uses, consider that Chapagain and Hoekstra's "Water Footprints of Nations" observes that "China . . . has net virtual water import in relation to trade in crop products, but net virtual water export in relation to trade in industrial products. In the USA we see the reverse."[50] What is surprising here is not that China's exported virtual water is found in industrial products, but that the US exports so much of its water in the form of agricultural crops.[51] Does it not seem odd to have the world's leading national economy occupying a similar position in the global division of labor (net agricultural exporter) as a country like Argentina? This is even more puzzling when we recall Allan's observation that virtual water is so attractive to importers because grains are "wonderfully subsidized," often trading on world markets below their price of production. The US—despite its position in the global order—continues to be the world's pre-eminent exporter of relatively low-value crops such as cereals, with US export volumes of four staple crops (wheat, rice, maize, soybeans) doubling between the latter half of the 1960s and the first five years of the twenty-first century.

The US is the world's single largest grain exporting country and shows little sign of decreasing agricultural productivity; net exports of corn, wheat, rice, and soy were about 10 percent higher in 2009 (the most recent year for which Comtrade data is available) than in 2005. And many of the other countries that export grains in significant amounts, including Canada and relatively dry Australia, are also highly economically advanced. As noted above, one possible explanation is that these geographically expansive countries are simply using their comparative advantage of a larger surface area, which effectively translates into large supplies of soil moisture, or green water.[52]

However, a great deal of US agriculture, at least, relies on irrigation and the mining of blue water sources. About 40 percent of US wheat exports, the largest export crop by virtual water volume, derive from blue water sources; for maize and soybeans, it is about 20 percent.[53] The Ogallala aquifer, which lies under about 448,000 km^2 of the US Great Plains, provides irrigation water to some 20 percent of US farmland, including most of Nebraska and a significant part of

48. Gleick 2009; and Aldaya, Allan, and Hoekstra 2009.
49. Kumar and Singh 2005.
50. Chapagain and Hoekstra 2004, 46.
51. Chapagain and Hoekstra 2004, 47. The US is identified as a major virtual water exporter, but for both livestock and industrial goods, US virtual water imports and exports are roughly equal.
52. Kumar and Singh 2005, 782.
53. Aldaya, Allan, and Hoekstra 2009.

Kansas. Both these states rely on blue water sources for over 50 percent of maize and soybean production, as well as about one-third of wheat production; Kansas is by far the largest wheat-producing state.[54] Intensive mining of groundwater from the Ogallala began only in the 1940s; US agricultural production has soared, and the aquifer has been drained at an unsustainable rate, even as conflicts over water uses in the western US have intensified.[55]

Similarly, while Australia has a relatively large landmass, much of it is desert, with correspondingly low levels of green water. Yet Australia—"the world's driest inhabited continent"—is reckoned to be the world's largest net virtual water exporter,[56] and also the sixth-largest net exporter of virtual water embedded in agricultural goods,[57] with over one-fourth of Australian wheat exports coming from blue water sources.[58]

But if much of this agricultural bounty is produced with blue rather than green water—and, furthermore, if much of it is made up of basic cereal crops sold near or even below the cost of production—then surely it is worth raising the question of why these seemingly irrational hydrological investment decisions are being made in some of the world's most advanced national economies. There are, after all, a wide variety of goods whose trade may be described as virtual water exports: beef (15.5 tons of water to produce one 1kg), paper (10 liters per page), or even computer chips (32 liters per two-gram chip).[59] Not all forms of virtual water are equal. Judging by the mass of the commodities produced, computer chip manufacturing compresses water more effectively than cereal production by a factor of about sixteen. And the difference in terms of economic value added by a given volume of water is far greater again—a kilogram of computer chips is worth far more than a kilogram of rice. Chapagain and Hoekstra calculate average virtual water content in industrial products to be 80 liters per US dollar; for wheat or corn priced at US$200–300 per ton, the comparable figure would be in the thousands.[60] But even this of course masks vast differences between goods and even differing production processes for the same goods. In short, some commodities represent a more intense or effective "compression" or "virtualization" of water resources than others.

So why would one of the world's largest, most technologically advanced national economies bother to continue to put its water to such relatively unprofitable use? Why are some of the world's wealthiest countries investing their water in such an inefficient manner? With a neoclassical or market environmentalist framing, such questions appear to be answerable only in terms of seeing the persistence of strong agricultural production in post-industrial societies

54. Aldaya, Allan, and Hoekstra 2009.
55. McGuire et al. 2003.
56. Chapagain and Hoekstra 2004.
57. Hoekstra and Hung 2005.
58. Aldaya, Allan, and Hoekstra 2009, 890.
59. Water Footprint Network, "Water Footprint Product Gallery," http://www.waterfootprint.org/?page=files/productgallery, accessed 21 April 2011; Williams, Ayres, and Heller 2002, 5504.
60. Chapagain and Hoekstra 2004, 43.

as a result of some sort of obstacle (either political or cultural), as a path-dependence that prevents the efficient allocation of resources.[61] To be sure, there is likely some truth to this, owing to the concentrated power of global agribusiness (largely US-based) and their control of vertically integrated commodity chains. The current system is highly profitable for these firms, as it provides both a liberalized global trading and investment regime, along with significant agricultural subsidies in exporting developed countries, including, although not exclusively, the US.[62]

The persistence of this economic inefficiency seems dysfunctional for the global economy, to the extent that we understand the global economy to be a site of abstract universal equality. On the other hand, economic inefficiency can be seen as functional for the global economy if we understand it as a political economic order, under US hegemony, and increasingly sustained through the "hyperconsumption" or "overconsumption" of a relatively small elite. Rather than seeking efficiency in the abstract, economic transactions always take place in a particular rule-bound order where specific actors with particular interests set the rules that govern the economy.

Recall that the concept of virtual water was originally developed to analyze grain shipments to the MENA and tended to stress the functionality of virtual water imports—that is, the benefits of virtual water imports for the country's rulers, in terms of assuring stability and regime legitimacy.[63] Although unstated, virtual water in this case could also be seen as serving a political function for the exporting countries (pre-eminently, the United States), which is not too difficult to discern: water is invested into low-cost food production, but as these food exports help assure regime stability in the Middle East, they can equally be seen as an investment in oil supply security.

But as we have seen, the more truly typical virtual water importers may be newly industrialized countries in East Asia and Mexico. The rise in Mexican corn imports, for example, is largely attributable to Mexican economic integration with the US. Since the North American Free Trade Agreement (NAFTA) was implemented in 1994, US-grown corn is regularly sold in Mexico below its cost of production (and in some years 30 percent or more below its cost of production).[64] Mexican corn producers are unable to compete, resulting in huge job losses in the Mexican agricultural sector; by one estimate, over two million agricultural jobs—one quarter of the agricultural work force—were lost between the pre-NAFTA period and 2006.[65] But the flip side of this has been the industrialization of the Mexican economy. Over the same period, the number of export-manufacturing jobs in Mexico increased by about 700,000. There is a notable discrepancy in the numbers: two million agricultural jobs lost, and 700,000 ex-

61. See, for example, OECD 2006; and SIWI-IWMI 2004, 16.
62. Murphy, Lilliston, and Lake, 2005.
63. Allan 1998.
64. Murphy, Lilliston, and Lake 2005, Annex I, x.
65. Polaski 2006, 9.

port-manufacturing jobs gained, resulting in a labor market glut that has kept wages low, and has shifted many displaced agricultural workers into "low-pay, low-productivity jobs in the service sector such as domestic work, street vending, and personal services and repairs."[66] Flooding the Mexican market with subsidized US corn thus acts a huge lever on the Mexican labor market, moving millions of Mexicans from agricultural employment either into export-oriented manufacturing, or precarious employment in the informal service sector.

Mexico surely provides only one example of what is occurring in large swathes of the Global South. The political economic function of virtual water exports is thus to push workers into labor markets for manufacturing, which are becoming fully globalized. The investment of water in subsidized grain pays its dividend, as it is effectively reinvested in low-cost manufacturing processes and export processing zones the world over. American as well as Canadian and Australian grain exports provide the lever for the massive economic restructuring necessary to integrate large portions of the Global South into the global economy: the transformation of tens if not hundreds of millions of rural peasants, into an urbanized manufacturing working class.

This is of course not necessarily to say that there is a conscious neoliberal-globalization grand strategy operating in the persistence of American agricultural subsidies. The persistence of those subsidies can reasonably be attributed to say, the overrepresentation of rural interests in American electoral politics, as argued by interest group-oriented public choice theory,[67] or to the structural power of transnational agribusiness conglomerates.[68] But these subsidies are also essential for the functionality of a global system that has been—at least until the global financial crisis that started in 2008–2009—predicated on the hyperconsumption of resources by the wealthiest fraction of the population in the wealthiest of the world's countries.[69] This of course includes the growing profitability of largely US-based global agribusiness conglomerates—a point that virtual water policy prescriptions, which aim at increasing the efficiency of global water use, tend to understate.

Virtual Water Trade and Uneven Development

At the same time, in spite of these coincident interests, we should recall that the efforts of both state and corporate bureaucracies to rationally plan for development are constantly thwarted by capitalism's dynamic nature. One need only note the glaring mismatch mentioned in the discussion of Mexico above: the number of jobs added in the export-manufacturing sector is barely one-third the number of agricultural producers thrown out of work.

Thus, the other side of this hyperconsumption-driven system is a global

66. Polaski 2006, 9–10.
67. Zhang and Laband 2005.
68. Murphy, Lilliston, and Lake 2005.
69. Duménil and Levy 2004.

environmental crisis, manifested in the proliferation of slums throughout the Global South. These built environments are crisis-prone or crisis-ridden not only because residents are more susceptible to natural disasters such as earthquakes, mudslides, and flooding, but also because "crisis" is the norm, in the sense that access to basic amenities, including clean water, is tenuous at best. As Mike Davis emphasizes, in many of the cities of the Global South, "urbanization . . . has been radically decoupled from industrialization, even from development per se." And rather than an inevitable feature of capitalism's post-industrial phase, "urbanization-without-growth is . . . the legacy of a global political conjuncture—the debt crisis of the late 1970s and subsequent IMF-led restructuring of Third World economies in the 1980s."[70]

The enormous exception to the phenomenon of "urbanization-without-growth" of course is China, where massive manufacturing export drives double-digit annual economic growth. For boosters of virtual water trade, such as Neil Reynolds (who was referred to above), China's deruralization gives Canada, for example, with its disproportionate amount of the world's supply of fresh water, an opportunity. Rather than, say, attempt to resuscitate diversion megaprojects that would export Canadian water in bulk to the US or elsewhere, Reynolds sees the export of virtual water as a more profitable strategy: "China—with declining agricultural productivity—presents a prime opportunity. As China's countryside empties into its cities, China must divert water from agricultural to urban uses. Since it takes 1000 tons of water to produce one ton of grain, one of China's most economical ways to import water would be to buy grain—from Canada."[71]

In Chinese cities, the problems are the mirror-image of those faced in other cities outside the First World: built environments facing incipient labor shortages and some of the world's worst urban pollution. But as Reynolds presents it, the "emptying" of the Chinese countryside appears as a natural phenomenon, and thus not at all amenable to human control, rather than as a function of political-economic institutions and practices, and investment, trade, and consumption decisions, made both in China and elsewhere.

Conclusion

In this paper I have sought to show that "virtual water," while often presented as a technocratic response to the biophysical problem of water scarcity, is in fact a highly political discourse. On its face, a policy of encouraging "virtual water" trade would appear to provide a number of unquestionably good outcomes: peaceful resolution of international tensions, political stability, and efficient use of finite ecological resources. But it is able to do so only by defining the problem in a particular way—that is, the world's "water crisis" is understood in terms of physical water scarcity at global and national scales. It thus ignores another,

70. Davis 2004.
71. Neil Reynolds, "Swap Water for Food? It's a good deal," *Globe & Mail*, 26 January 2007.

arguably more pressing, definition of the world's water crisis: individualized water insecurity, resulting in annual deaths in the millions, as a result of inadequate infrastructure investment and political-economic exclusions that currently prevent nearly a billion people from accessing adequate clean water supplies to meet basic human needs. As we have seen, this discursive framing of the problem is achieved in part by positing the water-scarce MENA region as the prototypical virtual water importer. The implication is that in a world of finite water supplies and increasing human population, tomorrow, other parts of the world will need to develop policies to confront water scarcity like the MENA region does today. The virtual water discourse frames the issue so as to suggest that if virtual water policies have worked to solve the problems of water scarcity in the MENA region, then they can and should be applied globally. But actual patterns of virtual water trade do not bear out the assumption that the MENA region is exemplary. Rather than solving problems of physical water scarcity at the national level, virtual water trade has to a greater extent been about lubricating the process of industrialization and urbanization, particularly in places like Mexico and China. At the same time, a global "water crisis" in the sense of individualized insecurity and exclusion across the Global South is exacerbated by rapid urbanization and geographically uneven development. That the efficient allocation of resources can lead to tremendous short-term disruption, and even in the longer term can have devastating consequences in a context of stark social inequalities, can be ignored to the extent that "water crisis" is assumed to be an essentially technical, rather than political, problem.

The fundamental problem with the virtual water thesis thus lies here, in its treatment of the socioeconomic environment as either essentially ahistorical as in the theory of comparative advantage, or as an uncontrollable, preexisting given, rather than the product of human decisions. To be sure, localized water scarcity may well be alleviated more rationally through the trade of virtual water, rather than bulk trade of water itself. But it is also important to see that environmental crises, including localized physical water scarcity, but also widespread individualized water insecurity, may be a result of the production and reproduction of political-economic structures and processes that defy rational management. The concept of "virtual water," in this sense, does not just prevent water wars; it also actively produces a particular social environment, presented as a reified and uncontrollable "second nature," where, for too many, life is nasty, poor, brutish, and short.

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