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8 The relation between international trade and water resources management

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Unlike oil, water is generally not regarded as a global resource. Whereas in most countries the energy sector has an obvious international component, this is different for the water sector. The international component of water is recognized only in the case of transboundary rivers. The relation between international trade and water management is generally not something that water sector officials think about. The reason is that water is not traded internationally, due to its bulky properties. Besides, there is no private ownership of water, so that it can also not be traded as in a market (Savenije, 2002). Water sector specialists often forget, however, that water is traded in virtual form, i.e. in the form of agricultural and industrial commodities. Although invisible, import of 'virtual water' can be an effective means for water-scarce countries to preserve their domestic water resources (Allan, 2001a).

Water sector specialists do not usually explicitly study the relation between water use and import or export. At the same time, trade specialists and economists engaged in or studying international trade generally do not bother much about the implications of international trade for the water sector. The reason here is that the water inputs generally hardly contribute to the overall price of traded commodities. This seems to justify the conclusion that water cannot be a significant factor influencing trade patterns. The fact that water inputs are generally heavily subsidized by national governments is hereby ignored. Trade specialists also tend to forget that external effects of water use can be very significant, but are never included in the price of water, and that no country charges a scarcity rent for water inputs even though water is sometimes very scarce. When one merely looks at the prices of traded commodities one will indeed get the impression that water scarcity cannot be a driving force of or limiting factor to international trade.

One of the principles widely accepted in water resources management is the subsidiarity principle, according to which water issues should be settled at the lowest community level possible (GWP, 2000). In cases where upstream water users affect downstream users, it has been recognized that it is necessary to take the perspective of a river basin as a whole, considering water as a river-basin resource. Regarding water as a global resource is very uncommon. To illustrate this, read what the Global Water Partnership writes about how to come towards good water resources management (GWP, 2000, pp. 28 and 33):

> In order to achieve efficient, equitable and sustainable water management . . ., a major institutional change will be needed. Both top-down and bottom-up participation of all stakeholders will have to be promoted – from the level of the nation down to the level of a village or a municipality or from the level of a catchment or watershed up to the level of a river basin. The principle of subsidiarity, which drives down action to the lowest appropriate level, will need to be observed.

There is no word about the fact that there might be a global dimension to water management.

Considering water management from a local, national or river-basin perspective is, however, not always sufficient. Many water problems bear an international trade component (Hoekstra and Chapagain, 2008). Subsidized water in Uzbekistan is overused to produce cotton for export; Thailand experiences water problems due to irrigation of rice for export; Kenya depletes its water resources around Lake Naivasha to produce flowers for export to the Netherlands; Chinese rivers get heavily polluted through waste flows from factories that produce cheap commodities for the European market. Not only water problems, but also water solutions have an international trade component. Jordan and various other countries in the Middle East meet their demand for food and save their scarcely available water resources through food imports from overseas. Mediterranean countries will expectedly experience increased water scarcity due to climate change, forcing them into the direction of increased import of water-intensive products. Apparently there are more connections between seemingly local or national water issues and international trade than recognized at first sight.

This chapter reviews current knowledge with respect to three questions:

1. What is the effect of international trade on domestic water resources?
2. What is the effect of water availability on international trade?
3. Can international trade increase global water-use efficiency?

The chapter concludes with a discussion of risks and opportunities associated with the intensification of international trade in water-intensive commodities.

The effect of international trade on domestic water resources

An obvious effect of international trade on water-intensive commodities is that it generates water savings in the countries that import those commodities. This effect has been discussed since the mid-1990s (Allan, 2001b; Hoekstra, 2003). The national water saving associated with import can be estimated by multiplying the imported product volume by the volume of water that would have been required to produce the product domestically. The other side of international trade in water-intensive commodities is that it takes water in the exporting countries that can no longer be used for other (domestic) purposes. Besides, the social and environmental costs that are often associated with water use remain in the exporting countries; they are not included in the price paid for the products by the consumers in the importing countries.

Import of water-intensive commodities reduces national water demand

In many countries international trade in agricultural products effectively reduces domestic water demand. These countries import commodities that are relatively water intensive while they export commodities that are less water intensive. In the period 1997–2001, Japan, the largest (net) importer of water-intensive goods in the world, annually saved 94 billion m^3 from its domestic water resources. This volume of water would have been required, in addition to its current water use, if Japan had produced all imported products domestically. In a similar way, Mexico annually saved 65 billion m^3, Italy 59 billion m^3, China 56 billion m^3 and Algeria 45 billion m^3 (Chapagain et al., 2006).

One of the water-scarce countries that most heavily depends on imports of water-intensive commodities is Jordan. It imports 5 to 7 billion m^3 of water in virtual form per year, which is in sharp contrast with the 1 billion m^3 of water withdrawn annually from domestic water sources (Haddadin, 2003; Hoekstra and Chapagain, 2007, 2008). People in Jordan thus survive owing to the fact that their 'water footprint' has largely been externalized to other parts of the world, for example the USA. Intelligent trade largely covers up Jordan's water shortage: export of goods and services that require little water and import of products that need a lot of water. The good side of Jordan's trade balance is that it preserves the scarce domestic water resources; the downside is that the people are heavily water dependent.

For countries that depend on the import of water-intensive products, it is important to know whether the water thus saved has higher marginal benefits than the additional cost involved in importing these products. Let us consider the example of Egypt, a country with a very low rainfall – the mean rainfall is only 18 mm/yr – and with most of its agriculture being irrigated. The import of wheat in Egypt implies a saving of their domestic water resources of 3.6 billion m^3/yr, which is about 7 percent of the total volume of water Egypt is entitled to according to the 1959 agreement on the use of the Nile. The national saving is made with the investment of foreign exchange of US$593 million/yr (ITC, 2004), so that the cost of the virtual water is US$0.16/$m^3$ at most. In fact, the cost will be much lower, because the costs of the imported wheat cover not only the cost of water, but also the costs of other input factors such as land, fertilizer and labor. In Egypt, fertile land is also a major scarce resource. The import of wheat not only releases the pressure on the disputed Nile water, but also reduces pressure to increase the area of land under agriculture. Greenaway et al. (1994) and Wichelns (2001) have shown that in the international context Egypt has a comparative disadvantage in the production of wheat, so that the import of wheat into Egypt implies not only a physical water saving, but also an economic saving.

Export of water-intensive commodities raises national water demand

Water is not merely a local resource to meet local demands for water-based products. In the period 1997–2001, 16 percent of world water use was not for producing products for domestic consumption but for making products for export (Hoekstra and Chapagain, 2007; 2008). The nations with the largest net annual water use for producing export products were the USA (92 billion m^3), Australia (57 billion m^3), Argentina (47 billion m^3), Canada (43 billion m^3), Brazil (36 billion m^3) and Thailand (26 billion m^3). The main products behind the national water use for export from the USA were oil-bearing crops and cereal crops. These products are grown partly rain-fed and partly irrigated. In Australia and Canada, the water use for export was mainly related to the production of cereals and livestock products. In Argentina and Brazil, water use for export was primarily for producing oil-bearing crops. The national water use for export in Thailand was mainly the result of export of rice. Much of the rice cultivation in Thailand is done during the rainy season, but irrigation is widespread, to achieve two harvests per year. In the period 1997–2001, Thailand used 27.8 billion m^3/yr of water (sum of rainwater and irrigation water) to produce rice for export, mostly grown in the central and northern regions (Maclean et al., 2002). The monetary equivalent of the rice export was US$1556 million/yr (ITC, 2004). Hence Thailand generated a foreign exchange of US$0.06/$m^3$.

Recall that currently 16 percent of the water use in the world is not for producing products for domestic consumption but for making products for export and let us simply assume that, on average, agricultural production for export does not cause significantly more or fewer water-related problems (such as water depletion or pollution) than production for domestic consumption. That means that roughly one-sixth of the water problems in the world can be traced back to production for export. Consumers do not see the effects of their consumption behavior due to the teleconnection between areas of consumption and areas of production. The benefits are on the consumption side, but since water is generally grossly underpriced, the costs remain on the production side. From a water resources point of view it would be wise for the exporting countries in the world to review their water use for export and see to what extent this is good policy given the fact that the foreign income associated with the exports generally does not cover most of the costs associated with the use of water. The construction of dams and irrigation schemes and even operation and maintenance costs are often covered by the national or state government. Negative effects downstream and the social and environmental costs involved are not included in the price of the export products either.

The effect of international trade on local water pollution

International trade brings another phenomenon: natural cycles of nutrients such as nitrogen and phosphorus are disturbed through depletion of the soil in some places, excessive use of fertilizers in others, long-distance transfers of food and animal feed, and concentrated disposal of nutrient-rich wastes in densely populated areas of the world (Grote et al., 2005). This has already led and will further lead to depletion of the soil in some areas (Sanchez, 2002; Stocking, 2003) and eutrophication of water elsewhere (McIsaac et al., 2001; Tilman et al., 2001). The surplus of nutrients in the Netherlands, for instance, is partially related to deforestation, erosion and soil degradation in those areas of the world that export food and feed to the Netherlands, for example in Brazil, which exports large amounts of soybeans for Dutch pigs and chickens. This implies that the nutrient surplus in the Netherlands is not an issue that can simply be understood as a Dutch issue. Dutch water pollution is part of the global economy.

The disturbance of nutrient cycles is not the only mechanism through which international trade influences the quality of water resources worldwide. Meybeck (2004) shows how other substances are also dispersed into the global environment and change the quality of the world's rivers. Nriagu and Pacyna (1988) set out the specific impacts of the use of trace metals in the global economy on the world's water resources. The regular publication of new reports on global pollution shows that this phenomenon in itself is no longer news; what is now gradually being uncovered and is therefore relatively new is the fact that pollution is not simply 'global' because pollution is so 'widespread', but that it is interlinked with how the global economy works and is therefore a true global problem. Water pollution is intertwined with the global economic system to such an extent that it cannot be dealt with independently from that global economy. Indeed, pollution can be tackled by end-of-pipe measures at or near the location of the pollution, but a more cause-oriented approach would be to restructure the (rules for the) global economy, with the aim to close the element cycles.

The effect of water availability on international trade

There is an immense volume of literature on international trade, but few scholars address the question of to what extent international trade is influenced by regional differences in water availability. Rather, international trade is explained in terms of differences in labor productivities, availability of land, domestic subsidies to agriculture, import taxes, production surpluses and associated export subsidies, etc. It will be hard to find evidence that regional water abundance benefits the export of water-intensive commodities and that regional water scarcity promotes the import of water-intensive commodities.

According to international trade theory that goes back to Ricardo ([1817] 2006), nations can gain from trade if they specialize in the production of goods and services in which they have a comparative advantage, while importing goods and services in which they have a comparative disadvantage. The meaning of the principle for the field of water resources has been elaborated by Wichelns (2004). The economic efficiency of trade in a water-intensive commodity between two countries should be evaluated based on a comparison of the opportunity costs of producing the commodity in each of the trading nations. Export of a water-intensive commodity is attractive if the opportunity cost of producing the commodity is comparatively low. This is the case when there is a relatively high production potential for the water-intensive commodity due to, for example, relative abundance of water and/or a relatively high water productivity (yield per unit of water input) in the country. Import of a water-intensive commodity (instead of producing it domestically) is attractive if the opportunity cost of producing the commodity is comparatively high, for example because water is relatively scarce and/or water productivity in the country is low.

The most convincing research providing evidence that water availability influences international trade has been carried out by Yang et al. (2003; 2007). As they have quantitatively shown, cereal imports have played a crucial role in compensating water deficits in various water-scarce countries. They demonstrate that below a certain threshold in water availability, an inverse relationship can be identified between a country's cereal import and its per capita renewable water resources. In the early 1980s the threshold was at about 2000 m^3 per capita per year. At the end of the 1990s it had declined to about 1500 m^3 per capita per year. Countries with less water than the threshold cannot do without the import of staple foods. The threshold has declined over the past couple of decades due to the improvement in water productivities and the expansion of irrigated areas.

There is clear evidence that the trade balance of countries with very low water availability (per capita) is partly determined by the fact that those countries have a comparative disadvantage in producing water-intensive products. One does not need to be an economist to see that; the available water resources simply fall short in some countries to produce the food to survive. Most international trade in the world, however, has little to do with the intentional trade in water-intensive commodities to countries with low water availability from countries with higher water availability. The driving force behind international trade in water-intensive products may be water scarcity in the importing countries, but more often other factors play a decisive role (Yang et al., 2003; De Fraiture et al., 2004).

International trade in agricultural commodities depends on many more factors than differences in water scarcity in the trading nations, including differences in availability of land, labor, knowledge and capital, and differences in economic productivities in various sectors. The existence of domestic subsidies, export subsidies, or import taxes in the trading nations will also influence the trade pattern. As a consequence, international virtual-water transfers usually cannot – or can only partly – be explained on the basis of differences in water availability and productivity.

In some cases, the relation between water availability and the actual trade pattern is even counter-intuitive. North China, for instance, has a very low availability of water per capita, unlike South China, but nevertheless, there is a very significant trade in food from North to South China (Ma et al., 2006). Of course, this does intensify the water problems in the North. A similar case can be found in India, where water has become relatively scarce in the northern states of Punjab, Uttar Pradesh and Haryana. Nevertheless, these states export significant volumes of food to the eastern states of Bihar, Jharkhand and Orissa, which have much larger water endowments than the northern states (Verma et al., 2008). No simple explanation will suffice to explain the counter-intuitive situations with respect to internal trade within China and India, because various factors will play a role, including historical, political and economic ones. One factor that may play a role as well is that in water-scarce regions the incentives to increase water productivity are highest. As a result, it becomes attractive to produce in those regions, which however enhances the scarcity of the water. This may be a factor in northern India, where water productivities are indeed much higher than in the eastern states, providing them with a comparative advantage although the water availability in absolute terms is much lower.

Global water-use efficiency

In the water sector, the term water-use efficiency is most often used to refer to the inverse of local water productivity. The latter is expressed as the amount of product made per unit of water (in the agricultural sector known as 'crop per drop'). Water-use efficiency is expressed as the volume of water required to make one unit of product. A water user can increase local water-use efficiency by producing the same with less water input. Water users can be encouraged to do so by charging them a water price that is based on full marginal cost, by stimulating them to adopt water-saving technology, or by creating awareness that saving water is good for the environment.

The local view on water-use efficiency is only one way of looking at the subject; there are two other levels at which one can consider the efficiency of water use (Hoekstra and Hung, 2005). At the catchment or river-basin level, water-use efficiency refers to the efficiency of water allocation to alternative uses. Water-use efficiency at this level can be enhanced by reallocating water to purposes with higher marginal benefits (Rogers et al., 1998). At the global level, water-use efficiency can be increased if nations use their comparative advantage or disadvantage in producing water-intensive goods to either encourage or discourage the use of domestic water resources for producing export commodities.

Much research effort has been dedicated to studying water-use efficiency at the local and river-basin levels. The research on global water-use efficiency is of more recent date. Only four studies have been carried out so far, all of them focusing on the quantification of physical water savings as a result of global trade, not on the associated economic savings. All four studies indicate that the current pattern of international trade results in a substantial global water saving (Oki and Kanae, 2004; De Fraiture et al., 2004; Chapagain et al., 2006; Yang et al., 2006).

Volume of water saved as a result of international trade

The most comprehensive study on global water saving in relation to international trade was the one carried out by Chapagain et al. (2006). According to their study, the global water use for producing agricultural products for export amounted to 1250 billion m^3/yr (in the period 1997–2001). If the importing countries were to have produced the imported products domestically they would have required a total of 1600 billion m^3/yr. This means that the global water saving by trade in agricultural products was 350 billion m^3/yr. So the average water saving accompanying international trade in agricultural products has been (350/1600=) 22 percent. The global volume of water used for agricultural production is 6400 billion m^3/yr. Without trade, supposing that all countries had to produce the products domestically, agricultural water use in the world would amount to 6750 instead of 6400 billion m^3/yr. International trade thus reduces global water use in agriculture by 5 percent.

The above figures do not differentiate between the use of green water (rainwater) and the use of blue water (ground and surface water). The global water saving associated with a certain trade flow can refer to either a global blue or a global green water saving (or a combination of both). Even if there is a net global water loss from a trade relation, there might be a saving of blue water at the cost of a greater loss of green water or vice versa. From an economic point of view there is a substantial difference between blue and green water saving, because the opportunity costs of blue water are generally much higher than the opportunity costs of green water. As a result, trade with an associated blue water saving but a greater green water loss could still be efficient from an economic point of view.

The downside of virtual-water import as a solution to water scarcity

Saving domestic water resources in countries with relative water scarcity through virtual-water import (import of water-intensive products) looks very attractive. There are, however, a number of drawbacks that have to be taken into account. First, saving domestic water through import should explicitly be seen in the context of the need to generate sufficient foreign exchange to import food that otherwise would be produced domestically. Some water-scarce countries in the world are oil rich, so they can easily afford to import water-intensive commodities. However, many water-scarce countries lack the ability to export energy, services or water-extensive industrial commodities in order to afford the import of water-intensive agricultural commodities. Second, import of food carries the risk of moving away from food self-sufficiency. This plays an important role in the political considerations in countries such as China, India and Egypt. Third, import of food will be bad for the domestic agricultural sector and lead to increased urbanization, because import reduces employment in the agricultural sector. It will also result in an economic decline and worsening of land management in rural areas. Fourth, in many water-scarce developing countries, where an important part of the agriculture consists of subsistence farming, promoting food imports may threaten the livelihoods of those subsistence farmers and reduce access to food for the poor. Finally, increases in virtual-water transfers to optimize the use of global water resources can relieve the pressure on water-scarce countries but may create additional pressure on the countries that produce the water-intensive commodities for export. The potential water saving from global trade is sustainable only if the prices of the export commodities truly reflect the opportunity costs and negative environmental impacts in the exporting countries. Otherwise the importing countries are simply gaining from the fact that they would have had to bear the cost of water depletion if they had produced domestically whereas the costs remain external if they import the water-intensive commodities instead.

Discussion

International transfers of water in virtual form are substantial and likely to increase with continued global trade liberalization (Ramirez-Vallejo and Rogers, 2004). Intensified trade in water-intensive countries offers both opportunities and risks. The most obvious opportunity of reduced trade barriers is that virtual water can be regarded as a possibly cheap alternative source of water in areas where freshwater is relatively scarce. Virtual-water import can be used by national governments as a tool to relieve the pressure on their domestic water resources. This import of virtual water (as opposed to real water, which is generally too expensive) will relieve the pressure on the nation's own water resources. For water-abundant countries an argument can be made for export of virtual water. Trade can physically save water if products are traded from countries with high to countries with low water productivity. For example, Mexico imports wheat, maize and sorghum from the USA, which requires 7.1 billion m^3 of water per year in the USA. If Mexico were to produce the imported crops domestically, it would require 15.6 billion m^3 of water per year. Thus, from a global perspective, the trade in cereals from the USA to Mexico saves 8.5 billion m^3/yr. Although there are also examples where water-intensive commodities flow in the opposite direction, from countries with low to countries with high water productivity, the available studies indicate that the resultant of all international trade flows works in a positive direction. We showed that international trade in agricultural commodities reduces global water use in agriculture by 5 percent. Liberalization of trade seems to offer new opportunities to contribute to a further increase of efficiency in the use of the world's water resources.

A serious drawback of trade is that the indirect effects of consumption are externalized to other countries. While water in agriculture is still priced far below its real cost in most countries, an increasing volume of water is used for processing export products. The costs associated with water use in the exporting country are not included in the price of the products consumed in the importing country. Consumers are generally not aware of – and do not pay for – the water problems in the overseas countries where their goods are being produced. According to economic theory, a precondition for trade to be efficient and fair is that consumers bear the full cost of production and impacts. Another downside of intensive international virtual-water transfers is that many countries increasingly depend on the import of water-intensive commodities from other countries. Jordan annually imports a virtual-water volume that is five times its own annual renewable water resources. Other countries in the Middle East, but also various European countries, have a similar high water import dependence. The increasing lack of self-sufficiency has made various individual countries, but also larger regions, very vulnerable. If for whatever reason food supplies cease – be it due to war or a natural disaster in an important export region – the importing regions will suffer severely. A key question is to what extent nations are willing to take this risk. The risk can be avoided only by promoting national self-sufficiency in water and food supply (as Egypt and China do). The risk can be reduced by importing food from a wide range of trade partners. The current worldwide trend, however, facilitated by the World Trade Organization, is toward reducing trade barriers and encouraging free international trade, and reducing interference by national governments.

The current global trade pattern significantly influences water use in most countries of the world, either by reducing domestic water use or by enhancing it. Future national and regional water policy studies should therefore include an assessment of the effects of trade on water policy. For water-scarce countries, it would also be wise to do the reverse: study the possible implications of national water scarcity on trade. In short, strategic analysis for water policy-making should include an analysis of expected or desirable trends in international or inter-regional virtual-water flows.

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