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Department of Economics

1/2011

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March 2011

Publisher:
Helmholtz-Zentrum für Umweltforschung GmbH - UFZ
Permoserstr. 15
04318 Leipzig

ISSN 1436-140X

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Keywords: Virtual water, water footprint, international trade, global water governance

JEL Classifications: F 18, Q 25, Q27, Q56

Abstract

So-called virtual water, the water „embedded" in internationally traded goods, has come under discussion. The amount of quantitative studies which attempt to estimate volumes and flows of virtual water in relation to agricultural trade is rising rapidly, while the concept has been recognized by large firms and international institutions. From the viewpoint of economic trade theory, the endowment with abundant water resources gives countries a comparative advantage in the export of water-intensive goods, while water scarce countries gain the option to alleviate stress on domestic water resources by substituting the production of water-intensive goods by imports. However, fairness implications are seen to arise in the reallocation of water resources through the means of mostly agricultural trade. In this perspective, moral problems can be attached to both imports and exports, and even to a country's own consumption of virtual water. Global institutional arrangements are therefore suggested, to regulate virtual water flows in a "fair" and "efficient" manner. This paper will give a short overview of the concept's history and findings, and subsequently analyse it from the perspective of economic trade and resource theory. The contribution of this paper will be to examine the concept of virtual water in terms of the problems it evokes, its informative value and the policy suggestions which are made in this context. It must be concluded that the concept is unspecific and inconsistent, implying governance schemes which will neither improve efficiency nor sustainability in today's trade patterns.

1. Introduction

In the 1990s, virtual water was introduced as a concept to measure the amount of water contained in a commodity. The term virtual water denotes all water used in a commodity's value added chain including the water which crosses borders as a result of trade. These trade flows and their implications are being discussed controversially, especially since the beginning of the 2000s, when the concept of "water footprints" was additionally introduced. This measure has by now been employed by institutions like UNESCO or the European Commission (e.g. European Commission 2008), large companies like Coca Cola have included water footprint accounting into their environmental strategy (The Coca Cola Company 2010).

The volumes and flows of virtual water are often seen to have problematic implications, especially in the context of trade between industrial and developing countries. Several aspects of virtual water trade are thought to entail negative consequences for the poorest countries like rising dependencies on external water resources or the possibility given by trade to "exploit" water resources in other parts of the world. Due to these global interlinkages of water resources induced by trade, a system of global water governance is deemed necessary to encounter adverse impacts of trade on a sustainable and "fair" use of water. These normative concerns related to virtual water trade will be examined in the following. The question arises as to whether virtual water accounting is able to provide sound and appropriate information about water-related problems and to guide sustainability-oriented policies. Can virtual water calculations legitimate a global governance of water and is regulation needed in this field at all?

The paper is organised as follows: In section 2, the concept of virtual water in its various forms and measures, which range from a product's water intensity to the magnitude and direction of global virtual water trade flows, will be introduced, followed by an overview of empirical virtual water contents, consumption and trade flows, as has been investigated in numerous empirical studies. The third section will clarify the various criticisms of virtual water trading and their normative implications, followed by the corresponding policy implications. What can be said about the benefits of virtual water trading from a trade theory perspective in a perfect world is subject of section 4. The potential performance of global governance schemes based on virtual water measures is analysed in section 5. If we look at real world conditions the question arises whether market failures or "bad governance" might justify trade regulations (section 6). Some policy conclusions with respect to the use of virtual water calculations are derived in the final section 7.

2. The concept of virtual water

2.1 Measures and Applications

The term „virtual water“ was coined in the 1990s by the geographer Anthony Allan (see e.g. Allan 1997) and replaced the notion of „embedded water“, which had been used beforehand without capturing much attention of the water managing community (Merrett et al. 2003, p. 4). Virtual water is the amount of water embedded in a commodity, that is, the amount of water used on every stage of its production process (Hoekstra 2003, p. 13). Since the biggest part of the world's water consumption is devoted to food production, the water content of agricultural products, as well as the amount of water which crosses international borders through agricultural trade has gained increased attention. This linkage of the problems of water scarcity, agricultural trade and food security is oftentimes denoted as the „water-food nexus“ (Allan 1998, p. 545).

In case of a country, which exports agricultural commodities that require large amounts of water in their production process, the water thus consumed is said to be exported in virtual form, since it is withdrawn from domestic consumption. The importing country in turn purchases water in virtual form, since the water which would have been required to produce the imported goods domestically is thus saved.

The concept of virtual water has gained prominence owing to the following virtues:

- The concept of virtual water has first been discussed in the context of arid countries in the Middle East-North African (MENA) region, which do not dispose of sufficient water resources to nourish their populations, and therefore rely heavily on food imports. In this way, virtual water has gained political importance, since it enables governments in these countries to preserve their scarce water resource, and may even prevent conflict over water, as it is oftentimes claimed (Allan 1998, p. 546).
- By importing food from a water-abundant country, productive efficiency gains can be achieved as well as real water savings at a global scale, due to the fact that there are smaller negative externalities to water consumption in these countries, and often less water is needed per unit of product because of more favourable climatic conditions (Hoekstra 2003, p. 14). Not only the spatial, but also the temporal dimension plays a role in this context, because grain can be stored over time more easily than water, which makes it easier to insure against periods of drought or bad yields, thus virtual water trade may as well become a substitute for artificial water transport or storage (Verma 2009, p. 262).

Virtual water can be captured in a multitude of indicators and measures, as shown in table 1. From the virtual water contained in a single product, to the water consumption of a person or a company, these measures can be aggregated to national or global consumption measures. On the basis of these indicators, trade flows and trade balances of whole nations can be calculated.

Table 1: The Different Measures of Virtual Water.

	Indicators of Virtual Water
Virtual Water Specific Consumption	**Virtual Water Content of a Commodity** Virtual Water embedded in a product is the water consumed during its production process, and can be expressed as volume of water per unit of product (e.g. m³/kg). The following types of products can be distinguished: primary products, processed products, by-products, multiple products. The so called Virtual Water Value (VWV) captures the m³ of water required per kg of crop yield at field level, whereat a distinction can drawn between the water requirement at some reference production site, or the water theoretically required if the commodity were produced in the importing country.
	Water Footprint of a Product The Water Footprint of a product depicts the water consumed during its production process, broken down into commonly used units like one slice of bread, one cup of coffee, etc. Unlike the Virtual Water content, the Water Footprint makes a distinction between blue, green and grey water (the water needed to absorb pollutants), and a distinction between places of origin.
	Water Footprint of a Person A person's Water Footprint consists of her "direct Water Footprint" (home consumption) and her "indirect Water Footprint" (the water use and pollution behind all products consumed). Again a distinction can be made between places of origin, green, blue and grey water.
	Water Footprint of a Company A company's water footprint consists of its operational water use as well as water used in its supply chain. Additionally the "Grey Water Footprint" looks at the water quantity required to assimilate wastes emitted by the company.
	Water Footprint of a Country The water footprint of a country is defined as the volume of water needed for the production of the goods and services consumed by the inhabitants of the country. The "Internal Water Footprint" is the volume of water used from domestic water resources, the "External Water Footprint" is the volume of water used in other countries to produce goods and services imported and consumed by the inhabitants of the country.
	Global Virtual Water Budget Total production of each (primary/processed) product X Virtual Water Content.
Virtual Water Trade Flows	**Magnitude of Virtual Water Trade** 1) Virtual Water trade between nations: traded commodities X Virtual Water Content of the respective commodities ▪ From the perspective of exporting countries ▪ From the perspective of importing countries 2) Ratio of Virtual Water traded as part of the Global Virtual Water Budget (water which is not meant for domestic consumption but for export)
	Water Savings through Virtual Water Trade Local water savings: Water savings(m³)=Import(kg) X VWV(m³/kg) Global water savings: water savings(m³/kg)=VWV(consumption site) – VWV(production site) Water savings from food storage: water savings(m³/kg)=VWV(storing period) – VWV(using period)
	Virtual Water Trade Balance Shows if a country is net importer/exporter of Virtual Water: NVWI = GVWI-GVWE (net virtual water import = gross virtual water import – gross virtual water export)
	Virtual Water Import Dependency Reflects the level to which a nation depends on foreign water resources: WD = NVWI/(WU+NVWI) X 100 (if NVWI>0)* **Water Dependency is the ratio of water imports to total water use. WU denotes the total domestic water use (m³/year) and NVWI the net virtual water imports of a country.* In contrast, water self sufficiency (WSS) is defined as follows: WSS = 1-WD.
	Top Exporters and Top Importers Countries which contribute most to Virtual Water imports/exports, e.g. the Big Five exporters (USA, Australia, Argentina, Canada and France).
	Interregional Trade Flows Depicts, which world regions are net importers/net exporters of virtual water, and which direction the major interregional trade flows take.
	External Water Footprint of a Country Regarding a specific country's Virtual Water imports and resulting trade flows from the countries of origin, it can be shown where in the world this country is putting stress on external water resources.

The virtual water content of commodities has been investigated thoroughly. A common definition of the so called „virtual water value“ has been the amount of virtual water embedded in a primary product as the reciprocal of water productivity (m^3/kg instead of kg/m^3), whereat a distinction can be drawn between the amount of water actually used at production site, and the amount of water which would have theoretically been needed to produce the same commodity in the importing country (Renault 2003, pp. 79). For processed products, subsequent production steps have to be considered as well.

The water footprint concept, which has been introduced in 2002 by Arjen Hoekstra, is thought to be a transfer of other footprint concepts like the carbon footprint[1] or the ecological footprint to the domain of water resources, depicting the overall, direct and indirect, water consumption of individual water users or entire nations. The water footprint of a nation is defined as the total volume of freshwater that is used to produce the goods and services consumed by the people of the nation which usually includes water resources consumed in other countries in the case of import goods („exogenous water“). Although similar to the virtual water content, the water footprint concept intends not only to quantify the volume of virtual water used, but to give an impression of the actual impact of a product or person (through his consumption of products) on water resources at home and abroad, which is why this indicator includes a distinction between blue, green and grey water, as well as time and place of production (Hoekstra et al. 2009, p. 31). Thus, the main difference can be seen in the production focus of the virtual water content, and the consumption focus of the water footprint (Velázquez et al. 2011, pp. 752).

„Green water“ refers to the water contained in unsaturated soils and plants, and constitutes the source of rain fed agriculture, while „blue water“ refers to the water in rivers, lakes, reservoirs, ponds and aquifers, and is used as a supplement to green water in irrigated agriculture. “Grey water” relates to the pollution resulting from the production of a commodity, i.e. the quantity of water required to assimilate the load of pollutants based on existing ambient water quality standards.

The distinction between blue and green water is important if one considers the alternative uses of water apart from agriculture, because these alternative uses determine the benefits that can be achieved by substituting a country’s own agricultural production by imports. The following table is taken from Yang and Zehnder (2008) to illustrate the different characteristics of blue and green water.

[1] For a comparison of the water footprint concept to the carbon footprint, see section 6.

Table 2: Features of Green and Blue Water.

Type of Water	**Blue**	**Green**
Sources	Rivers, lakes, ponds, aquifers, reservoirs	Water that is stored in the unsaturated soil and plants
Mobility	Highly mobile	Highly immobile
Substitution of sources	Possible	Impossible
Competitive uses	Many	Few
Cost of use	High	Low

Yang/Zehnder (2008), p. 10.

Green water, on the one hand, has little alternative uses except for natural vegetation, that is, it is a specific factor in the sense that it can only be employed for the purposes of agriculture and natural vegetation, whereas blue water has many alternative functions like industrial or domestic uses, of which agricultural irrigation often yields the lowest economic value, meaning that irrigation water usually has high opportunity costs. It can furthermore be concluded, that the export of green water is technically more efficient than the export of blue water, because it involves lower opportunity costs (Yang / Zehnder 2008, p. 38). Thus, savings of blue virtual water are in general regarded to be more desirable than green water savings [2].

2.2 Quantification of Virtual Water Flows

Much effort has been put into calculating individual water footprints of nations, products or people. With regard to agricultural commodities, rice has by far the largest share in virtual water consumption, both because the consumed and traded volume of rice and its individual water requirements (2291 m³/ton) are relatively high. Livestock products are higher on the value chain than crops, and therefore more water intensive: Beef, which is the most water intensive meat consumes about 15500 m³/ton (Hoekstra / Chapagain 2007, pp. 38). Globally, 7451 billion m³ of water are consumed each year for the production of agricultural and industrial goods, a figure to which different countries contribute to varying degrees. People in the USA for instance have the largest per capita water footprint with 2483 m³/capita/year, closely followed by South European countries like Spain and Greece. Chinese people, in contrast, have a high water footprint on a national level, but a relatively low water footprint per capita of only 702 m³/capita/year (Hoekstra/Chapagain 2007, p. 39).

Chapagain and Hoekstra (2008) estimate the global virtual water flows between nations to amount to an average of 1625 billion m³/year in the period 1997-2001, which means that, with a global an-

[2] Yet these accounts consider technical efficiency only, without taking into account the valuation of a good by the demand side. Similarly, Wichelns (2010a) emphasises that it is not compelling to assume that the opportunity costs of green water always have to be lower than those of blue water (p. 2205).

nual water use of 7451 billion m³/year, 16% of the global water use is not meant for domestic consumption but for export. The major share of internationally traded virtual water relates to trade in crops (61%), whereas trade in livestock products and industrial products contribute 17% and 22% respectively (Chapagain/Hoekstra 2008, p. 22). According to Liu, Zehnder and Yang (2007) the USA, Australia, Argentina, Canada and France are by far the biggest exporters of virtual water related to trade in crops (the “Big Five”). Countries depend on virtual water imports to varying degrees. The Netherlands for instance, import an amount of virtual water which is equivalent to the country’s own annual net precipitation, while Jordan imports an amount five times its own annual renewable water resources (Chapagain/Hoekstra 2008, p. 22). Other countries, like India are almost self-sufficient with regard to water (Hoekstra/Chapagain 2007, p. 42).

Table 3 gives an overview of water footprints, water scarcity and import dependency of 24 selected countries. The external water footprint is defined as all virtual water related to gross imports (not including commodities imported for re-export). Water scarcity is defined here as the total water footprint of a nation, the water required to produce all goods and services consumed, divided by its own renewable water resources. Water import dependency is defined as the ratio of the external water footprint of a country to its total water footprint (Chapagain/Hoekstra 2008, p. 23). It can be seen from table 3, that virtual water consumption and imports vary widely between countries, but also that there is no clear correlation between a country’s water scarcity and its import dependency.

Table 3: Country water footprints, Water Scarcity and Import Dependency of Selected Countries.

Country	Total renewable water resources (10^9m^3/year)	Total water footprint (10^9m^3/year)	External water footprint (10^9m^3/year)	Per Capita water footprint (m^3/capita/year)	Water Scarcity (%)	Water Import Dependency (%)
Argentina	814,00	51,66	3,34	1404	6	6
Australia	492,00	16,56	4,80	1393	5	18
Bangladesh	1210,64	116,49	4,05	896	10	3
Brazil	8233,00	233,59	17,87	1381	3	8
Canada	2902,00	62,80	12,81	2049	2	20
China	2896,57	883,39	57,44	702	30	7
Egypt	58,30	69,50	13,13	1097	119	19
France	203,70	110,19	41,09	1875	54	37
Germany	154,00	126,95	67,09	1545	82	53
India	1896,66	987,38	15,99	980	52	2
Indonesia	2838.00	269,96	27.66	1317	10	10
Italy	191.30	134,59	68.67	2332	70	51
Japan	430,00	146,09	94,22	1153	34	64
Jordan	0,88	6,27	4,58	1303	713	73
Korea Rep.	69,70	55,20	34.18	1179	79	62
Mexico	457,22	140,16	42,14	1441	31	30
Netherlands	91,00	19,40	15,91	1223	21	82
Pakistan	222,69	166,22	88,88	1218	75	5
Russia	4507,25	270,98	42,13	1858	6	16
South Africa	50,00	39,47	8,60	931	79	22
Spain	111,50	93,98	33,60	2325	84	36
Thailand	409,94	134,46	11,22	2223	33	8
United Kingdom	147,00	73,07	51,40	1245	50	70
USA	3069,40	696,01	130,19	2483	23	19

Own representation after www.waterfootprint.org/?page=files/NationalStatistics.

According to Yang et al. (2003), a correlation between a country's water scarcity and the import of grains exists only below a so called water scarcity threshold of approximately 1500 m³/capita/year (p. 115). Below this threshold, the import of grains rises exponentially with rising water scarcity, above the threshold, no clear correlation can be seen. This means that countries, which are relatively close to each other in terms of geography and development, can have completely different virtual water trading patterns. This leads to the water savings or losses which occur in the course of virtual water trade. As has been calculated by Chapagain et al. (2005), the annual water savings related to trade in agricultural products (as a result from a higher water productivity in the exporting country) amount to 352 billion m³/year, which is perceived to be the main benefit of virtual water trade. Thus, "global water use efficiency" is thought to be attained, if virtual water flows from water abundant to water scarce regions (Hoekstra/Hung 2003, p. 26), or from water productive to less water productive regions, leading to global water savings (Chapagain et al. 2005, p. 29).[3]

3. Criticism of virtual water trade: Normative implications and the need for "global water governance"

3.1 Normative criteria for and "moral" implications of virtual water trade

Not only are virtual water flows calculated, measured and quantified, but the resulting figures are also valued "morally", that is, various normative implications are attached to the interlinkage of trade and water. Virtual water flows are not solely seen as an expression of trade in water-intensive goods, but also as an indicator for various global "injustices", from which a justification for globally regulating arrangements is derived. A "fair" or equal distribution of water resources around the globe seems to be one of the main concerns, as it is expressed in the suggestion to apply a "water Gini-coefficient" to the distribution of water around the world (Verkerk et al. 2006, p. 13). The second major concern has been a realignment of virtual water trade with water scarcity and water productivity, pursuing the objective of "global water use efficiency".

The following section will summarise the main normative implications which are associated with the concept of virtual water trade. The main impediments to a "fair" distribution of virtual water among countries are seen in the current trade regime, industrial countries' unsustainable consumption patterns and possible political implications, which result from rising interdependencies through international trade.

For clarity, criticism towards virtual water trade is divided into three main dimensions.

(1) The consequences of trade

Generally speaking, virtual water trade allows the reallocation of property rights over water on a global level. For some people, this fact already presents the root of the problem, since, at the outset, water resources are not distributed "fairly" or evenly around the globe, which is apparently thought to present an unfair disadvantage for some countries, while giving some (mostly wealthy industrial) countries an unfair advantage to start from (Verkerk et al. 2008, p. 33). In the course of reallocation, virtual water flows mostly follow agricultural trade, which is, additionally, not a level playing field but dominated by "nefarious food trade practices" (World Water Council 2004, p.14) of the industrial countries.

[3] These two properties do not have to coincide however, as for instance a water scarce country like Egypt may have a higher water productivity in certain crops than a water rich country like Canada, so trade flows in wheat from Canada to Egypt lead to "global water losses" (Chapagain et al. 2005, p. 23).

The agricultural trade regime

Feelings of unfairness arise due to the fact that those countries, which are endowed with the most abundant water resources and thus are able to supply virtual water to the arid countries of the South (the Big Five), belong to the group of wealthy industrial countries, which are able to influence agricultural trade in many ways. On the one hand, high levels of protection in the form of tariffs and quotas, especially of the European Union, the USA and Japan, are criticised for being a major constraint for "the development of the virtual water market" (World Water Council 2004, p.14). The bigger part of criticism however relates to the magnitude of agricultural subsidies in OECD countries, which enable producers to place their export commodities on the world market at a price far below production costs. These goods sold at dumping prices are crowding out domestic agricultural production in some developing countries, which are unable to compete under these conditions, which will destroy livelihoods in these countries and endanger local food security (Yang et al. 2006, p. 452).

Interdependencies

Trade naturally leads to interdependencies between countries: importing countries rely on the supply of goods, while exporting countries rely on other countries to purchase their products. According to the critics of virtual water trade, interdependence means "opportunity for some, but dependence and vulnerability for others", as countries move away from self-sufficiency (Warner 2003, p. 132). At times, virtual water trade is seen as a unidirectional business, with poor developing countries on the demand side, and the Big Five countries on the supply side (Zehnder 2003, p. 14), which do not only dispose of the essential water, but also of the power to set the rules of trade. While, for instance, some agricultural policies of OECD countries are denounced as dumping practices, a fear of fluctuating or rising prices exists concurrently, which could compromise food security (World Water Council 2004, p. 14).

Furthermore, the fact that poor countries, especially in the Middle East North African (MENA) region should be dependent on the Big Five countries in such important and vital goods as food and water is seen as politically problematic, entailing the danger of blackmail: "Just like water conflict is not necessarily about water, food (virtual water) trade is not necessarily about trade, but about serving foreign and domestic policy goals" (Warner 2003, p. 131).

(2) Unequal consumption patterns and purchasing power

Consumption patterns

Water footprints differ among countries, which raises the "question of whether this is fair and sustainable" (Hoekstra 2006, p. 17): Countries like the USA or Canada consume 2483 (2049) m³/capita/year, while poorer countries like China or India show a per capita water footprint of only 702 (980) m³/capita/year (see table 3). The high per-capita (virtual) water consumption is, on the one hand, a result of the abundant water resources in most northern industrial countries; on the other hand, it reflects a great demand for water intensive products from overseas. Yet here, not the potential revenues for the exporters are seen[4], but only the exploitive and wasteful consumer habits of the global North, which are oftentimes recapped under the label of "(western) lifestyles" (Lotze-Campen&Welp 2007, p. 208).

Purchasing power

Through their wasteful consumer habits, the industrial countries divert more virtual water in their direction than would be a "fair share". Not only are the lifestyles of people in the industrialised world unsustainable, but their wealth allows the developed nations to put pressure on their own, domestic water resources as well as on the scarce water resources of the South ("teleconnections"), through the means of trade (Hoff 2009, p. 144). Assuming the existence of a worldwide "maximum sustainable water footprint" (consisting of annual precipitation which can be used productively, less minimum requirements for ecosystems), which is to be divided equally among earth's citizens, it can only be denounced as "unfair" that some people in the USA or western Europe consume more than their share (which would be an average per capita water footprint of 1240 m³/year).

Here already the dilemma (or rather: a trilemma) that a water rich country like for instance the USA might have to face becomes visible, as to what should such a country do with its abundant water resources? An above average consumption of water is clearly unfair with regard to other countries which may not dispose of the same amount of water: a per-capita consumption of 2483 m³/year is clearly more than the fair share to which every human being on earth is entitled. The same argument could be applied to a hoarding strategy, since this would also be tantamount to deny the rest of the world their fair share in the world's water resources. The only available option left would be to produce more crops than can be consumed locally and export these goods to water scarce countries, that is to say, exporting virtual water. But, as has been illustrated above, this would entail inacceptable states of dependence, rendering developing countries susceptible to price fluctuations political blackmail.

[4] In one study, it has even been suggested to drink plain water instead of coffee to reduce one's personal water footprint (Hoekstra 2009).

(3) Adverse local impacts

Transfer of environmental pollution

As was mentioned in chapter three, about 16% of global water use is not used for producing domestically consumed products, but for producing export goods, which means that “one-sixth of the water problems in the world can be traced back to production for export” (Hoekstra 2006, p.17). If a nation intensifies its agricultural production induced by export possibilities, and therefore bears the consequences of an increased use of water, pesticides and fertilizer, while the importing country can avoid any environmental damage, there seems to be a problematic imbalance. This idea is manifested, for instance, in the concept of “territorial transfer of sustainability” according to which a country or region achieves sustainable development at the expense of another country or region, by importing products which cause environmental damage in the place of origin (Adhikary&Chowdhury 2010, pp. 39). Moreover, through the disturbance of natural cycles of nutrients, environmental damage will affect both importing and exporting countries, leading to depletion of water and soil in some areas and eutrophication of water elsewhere, especially in the densely populated areas of the world. Thus, through the means of trade, water pollution becomes “a true global problem” (Hoekstra 2010, pp. 9). In summary, there seems to be a “disconnection” of consumption decisions and local consequences of production (Hoekstra 2006, p.18). One further problem with local implications which is evoked will be a so called “undersecuritisation”, the fact that policy makers in water scarce countries rather rely on the “reserve army of virtual water” than to switch to a more reasonable and sustainable water management strategy (Warner 2003, pp. 130).

Unemployment in agriculture

Local stress is also seen to occur in the importing countries, if domestic agricultural production were to be reduced in favour of food imports. One consequence would be the rise of unemployment in rural areas and a flow of migration towards urban centres, whereat not every country can dispose of a sufficiently diversified economy, which can absorb a large amount of unemployed farm workers in other economic sectors (Brüntrup 2005). Thus, an economic decline and worsening of land management in rural areas is seen to be the consequence.

Here again, a dilemma is present: if a country shows net exports of virtual water, it runs the risk of being taken advantage of by the importing countries, which transfer the environmental damages of agricultural production to the exporter. But importing virtual water in turn means neglecting or even destroying the rural economy and livelihoods. The only solution might be not to engage in any trade at all and switch back to subsistence economy.[5] But even this option may not serve justice, as can be seen from the trilemma mentioned above: by chance, a country might attain an above average water consumption level solely by the means of its own water endowments, which makes it ever more difficult to find a course of action which is not entirely contemptible from a moral standpoint. What has to be found is a means of sharing water among countries without recourse to the direful rules of trade.

After the normative implications of the virtual water concept have been illustrated, table 1, which has introduced the various guises of virtual water is reintroduced here in a modified form, to summarise the problems or normative implications, to which an indicator like a high virtual water content or a negative virtual water trade balance might point. The right column assigns these measures and their implications to one or several of the three normative categories mentioned above. The question remains, whether the respective indicator points to an actual water problem, or if the problem considered is rather political, related to the existing trade regime or "exploitive" consumption patterns in industrial countries, that is, poverty and income gaps.

[5] A similar suggestion has been made by the inventors of ecological footprints, that is, trade is only allowed up to the point where the sum of hypothetical land use (domestically and in the exporting country) equals the available productive land in a country, so no more can be consumed than could have been produced in isolation (Van den Bergh&Verbrüggen 1999, p. 67).

Table 4: Measures of Virtual Water and their Implications.

	Indicators of Virtual Water	*Corresponding Set of Problems*	*Dimension of the Problem*		
			Trade Regime	*Consumption Patterns*	*Adverse local impacts*
Virtual Water Specific Consump-tion	**Virtual Water Content of a Com-modity**	A high Virtual Water content means a low water productivity and there-fore high water consumption of the respective product. Processed prod-ucts like livestock are more water intensive than primary products, which is why the high meat consumption in industrialised countries is criticised.		■	■
	Water Footprint of a Product	A high water footprint of a product is meant to show consumers their negative impact on (external) water resources, which addresses especially the unsustainable lifestyles of the North *(www.waterfootprint.org)*.		■	■
	Water Footprint of a Person	Can be an indicator of the "wasteful" behaviour of people in the industri-alised world *(www.waterfootprint.org).* May lie below or above the average "fair share" that a person is entitled to.		■	
	Water Footprint of a Company	Indicator for the awareness of a company of its water use throughout all of its operations and supply chains *(www.waterfootprint.org).*		■	■
	Water Footprint of a Country	An indicator for the extent to which a nation is depleting its own water resources, as well as water resources in other parts of the world *(Hoek-stra/Chapagain 2007)*. May differ from a nation's "reasonable share" (population times average personal water footprint).		■	
	Global Virtual Water Budget	An indicator of an overall high consumption of water in agriculture *(Ren-ault 2003).* May not coincide with the "maximum human global water footprint"		■	■
Virtual Water Trade Flows	**Magnitude of Virtual Water Trade**	Shows the importance of Virtual Water trade and as a result the rising interdependencies between countries *(Zimmer/Renault 2003).* Interde-pendencies are usually thought to be at the detriment of the poorest countries which are vulnerable to rising prices or political blackmail. Also an indicator for the extent to which environmental problems are "trans-ferred".	■		■
	Water Savings through Virtual Water Trade	Shows the global water savings of Virtual Water trade that may or may not occur *(de Fraiture et al.* 2004*)*: if no water savings are visible, no benefits are attributed to the trading activity.			■
	Virtual Water Trade Balance	Some countries are blamed for having high Virtual Water trade deficits. Water scarce countries may have a trade surplus while water rich coun-tries may have a trade deficit *(Chapagain/Hoekstra 2008).* Large trade surpluses in industrial countries are seen to be problematic because of the resulting dependencies of importing countries, while trade surpluses in developing countries point to an "exploitation" by the industrialised North. Furthermore, adverse local impacts may result from virtual water net imports (unemployment), as well as net exports (environmental degradation, "water losses").	■	■	■
	Virtual Water Import Dependency	Import dependency is often seen as problematic from the viewpoint of poor arid countries, which rely heavily on food imports. In addition, water dependency and water scarcity are usually not correlated *(Hoekstra/Hung 2003).*	■		
	Top Exporters and Top Importers	It is seen as problematic, that Virtual Water exports are dominated by industrialised countries *(Zehnder 2003).*	■		
	Interregional Trade Flows	Dry regions may be net exporters or on the other hand be too dependent on Virtual Water imports from another region *(World Water Council 2004).* On the other hand, some (northern) regions "divert" too much virtual water in their direction.	■	■	
	External water footprint of a Country	A country can be blamed for certain environmental problems in the exporting nation *(Chapagain/Orr 2008).* Industrial countries are generally seen to have a too high external water footprint.			■

To conclude the descriptions of the virtual water concept and its normative implications, it can be observed, that here already some contradictions and inconsistencies become visible. Firstly, from the above one might have to conclude that virtually every possible trade constellation would have to be condemned from a "moral" standpoint, because it entailed unacceptable disavowals from the viewpoint of poor countries. But not only trade, but also a country's own consumption of virtual water can be contemptible if it is related to an above average consumption level, leading to the dilemmas and trilemmas mentioned above. The question arises furthermore, how the conceptions of global water use efficiency mentioned in section 2, and the conceptions of justice introduced in this section will relate.

3.2 The solution: "global water governance"?

Since virtual water trade will in every conceivable trade constellation lead to problematic scenarios, the definite need for a global governance scheme has been seen, in order to realign virtual water flows with notions of fairness and efficiency. According to a relatively new school of thought water has been regarded as a "major global public good", calling for a strengthening of the global aspect of water governance. On the one hand, ecological phenomena like climate change or cause effect relationships between for instance deforestration in one region and changed precipitation patterns in other places are named, on the other hand, global socio-economic developments which influence local water use like trade patterns or urbanisation raise the need to address problems of water depletion and pollution in the framework of global water governance (Pahl-Wostl et al. 2008, pp. 421). In the following, policy suggestions which have been evoked in the framework of virtual water trade and water footprint analysis will be introduced. Up to now, it is impossible for countries to raise trade barriers against certain products from certain places of origin and favour other, otherwise identical, products based on production circumstances (here, water use), since this would conflict with WTO's non-discrimination principles. A Virtual Water Trading Council within the WTO, concerned with the redistribution of virtual water on ethical grounds as has been proposed by McKay (McKay 2003), has not been implemented so far either, nor a scheme of virtual water trading units analogously to emissions permits under the Kyoto protocol (Mori 2003, p. 123). Thus, various institutional arrangements are suggested to manage water as a global resource, to coordinate the "global water market" in a fair manner. In this perception, the subsidiarity principle suggesting that water problems should be managed at the local or river basin level, that is, at the lowest level possible, has to give way if interdependencies (e.g. through agricultural trade) are present on a global scale. Due to the increasing import dependency of water scarce countries on virtual water imports, water is seen to become a "global geopolitical resource", enabling exporting countries to impose their own political objectives on the importer (Hoekstra 2006, pp. 19). Finally, the lacking correspondence of water scarcity or productivity and virtual water trade flows may have to be addressed in the framework of global water governance, to increase the scope for “water savings” on a global scale (Hoekstra 2006, p. 16).

According to the global water governance approach, local measures to include opportunity costs and environmental costs in agricultural water prices will not be successful, because producers will run the risk of creating a competitive disadvantage for themselves, since their products will become more expensive in comparison to producers who do not include these costs in their product prices, leading to a sort of race-to-the-bottom in water prices.

The Water Pricing Protocol

The Water Pricing Protocol is supposed to address only large scale irrigation schemes producing for export to address distortions in trade patterns. The general principle of the Water Pricing Protocol is to be marginal cost pricing, whereat every country should apply the same pricing methodology according to a “water pricing toolbox” set up by the Global Water Partnership. If the producers affected by the protocol should also serve the domestic market, a subsidy scheme has to be set up to ensure affordable food prices for the local population (Hoekstra 2006, pp. 23).

Tradable water footprint Permits

Another problem which is to be addressed on a global scale is the question of fairness and redistribution in the field of water consumption. The average per capita water footprint lies at 1240 m^3/year, whereat, as has been mentioned above, some countries lie below, and some countries lie above the average: “Redistribution of welfare among individuals is normally done within the borders of the nation state, but since the distribution of water and water-intensive products is very uneven across the globe, the redistributive question becomes a global one as well.”[6] (Hoekstra 2006, p. 18). To address fairness issues on a global scale, a system of water footprint permits is suggested, which will be tradable “to promote not only an equitable, but also an efficient allocation of water footprint permits”. This scheme is thought to reflect the idea that every human being is entitled to a “reasonable share” in the (yet to be specified) maximum human water footprint, similar to the emissions targets agreed upon under the Kyoto protocol. Taking the maximum human water footprint as a cap, tradable water footprint permits will be allocated “not according to natural water endowments, but ac-

[6] Here, the idea of a World Water Contract addressing the “world human community” as a legal entity (Petrella 2001) is referred to. Here, too, the responsibility to support the water scarce countries of the world is emphasized, however, not by the means of free trade but “by sharing, on a basis of solidarity, water available in other regions near or far” (p. 94).

cording to the philosophy of fair shares" (Hoekstra 2011, p. 37), that is, the fraction of a nation's population multiplied by the global sustainable water footprint. In this view, people being disadvantaged by living under unfavourable climatic conditions should be accounted for by receiving compensation in form of a higher tolerable water footprint (Verkerk et al. 2008, p. 33). Making water footprint tradable in the following may thus even generate income for the poor, even though tradability is not seen as an absolute necessity. water footprint analysis will naturally serve as a monitoring instrument to observe states' compliance.

Virtual Water Taxes

To "match national water footprints to their water footprint permits", countries are advised, among others, to reduce or change domestic consumption patterns by raising a tax on water intensive goods. The idea of a virtual water tax has furthermore been extended to include border tax adjustments for water intensive goods, to make importing nations take external water scarcities into account (Hoff 2009, p. 144). Moreover, a 'pollution tax' or 'disposal tax' has been suggested by Hoekstra (2011) to account for pollution which occurs in the waste stage of a product and which is to be paid by the consumer (as trade in food products may lead to soil depletion in one region, and eutrophication in another part of the world). The intent is to "close the nutrient cycle" by changing consumers' behaviour; alternatively, we might have to "bring back" the nutrients that we have imported in the form of food or feed to the place of origin in the form of food, feed or fertiliser shipments.

Finally, the idea of a label on water intensive products has been raised repeatedly to enable consumers to choose between water intensive and non-water intensive products whereat here, too, an international agreement is recommended to facilitate restrictions on trade (Segal/MacMillan 2009, Hoekstra 2010).

4. Trading Virtual Water in a Perfect World

In contrast to the contradictory normative critique of virtual water trade there are real and potential advantages of trading virtual water according to international trade theory. The possible limitations to theory will be discussed in the next section, while for now, a perfect world will be assumed. Perfect means here, that all prices of input factors in production reflect their true scarcity and external costs of production (including perfect water prices), and that furthermore, all these costs are perfectly reflected in commodity prices (perfect commodity markets), so that neither consumption nor production decisions will be distorted. Furthermore, perfect governance will be assumed, meaning that local decisions about water use will be made democratically and sustainably, precluding unreasonable and wasteful water uses.

Absolute and comparative advantage

According to traditional trade theory, all nations can gain from trade by specialising in the production and export of the commodity which they can produce best. Adam Smith was the first to introduce the idea of mutually beneficial trade in his theory of absolute advantage. If one nation could produce a good more productively than a second nation, e.g. because it needed less labour input per unit of the product, and if the second nation produced another good more productively than the first nation, both countries could gain from trade by exchange of these goods. According to the theory of comparative advantage, which was established by David Ricardo, mutually beneficial trade is possible, even if one country is more productive in all lines of production. The principle of comparative advantage does not consider the absolute amounts of inputs that are required for production, but the opportunity cost of production. To produce one good, a nation has to draw resources from the production of other goods: the cost of a commodity is therefore the amount of a second commodity that must be given up to release just enough resources to produce one additional unit of the first commodity. The nation, which has the smaller opportunity costs in producing a good is said to have a comparative advantage. These differences in opportunity costs and comparative advantage create the gains from trade: if every nation specialises in the production of those goods, for which it has a comparative advantage, total production rises, and every country can achieve a higher consumption level than its own production possibilities would permit in isolation.

Resource endowments as a source of comparative advantage

The Heckscher-Ohlin-Theorem explains comparative advantage with the help of a country's factor endowments. Trade is initiated by differences in commodity prices. If a good can be produced more cheaply in one country than in another, specialisation and trade will proceed, given that tariffs and transportation costs do not exist, until relative prices are equal in both nations. Commodity prices are determined by their production costs, and these in turn are determined by factor prices, which is why factor abundance plays a crucial role in explaining a nation's comparative advantage. Factor prices are determined by demand for final products and by their relative abundance. Factor abundance can be measured in terms of absolute amounts or in terms of relative prices: the more abundant an input factor is, the lower its relative price in a country. The Heckscher-Ohlin theorem states that a nation will export the commodity whose production requires the intensive use of the nation's relatively abundant and cheap factor and import the commodity whose production requires the intensive use of the nation's relatively scarce and expensive factor (Salvatore 2007).

The Heckscher-Ohlin Theorem and virtual water

If this concept is applied to virtual water, gains from trade can be achieved, if a water rich country produces water intensive products, for which it has a comparative advantage and therefore lower opportunity costs of production, while a water scarce country can import those goods, for which it has a comparative disadvantage. For this reason, virtual water has been described as a „descendant“ of the concept of comparative advantages in international trade theory (Wichelns 2004, pp. 51).
Arid countries, for instance, have a comparative disadvantage in producing water-intensive agricultural products because water is scarce here and opportunity costs are high. If water is scarce, the opportunity cost consists of its value in the next best alternative use. Especially in the case of blue water which is used in irrigated agriculture, many alternative uses can be thought of, like domestic or industrial uses, which would yield a much higher economic value. In contrast, if the exporting country is water-rich and produces its commodities under rain-fed agriculture, the opportunity costs here are close to zero. These countries can gain from trade by making use of their comparative advantage, while the export of agricultural goods may enable them to import other goods which are of higher value to them. Thus, it can be concluded that, from the viewpoint of neoclassical trade theory, voluntary (virtual water) trade unambiguously increases welfare for every country involved.[7]

It has been pointed out, that water is not the only input factor in agricultural production, which may be scarce and therefore determine comparative advantages and trade patterns (Wichelns 2004). Studies show, that water scarcity and imports of virtual water are not clearly correlated, and that there exists a multitude of other factors, which determine agricultural trade flows (de Fraiture et al. 2004, Kumar/Singh 2005). Factors such as labour, land, capital and different technologies of production are important determinants of comparative advantages and, consequently, for import and export decisions in agriculture. Hence, agricultural trade flows do not always reflect water scarcity: A water rich country, which is densely populated and for this reason does not dispose of sufficient arable land, may import agricultural goods from a relatively water scarce but land rich country. A water scarce country may adopt more efficient irrigation technologies than a second country with more abundant water resources, which may give the first country a comparative advantage despite its

[7] Neoclassical models have, however, been criticised for taking a too static view, that is, neglecting that free trade based on comparative cost advantages between countries on different stages of development can reinforce the gap in existing economic structures. According to List, the young industrial sector in developing countries will not develop properly, if these countries specialise on the export of primary commodities or simple labour-intensive tasks, while technologically advanced goods are imported from industrial or middle income countries. Similarly, the Prebisch-Singer-Hypothesis predicts that terms of trade for developing countries will worsen in the long run, if these countries rely mostly on the export of primary commodities. Also the existence of economies of scale as a source of trade (according to Krugman) is not accounted for in the neoclassical models.

water resource endowments. In reality, many possible constellations can be thought of and do exist, while the non existence of a correlation between water scarcity and virtual water flows has been described as a sort of Leontief Paradox (Verma 2009, p. 267). The fact that trade flows are not solely determined by water scarcity is not a problem in itself, however, if the scarcity value, and therefore opportunity costs, of every input factor is equally taken into account, which means that water scarcity and external costs have to be reflected in agricultural water prices. If prices reveal all relevant information, the import and export decisions of countries will be rational. The water scarce but land rich country will export water intensive commodities only as long as the scarcity value of domestic water as an input factor in agriculture is lower than the scarcity value of water in the importing country. If it was higher, the country would prefer to put its water resources to alternative, domestic uses, which yield a higher economic value. Thus, if a country decides to export water-intensive commodities, this means that domestic water uses for the water which is consumed for export products are assigned a lower economic value than possible import goods, which can be produced more cheaply in another country.

In light of these reservations, it has to be stated that the virtual water perspective is not consistent with the theory of comparative advantages. Similarly Wichlens (2010, p. 2206) observes that the concept rather resembles the concept of absolute advantages). The true problem is, however, that while virtual water trade and the theory of comparative advantages are consistent, the importance of other input factors to production, as well as the difference between relative abundance (as in the Heckscher-Ohlin model) and absolute abundance (as in water footprint accounts) are oftentimes not taken into account (Ansenk 2010).

In summary, the above considerations show that optimal virtual water trade flows cannot be determined in advance without knowing every aspect of the economies involved in trade. This means that firstly, an equal distribution of virtual water consumption cannot reasonably be promoted, as claims for “virtual water for all” may imply, and secondly, that also a realignment of virtual water flows according to notions of “global water use efficiency” runs counter to economic efficiency conceptions. Consumers’ preferences as well as producers’ considerations according to opportunity costs should not be ignored. Many developing countries have a comparative advantage in agricultural production, due to, for instance, a large supply of labour and land, which is why agriculture is still an important source of income for these states. To constrain agricultural exports from developing countries to industrial countries even more, would not be in the best interest of developing countries whatsoever. Finally, an unfair imbalance, in which the exporting country bears all environmental costs of agricultural production cannot occur in a perfect world, where water scarcity and environmental costs are reflected in water prices, and therefore in commodity prices for the importing country.

Thus, in a perfect world, barriers to trade are superfluous and will entail nothing but welfare losses.

5. Do we really need a water footprint?

What is the problem according to water footprint analysis?

After having summarised the potential benefits of trade, also with regard to the management of water scarcity, the question should now be approached, which of the normative implications, as well as the various water footprint accounts, point to an actual water problem in the exporting or importing country. The main question is what exactly is problematic about virtual water trade, and which of these figures pose a problem in themselves, such as a high external water footprint, a high trade deficit, or virtual water flows in the “wrong” direction? Table four is referred to here, which depicts the “moral” implications of the various virtual water indicators. One further, more fundamental problem, which is not addressed in table four, concerns the initial natural distribution of water resources, which endows some countries with a comparative advantage in the production of water intensive goods, and other countries with a comparative disadvantage (if other input factors are left aside). The fact that the former make use of their comparative advantage by exporting water intensive commodities, for which other countries have to pay a *price*, seems to be perceived as inherently unfair, a different regime of “sharing” is claimed. Yet if other conceivable resources like oil, copper or natural gas are considered, even though these may not be as vital as water, it becomes clear that not only trade in these resources makes *importers* as well as *exporters* better off, but also that a declaration of these resources as “global” or “common” goods is not very promising.

What information does the water footprint contain?

What are the conclusions that should be drawn from virtual water indicators? Firstly, what is the water footprint of a product supposed to tell us? Should we forbear from consuming products which contain, maybe, more than 100 litres of water per piece? Or should we only abstain from products from certain “hot spot” sites? According to Hoekstra et al. (2009, p. 68) we should not only save water where it is scarce, but not the least constrain water use in humid regions to “free up” water resources for the arid parts of the world (as for instance the production of luxury foodstuffs like coffee, however sustainably produced, crowds out the production of more vital crops). Against this background, the scheduling of mere product lists and water volumes becomes an end in itself. Yet the water footprint cannot reflect the opportunity costs of production, which are the main determinant of (local) production decisions, as has already been mentioned by Frontier Economics (2008, pp. 11). The same authors note, that water footprints based on average product water requirements are of little value, since water use may vary not only from country to country, but even from farm to farm, depending on the source of water, the importance of water in production or local environmental conditions. However, even if water footprint analysis would be infinitely refined in the future, still no information is given about whether the very activity under consideration is the best, most valuable, alternative use that a country chooses to put its water resources to. In this way, even the use of scarce blue water can be economically reasonable.[8] No moral problem can be seen in a country choosing to employ its domestic water resources in the production of agricultural export goods, which it then exchanges against high tech products on the world market

Next, which information do we gain by comparing nations' or peoples' individual water footprints? Generally, comparisons of countries' overall water footprints are quite meaningless since countries may have differing population sizes and climatic conditions, that is, water availability. What about *external* water footprints (a country's virtual water imports less re-exports)? Since these figures do not show from where these virtual water imports have come, whether they have caused environmental damages, or whether the country considered is even a net importer, they are also completely nondescript. The USA for instance may have a high external water footprint in terms of gross imports, but still are one of the biggest net exporters. Moreover, small, densely populated countries like the Netherlands, which are oftentimes condemned for their high external water footprints, naturally show a high dependence on food imports, and a high degree of integration into the world economy. So far, this has not posed a problem for the producers, provided that one allows exporting countries to decide autonomously whether to employ their water resources in export production or for domestic purposes.

Do differences in per capita water footprints pose a problem? Similar to the water footprint of a nation, these depend on climatic conditions, water availability, preferences and also incomes, which is why the water footprint of a person has also been perceived as a sort of poverty indicator. The question remains, however, why problems of poverty and inequality should be addressed by equalising per capita water consumption around the globe?

This leads to virtual water trade flows, and the directions they should, or should not take. Since trade is widely ramified among countries, it is difficult to give a complete picture of virtual water trade relations, not to mention of local opportunity costs in production. Even if all virtual water trade flows

[8] Likewise Wichelns (2010) observes that "using scarce water to produce high-valued products is wise and efficient in many settings" (p. 646).

could be made visible, broken down into a spectrum of colours, the question remains as to whether these flows pose a problem in themselves or not, which, for the reasons mentioned above, cannot be answered by water footprint analysis. The fact, for instance, that Europe is importing large amounts of virtual water from Africa and Latin America through trade in coffee is not a problem in itself if coffee is cultivated in a sustainable way under rain-fed agriculture. The existence of a water problem can therefore only be detected by considering local water conditions and local water management.

Decisions about the desirability of virtual water flows are further complicated by the highly contradictory nature of the normative arguments. As has been described above, virtually every trade constellation seems to be unacceptable in fairness terms, except possibly a moderate virtual water equalisation transfer from the most water abundant to the most water scarce regions of the world. If however, as has been unveiled in section 3, import, export and even a nation's own consumption of virtual water are condemned, the very concept meets the limits of human reason.

It has to be asserted, in summary, that direction and magnitude of virtual water trade flows can be labelled neither good nor bad without information about local conditions and opportunity costs of production, which means that information about virtual water trade flows contain no useful information as to their desirability.

Finally, the accounts of global or countries' water "savings" or "losses" which arise in the course of virtual water trade are equally "flawed and misleading" (Wichelns 2010b, p. 649), since they take no account of local opportunity costs of water use, production conditions and livelihoods, thus, even a trade flow from a less to a more water productive country entailing "water losses" in an absolute sense cannot be rated good or bad, meaning that trade decisions based solely on the water footprint (import only if the water footprint in the exporting country would be smaller than in the importing country (Velázquez 2011, pp. 756)) are meaningless.

What is to be done?

Since the water footprint itself has hardly any significance, what can be said about policy suggestions based on this indicator? If a cup of coffee contains 140 l of water, should no more coffee be consumed, or should trade in general or trade between certain regions be restricted? Should the industrial countries e. g. pay a tax on virtual water?

If the instrument of a virtual water border tax is considered, as has been indicated by Hoff (2009, p. 144), some speculation is necessary concerning the design of such an instrument. Should certain countries raise tariffs on products which have been, in their opinion, produced unsustainably? If countries will not do so voluntarily, which countries should be forced, by whom, to pay the virtual water border tax? Certainly a distinction should be drawn between people indulging in wasteful western lifestyles and people in poor arid countries, which rely on virtual water imports for basic food supplies. This leads to the question, to which sources of virtual water the tax should apply, that is, if a distinction should be drawn between for instance, green or blue water sources or the country of origin, since not all water uses, everywhere, cause severe environmental damages. As has been mentioned above, the use of scarce blue water can be economically justified in one instance, and completely wasteful and unsustainable in another instance. Since drawing distinctions between an endless number of production sites and conditions would furthermore entail enormous costs, the only imaginable general virtual water tax would be an overall barrier to trade in water containing products. Yet taxes on water intensive goods present only a second best solution in addressing problems of local water depletion for the reason that such a tax would raise the price of all water containing products to the same extent, with no regard to local conditions of production, which leads to price distortions and inefficiencies, that is, welfare losses. Even if the objective of reducing demand for water intensive products can be attained, this policy is still a very imprecise way to address local water problems, since the reaction of the exporting country cannot be predicted in advance.

As has been mentioned frequently in other contexts, barriers to trade are inappropriate environmental policies since the distortion which represents the root of the problem is not addressed (see e.g. Robalino and Herrera (2010) in the context of deforestration). Furthermore, the new trade distortions may lead to further misallocations and environmental harm if, for instance, an isolated country overexploits its water resources to serve the domestic market, or for a lack of export possibilities employs its water resources in lower valued activities, which might not be any more sustainable. According to Schulz (1996) for instance, an import ban may have the short term effect of reducing demand for a resource or a good produced from a resource, which lowers producer prices and profitability, leading to a protection of the resource (p. 17f). In other circumstances, exactly the opposite may be true, that is, in response to a greater trade liberalisation the price of a good may rise, making a resource more valuable and worth preserving for the future, while trade restrictions would have the opposite effect (p. 20ff). In addition, if it is assumed that demand for environmental quality rises with income, a trade restricting policy which makes the targeted country worse off in terms of income may also increase short sightedness and lower the demand for environmental protection (p. 24 f.).

The most effective and efficient way to deal with local water problems would therefore be, according to the specificity rule, to address the root of the problem, that is agricultural water prices which do not reflect environmental and resource costs, corrupt and undemocratic local structures, and the current terms of the global agricultural trade regime. In the words of LeVernoy (2011), we should not "kill the messenger" by attempting to solve local water problems through the indirect channels of trade barriers.

Finally, the attempt to impose environmental standards or any other "desirable" production decisions on other countries through the means of trade barriers is highly pretentious – countries should be relied upon to make their own import and export decisions, provided that efficient and sustainable local water management practices, as well as representative political structures are in place. If we assume that the production and trade strategy of Uganda should be decided upon by Western scientists and not by local decisionmakers, the danger of eco-imperialism (Siebert 1996) arises.

The pollution which occurs in the consumption stage of a product (e.g. soaps containing toxic substances which will then be contained in household effluents) should still be regarded as a local problem. Every country or region should be able to set the water quality standards that it deems appropriate, and choose the instruments to attain its targets, which of course also includes the option of not importing products which violate national environmental and health standards.

There will always be densely populated regions which are net importers of food, while some regions engage in agricultural production, so a "closed nutrient cycle" will be difficult to achieve, as well as shipments of food and feed which balance off the "transfer" of nutrients. Again here the only resort would be a subsistence economy.

The main idea of the Tradable water footprints is that initially, every country receives permits according to their "fair resource share", which are then reallocated by trade (whereby even a scheme without trading has been suggested). Firstly the question arises as to how such a scheme could be implemented. A world government, which could force countries to hand in sovereignty and accept their national cap, possibly requiring them to purchase permits to even make use of domestic water resources, or deliver requisitions of virtual water does not exist. Who would for instance control that countries enlarge their tolerable water footprint by allowable means (e.g. desalination, "countries should benefit from their own efforts") instead of non-allowable means (e.g. pumping fossil groundwater)? In terms of efficiency gains, it has to be wondered how such a scheme, which distributes water footprint permits on a national scale, according to conceptions of justice, could ever improve local water use efficiency, even if countries complied to their cap. The reason is that the overall scale of global water use is irrelevant, as long as water is used inefficiently at the local scale, that is, if water prices do not reflect the scarcity of the resource and external costs. If both a system of efficient water prices and the permit scheme existed in parallel as has been suggested, there would certainly be some confusion and double counting: if a person pays the right shadow price for water, there is no need for any additional compensation for an above average consumption level. In a perfect world, price distortions and welfare losses would be the result, as from a certain point on, a country would have to purchase additional permits to be able to import water containing commodities. Again here a paternalistic element is present, as consumer preferences are perfectly ignored: even though an equal utilisation of water resources is not recommended, the imposition of an equal consumption level is just as counterproductive.

In any event, it is not clear where the gains in terms of fairness of such a scheme should lie in comparison to free trade, since here still purchasing power determines how many water footprint permits a nation could obtain. The wealthy nations could simply buy up as many permits as they choose from the poor, as the problem of unequal purchasing power remains.

In addition, here again a sort of moral dilemma is looming: for the realignment of virtual water trade flows which might result from the tradable water footprint scheme could be opposed to the concept of "global water use efficiency". The philosophical question is: Should virtual water flow down the "hill" of ecological scarcity, or should it be directed mainly by considerations of equity and justice?

Carbon and water footprint

The above mentioned scheme has been compared to a cap and trade approach to reduce or stabilise carbon emissions under the Kyoto protocol, while the water footprint concept is seen to be in line with other ecological footprint concepts like the carbon footprint. "The carbon footprint is a measure of the exclusive total amount of carbon dioxide emissions that is directly and indirectly caused by an activity or is accumulated over the life stages of a product", whereat activities of individuals, governments, organisations or industries can be considered (Wiedmann/Minx 2007). The carbon footprint can be measured in simple mass units (kg, tons), if only carbon dioxide as a greenhouse gas is considered, other approaches (as the European Commission) include all six greenhouse gases (GHG) of the Kyoto protocol and measure the carbon footprint as the Global Warming Potential of all relevant gases. Furthermore, area-based measures (the area of e.g. forest needed to absorb the resulting carbon emissions) exist in the framework of ecological footprint accounting. GHG are a global problem, since the emission of carbon dioxide or other GHG contributes to global warming in the same way, regardless of where the emission takes place. Thus, the carbon footprint, however it is measured, always reveals information about an activity's impact on climate change, no matter which product is considered, or where it is produced. The carbon footprint does not, however, give information about the desirability or non-desirability of the specific activity under consideration. That is to say, where emissions should be reduced is not to be decided by the magnitude of the carbon footprint, but by other indicators like abatement costs in an emissions trading scheme or the value people place on a good or activity.

Water on the other hand is a local resource with varying local impacts (opportunity costs) depending on where and when water is used. As has been mentioned above, the water footprint does not contain information about sustainability or non-sustainability of production conditions, and thus no information about the desirability or non-desirability of the good or trade flow considered. Thus, while a high carbon footprint indicates a high impact on climate change (even though no direct policy conclusions can be derived without information about abatement costs and benefits of an activity), a high water footprint does not even deliver the information whether environmental damages have actually occurred.

Similarly, the concept of water neutrality (Hoekstra 2008) seems to be somewhat more difficult to implement than carbon neutrality, since water depletion and pollution are very site-specific problems, so a project achieving "water neutrality" would have to be realised exactly where the abstraction or pollution has taken place, which seems to be a complicated task in the case of consumer goods imported from various places.

6. Does an imperfect world justify regulation of virtual water flows?

Certainly, virtual water trade does not yield perfect results under real world conditions. In reality, several factors are present, which constrain the potential benefits of trade. The main features of a perfect world were the existence of perfect prices in production factors and commodities, perfect governance that is, decision making processes, and a perfect trade regime. It is evident that these conditions are virtually never fulfilled under real world conditions. Hence, the question arises whether or not the conditions of an imperfect world might justify regulations of virtual water flows.

Imperfect prices

The problem remains that water prices in agriculture are heavily subsidised and virtually never reflect water scarcity, nor greatly influence decisions about production sites. When water scarcity is not reflected in commodity prices, it is not relevant for importer's and final consumer's decisions either. As to the policies which distort water and commodity prices, one can distinguish between water related subsidies, and general agricultural supports. Water related subsidies in agriculture oftentimes take the form of publicly financed irrigation projects. In most cases, user charges do not even cover operation costs, and virtually nowhere environmental and resource costs are taken into account. Tax exemptions, e.g. in the case of extraction or pollution charges, are another possible way of subsidising agricultural water use, as well as subsidised electricity, fertilizer and pesticide prices. Industrial countries support their agricultural sector in many more ways, of which output based subsidies, notably market price support, are criticised most for distorting farmers' production decisions. Payments based on other criteria like the area under cultivation or farmer income are implemented in many countries and may or may not be linked to production, and therefore influence farmers' decisions to varying degrees. General subsidies to the agricultural sector like infrastructure investment or investment in research and development are considered least trade distorting (OECD 2010). All of these polices, however, distort competition between farmers in industrial countries and the rest of the world, since agricultural commodities can be sold on world markets at a price far below production costs. In summary, prices oftentimes do not reflect true water scarcity, which is why it is not considered in import and export decisions. As a result, trade can give adverse incentives and lead to an overuse of local water resources, if the right local environmental policies are not in place. Induced by the increased demand from the world market, countries may overexploit their water resources, expand agricultural crop land or change their cropping patterns to more water consuming plants, which promise higher revenues.

Imperfect governance

UNDP identifies three main preconditions for good resource governance, which is sustainable and benefits society as a whole and not just a selected few: resource tenure and property rights, decentralisation of resource management and information and participation (UNDP 2005), which of course will not always be met in reality. Rogers and Hall (2003) list the main cases of water governance failure that are inherent in most countries, of which the most relevant here are ill defined property rights, perverse subsidies to resource users, inappropriate tax incentives, short-sightedness, special interest effects including political weakness and vested interests and the simple non-payment of water services, whereby many failures lie outside the water domain and concern the general institutional structures of a country. Especially in irrigated agriculture, the aforementioned cases of governance failure are relevant: As Renger (2000) observes, irrigated agriculture is a perfect feeding ground for rent seeking activities, because huge government investments and payments are involved, oftentimes supported by external financial assistance. Farmers, which constitute an important political pressure group, are interested in a low cost supply of water, while government ministries are interested in retaining power and possibly in conducting new prestigious irrigation projects. In such an environment, a more efficient water use and the introduction of water prices runs counter to the interests of both sides.[9]

[9] An example of a case in which water use is not in line with the need of the local population is Lake Naivasha in Kenya, where flower farms produce cut flowers for export, mainly to the European Union. The consumption of water from Lake Naivasha for flower cultivation has led to unsustainable levels of water abstraction and pollution by the flower farms and by the increasing number of workers that the business has attracted. In this way, water tables have fallen below sustainable levels, while the discharge of pesticides and fungicides is near to turn the lake's waters toxic. While the flower business profits primarily international firms, who own most of

An imperfect trade regime

The various agricultural supports in developing countries and the corresponding “dumping practices” which suppress world market prices and worsen market opportunities for developing countries have already been mentioned. In addition, export subsidies are still present in the European Union, while export credit agencies, which promote and insure export and trade activities from their respective countries have come under scrutiny for their intransparent environmental and social standards (Udall 2000). It is also known, that agricultural products from developing countries still face high tariffs in the industrialised world: for instance, EU tariffs on agricultural products are on average over four times higher than charges on other goods, all tariffs greater than 100% relate to agriculture (www.reformthecap.eu/issues/policy-instruments/tariffs). These practices, of course, hurt poor farmers in developing countries.

It is generally assumed that, although every country has an equal vote, WTO negotiations are dominated by industrial countries, which will of course be all the more true in bilateral negotiations. Even preferential trade agreements which are thought to support agricultural production in developing countries can do more harm than good here, in that they can undermine the cohesion between developing countries in trade negotiations, lead to further distortions and hurt those countries which are not part of the agreement (Anderson 2004). In total, the current agricultural trade regime leaves a lot to be desired, which of course applies to all goods and all aspects of trade, not only to water management problems.

Can trade barriers help?

Since many conditions for an unambiguously welfare improving effect of trade are not met under real world conditions, it is oftentimes assumed that exactly the opposite will be the case and trade barriers are called for. However, even in an imperfect world, environmental benefits of trade barriers are far from certain. As has been mentioned above, free trade may as well have a positive influence on resource conservation if a greater demand for a good produced from the resource increases its value and incentives for preservation. Therefore, even in an imperfect world, where externalities and open access problems are present, this effect may even improve local management practices under certain conditions (Copeland&Taylor 2004). External regulations like a cap or a tax on the other hand, have no conceivable correcting effect on the price imperfections described above; on the contrary, they add new distortions and are therefore ineffective in solving this aspect of the problem.

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the lands around Lake Naivasha, poor residents and cattle herders are denied free access to the lake’s water (Food&Water Watch 2008).

Oftentimes, excessive resource depletion results from bad governance practices and undemocratic decision making processes. Damania (2000) observes that even in such instances, trade barriers can worsen the situation if decisions are made by a corrupt government, which lives off bribery and contributions from the resource extracting industries: the reduced profitability of the resource could then accelerate its exploitation. Again, it is not conceivable how local governance and decision making processes could be positively affected by global water governance schemes.

It is even less clear, how the suggested instruments could contribute to a fairer world trade regime. Since, as has been mentioned above, one of the main flaws of the current trade regime from the perspective of developing countries are the high tariff walls of regions like the European Union, it is not obvious how an additional trade barrier could solve this problem; it again adds to existing problems, instead of mitigating them. In conclusion, focusing on international trade in commodities as a problem in itself without addressing the actual "imperfections" will not solve the problems of water in agriculture, which means that a global water governance concept will not be effective in improving the admittedly serious environmental problems in many countries.

7. Conclusions

Although trading with virtual water can be welfare-improving from the viewpoint of trade theory, problems in all conceivable trade scenarios are seen here. In the real world economy, however, we have to face market failure in the form of price distortions, structures of bad governance and an agricultural trade regime which clearly favours industrial countries. Nevertheless the concept of virtual water does not tell us anything about the desirability of virtual water trade flows for the following reasons: Firstly, the volumetric figures of the water footprint are an aggregation of entirely inhomogeneous water uses, with completely distinct opportunity and environmental costs in the place of production. It furthermore contains no information about a product's valuation in the importing country; without information about costs and values, the benefit of a trade flow simply cannot be assessed, nor can "desirable" directions of trade flows be determined. Moreover, the ideology behind the concept is highly contradictory and obscure, as are its policy suggestions. Besides all imaginable trade constellations, even a nation's own consumption of water may be condemned, which leaves some doubt about the concept's consistency. Thus while showing a high degree of arbitrariness and inconsistency, the concept leads to policy suggestions which will not only result in major inefficiencies in global trade patterns, but unfortunately are also ineffective in achieving the targeted environmental aims.

The main drawbacks of virtual water and corresponding global water governance concepts can be summarised as follows:

Drawbacks of the virtual water concept

- *Vagueness*: The merely quantitative concept offers no specific information, as to whether virtual water trade actually leads to an unreasonable exploitation of water resources in the place of origin. An ever more refined water footprint analysis would not change this fact. Since no information about costs and benefits are given, the "right" direction of virtual water trade flows cannot be assessed.
- *Inconsistency*: Even if every trade relation and water use could be assessed economically in a sound way, the normative framework of water footprint analysis is highly contradictory and offers no clear "guideline" as to which trade relations could be justified from a moral standpoint.
  - In the end, all conceivable trade relations could to be condemned: the only possible conclusion would be to cease trade altogether which would be a global pauperisation programme.
  - If it is concluded that every country should employ only what it can find on its own ground, the problem arises that some countries are naturally endowed with abundant water resources, while others are not. This means that the former, while trading is barred, are concurrently not allowed to indulge in an above average water consumption (or likewise, water hoarding). Paradox situations can now be imagined.
  - It is not clear whether the aspired objective is a realignment of virtual water flows according to principles of equity and justice, or according to "ecological scarcity": the distributional outcomes according to a quota scheme may not coincide with "global water use efficiency" conceptions.
- *Paternalism*: The concept is highly presumptive and paternalistic in that it
  - promotes ideas of global equality without taking into account preferences and needs of one human being; the concept of fairness which is adopted here is questionable.
  - denies the ability and maturity of developing countries to make production and trade decisions in their own best interest. This presumption and the resulting policy suggestions might be considered a kind of "eco-imperialism".

Drawbacks of the global water governance scheme:

- *Inefficiency*: The policy suggestions based on the virtual water concept (global water governance) lead to inefficiencies as trade barriers and realignments of trade flows according to "global use efficiency" lead to distortions and welfare losses.
- *Ineffectiveness*: These policy suggestions are not effective in solving local environmental problems, since neither the distortion of water and product prices, nor local structures of "bad governance", nor the rules of the agricultural trade regime are touched upon. Even in terms of fairness and equity, water footprint permits and virtual water taxes would not perform very well.

As the concepts of water footprint analysis and global water governance raise public attention, one should be clear about which are the actual problems one wants to tackle, like an unfair trade regime, poverty and inequalities, or local environmental problems. Some but not all problems which are attributed to virtual water trade actually relate specifically to water. The preconditions for a mutually beneficial virtual water trade, namely sustainable local water management practices including "true" water prices, fair and democratic decision making processes about the utilisation of water resources, as well as a fair regime of world trade have to be dealt with in their respective specific "arena", and not mixed up in a global water governance scheme based on the water footprint. Thus, international environmental and trade policy should refrain from drawing upon virtual water calculations and their insinuated, but misleading policy implications.

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