UNDERSTANDING AGRICULTURAL VIRTUAL WATER FLOWS IN THE WORLD FROM AN ECONOMIC PERSPECTIVE, A LONG TERM STUDY

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Abstract: The globalization process of the last half century entailed a growing trade in agricultural and food products. As a result, water has been transferred among countries, embodied in these goods. This paper studies the evolution of virtual water flows over the long term, analyzing the main driving factors through Decomposition Analysis. It contributes to the existing literature by offering a dynamic and economic interpretation of the historical changes in virtual water trade flows. In particular, this study points to a gradual increase in virtual water exchange, related to the upsurge of agricultural and food products trade in the world from 1965 to 2010. Although the origins and destinations of virtual water have changed, North America stands out as the primary net exporter of virtual water. Europe and Asia, on the other hand, with a high dependency on foreign water resources, appear as net importers of virtual water. Despite improvements in agricultural yields and the reallocation of production, the virtual water trade continues to increase globally via these significant commercial exchanges.

Keywords: virtual water trade, water consumption, globalization and environment

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1. Introduction

Food production has experienced a marked increase during the last fifty years (Federico, 2005; Rask and Rask, 2011). Alongside this expansion, commercial exchanges of agricultural and food products have experienced significant growth in the past half century (Serrano and Pinilla, 2010, 2011a). This globalizing process has involved not only an important trade in commodities, but also very large exchanges of the natural resources embodied in these goods (Schmitz et al., 2012).

This is certainly the case for embodied water, which has been growing strongly in the products of international trade. A large number of studies have been carried out over the last decade (Clark et al., 2015; Duarte et al., 2014b; Hoekstra and Hung, 2005; Tamea et al., 2014) to examine the displacement of water resources resulting from the growing integration of global economies. In this framework, virtual water, first defined by Allan (1997), is the volume of water necessary for the production of a commodity. The water footprint is an indicator of freshwater use that looks at both direct and indirect water use of a consumer or producer (Hoekstra et al., 2011). The studies of virtual water and the water footprint distinguish between green and blue water; according to Hoekstra and Chapagain (2008), green water is the rainwater evaporated as a result of the production of a commodity, and blue water is surface or groundwater evaporated during a production process. Both are interrelated in the hydrological system, but blue water has higher opportunity costs, as it can be reallocated among the different users (Yang et al., 2007). Virtual water has been methodologically studied from the top-down and bottom-up approaches. The former adopts environmental input-output analysis to obtain virtual water and water footprints by accounting for regional, national and/or global supply chains (Cazcarro et al., 2013; Deng et al., 2015; Duarte et al., 2015b; Feng et al., 2012; Steen-Olsen et al., 2012; Yu et al., 2010). The latter obtains footprints on the basis of the virtual water content of internationally traded goods and services determined from detailed process data (Duarte et al., 2014a, c, 2015a; Hoekstra and Hung, 2005; Hoekstra and Mekonnen, 2012; Vanham et al., 2013). In this paper, we will use the bottom-up methodology that, according to Feng et al. (2011), "has become one of the most popular approaches in water footprinting studies due to its simplicity and relatively good data availability". It allows us to study global virtual water flows of agricultural and food products in a highly disaggregated way.

Whereas many of these studies focus on the short term, to our knowledge there are few papers empirically addressing global virtual water trade flows over the long run (Clark et al., 2015; Tamea et al., 2014). From our viewpoint, the long-term approach is essential to assess the relationship between economic growth and natural resources, addressing the historical trajectories and feedbacks. This seems particularly important in the period studied, when the second wave of globalization took place. This long-term process has entailed an outstanding economic and commercial integration that has resulted in growing exchanges of factors and products that embody large volumes of water. The analysis of the environmental implications of globalization processes in the long term, from an economic perspective, is in our view one of the main contributions and innovations of our study. The broad sample considered, including a large number of products and countries, is another of the strong points of the paper. The high level of disaggregation allows us to go deeper into the explanation of virtual water trade in the long run. It is important to highlight that we estimate virtual water trade flows for a long period, but we also explain and quantify the factors behind these trends using an economic approach.

Thus, this paper assesses the trends in virtual water transfers in the world from 1965 to 2010, a period of intense internationalization that led to important environmental impacts. To that end, we analyze global trends paying special attention to those areas that exert the largest pressures on those domestic water resources that are exported, studying the amount and direction of global virtual water flows. We obtain and quantify those factors, driving the path followed by virtual water imports and exports. By means of a Decomposition Analysis (DA), trends in water exchanges are explained on the basis of changes in the volume of trade, in the product-trade composition, in the origin of flows, and in the main commercial countries dealing with agricultural and food products. DA has been utilized in other studies that explain the determinants of changes in virtual water trade flows (Duarte et al., 2014a, c; Kondo, 2005).

The intended contribution of the paper is the analysis of the effects that economic integration, trade expansion, specialization patterns, etc. and the historical factors occurring in the world, have had on the environment, from a long-term perspective, and particularly on an indicator of water pressures. Hence, this study is concerned with the relationship between globalization and natural resources, through the case study of water. To our knowledge, hitherto, water resources have been primarily analyzed from a short-term perspective, while we contribute to the scarce existing literature on virtual water trade flows in the long run (Clark et al., 2015), offering an analysis of the pressures on global water resources from an economic perspective. Our work builds on the prior literature describing water embodied in production and trade (Hoekstra and Chapagain, 2008; Hoekstra and Hung, 2005; Zhan-Ming and Chen, 2013).

The following Section addresses the main methodological aspects and explains the data, Section 3 deals with the main findings of our work, Section 4 contains a discussion of the results, and Section 5 presents our main conclusions.

2. Materials and methods

2.1. Methodological aspects

As a first step, we estimate virtual water trade flows following the methodology proposed by Hoekstra and Hung (2005). For a country *c* in year *t* virtual water exports $VWX(c,t)$ can be obtained as:

$$VWX(c,t) = \sum_{p} d_p^c(c,p,t) x_p^c(c,p,t) \quad (1)$$

With x_p^c being the quantity of product *p* exported (Tonnes) and d_p^c a coefficient indicating the volume of water necessary to produce a tonne of each commodity in the exporting country, i.e., water footprint (m^3/Tonne). d_p^c will distinguish between green or blue water.

For a country *c*, virtual water imports are the sum of the water embodied in the imported goods coming from all countries *z*.

$$VWM(c,t) = \sum_{pz} d_p^Z(z,p,t) m_p^z(z,p,t) \quad (2)$$

With m_p^z being the bilateral import flow from country z to country c (Tonnes) and d_p^Z representing the water required in country z to produce p (m^3/Tonne). Calculating the difference between virtual water exports and virtual water imports, we get the virtual water trade balance for each country c, as in Hoekstra et al. (2011):

$$VWB(c,t) = VWX(c,t) - VWM(c,t) \quad (3)$$

Second, we apply a Decomposition Analysis (DA) to obtain the factors driving virtual water export and import changes in the world, following the approach applied by Duarte et al. (2014a, c) for the case study of Spain . Embodied water in exports can be explained on the basis of four elements, obtaining:

$$VWX(c,t) = \sum_p w_{cpt} \frac{x_{cpt}}{x_{ct}} \frac{x_{ct}}{x_t} x_t \quad (4)$$

The former expression, for country c can be obtained as follows:

$$VWX(c,t) = \mathbf{w}_{\mathbf{ct}}' \boldsymbol{X}_{\mathbf{ct}} s_{\mathrm{ct}} x_t \quad (5)$$

With $\mathbf{w}_{\mathbf{ct}}'$ being a row vector of the water footprint per $ of product in m^3/$ (US dollars) in country c, $\mathbf{X}_{ct}$ is a vector showing the share that each product represents in total exports of country c in period t (product composition of the trade flow). s_{ct} is a scalar with the percentage of the country in total exports (country shares) and x_t is the total value of exports in the world in year t in US dollars (scale). Note that to be able to aggregate trade flows in the DA it is necessary to express the water footprints in m^3/$ instead of m^3/tonne.

For the whole world economy:

$$VWX(t) = \mathbf{w}_{\mathbf{t}}' \boldsymbol{X}_{\mathbf{t}} \boldsymbol{s}_{\mathrm{t}} x_t \quad (6)$$

With $\mathbf{w}_{\mathbf{t}}'$ being a vector of water footprints per product and country, $\boldsymbol{X}_{\mathbf{t}}$ a matrix of the share of product exports per country, $\boldsymbol{s}_{\mathrm{t}}$ a vector showing the country shares in total world exports, and x_t the total volume of world exports.

Regarding imports, virtual water imports can be explained on the basis of five drivers: product water footprints, the origin of flows, product composition of the trade flow, country shares, and the scale of trade.

$$VWM(c,t) = \sum_{p,z} w_{cpzt} \frac{m_{cpzt}}{m_{cpt}} \frac{m_{cpt}}{m_{ct}} \frac{m_{ct}}{m_t} m_t \qquad (7)$$

or, in matrix form,

$$VWM(c,t) = \mathbf{w}'_{\mathbf{czt}} \mathbf{M}_{\mathbf{czt}} \mathbf{m}_{\mathbf{ct}} r_{ct} m_t \qquad (8)$$

with $\mathbf{w}'_{\mathbf{czt}}$ being a row vector of the embodied water per product in each of the countries z, from which country c imported, measured in m^3/$ (US dollars). $\mathbf{M}_{\mathbf{czt}}$is a matrix that includes, for each product p, the percentage bought by c from each country z. $\mathbf{m}_{\mathbf{ct}}$ is a vector of product import composition in country c (with information on the share of each product in imports), r_{ct} is a scalar showing the participation of country c in global imports, and m_t is a scalar with the total value of global imports in year *t* (in US dollars).

Similarly, for the global economy, the total volume of water imports can be expressed as follows:

$$VWM(t) = \mathbf{w}'_{\mathbf{t}} \mathbf{M}_{\mathbf{t}} \mathbf{P}_{\mathbf{t}} \mathbf{r}_t m_t \qquad (9)$$

With $\mathbf{w}'_{\mathbf{t}}$ being a vector of water footprints per product and country, $\mathbf{M}_{\mathbf{t}}$ a matrix of the share of imports (per country of origin and per product, with main diagonal blocks equal to zero), $\mathbf{P}_{\mathbf{t}}$ a matrix of product composition of imports (for each country), $\mathbf{r}_t$ a vector of import country shares in total world imports, and m_t the total volume of world imports.

Note that while $VWX(c,t)$ differ from $VWM(c,t)$ at the country level, $VWX(t) = VWM(t)$ holds for the global economy, so that aggregated water balance is zero from this perspective. The above equations can be handled at the country or at the global level. Similarly, it is possible to derive these expressions for each product considered in the sample, on the basis of the above developments.

Departing from equations (5) and (8), we utilize the DA. This approach separates a time trend of an aggregated variable into a group of driving forces that can act as accelerators or retardants (Dietzenbacher and Los, 1998; Hoekstra and van den Bergh, 2002; Lenzen et al., 2001). In our case, decomposition is based on five factors for imports and four factors for exports; thus, it is possible to obtain 5! and 4! exact decompositions respectively. As a "commitment solution", the average of two polar solutions is considered (Dietzenbacher and Los, 1998). Taking the average of the polar decompositions for exports we get:

$$\Delta VWX(c) = \frac{\Delta \mathbf{w}_{\mathbf{c}}'\widehat{\mathbf{X}}_{\mathbf{ct}}\widehat{\mathbf{X}}_{\mathbf{t}}x_t + \Delta \mathbf{w}_{\mathbf{c}}'\widehat{\mathbf{X}}_{\mathbf{ct-1}}\widehat{\mathbf{X}}_{\mathbf{t-1}}x_{t-1}}{2} + \frac{\mathbf{w}_{\mathbf{ct-1}}'\Delta\widehat{\mathbf{X}}_{\mathbf{c}}\widehat{\mathbf{X}}_{\mathbf{t}}x_t + \mathbf{w}_{\mathbf{ct}}'\Delta\widehat{\mathbf{X}}_{\mathbf{c}}\widehat{\mathbf{X}}_{\mathbf{t-1}}x_{t-1}}{2}$$
$$+ \frac{\mathbf{w}_{\mathbf{ct-1}}'\widehat{\mathbf{X}}_{\mathbf{ct-1}}\Delta\widehat{\mathbf{X}}x_t + \mathbf{w}_{\mathbf{ct}}'\widehat{\mathbf{X}}_{\mathbf{ct}}\Delta\widehat{\mathbf{X}}x_{t-1}}{2}$$
$$+ \frac{\mathbf{w}_{\mathbf{ct-1}}'\widehat{\mathbf{X}}_{\mathbf{ct-1}}\widehat{\mathbf{X}}_{\mathbf{t-1}}\Delta x + \mathbf{w}_{\mathbf{ct}}'\widehat{\mathbf{X}}_{\mathbf{ct}}\widehat{\mathbf{X}}_{\mathbf{t}}\Delta x}{2}$$
$$= \mathrm{IE}_x + \mathrm{CE}_x + \mathrm{TSE}_x + \mathrm{SE}_x \qquad (10)$$

Similarly for imports we obtain:

$$\Delta \mathrm{VWM(c)} = \frac{\Delta \mathbf{w}_{\mathbf{cz}}'\mathbf{M}_{\mathbf{czt-1}}\widehat{\mathbf{M}}_{\mathbf{ct-1}}\widehat{\mathbf{M}}_{\mathbf{t-1}}m_{t-1} + \Delta \mathbf{w}_{\mathbf{cz}}'\mathbf{M}_{\mathbf{czt}}\widehat{\mathbf{M}}_{\mathbf{ct}}\widehat{\mathbf{M}}_{\mathbf{t}}m_t}{2}$$
$$+ \frac{\mathbf{w}_{\mathbf{czt}}'\Delta\mathbf{M}_{\mathbf{cz}}\widehat{\mathbf{M}}_{\mathbf{ct-1}}\widehat{\mathbf{M}}_{\mathbf{t-1}}m_{t-1} + \mathbf{w}_{\mathbf{czt-1}}'\Delta\mathbf{M}_{\mathbf{cz}}\widehat{\mathbf{M}}_{\mathbf{ct}}\widehat{\mathbf{M}}_{\mathbf{t}}m_t}{2}$$
$$+ \frac{\mathbf{w}_{\mathbf{czt}}'\mathbf{M}_{\mathbf{czt}}\Delta\widehat{\mathbf{M}}_{\mathbf{c}}\widehat{\mathbf{M}}_{\mathbf{t-1}}m_{t-1} + \mathbf{w}_{\mathbf{czt-1}}'\mathbf{M}_{\mathbf{czt-1}}\Delta\widehat{\mathbf{M}}_{\mathbf{c}}\widehat{\mathbf{M}}_{\mathbf{t}}m_t}{2}$$
$$+ \frac{\mathbf{w}_{\mathbf{czt}}'\mathbf{M}_{\mathbf{czt}}\widehat{\mathbf{M}}_{\mathbf{ct}}\Delta\widehat{\mathbf{M}}m_{t-1} + \mathbf{w}_{\mathbf{czt-1}}'\mathbf{M}_{\mathbf{czt-1}}\widehat{\mathbf{M}}_{\mathbf{ct-1}}\Delta\widehat{\mathbf{M}}m_t}{2}$$
$$+ \frac{\mathbf{w}_{\mathbf{czt}}'\mathbf{M}_{\mathbf{czt}}\widehat{\mathbf{M}}_{\mathbf{ct}}\widehat{\mathbf{M}}_{\mathbf{t}}\Delta m + \mathbf{w}_{\mathbf{czt-1}}'\mathbf{M}_{\mathbf{czt-1}}\widehat{\mathbf{M}}_{\mathbf{ct-1}}\widehat{\mathbf{M}}_{\mathbf{t-1}}\Delta m}{2}$$
$$= \mathrm{IE}_m + \mathrm{LE}_m + \mathrm{CE}_m + \mathrm{TSE}_m + \mathrm{SE}_m \qquad (11)$$

Accordingly, we can explain the change in virtual water exports and imports on the basis of the scale effect (SE), which quantifies how much of the change in virtual water flows is explained by changes in the volume of exports or imports. The composition effect (CE) measures the impact of changes in the product composition of trade flows of countries in virtual water exports and imports. The trade share effect (TSE) quantifies the contribution that variations in the weight of countries in global trade have on virtual water trends. The localization effect (LE) indicates to what extent changes in the origin of products affect virtual water flows (it only exists for virtual water imports). Finally the intensity effect (IE), identifies the contribution of changes in product water footprints to changes in virtual water trade flows. Similar effects can be obtained at the global level on the basis of the equations above.

2.2. Data

Bilateral trade data on agricultural and food products are taken from United Nations Statistics Division (UN, 2013) at the four-digit level of the Standard International Trade Classification, SITC, Revision 1. We work with annual trade data from 1965 to 2010, i.e., we have 46 time steps. Our sample considers 133 products and 77 countries, accounting for approximately 85% of all agricultural and food commercial exchange in the world during those years. The full list of countries and products covered are shown in the supplementary information (SI).

Since DA requires trade data in monetary units, we calculate the global prices of each product in 1985 and express trade data at constant 1985 dollars. We use Population data from WorldBank (2014) for the years 1965, 1980 and 2000. Water availability and withdrawal data for 1965, 1980 and 2000 are taken from from FAO (2014).

The product water footprints come from Mekonnen and Hoekstra (2011, 2012), who estimate water footprints following the approach developed by Allen et al. (1998) and Hoekstra et al. (2011). As the virtual water trade flows are obtained from published data on trade and water, some uncertainties could arise. As Hoekstra et al. (2011) pointed out, these uncertainties should be taken into account. In recent years, several studies have examined some of the variables generating uncertainty in the water footprint assessment, such as evapotranspiration, rainfall, crop coefficients, maximum yield, etc. (Bocchiola et al., 2013; Guieysse et al., 2013; Zhuo et al., 2014). Note that there are alternative studies quantifying the water consumption in agriculture, such as Siebert and Döll (2010), Schmitz et al. (2013), among others. Nevertheless, we choose to use the data from Mekonnen and Hoekstra (2011, 2012), given the large sample of agricultural products and countries covered, which allows us to study the environmental impact of globalization processes from an economic perspective.

Chenoweth et al. (2014) indicate there is no consensus regarding the methodological approach to calculating water footprints when working with cross-sectional data, particularly when dealing with time series data. In this line, Haberl et al. (2001) point out the difficulties involved in estimating environmental footprints in the long term. For the particular case of water, whereas some studies assume product water footprints to be constant over time (Renault, 2002; Shi et al., 2014), there are pioneering approaches that calculate variable water coefficients for different crops (Rockström, 2003; Rockström et al., 2007). In an attempt to capture the changes in the variables influencing the water footprint of crops and animal products (m^3/tonne) between 1965 and 2010 (improvements in irrigation techniques, variations in the crop mix, or the growing use of fertilizers and pesticides), we calculate the long-term variable water footprints of products considering historical yield changes. To that end, we follow the approach proposed by Doorenbos and Kassam (1986) and recently applied by Dalin et al. (2012), Konar et al. (2013), Cazcarro et al. (2015):

$$w_{cpt} = w_{cp}\frac{Y_{cp}}{Y_{cpt}} \qquad (12)$$

With w_{cpt} being the water footprint (we distinguish the green and blue water footprint) for each product in the period of analysis, expressed in m^3/tonne, and $\mathrm{w_{cp}}$ is the crop or livestock water footprint (differentiating between green and blue water) given by Mekonnen and Hoekstra (2011, 2012) in m^3/tonne. Y_{cp} represents the average yield of the reference period (1996-2005) measured in tonnes/ha, and Y_{cpt} are the annual product yields for each specific year studied, also in tonnes/ha. Data on crop and livestock yields from 1965 to 2010 are taken from the Food and Agriculture Organisation of the United Nations (FAO, 2013), giving us the average yield of rainfed and irrigated agriculture.

Equation 12 shows a decreasing, convex with respect to the origin, and hyperbolic relationship between the product water footprint and its yield, indicating that the water footprint of each good falls as its crop yield rises, showing a non-linear relationship (see Duarte et al. (2015a) for a more detailed discussion). The hypothesis underlying this approach is that long-term developments influence crop and livestock yields, and also affect the water footprints of products. In our view, calculating time series for the water footprint of products is important in accounting for the trends in virtual water exchanges. Keeping water footprints constant would involve assuming that agricultural management remained invariable from 1965 to 2010, which would ignore the developments introduced after the Green Revolution.

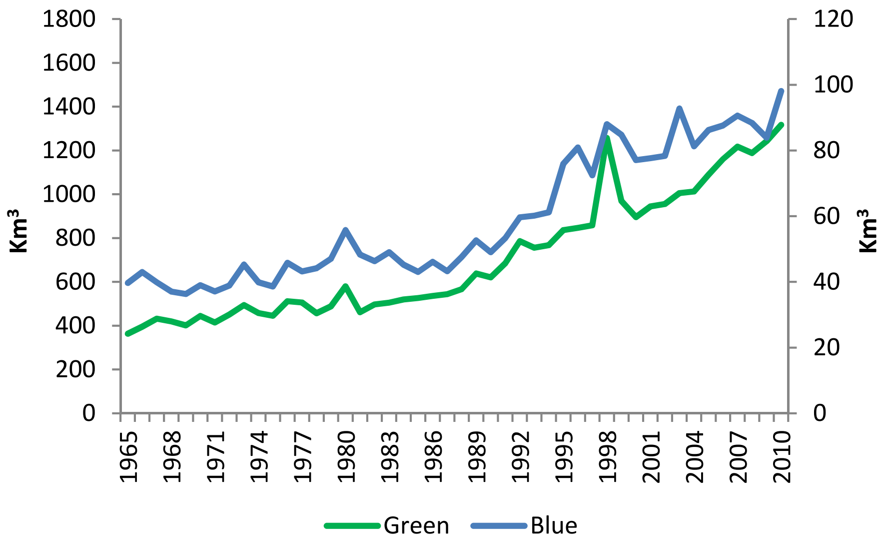
3. Results

3.1. Global virtual water flows assessment

From 1965 to 2010, the volume of water embodied in agricultural and livestock products traded went from 403 km^3 in 1965 to 1,415 km^3 in 2010, growing at an average annual rate of 2.7%. This increase was particularly intense from 1980 on, particularly during the 1990s, when global virtual water trade flows rose by 3.8% yearly on average. This growing dependence of countries on foreign water resources from 1965 to 2010 has been observed by Clark et al. (2015). As Figure 1 shows, green water was the most important component in total virtual water, since blue water only represented 8% of global water consumption, on average. Exchanges of green water depicted the most vigorous increase, growing at 2.8% every year, compared to blue water that rose at 2.2% annually.

This growing pattern was similar all over the world, with the exception of Africa and the former Soviet Union, where the trajectory was quite erratic. The latter had a very limited participation in international trade, given its centrally-planned economy. The successor republics were quickly opened after the collapse of communism.

Figure 1: Global virtual water flows, 1965-2010 (km^3). Green water is shown on the left axis, and blue water on the right. Source: own elaboration using trade data from United Nations Statistics Division (UN, 2013) and water footprints from Mekonnen and Hoekstra (2011, 2012).



On the whole, the percentages shown in Table 1 of the share of the world regions of exports and imports, and the tendency followed by virtual water trade flows, are similar to those resulting when analyzing trade values, in monetary units (Serrano and Pinilla, 2011a).

As is observed in Table 1, the contribution of each of the regions of the world (Africa, North America, Asia and Pacific, Europe, the former Soviet Union, Latin America, and Oceania) to virtual water trade flows is not homogenous, with large differences in the shares of each area. The largest exporter of blue water was North America throughout the period, followed by Europe. The importance of the U.S. as an exporter of agri-food products, due to the development of a very high-productivity agriculture, an agrifood industry closely linked to it, and the huge expansion of the irrigated area during the 20th century (Olmstead et al., 2000) explain the high virtual water exports of North America. Note that irrigated area in the USA went from 7.7 million acres in 1900 to 49.4 in 1992 (Carter et al., 2006).

The intense intra-European trade in agricultural and food products, clearly influenced by the processes of economic integration, together with the growing share of processed and high value-added agri-food exports, explains the importance and increasing weight of Europe in global virtual water trade (Serrano and Pinilla, 2011b). Although Table 1 and SI1 refer to interregional flows among the main regions in the world, all the exchanges of water through international trade are calculated in a disaggregated way, at the country and product level. In the case of green water, Latin America and North

America appear as the most representative exporters, with shares of 26.6% and 25.2% respectively. The downward trend in the weight of Latin American was caused by its poor agricultural exports performance from the 1950s until the last decade of the 20th century (Serrano and Pinilla, forthcoming).

Table 1: Average contribution of world regions to virtual water exports and imports (%)

	1965-1969	1970-1979	1980-1989	1990-1999	2000-2010	1965-1969	1970-1979	1980-1989	1990-1999	2000-2010
	Blue water exports					**Green water exports**				
Africa	16.4	12.4	7.9	4.9	5.5	4.5	4.1	3.1	2.1	1.4
North America	26.8	35.9	34.5	30.8	30.4	24.7	30.7	28.5	24.8	22.1
Asia and Pacific	17.9	16.8	20.6	19.7	20.8	12.9	11.8	14.5	17.9	18.4
Europe	15.9	18.8	22.5	22.1	22.6	17.2	17.4	20.8	20.1	18.9
Former Soviet Union	0.5	0.3	0.2	6.0	3.4	2.0	0.7	0.2	5.8	6.3
Latin America	17.7	11.6	8.4	9.5	10.9	30.7	26.3	24.6	24.5	28.3
Oceania	4.8	4.2	5.8	7.1	6.4	7.9	9.0	8.4	4.7	4.5
Total	100	100	100	100	100	100	100	100	100	100
	Blue water imports					**Green water imports**				
Africa	3.0	6.1	8.5	5.3	6.4	3.4	4.8	6.4	5.2	6.4
North America	12.2	9.2	7.8	8.5	9.5	16.1	13.3	10.9	9.0	8.8
Asia and Pacific	26.4	33.4	34.6	32.9	33.1	21.9	26.7	29.5	26.7	32.6
Europe	53.0	45.3	40.4	37.3	33.8	51.8	48.0	44.4	39.9	36.2
Former Soviet Union	1.2	0.4	0.0	5.3	4.7	0.4	0.3	0.2	9.0	4.6
Latin America	3.8	5.3	8.3	10.3	12.0	5.9	6.6	8.2	9.8	10.8
Oceania	0.4	0.3	0.4	0.5	0.7	0.4	0.4	0.4	0.4	0.5
Total	100	100	100	100	100	100	100	100	100	100

Source: own elaboration using trade data from United Nations Statistics Division (UN, 2013) and water footprints from Mekonnen and Hoekstra (2011, 2012).

Looking at imports, Europe and Asia and Pacific were the largest importers of both blue and green virtual water during the period considered. Europe accounted for more than 50% of global water imports during the 1960, but tended to decrease its importance, reaching a share of 36% today. This is related to the implementation of the Common Agricultural Policy that involved an increase in agricultural protectionism and a drop in the weight of European agricultural imports (Pinilla and Serrano, 2009). On the other hand, Asia and Pacific increased its significance in blue virtual water imports. The very strong economic growth in Asian countries since the 1980s, and especially in China, explain this rising importance in global virtual water imports. Table SI1 in the SI shows the average virtual water exports, imports, and balance of the regions in which we have divided the world, during each period. North America and Oceania were net exporters of water, Europe together with Asia and Pacific were net importers of both blue and green water, Latin America was a net exporter of blue water until 1989 (and stands out as the most remarkable net exporter of green water, particularly from 2000), and Africa appears as a net exporter of water until 1980, after which it became a net importer.

3.2. Results at the country level and by products

At the country level, interesting insights can be obtained from the analysis of countries with the highest global flows, and also the origins and destinations of those flows. Figures 2, 3 and SI1-SI4 in the SI show the largest net importers and exporters of green water and the five most important net exchanges of agricultural and food products for 1965, 1980, and 2010.

Figure SI2 shows that Latin American countries such as Brazil and Argentina exported most green water in 1965; Argentina exported wheat and maize to European countries such as the Netherlands and Italy, and Brazil used green water in the production of coffee, exported mainly to the USA. Developed countries that have traditionally been exporters of primary products, such as the USA, Canada and Australia, can also be seen as notable net exporters of green water. The USA exported large volumes of green water to the Netherlands and to Japan, the largest net importer of green water in the period. In this case, green water was embodied mainly in cereals like wheat and soya beans. Most of the green water from Canada or Australia was embodied in wheat.

The picture was somewhat different by 2010 (Figure SI4). The Americas (chiefly Brazil, Argentina, the USA, and Canada) continued to be the main exporter of green water in the world, and Italy, Japan and The Netherlands were the main destinations of virtual water flows. Nevertheless, China, with 14% of gross green virtual water imports in the world, is the largest net importer of green water today. Three of the five most important flows in the world go from the USA (raw cotton and soya beans), Brazil (wheat) and Argentina (soya beans) to China. Moreover, the exchange of water, mostly from the USA to Japan, is still significant (maize). (Further information on green water flows for the intermediate period, i.e., 1980, can be seen in the SI.)

As can be observed in Figures 2, 3 and SI1, for blue water, the USA appears as the highest net exporter in 1965, followed by Mexico and certain countries in the north of Africa, such as Algeria, Egypt, and Sudan. In contrast, Japan and France imported most blue water. As happened in the case of green water, the largest blue virtual water flow went from the USA to Japan, primarily in cereals and cotton. Important virtual blue water flows also took place as a result of the export of wine from Algeria to France, of cotton from Mexico to the USA and Japan, and cereals from the USA to the Netherlands.

Figure 2: Country net exports of blue water and top five net flows in the world, 1965. Source: own elaboration using trade data from United Nations Statistics Division (UN, 2013) and water footprints from Mekonnen and Hoekstra (2011, 2012).

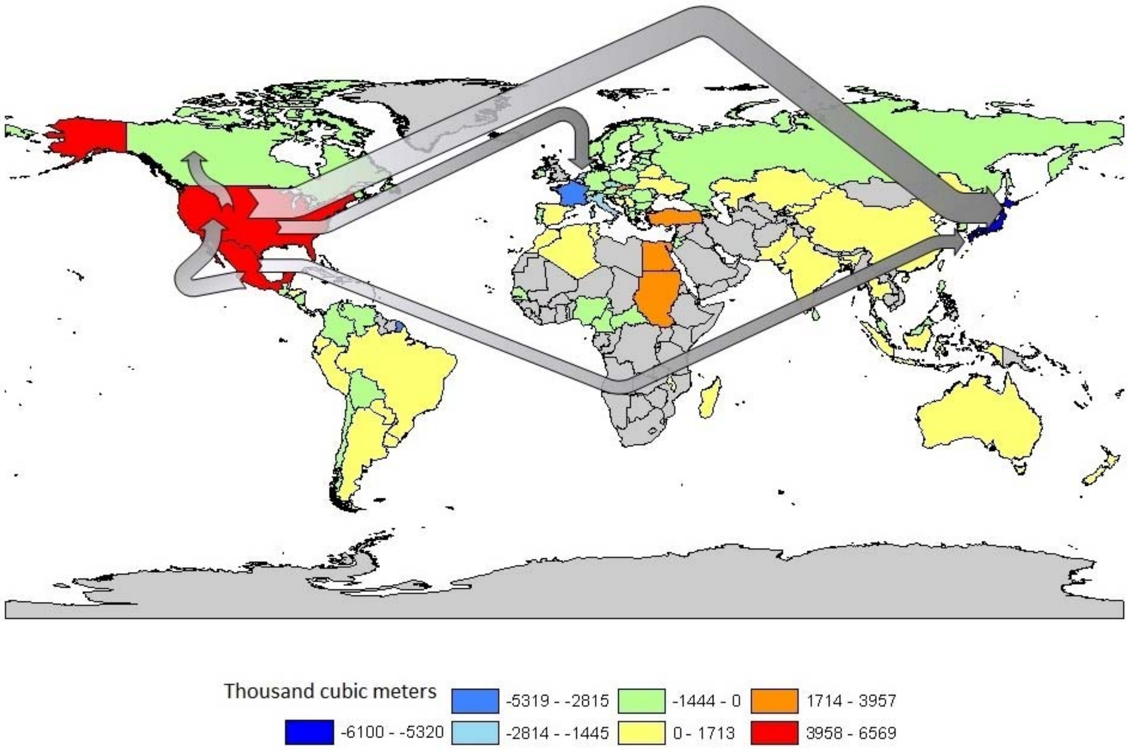
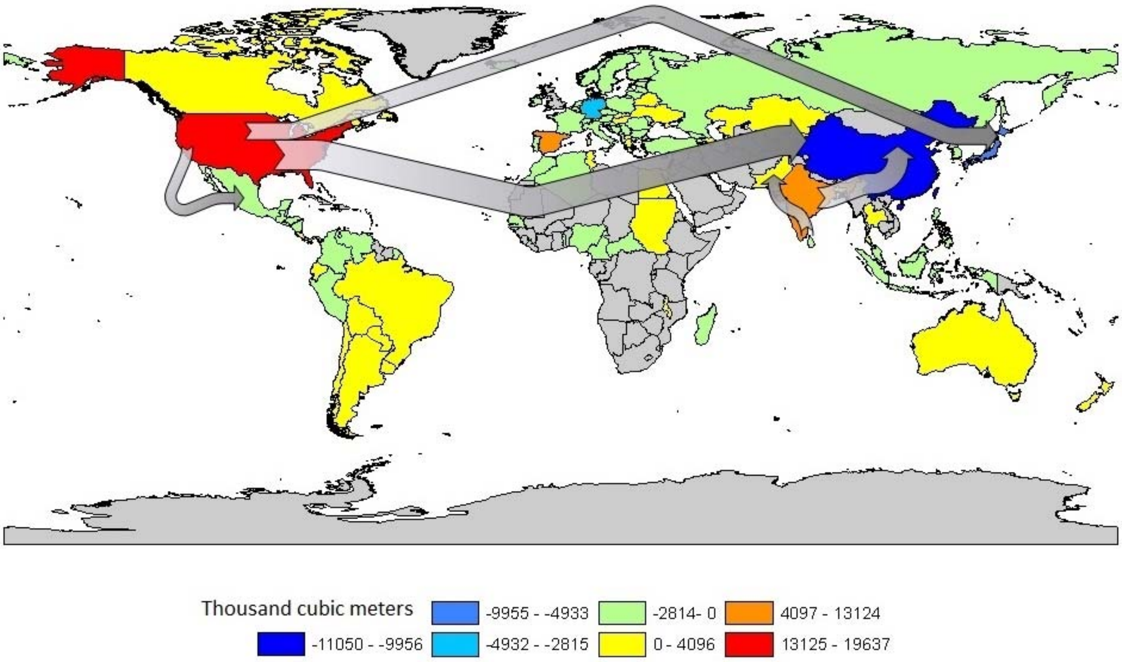


Figure 3: Country net exports of blue water and top five net flows in the world, 2010. Source: own elaboration using trade data from United Nations Statistics Division (UN, 2013) and water footprints from Mekonnen and Hoekstra (2011, 2012).



In 2010, the USA was still the largest blue virtual water exporter in the world, followed by India, Spain, Australia, and Argentina. China became the most significant importer of blue water in the world, with more than 14% of global blue water imports. Japan, Germany, Korea, and the United Kingdom were also notable net importers of blue water. While the USA blue water resources mainly went to China (soya beans), Japan (maize), and Mexico (cereals), Indian blue water was traded with China embodied in cotton and with Pakistan embodied in sugar.

One important feature to be analyzed is the relationship between water flows embodied in trade and the natural conditions (water endowments) of the countries. Following the proposal of Hoekstra and Hung (2005), Table 2 and Tables SI3, SI4 and SI5 display several water indicators (gross virtual imports and exports, net virtual water imports, scarcity, self-sufficiency, and dependency indexes) at the country level, calculated at the beginning and the end of the period studied (we use 2000 due to lack of data on water withdrawal at later periods for all the countries in the sample). Data for an intermediate year, 1980 are included in the SI Information. Population is included for reference. As in Hoekstra and Hung (2005), the scarcity index is obtained as the ratio between water availability and water withdrawal. The self-sufficiency index as defined by Hoekstra and

Hung (2005), is the ratio between domestic water use (green and blue water withdrawn) and the sum of it and net virtual water imports. This index indicates the capacity of a country to meet its water demands with their own resources. On the contrary, the dependency index is calculated by dividing net virtual water imports by the sum of these imports and domestic water use. As we have previously said, for the calculation of the self-sufficiency and dependency indexes we consider virtual water imports and water withdrawal data. The former are estimated using information on the product water footprints; the latter reflect the water used or abstracted from surface or groundwater sources. Given the different nature of the data used for the calculations (water use and consumption), the results and conclusions derived from the self-sufficiency and dependency ratios must be interpreted with caution. As pointed out by Lutter and Giljum (2015), water abstraction and consumption exert different impacts on aquatic ecosystems. Whereas water use affects water flows in a concrete watershed, water consumption is related to ecosystems as a whole.

As can be seen, the United States, Brazil, Canada, India, Colombia, and China display the largest water availability in the world. The countries with the most abundant per capita water resources are Canada, New Zealand, and Latin American areas of Paraguay, Bolivia, Peru, and Venezuela. The countries with the lowest per capita measures are China, the USA, India, Indonesia, Pakistan, and Japan. From 1965 to 2000, water withdrawals tended to increase in almost all countries. The global population increased dramatically during these years, leading to decreased per capita water withdrawals in the majority of countries. Extracted water is used to meet domestic demands, but also to produce goods that have been exchanged through international trade.

According to the scarcity index, during these years scarcity grew in most countries in the world, with the most significant values in Egypt, Israel, Jordan, Pakistan, Tunisia, and Sudan. Some of these countries are important net exporters of water, in spite of being subject to a notable lack of water. As is shown in Table 2, most of the countries that were self-sufficient in 1965 showed a similar profile in 2010. The same happened for most countries dependent on foreign water resources. We find exceptions, such as Malaysia, Bolivia, France, Ireland, and Denmark that were very dependent on water from abroad in the 1960s that today appear as net exporters of water resources and are self-sufficient. According to our results, countries such as The Netherlands, Korea, Algeria, Israel, and Jordan have a high dependency index as a result of agricultural and food product imports. It is possible to find an increase in the self-sufficiency of Austria, Greece, Norway, Poland, and the United Kingdom. Finally, Senegal, Jordan, Peru, Venezuela, Israel, Nigeria, Morocco, Algeria, Mexico, and Japan notably increased their dependency on foreign water resources.

Table 2: Gross VWM, Gross VWX, Net VWM and sustainability indexes for 1965 and 2010

	1965						2010					
Country	**Gross VWM (km^3)**	**Gross VWX (km^3)**	**Net VWM (km^3)**	**Scar. Index (%)**	**SS index (%)**	**Dep. index (%)**	**Gross VWM (km^3)**	**Gross VWX (km^3)**	**Net VWM (km^3)**	**Scar. Index (%)**	**SS index (%)**	**Dep. Index (%)**
Albania	0.3	0	0.3	35	82	18	3.7	3.3	0.4	21	89	11
Algeria	1.2	2.5	-1.3	4	100	0	14.3	6.9	7.5	5	85	15
Argentina	1.5	44.1	-42.5	29	100	0	10.6	89.6	-79	25	100	0
Australia	1	19.4	-18.4	n.a.	100	0	2.8	36.3	-33.5	22	100	0
Austria	1.6	0.6	1	23	76	24	0	0.1	0	2,181	100	0
Bolivia	0.4	0.1	0.3	502	80	20	1.4	4.6	-3.2	235	100	0
Brazil	7.2	34.4	-27.2	235	100	0	27.7	77	-49.3	139	100	0
Bulgaria	1	1.5	-0.6	2	100	0	1.4	2.1	-0.8	4	100	0
Cameroon	0.1	1.4	-1.3	714	100	0	0.4	3.9	-3.4	295	100	0
Canada	11.4	23.1	-11.6	69	100	0	16.4	62.2	-45.8	n.a.	100	0
Chile	2.3	0.2	2.1	45	91	9	4.1	0	4	1	19	81
China	9.2	8.2	1	6	100	0	24.8	9.2	15.6	9	50	50
Colombia	1	8.5	-7.6	n.a.	100	0	7.5	11.8	-4.2	169	100	0
Denmark	5.2	5	0.2	5	85	15	7	7.1	-0.1	9	100	0
Ecuador	0.2	1.8	-1.5	n.a.	100	0	1.9	3.1	-1.2	45	100	0
Egypt	7.2	2.8	4.4	1	92	8	10.1	0.1	10	2	36	64
El Salvador	0.7	1	-0.2	35	100	0	2	2.2	-0.2	18	100	0
Finland	2.2	0.3	1.9	30	67	33	0.6	0	0.6	23	75	25
France	24.9	7.7	17.2	7	64	36	31.9	33.5	-1.6	7	100	0
Greece	3.1	0.9	2.3	15	69	31	2.5	1.1	1.4	17	62	38
Guatemala	0.4	2.5	-2.1	n.a.	100	0	2.4	5.9	-3.5	40	100	0
Hungary	2.2	3	-0.8	22	100	0	1.9	7.2	-5.3	18	100	0
India	1.3	12.6	-11.3	4	100	0	26.3	29	-2.7	3	100	0
Indonesia	0.6	4.5	-3.8	27	100	0	19.1	37.1	-18	18	100	0
Ireland	1.4	0.9	0.5	66	59	41	2.5	4.1	-1.5	n.a.	100	0
Israel	3.1	0.3	2.8	1	38	62	6.2	1.3	4.9	37	83	17
Italy	37.9	2.2	35.7	5	54	46	60.6	26.7	33.9	10	21	79
Japan	46	0	46.3	5	66	34	50	14.7	34.8	6	68	32
Jordan	0.5	0	0.5	2	53	47	12.6	9.3	3.3	6	96	4
Madagascar	0.3	2.4	-2.1	21	100	0	0.5	1.4	-1	20	100	0
Malawi	0	0.5	-0.5	n.a.	100	0	0	0.8	-0.8	13	100	0
Malaysia	3.8	1.2	2.6	57	79	21	14.3	29.4	-15.1	62	100	0
Mexico	1	14	-13.4	8	100	0	31.5	1.3	30.2	3	46	54
Morocco	1.9	1.9	-0.1	3	100	0	9.7	3.1	6.6	8	56	44
Netherlands	31.1	7.9	23.2	10	28	72	46.7	22.4	24.4	5	96	4
New Zealand	1	7.9	-6.8	273	100	0	1.1	15.3	-14.1	69	100	0
Nicaragua	0.2	2.7	-2.5	n.a.	100	0	0.7	3.4	-2.8	142	100	0
Nigeria	0.4	0.2	0.2	79	94	6	6.8	0.7	6.1	1	23	77
Norway	3	0.1	2.9	191	41	59	6.7	4.9	1.9	8	83	17
Pakistan	0	0	0	2	100	0	5.4	2	3.5	99	85	15
Paraguay	0.2	0.8	-0.6	781	100	0	0.7	8.7	-8	686	100	0
Peru	3	2.1	0.9	101	95	5	6.5	3.6	2.9	5	82	18
Poland	7.2	2.9	4.2	4	78	22	3.9	1.1	2.8	65	49	51
Portugal	1.7	0.3	1.4	n.a.	n.a.	n.a.	6.6	1	5.6	136	62	38
Rep. of Korea	2.8	0.1	2.7	n.a.	n.a.	n.a.	24.8	9.2	15.6	1	78	22
Romania	0.4	2	-1.5	11	100	0	2.8	3.2	-0.4	23	100	0
Senegal	0.9	2.3	-1.4	29	100	0	2.1	0.8	1.3	48	64	36
Spain	8.1	3	5.1	3	89	11	8.6	1.4	7.1	2	64	36
Sudan	0.5	4.3	-3.7	4	100	0	1.1	2.9	-1.8	2	100	0

Sweden	4.8	0.8	4	42	51	49	2.5	0.3	2.3	160	51	49
Thailand	0.6	10.3	-9.7	n.a.	100	0	10.4	25.6	-15.2	8	100	0
Tunisia	1	2.7	-1.7	2	100	0	4.8	5.8	-1	2	100	0
Turkey	1.2	3.9	-2.7	7	100	0	6.7	0	6.7	28	60	40
United Kingdom	47.6	1.3	46.2	11	23	77	29	20.7	8.3	3	81	19
Uruguay	0	2	-1.8	214	100	0	3	4.9	-1.6	38	100	0
USA	53.9	92.5	-38.6	6	100	0	77.2	187.6	-110.4	6	100	0
Venezuela	2.4	1.4	1	301	80	20	9.8	4.9	4.8	1	97	3

VWM: green and blue virtual water imports, VWX: green and blue virtual water exports, Scar. Index: Scarcity index, SS index: Self-sufficiency index, Dep. Index: Dependency index. Source: own elaboration using trade data from United Nations Statistics Division (UN, 2013) and water footprints from Mekonnen and Hoekstra (2011, 2012).

In addition to the increased volume of virtual water traded, significant shifts in the agricultural and food products exchanged also took place (Table 3). An important group of goods, such as cereals, that entailed more than 32% of green virtual water trade during the 1970s, experienced a notable loss of weight, declining to around 22% in the case of green water and 27% for blue water. Textile fibers also went through a reduction in their share, particularly in the case of blue water, from 33% during the 1960s to approximately 14% today, mainly due to the substitution of natural fibers by synthetic fibers. A similar decline occurred with the group coffee, tea and spices. Other crops and products made up for these reductions. This was the case of fruit and vegetables, which considerably increased their participation, primarily in blue water, accounting for 15% of total exchanges of blue water today. Dairy products and eggs (4% of blue water) as well as meat (6.9% of blue water currently), also experienced an upturn, chiefly in blue water. Regarding green water, the meat group has remained quite stable at 11%. Vegetable oils, staples of human diets, more than doubled their participation in commercial exchanges of green water. Eventually, crops commonly used as animal feed such as feed stuff or oil seeds, oil nuts, and kernels, show growing and outstanding percentages for green water, reaching 8% and 15.4% respectively. We have seen that the increasing level of development in certain regions of the world lead to an important change in world diets, with a growing weight of high value-added commodities, such as fruit, vegetables, dairy products, vegetable oils, and meat. The rise of meat and other goods derived from livestock resulted in an upward trend of animal feed crops and oil seeds. Changes in the product composition of virtual water trade tend to be similar when the composition of world trade in agri-food products is analyzed in monetary value. In this case, processed and high value-added commodities have also increased their share, whereas basic products have lost weight. Processed products of higher value have benefited from freer trade and from the new intra-industry trade patterns (Serrano and Pinilla, 2014).

Table 3: Average contribution of products to virtual water exports and imports (%)

	Blue water					Green water				
Sitc rev.1 product classification	**1965-1969**	**1970-1979**	**1980-1989**	**1990-1999**	**2000-2010**	**1965-1969**	**1970-1979**	**1980-1989**	**1990-1999**	**2000-2010**
00 Live animals	1.1	0.9	0.8	0.6	0.5	3.6	2.6	2.2	1.3	1.0
01 Meat and meat prep.	5.3	5.6	5.5	5.9	6.9	13.2	11.3	11.6	10.0	11.1
02 Dairy products and eggs	2.7	3.2	3.4	3.7	4.1	3.2	3.6	4.0	3.9	4.0
04 Cereals and cereal prep.	26.2	31.5	29.7	28.8	26.9	34.5	33.8	27.0	26.5	22.1
05 Fruit and vegetables	6.9	7.9	9.2	12.9	15.0	2.6	3.5	4.2	4.9	5.6
06 Sugar, sugar prep., honey	5.2	5.9	5.2	6.5	5.5	2.1	2.3	2.0	2.2	2.2
07 Coffee, tea, spices	2.3	2.1	2.0	2.0	1.7	17.3	14.8	13.2	14.0	7.9
08 Feed Stuff and unmilled cereals	3.5	3.9	4.8	5.6	5.6	3.1	3.9	6.6	8.3	8.0
09 Miscellaneous food prep.	0.0	0.0	0.1	0.3	0.4	0.0	0.0	0.0	0.1	0.1
11 Beverages	3.2	1.5	0.9	1.5	1.5	0.5	0.7	0.8	0.9	0.9
12 Tobacco	0.4	0.4	0.3	0.4	0.4	0.6	0.4	0.3	0.3	0.3
21 Hides, skins and furs	0.4	0.4	0.8	1.6	0.7	0.9	1.0	1.8	1.7	1.2
22 Oil seeds, oil nuts	6.3	7.6	8.4	8.8	10.0	7.6	10.1	12.3	11.5	15.8
26 Textile fibres, not manuf.	32.7	22.7	20.6	15.1	13.9	5.5	4.1	3.1	2.3	2.2
42 Fixed veg. oils and fats	3.5	6.0	7.6	5.9	5.4	4.8	7.2	10.1	10.7	15.4
59 Chemical materials	0.1	0.1	0.1	0.1	0.2	0.2	0.1	0.2	0.2	0.3
61 Leather, lthr. manufs.	0.1	0.2	0.4	0.6	1.3	0.3	0.5	0.8	1.2	1.7
Total	100	100	100	100	100	100	100	100	100	100

Source: own elaboration using trade data from United Nations Statistics Division (UN, 2013) and water footprints from Mekonnen and Hoekstra (2011, 2012).

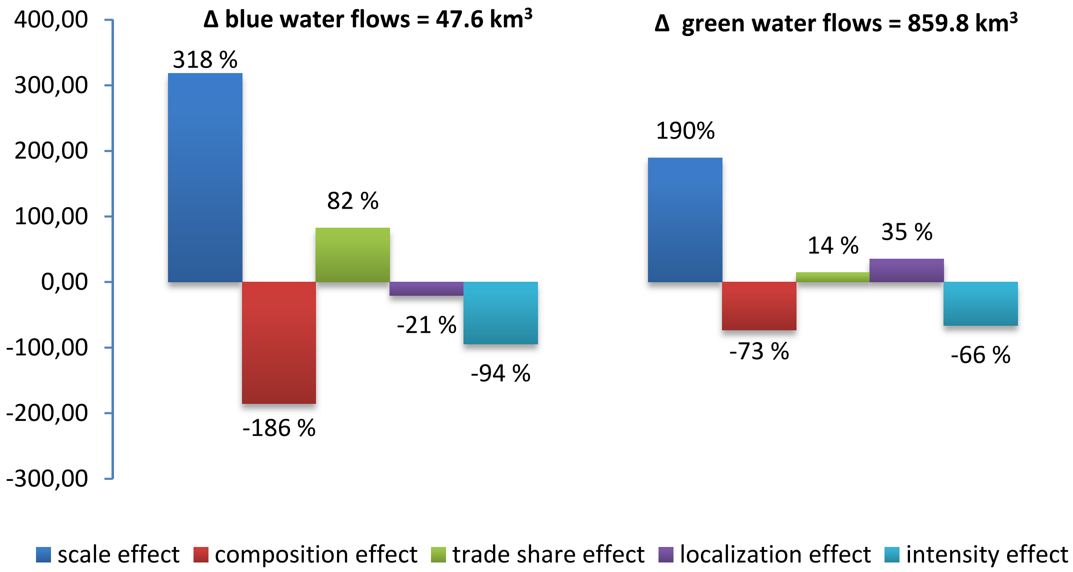
4. Discussion: Factors driving global virtual water flows in the long term

In the following, we examine further the factors that could drive the increase in virtual water trade between 1965 and 2010. We apply a DA to study the role of growth in the volume of trade, changes in the main products traded, changes in the origin of virtual water, variations in the most important exporters and importers of water, and yield improvements.

Figure 4 shows the global impact that each of the factors previously defined had on the increase in blue and green water from 1965 to 2010. Scale effects, that is, the significant growth of commercial exchanges during these years, all other things constant, was responsible for most of the increase in blue and green water consumption. From 1965 to 2010, certain Latin-American countries, such as Mexico, and African countries such as Egypt, Algeria, and Sudan, reduced their share of the trade of embodied water resources. However, Asian regions, such as China, India, and Indonesia, along with Canada and Spain hugely increased their weights. These changes in the share of countries in the virtual water trade also involved a boost of exchanges of virtual water.

Product compositional changes (variations in traded products), together with yield improvements at the global level, contributed to the slowdown in virtual water trade. In other words, without the key role of these two elements (composition and intensity effects) the virtual water trade would have increased by 1,328 km^3 more. On the one hand, the decreasing shares of cereals, such as wheat and maize, highly intensive in green water, as well as the reduced importance of coffee, moderated green water consumption rise to a great extent. On the other hand, we observe an outstanding loss of weight of raw sugar and raw cotton, crops that embody large volumes of blue water and that consequently drove the leveling-off of blue virtual water flows. The fact that agricultural yields increased in most of the world involved a decrease in the volume of water necessary to produce a tonne of product, and therefore a deceleration of virtual water exchanges.

Figure 4: Factors explaining the increase in virtual water flows in the world, 1965-2010. Source: own elaboration using trade data from United Nations Statistics Division (UN, 2013) and water footprints from Mekonnen and Hoekstra (2011, 2012).



As is seen in Figure 4, localization had a negative effect on the blue virtual water trade, but a positive impact in the case of green water. As for blue water, on the whole, products were produced in less water-intensive countries and then exported, resulting in a smoother growth. Mexico and the USA were the most significant providers of blue water in the world, which appears to be constant over time. Although, in 1965, African countries such as Egypt and Algeria, and Oceania areas such as New Zealand and

Australia, also stand out, they have since been superseded as exporters of virtual water by India and Spain, while the reallocation of the production of green-water-intensive goods have increased the virtual water trade. In this regard, green water had its origin mainly in the USA and Argentina during these years. Whereas Brazil, Australia, Colombia and the Philippines could be highlighted as important origins of green water trade flows in 1965, Canada, Indonesia, the Netherlands and India stand out today. These reallocations entailed greater pressures on global green water resources, as the production of agricultural goods tended to move to regions that are less efficient in the use of green water.

After examining the impact that these different effects exerted on the trend in global virtual water, we study their impact in seven regions (Table 4) of the world. (Results at the country level are given in Tables SI6 and SI7 in the SI.) Regarding exports, blue and green virtual water increased in all areas except Africa, where slight decreases took place, and a scale effect appears to be the most important factor driving blue and green water exports growth. However, there are certain regional disparities in the case of composition and trade share effects. As for green water, compositional changes partially offset the increase in virtual water flows, displaying a higher contribution in Latin America and North America. In the case of blue water, the former effect had an important contribution to the moderation of the virtual water trade in Latin America, but triggered the exchanges of virtual water in Oceania and in the Former Soviet Union. Changes in the importance of countries in exports, i.e. the trade share effect, involved the stabilization of virtual water trade in North America, Latin America, Oceania and Africa. However, it boosted the exchanges of virtual water in Europe and the Former Soviet Union. For Asia, the trade share effect leads blue virtual water exports to level off but entails a slight growth of green water exports. Finally, yield improvements occurred in every region of the world and mitigated larger increases in the virtual water trade. As an example, these advances reduced virtual water flows in Asia and Europe by approximately 204 km^3.

Table 4: Change in virtual water flows and decomposition analysis effects, 1965-2010

	VWX Change (km^3)	**SE** (%)	**CE** (%)	**TE** (%)	**IE** (%)	**VWM Change** (km^3)	**SE** (%)	**CE** (%)	**LE** (%)	**TE** (%)	**IE** (%)

					Blue water						
Africa	-3.1	-631	109	572	51	5.4	122	-26	59	-6	-49
North America	16.7	241	-25	-59	-57	3.4	480	-99	-159	-38	-83
Asia	10.4	274	11	-63	-122	19.1	225	-162	124	-6	-80
Europe	15.4	163	-11	29	-81	8.2	890	-378	-107	-71	-234
Fmr. Soviet Union	3.6	54	13	58	-25	2.6	127	-833	854	0	-48
Latin America	3.7	630	-344	-74	-113	8.4	101	1	51	-14	-40
Oceania	2.2	362	14	-184	-92	0.6	162	-39	28	-6	-45
					Green water						
Africa	-6.2	-889	16	913	60	70.5	120	-50	66	12	-49
North America	144.6	274	-50	-54	-71	35.3	572	-180	-204	19	-107
Asia	184.4	142	-6	9	-45	353.6	127	-84	52	47	-42
Europe	183.5	142	-6	69	-104	235.8	314	-70	-54	34	-123
Fmr Soviet Union	101.2	62	-17	90	-35	58.4	51	-79	97	59	-27
Latin America	221.4	207	-55	2	-54	100.4	115	-17	35	6	-39
Oceania	30.5	346	-7	-175	-63	5.9	134	-30	18	16	-38

VWX change: change in virtual water exports (km^3), VWM change: change in virtual water imports (km^3), SE: Scale effect (%), CE: Composition effect (%), LE: localization effect (%), TE: Trade share effect (%), IE: Intensity effect (%)
Source: own elaboration using trade data from United Nations Statistics Division (UN, 2013) and water footprints from Mekonnen and Hoekstra (2011, 2012).

When we look at the explanatory factors of the increase in virtual water imports at the regional level, again the scale effect is the main contributing factor to their growth. Product compositional changes drove virtual water stabilization, with the exception of green water in Latin America, where it showed a small but positive sign. Changes in the origin of products led to a moderation of the embodied blue and green water in imports in Europe and Latin America. As happened with exports, yield improvements boosted the deceleration of the virtual water exchanges all over the world, particularly in Europe and North America. Whereas variations in the share of countries in international trade led to a reduction of blue water, the trade share effect had the opposite impact for green water, triggering its exchange. This means that the growing presence of certain countries in international trade involved an increase in the exchanges of blue water because they demanded products that embody a high volume of blue water, while the greater share of these areas in international trade led to a slowing of green virtual water trade flows.

The analysis of the determinants of virtual water trade flows points to the increasing separation of consumer and producer responsibilities regarding water resources, meaning that consumption of products from other parts of the world necessarily entails the use of water from distant places. In some cases, the intensity of commercial exchange generates large pressures on water resources. An illustrative example of this issue is the food industry in Spain, one of the major global exporters of food. The significant increase in Spain's net exports explains over 60% of the growth of blue water consumption in Spain between 1960 and 2010 (Duarte et al., 2015a). Hence, the concentration of a growing part of agricultural production in one of the most arid regions in the world poses pressing problems for the sustainability of these activities (Cazcarro et al., 2015).

5. Conclusions

This paper has studied global virtual water trade flows from 1965 to 2010. To the best of our knowledge, this is one of the first attempts to estimate the exchanges of water embodied in agricultural and food products over the long term, explaining the global and country trends of virtual water, following an economic and historical interpretation. We examine in depth the impact of economic change on virtual water distribution over many years, focusing on the effects of economic integration, globalization, and the growth of international trade on water.

We show that the commercial integration between 1965 and 2010, the period of the second wave of globalization, entailed large pressures on water resources at the global level, supporting the findings of the literature on this topic (Clark et al., 2015). The changes in the composition of trade as a result of the decline of the exchanges of water-intensive crops such as cotton, coffee, maize, and rice alleviated pressures on water. The same phenomenon happened with yield improvements, which also contributed to alleviate the pressure on water resources.

As we have seen, the linkages and dependencies among countries tended to strengthen during this period. In order to set a general pattern, it is necessary to consider natural and economic variables that may condition the volume and trajectory of virtual water trade flows. On the whole, the availability of such natural resources as water and land, together with the level of economic development, can contribute to our understanding. Hence, developed countries with less land per capita usually show a high dependence on foreign water. This is the case of European countries like the United Kingdom, Italy, the Netherlands, and Portugal, and certain other countries, such as Israel, Japan, and Korea behave in the same way. Similarly, developing countries that need to import large volumes of agricultural and food products are also dependent on foreign water, as for instance, China, Egypt, and Mexico. For countries with high net exports of virtual water, we find different patterns; there are the developed countries that are abundant in land and that have historically been exporters of agricultural products, such as the USA, Canada, Australia, and New Zealand, and then there are the emerging countries, also abundant in land, with a long-term specialization in agricultural exports, such as Argentina, Brazil, Indonesia, Thailand, and Malaysia. These patterns have hardly changed throughout this period. Some industrialized countries, with relatively limited availability of land tend to externalize the most intensive production systems to emerging regions that stand out for being mostly producers of primary inputs and agricultural goods, as well as to industrialized countries abundant in land.

Our main findings suggest the need to analyze environmental problems at the global level, since the growing integration in international trade of many countries is essential to an understanding of their final water consumption (Hoekstra and Chapagain, 2008). Even for the case of water resources that show a local dimension and are commonly managed at the basin level, globalization is of global concern, and there is a growing pressure in certain areas of the world. Together with water-abundant countries, we can also find other regions that, given their economic competitiveness in certain products, and thanks to their climatic conditions, or the construction of hydraulic infrastructures, tend to specialize in - and export - goods intensive in blue water. This involves important pressures on blue water resources. Increasing globalization involves diverse consequences from an environmental perspective, which require a more efficient use of natural resources in, for example, a country abundant in natural capital that exports to other countries where that resource is scarce. It is a fact that globalization can generate or exacerbate environmental problems. Good commercial opportunities can induce economic specializations that involve more pressures on natural resources. Under these circumstances, the economic logic, i.e. the profitability of the exporting specialization, comes into conflict with the environmental logic and the maintenance of water ecosystems (see Cazcarro et al. (2015) for an example of this conflict for the case of Spain). Our results suggest the existence of room for improvement, both at the local and global levels, to alleviate the impacts on water resources. First, the work of improving the technological conditions at the local level is a determining factor for water pressure alleviation. In this regard, significant improvements in water productivity can be achieved by reducing water losses, in the field and in the system (D. Chukalla et al., 2015). In this same line, the reduction of technological gaps between and within countries can be an important factor for improving water productivity of rain-fed products, and for the alleviation of water pressures in certain regions of the world. Second, the water footprint is a consumption-based indicator (Hoekstra and Chapagain, 2008). Thus, behind the evolution of trade and the water embodied in agricultural flows, we must highlight the role of the consumer at the end of the supply chain, as a driver of economic activity and trade and, in consequence, as one who shares the responsibility for environmental pressures. Increased environmental awareness of consumers, and the path towards more sustainable lifestyles, can have a measurable effect on global water pressures. In this context, measures such as product labelling and communication strategies that show responsibility and the effects of lifestyles can be considered at different decisional levels. Finally, our results suggest the existence of a strong link between global and national economic trends and the environmental impacts that, as in the case of water, may have a local character. The inclusion of water foot-printing assessment agendas as a measure of economic relationships, and their impact on resources, and of the internal and external impact of the production and trade of countries, can inform policy actions, at every level, for the definition of sustainable development strategies.

Accordingly, in the light of historical processes, it seems necessary to look globally for a better understanding of the link between economic growth, international trade, and environmental pressures. To that end, it is essential to develop useful tools to accurately measure impacts on water resources throughout the global chains of production, distribution and consumption.

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Supplementary Information

Table SI1: Average virtual water exports, imports and balance (km³)

	1965-1969	1970-1979	1980-1989	1990-1999	2000-2010	1965-1969	1970-1979	1980-1989	1990-1999	2000-2010
			Blue water exports					**Green water exports**		
Africa	5.3	4.5	3.5	3.1	4.8	15.7	15.9	14.5	16.2	13.5
North America	7.2	11.1	13.5	19.6	27.3	67.3	107.3	123.9	194.3	249.4
Asia and Pacific	4.3	4.9	7.7	12.2	19.7	36.1	41.1	63.8	142.8	213.9
Europe	3.8	5.6	8.6	13.9	19.6	40.3	57.9	88.8	153.7	209.7
Former Soviet Union	0.1	0.1	0.1	3.8	3.2	5.7	3.0	1.0	45.3	76.0
Latin America	5.0	4.1	3.4	5.8	10.0	77.3	88.0	106.1	183.2	334.8
Oceania	1.4	1.4	2.3	4.4	5.9	21.2	31.4	35.3	36.7	49.0
Total	27.1	31.6	39.1	62.8	90.5	263.6	344.7	433.5	772.2	1,146.3
			Blue water imports					**Green water imports**		
Africa	0.8	1.9	3.3	3.3	5.9	8.7	15.4	26.7	40.8	74.9
North America	3.5	3.1	3.2	5.3	8.3	45.4	48.3	48.9	70.4	98.6
Asia and Pacific	6.9	10.4	13.5	20.7	30.9	59.3	92.4	127.4	206.9	376.8
Europe	14.4	14.4	15.8	23.3	29.8	133.4	163.9	191.4	302.6	413.1
Former Soviet Union	0.2	0.1	0.0	3.3	4.2	0.9	0.7	1.1	71.0	53.9
Latin America	1.0	1.7	3.3	6.6	10.8	14.9	22.6	36.1	77.4	122.9
Oceania	0.1	0.1	0.1	0.3	0.6	1.0	1.3	2.0	3.1	6.1
Total	27.1	31.6	39.1	62.8	90.5	263.6	344.7	433.5	772.2	1,146.3
			Blue balance					**Green balance**		
Africa	4.5	2.7	0.3	-0.1	-1.0	7.1	0.5	-12.2	-24.6	-61.4
North America	3.6	8.0	10.3	14.3	19.0	21.9	59.1	75.0	123.9	150.8
Asia and Pacific	-2.7	-5.5	-5.8	-8.5	-11.2	-23.2	-51.3	-63.6	-64.2	-163.0
Europe	-10.6	-8.9	-7.1	-9.4	-10.2	-93.2	-106.1	-102.6	-148.9	-203.4
Former Soviet Union	-0.1	0.0	0.1	0.4	-1.0	4.8	2.3	0.0	-25.6	22.1
Latin America	4.0	2.4	0.1	-0.7	-0.8	62.4	65.4	70.0	105.8	211.9
Oceania	1.3	1.3	2.1	4.1	5.2	20.2	30.1	33.4	33.6	43.0
Total	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source: own elaboration using trade data from United Nations Statistics Division (UN, 2013) and water footprints from Mekonnen and Hoekstra (2011, 2012).

Table SI2: Similarity index of virtual water trade flows, 1965-2010

Country	Green water	Blue water	Country	Green water	Blue water
Albania	2.4	21.9	Rep. of Korea	37.9	53.6
Algeria	43.3	27.3	Madagascar	28.3	8.4
Argentina	24.3	23.3	Malawi	25.5	61.8
Australia	43.7	57.7	Malaysia	18.1	48.9
Austria	38.1	41.8	Malta	33.8	27.1
Barbados	40.8	49.4	Mexico	**78.1**	**85.0**
Belgium-Lux.	58.1	46.7	Morocco	47.7	45.4
Bolivia	31.8	27.2	Netherlands	44.1	41.7
Brazil	54.8	41.7	New Zealand	40.0	42.7
Bulgaria	29.0	47.5	Nicaragua	61.5	**80.7**
Cameroon	30.7	14.2	Nigeria	59.4	38.1
Canada	**81.2**	**86.0**	Norway	53.4	46.1
Cent.African Rep.	25.8	19.2	Pakistan	22.9	4.1
Sri Lanka	32.3	38.1	Paraguay	45.6	47.0
Chile	49.0	37.9	Peru	63.7	61.9
China	25.4	13.8	Philippines	56.0	51.9
Colombia	47.5	69.2	Poland	15.7	20.7
Costa Rica	**65.2**	57.5	Portugal	56.3	17.5
Czechoslovakia	8.7	13.5	Romania	25.4	29.4
Denmark	30.3	31.2	Senegal	50.1	44.7
Ecuador	36.9	57.6	Singapore	55.4	58.2
El Salvador	63.5	66.7	Spain	50.7	47.2
Finland	54.1	41.1	Sudan	35.8	67.5
France	41.0	29.5	Sweden	45.6	44.0
Germany	28.3	12.9	Switzerland	41.3	34.8
Greece	44.3	41.5	Thailand	44.7	49.9
Guatemala	**65.8**	**77.3**	Togo	16.5	16.4
Honduras	62.4	61.0	Trinidad Tobago	62.7	**71.5**
Hungary	10.8	22.6	Tunisia	30.1	30.9
Iceland	17.6	46.1	Turkey	29.3	53.6
India	10.4	8.8	Fmr USSR	3.6	10.0
Indonesia	41.9	48.0	Egypt	53.4	50.4
Ireland	39.7	47.8	United Kingdom	42.3	53.9
Israel	29.4	40.4	USA	54.3	64.2
Italy	54.5	41.5	Uruguay	52.9	30.3
Japan	**76.4**	65.5	Venezuela	32.6	61.4
Jordan	19.5	33.1	Fmr Yugoslavia	20.7	10.7

Note: The highest values are highlighted in bold, whereas the smallest ones are underlined. Source: own elaboration using trade data from United Nations Statistics Division (UN, 2013) and water footprints from Mekonnen and Hoekstra (2011, 2012).

In order to go into the structural changes in the virtual water transfers in more detail, a similarity index is calculated in Table SI2. The similarity index proposed by Le Masne (1988) allows us to have a first glimpse of the similarity (or changes) in the patterns/structure of water flows for each country, in different periods. This index is defined as $100 * [1 - 0.5 * (\sum_c |VWX(c, z, 2010) - VWX(c, z, 1965)|)]$ and ranges between 0 and 100. The closer the index is to 100, the less the difference between the two periods, and thus the greater the similarity. On the basis of this index, a remarkable structural change in terms of commercial partners of countries took place between 1965 and 2010. Only certain areas - Guatemala, Nicaragua, Mexico and Canada - display a similarity index higher than 75 for blue water. As for green water, Japan, Mexico and Canada have the largest rating, while India, the Former Soviet Union, and Hungary have notably changed their commercial partners concerning virtual water, showing low values of the Le Masne Index. Moreover, China, one of the largest importers of water in the world, has a similarity index of 25 and 14 for green and blue water respectively, indicating a clear reorientation of its imports. In 1965, China imported more than 80% of blue water from Pakistan, Egypt and Sudan. This picture had changed radically by 2010, when 43% of blue water came from United States and 25% from India. Likewise, India changed its trade patterns throughout the period, with a similarity index around 8 for blue water. In 1965, 95% of blue water resources consumed in India had their origin in Pakistan, while today India imports more than 50% from the USA and Egypt, and only 5% from Pakistan. If we look at the USA, outstanding as an exporter of virtual water, its similarity index is 54 and 64 for green and blue water, respectively, indicating a smooth structural change. Most blue water was imported from Mexico in both years.

Table SI3: Water availability, withdrawal, Gross VWM, Gross VWX and Net VWM in 1965

Country	Population (000 hab.)	Water avail. (km^3)	Water with. (km^3)	Gross VWM (km^3)	Gross VWX (km^3)	Net VWM (km^3)	Scar. Index (%)	SS index (%)	Dep. index (%)
USA	194,303	3,069	517.7	53.9	92.5	-38.6	6	100	0
Argentina	22,283	814	27.6	1.5	44.1	-42.5	29	100	0
Brazil	83,093	8,233	35.0	7.2	34.4	-27.2	235	100	0
Canada	20,071	2,902	42.2	11.4	23.1	-11.6	69	100	0
Australia	11,439	492	n.a.	1.0	19.4	-18.4	n.a.	100	0
Indonesia	105,913	2,019	74.3	0.6	4.5	-3.8	27	100	0
Thailand	32,062	439	n.a.	0.6	10.3	-9.7	n.a.	100	0
Malaysia	9,648	580	10.1	3.8	1.2	2.6	57	79	21
New Zealand	2,640	327	1.2	1.0	7.9	-6.8	273	100	0
Paraguay	2,170	336	0.4	0.2	0.8	-0.6	781	100	0
Hungary	10,153	104	4.8	2.2	3.0	-0.8	22	100	0
Colombia	18,646	2,132	n.a.	1.0	8.5	-7.6	n.a.	100	0
Guatemala	4,746	111	n.a.	0.4	2.5	-2.1	n.a.	100	0
Cameroon	6,104	286	0.4	0.1	1.4	-1.3	714	100	0
Bolivia	3,853	623	1.2	0.4	0.1	0.3	502	80	20
Nicaragua	1,750	197	n.a.	0.2	2.7	-2.5	n.a.	100	0
India	485,000	1,911	438.3	1.3	12.6	-11.3	4	100	0
Sudan	12,086	53	14.1	0.5	4.3	-3.7	4	100	0
France	49,802	211	31.0	24.9	7.7	17.2	7	64	36
Uruguay	2,693	139	1	0	2	-1.8	214	100	0
Ireland	2,876	52	0.8	1.4	0.9	0.5	66	59	41
Ecuador	5,118	424	n.a.	0.2	1.8	-1.5	n.a.	100	0
Tunisia	4,566	5	1.9	1.0	2.7	-1.7	2	100	0
Madagascar	6,070	337	16.3	0.3	2.4	-2.1	21	100	0
Malawi	3,914	17	n.a.	0.0	0.5	-0.5	n.a.	100	0
Bulgaria	8,201	21	14.2	1.0	1.5	-0.6	2	100	0
Romania	19,027	212	18.8	0.4	2.0	-1.5	11	100	0
El Salvador	3,018	25	0.7	0.7	1.0	-0.2	35	100	0
Denmark	4,758	6	1.1	5.2	5.0	0.2	5	85	15
Central African Rep.	1,628	144	n.a.	0.0	2.4	-2.4	n.a.	100	0
Austria	7,271	78	3.3	1.6	0.6	1.0	23	76	24
Albania	1,884	42	1.2	0.3	0.0	0.3	35	82	18
Finland	4,564	110	3.7	2.2	0.3	1.9	30	67	33
Senegal	3,744	39	1.4	0.9	2.3	-1.4	29	100	0
Greece	8,550	74	5.0	3.1	0.9	2.3	15	69	31
Norway	3,723	382	2.0	3.0	0.1	2.9	191	41	59
Sweden	7,734	174	4.1	4.8	0.8	4.0	42	51	49
Poland	31,262	62	15.1	7.2	2.9	4.2	4	78	22
Philippines	33,268	479	n.a.	3.2	8.2	-5.1	n.a.	100	0
Peru	11,467	1,913	19.0	3.0	2.1	0.9	101	95	5
Jordan	1,061	1	0.5	0.5	0.0	0.5	2	53	47
Pakistan	57,495	247	155.6	0.0	0.0	0.0	2	100	0
Chile	8,510	922	20.3	2.3	0.2	2.1	45	91	9
Venezuela	9,068	1,233	4.1	2.4	1.4	1.0	301	80	20
Israel	2,578	2	1.7	3.1	0.3	2.8	1	38	62
Portugal	9,129	69	n.a.	1.7	0.3	1.4	n.a.	n.a.	n.a.
Nigeria	48,064	286	3.6	0.4	0.2	0.2	79	94	6
Morocco	14,066	29	10.1	1.9	1.9	-0.1	3	100	0
Turkey	31,951	212	31.6	1.2	3.9	-2.7	7	100	0
Spain	32,085	112	39.9	8.1	3.0	5.1	3	89	11
Algeria	11,963	12	3.0	1.2	2.5	-1.3	4	100	0
United Kingdom	54,350	147	13.5	47.6	1.3	46.2	11	23	77
Egypt	30,265	57	48.2	7.2	2.8	4.4	1	92	8
China	715,185	2,840	443.7	9.2	8.2	1.0	6	100	0
Rep. of Korea	28,705	70	n.a.	2.8	0.1	2.7	n.a.	n.a.	n.a.
Netherlands	12,292	91	9.2	31.1	7.9	23.2	10	28	72
Mexico	45,142	457	56	1	14	-13.4	8	100	0
Italy	51,987	191	41.6	37.9	2.2	35.7	5	54	46
Japan	98,883	430	88	46	0	46.3	5	66	34

Water avail.: water availability, Water with.: water withdrawal, VWM: green and blue virtual water imports, VWX: green and blue virtual water exports, Scar. Index: Scarcity index, SS index: Self-sufficiency index, Dep.Index: Dependency index. Source: own elaboration using trade data from United Nations Statistics Division (UN, 2013) and water footprints from Mekonnen and Hoekstra (2011, 2012).

. Population data stem from World Bank (2014). Water availability and withdrawal come from FAO (2014).

Table SI4: Water availability, withdrawal, Gross VWM, Gross VWX and Net VWM in 1980

Country	Population (000 hab.)	Water avail. (km^3)	Water with. (km^3)	Gross VWM (km^3)	Gross VWX (km^3)	Net VWM (km^3)	Scar. Index (%)	SS index (%)	Dep. index (%)
USA	227,726	3,069	517.7	55.1	230.7	-175.6	6	100	0
Argentina	28,370	814	27.6	1.8	28.4	-26.6	29	100	0
Brazil	123,020	8,233	35.0	16.8	58.5	-41.7	235	100	0
Canada	24,593	2,902	42.2	10.0	33.6	-23.6	69	100	0
Australia	14,616	492	n.a.	1.5	39.8	-38.3	n.a.	100	0
Indonesia	147,490	2,019	74.3	11.3	8.9	2.4	27	97	3
Thailand	47,026	439	n.a.	2.5	16.1	-13.5	n.a.	100	0
Malaysia	13,764	580	10.1	5.6	10.8	-5.2	57	100	0
New Zealand	3,170	327	1.2	0.6	9.1	-8.5	273	100	0
Paraguay	3,196	336	0.4	0.3	1.7	-1.4	781	100	0
Hungary	10,711	104	4.8	1.9	2.2	-0.3	22	100	0
Colombia	26,631	2,132	n.a.	2.2	12.8	-10.5	n.a.	100	0
Guatemala	6,650	111	n.a.	0.6	3.5	-2.9	n.a.	100	0
Cameroon	8,762	286	0.4	1.5	3.2	-1.7	714	100	0
Bolivia	5,441	623	1.2	1.1	0.6	0.5	502	73	27
Nicaragua	2,805	197	n.a.	0.6	1.8	-1.2	n.a.	100	0
India	679,000	1,911	438.3	7.4	7.1	0.3	4	100	0
Sudan	19,064	53	14.1	0.8	4.4	-3.6	4	100	0
France	55,110	211	31.0	34.6	19.6	15.0	7	67	33
Uruguay	2,930	139	1	0	2	-1.9	214	100	0
Ireland	3,401	52	0.8	1.5	4.2	-2.6	66	100	0
Ecuador	7,920	424	n.a.	1.2	3.0	-1.8	n.a.	100	0
Tunisia	6,443	5	1.9	2.6	1.7	0.9	2	68	32
Madagascar	8,691	337	16.3	0.4	2.4	-2.1	21	100	0
Malawi	6,259	17	n.a.	0.0	0.8	-0.8	n.a.	100	0
Bulgaria	8,844	21	14.2	1.0	0.8	0.2	2	99	1
Romania	22,130	212	18.8	6.0	1.0	5.0	11	79	21
El Salvador	4,566	25	0.7	0.6	0.8	-0.2	35	100	0
Denmark	5,123	6	1.1	5.4	4.3	1.1	5	49	51
Austria	2,349	144	n.a.	0.0	3.8	-3.8	n.a.	100	0
Albania	7,549	78	3.3	1.8	0.7	1.1	23	75	25
Finland	2,671	42	1.2	0.1	0.1	0.0	35	97	3
Senegal	4,780	110	3.7	2.2	0.3	1.9	30	66	34
Greece	5,787	39	1.4	2.1	1.5	0.7	29	67	33
Norway	9,643	74	5.0	5.8	1.2	4.6	15	52	48
Sweden	4,086	382	2.0	3.7	0.3	3.4	191	37	63
Poland	8,310	174	4.1	4.3	0.6	3.7	42	52	48
Peru	35,578	62	15.1	14.3	2.3	12.0	4	56	44
Jordan	50,940	479	n.a.	4.0	12.4	-8.4	n.a.	100	0
Pakistan	17,295	1,913	19.0	4.2	1.0	3.2	101	85	15
Chile	2,163	1	0.5	1.5	0.0	1.5	2	27	73
Venezuela	85,219	247	155.6	3.2	6.4	-3.3	2	100	0
Israel	11,094	922	20.3	4.9	0.5	4.4	45	82	18
Portugal	14,768	1,233	4.1	5.8	0.2	5.6	301	42	58
Nigeria	3,737	2	1.7	3.6	0.7	2.9	1	37	63
Morocco	9,778	69	n.a.	7.9	0.6	7.3	n.a.	n.a.	n.a.
Turkey	74,821	286	3.6	5.1	0.1	5.1	79	42	58
Spain	19,487	29	10.1	4.3	1.5	2.8	3	78	22
Algeria	45,048	212	31.6	1.1	3.1	-2.1	7	100	0
United Kingdom	37,488	112	39.9	18.8	5.7	13.1	3	75	25
Egypt	18,806	12	3.0	7.9	1.5	6.3	4	32	68
China	56,314	147	13.5	24.8	7.0	17.8	11	43	57
Rep. of Korea	42,634	57	48.2	16.5	1.6	14.9	1	76	24
Netherlands	981,235	2,840	443.7	42.6	5.7	36.9	6	92	8
Mexico	38,124	70	n.a.	16.2	0.3	15.9	n.a.	n.a.	n.a.
Italy	14,144	91	9.2	58.0	14.8	43.2	10	18	82
Japan	68,347	457	56	21	6	14.4	8	80	20

Water avail.: water availability, Water with.: water withdrawal, VWM: green and blue virtual water imports, VWX: green and blue virtual water exports, Scar. Index: Scarcity index, SS index: Self-sufficiency index, Dep.Index: Dependency index. Source: own elaboration using trade data from United Nations Statistics Division (UN, 2013) and water footprints from Mekonnen and Hoekstra (2011, 2012). Population data stem from World Bank (2014). Water availability and withdrawal come from FAO (2014).

Table SI5: Water availability, withdrawal, Gross VWM, Gross VWX and Net VWM in 2000

Country	Population (000 hab.)	Water avail. (km^3)	Water with. (km^3)	Gross VWM (km^3)	Gross VWX (km^3)	Net VWM (km^3)	Scar. Index (%)	SS index (%)	Dep. index (%)
USA	282,158	3,069	473.4	77.2	187.6	-110.4	6	100	0
Argentina	37,336	814.0	32.6	10.6	89.6	-79.0	25	100	0
Brazil	176,320	8233.0	59.3	27.7	77.0	-49.3	139	100	0
Canada	31,100	2902.0	n.a.	16.4	62.2	-45.8	n.a.	100	0
Australia	19,053	492.0	22.6	2.8	36.3	-33.5	22	100	0
Indonesia	205,132	2019.0	113.3	19.1	37.1	-18.0	18	100	0
Thailand	61,863	438.6	57.3	10.4	25.6	-15.2	8	100	0
Malaysia	21,804	580.0	9.3	14.3	29.4	-15.1	62	100	0
New Zealand	3,802	327.0	4.8	1.1	15.3	-14.1	69	100	0
Paraguay	5,592	336.0	0.5	0.7	8.7	-8.0	686	100	0
Hungary	10,137	104.0	5.8	1.9	7.2	-5.3	18	100	0
Colombia	39,817	2132.0	12.7	7.5	11.8	-4.2	169	100	0
Guatemala	11,085	111.3	2.8	2.4	5.9	-3.5	40	100	0
Cameroon	15,343	285.5	1.0	0.4	3.9	-3.4	295	100	0
Bolivia	8,195	622.5	2.6	1.4	4.6	-3.2	235	100	0
Nicaragua	4,935	196.6	1.4	0.7	3.4	-2.8	142	100	0
India	1,004,124	1911.0	610.4	26.3	29.0	-2.7	3	100	0
Sudan	34,194	52.8	27.2	1.1	2.9	-1.8	2	100	0
France	61,137	211.0	32.4	31.9	33.5	-1.6	7	100	0
Uruguay	3,328	139	4	3	4.9	-1.6	38	100	0
Ireland	3,792	52.0	n.a.	2.5	4.1	-1.5	n.a.	100	0
Ecuador	12,446	424.4	9.4	1.9	3.1	-1.2	45	100	0
Tunisia	9,568	4.6	2.9	4.8	5.8	-1.0	2	100	0
Madagascar	15,742	337.0	16.5	0.5	1.4	-1.0	20	100	0
Malawi	11,560	17.3	1.3	0.0	0.8	-0.8	13	100	0
Bulgaria	7,818	21.3	5.7	1.4	2.1	-0.8	4	100	0
Romania	22,452	211.9	9.2	2.8	3.2	-0.4	23	100	0
El Salvador	6,126	25.2	1.4	2.0	2.2	-0.2	18	100	0
Denmark	5,337	6.0	0.7	7.0	7.1	-0.1	9	100	0
Austria	3,940	144.4	0.1	0.0	0.1	0.0	2,181	100	0
Albania	8,113	77.7	3.7	3.7	3.3	0.4	21	89	11
Finland	3,474	41.7	1.8	0.6	0.0	0.6	23	75	25
Senegal	5,169	110.0	2.3	2.1	0.8	1.3	48	64	36
Greece	10,678	38.8	2.2	2.5	1.1	1.4	17	62	38
Norway	10,559	74.3	9.3	6.7	4.9	1.9	8	83	17
Sweden	4,492	382.0	2.4	2.5	0.3	2.3	160	51	49
Poland	8,872	174.0	2.7	3.9	1.1	2.8	65	49	51
Peru	38,654	61.6	12.9	6.5	3.6	2.9	5	82	18
Jordan	81,222	479.0	78.9	12.6	9.3	3.3	6	96	4
Pakistan	26,087	1913.0	19.3	5.4	2.0	3.5	99	85	15
Chile	4,999	0.9	0.9	4.1	0.0	4.0	1	19	81
Venezuela	146,405	246.8	172.6	9.8	4.9	4.8	1	97	3
Israel	15,156	922.0	24.7	6.2	1.3	4.9	37	83	17
Portugal	23,493	1233.0	9.1	6.6	1.0	5.6	136	62	38
Nigeria	6,115	1.8	1.8	6.8	0.7	6.1	1	23	77
Morocco	10,336	68.7	8.5	9.7	3.1	6.6	8	56	44
Turkey	123,179	286.2	10.3	6.7	0.0	6.7	28	60	40
Spain	30,184	29.0	12.6	8.6	1.4	7.1	2	64	36
Algeria	67,329	211.6	42.0	14.3	6.9	7.5	5	85	15
United Kingdom	40,016	111.5	36.0	29.0	20.7	8.3	3	81	19
Egypt	30,429	11.7	5.7	10.1	0.1	10.0	2	36	64
China	59,522	147.0	15.6	24.8	9.2	15.6	9	50	50
Rep. of Korea	70,512	57.3	55.3	24.8	9.2	15.6	1	78	22
Netherlands	1,262,645	2840.0	554.1	46.7	22.4	24.4	5	96	4
Mexico	46,839	69.7	25.5	31.5	1.3	30.2	3	46	54
Italy	15,908	91.0	8.9	60.6	26.7	33.9	10	21	79
Japan	99,927	457.2	73	50	14.7	34.8	6	68	32

Water avail.: water availability, Water with.: water withdrawal, VWM: green and blue virtual water imports, VWX: green and blue virtual water exports, Scar. Index: Scarcity index, SS index: Self-sufficiency index, Dep.Index: Dependency index. Source: own elaboration using trade data from United Nations Statistics Division (UN, 2013) and water footprints from Mekonnen and Hoekstra (2011, 2012). Population data stem from World Bank (2014). Water availability and withdrawal come from FAO (2014).

Table SI6: Change in virtual water exports and decomposition analysis at the country level, 1965-2010

	Green virtual water exports					Blue virtual water exports				
	VWE change (km^3)	SE (%)	CE (%)	TE (%)	IE (%)	VWE change (km^3)	SE (%)	CE (%)	TE (%)	IE (%)
Albania	0.07	115	-90	46	30	0.02	86	-41	29	26
Algeria	-1.21	-289	-20	377	31	-1.44	-267	19	321	27
Argentina	62.74	230	-53	-47	-30	1.81	270	-52	-57	-61
Australia	19.83	391	-17	-194	-81	1.45	402	24	-199	-126
Austria	3.55	90	-21	62	-31	0.11	76	12	45	-33
Barbados	-0.47	-306	2	370	34	0.00	471	517	-874	-14
Belgium-Lux.	12.16	97	-47	79	-29	0.42	83	-26	61	-18
Bolivia	5.16	50	-41	44	47	0.04	55	-42	67	20
Brazil	99.94	173	-52	63	-84	0.71	374	-341	155	-88
Bulgaria	5.01	156	-9	-48	1	0.14	117	1	-33	15
Cameroon	0.14	3982	-307	-3543	-32	0.00	152	80	-126	-5
Canada	58.77	163	-28	6	-41	3.23	76	27	2	-4
Cent. African Rep.	-2.84	-311	0	394	17	0.00	-300	-24	373	50
Sri Lanka	-0.82	-1140	-27	1126	141	0.03	73	113	-70	-15
Chile	1.89	65	-146	192	-10	0.68	95	-410	430	-16
China	5.28	492	-394	201	-199	-0.11	-2693	3190	-1204	807
Colombia	6.22	467	-58	-284	-26	0.06	178	9	-99	12
Costa Rica	5.36	207	-154	45	1	0.18	157	-64	32	-25
Czechoslovakia	5.53	394	705	1452	-2451	0.38	176	1403	558	-2037
Denmark	3.55	450	-26	-244	-80	0.17	423	-26	-228	-68
Ecuador	1.42	502	-339	-47	-17	0.26	166	-1	-13	-52
El Salvador	0.56	532	11	-444	1	0.02	424	127	-352	-100
Finland	0.76	188	-4	-24	-60	0.01	304	-81	-42	-80
France	22.63	146	-18	36	-64	1.38	127	1	29	-57
Germany	23.57	76	-15	66	-27	0.60	66	11	47	-23
Greece	1.36	364	-96	-118	-49	1.12	140	35	-39	-36
Guatemala	3.57	278	-73	-18	-87	0.15	70	88	-3	-55
Honduras	4.85	126	64	-15	-75	0.03	458	-230	-68	-61
Hungary	13.93	121	-53	40	-9	0.34	77	-14	19	18
Iceland	0.01	862	14	-745	-31	0.00	6394	-436	-5589	-269
India	40.60	113	58	0	-71	6.37	125	89	0	-114
Indonesia	88.65	60	9	54	-23	0.38	128	-235	233	-26
Ireland	2.52	175	4	-30	-49	0.16	181	4	-31	-54
Israel	0.38	137	41	-65	-12	0.59	175	27	-87	-14
Italy	12.62	89	12	24	-25	1.54	101	-8	29	-22
Japan	0.11	599	-39	-350	-111	0.00	1098	-42	-655	-301
Jordan	0.06	48	-804	832	24	0.03	43	-90	99	48
Rep. of Korea	1.10	67	9	62	-38	0.02	139	-226	223	-36
Madagascar	-1.72	-355	-16	459	12	0.11	254	338	-573	81
Malawi	-0.82	-538	14	480	143	0.02	1119	197	-968	-248
Malaysia	41.66	52	11	61	-24	0.09	119	-418	433	-34
Malta	0.00	-3553	-900	5238	-684	-0.01	-276	67	318	-9
Mexico	2.16	1422	-666	-522	-134	-0.19	-5753	2857	2171	825
Morocco	0.19	2339	-512	-1706	-21	0.03	1620	-204	-1177	-139
Netherlands	27.98	116	-39	48	-25	1.82	119	-44	50	-25
New Zealand	10.63	262	10	-141	-31	0.73	284	-5	-154	-25
Nicaragua	2.22	392	57	-225	-124	0.06	118	44	-57	-5
Nigeria	0.15	418	-639	289	32	0.02	74	-26	27	25
Norway	0.07	610	78	-464	-124	0.00	-3127	245	2466	516
Pakistan	0.20	2554	214	-2082	-587	0.37	2889	350	-2357	-782
Paraguay	20.43	56	2	53	-10	0.11	62	-73	75	36

Peru	1.72	265	0	-121	-44	-0.52	-405	256	221	28
Philippines	1.42	1578	-116	-1147	-216	-0.19	-322	137	252	33
Poland	7.76	153	-18	12	-47	0.15	225	-74	20	-71
Portugal	2.73	83	-17	20	14	0.93	63	-1	11	27
Romania	5.74	215	-14	-58	-42	0.20	176	5	-46	-35
Senegal	-2.30	-305	7	397	1	0.00	122	460	-502	20
Singapore	-14.84	-267	20	336	11	-0.25	-264	33	321	10
Spain	19.45	96	-25	50	-21	7.30	80	3	36	-19
Sudan	-1.63	-373	28	426	19	-1.45	-394	23	452	19
Sweden	0.63	398	-93	-150	-55	0.01	424	-130	-160	-33
Switzerland	0.24	143	-83	79	-40	0.01	136	-60	74	-50
Thailand	20.63	173	-106	59	-26	3.10	129	-25	39	-43
Togo	-0.02	-3727	3	4047	-223	0.00	109	71	-130	50
Trinidad Tobago	-0.67	-269	40	317	11	-0.02	-265	31	310	23
Tunisia	3.54	212	41	-124	-29	0.19	509	-68	-320	-22
Turkey	3.14	186	-32	-40	-13	-1.44	-486	377	136	73
Fmr USSR	101.21	62	-17	90	-35	3.59	54	13	58	-25
Egypt	0.31	187	44	-94	-36	-0.60	-1351	504	805	142
United Kingdom	6.88	127	-52	57	-33	0.13	511	-619	301	-92
USA	85.83	350	-64	-94	-92	13.46	281	-37	-74	-70
Uruguay	5.26	155	-35	13	-33	0.44	79	89	5	-73
Venezuela	-1.00	-332	23	371	38	-0.11	-279	35	307	38
Fmr Yugoslavia	1.65	887	-270	-445	-72	-0.03	-902	274	481	247

VWE change: change in virtual water exports (km^{3}), SE: Scale effect (%), CE: Composition effect (%),TE: Trade share effect (%), IE: Intensity effect (%). Source: own elaboration using trade data from United Nations Statistics Division (UN, 2013) and water footprints from Mekonnen and Hoekstra (2011, 2012).

Table SI7: Change in virtual water imports and decomposition analysis at the country level, 1965-2010

	Green virtual water imports						Blue virtual water imports					
	VWM change (km^3)	SE (%)	CE (%)	TE (%)	LE (%)	IE (%)	VWM change (km^3)	SE (%)	CE (%)	TE (%)	LE (%)	IE (%)
Albania	0.93	123	-96	59	52	-37	0.07	86	-36	34	41	-26
Algeria	12.87	95	19	36	-2	-47	0.91	88	25	32	-1	-43
Argentina	2.27	299	-128	-26	1	-45	-0.01	-2194	1304	222	562	206
Australia	3.87	124	-10	9	13	-37	0.45	107	20	7	1	-36
Austria	6.65	113	-7	13	545	-563	0.28	221	-117	33	795	-832
Barbados	0.07	663	-542	88	-16	-93	0.02	154	-74	15	35	-30
Belgium-Lux.	14.92	343	-72	-60	-23	-89	0.11	4623	-	-1007	-1456	-780
Bolivia	0.35	424	-112	-129	40	-124	0.02	471	79	-143	-194	-113
Brazil	10.62	289	-38	-82	25	-94	0.65	202	32	-37	-34	-63
Bulgaria	0.72	624	-605	164	28	-112	0.03	2592	-	710	-190	-325
Cameroon	1.17	66	18	9	48	-42	0.25	72	81	15	-13	-55
Canada	6.71	447	-57	-198	2	-95	1.13	397	-60	-123	-25	-89
Cent. African Rep.	0.05	142	-156	115	22	-24	0.01	65	76	21	-56	-7
Sri Lanka	2.09	395	96	-261	-49	-80	0.20	651	-67	-440	135	-180
Chile	4.80	219	23	-109	29	-61	0.05	2085	95	-1166	-508	-405
China	142.12	78	-153	137	71	-34	8.10	82	0	150	-72	-60
Colombia	10.38	69	-99	142	18	-31	0.53	82	-120	208	-34	-35
Costa Rica	1.48	100	-22	115	-52	-40	0.20	86	-31	90	-8	-37
Czechoslovakia	2.86	479	-344	52	664	-751	-0.65	-438	466	-53	-55	180
Denmark	3.25	517	-20	-236	-63	-98	0.06	1879	63	-894	-680	-268
Ecuador	2.88	68	11	35	12	-26	0.14	93	8	65	-30	-35
El Salvador	1.46	168	-71	96	-47	-45	0.24	79	-6	31	35	-40
Finland	0.92	916	-313	-307	7	-204	-0.06	-881	496	232	141	113
France	8.39	904	-648	50	-60	-146	-0.33	-3291	2982	-403	312	500
Germany	63.41	74	72	23	15	-85	3.63	87	46	39	16	-88
Greece	5.95	170	-167	143	1	-47	0.19	567	-867	591	-83	-108
Guatemala	2.26	91	8	65	-35	-29	0.33	62	28	31	10	-30
Honduras	1.14	97	-9	97	-44	-41	0.23	64	0	41	29	-34
Hungary	1.52	482	-285	-22	575	-651	-0.18	-681	599	35	-231	377
Iceland	-0.01	-4536	2644	1130	89	774	0.00	-1338	1934	-984	319	169
India	43.30	53	-77	96	46	-18	0.63	221	-	1401	14	-43
Indonesia	26.92	53	-6	63	27	-37	2.22	86	-201	230	39	-53
Ireland	2.81	184	-131	106	-6	-53	0.20	219	-141	131	-50	-59
Israel	4.99	228	-30	-63	30	-65	0.30	358	-72	-104	-14	-68
Italy	22.64	561	-84	-222	-24	-131	1.11	796	-204	-321	-44	-127
Japan	22.07	649	-127	-279	-10	-133	-1.21	-1538	688	705	-3	247
Jordan	3.41	166	-170	142	-1	-37	0.28	290	-399	282	-17	-56
Rep. of Korea	29.36	73	-34	73	31	-43	1.86	121	-136	177	-10	-52
Madagascar	0.27	340	-633	497	-44	-60	0.20	133	-224	142	135	-86
Malawi	0.17	102	106	-49	-3	-55	0.00	175	58	-84	11	-60
Malaysia	5.90	962	-168	-621	49	-122	0.46	571	-287	-42	-32	-109
Malta	-0.01	-	51498	-39491	-7744	10303	0.03	346	-	1529	246	-237
Mexico	39.75	47	19	57	7	-30	4.95	48	21	63	-2	-30
Morocco	8.15	139	-213	225	12	-63	0.54	128	-107	129	-12	-38
Netherlands	35.29	297	-90	-29	-1	-77	0.54	1395	-622	-143	-221	-309
New Zealand	2.07	153	-69	34	21	-40	0.12	374	-267	108	-33	-82
Nicaragua	0.64	156	-110	131	-30	-47	0.13	105	-69	73	29	-39
Nigeria	9.94	58	-3	58	25	-38	0.99	51	107	36	-58	-37
Norway	-0.56	-1956	583	1134	-32	371	-0.05	-1067	405	469	117	176
Pakistan	41.66	43	16	30	42	-32	4.28	44	-55	83	81	-53
Paraguay	0.14	719	-1361	823	52	-132	0.03	115	-47	85	-29	-24
Peru	5.08	234	6	-81	-8	-51	0.24	318	43	-113	-47	-101
Philippines	11.53	120	-5	17	11	-43	0.72	265	-133	46	5	-83
Poland	6.43	344	-149	-18	198	-275	-0.34	-954	686	57	-59	370
Portugal	10.16	106	-62	99	2	-45	1.58	103	-93	99	25	-34

Romania	7.01	58	7	22	36	-23	0.03	3823	-	4166	-920	-469
Senegal	1.59	220	-170	112	4	-66	0.34	198	-161	108	39	-84
Singapore	6.69	238	-43	-61	14	-48	0.12	1352	-611	-476	78	-242
Spain	28.01	147	-3	8	1	-54	1.94	178	-61	22	-9	-30
Sudan	2.91	142	-12	22	-6	-47	0.29	143	-31	35	1	-47
Sweden	0.07	22122	-3455	-13412	-1336	-3819	0.03	2836	-208	-1890	-296	-342
Switzerland	-1.76	-1026	281	702	-23	165	-0.62	-402	236	169	54	44
Thailand	13.60	57	37	6	47	-48	1.11	69	60	0	26	-56
Togo	0.99	52	-8	36	51	-30	0.18	50	38	36	27	-50
Trinidad Tobago	0.30	497	-199	-112	6	-93	0.04	237	-37	-44	2	-59
Tunisia	5.06	117	-15	24	18	-44	0.37	111	-22	24	27	-40
Turkey	22.39	54	-67	98	49	-34	2.58	52	107	79	-107	-31
Fmr USSR	58.37	51	-79	97	59	-27	2.60	127	-833	854	0	-48
Egypt	27.31	145	-53	46	13	-51	1.28	197	-94	67	-17	-53
United Kingdom	-13.43	-863	94	733	31	105	-2.18	-626	71	535	48	73
USA	28.55	601	-209	-206	23	-110	2.27	522	-119	-177	-45	-81
Uruguay	4.11	70	-44	93	2	-21	0.03	303	-954	819	4	-71
Venezuela	12.63	99	-14	36	-2	-20	0.58	153	-10	64	-60	-48
Fmr Yugoslavia	7.23	96	-3	84	-7	-69	0.19	272	-367	420	-127	-98

VWM change: change in virtual water imports (km^{3}), SE: Scale effect (%), CE: Composition effect (%), LE: localization effect (%), TE: Trade share effect (%), IE: Intensity effect (%). Source: own elaboration using trade data f from United Nations Statistics Division (UN, 2013) and water footprints from Mekonnen and Hoekstra (2011, 2012).

Figure SI1: Country net exports of blue water and top five net flows in the world, 1980. Source: own elaboration using trade data from United Nations Statistics Division (UN, 2013) and water footprints from Mekonnen and Hoekstra (2011, 2012).

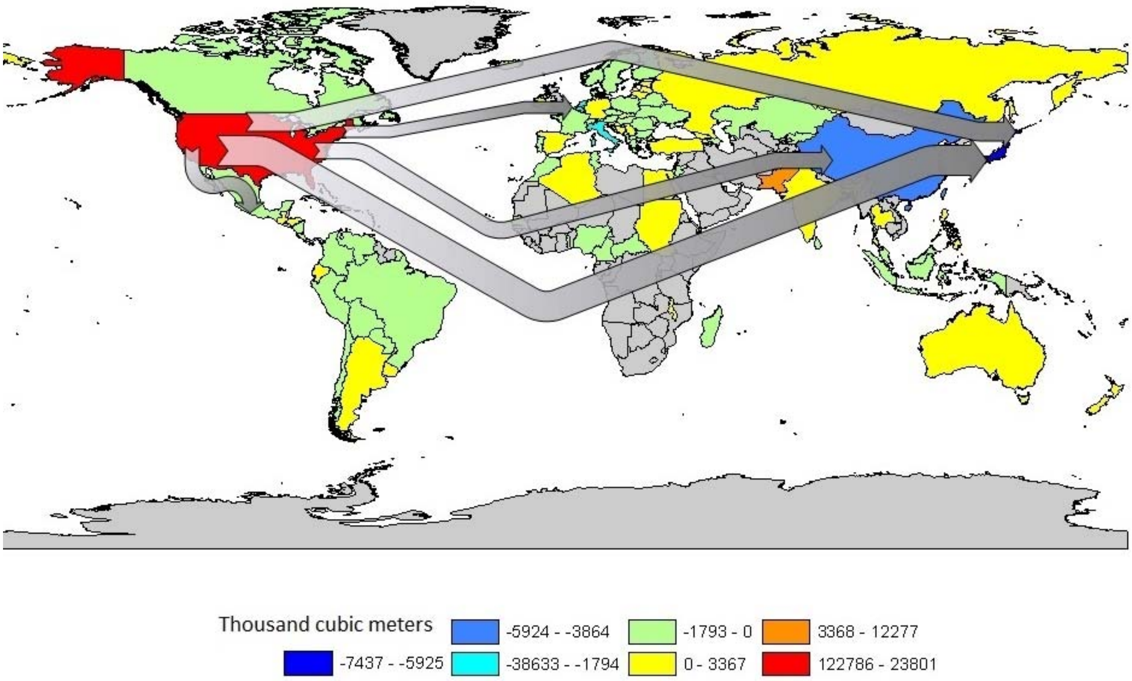


Figure SI2: Country net exports of green water and top five net flows in the world, 1965. Source: own elaboration using trade data from United Nations Statistics Division (UN, 2013) and water footprints from Mekonnen and Hoekstra (2011, 2012).

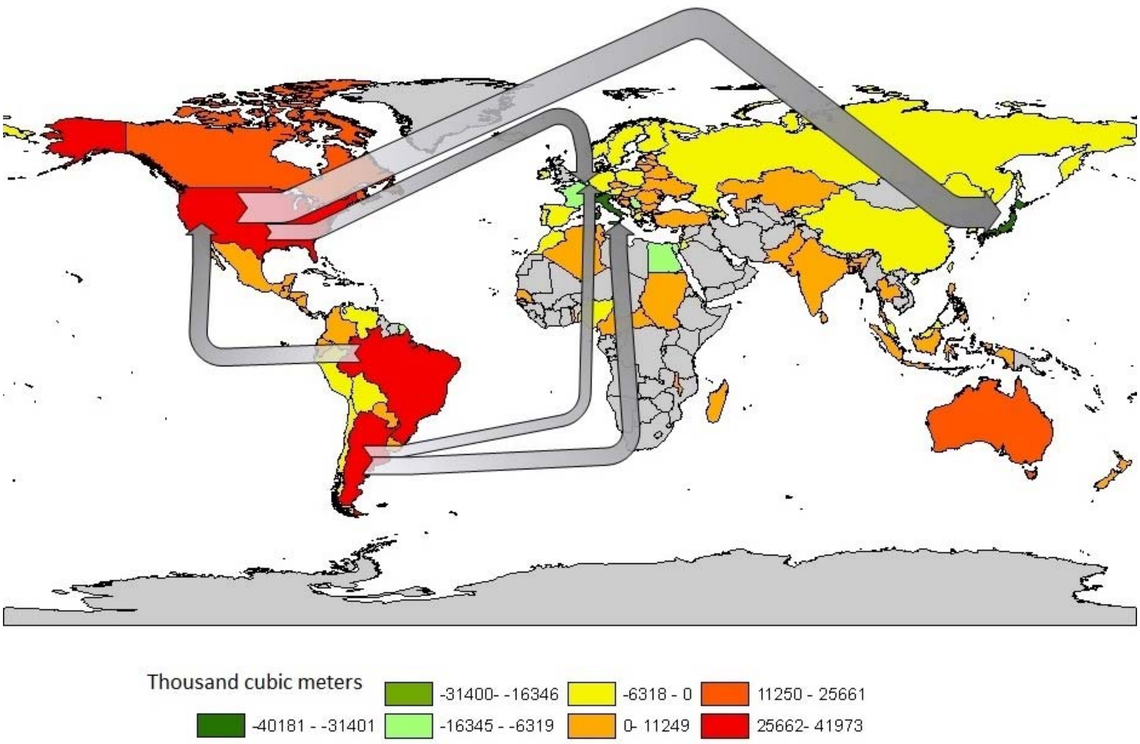


Figure SI3: Country net exports of green water and top five net flows in the world, 1980. Source: own elaboration using trade data from United Nations Statistics Division (UN, 2013) and water footprints from Mekonnen and Hoekstra (2011, 2012).

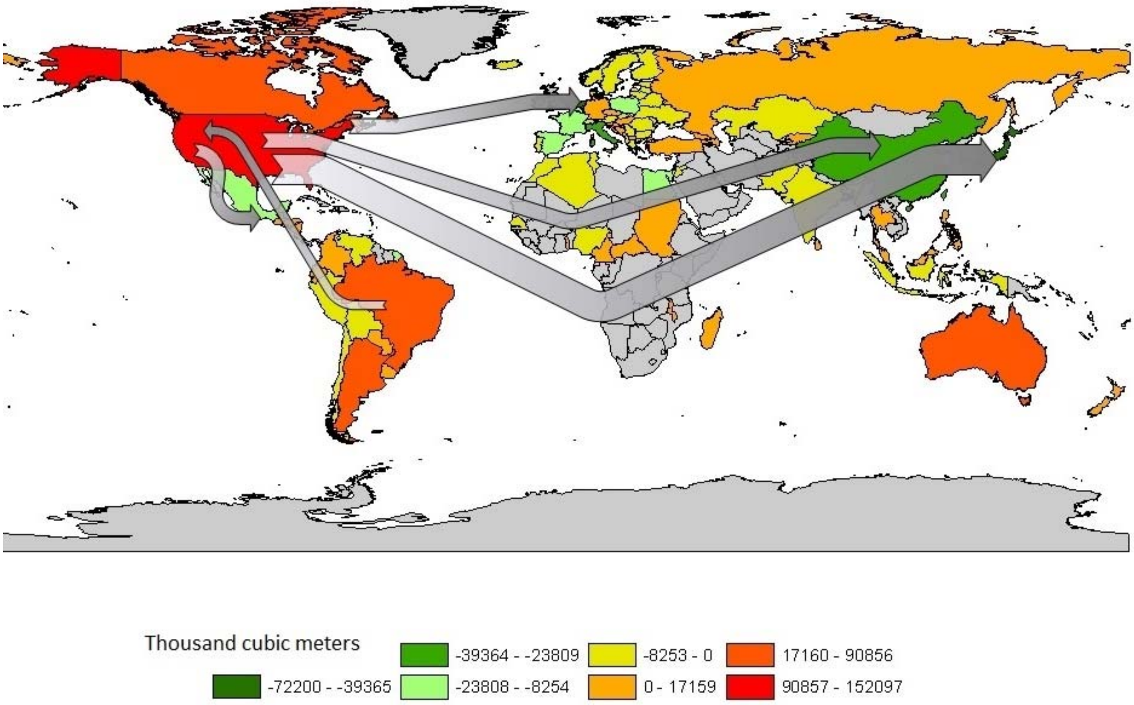
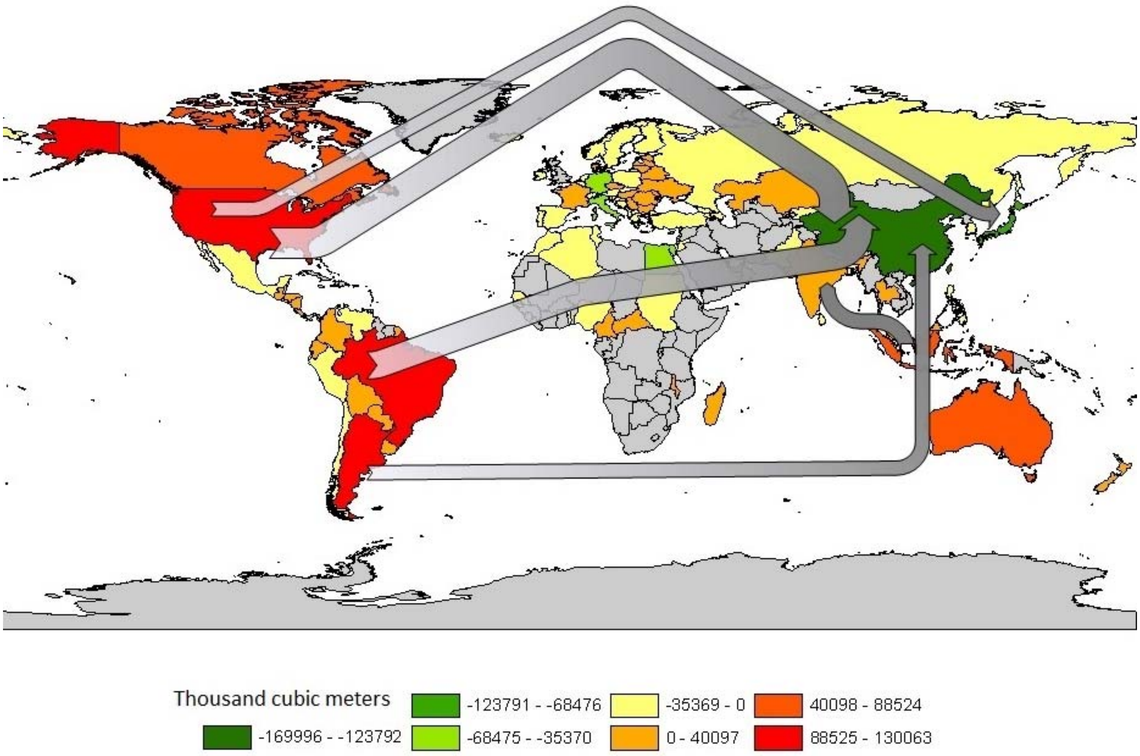


Figure SI4: Country net exports of green water and top five net flows in the world, 2010. Source: own elaboration using trade data from United Nations Statistics Division (UN, 2013) and water footprints from Mekonnen and Hoekstra (2011, 2012).



List of products

SITC rev. 1	Group	Product
00	Live animals	Bovine cattle including buffaloes Sheep,lambs and goats Swine Poultry,live Horses,asses,mules and hinnies
01	Meat and meat preparations	Meat of bovine animals,fresh,chilled or frozen Meat of sheep & goats, fresh, chilled or frozen Meat of swine,fresh,chilled or frozen Meat of horses,asses,mules & hinnies,fr.ch.fro. Edible offal of animals,fresh,chilled,frozen Bacon,ham & other dried,salted,smoked pig Meat & edible offal. Dried,salted,smoked Other prepared or preserved meat
02	Dairy products and eggs	Milk & cream evaporated or condensed Milk & cream in solid form,blocks or powder Milk & cream fresh Butter Cheese and curd Eggs
04	Cereals and cereal preparations	Wheat and meslin,unmilled Rice in the husk or not,not further prepared Rice, glazed or polished, not further prepared Barley, unmilled

		Maize corn unmilled Rye,unmilled Oats,unmilled Cereals,unmilled,nes Malt including malt flour Flour of wheat or of meslin Meal & groats of wheat or of meslin Cereal flours exc.of wheat or of meslin Cereal meal & groats exc. Of wheat or meslin Cereal grains,rolled,flaked,polished
05	Fruits and vegetables	Oranges, tangerines and clementines Other citrus fruit Bananas including plantains ,fresh Apples, fresh Grapes,fresh Fruit juices & vegetable juices,unfermented Potatoes, fresh, not including sweet potatoes Beans,peas,lentils & leguminous vegetab.,dried Tomatoes, fresh Other fresh vegetables Vegetables,dehydrated excl.leguminous vegetab. Other edible nuts,fresh or dried Pears & quinces,fresh Stone fruit,fresh Berries,fresh Tropical fruit other than bananas,fresh Other fresh fruit Tropical fruit,dried Figs,dried Grapes,dried (raisins) Other dried fruit Fruit pres. By freezing, not cont. Added sugar Fruit in temporary preservative Peel of melons & citrus fruit not pres by sugar Vegetables,frozen Vegetables in temporary preservative Roots & tubers,fresh or dried,sago pith Sugar beet,fresh or dried;sugar cane Hops Vegetable products,fresh or dried,n.e.s. Flours of the fruits falling within group 051 Flour,meal & flakes of potato
06	Sugar, sugar preparations and honey	Raw sugar,beet & cane Refined sugar & other prod.of refining,no syrup Molasses Sugars & syrups nes incl.art.honey & caramel
07	Coffee, tea, cocoa, spices & manufacs.	Coffee,green or roasted Tea Pepper & pimento,whether or not grond Vanilla Cinnamon & cinnamon tree flowers Cloves (whole fruit,cloves & stems) Nutmeg,mace & cardamons Seeds of anise,badian,fennel,coriander,cumin et Thyme,saffron,bay leaves & other spices
08	Feed. Stuff for animals excl. Unmilled	Oil seed cake & meal & other veg. Oil residues
09	Miscellaneous food preparations	Other miscellaneous food preparations
11	Beverages	Cider & fermented beverages,nes Beer including ale,stout,porter Distilled alcoholic beverages Grap must,in fermantation or with

		Wine of fresh grapes, grape must Vermouths & other wines of fresh grapes
12	Tobacco	Tobacco,unmanufactured & scrap
21	Hides, skins and fur skins, undressed	Bovine & equine hides excl. Calf & kip skins Calf skins and kip skins Goat skins and kid skins Sheep and lamb skins, with the wool on Sheep and lamb skins, without the wool
22	Oil seeds, oil nuts and oil kernels	Groundnuts peanuts green, ex.flour and meal Copra, ex.flour and meal Palm nuts & kernels Soya beans Linseed Cotton seed Castor oil seed Oil seeds,oil nuts & oil kernels,nes Flour & meal of oil seeds,nuts,kernels, fat
26	Textile fibres, not manufactured, and	Raw cotton, other than linters Cotton linters Cotton waste, not carded or combed Cotton,carded or combed Jute & waste Flax and flax tow and waste True hemp and true hemp tow and waste Sisal and other fibres of the agave family Manila fibre and manila tow and waste Vegetable textile fibres,nes and waste Horsehair & other coarse hair,not
29	Crude animal and vegetable materials, nes	Bristles and brush making hair & their wastes
42	Fixed vegetable oils and fats	Soya bean oil Cotton seed oil Groundnut /peanut/ oil Olive oil Sunflower seed oil Rape,colza and mustard oils Linseed oil Palm oil Coconut copra oil Palm kernel oil Castor oil Fixed vegetable oils,nes
51	Chemical elements and compounds	Sugars,chem.pure excl.sucrose glucose lactose
59	Chemical materials and products, nes	Starches and inulin Gluten and gluten flour
61	Leather, lthr. Manufs., nes & dressed fur	Calf leather Leather of other bovine cattle & equine leather Leather of sheep and lamb skins Leather of goat and kid skins Other leather

List of countries

Albania, Algeria, Argentina, Australia, Austria, Barbados, Belgium, Bolivia, Brazil, Bulgaria, Cameroon, Canada, Central African Republic, Chile, China, Colombia, Costa Rica, Croatia, Denmark, Ecuador, Egypt, El Salvador, Finland, Former Czechoslovakia, Former USSR, Former Yugoslavia, France, Germany, Greece, Guatemala, Honduras, Hungary, Iceland, India, Indonesia, Ireland, Israel, Italy, Japan, Jordan, Luxembourg, Madagascar, Malawi, Malaysia, Malta, Mexico, Morocco, Netherlands, New Zealand, Nicaragua, Nigeria, Norway, Pakistan, Paraguay, Peru, Philippines, Poland, Portugal, Republic of Korea, Romania, Senegal, Singapore, Slovenia, Spain, Sri Lanka, Sudan, Sweden, Switzerland, Thailand, Togo, Trinidad and Tobago, Tunisia, Turkey, United Kingdom, Uruguay, USA, Venezuela.