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Content

Virtual Water in The Rural Sector of Argentina, Brazil, Paraguay and Uruguay and its Potential Impact on Global Water Security

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Summary

There are strong links between water, agriculture and the economy in the ABPU region (Argentina, Brazil, Paraguay and Uruguay). Even more, agriculture is a significant economic sector for this region with some being major world players in the agricultural commodities world markets, such is the case for Brazil and Argentina who contribute to 13% of the global green water export. Virtual water (VW) was used as an indicator to estimate the total volume of freshwater that is used to produce goods and services consumed and traded by a nation as result of activities within the different sectors of the economy, in this case agriculture. The consumptive water use of agricultural production was on average 696.5Gm^3/yr (or billion m^3/yr) for the period 1996-2005; of which, 94% corresponds to the green VW (water from soil moisture and rain), whereas 3% refers to the blue component (water for irrigation). Grazing represents 25% of the total green VW of agriculture production in these countries. The remaining 75% belongs to crop production, with a large share destined to soybean production. This indicates that ABPU relies heavily on green water for agricultural production, i.e. rain-fed agriculture. The incidence of irrigation is not important in the ABPU region.

Concerning agricultural products, the ABPU region has been a net exporter of green (182.7 Gm^3/yr) with negligible amounts of blue (1.9 Gm^3/yr) VW. Besides, all ABPU countries show high national water self-sufficiency (91%), defined as the ratio of the internal to the total VW of national consumption. This means that these countries use their own available resources to supply most of the agricultural products consumed by their inhabitants. Under this view, ABPU agricultural production significantly contributes to the water security of destination countries of its exports (mainly Asian and European countries). Most of the VW is provided by Brazil through traded meat. Thus, mainly green, but also blue water plays a significant role for ABPU economies and for food security. Sustainable water management should not be seen as a barrier for the development of the region, but rather as the way to develop and grow as a region.

Introduction

Human activities consume and pollute a lot of water. The sustainable use of water as a vital resource is one of the major global challenges of the 21st century. At a global scale, most of the water use occurs in agricultural production: approximately 70% of the freshwater used worldwide is used for irrigation. Also there are substantial water volumes consumed and polluted in the industrial and domestic sectors (WWAP, 2009). The ABPU region is relatively well endowed with water resources. However, the spatial and temporal variability of water, coupled with rapid urbanization and inadequate water governance is putting considerable pressure on the available water resources (Zárate, 2014). Until the recent past, there have been few thoughts in the science and practice of water management about consumption and pollution during the production process.

The VW of national production is defined as the total freshwater volume consumed or polluted within the territory of the nation as a result of activities within the different sectors of the economy (Hoekstra and Mekonnen, 2012). VW trade (also known as trade in embedded or embodied water) refers to the hidden flow of water if food or other commodities are traded from one place to another. Freshwater is increasingly becoming a global resource, driven by growing international trade in water-intensive commodities. Apart from regional markets, there are also global markets for water-intensive goods such as crop and livestock products, natural fibers and bio-energy. As a result, use of water resources has become spatially disconnected from the consumers. Hoekstra and Chapagain *et al.* (2008) have shown that visualizing the hidden water use behind products can help in understanding the global character of fresh water and in quantifying the effects of consumption and trade on water resources use. The improved understanding can form a basis for a better management of the globe's freshwater resources.

Within this framework, in a previous GPS report (Viglizzo and Ricard, 2015) the issue of greenhouse gases (GHG) emission, global warming, food and VW exports from the ABPU (Argentina, Brazil, Paraguay and Uruguay) region to China and European Union was undertook. In this new report current figures and trends of VW management from the perspective of the agricultural sector are analyzed by: providing a broad review of several water-agricultural related issues, virtual water trade and water availability of ABPU and discussing the capacity of the region to ensure global water security.

On Methods

In this report, VW was used as a multidimensional indicator to calculate the total volume of freshwater that is used to produce goods and services consumed and traded by a nation (Hoekstra *et al.*, 2011). The blue VW refers to consumption of blue water resources (surface and groundwater) of a product. The green VW refers to consumption of green water resources (rainwater insofar as it does not become run-off). The grey VW refers to pollution and is defined as the volume of freshwater that is required to assimilate the load of pollutants given natural background concentrations and existing ambient water quality standards. The grey VW data used refer to the nitrogen pollution alone and are based on Mekonnen and Hoekstra (2011), who estimated it based on nitrogen leaching-runoff from fertilizer use.

In this context, the accounting is applied from two perspectives: the VW of agricultural production and the VW of agricultural consumption. The first one, related to agricultural production, refers to the total freshwater volume consumed or polluted (blue, green and grey VW) of all the agricultural processes (crop and livestock production), taking place within the political borders of the country as a result of activities within the different sectors of the economy (Hoekstra *et al.*, 2011; Zárate *et al.*, 2014). The VW of agricultural consumption refers to the quantification of the water consumed and polluted to produce the agricultural products consumed by the population of a country. It national consumption consists of two components: the internal (water volume consumed by the population of the country) and external VW (water volume exported and used in other nations) (Zárate *et al.*, 2014).

This work was based on the analysis of secondary sources of data provided by FAOSTAT (FAO, 2016a), AQUASTAT (FAO, 2016b), World Bank (2016), and Water Footprint Network (WFN, 2016). Given that these global organizations have standardized and unified statistical estimates for all countries in the world, we considered that those data sources were more suitable to this assessment than those independently collected and published by each country in the region. Then, these databases were processed together with those available from Mekonnen and Hoekstra (2011) to address the specific objectives of this work.

Background

In ABPU region, agricultural production has notably increased during the last years, with Brazil expanding production by more than 70 % (Zárate *et al.*, 2014). This region as a whole is increasingly becoming a major source of agricultural commodities for the world market and thus influencing food security. As such, improving resource management in the region promises to have important benefits for both the inhabitants of ABPU and the world. Agriculture is essential to food security. However, food production requires substantial amounts of water, both stored in the soil as soil moisture from rain (green water) and as water for irrigation (blue water). ABPU values are even higher than the global share. In this region, the VW related to agricultural production takes the largest share in the total VW within the country. About 97% of VW is related to agricultural production (696.5 Gm^3/yr), whereas 2% and 1% correspond to the domestic and industrial sectors, respectively (Table 1). The highest amount of agricultural water use is recorded in Brazil (464 Gm^3/yr) which reaches 67% of the total consumed in the region (Table 1). Uruguay has the lowest agricultural VW use with a share of 2% (12.6 Gm^3/yr) (Table 1).

Table 1. Virtual water (VW) of production in ABPU countries (in cubic gigameters per year and % of total VW) (average 1996-2005)

	VW Agricultural production ([Gm^3/yr] [%])	VW Industrial production ([Gm^3/yr] [%])	VW Domestic water supply ([Gm^3/yr] [%])	Total VW (Gm^3/yr)
Argentina	186.2 (97.4%)	1.6 (0.9%)	3.2 (1.7%)	191.1
Brazil	464.0 (96.3%)	8.0 (1.7%)	9.7 (2.0%)	481.7
Paraguay	33.7 (99.6%)	0.03 (0.1%)	0.09 (0.3%)	33.8
Uruguay	12.6 (99.1%)	0.04 (0.3%)	0.08 (0.6%)	12.7
ABPU	696.5 (96.8%)	9.7 (1.4%)	13.1 (1.8%)	719.4

Source: *Data fromMekonnen and Hoekstra (2011)*

Water Withdrawal in ABPU Agricultural Production

Quantifying actual crop water consumption is crucial to understand real water needs for agriculture. The consumptive water use of agricultural production (crops and livestock) for the ABPU region (green and blue VW), was on average 674.87 Gm^3/yr for the period 1996-2005, corresponding to 9% of the global VW of agricultural production (Table 2). Of these 674.87 Gm^3, 94% corresponds to the green component of the VW (656,51 Gm^3/yr), whereas only 3% corresponds to the blue component (18.36 Gm^3/yr) (Table 2). The major proportion of green and blue VW of this region belongs to crop production with 75 and 77%, respectively (estimated from Mekonnen and Hoekstra, 2011). The remaining ratio of green (25%) and blue (23%) VW is used for grazing and animal water supply, respectively (estimated from Mekonnen and Hoekstra, 2011). Brazil accounts for 66% of the total (green and blue) VW of the region, followed by Argentina (27%), Paraguay (5%) and Uruguay (2%) (Table 2). This data points towards two fundamental issues: (i) ABPU relies heavily on green water (94%) for agricultural production, i.e. rain-fed agriculture; (ii) Brazil and Argentina alone account for 93% (629.33 Gm^3/yr) of agricultural water consumption in ABPU.

This provides an indication of the global significance of these two countries in terms of agricultural water consumption and VW trade.

Table 2. Green, blue and grey agricultural VW of ABPU region for the period 1995-2006.

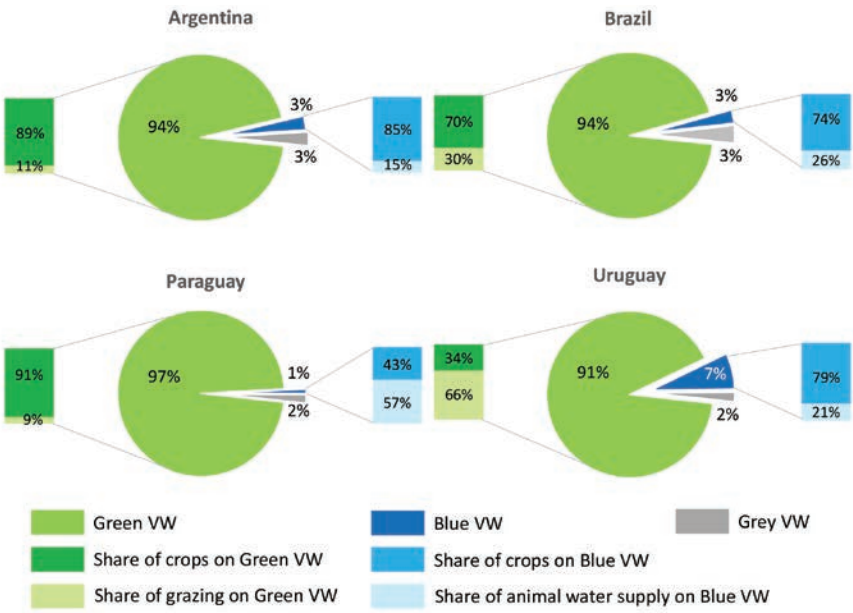
	Green VW (Gm^3/yr)	Blue VW (Gm^3/yr)	Grey VW (Gm^3/yr)
Argentina	176.19	5.08	4.96
Brazil	435.97	12.09	15.92
Paraguay	32.85	0.31	0.54
Uruguay	11.50	0.88	0.23
ABPU	656.51	18.36	21.65
World	6684.06	945.05	733.18

Source: *Data from Mekonnen and Hoekstra (2011)*

Irrigated areas in ABPU region increased steadily during the 20th century and particularly from the 1950s onwards (FAO, 2016). These increases are, however, modest in comparison to Asia and sub-Saharan Africa. Indeed, the proportion of area under irrigation in these countries is negligible, with values of 0.8, 0.6, 0.3 and 1.5% for Argentina, Brazil, Paraguay and Uruguay, respectively. The total blue VW of agricultural production in the region is 18.36 Gm^3/yr (Table 2). Brazil has by far the largest irrigated area with over 3.2 million hectares (FAO, 2016) and the biggest contribution (12.09 Gm^3/yr or 66%) to ABPU blue agricultural VW (Table 2). Is followed by Argentina (27%), Uruguay (5%) and Paraguay (2%) (Table 2). Brazil and Argentina occupy together 95% of the ABPU area and therefore contribute with a significant blue VW. These data show that most food is produced by rain-fed agriculture in ABPU. The irrigation potential for the region is estimated at 4.7 million hectares (FAO, 2016). Most of the regional irrigation potential (96%) is located in Argentina and Brazil (estimated from FAO, 2016).

Figure 1 shows the differences in agricultural VW partitions of each ABPU country. Green water ranges from 91 to 97% of total VW. The percentages of blue oscillate only between 3 and 7% (Figure 1). ABPU primarily produce for world markets under rain-fed conditions, indicating an increased use of green water instead of blue water. In general, the largest proportion of green water is allocated to crops with higher values in Argentina and Paraguay (89 and 91%, respectively). On the contrary, two thirds of green agricultural VW is destined to grazing cattle in Uruguay. The proportion of blue water used for crop, although insignificant in absolute terms, is also higher in most countriesin relation to the total blue water used (between 74 and 85%), except in Paraguay, where the main uses are for animal water supply. In all countries the proportion of grey water was very low.

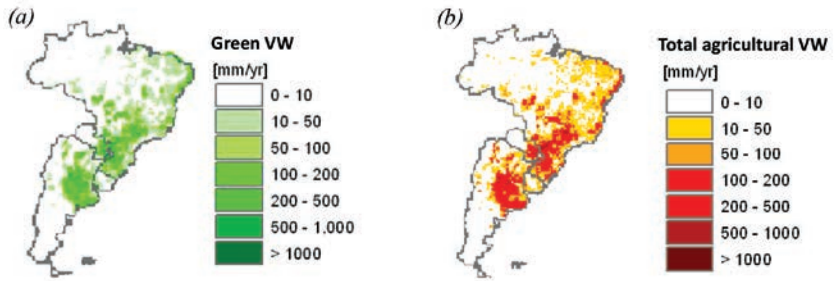
Figure 1. Partition of VW provided by agricultural products in the ABPU countries. Average period 1996-2005.



Source: *Data from Mekonnen and Hoekstra (2011).*

The spatial distribution of the green and total VW of agricultural production (crop and livestock) within ABPU nations is shown in Figure 2. VW density overlaps with core areas of dense cultivation.This Figure confirms the idea that the total VW used for agriculture also spatially corresponds with the increased use of green water throughout the region.

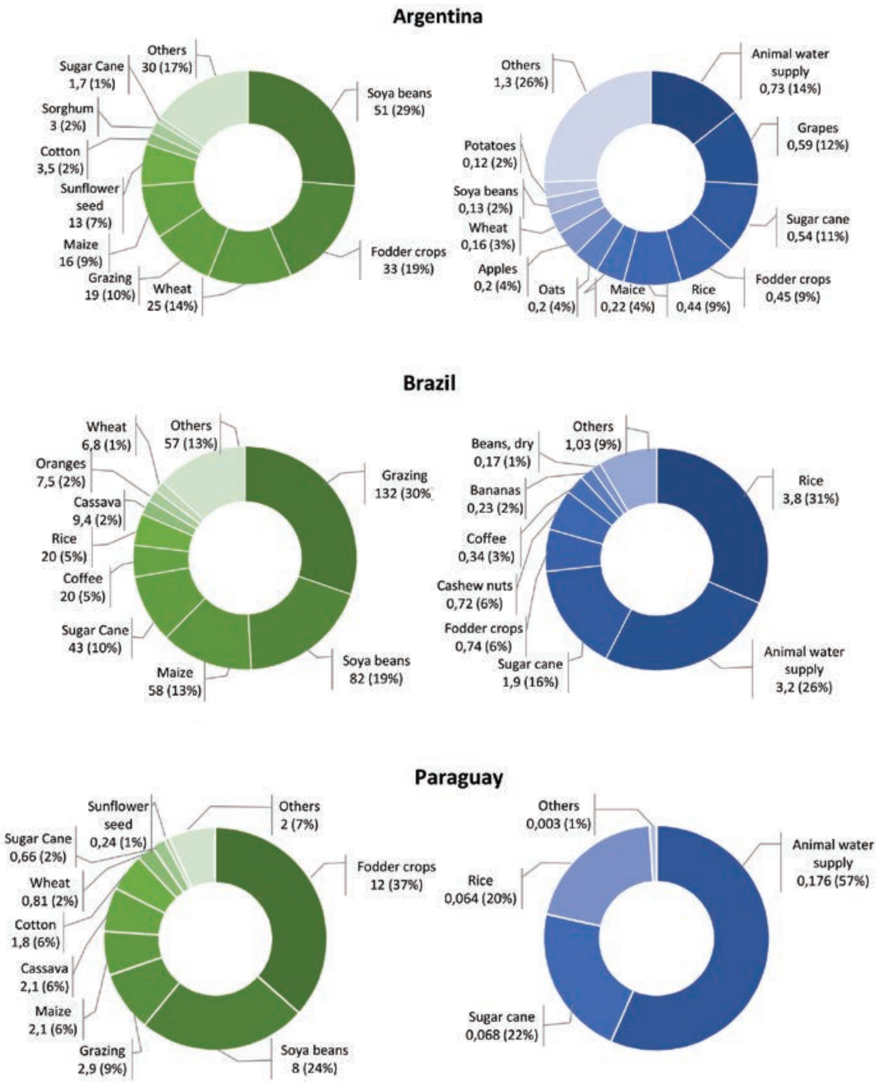
Figure 2. The green (a) and total VW provided by agricultural products (b) in the ABPU region at a 5x5 arc minute resolution. Average period 1996-2005.



Source: *modified from Hoekstra and Mekonnen (2012).*

Figure 3 shows the distribution of agricultural green and blue VW for Argentina, Brazil, Paraguay and Uruguay, according to their main agricultural uses. Soybean is a fundamental crop in ABPU countries. It represents 21% of the total agricultural (green and blue in a lesser extent). The estimated VW used by this crop in the four countries amounts 141.5 Gm^3/yr. Soybean is especially important in Argentina, Brazil and Paraguay. Maize is another important crop, with a share of 11% (76.6 Gm^3/yr) of the total agricultural VW, followed by wheat and rice with 5 and 4%, respectively. Sunflower, sorghum, cotton and sugar cane are also important crops for these countries with different participations in each one. Grazing contributes significantly with 24% of the total green VW of the regional rural sector (161.1 Gm^3/yr). Rice, in particular, makes up a significant contribution to the blue VW, which represents 27% of total blue VW used inthe region. The consumption of blue water by livestock - an essential activity to support food security in the ABPU region - amounts 23%, or 4.2 Gm^3/yr.

Figure 3. Contribution of different crops to the total volume of water used for agricultural production (in cubic gigameters per year) in ABPU region.Average for the years 1996–2005.



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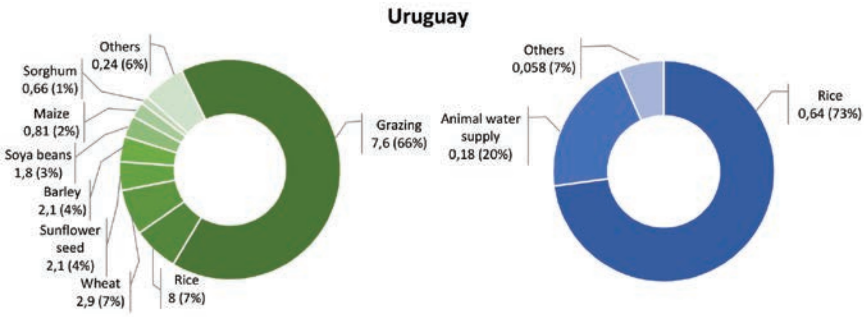


Source: *Data from Mekonnen and Hoekstra (2011) and the Water Footprint Assessment Tool (WFN, 2013).*

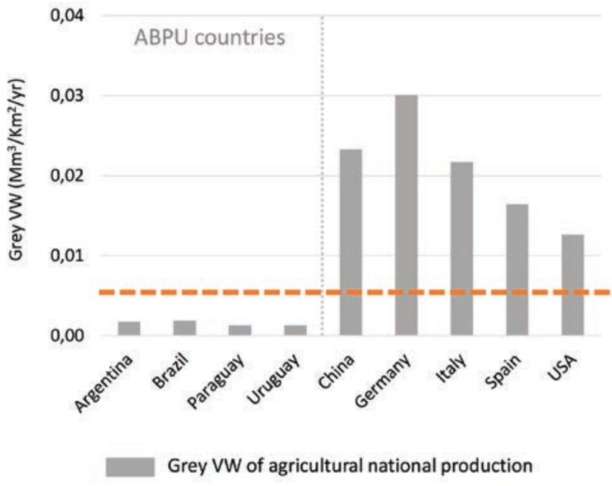
Water Quality

Water quality deserves as much attention as water quantity. Water scarcity problems are exacerbated by water quality. The most well-known effect of agriculture on water quality is chemical contamination by fertilizers and pesticides. In addition, the problem of salinity caused by irrigation is a serious constraint in Argentina and to a lesser extent, in the arid regions of northeastern Brazil (Biswas *et al.*, 2006). This section focuses on demonstrating the insignificance has the agricultural grey VW caused by nitrogen pollution in ABPU due to the use of fertilizers.

The agricultural grey VW amounted to 21.65 Gm^3/yr for the period 1996 to 2005. This value corresponds to just 3% of the total agricultural VW used in the region. Although this component of VW used in the rural sector is negligible, Brazil and Argentina are the largest contributors to the agricultural grey VW of the region. These two countries amounts 20.88 Gm^3/yr, corresponding to 96% of the agricultural grey VW in ABPU. Brazil alone already constitutes 74% of the agricultural grey VW in the region. These values are disproportionate due to the area occupied by each country.

Figure 4 shows the grey agricultural VW of different countries according to the surface of each one. When analyzing the grey VW of each ABPU country regarding the major importer of raw materials from this region, is possible to detect several aspects. On the one hand, the production systems in the four ABPU countries are much more environmentally friendly than those implemented in Asia, Europe and the USA. Even more, the volume of freshwater that is required in ABPU countries to assimilate the load of pollutants given natural background concentrations and existing ambient water quality standards is much lower than the world average. Grey agricultural WF in ABPU countries is between 62 (Brazil) and 73% (Paraguay and Uruguay) lower than the world average. Conversely, grey agricultural WF in developed countries analyzed ranges between 256% (USA) and 611% (Germany) above the world average. This means that the growing challenges of ensuring food security, environmental sustainability and limit the negative impacts of the production, position ABPU countries very favorably. The low level of grey water used by the rural sector in the ABPU region is indicative of low contamination of water sources, and this represents a comparative environmental advantage regarding other agricultural countries in el world.

Figure 4. Grey VW of agricultural production of ABPU countries and some developed countries compared to the world average (average 1996–2005).

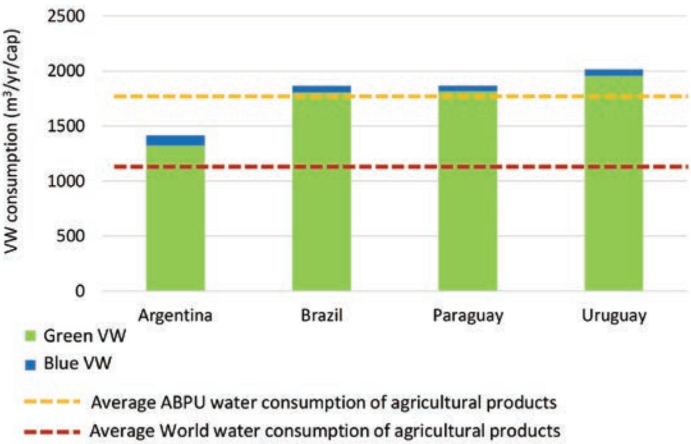


Source: *Data from Mekonnen and Hoekstra (2011).*

Water Footprint of Agricultural Products' Consumption

As Figure 5 shows, the consumption of water through agricultural products - mainly green water - in the ABPU countries exceeds that of the global average consumption (1268 m^3/capita/yr). The contribution of blue and grey water is negligible. The equivalent value for the ABPU region was 1843 m^3/capita/yr (96% green, 4% blue), with 1,790 m^3/capita/yr corresponding to the blue and green VW and 53 m^3/capita/yr to the grey VW, equivalent to 97 and 3%, respectively. Figure 5 shows that VW of agricultural products consumption range between 1454 m^3/capita/yr (91% green, 6% blue, 3/ grey) for Argentina and 2065 m^3/capita/yr (95% green, 3% blue, 2% grey) for Uruguay. Argentina besides has the highest percentage of blue water in their VW of consumption (6%). Despite this, the share of blue water in the consumption of agricultural products from these countries is low (remaining ABPU countries have values of 3%).

Figure 5. Average ABPU and world consumption of VW provided by agricultural products during the period 1996-2005.

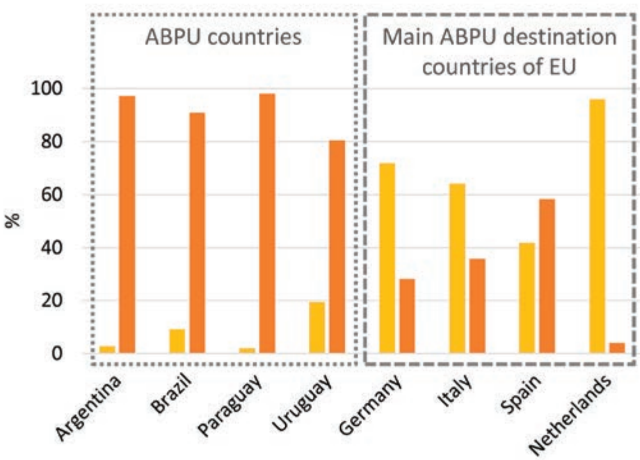


Source: *Data from Mekonnen and Hoekstra (2011).*

At this point, it is interesting to delve into the components of the VW consumption of agricultural products: (i) the internal (VW resources consumed by the population of the country) and (ii) the external (volume of water used in other nations to produce commodities consumed by the population in the nation under consideration) (Zárate *et al.*, 2014). The VW import dependency of a nation is defined as the ratio of the external to the total VW for national consumption, whereas the national water self-sufficiency is defined as the ratio of the internal to the total VW for national consumption (Zárate *et al.*, 2014).

Figure 6 shows the VW import dependency versus national water self-sufficiency of ABPU countries and some of the major importers from the region belonging to the European Union (EU). While ABPU are self-sufficient in terms of VW provision, countries like Netherlands, Germany, Italy and Spain strongly depend on ABPU countries to get VW through agricultural product import (Figure 6). VW demands the four European countries from the ABPU region range between 42% and 96% of total VW consumption. This means that these countries import most of the VW required to cover the agricultural needs of its population, showing a notable dependency on external water resources. Conversely, Argentina, Brazil, Paraguay and Uruguay have very low VW import dependency values (3, 9, 2 and 20% respectively) indicating high self-sufficiency. This means that these countries use their own available resources to supply most of the agricultural products consumed by their inhabitants. Overall, ABPU region has a high self-sufficiency averaging 91%.

Figure 6. Domestic and external dependency on VW in ABPU and some European countries (average 1996–2005).



Source: *Data from Mekonnen and Hoekstra (2011).*

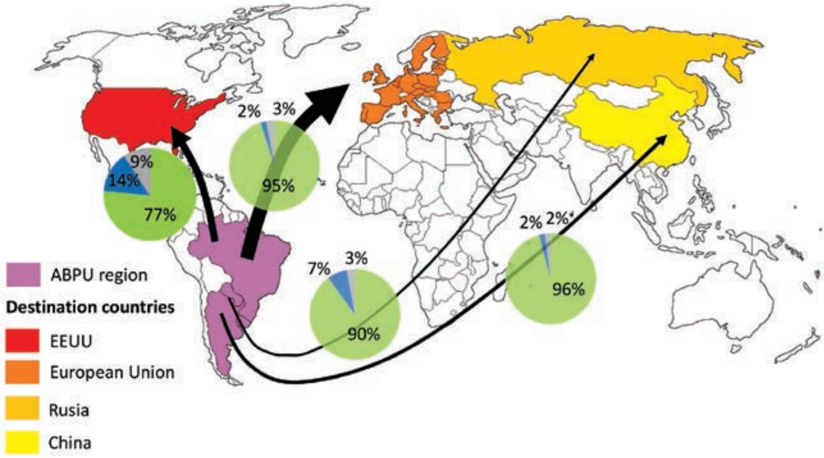
Virtual Water Flows Related to Trade of Agricultural Products

Countries can both import and export VW through their international trade relations. This enables us to map out the dependency of some economies from other economies. This has implications on food security, economy and diplomacy. In the case of water-scarce countries it may be attractive to import VW in order to deliver their own water sources to be used in activities other than those of agricultural production. In Europe as a whole, 40% of the VW lies outside of its borders (Mekonnen and Hoekstra, 2011).

Figure 7 shows the principal exports destination countries from ABPU region related to agricultural products over the period 1996-2005. The width of arrows indicates the amount of VW exported to those countries/group of countries. The greater amount of VW exported, related to crop and animal products, is made to the European Union (close to 65% or 147 Gm^3/yr). Followed in importance USA, China and Rusian Federation with 19, 11 and 5% of the total VW export from the region, respectively.

While ABPU's gross VW export to the rest of the world related to agricultural products was 228.2 Gm^3/yr (95% green, 2% blue and 3% grey) in the period 1996-2005, gross VW import was 39.8 Gm^3/yr (Table 3). These values confirm the role of ABPU as a net VW exporter of agricultural products, with an average net VW export of 188.3 Gm^3/yr during the period 1996-2005, mostly (97%) in the form of green water (Table 3). A high proportion of the net exports, around 87% (163.7 Gm^3/yr), corresponds to crops (Table 3).

Figure 7.Global map showing export-destination countries from ABPU region related to agricultural products over the period 1996-2005.



Only the biggest gross virtual water flows (over 10 cubic gigameters per year) are shown. Arrows and circles represent the proportion of VW (green, blue and grey) exported.
Source: *Data from Mekonnen and Hoekstra (2011).*

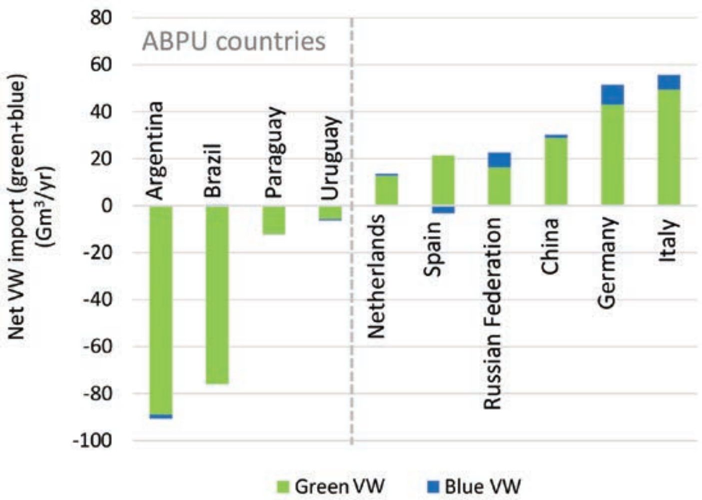
Table 3. ABPU's virtual water trade balance (Gm^3/yr) related to agricultural products. Period 1996-2005.

	Gross virtual water import			Gross virtual water export			Net virtual water imort		
	Green	Blue	Grey	Green	Blue	Grey	Green	Blue	Grey
Related to crop producs	32.8	2.3	2.2	192.5	2.8	5.6	-159.7	-0.5	-3.5
Related to animal products	2.4	0.2	0.1	25.4	1.6	0.3	-23.1	-1.5	-0.2
Total agricultural products	35.2	2.5	2.2	217.9	4.4	5.9	-182.7	-1.9	-3.7

Source: *Data from Mekonnen and Hoekstra (2011)*

Figure 8 shows VW flows related to trade of agricultural products in the ABPU region and the principal importers of ABPU's products. Negative net import of VW recorded in Argentina, Brazil, Paraguay and Uruguay implies a net outflow of VW, which means that these countries are net exporters of VW. On the contrary, Netherlands, Spain, Russian Federation, China, Germany and Italy are net importers (positive values) of virtual water, which implies a net inflow of virtual water to these countries. Italy, in particular, is the largest virtual water importer.

Figure 8. Total net imports of green and blue VW provided by agricultural products (average 1996–2005).



Source: *Data from Mekonnen and Hoekstra (2011).*

Table 4 shows the contribution of ABPU region to the global water security. Through the trade of agricultural products (crops and animal products), Argentina, Brazil, Paraguay and Uruguay provide 24% of the VW that European Union, USA, China and Russian Federation purchased in the world. Most of the VW is provided by Brazil, which amounts 48% (110.3 Gm^3/yr) of the total ABPU contribution. The most significant portion of the VW traded from ABPU region (88% or 200.9 Gm^3/yr) is related to crop products. However, each country contributes differentially to the total export of VW (see Figure 9). For example, more than half of VW exported by Uruguay (although in smaller quantities) comes from beef production.

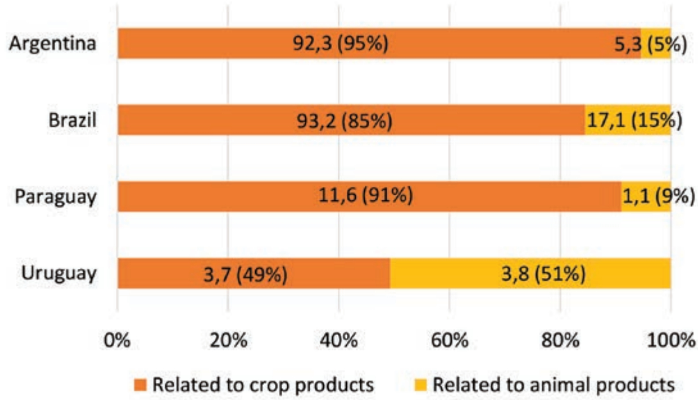
What does this mean in terms of global food and water security? The ABPU region provides EU, USA, China and Russian Federation more or less 228 Gm^3/yr of VW. This hydrological transference covers the 24% of annual water needs of the population of thirty-one countries (almost 564 million people). Even more, according to data from Mekonnen and Hoekstra (2011), only Argentina and Brazil contribute with almost 13% (198.7 Gm^3/yr) of the total (relate to crop and animal products) green water exported to the world. ABPU countries in total contribute with almost 14% (Table 5).

Table 4. Absolute and relative participation of ABPU in the amount of total (green, blue and grey) VW demand by the principal importers from the region (average 1996–2005).

		Trade of agricultural VW (Gm^3/yr)		Trade of agricultural VW (%)
		Country/Region	Total	
Demand	European Union	615.6	957.4	100
	USA	183.8		
	China	107.6		
	Russian Federation	50.3		
Supply	Argentina	97.6	228.2	24
	Brazil	110.3		
	Paraguay	12.7		
	Uruguay	7.6		

Source: *Data from Mekonnen and Hoekstra (2011).*

Figure 9. The partition of total VW provided by crop and animal products in the ABPU region (average period 1996-2005).



Source: *Data from Mekonnen and Hoekstra (2011).*

The amount of VW that an exporter sells and transfers to the importer is highly influenced by the composition of the bulk product. Different foods have different water footprint, that is, the content of VW may vary greatly from one product to another (Viglizzo and Ricard, 2015). Besides, ABPU countries primarily produce different agricultural products for the world market under rain-fed conditions, suggesting a predominant use of green water in relation to the blue one. This is reflected in the scale differences used to represent green (Figure 10) and blue (Figure 11) virtual water exports of the main products traded by each ABPU country.

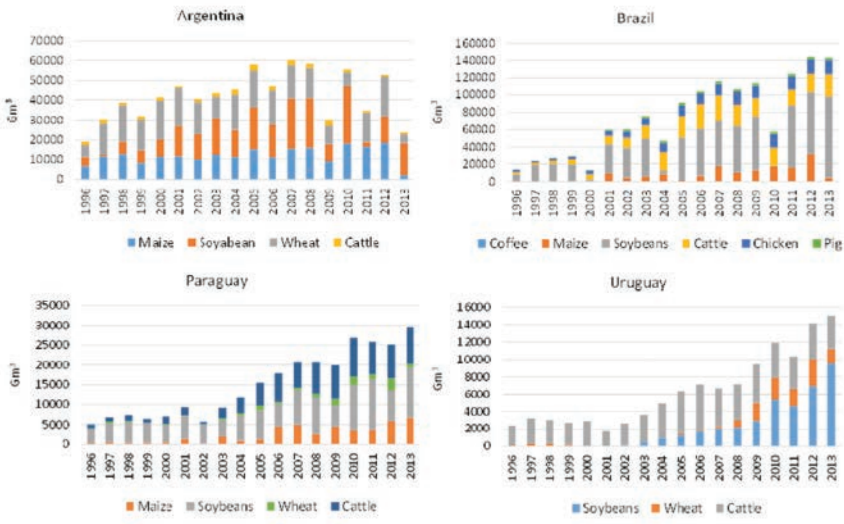
In general, four major products have dominated the virtual water export from ABPU. Soybean accounts for the largest share of green virtual water export in the four countries (Figure 10). With the exception of Argentina, the other three countries export a significant amount of green waterthrough livestock products (Figure 10). Moreover, these countries export a lot of blue water through these products, while Argentina does mainly through maize and to a lesser extent, wheat and cattle (Figure 11).

Table 5. Green, blue and grey VW export from ABPU region and the world (average 1996-2005).

	Green VW (Gm^3/yr)	Blue VW (Gm^3/yr)	Grey VW (Gm^3/yr)	Participation in green VW world exports (%)
Argentina	93.31	1.83	2.49	5.9
Brazil	105.43	1.79	3.10	6.6
Paraguay	12.52	0.06	0.14	0.8
Uruguay	6.65	0.73	0.18	0.4
ABPU	217.91	4.41	5.91	**13.7**
World	1585.55	279.01	173.43	100.0

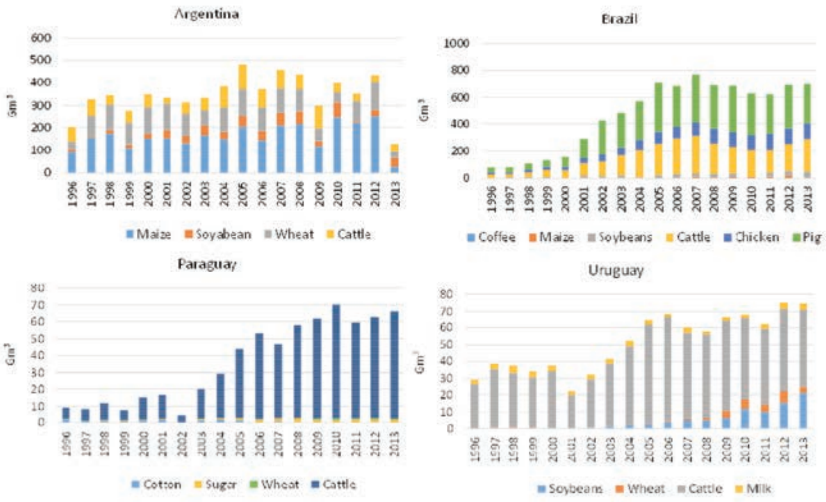
Source: *Data from Mekonnen and Hoekstra (2011).*

Figure 10. Temporal trends in the partition of green water among principal agricultural exports in the ABPU region. Values expressed in cubic gigameters.



Source: *Data from Mekonnen and Hoekstra (2011) and FAO (2016).*

Figure 11. Temporal trends in the partition of blue water among principal agricultural exports in the ABPU region. Values expressed in cubic gigameters.



Source: *Data from Mekonnen and Hoekstra (2011) and FAO (2016).*

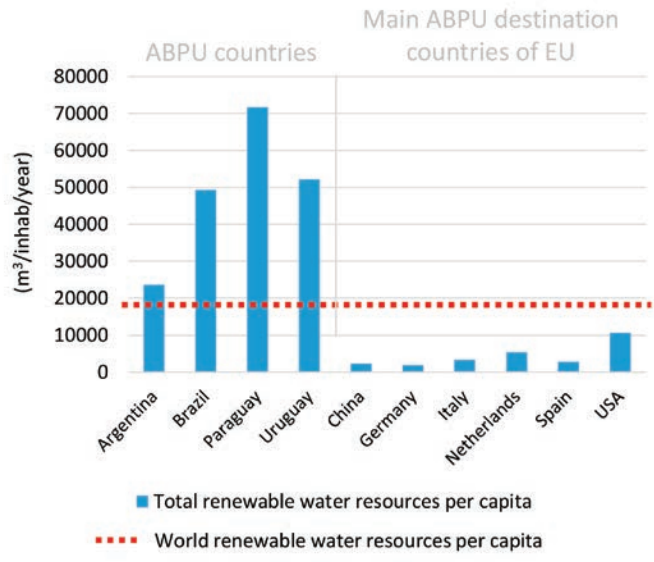
Water Availability in the ABPU Region

Availability of renewable water resources per capita is shown in Figure 12. In ABPU countries, the existence of freshwater is high, ranging between 23600 and 71700 m^3/inhab/yr for Argentina and Paraguay, respectively. Moreover, average water availability for the region is 250% higher than the global average availability (19400 m^3/inhab/yr). Conversely, all major importers of agricultural products from the region exhibit a low water availability, even lower than the world average, with values ranging from 1800 and 10600 m^3/inhab/yr for Germany and USA, respectively.

Figure 13 shows the pressure on freshwater resources as a relation between the availability of renewable water resources per capita and the total water withdrawal per capita. This figure shows that water withdrawals account for little of the total renewable water resources in ABPU (0.6 and 4%). Even more, for most of these countries the use of this resource represents less than the world average (2.7%). By contrast, the main importers of agricultural products from the region have higher values than the world average, with a maximum of 33% for Spain (Figure 13).

Probably, the smaller pressure on water resources in the ABPU region may be related, in an underlying way, with the considerable effort of private and public sectors to boost the incorporation of conservation agriculture practices such as minimum/zero-tilling. These practices are very effective in improving soil moisture conservation and achieve a more efficient use of water. Despite disparities among the proportion of arable area under conservation practices in these countries, the widespread adoption of reduced tillage was an outstanding achievement of agriculture in ABPU, still much higher than in the major importers countries from the region (Figure 13).

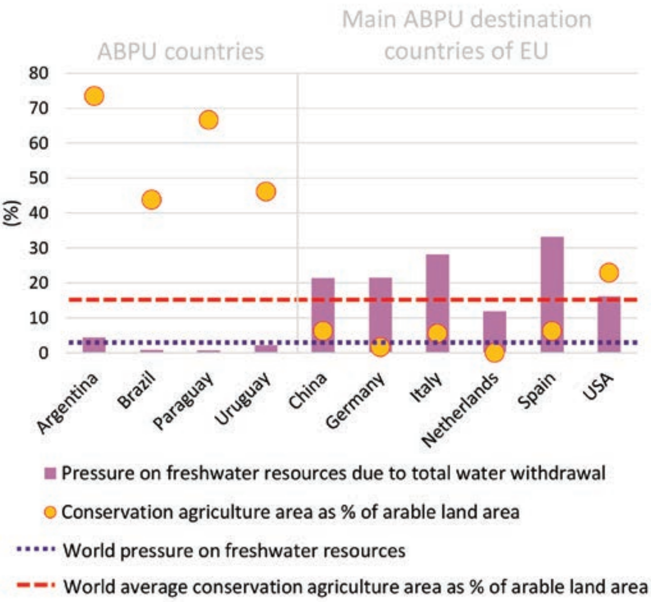
Figure 12. Per capita water availability of ABPU countries and their principal demanders.



Source: *Data from FAO (2016b).*

Although irrigated area in the ABPU region has expanded at an average annual rate of 63300 hectares over the past two decades (FAO, 2016), the proportion of blue water used for agricultural purposes has been very low. Areas of high irrigation density are located along the border between Brazil and Uruguay. In addition, numerous other, smaller irrigation areas are spread across the ABPU region (Mekonnen *et al.*, 2015). The results of Figure 12 and 13 reveal abundant water resources relative to use for human purposes in this region and, certainly, a significant connection exists between a country's capability to produce food and its renewable water resources availability. With this, is possible to argue that ABPU has a high potential to provide blue water and developing large-scale irrigation systems. Irrigation delivers a powerful management tool against the vagaries of rainfall and makes it economically attractive to grow high-yield seed varieties and to apply adequate plant nutrition as well as pest control and other inputs, thus giving room for a boost in yields. There is an effective synergy between irrigation, crop variety and inputs.

Figure 13. Pressure on water resources and application of tillage conservation practices in ABPU countries and their principal demanders.



Source: *Data from FAO (2016b).*

There are strong links between water, agriculture and economy in ABPU. Both green and blue water are a vital fuel for ABPU's economies and for its food security. This region is producing and supplying more and more food to other parts of the world using rainwater. Many parts of the region have abundant green water resources, which suggest that there is room for expansion of rain-fed agriculture. However, this "abundance of green water" is misleading, because a great part of the green water resources in the region is attached to forested lands. Claiming new land and associated green water resources for agriculture will be at the expense of natural forests. At this point, the good availability of blue water in ABPU represents a good opportunity to produce and supply more food for itself and for other parts of the world. Irrigation is a key component of the technical package needed to achieve productivity gains. In the future, as high levels of costly inputs are added to cropland to sustain yield increases, the security and efficiency of irrigated production will become even more important to world farming, and the ABPU region is in position to do so.

Epilogue

World's agriculture still accounts for the majority of human water use. ABPU region is not the exception to this trend.The challenges facing agriculture and the water resources upon which it depends are clear and multiple: to produce more food in the future is necessary reconcile the use of land and water resources and improve food security; all this in the context of a changing climate and associated risks.

This work has set out the evidence that some countries are under stress or vulnerable, respect to water availability. There is a risk, as demand rises, that current trends will deteriorate further, with consequent threats to local food security and the resource base on which production and livelihoods depend. The possible repercussions for global food security are not negligible. ABPU's exports of virtual water could help to alleviate the future increase of water demand for food due to climate change impacts and population growth. Through importation of food and certain commodities that would otherwise consume great quantities of water, such as agricultural and livestock products, countries affected by water scarcity could alleviate this issue. Agricultural imports from ABPU region has already played a key role in compensating local water shortages in those countries with water scarce. In other words, ABPU region has been key to generate global water safety.

Appropriate water management can expand production efficiently while limiting impacts upon productive regions, such ABPU, on which many countries depends. The use of technology for water conservation and efficiency in agriculture offers the best hope to increase productivity security and facilitate economic growth. Irrigated agriculture is expected to produce much more in the future while using less water than it uses today. This positions the ABPU region in a favorable condition to feed its citizens and export large quantities of agricultural products in the short and long term, through a more efficient agriculture. Future of food and water security are inextricably connected.

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