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VIRTUAL WATER TRADE AND WATER ENDOWMENTS IN SOUTHERN AFRICA

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Abstract

The virtual water content of a product (a commodity, good or service) relates to the amount of water that is used in its production. Virtual-water 'trade' represents the amount of water embedded in products traded. With this background, countries that export agriculture commodities also export water. The purpose of this paper is to explore trends in virtual water trade in the Southern Africa Development Community (SADC) region focusing on Malawi, Mozambique, Zimbabwe and Zambia, in order to understand whether water rich countries export more water into the SADC through virtual water trade in cereals. The analysis is based on data on trade volumes, crop yields, and crop water requirements. The results show that South Africa, Zambia and Malawi, are the main exporters of virtual water embedded in Maize, Soybean and Groundnuts into the SADC. The Results also show that while virtual water trade has generally been increasing over time, an inquiry into whether water rich countries relatively export more water intensive commodities such as groundnuts and soybean, yields mixed results. For example groundnuts virtual water movement is stronger from both water scarce and water rich places of the SADC implying that other underlying factors than just water endowments may determine virtual water trade flows. For countries to improve water resource allocation through trade, more advocacy and analysis may be useful.
Keywords: *Virtual water; SADC; agriculture*
Jel Codes: *Q17, Q25, F14*

1. Introduction

Every crop-based commodity has water embedded in it because the latter is an integral ingredient for crop production. To illustrate the virtual water concept, note that to produce a kilogram of grain, under rain-fed and favorable climatic conditions, one typically needs around one to two cubic meters of water, (that is 1000 to 2000 kg of water). For the same amount of grain, but growing in unfavorable (high temperature, high evapotranspiration) conditions, it would take up to 3000 to 5000 kg of water (A. Hoekstra & Hung, 2002). Hence, if a country exports a water-intensive product to another country, it exports water in virtual form. For water-scarce countries, it could be attractive to achieve water security by importing water-intensive products instead of producing all water-demanding products domestically.

International trade can save water (hence encourage sustainable water use) globally or regionally if water-intensive commodities are traded from areas where they are produced with high water productivity (resulting in products with low virtual-water content) to areas with lower water productivity (Chapagain, Hoekstra, & Savenije, 2006). It has been shown that current water use in agriculture globally is reduced by 5 percent (5%) through an enhanced international virtual water trade (Hoekstra, 2010), and there is support to the conjecture that global virtual water trade associated with international food trade has increased global water use efficiency and contributes to global water resources saving (Dalin, Hanasaki, Rinaldo, & Rodriguez-Itur, 2012). Thus, a country can preserve its domestic water resources by importing water intensive products instead of producing them domestically. This is particularly relevant to the Southern Africa Development Community (SADC) arid or semi-arid countries with scarce water resources, low investments in water development and erratic rainfall patterns.

With the above background, countries with low water endowments may be better off importing water intensive products rather than producing them. The concept is also useful because trading water in a more direct way can be too costly and demanding in terms of the investment needs for the relevant infrastructure that may have to be developed over thousands of kilometers to deliver the water. To put it differently, if one region/country exports a water-intensive product to another region/country, it exports water in virtual form. In this way, some regions/countries support other regions/countries in their water needs. Despite the potential of the virtual water concept to help societies achieve some levels of water security through trade, research in this area in southern Africa is limited. Therefore, the main objective of this paper is to analyze the virtual water trade flows for the period 2005-2014 in selected SADC member states namely, Malawi, Mozambique, South Africa, Zambia and Zimbabwe. We then examine whether water scarce countries export less water intensive products and vice versa in order to understand whether there is room for water saving through trade. The findings of this paper are expected to spur a debate and discussions on the role of virtual water trade in development and in addressing water security challenges especially in water scarce regions of the SADC.

2. Water Scarcity and the Policy Position in SADC

The SADC is a regional economic community with 15 countries namely: Angola, Botswana, Comoros, Democratic Republic of Congo, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Swaziland, Tanzania, Zambia and Zimbabwe. Some countries in the region have larger water resources (for example Mozambique, Zambia, Madagascar), whereas other countries including South Africa and Zimbabwe, face physical water scarcity (SADC, 2005).

Within the SADC region, some conspicuous problems ravaging agriculture are erratic rainfall and poor investment in water infrastructure. SADC (2005) notes that the available water in SADC region is unevenly distributed such that there is a mismatch between water availability and demand. Areas of highest water demand happen to be in the water scarce semi-arid zones of the region. This poses a challenge in terms of the sustainable allocation of available water resources to various users, particularly with respect to transboundary water resources (SADC, 2005). Water scarcity in the SADC region is made worse because of the poorly developed water infrastructure which implies that long distance distribution of water from water abundant areas to water deficit areas for agricultural and other purposes is not an option.

In response to SADC's water challenges, SADC water policies have changed to reflect the challenges. One policy that seeks to hasten the achievement of water security within the SADC region relates to the need for enhancing regional trade from areas of high water sufficiency to those of water scarcity. For example, SADC's policy statement 4.1.4 focusing on water for development strives to achieve regional water resource management, taking cognizance of the overarching imperatives for resources utilization. It goes further to articulate that as a matter of policy, the region shall consider the concept of comparative advantage in water availability as a means of promoting intra-regional trade, services, poverty reduction and balancing national water budgets in a sustainable manner (SADC, 2005).

The idea embedded in this policy statement is that in the context of regional integration, countries should easily benefit from water resources from neighboring countries through trade. Thus, other factors being equal, intra-regional trade has the potential to minimize the impact of water scarcity within the SADC region as trade would move water intensive goods from water abundant areas to places of water scarcity.

2.1 Overview of Key Water Indicators in the SADC Region

This section presents an overview of relevant and key water indicators in the SADC region and in so doing, it provides a context in which virtual water trade is discussed in the section that follows. Specifically, this section presents SADC average rates of water usage and storage, before presenting how the abstracted water is used across industries and across countries (focusing on the selected countries). Thereafter this section presents the predominant sources of water in each country. This is done to provide a background on the spatial differences in available water resources, which ordinarily, should form the basis for trade, other factors being equal.

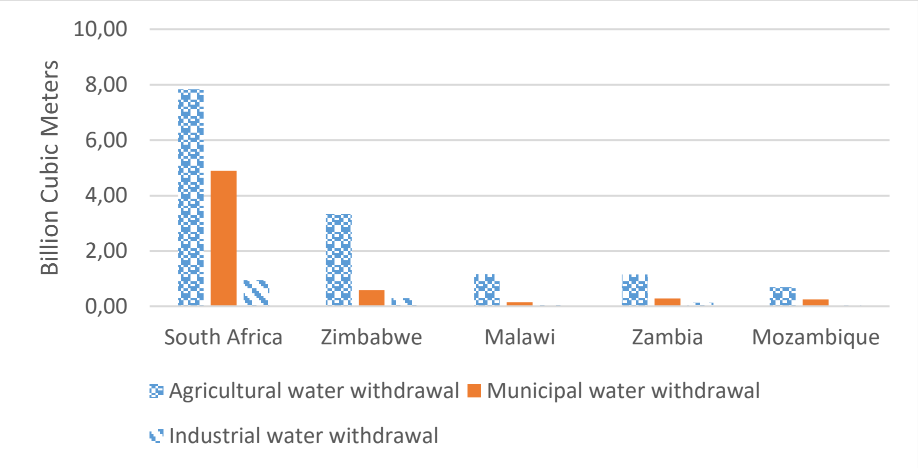
Table 1. Water Abstraction, Surface Water Storage and Irrigated Land-SADC Averages

Sector	**SADC status**	**African continent (including North Africa)**	**World averages**	**Developed world status**
Water Abstraction	170m3/capita/ year	251m3/capita/ year	570m3/capita/ year	1330m^3/capita/ year
Surface water storage	14% of ARWR stored	14% of ARWR stored	25% of ARWR stored	70% to 90% of ARWR stored
Irrigated Land	Under 7% irrigated of available irrigable land	20% irrigated of available irrigable land	20% irrigated of available irrigable land	70% irrigated of available irrigable land

Source: SADC (2012)
Note: ARWR: Actual Renewable Water Resources

Table 1 shows the levels of water abstraction, storage and irrigation in the SADC region in comparison with other regions. The results show that at 170m3 /capita/year, SADC has the least amount of water abstraction per capita per year when compared to the continental average (251 m3/capita/year) and 570 m3/capita/year in the world. While this may imply that the SADC region is saving water by having low levels of abstraction, this is not the case as its share of surface water stored as a share of Actual Renewable Water Resources (ARWR) stands at a meagre 14% as compared to the world and developed countries' storage averages of 20% and 70% respectively. Thus, a huge amount of water that lands in the SADC region is never stored for potential industrial, domestic or agricultural use, even if dams including the Kariba and the Cahoro Bassa are accounted for (Chapagain et al., 2006). Not surprisingly, the irrigated land in the SADC region as a share of irrigable land available is low and stands at an underwhelming 5% (below the target of 7% set by the SADC member states as elaborated in the Regional Indicative Strategic Development Plan (RISDP)) (SADC, 2015). By contrast, the share of irrigated land to irrigable land in the region, averages 20% and in developed countries, reaches 70%. Thus water infrastructure as noted from both water abstraction, storage and irrigation levels is likely underdeveloped in the SADC region which may limit the ability of trade to reduce effects of water scarcity within the region.

Figure 1 presents the water use distribution across sectors in the focus countries for this paper. In all the countries, a huge quantity of water is used for agricultural production but the volumes are highest in South Africa followed by Zimbabwe. Agriculture uses the largest amount of water be it in very poor countries such as Malawi or middle income countries of the SADC region such as South Africa. South Africa uses as much as (7.8 billion m3) of water annually for agricultural production and about 4.9 billion m3 for municipal use, and about 0.95 billion m3 for industrial use. Zimbabwe comes second with as much as 3.3 billion m3 of water used in agricultural production whereas municipal and industrial withdrawals stand at just 0.59 billion m3 and 0.3 billion m3 respectively. By contrast, and on the extreme, Mozambique and Malawi use just 0.69 billion m3 and 1.17 billion m3 for agriculture, 0.25 billion m3 and 0.14 billion m3 respectively for municipal use and almost ignorable amounts for industrial use.



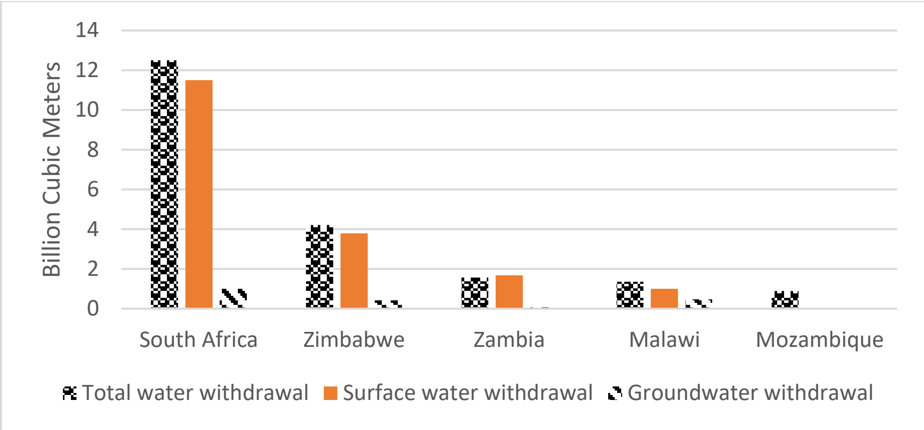
Source: Authors' computation based on FAO (2014)[1]

Figure 1. Annual Water Use Distribution across Sectors

The surface and groundwater use across the selected countries are shown in **Figure 2**. The use of groundwater resources is still very low compared to the amount of water generally used per country. Of the countries in focus, South Africa uses more blue water (groundwater) whereas the rest use more green water (proxied by surface/rain water). Generally, the use of blue water is limited perhaps due to absence of cost-effective technologies for groundwater

[1] Note that 1billion cubic metre makes 1 cubic kilometre

extraction in the SADC region. The implication of this is that unabated abstraction of water resources in South Africa could also put at risk their ground water resources.



Source: Authors' computation based on (FAO, 2014)

Figure 2 Surface and Groundwater Use across the Countries

If the water use reported is disaggregated in terms of whether it is surface water or groundwater, it is noted that most of the water used in the selected countries is surface water. Groundwater use is limited perhaps because in some cases using groundwater is unnecessary or is costly. For example, of South Africa's 12.5 billion m3 total fresh water withdrawals, surface water constitutes an overwhelming 11.5 billion m3 whereas groundwater constituted just 1 billion m3. In Zimbabwe, groundwater contributes 0.42 billion m3 to the total withdrawals of about 3.8 billion m3.

2.2 Virtual Water Trade and Water Scarcity

The importance of virtual water trade manifests in various forms in literature. For instance, an empirical analysis of the relationship between virtual water trade, population and development in Africa (Konar & Caylor, 2013) found that levels of undernourishment tend to fall with increased values of virtual water trade openness. Another benefit is in the form of water saving for the water poor country. Export of agricultural products entails that national water resources are expended whereas import of agricultural products saves national water resources (Chapagain et al., 2006). National water exports may be positive or negative from an economic perspective depending on the context. According to Chapagain, Hoekstra and Savenije (2006) water losses are positive in economic sense if the benefit in terms of foreign earnings they provide is outweighed by the opportunity costs of water use and the negative externalities left at the production site. Water-rich countries could profit from their abundance of water resources by producing water-intensive products for export. Trade of real water between water-rich and water-poor regions is generally impossible due to the large distances and associated costs, but trade in water-intensive products (virtual water trade) is realistic. Virtual water trade between nations and even continents could thus be used as an instrument to improve regional water use efficiency and to achieve water security in water-poor regions/countries of the world (Shi, Liu, & Pinter, 2014).

A country which is water-scarce may plan to import products that require high amounts of water in their production (water-intensive products) but then export products or services that require less water (water extensive products) in production. The implication of the foregoing is that net import of virtual water (as opposed to import of real water, which is generally too expensive) and will relieve the pressure on the nation's own water resources (A. Hoekstra & Hung, 2002) (see (Konar & Caylor, 2013) for a corroborative discussion). This can be very instrumental in reducing the negative livelihood impacts of water vulnerabilities facing some of the countries in the SADC.

Furthermore, in countries with water abundance, an argument can be made for export of virtual water. An import of water-intensive products and export of such products by others constitutes virtual water trade between the countries (A. Hoekstra & Hung, 2002). So, even if a country is water constrained, it should worry about how the neighbor uses its water because in essence less water sufficient countries may depend on those with more water through virtual water trade.

3. Materials and Methods

3.1. Overview of Methods for Analysis

The empirical analyses in this paper follow the approach developed by Hoekstra (2003). According to Chapagain and Hoekstra (2004) virtual water trade flows between countries are a product of the international crop trade flows (kg) and the associated virtual water content. The virtual water content depends on the water demand of the specific crop in the country that is producing and exporting it. For the purpose of this paper, the empirical analyses focused on the following SADC countries: Malawi, Zambia, Zimbabwe, Mozambique and South Africa. Out of the 15 member states in the SADC region, the selected five countries account for more than 40% of the region's agricultural output and trade. In addition, agriculture constitutes a large share of these economies in general. Except South Africa, all the four countries in focus are highly agro-based with agricultural GDP exceeding 14% of the total GDP. Therefore, focusing on these countries gives a fair understanding and a starting point to spur discourse about agricultural virtual water trade trends in the region. Of the remaining 10 countries not covered in this analysis, only 3 (Tanzania, Madagascar and DRC) are heavily agrarian, the rest including Seychelles, Mauritius, Lesotho, Namibia, Swaziland and Botswana have agriculture GDPs of under 10% of the respective total GDPs

The analysis of international trade flows focused on the following primary crops (grain crops): maize, soybean and groundnuts. The choice of these primary crops was motivated by the fact that maize is a staple food for most countries in southern Africa, whereas soybean and groundnuts are the two most important sources of plant-based protein in the region. In selecting the crops above, it has not escaped our notice that the choice of few crops may imply that the virtual water estimates will be lower than the totality of virtual water trade through agriculture by those countries. However, this does not undermine the importance of the analysis after all, no study in literature has dealt or can deal with all the means through which a country engages in virtual water trade. For instance, in a technically and policy useful study on virtual water trade for Brazil, da Silva et al., (2016), the authors noted that there were disparities in virtual water trade figures related to Brazil due to the choice of crops. Overall, the authors found that this finding did not negate the ability of the study to offer useful insights into the importance of virtual water trade in Brazil (da Silva et al., 2016). As highlighted above, the results from the selected crops are expected to help provide the basis to spur discussions on how virtual water can be economically and sustainably utilized in the region.

As indicated above, the paper applied the approach developed by Hoekstra (2003) to calculate virtual water trade in the SADC region based on the selected countries and crops described above. Following (A. Hoekstra, 2003), we calculate virtual water trade as:

$$VWT(ne,ni,c,t)=CT(ne,ni,c,t)*SWD(ne,c) \quad (1)$$

In which VWT = Virtual Water Trade in m3 per year; CT = Crop Trade in tons; SWD = Specific Water Demand (in m3 per ton); ne,ni,c,t are exporting country, importing country, crop, time, SWD=CWR/CY, where CWR = Crop Water Requirement (m3per hectare); CY = Crop Yield in ton per hectare. In this case VWT represents virtual water trade (m3 per year) emanating from the sending (exporting) country (ne) to the country that receives (the importer) (ni) in year (t) as a result of trade in crop (c). On the other hand, CT represents the volume of trade for the crop (ton per year) from the exporter (ne) to the importer (ni) in year (t) for crop (c). SWD represents the specific water demand (m3 per ton) of crop (c) in the exporting country (see (A. Hoekstra, 2003) and (Chapagain & Hoekstra, 2004).

The underlying assumption is that a country exports what it produces. The gross virtual water import to a country (ni) is the sum of all imports. The gross virtual water export from a country (ne) is the sum of all water exports. The amount of net virtual water import of a particular country equates to the gross virtual water import minus the gross virtual water export. The virtual water trade balance of country x for year t can thus be written as its imports minus its exports (Chapagain & Hoekstra, 2004). A positive net import value means importing more water and is good for water constrained countries. On the other hand, the sum of water used for domestic purposes and net virtual water import can be seen as water footprint of a country, if we interpret it within the context of the 'ecological footprint' of that country (see (Chapagain & Hoekstra, 2004). Once the net imports are analyzed, this paper further relates this to general water uses in the same countries.

We used specific water demand averages for a crop in a country as a cut-off point to determine which country should export more of the crop or less based on the deviation of the specific water demand from the average. Any country with crop specific water demand that are higher than the average are candidate importers because they can save water by importing from where the same crop is produced with least water demands. Similarly, any country that has water demands below the average for a crop, is a candidate for export because it produces the crop at least cost in terms of water. Differences in specific water demands are related to other characteristics that aid crop growth and development in a country and may be related to agro-climatic and soil conditions.

In analysis of virtual water trade, we focused on year 2005-2014 or an average over the same period. We construct graphs with trends to show the volumes of virtual water trade over time for each country, and we used maps to show the water availability and values of trade in order to show the relationship between water availability and virtual water trade. This allows the reader to understand quickly whether water rich countries are also the ones exporting more water through agricultural trade.

3.2. Data Used to Calculate Virtual Water Trade Flows

In line with literature, the data on trade values and volumes used herein were based on the Commodity Trade Statistics Data Base (COMTRADE) of the United Nations Statistics Division (UNSD), following Chapagain & Hoekstra (2004) as highlighted previously. The data are supplied by countries every year and the data are often detailed by commodity and partner country. Data on yield, crop water requirements were obtained from FAO. The volumes and values were limited to soybean, maize (corn) and groundnuts in shells whether broken or not, and groundnuts in shells or roasted. Highly processed forms of these crops have not been included to simplify the analysis. For the purpose of this paper, the crop water requirements were calculated in light of climatic data (A. Hoekstra, 2003) and no further calculation were conducted on water requirements. The focus period is 2005 to 2014 and for each year, exports volumes from each country into each SADC country were obtained for each crop in focus. The same was performed for imports from the SADC countries into each of the focus countries for a specify crop. This data was then converted to virtual water through the procedure outlined above and then relevant tables and graphs were constructed.

4. Results and Discussion

4.1 Virtual Water Trade Flows

Table 2 presents water requirements for soybean, groundnuts and maize. Specific crop water demands (crop water requirements divided by yield) are highest for groundnut production and lowest for maize. The implication of this is that producing groundnuts is water intensive than producing maize all other factors being equal. For the 5 selected SADC countries, it is clear that for both maize and groundnuts, water requirements per hectare are lowest in Mozambique (3510 m3 for groundnuts and 3230 m3 for maize), followed by Malawi and Zimbabwe. The meaning of this is that owing to various factors including agro-ecological factors, maize and groundnut production in Mozambique requires less water resources compared to other countries. South Africa and Zambia need relatively more water per hectare to grow groundnuts and soybean at optimal levels. For optimum production, crop water requirements for soybean are higher than for all the other crops in all the countries in focus, although the water requirements are highest in Zimbabwe (6420 m3/ha) and lowest in Malawi (4430 m3/ha). The figures on specific water demands are then used together with trade tonnage data to calculate each country's yearly levels of virtual water that those exports contain.

Table 2. Water Requirements for Soybean, Groundnuts and Maize in Selected Countries of SADC Region

		Malawi	Mozambique	South Africa	Zambia	Zimbabwe	Average
Specific water demand (m^3 /ton	Maize	1558	2630	938	2038	4697	2372,2
	Soybean	4433	4573	3290	2400	4504	3840,0
	Groundnts	3518	10595	4076	6459	9056	6740,8
Crop water requirement (m^3/ha)	Maize	3350	3230	4380	4800	3580	3868,0
	Soybean	4430	5030	5810	4840	6420	5306,0
	Groundnuts	3670	3510	5930	5180	3910	4440,0
Crop yield (ton/ha)	Maize	2.15	1.228	4.668	2.355	0.762	2,3
	Soybean	0.999	1.1	1.766	2.017	1.425	1,6
	Groundnuts	1.043	0.331	1.455	0.802	0.432	0,8

Source: Hoekstra (2003) and authors calculation based on ReSAKSS (2014)

Again, based on Table 2, and embracing the specific water demands per crop in each country as a guide, the countries can be classified as potential exporters and importers of that specific crop. The final column shows the average values of specific water demands. Once the methodology on cutoff points for exporter-importer classification, discussed under methods is applied, we expect that the countries may be classified as shown in Table 3 in terms of potential exports or imports if specific water demand was the only factor determining exports of virtual water.

Table 3. Potential Exporters and Importers Based on Specific Water Demand

	Maize	Soybean	Groundnuts
Exporters	Malawi		Malawi
	South Africa	South Africa	South Africa
	Zambia	Zambia	Zambia
Importers	Mozambique	Mozambique	Mozambique
	Zimbabwe	Zimbabwe	Zimbabwe
		Malawi	

Source: Authors' tabulation

But determining potential exporters based just on specific water demand is problematic because while specific water demand considerations focus on production of crops at least water costs, calculation of specific water demand does not account for total per capita water resources. Given the information on water stress and water scarcity under the literature section, it is clear that while certain crops may be produced at least water costs in Malawi, South Africa and Zimbabwe, the three countries also face water stress and water scarcity. To minimize the likelihood of negative impacts of water availability on livelihoods in future, exporting less of water intensive products may be an option. On the other hand, Zambia and Mozambique should export more into the SADC region because they have more water endowments per capita than the rest of the countries in focus.

Table 4 presents results of virtual water trade (exports) in the SADC region (2005-2014 averages). The results show that on average, Malawi exported the most water (147.7 million m3) every year between 2005-2014 to the SADC region in the form of groundnuts followed by Mozambique, whereas Zimbabwe exported the least water to the SADC region. For Malawi this appears logical because although groundnuts require more water to produce than the other crops, in terms of cross-country comparisons, groundnut production in Malawi requires less water per ton (3518 m3/ton) compared to an overwhelming 10595 m3/ton for Mozambique or the 9056 m3/ton for Zimbabwe. If these countries are considered separately, it makes sense for Malawi to export more into SADC region as it produces groundnuts at least water costs. Similarly, it can be argued that Mozambique exports of groundnuts into the SADC region implies a loss to its water resources because it expends more water per ton of groundnuts produced than most of the other countries implying that importing some groundnuts would be water-saving. The underlying message from these virtual water export figures is that more water-endowed countries such as Mozambique are not per se the ones also exporting more of the water intensive commodities (groundnuts and soybean) into the SADC.

Table 4 shows that South Africa exports more virtual water embedded in maize. This is followed by Zambia then Mozambique. Although Malawi produces maize with low specific water demands per ton, its yearly average exports amounted to a meagre 10.9 million m3 as compared to the overwhelming 1770 million m3 from South Africa. Table 5 also shows that virtual water embedded in soybean exports are highest from South Africa (914.6 million m3) and least for Zimbabwe at 4.6 million m3. Soybean production costs more water in

Mozambique, followed by Malawi and then Zimbabwe. On the other hand, soybean production demands less water in Zambia and then South Africa (see Table 2 for specific water requirements per ton). The findings depict that virtual water trade into the SADC region is highest from South Africa followed by Zambia (263 million m3) is in line with what would be expected of the two countries given their costs of soybean production in terms of water spent. However, South Africa does not have the same abundant water resources as Zambia, and so, it would probably be water saving if South Africa were to import (and not export more) from the SADC region. Thus, the evidence of the relationship between water endowments and the likelihood of exports from a country appears to be mixed on this basis. Enhancing imports in virtual water into South Africa from water rich countries such as Zambia and Mozambique may help South Africa limit the rate at which it is increasingly becoming water scarce.

Table 4. Virtual Water Trade (exports) in the SADC Region (Yearly Average between 2005-2014) (million m^3)[2]

Country	Groundnut	Maize	Soybean	Total VWT
Malawi	147.7	10.9	146.8	305.4
Mozambique	107.3	170.0	13.7	291.0
South Africa	54.1	1770.1	914.6	2738.8
Zambia	46.4	362.2	263.2	671.8
Zimbabwe	2.2	3.1	4.6	9.9

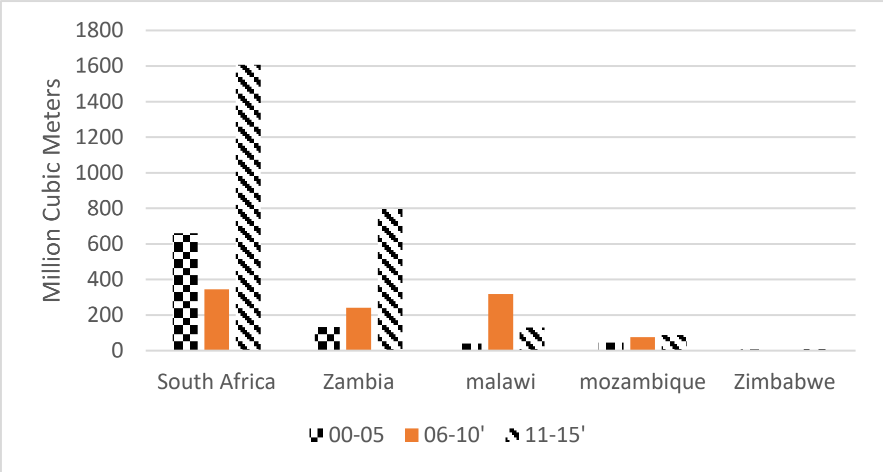
Source: Authors' calculation based on COMTRADE 2014;

Figure 3 shows evolution of maize virtual water trade summarized semi-decadal. Despite few exceptions, it is clear that virtual water trade in maize has been increasing over time across the countries of focus and South Africa has persistently exported the highest amount per period considered. This is important and in line with the regional integration goals of the SADC as a step towards optimizing the use of SADC's water resources. This is not strange because South Africa is an important player in regional trade in the SADC region and some estimates have shown that the country agricultural trade accounts for over 50% of total agricultural trade in the SADC region (Matchaya, Nhlengethwa, & Nhemachena, 2016). Nevertheless, this also shows that South Africa is exploiting its scarce water resources further with every volume of virtual water exports, which is undesirable as it is a water insecure country. To save water, South Africa should consider importing water-based products from the regions. With the exception of Malawi where virtual water trade in maize went down in the 2011-2015 possibly because of negative political changes and erratic rainfall in that country, virtual water trade has been increasing over time. Given that Zambia and Mozambique are the most water-endowed in the SADC, it is worth noting that Mozambique's exports are among the lowest, which again gives mixed evidence on the relationship between virtual water exports and water endowments.

Figure 4 presents the evolution of groundnut virtual water trade in the selected countries. Water trade has generally increased over time in all the countries and it appears that Malawi, which is associated with low water costs in groundnut production, but generally with scarce

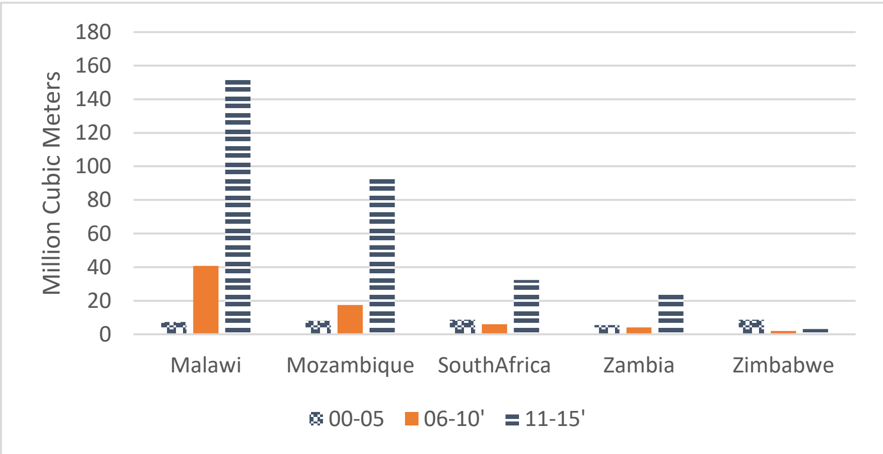
2 Total VWT in tons per Yr = SWD *total of the crop exported for 2014 for that country

water resources, exports more groundnut virtual water (over 150 million m3) into the SADC region. From the viewpoint of water resource endowments, Zambia and Mozambique should export more of groundnuts given that groundnuts production requires more water. The figures in this figure however show that it is Malawi and Mozambique, and not Mozambique and Zambia that export more. South Africa comes third despite its weak water resources, which again provides mixed evidence on the relationship between water resources and virtual water exports.



Source: Authors' computation based on FAO data 2014

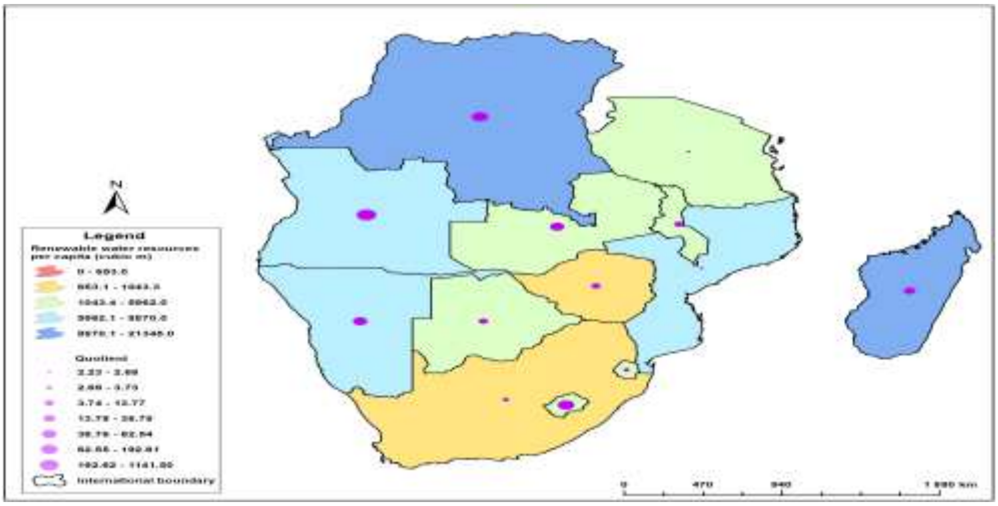
Figure 3. Evolution of Maize Virtual Water Trade in the SADC



Source: Authors' computation based on FAO data 2014

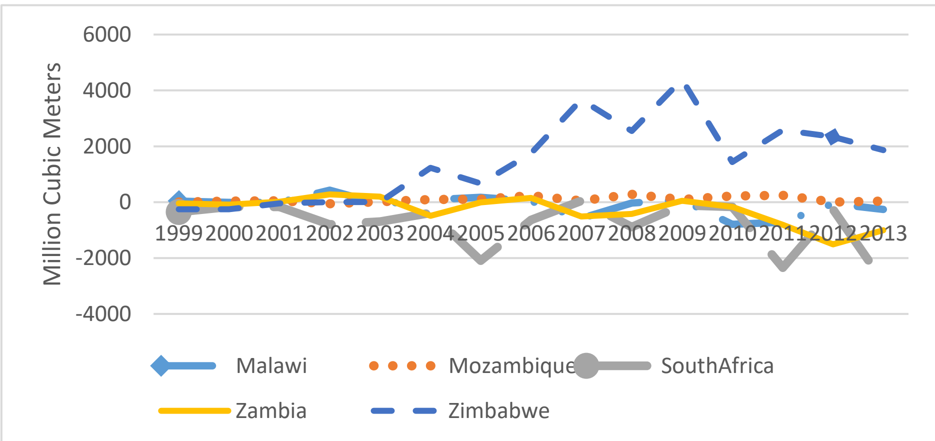
Figure 4. Evolution of Groundnut Virtual Water Trade in the SADC

The trends presented so far should be understood in the context presented in Figure 5. The quotient of a country's renewable freshwater resources per capita and fresh water withdrawals per capita may show the pressure on available water resources so that the larger the quotient the more water secure the country is, whereas the lower the quotient, the more pressure water resources face in the country (Rushforth & Ruddell, 2016). Thus, South Africa, which is already physically water scarce, has a small quotient implying that its water is under pressure from extraction (Figure 5). The same is the case with Zimbabwe, The quotient presented can proxy water stress and in this case supports the finding that South Africa, Zimbabwe and Malawi are water stress countries while Zambia and Mozambique are not. In view of this, it can be said that while virtual water trade as increased over time in the 5 focus countries, there is no clear-cut pattern as to whether water endowed countries are necessarily the ones exporting more water intensive commodities into the SADC. Instead, there are some periods where water-endowed countries export more and others where this is the opposite.



Source: Authors' computation based on AQUASTAT 2015 data

Figure 5. Water Stress Quotient



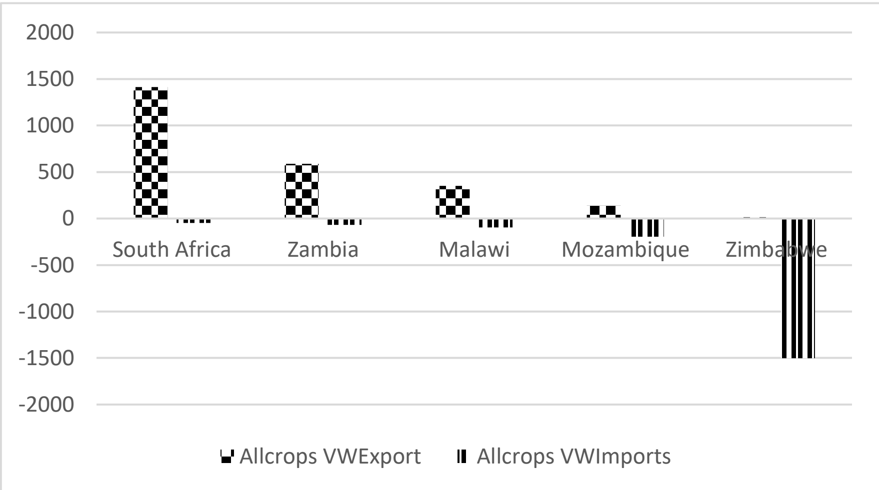
Source: Authors' computations based on FAO 2015 data

Figure 6. Net Virtual Water Imports in the SADC (soybean, groundnuts & maize)

4.3 Flows of Net Virtual Water Imports

This section discusses flows of net virtual water imports. As highlighted previously, net virtual water import is calculated by subtracting a country's virtual water exports from the imports. A positive figure therefore means more imports than exports of virtual water. Figure 6 shows net water imports for the SADC countries for all the crops combined. For example, Zimbabwe imports more water than she exports whereas South Africa generally exports more than she imports. Ideally, if countries are exporting and importing virtual water embedded in these commodities based on water endowments, then Zambia and Mozambique need to have negative values implying that they export more than they import, while Zimbabwe and South Africa ought to register positive trends implying more imports than exports. The water abundant Zambia, appears to have small net water import implying it exports more than it imports but Mozambique, a similarly water abundant country either is a net importer or just balances its exports and imports, which again provides conflicting evidence about the relationship between water endowments and net virtual water exports. The implication of these findings is that there may be room for improving water allocation in the SADC by encouraging countries with least water endowments to import water intensive products to save water instead of producing them for exports.

Intertemporal trends in net virtual water trade embedded in maize shows that Zimbabwe imports more virtual water than the rest of the countries whereas Mozambique almost balance sits levels of imports and exports of maize virtual water. South Africa and Zambia show significant intertemporal negative net maize virtual water imports implying that Zambia as well as South Africa export more maize virtual water than they import (see), leading to the same conclusions that water endowed countries are not necessarily also exporting more water into the region



Source: Authors' computations based on FAO 2015 data

Figure 7. Yearly VW maize Trade

Indeed, on average between 2005 and 2014 Malawi, South Africa and Zambia have exported more virtual water embedded in all the crops than they have imported, although the exports are more in South Africa followed by Zambia and the Malawi (Figure 7). By contrast, Zimbabwe has predominantly been an importer of maize virtual water. When all imports and exports for all years are summed up separately per country, the results are clearer and show that Zimbabwe has been a net importer, which is not a problem given the level of water scarcity the country faces. However, South Africa, a water scarce country exports more into SADC which may imply that it is overexploiting its water resources. Finally, Mozambique, a water abundant country is a net importer of the products in focus, which alongside the findings for South Africa precipitate the conclusion that it is not clear-cut as to whether water abundant countries are net virtual water exporters as would be preferred by SADC authorities.

It should be noted however that the issue is not about encouraging the countries to export or not to export water through trade, but rather to export if they are relatively water abundant and import if not. More importantly, a country should export products, which it produces with least water costs. A point should be made to note that exports in the form of virtual water trade are also a form of water loss from the country. Thus, if the country is facing an acute physical water scarcity and insists on exporting virtual water, problems could ensue (see (Faramarzi et al., 2010)).

5. Conclusions

The overall findings of this study are that virtual water trade in the selected countries increased over time, which is an important finding, given the recent emphasis on regional trade and integration by African governments. It is also in line with the goals of the SADC as a region as elaborated in the SADC water policy. It is important to note that while we expected to find that water rich countries such as Mozambique and Zambia export more virtual water and the least water endowed ones (South Africa and Zimbabwe) import more virtual water, the results are mixed. South Africa exports generally more of everything while alongside Zimbabwe, Mozambique imports more of everything despite Mozambique being a water rich country. This means that as long as this is the case, South Africa will continue to overexploit its water resources when this would have been averted through trade with Zambia and Mozambique. Furthermore, countries with scarce water resources gain more through trade of agricultural products. For water poor countries, trade in less water intensive production will provide the necessary resources for imports of water intensive products and vice versa for the water rich countries, otherwise, water resources are not being sustainably used. Water rich countries ought to be taking advantage of this to trade in water intensive products with water poor SADC countries thereby reducing the negative impacts of water scarcity in the region as well as improving water security in water-poor countries/areas of the region.

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