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# An Assessment of Virtual Water Flows Through Crop Trade in South Africa

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**ABSTRACT**

South Africa is a water scarce country, where water has become a very essential natural and economic asset of a nation and the universe equally. It has taken place a very important place as a major voice of concern for policy makers at different strata of society. Currently, the major global concerns are associated with the water deficit countries, where all other major problems linked with water, toning down the country's growth and development. The main purpose of this research theme is to analysis the movement of water through agricultural sector in South Africa, because major water withdrawals take place through agriculture sector. And to assess the virtual water flow through exports and imports of agriculture products by calculating the virtual water content of a product. Virtual water trade has been calculated by multiplying commodity trade volume (tonne/ year) by their associated virtual water content ($km^3$/ tonne). The crux of this study is to assess the export and import of virtual water and sucking up the attention towards this event, from where water needs to be checked through certain measures which controls the disastrous condition of water scarcity in South Africa. This concept of virtual water also provides a new lens to the quantitative framework for the study of water utilized for farming and farm animal production worldwide, and the water exchanges hidden in the food trade. In summation to this view, by counting the virtual water content of diverse nutrients, scientists have highlighted the voluminous need for water for the production purposes especially, food grain production.

**Keywords:** Water, Water scarcity, Virtual Water Trade, Agriculture Sector, South Africa.

## Introduction

Water has become an economic asset in today's global scenario of globalization and competition at different levels of economic-socio-political frontiers (Hoekstra and Hung, 2002). It's also a scarce commodity in South Africa with an average rainfall of approximately 464mm compared with a world average of 860mm, courting one of the lowest Mean precipitations with a world average ratio in the world (WESSA, 2012). With the advent of recent demographic changes, urbanization and a rising middle class society, with high water, food and electricity demands, South Africa already harnessed nearly the entire extent of its water resources through technology for economic development. Granting to the highly centralized existing water provisions and internationally well augmented water policy, it has been shown that the ecosystem associated with the great rivers in South Africa is alarming; very unaccountable than for terrestrial ecosystem: 84% of the 112 unique river ecosystem types assessed were threatened, with a disturbing 54% critically endangered, 18% endangered and 12% vulnerable; and more than 50% of our wetlands are taken down. By and forth supply of water witnessing only a 98% assurance indicating the coming danger of deficits and the likelihood of a state which would not be able to overcome the optimum needs of social, economic and environmental requirements in the near future.

By and forth supply of water witnessing only a 98% assurance indicating the coming danger of deficits and the likelihood of a state which would not be able to overcome the optimum needs of social, economic and environmental requirements in the near future. Climate alteration is also a big leap which hinders narrowing the further stage of complexity attached to the water crisis, as a fluctuating rainfall patterns also influence water quantity and quality including risks of flood events as well. These challenges calling the shots in recent scenario and will abruptly overtake the prior position as a degree of danger to our water security. Approximately 1.4 billion people live in river catchment areas where all the low water is already employed to its desired ends or overcommitted. Risks associated alike over-commitment of water use is a problem in many regions of the globe. With current levels of water productivity, the additional consumptive use of water tied to food security by 2025 and 2050 is estimated at 3800 and 5600

km3/year, respectively. Presently, the total annual withdrawals of blue water are between 3500 to 4000 km3. This brings up the question: From where can the additional water needed to achieve food security be taken? Is it through additional withdrawals from blue water resources, i.e. rivers, lakes and aquifers? Is it from proper utilization of green water, i.e. the invisible soil moisture? Or is it through enhanced water productivity and yield improvements?.

The major water withdrawal of water is taking place through agricultural sector. As a fundamental unit of agricultural input, water is exclusively linked to food security because of its direct multi dimensional link to the aspect of food availability, utilization, stability and access. South Africa is the 30th driest country in the world and holds less water per person than countries widely considered as more arid, such as Namibia and Botswana. Water is now the number one food production limiting factor in many regions of Sub-Saharan Africa.

Trade in food is literally also trading in water. At the worldwide level, trade in virtual water can reduce consumptive water usage in agriculture if exporters are able to achieve higher water productivity than importers. The mass of virtual Water 'hidden' or embodied in a particular product is fixed as the intensity of water employed in the output process of that product (Allan, 1997; Hoekstra, 1998). The virtual water content of a commodity is the volume of water used to produce this commodity. International trade in food implies international flows of virtual water. For water-scarce countries, it can be attractive to import virtual water (through import of water-intensive products), thus alleviating the pressure along the domestic water resources. The term 'virtual water' was introduced by Tony Allan in the early 1990s (Allan, 1993; 1994). It is defined as the volume of water required to produce a commodity or service (Allan, 1998, 1999; Hoekstra, 1998). When there is a transfer of products or services from one place to another, there is little direct physical transfer of water (apart from the water content of the product, which is quite insignificant in terms of volume). There is, however a significant transfer of virtual water.

Consumption of water in the process of an agricultural or industrial product is said to be the 'virtual water' contained in the product (Allan, 1998). For improving global water use efficiency, for achieving water security in water-poor parts of the globe and for alleviating the constraints on the environment by using best suited production sites an instrument, i.e. virtual water trade between countries and even continents can be used (Turton, 2000).

Efficiency of water use can be improved at different degrees. At the user layer, which is the lowest point, adopting water-preservation technologies and standards such as water pricing, awareness raising etc. can improve the efficiency. The allocation and re-apportionment of water resources to specific higher-value functions, which is the second level, refers to more equitable use by all stakeholders. Generally through government interventions in the course of different policies in the water sector efficiency is accomplished at this stage. The trade in water is the highest level where efficiency of water use can be improved. Trading water in its actual form is costly, because water in large amount is difficult to transport. Thus the concept of virtual water has evolved.

Crops which are grown under rain-fed area and favorable climatic conditions (like in the Netherlands or Canada), one to two cubic meters of water, which is 1000 to 2000 kg is needed for making one kilo of cereal. And where the climatic conditions are less favorable, the climate is arid (like in Egypt or Israel); 3000 to 5000kg of water is needed due to high temperature and high rate of transpiration for growing same amount of grain. Livestock and livestock products need heavy amounts of water. Roughly, contain about 5 to 20 times more virtual per kg water is contained in livestock products than crop products.

Producing and exporting products with relatively low virtual water content and importing products having higher virtual water content can be an attractive policy for a country which is water scarce. To maximize the value of their limited water supplies, in water scarce nations, volume of virtual water embodied in food imports and exports will remain a great worry. Elements of production either land, labor or capital incorporated in the products must also be considered in countries where one or more of those resources is limited (Wichelns, 2001). The physical volume of trade and the content of the virtual water in the product traded define the volume of the virtual water flow between two nations.

The aim of this paper is to analyze the current scenario of total virtual water flow taking place through agricultural products in South Africa and its trend across 2000-2011. And assessing the major agricultural commodities due to which virtual water trade is taking place. In particular, this study provides a transparent in sight to acquire more optimum allocation of water resources through analyzing patterns and extent of virtual water trade with the world or other countries of the world to execute more appropriate and efficient, low water intensive cropping system for import substitution.

**Methodology**

This study is based on secondary data and various published sources. Data for food production and international trade data has been compiled for the period 2000-2011 from the Food and Agricultural

Organization of United Nations (FAO), United States Department of Agriculture (USDA) and World Development Indicators Database.

The estimation of virtual water has primarily been done with the help of available literature on water contents in each agricultural and livestock produces (Allan, 1993; Haddadin, 2003; Chapagain and Hoekstra, 2003; Chapagain and Hoekstra, 2004). Virtual water trade has been calculated by multiplying commodity trade volume (tonne/ year) by their associated virtual water content ($m^3$/ tonne). Virtual water trade is thus calculated as:

$$VWT_t = \sum_{i=1}^{n} \left( QT_{it} \times VWC_{it} \right)$$

Where,

$VWT_t$ = Total volume of virtual water traded by South Africa by importing $i^{th}$ agricultural/ livestock produce in time *t*.

$QT_{it}$ = Quantity imported (tonne/ year) by South Africa of $i^{th}$ agricultural/ livestock produce in time *t*.

$VWC_{it}$ = Virtual water content ($m^3$/ tonne) by $i^{th}$ agricultural/ livestock produce in time

**Limitations of the study**

- Only agricultural crops have been studied for this work. Due to the large content of water embedded in a product.
- Virtual water coefficients of less than 10% of trade crops are not available.
- Global virtual water content coefficients were used (i.e. Hoekstra and Mekonnen)

**Results**

**Agriculture Sector in South Africa**

Agriculture industry in South Africa constitutes around 10% of formal employment, relatively low as compared to other parts of Africa, giving almost 2.6% for the nation. The Aridity of land is the major reason due to which only 13.5% of the land can be applied for crop production, only 3% is considered high potential land. Likewise, the low productivity potential of land, agriculture sector continuously facing problem due to the increased foreign competition, lack of optimum land, water and soil potential and crime being the major challenges for the industry.

Edible fruit and nuts, drinks, preserved food, tobacco, cereals, wool not carded or combed, miscellaneous food, sugar, meat, milling products, meat and starch are the most important agricultural exports of South Africa. The most important agricultural exports of South Africa. 80% of agricultural export revenue in the first quarter of 2010, was because of these products. Food grains, meat, soya-bean oil cake, drinks, soya-bean oil and its fractions, tobacco, palm oil and its fractions, mixed food, spices, coffee, tea, and preserved food are the most important agricultural imports, which accounted for over 60% of agricultural import value during first quarter of 2010.

According to FAOSTAT, South Africa is one of world's largest producers of: chicory roots (4th); grapefruit (4th); cereals (5th); green maize and maize (7th); castor oil seed (9th); pears (9th); sisal (10th); fibre crops (10th). In the first quarter of 2010, a positive trade balance of only R1.7 billion was earned, while the agricultural sector earned export revenues for R10.1 billion but R8.4 billion was used in payment for imported agricultural products.

The dairy industry in South Africa compiles 4,300 milk producers and provides employment to 60,000 farm workers, leading to the livelihoods of around 40,000 others.

The food sub-sector contributes to 1.4% of total employment and is the largest employer within the agro-processing sector, and 11.5% within the manufacturing sector.In 2006, 24.7% of the total manufacturing output was from agro-processing sector. The use of sectors like food, clothes and paper sub-sectors in exports has declined as firms in these sectors increasingly compete with lower cost producers, particularly from China and India. Large dominant firms in sectors like beverages, tobacco, wood and leather sub-sectors have managed to remain competitive and have increased exports from South Africa over the point. And other parameters related with agriculture sector in South Africa have been shown in Table 1, which indicated that the share in the agricultural land area is decreasing, though at a very negligent rate of 0.16%. Food Imports showing an increasing trend with 2.45%, on the other hand Food exports showing a decreasing trend but at a very negligible rate

**Virtual Water Trade from Agricultural Products**

Table 2 shows total virtual water trade of agricultural products in South Africa during the period 2000-2011. According to the estimates as shown in table 2, depicts that the South Africa has been the virtual water exporter except in the year 2004, 2007 & 2008. The major water withdrawal took place in the year 2009 with 18165 million cubic meters.

According to the figure 1 the trend line with a growth rate of virtual water export is increasing and trend line of virtual water imports is decreasing. These numbers suggest that the virtual water consumption, dominated by food products, exceeds by an order of magnitude the water used by people for drinking and domestic usage, confirming the large impact of virtual water on the local and global water balance. Due to its economic, social, political, and environmental implications, virtual water trade has attracted a growing amount of attention from the scientific

community in the last decade (e.g., Hoekstra and Chapagain, 2008; Hoekstra and Mekonnen, 2012).

| Parameters | 2000 | 2006 | 2011 | ACGR |
|---|---|---|---|---|
| Agricultural land (% of land area) | 80.89 | 79.87 | 79.45 | -0.16% |
| Agricultural land (000 sq. km) | 981.25 | 968.88 | 963.74 | -0.16% |
| Agricultural raw materials exports (% of merchandise exports) | 3.38 | 1.76 | 2.08 | -4.31% |
| Agriculture, value added (000 000 000 current LCU) | 27.45 | 45.35 | 64.58 | 8.09% |
| Agriculture, value added (000 000 000 current US$) | 3.96 | 6.70 | 8.89 | 7.64% |
| Land under cereal production (000 000 hectares) | 5.27 | 2.99 | 3.21 | -4.41% |
| Arable land (000 000 hectares) | 13.81 | 12.60 | 12.03 | -1.25% |
| Agriculture, value added (% of GDP) | 3.27 | 2.88 | 2.46 | -2.56% |
| Agriculture value added per worker (constant 2005 US$) | 3688.36 | 4257.41 | 5665.88 | 3.98% |
| Cereal production (metric tons) | 14.53 | 9.44 | 12.92 | -1.06% |
| Cereal yield (kg per hectare) | 2755.33 | 3159.10 | 4023.96 | 3.50% |
| Crop production index (2004-2006 = 100) | 102.54 | 93.79 | 103.75 | 0.11% |
| Food production index (2004-2006 = 100) | 95.78 | 99.16 | 115.62 | 1.73% |
| Export value index (2000 = 100) | 100 | 206.03 | 321.94 | 11.21% |
| Export volume index (2000 = 100) | 100 | 125.13 | 110.84 | 0.94% |
| Food exports (% of merchandise exports) | 8.47% | 7.11% | 7.98% | -0.55% |
| Food imports (% of merchandise imports) | 4.68% | 4.36% | 6.11% | 2.45% |
| GDP per capita (000 constant LCU) | 29.59 | 34.76 | 37.67 | 2.22% |
| GDP growth (annual %) | 0.04% | 0.06% | 0.03% | -1.66% |
| Improved water source (% of population with access) | 86.50% | 89.50% | 91.50 | 0.51% |
| Improved water source, rural (% of rural population with access) | 71% | 76% | 79.30% | 1.01% |
| Improved water source, urban (% of urban population with access) | 98.30% | 98.70% | 99% | 0.06% |
| Improved sanitation facilities, urban (% of urban population with access) | 82.10% | 83.40% | 84.30% | 0.24% |
| Population growth (annual %) | 2.48% | 1.12% | 1.18% | -6.49% |

**Table 1:** Analysis of Agriculture Sector in South Africa **Source:** World Bank Data, 2013

Virtual water trade patterns in South Africa from 2000 to 2011 are highlighted in figure 1. In the past decade, virtual water trade has increased in South Africa. But the growth rate was about 4% to 5% annually. Except for a few years of the last decade, South Africa has always been a net exporter of virtual water embedded in agricultural commodities. From 2000 to 2011, the year 2005 has been the year of highest net export of virtual water and the year 2004 the lowest.

| Year | Global | | |
|---|---|---|---|
| | Export | Import | Net Trade |
| **2000** | 11127 | 8159 | 2969 |
| **2001** | 11748 | 6285 | 5463 |
| **2002** | 12809 | 8950 | 3859 |
| **2003** | 11479 | 9085 | 2393 |
| **2004** | 7172 | 10612 | -3440 |
| **2005** | 19350 | 9734 | 9616 |
| **2006** | 12831 | 11608 | 1223 |
| **2007** | 11079 | 13413 | -2335 |
| **2008** | 14808 | 15100 | -293 |
| **2009** | 18165 | 11078 | 7087 |
| **2010** | 15082 | 12116 | 2965 |
| **2011** | 18293 | 12891 | 5402 |

**Table 2:** South Africa's Virtual Water Trade from Agricultural Products ($10^6 m^3$)

**Source:** own calculation based on FAOSTAT

Figure 2 shows the major commodities due to which virtual water trade is taking place. The major commodities due to which virtual water export is taking place were maize, grapes and all other fruits. And the important commodities witnessing virtual water imports were oil crops, cereals, industrial crops and Stimulants (cocoa, coffee, tea)

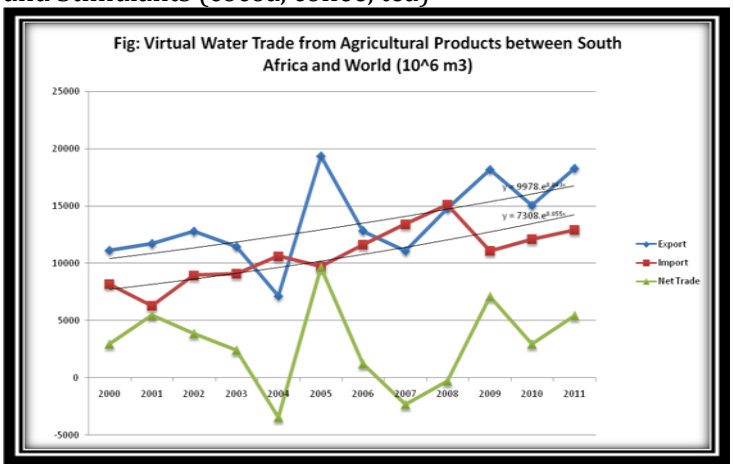


**Figure 1:** Virtual Water Trade from Agricultural products between South Africa and World ($10^6 m^3$) **Source:** Own calculation based on FAOSTAT

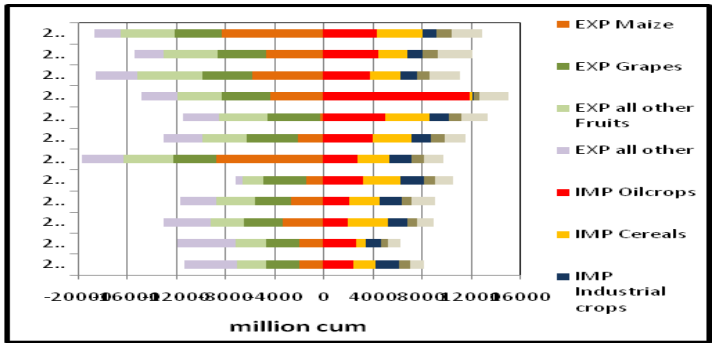


**Figure 2:** Water embodied in imports and exports of South Africa's crop trade, 2000 – 2011 **Source:** own calculation based on FAOSTAT

## Conclusion

This study concludes that being the water scarce nation, South Africa needs to focus on the issues

related to agriculture sector due to which water withdrawal is taking place on the large scale. Ways and means must be confounded to increase water use efficiency in both irrigated and rain-fed agriculture, and integration of food production systems (agriculture and inland fisheries). It is equally essential that efforts must be launched to keep the demand for water intensive food items within reasonable limits. Indigenous management and sound stewardship of the entire water resource is the need of the hour. Assessing the direction and composition of virtual water flows will enhance the scope for defining the major areas from where water conservation strategies would evolve to save water resources.

This concept of virtual water also provides a new lens to the quantitative framework for the study of water used for agriculture and livestock production worldwide, and the water exchanges hidden in the food trade. In addition to this aspect, by calculating the virtual water content of various foods, scientists have highlighted the voluminous need for water for the production purposes especially, food grain production.

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