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EXPLORING EGYPT'S VIRTUAL WATER TRADE IN AGRICULTURAL PRODUCTS: IS THERE A NEED FOR RETHINKING?

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ABSTRACT

Virtual water trade as a mean to balance the national and global water budget has recently received much attention. Building upon the knowledge of virtual water accounting in the literature, this study quantitatively assess the virtual water flows in Egypt's agricultural trade (i.e., the embodied water used) from the perspectives of exports and imports at the country level. The investigation reveals that Egypt has exported an average of 6.69 billion m^3/yr and imported 27.5 billion m^3/yr with a net import of 20.9 billion m^3/yr of virtual water related to crop and livestock products throughout the period 2003-2009 (on average). Thus, Egypt is to be considered a net importer of virtual water, and in such case, the country saves this amount of its national water resources. Of which, it saves about 5.7 billion m^3/yr and 3.2 billion m^3/yr of its wheat and maize imports respectively.

INTRODUCTION

Owing to (Yang *et al*., 2006), the global total water withdrawal for usage is estimated at about 80%, this is mainly due to the continuous population growth and related developments. As a result, water resources have become increasingly scarce. However, food production is directly affected by water scarcity (Cosgrove and Rijsberman, 2000; Rosegrant *et al*., 2002). In many water scarce countries, an increasing amount of food is being imported to meet the domestic food demand.

Dabo and Hubacek (2007) argued that, the idea of virtual water was derived from the concept of 'embedded water' applied to agriculture in Israel by Gideon and Shuval (1994). Their research concluded that exporting Israeli water embedded in water intensive-crops was not sustainable. The term 'virtual water' was first developed in 1994 by J. Anthony Allan (Allan 1994). Allan defines virtual water as the water used to produce food crops that are traded internationally. He found that a few countries characterized as water-scarce have secured their food supply by importing water intensive food products, rather than producing all of their food supply with inadequate water resources. Limited water resources should be used efficiently by not allocating the majority of the water resources to the production of water-intensive products (e.g. crops, paper etc.) but rather water should be made available for other economic purposes that can contribute more to regional value added by consuming less water (Allan 1998; 2002).

Most of the studies on virtual water flows have been conducted in drought areas such as the Middle East and North Africa and have emphasized the amount of water embedded in different agricultural products related to food security, with agriculture being the largest water consumer.

In recent years, the concept of virtual water has been extended to refer to the water that is required for the production of agricultural commodities as well as industrial goods (Hoekstra and Hung, 2003). Nevertheless, discussions on virtual water issues have so far focused primarily on food commodities due to their large share in total water use. With the continuous intensification of water scarcity in many areas of the world, the role of virtual water trade in balancing local water budget is expected to increase (Yang *et al*., 2003).

Water scarcity, food security and virtual water trade topics have been interesting research materials for many researchers. These efforts have remarkably enriched the understanding of water and food challenges and provided significant information for formulating national and international policies to deal with them. Since the development of virtual water concept, it has been widely used by academics and international organizations (Food and Agriculture Organization[1]and World Water Council) in a wide range of applications across developing and developed countries such as (Hoekstra 2003; Hoekstra and Hung 2002, 2003, 2005; Chapagain and Hoekstra 2003; Yang *et al*., 2003, 2006; Renault 2003; Oki *et al*., 2003; Zimmer and Renault 2003; De Fraiture *et al*., 2004; Oki and Kanae 2004; Wichelns 2004). The obtained results from these studies vary to some extent, this is presumably due to the different coverage in geographical scales and the food commodities in the calculation. The variations also reflect the complexity of site-specific conditions in different regions and countries.

The paper is structured as follows. The next section is devoted to illustrate the aim of the paper. Data collection is the subject of part three of this paper. Section four briefly offers an overview for water resources and usage in Egypt. The fifth section investigates the tends in Egypt's agricultural trade. Section six discusses the employed methodology. The seventh and last section is devoted to conclusion.

Aim of the Paper

The aim of this paper is twofold. First, it attempts to estimate the volumes of virtual water embodied in Egypt's main agricultural trade. Thus, enabling the estimation of what could be called 'Egypt's water trade balance'. Second, suggesting other options for achieving water security.

Data

Data was mainly obtained from Food and Agriculture Organization on line statistical database (FAO), World Bank, and Ministry of Agriculture and Land Reclamation published data.

Water Resources and Uses in Egypt.

Water Bodies and Nile River

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[1] Related research work could be available via FAO website at the following URL:
http://www.fao.org/about/en/?search=&cx=014355652153930272035%3Aoyuqpnjadfs&cof=FORID%3A10&q=virtual+water+trade&x=6&y=9#1056

FIGURE (1): RIVERS, WATER BODIES AND IRRIGATION ZONES IN EGYPT
Source: FAO-AQUASTAT, online database.

The majority of Egypt's area (about 1 million Km2) is desert. Most of the cultivated land is located close to the banks of the Nile River, its main branches and canals, and the Nile Delta. Rangeland is restricted to a narrow strip, only a few kilometers wide, along the Mediterranean coast and its bearing capacity is quite low. The total cultivated area (arable land plus permanent crops) is 3.3 million ha (2008), or about 3% of the total area of the country. Arable land is about 2.8 million ha, or 85 percent of the total cultivated area, and permanent crops occupy the remaining 0.5 million ha. Moreover, in 2008, the irrigated cropland area was estimated at about 99.8%.

The River Nile (see Figure 1) is the main source of water for Egypt, with an annual flow of 55.5 km^3/Yr (stated by the Nile Waters Agreement of 1959). In addition to, agricultural sewage recycling water and internal renewable groundwater resources in the Valley and Delta estimated at 11.1 km^3/Yr and 8.6 km^3/Yr respectively. For sewage recycling water and floods & rains (1.8 km^3/Yr each) and only 0.1 km^3/Yr for sea desalination water.

River Basins and Water Usage

Figures (1) and (2) shows that the Egyptian territory comprises four main river basins. The Northern Interior Basin, (constituting 52% of the total area of the country in the east and southeast of the country). The Nile Basin, (accounting 33% in the central part of the country in the form of a broad north-south strip). The Mediterranean Coast Basin, (about 6%), and the Northeast Coast Basin, a narrow strip along the coast of the Red Sea (covering 8%).

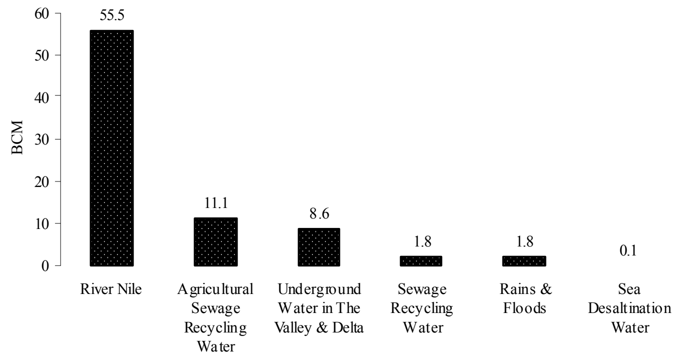

Figure (2): Egypt's Water Resources by Source during the period (2007-2009) on average

Source: CAMPS

Figure (3): River Basins In Egypt

Figure (4): Percentage Distribution of Water Uses (2007-2009 on average)

Source: Centre of AMPS

Moreover, total water withdrawal in Egypt is estimated at about 78.9 km^3 (2008-2009 on average). Of which, nearly 78% is devoted for agriculture; whereas about 14% and 8% are devoted for industry and domestic use (see Figure 3).

Egypt's Agricultural Trade

In 2009, Egypt's GDP was estimated at about US$188.4 billion with an annual growth rate of 4.6%. The value added of the agricultural sector accounted for 14% of GDP, employing about 31% of the labor force. Moreover, the aggregate exports and imports of goods and services reached 25% and 32% of GDP respectively. However, the agricultural exports and imports were estimated at US$1.4 billion and US$5.5 billion respectively throughout the period 2005-2009 (on average), representing about 12.5% and 17% of total exports respectively during the same period.

The agricultural trade deficit grew from US$1.7 billion in 1974-85 to US$2.5 and further to US$ 2.7 billion and US$3.2 billion in 1986-89, 1990-2000 and 2001-2009 respectively. However, Figure 4 shows that, the agricultural imports are about four times that of exports throughout the last decade.

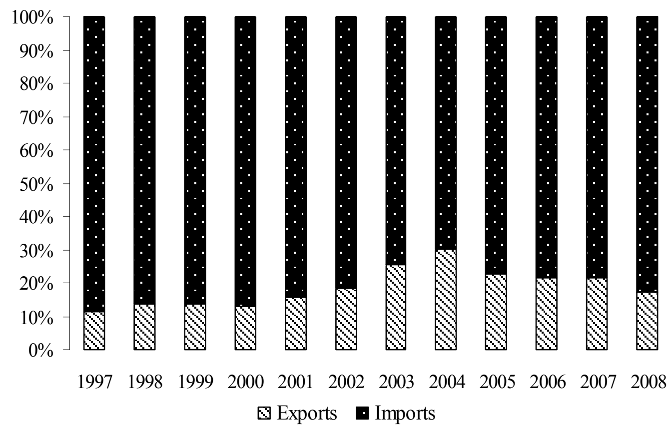

FIGURE (5): EGYPT'S AGRICULTURAL TRADE THROUGHOUT THE PERIOD (1997-2008)

This agricultural trade deficit is a direct result of the dramatic growth in food imports, particularly wheat and wheat flour imports. This is presumably in part due to the rapid increase in population (2.8% annual growth) which was well in excess of the 2% growth in agricultural output. This means that the domestic production of major crops, especially wheat, failed to meet the growing demand for food. Consequently, imports increased and the rate of self- sufficiency rapidly declined.

The paper assumes that agricultural exports Y_t may be described by a simple linear trend model $Y_t = \alpha + \beta T + \mu_t$ where the slope is given by β, T is a time trend and μ_t is a random variable of zero mean and constant variance. Consequently we can recover the underlying trend by regressing the variable (exports) on the time trend *(T).*

Table (--) shows the modelling of the regression analyses for agricultural exports and imports. The results depicts that all of the series appear to be trending over time. Results from the t test results (at 1% level of significant), depicts an evidence of statistical significance in both slope and intercept coefficients for all investigated variables. Exports and imports are significantly confirming the gradual increase in their trend. These results were also confirmed by F test results (at 1% level of significant) see Table 1.

TABLE (1): ESTIMATED COEFFICIENTS FOR AGRICULTURAL EXPORTS AND IMPORTS

Coefficients			SE	T ratio	P value	F (Calculated)
Exports	α	0.20*	0.10	2.02	0.0711	68.26**
	β	0.11**	0.01	8.26	0.0000	
	R^2	0.87				
Imports	γ	2.32*	0.82	2.84	0.0176	5.76*
	Ω	0.27*	0.11	2.40	0.0373	
	R^2	0.67				

Source: Author calculation.

Tables (1 & 2) and Figures (5 & 6) portrait a detailed picture for top agricultural exports and imports, in addition to, their destination flows during the periods 2003-2008 and 2006-2008. For exports, Table 1 depicts that, main exports are ranked according to their value relative share throughout the period 2008-2008 (on average) as follows; cotton lint (24.8%), milled rice (23.5%), oranges (9.8%), potatoes (8.9%), molasses (4.3%), grapes (3.4%), dry onions and dehydrated vegetables (3.3%) each and frozen vegetables (2.9%). Whereas, imports (during the same period), included 5.6 million tones of wheat, 3.9 million tones of maize, 0.15 million tones of beef and veal, 0.6 million tones of palm oil, 0.7 million tones of soybeans and 0.4 million tones of sugar.

Figures 5 and 6 reveals that, the European Union (EU) and the United States (US) are Egypt's largest trading partners accounting for about 52% of Egypt's foreign trade (2006-2008 on average). Almost 54% of all Egyptian imports originate from these two sources. Relations with Europe dominate Egypt's trade policy. The (EU) accounts for about 38% of Egypt's foreign trade. The EU accounted for 39% of exports and some 33% of imports in 2008. Germany, Italy, The Netherlands and France are the most important trading partners. In 2008, Egypt imported more than three times as much (in value terms) from the EU as it exported to the EU[2].

[2] In 2008, Egyptian imports from the EU accounted for 4.4 billion US$ while exports to the EU were estimated at 1.1 billion US$.

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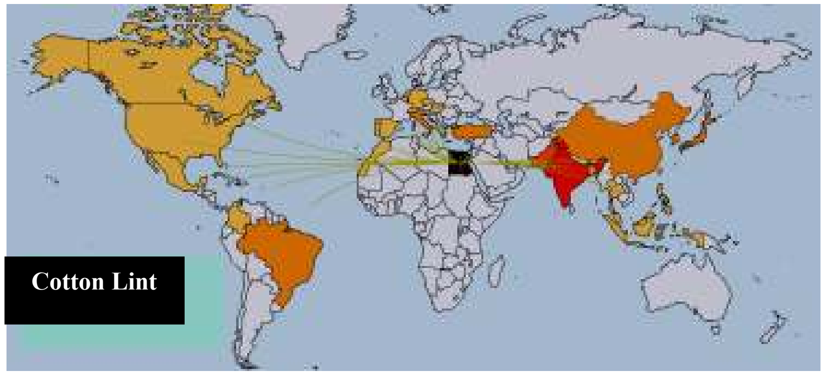
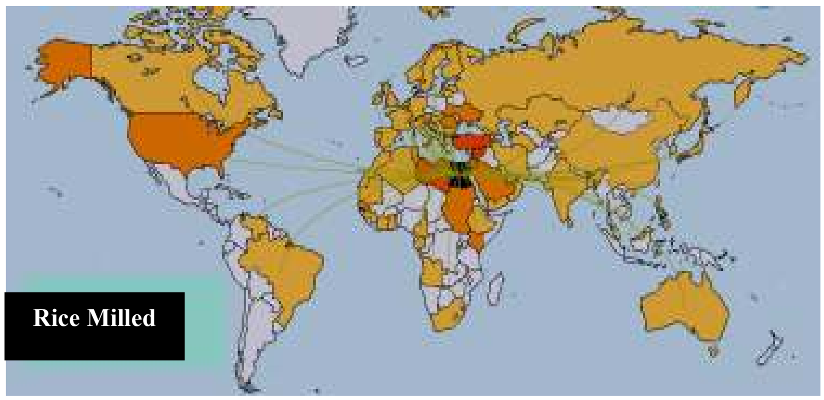
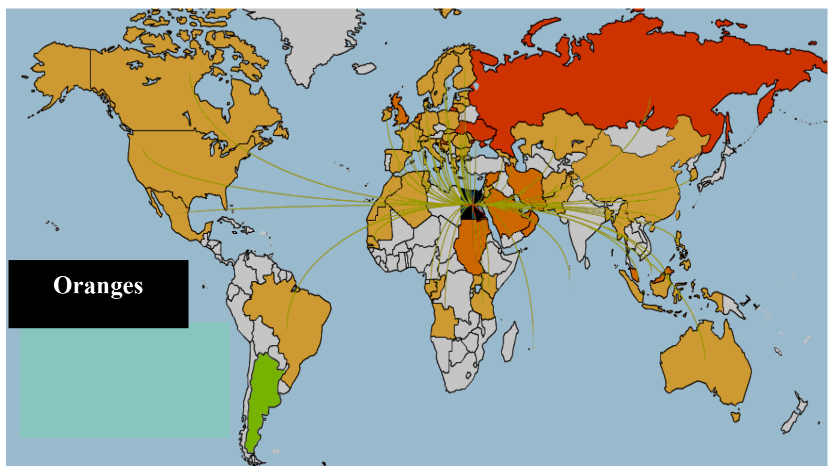
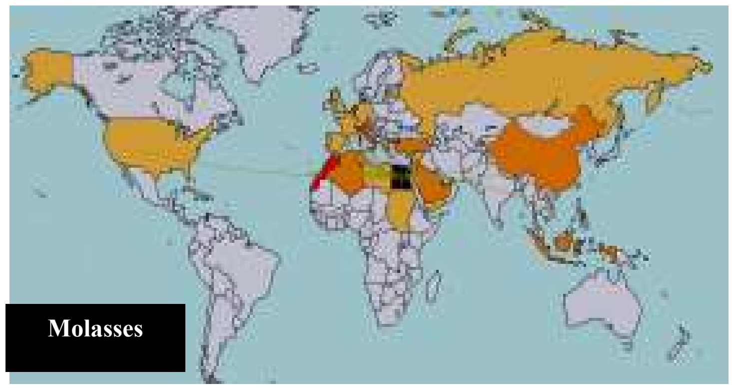


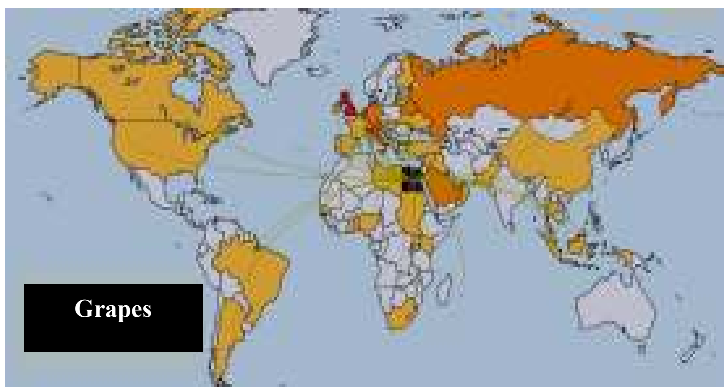




*The darker the shaded area the greater the share of Egypt's exports to that country.


Potatoes


Molasses


Grapes

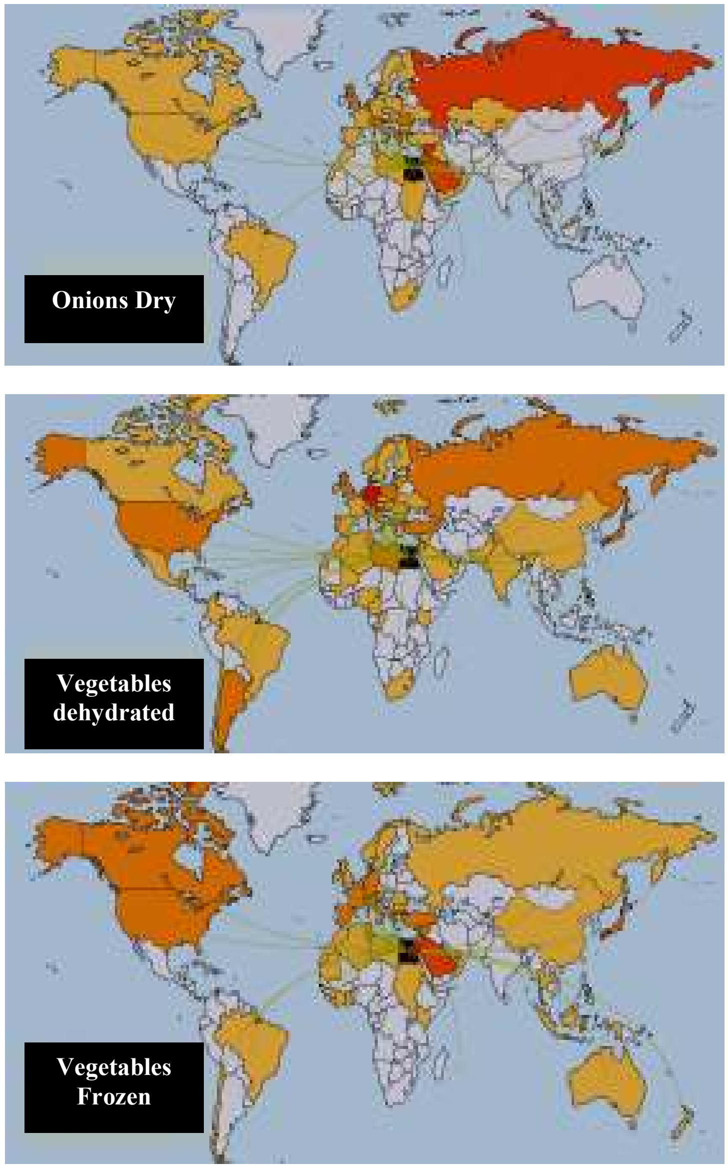
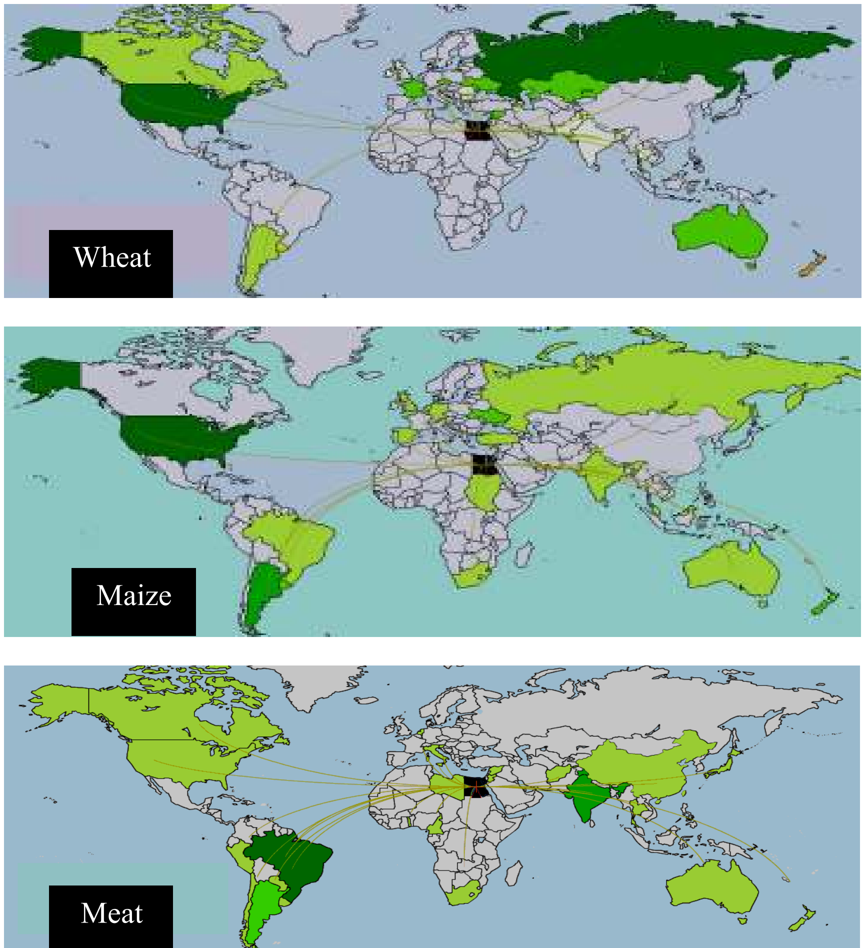
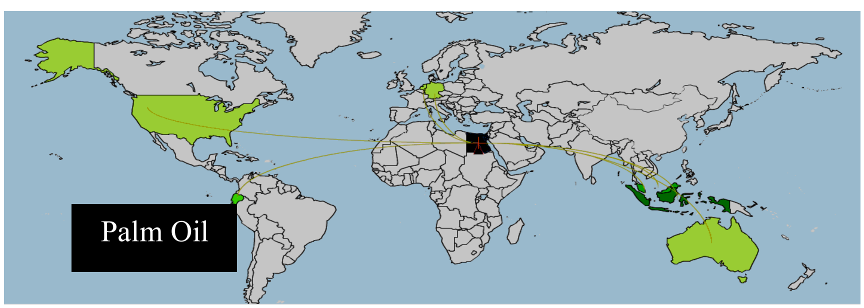


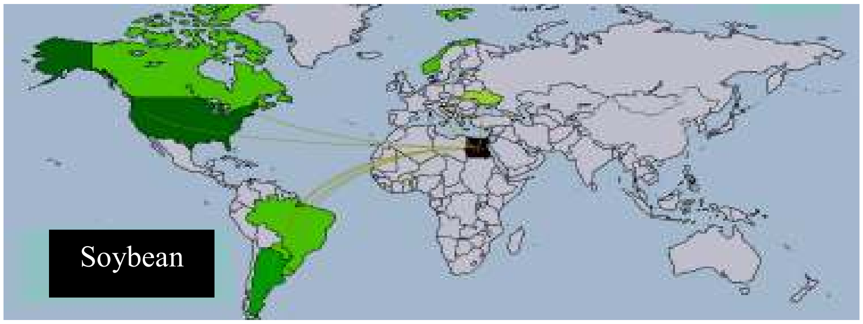
FIGURE (5): EGYPTIAN EXPORT FLOWS TO WORLD COUNTRIES FOR MAIN AGRI-PRODUCTS DURING THE PERIOD 2006-2008 (ON AVERAGE)

Source: FAO online database.

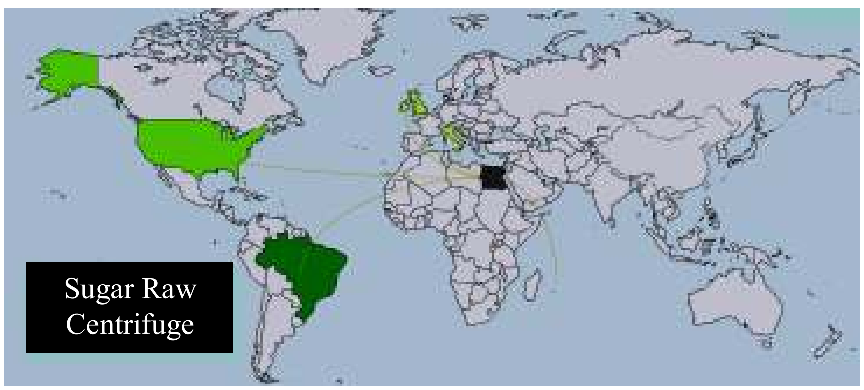


*The darker the shaded area, the greater the share of that country in Egypt's imports.




Soybean


Soybean Oil


Sugar Raw
Centrifuge

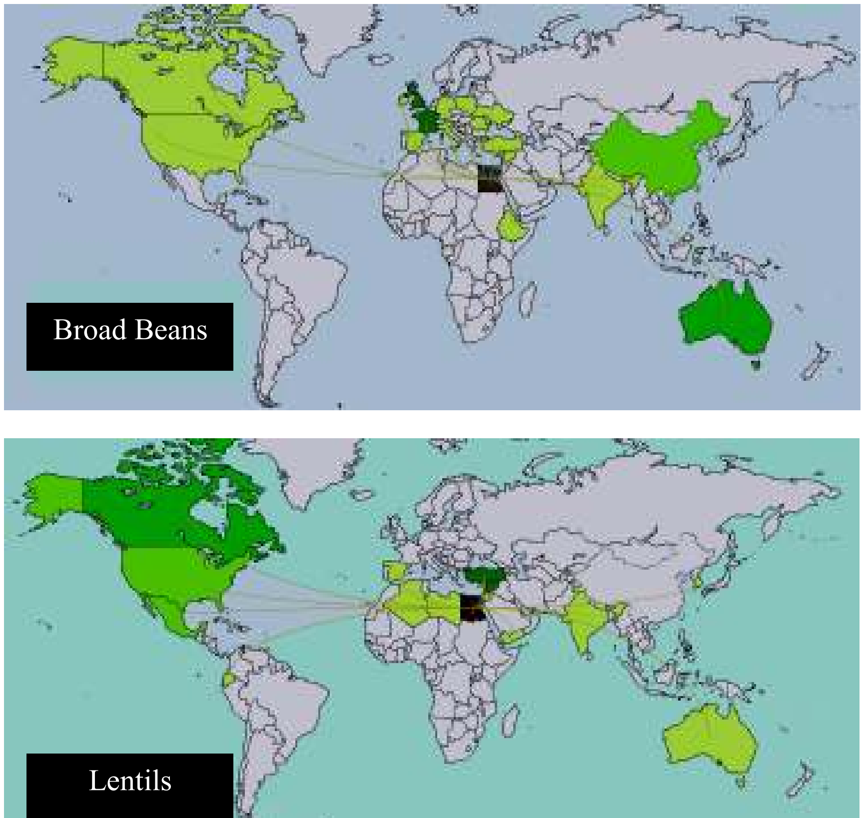


FIGURE (6): THE SHARE OF WORLD COUNTRIES IN EGYPT'S MAIN IMPRTS* DURING THE PERIOD 2006-2008 (ON AVERAGE)
Source: FAO online database.

Virtual Water: Concept and Methodology.
Concept

Owing to Kumar and Sharad (2007), virtual water content of a product depends upon the technology and conditions of production. Considerable saving of water is possible if water-efficient technology is employed to produce the product. Further, water consumed in a production process also depends upon climate; more water is needed to produce each unit of a crop in arid climates compared to that in humid areas. The virtual water content of various primary and processed crop products, livestock products and industrial products for different countries was estimated by Chapagain and Hoekstra (2004). While computing the virtual water content of products, a distinction is made between primary products (e.g. vegetables), processed products (e.g. sugar), and transformed products (e.g. cheese). Some processes may yield multiple products and in this case, total quantity of water used is allocated amongst these.

3

Further, not all products require water and for such items, virtual water content is nil. The virtual water content of a crop in a country is calculated as the ratio of total water used for the production of the crop to the total volume of the crop produced in that country. Crop water use is assumed to be equal to the crop water requirement, which is calculated by accumulation of data on daily crop evapotranspiration over the complete growing period. Crop water requirements for different crops have been calculated10 using the CROPWAT model of the Food and Agriculture Organization (FAO), United Nations.

Methodology

Estimation of Virtual Water and Virtual Water Trade Balance

Per crop type, average specific water demand has been calculated separately for each relevant nation on the basis of FAO data on crop water requirements and crop yields:

$$SWD_{(c)} = \frac{CWR_{(c)}}{CY_{(c)}} \quad \text{………………………………………………………………………… (1)}$$

Where,

SWD = denotes the specific water demand ($m^3 ton^{-1}$) of crop *c*

CWR = crop water requirement ($m^3 feddan^{-1}$)

CY = crop yield

However, Virtual water flows between have been calculated by multiplying the crop trade flows by their associated virtual water content. The latter depends on the specific water demand of the crop. Virtual water trade is thus calculated by:

$$VWT_{(c,t)} = CT_{(c,t)} \times SWD_{(c)} \quad \text{…………………………………………………………(2)}$$

Where,

VWT= denotes the virtual water trade ($m^3 ton^{-1}$) in year *t* as a result of trade in crop *c*

CT = represents the crop trade (ton yr^{-1}) in year *t* for crop *c*

SWD = denotes the specific water demand ($m^3 ton^{-1}$) of crop *c*

Thus, the gross virtual water imported to Egypt is the sum of all imports that could be represented as follows:

$$GVWI_{(t)} = \sum_{c} VWT_{(c,t)} \quad \text{……………………………………………..(3)}$$

Similarly, the gross virtual water exported from Egypt is the sum of all exports that could be represented as follows:

$$GVWE_{(t)} = \sum_{c} VWT_{(c,t)} \quad \text{………………………………………… (4)}$$

Then, the net virtual water import of Egypt is equal to the gross virtual water import minus the gross virtual water export. The virtual water balance of for year t can thus be written as

$$NVWI_{(x,t)} = GVWI_{(x,t)} - GVWE_{(x,t)} \quad \text{..............................(5)}$$

In which, *NVWI* stands for the net virtual water import (m^3yr^{-1}) to the country. Net virtual water import to a country has either a positive or a negative sign. The latter indicates that there is net virtual water export from the country.

In practice, the first step to estimate Egypt's agricultural virtual water trade is to calculate its agricultural virtual water exports. To achieve this goal, it is necessary to estimate the specific water demands for main agric-exports by the aid of area, production, yield and crop water requirement per feddan data. Table (4) shows that crops are differing widely in their water use, for example, producing one ton of raw cotton requires about 4337 m^3, while it accounts for sunflower, lentils and soybean about 2853 m^3 (on average). Next come rice (1931 m^3), dry beans (1469 m^3), oranges and apples (1372 m^3 on average), broad beans (1001 m^3), green beans, grapes, maize and wheat (900 m^3 on average), vegetables, dry onion and potatoes (286 m^3 on average) and lastly sugarcane (191 m^3).

Estimation of Water Scarcity, Dependency and Self-sufficiency.

Countries with high water scarcity is seeking profit from net virtual water import, while others with excess water resources could make profits by exporting water in virtual form. In order to check this hypothesis, we need indices of both water scarcity and virtual water import dependency. A proper indicator of 'virtual water import dependency' or 'water dependency' should reflect the level to which a nation relies on foreign water resources (through import of water in virtual form). However, the study adopted the way employed by (Hoekstra and Hung, 2005) to calculate water dependency *WD* and water self-sufficiency *WSS*, which could be estimated as follows:

$$WD = \frac{NVWI}{WU + NVWI} \times 100$$

……………………………………………………(6)

Where, *WU is* the total water use in the country. However, the value of the water dependency *WD* is expected to range between 0% and 100%. A value of zero means that gross virtual water import and export are in balance or that there is net virtual water export. If on the other extreme the water dependency of a nation approaches hundred percent, the nation nearly completely relies on virtual water import.

As a counterpart of water dependency (WD), water self-sufficiency (WSS) indicates the national capability of supplying the water needed for the production of the domestic demand for goods and services. Self-sufficiency is 100% if all the water needed is available and indeed taken from within the country. Water self-sufficiency approaches zero if a country heavily relies on virtual water imports. However, it could be estimated as follows:

$$WSS = \frac{WU}{WU + NVWI} \times 100 \quad \ldots\ldots(7)$$

Or, in other words

$$WSS = 100 - WD \quad \ldots\ldots(8)$$

TABLE (4): AREA, PRODUCTION, YIELD, CROP WATER REQUIREMENT AND SPECIFIC WATER DEMAND FOR MAIN AGRICULTURAL CRPOS IN EGYPT THROUGHOUT THE PERIOD 2003-2009 (ON AVERAGE)

Item	Area (000 Fed)	Production (000 ton)	Yield (ton/Fed)	Crop Water Requirement* (m^3/Fed)	
Cotton	520.3	545.8	1.0	4337	4337
Rice	1623.8	6744.3	4.2	8109	1931
Oranges	453.4	2060.4	4.5	5733	1274
Potatoes	100.0	1194.5	11.9	3200	269
Sugar cane	324.8	16614.3	51.2	9789	191
Grapes	317.3	1478.0	4.7	4305	916
Onions, dry	98.3	1460.8	14.9	4104	275
Vegetables	857.6	8950.4	10.8	3375	313
Beans, dry	58.5	72.3	1.2	1763	1469
Beans, green	218.5	429.3	2.0	1986	993
Wheat	2961.8	8038.3	2.7	2260	837
Maize	1401.3	5817.3	4.2	3591	855
Soybeans	19.5	26.0	1.3	3620	2785
Sunflower	33.7	33.9	1.0	2922	2922
Broad beans	192.3	274.0	1.4	1402	1001
Lentils	1.8	1.3	0.7	1996	2851
Apples	122.4	555.8	4.5	5200	1156

Source: Complied and calculated from FAO online database.
***Data for this column is mainly obtained from Central Agency for Public Mobilization and Statistics (CAMPS).**

RESULTS

Main Findings

Relying on specific water requirements per ton (previously estimated in Table 4), the study could estimate virtual water trade for main agric-products. Tables (5 and 6) depicts that the total virtual water embodied in main agric-exports and imports during the period 2003-2008 (on average) are estimated at about 6.69 billion m^3 and 27.5 billion m^3 (on average).

Table 5 shows that, rice export is ranked the first in its virtual embodied water that accounts for about 2119 million m^3. Next come molasses and cotton lint (1833 million m^3 on average), oranges (350 million m^3), broken rice and cheese of whole cow milk (142 million m^3), potatoes (100 million m^3), dry onions (68 million m^3), dry beans

5

6

*The average quantity values for imports and exports may differ from that listed in Tables (1 and 2), that is because they have been adjusted to be equivalent to exported or imported parity quantities. For example, one ton of raw cotton needs about 12047 M^3 of water to be produced, but Egypt exports lint cotton not raw cotton. However, one ton of raw cotton yields about 31.8% of lint, i.e, 0.318 ton of lint. In other words, the average exported quantity of cotton lint during the period (2003-2009 on average) accounted about 126 thousand ton (see Table 1), this quantity needs a production of 396.2 thousand ton of raw cotton or a requirement of 1718×10^6 M^3.

[1] Sugar cane have a high water content, accounting for about 75 percent of the total weight of the plant. The sugar content of sugar cane ranges from 10 to 15 percent of the total weight. The yield of molasses per ton of sugarcane varies from 3.5 to 4.5 percent (for more detail, see Gonsalves, 2006).

[2] Oil and protein content account for about 60% of dry soybeans by weight; protein at 40% and oil at 20%. The remainder consists of 35% carbohydrate and about 5% ash. Soybean cultivars comprise approximately 8% seed coat or hull, 90% cotyledons and 2% hypocotyl axis or germ (Oil World, 2008)

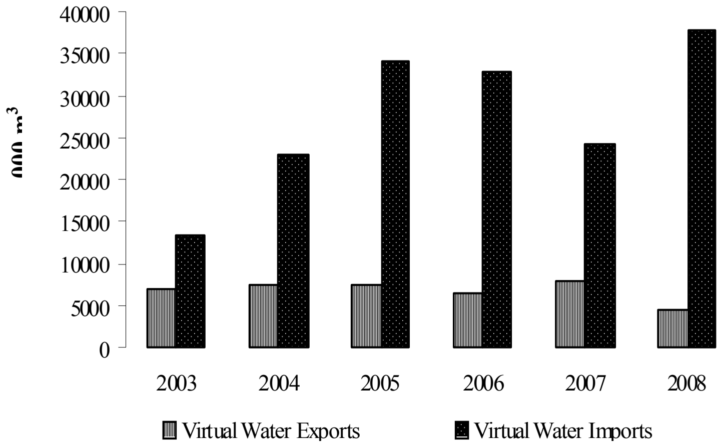
[3] Average oil content of the seed: 40-50% (Entire fruit), 50-60% (kernel only).

[4] Modern high-yielding varieties developed by breeding programs, under ideal climatic conditions and good management, are capable of producing in excess of 20 tonnes of bunches/ha/yr, with palm oil in bunch content of 25 percent. This is equivalent to a yield of 5 tones oil/ha/yr (excluding the palm kernel oil), which far outstrips any other source of edible oil (41 million m^3), grapes (27 million m^3), green beans and frozen vegetables (14.5 million m^3 on average) and finally 6 million m^3 for de-hydrated vegetables.

Whereas, Table (6) shows that imports of palm oil constitutes about 35.2% in its imported virtual water during the same period. Whereas, wheat and maize account for 20.5% and 12% respectively. Next come beef and veal and soybean (6.9% on average), soybean oil and cotton lint (4.9% on average), sunflower oil (2.9%), raw sugar (2%), lentils and soybean (1.2% on average) and finally refined sugar, apples and potatoes (0.6% on average)

Moreover, Figure (7) illustrates the trend of imported and exported virtual water throughout the period 2003-2008. For imports, it shows a gradual increase in virtual imported water from 2003 to 2005, this increment may be explained by the gradual rise in Egyptian agric-imports throughout this period. Then, a significant fall in 2007 that could be explained by the dramatic fall in palm oil imports by about 65%. Finally, a dramatic rise in 2008 that presumably due to the significant rise in wheat, palm oil and soybean oil imports (see table 6).

FIGURE (7): VIRTUAL WATER EMBODIED IN AGRICULTURAL EXPORTS AND IMPORTS DURING 2003-2008



For agric-exports, it is obvious that they could be characterised by relatively stable trend till 2005, then it shows a slight fall in 2006 that could be explained by the fall in cotton lint exports. However, the trend returned back to its level in 2007 and then sharply fell in 2008 due to the significant fall in milled rice and molasses exports (see Table 5)

Table (7) shows that Egypt enjoys a water self sufficiency estimated by about 77% (on average) during the period 2003-2008. However, it varies from year to year relying on the associated volumes of imports and exports. Moreover, this result mirrors the obtained results in Figure (7).

TABLE (7): WATER DEPENDENCY AND SELF-SUFFICIENCY IN EGYPT DURING 2003-2008

Year	2003	2004	2005	2006	2007	2008	Average
Water Dependency (WD)	9	19	28	28	19	32	**23**
Water Self-Sufficiency (WSS)	91	81	72	72	81	68	**77**

Source: Author calculation

Consistency/Inconsistency of Results Estimated by This Study and Other Studies.

A number of studies have estimated the virtual water trade and/or content for Egypt in about the last two decades. Table (8) shows the results obtained from previous studies compared to this study. Despite the differences in the selected agric-products and the methodology of the obtained results, they reveal two main findings.

First, the study results are consistent with the results estimated by other researchers during the periods of study. For example, the exported virtual water (during the period 2003-2009) for livestock products in this study is estimated at 141 ($10^6 m^3$), where as the average for the same measure in previous studies is about 148 (106m^3) and 221 (106m^3) during the periods 2003 and (1997-2001) respectively.

Second, the estimated imported virtual water during the periods 1995-2001 (that were estimated by earlier studies) are significantly different from those estimated by this study during the period 2003-2009, which is consistent with the gradual increase in Egypt's imports (see Table 3 which shows an annual growth rate of imports by about 21.9%). The same outcome is observed when the estimates of imported virtual water for livestock products in this study are compared with those from other studies.

TABLE (8): EGYPT'S VIRTUAL WATER TRADE RESULTS DURING 1995-2009

Year	Source	Virtual Trade: Exports 10^6m^3		Virtual Trade: Imports 10^6m^3	
1995	**Hokestra and Hung, (2002)**	**-**		**15302**	
1995-1999 (average)	**Hokestra and Hung, (2003).**	**902**		**16937**	
	Chapagain and Hokestra, (2003).	-		Crop Products	**16036**
				Livestock Products	**2374**
				Total	**18410**
	Average	**902**		**17674**	
1999	**Zimmer and Renault, (2003).**	**1000**		**22000**	
1997-2001 (average)		Crop Products	**1755**	Crop Products	**11445**
		Livestock Products	**221**	Livestock Products	**1466**
		Total	**1976**	*Total*	**12911**
	Chapagain and Hokestra, (2003).	Crop Products	-	Crop Products	-
		Livestock Products	**148**	Livestock Products	**-**
2003-2009 (average)	**This Study**	Crop Products	**6549**	Crop Products	**25627**
		Livestock Products	**141**	Livestock Products	**1920**
		Total	**6690**	*Total*	**27547**

Source: Author calculations.

Is There a Need for Rethinking on Egypt's National Food and Water Security?

Irrigation Water Rationalization

Regardless all expenditures paid for the new irrigation systems in new land, a considerable number of farmers tend to ignore the existence of these systems and use surface irrigation instead. They do not know much about crop water requirements to restrict themselves to fulfilling their crops' actual requirements. Thus, all components - knowledge, beliefs, or experience - should be changed by the implementation of an effective scientific approach that affects their practices. However, this should go hand in hand with other changes needed in the water distribution system to ensure a fair, timely, and sufficient distribution process. Rational practices of water use and the high economic value of water were found closely related to the farmer's educational status and the type of irrigation system applied. The correct knowledge is a prerequisite for positive attitudes and rational practices of water use: the awareness campaigns about water value should be undertaken to impose national use of water on all users, whether in the agricultural, industrial, or other sectors (MWRI, 2002).

Gad and Ramadan (2009) argued that, the government has imposed modern irrigation methods in the new lands, however the relatively high maintenance costs caused the farmers to remove drippers or sprays and thus convert modern irrigation methods into surface ones. The government is planning to switch the orchards and other fruits farms into drip irrigation to save about 0.75 BCM/year. The main obstacle that faces this program was providing the funds needed for modernization. Farmers have no significant incentive to share the cost, as long as the government provides their water requirements free of charge. The crops of high water requirements are mainly sugarcane, banana and rice. Sugarcane is cultivated in Upper Egypt with a total area of about 325 thousand feddan. However, one Feddan of sugarcane consumes triple the amount of water required for one Feddan of sugar beets, it is too difficult to divert sugarcane agriculture into sugar beets. Firstly, because most of the existing sugar mills are sugarcane mills. Secondly, sugar beet is a winter crop and may not be suitable for the relatively hot climate of Upper Egypt. Therefore, the alternative may be the improvement of the irrigation methods for sugarcane to decrease the losses. The same argue could be seen in the case of rice. In which, it became one of the most important lucrative crops for farmers and one of the most important Egyptian exportable crop in the agricultural sector. Its cropped area has gradually increased from about 0.97 million feddan throughout the 80's to about 1.3 million feddan during the 90's and further to 1.6 million feddan during 2003-2009 (on average).

Reducing Food Wastage

Vama and De Fraiture (2009) noted that, the increasing consumption of meat and shift to diets based on meat from grain-fed cattle has increased the demand for water significantly. A vegetarian diet requires 2000 litres of water a day to produce, whereas a non-vegetarian diet requires 5000 litres, more than twice the amount (Renault and Wallender 2000). The potential to reduce the demand for water through policies that affect food consumption patterns exists, however it is very difficult to influence or change food habits. At present, most efforts to reduce water use are focused on food producers rather than food consumers. One other option to reduce water use in food production is to limit the wastage of food. It is estimated that about 40% to 50% of agricultural produce is lost at different stages during the chain from cultivation of the crop to its consumption. At field scale, pathogens and pests can result in between 20%-40% of the harvest being lost. Transportation of the product and processing can result in about 10% and 15% of loss respectively, although at this stage the losses could reduce the economic value of the food product between 25%-50%. At the retail and consumption stage, considerable losses also occur as perishable, unused food is discarded. The quantities of food lost at this stage vary greatly between countries; in the US, about 25% of fresh food and vegetables is not consumed, while in developing countries it is about 10%. Although the estimates for the quantity of food wasted vary, there is still great potential to reduce wastage and thus save water.

Conclusion

In the early 1990s, Tony Allan introduced concept of ‘virtual water’ as a tool to describe the ‘virtual’ water flows exported from a region as a result of export of water-intensive commodities. The aim of this paper is to quantitatively assess the virtual water flows in Egypt’s agricultural trade.

In line with Zimmer and Renault (2003), the water consumed in the production process of an agricultural or industrial product has been called the 'virtual water' contained in the product (Allan, 1998). If one country exports a water intensive product to another country, it exports water in virtual form. In this way, some countries support other countries in their water needs. 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. In contrast, 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 (Hoekstra and Hung, 2002). Virtual water trade between nations and even continents could thus ideally be used as an instrument to improve global water use efficiency, to achieve water security in water-poor regions of the world and to alleviate the constraints on environment by using best suited production sites (Turton, 2000).

Virtual water trade is an interesting concept which is getting more attention from researchers and practitioners regardless not being considered in decision- making. However, there are countries that suffer from water shortage and still involved in production processes that consume large quantities of water. Nevertheless, it is a useful concept, which is likely to gain more attention and wide applications in future. In other words, it may play a role in making agricultural choices and deciding the country’s trade of what to export or import. Moreover, it may be useful in evolving water management policies by being integrated with other aspects such as engineering, financial, social, food and energy security, as policies that has been evolved on virtual water consideration only might not be optimal and acceptable.

The results suggest that Egypt has exported an average of 6.7 $10^9 m^3$/yr and imported about 27.5 $10^9 m^3$/yr with a net import of 20.9 $10^9 m^3$/yr of virtual water related to crop and livestock products throughout the period of study 2003-2009. Thus, Egypt is to be considered a net importer of virtual water.

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التعرف على حجم تجارة ا لمياه الإفتراضية للمنتجات الزراعيـة المصرية: هل هناك حاجة لإعادة التفكير؟

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تلقـي تجـارة الميـاه الافتراضـية كوسـيلة لتحقيـق التـوازن فـي الموازنـة المائيـة الوطنيـة والعالميـة فـي الآونـة الأخيـرة الكثيـر مـن الاهتمـام. يهـدف البحـث إلـى التقيـيم الكمـي لتـدفقات الميـاه الافتراضية في تجارة مصر الزراعية (أي المياه المستخدمة من وجهة نظر الصـادرات والـواردات). وتشير النتائج إلى أن مصر تصدر ما يعادل نحو ٦.٦٩ م٣ / سنة بينمـا يقدر حجم الميـاه المسـتوردة بنحو ٢٧.٥ مليار م٣ / سنة . أى أن حجم الواردات الصـافية من الميـاه الافتراضـية المتعلقـة بمنتجـات المحاصـيل الزراعيـة والثـروة الحيوانيـة خـلال الفتـرة (٢٠٠٣-٢٠٠٩) يمكـن تقـديره بحـوالى ٢٠.٩ مليار م٣ / سنة. وبالتالي فإن مصر أن تعتبر مستوردا صـافيا للمياه ، وفي مثل هذه الحالة يمكن القول بأن مصر تقوم بتوفير ذلك الحجم المـائى من مواردهـا المائيـة. و من الجدير بالـذكر فـإن نحـو ٥.٧ مليار م٣ / سنة و ٣.٢ مليار م٣ / سنة يتم توفيرهم فى حالـة إستيراد الإحتياجـات المحليـة من القمـح والذرة على التوالي.

قام بتحكيم البحث

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FIGURE (2): EGYPT'S TOP EXPORTS AND THEIR ASSOCIATED RELATIVE IMPORTANCE DURING THE PERIOD (2003-2008)

Item	2003		2004		2005		2006		2007		2008		Average Quantity (2003-2008)	Average Value (2003-2008)	Relative Importance %
	Quantity 000 Ton	Value Mn $	Quantity 000 Ton	Value Mn $	Quantity 000 Ton	Value Mn $	Quantity 000 Ton	Value Mn $	Quantity 000 Ton	Value Mn $	Quantity 000 Ton	Value Mn $			
Cotton lint	197	366	184	483	97	181	55	133	128	153	97	185	126	250	24.8
Rice Milled	572	148	807	224	1017	294	917	288	1123	380	173	89	769	237	23.5
Oranges	167	39	258	77	214	75	283	65	272	99	454	239	275	99	9.8
Potatoes	296	44	382	67	392	77	367	65	390	108	398	176	371	90	8.9
Molasses	449	30	407	41	477	54	456	44	385	51	266	42	407	44	4.3
Grapes	7	3	15	11	25	17	28	22	54	60	50	92	30	34	3.4
Onions, dry	320	33	351	36	301	31	205	24	201	36	103	42	247	34	3.3
Vegetables Dehydrated	15	21	16	28	20	29	18	26	21	40	25	56	19	33	3.3
Cheese of Whole Cow Milk	8	12	11	17	18	31	17	31	19	33	26	53	17	29	2.9
Vegetable Frozen	20	15	22	20	33	25	26	21	38	34	34	39	29	26	2.5
Food Prep Nes	5	6	6	5	10	8	8	9	12	11	27	85	11	21	2.1
Beans, dry	14	6	22	12	24	11	26	14	45	30	38	26	28	16	1.6
Beans, green	6	2	9	5	11	6	25	12	29	19	23	44	17	15	1.4
Rice Broken	13	2	25	5	88	13	63	12	99	22	62	25	59	13	1.3
Frozen Potatoes	4	2	18	10	18	8	32	16	31	16	24	20	21	12	1.2
Fruit Prp Nes	5	3	12	7	7	5	7	6	17	16	31	31	13	12	1.1
Olives Preserved	3	2	6	4	10	9	6	5	10	7	31	33	11	10	1.0
Sugar Raw Centrifugal	58	14	16	4	60	10	20	5	25	8	37	17	36	10	1.0
Fruit Juice Nes	11	6	11	6	16	9	16	9	20	13	25	14	17	10	0.9
Sunflower oil	3	1	4	2	1	1	8	6	5	4	10	15	5	5	0.5
Beverage Non-Alc	9	3	7	3	11	4	7	3	7	2	26	15	11	5	0.5
Tomatoes	3	1	7	2	18	4	7	2	20	4	3	5	10	3	0.3
Soybean oil	3	3	2	1	4	3	5	3	3	2	13	2	5	2	0.2

Source: FAO Online Statistics

TABLE (3): EGYPT'S TOP IMPORTS AND THEIR ASSOCIATED RELATIVE IMPORTANCE DURING THE PERIOD (2003-2008)

Item	2003		2004		2005		2006		2007		2008		Average Quantity (2003-2008)	Average Value (2003-2008)	Relative Importance %
	Quantity 000 Ton	Value Mn $	Quantity 000 Ton	Value Mn $	Quantity 000 Ton	Value Mn $	Quantity 000 Ton	Value Mn $	Quantity 000 Ton	Value Mn $	Quantity 000 Ton	Value Mn $			
Wheat	4057	607	4367	728	5688	924	5817	967	5911	1567	8328	2462	5695	1209	31.5
Maize	4053	529	2429	365	5095	696	3769	545	4474	940	3980	1037	3967	685	17.9
Meat-CattleBoneless (Beef&Veal)	92	149	102	181	151	277	221	408	253	489	69	252	148	293	7.6
Palm oil	17	6	619	203	755	267	957	334	261	132	830	735	573	279	7.3
Soybeans	332	89	215	65	574	194	573	163	1136	428	1192	450	670	231	6.0
Tobacco, unmanufactured	64	151	73	172	58	155	68	166	69	173	73	208	68	171	4.5
Cake of Soybeans	826	196	712	214	582	141	301	71	292	85	166	50	480	126	3.3
Soybean oil	107	57	92	56	88	50	45	24	96	70	229	446	110	117	3.1
Sunflower oil	123	70	116	72	116	78	127	79	151	112	214	287	141	116	3.0
Sugar Raw Centrifugal	136	23	157	33	293	74	331	124	309	92	1161	346	398	115	3.0
Broad beans, horse beans, dry	308	76	314	93	380	100	459	113	301	109	278	154	340	108	2.8
Cotton lint	8	15	82	93	21	51	40	71	23	70	74	143	41	74	1.9
Offals of Cattle, Edible	33	35	14	17	40	39	79	67	82	70	80	101	55	55	1.4
Lentils	61	34	89	44	108	43	77	34	84	52	66	74	81	47	1.2
Potatoes	69	42	23	15	73	46	58	30	69	61	82	67	62	44	1.1
Sugar Refined	226	51	138	30	285	71	63	24	123	43	93	32	155	42	1.1
Gluten Feed&Meal	54	16	61	26	56	23	52	24	172	81	129	64	87	39	1.0
Meal Meat	137	45	93	30	90	30	84	30	87	30	62	24	92	32	0.8
Apples	31	14	49	26	58	31	64	33	53	30	72	44	54	30	0.8
Rice Milled	1	1	2	1	3	2	104	34	117	32	6	7	39	13	0.3
Bran of Wheat	95	12	48	5	80	10	13	2	65	10	65	13	61	9	0.2

Source: FAO Online Statistics

TABLE (5): ANNUAL VIRTUAL WATER EXPORT THROUGHOUT THE PERIOD 2003-2008

Item	Average Relative Importance as a Percentage of Total Exports during (2004-2009)	Average Specific Water Demand (2005-2008) m^3/ton	Adjusted* Average Exports (2004-2009) 000 ton						Virtual Water Embodied in Main Agric Exports 10^6 m^3						
			2003	2004	2005	2006	2007	2008	2003	2004	2005	2006	2007	2008	Average (2003-08)
Cotton lint	24.8	4337	619	579	305	173	403	305	2687	2509	1323	750	1746	1323	1723
Rice Milled	23.5	1931	817	1153	1453	1310	1604	247	1578	2226	2805	2530	3098	477	2119
Oranges	9.8	1274	167	258	214	283	272	454	213	329	273	361	347	578	350
Potatoes	8.9	269	296	382	392	367	390	398	80	103	105	99	105	107	100
Molasses[1]	4.3	191	11225	10175	11925	11400	9625	6650	2144	1943	2278	2177	1838	1270	1942
Grapes	3.4	916	7	15	25	28	54	50	6	14	23	26	49	46	27
Onions, dry	3.3	275	320	351	301	205	201	103	88	97	83	56	55	28	68
Vegetables Dehydrated	3.3	300	15	16	20	18	21	25	5	5	6	5	6	8	6
Cheese of Whole Cow Milk	2.9	8573	8	11	18	17	19	26	69	94	154	146	163	223	141
Vegetable Frozen	2.5	430	20	22	33	17	38	34	9	9	14	7	16	15	12
Beans, dry	1.6	1469	14	22	24	26	45	38	21	32	35	38	66	56	41
Beans, green	1.4	993	6	9	11	25	29	23	6	9	11	25	29	23	17
Rice Broken	1.3	1931	19	36	126	37	141	89	36	69	243	72	273	171	144
Total	91%					(10^6 m^3/ Year)			6939	7440	7353	6292	7792	4325	6690

TABLE (6): ANNUAL VIRTUAL WATER IMPORTS THROUGHOUT THE PERIOD 2003-2008

Item	Average Relative Importance as a % of Total Imports during (2004-2009)	Average Specific Water Demand (2005-2008) m^3/ton	Adjusted* Average Imports (2004-2009) 000 ton						Virtual Water Embodied in Main Agric Imports 10^6 m^3						
			2003	2004	2005	2006	2007	2008	2003	2004	2005	2006	2007	2008	Average
Wheat	32	993	4057	4367	5688	5817	5911	8328	4029	4336	5648	5776	5870	8270	5655
Maize	18	837	4053	2429	5095	3769	4474	3980	3392	2033	4265	3155	3745	3331	3320
Meat-Cattle Boneless (Beef&Veal)	7.6	12972	92	102	151	221	253	69	1193	1323	1959	2867	3282	895	1920
Palm oil	7.3	4230	68	2476	3020	3828	1044	3320	288	10473	12775	16192	4416	14044	9698
Soybeans	6.0	2785	332	215	574	573	1136	1192	925	599	1599	1596	3164	3320	1867
Soybean oil[2]	3.1	2785	535	460	440	225	480	1145	1490	1281	1225	627	1337	3189	1525
Sunflower oil[3]	3.0	2922	246	232	232	254	302	428	719	678	678	742	882	1251	825
Sugar Raw Centrifugal	3.0	191	1088	1256	704	2648	2472	9288	208	240	134	506	472	1774	556
Broad beans, horse beans, dry	2.8	1001	308	314	116	459	301	278	308	314	116	459	301	278	296
Cotton lint	1.9	4337	25	258	921	126	72	233	109	1118	3996	546	314	1009	1182
Lentils	1.2	2851	61	89	380	77	84	66	174	254	1083	220	239	188	360
Potatoes	1.1	269	69	23	21	58	69	82	19	6	6	16	19	22	14
Sugar Refined	1.1	191	1808	1104	2280	504	984	744	345	211	435	96	188	142	236
Apples	0.8	1156	137	49	108	64	53	72	158	57	125	74	61	83	93
Total	88.9%	Virtual Water Embodied (10^6 m^3/ Year)							13357	22924	34044	32871	24290	37796	27547