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Water scarcity and food security : the role of virtual water flows in cereals trade in the north Africa countries

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ABSTRACT

North Africa is one of the driest regions in the world. Consequently, all countries in the region depend mainly on agricultural imports to achieve the food security. The present study endeavor to estimate: firstly, the national and the global water saving achieved through the North African international cereal trade by using the concept of virtual water trade. Secondly, the relation between the imports of cereal trade, as endogenous variable, and the available water resources availability with other important factors as exogenous variables.

The results showed that, at the national level, all North African countries achieved water saves to the extent that exceed the endowment total fresh water resources in Libya, Algeria, and Tunisia. Importing of maize and wheat is the most important player of the saving national water imports of among the cereal crops. All countries in the North Africa region achieved water saving except Egypt.

The model results has shown statistically significant coefficients of factors affecting the total imports of cereal crops such as, per-capita fresh water resources, the area of irrigated water, the area of Arable land . the negative sing of per-capita fresh water resources indicates that the importing cereals using intensive water is not optional decision but due to the shortage of the available of water resources . Negative signs of irrigated area and of arable land are consistent indicating that the increasing of the irrigated area and the arable land will intuitively reduce the importing of cereals.

INTRODUCTION

Although the water covers about 71 percent of our planet surface, 98 percent of it has too high salt content to be used for drinking water, for irrigation, or even for most industrial purposes. Fresh water represents one percent of all the water on the earth and is distributed unevenly on the earth surface. As a result of the dramatic increase in population, in economic activities, and a subsequent increase in water appropriation, the world fresh water resources become scarce during the past decades (Hoekstra & Chapagain, 2007; Postel, Daily, & Ehrlich, 1996).

The first region in the world to be confronted by a water deficit to the extent that economic growth is being hampered and social stability is being threatened, is the Middle East and North Africa (John Anthony Allan, 2000). With continuous population growth and related development, water resource becomes increasingly scarce in North Africa. The total population of the North Africa region increased from 86.9 million in 1970 to 202.3 million in 2007. Furthermore, the oil boom in 1970s in most of the region countries has produced high income followed by increasing in food consumption and changing in food patterns. As a result, water demand began to exceed supply in the early of 1970s for the region (J. A. Allan, 1998) and the water scarcity problem continues from bad to worse.

While trade of real water between water-rich and water-poor regions is generally impossible due to the large distances and associated costs, it is argued that international trade moves the " virtual water" from a comparative advantaged region, where there is a surplus of soil water in soil profiles, to comparatively disadvantaged regions such as the MENA region. The virtual water is defined as the volume of water used in producing a unit of commodity, or service (J. A. Allan, 1998). Agricultural trade is by far the largest transporter to move water virtually around the world. Globally, the volume of virtual water associated with crop trade is about 15% of the total water use in crop production (H Yang, Zehnder, & Zurich, 2008).

The idea of actively promoting the import of virtual water in water-scarce countries is based on the idea that a nation can save its domestic water resources by importing a water-intensive product rather than produce it domestically. Import of virtual water therefore leads to a "national water saving" (Hoekstra & Chapagain, 2007). In a widely scope, Oki and Kanae (2004) argue that the virtual water trade produce "global water saving" when agricultural product traded from country in which the unit requirement of water to produce a commodity (UW) is low to the country in which the UW is high. Conversely, the global water loss occurs when the trade is from a high UW country to a low UW country for a particular crop.

The aim of this study is to analyze the consequences of North African international virtual water flows associated with cereals trade on national and global water budgets. With this aim, it quantifies and assesses national and global water saving and losses per cereal crop in the North Africa region. According to regional classification of United Nation Statistics Division (UNSD), the countries included in the North Africa region are, In alphabetical order, Algeria, Egypt, Libya, Morocco, Sudan, Tunisia, and Western Sahara(UNSD, 2009). Thus, the present study engages all the mentioned countries except Western Sahara due to data insufficiency.

1. Methodology

2.a Calculation of national water saving

The national water saving NWS_{ij} as a result of trade of crop *i* in country *j* is:

$$NWS_{ij} = VWM_{ij} - VWX_{ij} \quad (1)$$

where VWX_{ij} and VWM_{ij} are The virtual water exported and imported respectively contained in crop *i* by country *j*. We can calculate them by multiplying the specific water demand of crop *i* with exported/imported quantities of the same crop in a given year. Both exported and imported virtual waters are calculated as if the mentioned crop is produced domestically.

$$VWX_{ij} = SWD_{ij} \times X_{ij} \quad (2)$$

$$VWM_{ij} = SWD_{ij} \times M_{ij} \quad (3)$$

where X_{ij} refers to the exported quantities (ton) of crop *i* in given year by country *j*, and M_{ij} is the imported quantities (ton) of crop *i* by country *j*. SWD_{ij} refers to the specific water demand (m^3 ton^{-1}) of crop *i* in country *j*.

Intuitively, the virtual water exported ($VWX_{\varphi j}$) or imported ($VWM_{\varphi j}$) contained in a group of crops φ by country *j* is calculated by the summation of multiplying the specific water demand of each crop *i* in the group φ with the exported/ imported quantities of the same crop in given year.

$$VWX_{\varphi j} = \sum_{i=1}^{n}(SWD_{ij} \times X_{ij}) \qquad (4)$$

$$VWM_{\varphi j} = \sum_{i=1}^{n}(SWD_{ij} \times M_{ij}) \qquad (5)$$

For crop *i* in country *j*, specific water demand can be calculated by (Hoekstra & Hung, 2005)

$$SWD_{ij} = \frac{CWR_{ij}}{CY_{ij}} \qquad (6)$$

CY is the crop yield (ton ha^{-1}). Although the values for crop evapotranspiration and crop water requirement are identical, crop water requirement refers to the amount of water that needs to be supplied, while crop evapotranspiration refers to the amount of water that is lost through evapotranspiration under the standard conditions (Allen, Pereira, Raes, & Smith, 1998).

It is sensible to mention that a country may not produce a specific crop and imports all the needed quantities. In this case, we have no data that required for calculating the specific water demand such as crop yield and some factors required for calculating the crop water requirements. Thus, we compensate the domestic specific water demand of crop *j* by the weighted average of the regional specific water demand of the same cereal crop.

Crop water requirements calculated by accumulation of data on daily crop evapotranspiration ET_c (mm/day) over the complete growing period as follows:

$$CWR_{ij} = 10\sum_{d=1}^{L} ET_{c(ij)} \qquad (7)$$

where, the factor 10 is meant to convert (mm ha^{-1}) into (m^3 ha^{-1}). The summation is done over the period from day 1 to the last day of the growing period (L) (Sallam & Abd El Nasser, 2006).

The crop evapotranspiration ET_c is given by multiplying reference crop evapotranspiration ET_0 with the crop coefficient K_c.

$$ET_c = K_c \times ET_0 \qquad (8)$$

The concept of the reference evapotranspiration was introduced to study the evaporative demand of the atmosphere independently of crop type, crop development and management practices. ET_0 is a climatic parameter and can be computed from weather data. ET_0 expresses the evaporating power of the atmosphere at a specific location and time of the year and does not consider the crop characteristics and soil factors (Allen *et al.,* 1998).

Reference to (Hoekstra & Hung, 2002), crop evapotranspiration is calculated on the basis of the FAO Penman-Monteith equation:

$$ET_0 = \frac{0.408(R_n - G) + \gamma 900/(T+273)\, U_2 (e_a - e_d)}{\Delta + \gamma(1 + 0.34 U_2)} \quad (9)$$

in which

ET_0 =reference crop evapotranspiration (mm day^{-1});
R_n =net radiation at the crop surface (MJ m^{-2} day^{-1});
G =soil heat flux (MJ m^{-2} day^{-1});
T =average air temperature (^oC);
U_2 =wind speed measured at 2 m height (m s^{-1});
e_a =saturation vapor pressure (kPa);
e_d =actual vapor pressure (kPa);
$e_a - e_d$ =vapor pressure deficit (kPa);
Δ =slope of the vapor pressure curve (kPa $^oC^{-1}$);
γ = psychrometric constant (kPa $^oC^{-1}$).

2.b. Calculation of the global water saving $GWS_{i,ej}$

The global water saving $GWS_{i,ej}$ through trade of crop *i* from an exporting country *e* to an importing country *j* is:

$$GWS_{i,ej} = VWM_{ij} - VWX_{ie} \quad (10)$$

Where, VWM_{ij} and VWX_{ej} are the virtual water content of the importing and exporting quantities of crop *i* in favor of the actual specific water demand and the actual crop yield of the import and export countries.

Due to the difficulties and complications of calculating specific water demand in each exporting country as each importing country imports from many variable sources over the given period, we compensate each specific water demand of exporting country by the world average specific water demand for each crop.

2.C. Quantitative analysis of water resources availability and Cereal trade relation

The model used to formulate cereal-trade and water relations is the double-log regression function. This model investigates the overall relation between water resource availability and cereal trade in the North Africa region assuming the homogeneity across the countries. Therefore, the specific effect of each country has not been taken into the account. The model is formulated as follows:

$$ln(CT) = \propto + \beta_1 \ln(wa) + \beta_2 \ln(GDP) + \beta_3 \ln(irr) + \beta_4 \ln(Al) + \beta_5 \ln(t) + \varepsilon \quad (11)$$

Where *CT* is the net trade of cereal crops in each country volume in kg/capita. *wa* refers to the available water resources in m^3/capita. GDP is gross domestic product in US dollars/capita converted to 2000 constant US dollars. *irr* is the irrigated area in each country in ha/capita reflecting the maximum area could be cultivated by cereal crops in the individual country. *Al* refers to the area of land in the country in ha/capita. t is time variable. ε is the error term.

2. Data sources

Data of crop water requirements are calculated with FAO's CropWat software for windows version 8.0 that is available at FAO website (www.fao.org/nr/water/). CropWat is a decision support system developed by the Land and Water Development Division of FAO. The climatic data needed for CropWat are taken from ClimWat which is a climatic data-base to be used in combination with CropWat. It includes data from a total of 3262 meteorological stations from 144 countries. Following (Hoekstra & Hung, 2005), the capital climatic station have been taken for each North Africa country. The data of crop parameters, crop coefficients in different crop development stages (initial, middle and late stage) and crop calendars were based on (Allen *et al.,* 1998). The world average crop water requirements have been taken from (Doorenbos & Kassam, 1979). Data of cereal crops yield, exports, and imports are from FAO-STAT data-base which available through FAO website.

3. Water resources availability in North African countries (NA)

According to FAO, Water resources: total renewable water resources (TRWR) is defined as the sum of internal renewable water resources (IRWR) and external actual renewable water resources (ERWR). It corresponds to the maximum theoretical yearly amount of water actually available for a country at a given moment. TRWR are widely varied among NA countries. Table 1 show that the TRWR ranged between 0.6 km^3/year in Libya and 64 km^3/year in Sudan. Almost all of TRWR in all countries, except in Egypt and in Sudan, are derived from the IRWR rather than the ERWR. In Egypt and Sudan, 96.6% and 53.5% of TRWR respectively derived from ERWR that originated from River Nile.

The volume of per capita freshwater resources is an important indicator of the water endowment of a country. Sudan has the highest figure, over 1800 m^3/capita/year. The figure for Morocco and Egypt are 984 and 830 m^3/capita/year respectively, the second and the third highest in the region. Water resources in the rest countries in the region are below 500 m^3/capita/year. According to (Falkenmark & Widstrand, 1992) all NA countries, except Sudan, are below the water scarcity threshold of 1500-1700 m^3/capita/year.

The per capita water use indicator reflects the extent of the human activities in favor of water consumption. Sudan and Egypt have highest figure, 1073 and 990 m^3/capita/year respectively followed by Libya by 778 m^3/capita/year. The other rest countries are below 300 m^3/capita/year.

The ratio of water use to total renewable water resources reflects the water scarcity as well as reveals the water use intensity. In some cases, a country may use more water than the renewable water available producing more stresses on the water resources. Libya and Egypt are utilizing more than their internal renewable water resources by either overexploiting groundwater, or desalinating seawater or recycling wastewater. Consequently, Libya recorded the highest water scarcity, as the per capita water use is more than seven times of per capita TRWR by 722% and Egypt figures 119.3%. The rest countries in the NA region are below 60%.

On the world average, agriculture uses about 70% of the total water withdrawals, making by far the largest water user among all sectors (Johnson, Revenga, & Echeverria, 2001). NA countries are far more than the world average except in Algeria 64.9%. Sudan has 97% while Egypt, Libya, Morocco, and Tunisia lie in the range 81% - 88%. On the other hand, the indicator of agricultural water withdrawal as percent of TRWR introduces addition evidence on the cause for worry concerning the future development of the agricultural sector in Egypt and Libya. That is horizontal growth in agriculture sector can no longer continue since Egypt and Libya reached their water frontier.

Dependency ratio is an indicator expressing the percent of total renewable water resources originating outside the country. This indicator may theoretically vary between 0% and 100%. A country with a dependency ratio equal to 0% does not receive any water from neighboring countries. A country with a dependency ratio equal to 100% receives all its renewable water from upstream countries, without producing any of its own (FAO). The dependency ratio is thus a good indicator of which direction different water scarce countries might want to take. A low dependency ratio for a water scarce nation means it has to take hard decisions on improving internal efficiencies in water usage in the future. Libya and Morocco are not receiving any external water resources while Algeria and Tunisia have low dependency by 4.27%, and 8.69% respectively. In contrast, Egypt and Sudan depend upon River Nile as a main source of fresh water resource. As a result, Egypt has remarkable dependency near 100% followed by Sudan, which has moderate dependency with 52.71%. By the context, dependency ratio meant with only the natural water movement across countries and ignoring water transfer associated with international trade activity.

Table (1): Water resources, use, and scarcity in the North Africa countries (2003-2007)

	Algeria	Egypt	Libya	Morocco	Sudan	Tunisia
Total renewable water resources (10^9 m^3/year)	11.70	57.30	0.60	29.0	64.5	4.6
Total internal renewable water (10^9 m^3/year)	11.20	1.80	0.60	29.00	30.0	4.2
Total water use (10^9 m^3/year)	6.07	68.30	4.33	12.60	37.30	2.64
Per capita water resources (m^3/capita/year)	371.00	830	107.75	984.42	1856	470
Per capita water use (m^3/capita/year)	193.00	990	777.66	427.11	1073	269.94
Agricultural water withdrawal (10^9 m^3/year)	3.94	59.00	3.58	11.00	36.1	2.16
Water use as % of total water resources	51.88	119.20	700.21	43.45	57.83	57.39
Agricultural water withdrawal as % of total water resources	33.68	102.97	596.67	37.93	55.97	46.96
Agricultural water withdrawal as % of total water use	64.91	86.38	82.68	87.30	96.78	81.82
Water scarcity (%)	52.0	119.3	722	43.4	57.8	56.4
Dependency (%)	4.27	96.86	0.00	0.00	52.71	8.69

RESULTS AND DISCUSSION

Virtual water trade has a positive direct effect on water saving for the importing countries. This effect has been intensively discussed in virtual water studies since the concept of virtual water raised by Allan in the nineties. In this study, we examine the water saving at two levels. Firstly, national water saving that concentrates on the benefit gained by importing countries. Secondly is the global water saving, the global net effect of virtual water trade between two nations will depend on the actual water volume that would have been required to produce a commodity in the importing and exporting countries. (Chapagain, Hoekstra, & Savenije, 2006).

Figure 1 shows the notable variations among the specific water demand for the cereal crops production in North Africa countries and on the world average. Such highly significant variations come mainly from two reasons. One reason is that in North Africa region the evaporative demand is relatively high. The second reason is the low yield of the cereal crops in most NA countries. The water requirements to produce one ton of cereals in NA are equal to five times those in the world average. Highest differences were witnessed in maize and sorghum crops.

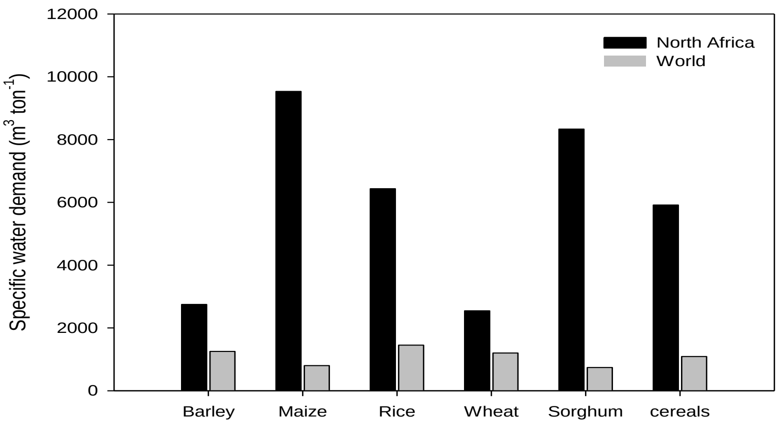

Fig. (1): Specific water demand for cereal crops in the North African and world (m^3/ton), average 2003-2007

3.1. National water saving in NA countries through cereals trade

Table 2 gives estimates of the national water saving of the North Africa countries expressed in volumes of virtual water embedded in net cereals trade. Seeing that the cereals trade varies significantly from year to year, the figure presented is the annual average for 2003-2007. Furthermore all respective countries are net virtual water importers, there is widely range of national water saving from 4.93 billion m^3 in Egypt to 44.23 billion m^3 in Algeria. The percentages of the national water saving ,through cereals net trade, to the total fresh water resources availability in each NA countries are extremely varied from around 9 in Egypt to 2136 in Libya. One can intuitively explain such wide span in these percentages due to the fact that Egypt and Sudan are mainly irrigated agriculture countries while the rest countries are mainly rain fed agriculture. In addition, Libya is one of driest countries in the world. The annual rainfall is very low with more than 95% of the country receiving less than 100 mm/y (Wheida & Verhoeven, 2007).

Table (2): National water save (10^6 m^3) achieved by the North Africa net trade of cereals crops, average 2003-2007

	Barley	Wheat	Maize	Rice	Sorghum	Others	Total	%
Algeria	134.45	24205.66	19489.55	370.40	2.32	32.49	44234.86	378.08
Egypt	1.54	2755.53	3464.96	-1306.95	NR	14.97	4930.04	8.60
Libya	921.70	5786.95	3667.97	912.90	NR	1524.56	12814.08	2135.68
Morocco	1361.37	5597.50	17375.86	5.48	NR	101.18	24441.40	84.28
Sudan	NR	4557.40	520.64	334.41	2160.12	15.52	7588.08	11.76
Tunisia	1581.47	2506.55	6368.39	30.18	326.87	7.25	10820.71	235.23
region	4000.53	45409.59	50887.37	346.41	2489.31	1695.96	104829.17	62.51

Note: % is the percentage national water saving achieved by each country to the total water resources in the same country.NR refers that such crop is not relevant in this country

Figure 2 show that Maize and wheat are the prominent cereal crops in terms of net virtual water imports. Wheat representations vary from around 23% in Tunisia to around 60% in Sudan. In summation, wheat represents about 44% of the national water saving in cereal net trade in NA region.

On the other hand, maize representations vary from 7% in Sudan to 71% in Morocco. On the region level, Maize is the highest cereal crop in terms of virtual water imports by around 50%. From what has been said, one can conclude that Maize and wheat are representing around 91% of the national water saving the North Africa region. In addition, all crops in the region and in each individual country attain national water saving except rice in Egypt. That because Egypt is a rice net exporter.

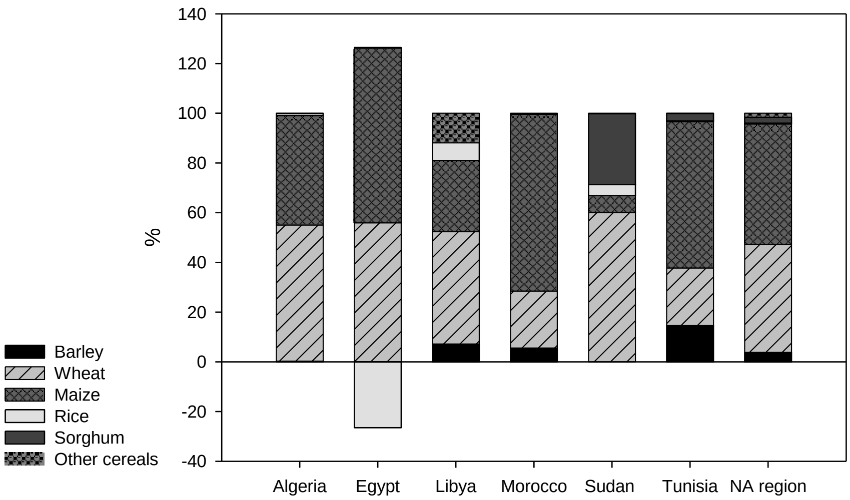

Fig. (2): Percentages of net virtual water trade embedded in each cereal crop, in the North African countries, average 2003-2007

3.2. Global water saving through North Africa cereals trade.

The international trade theory confirms that the global food import is approximately equal to the global food exports to achieve the global food market equilibrium over a given period. On the other hand, such equilibrium does not take place in the global virtual water trade associated with global food trade system. This imbalance is a result of the inequality of water used for producing a given amount of food between importing and exporting countries (H. Yang, Wang, Abbaspour, & Zehnder, 2006). Seeing that the global saving is obtained as the difference between the water productivities of the trading partners (Hoekstra & Chapagain, 2007), the positive sign on the difference, in the direction of exporting to importing countries, intuitively indicates global water saving. In contrast, the negative sign refers to global water loss.

Table 3 shows that the global saving resulting from international cereals trade between NA and the world countries is 77.18 billion cubic meter per year as on average of the period 2003 – 2007 . Approximately half of the amount of saved water originated only from Algeria. In addition, more than quarter of the referred global water saving originated from Morocco. Thus, about 75% of the global water saving through the international trade of cereals crops in NA is derived only from Algeria and Morocco.

One can see that there is a notable global water saving achieved by cereal trade in all NA countries except in Egypt. The global water losing achieved by Egypt reflects a relatively high water productivity of cereal crops (table 4). Furthermore, Egypt is the only country in the NA region that completely irrigated coverage. Consequently, the 100% irrigation coverage, adopting modern technology, and agricultural policy reforms explain its stable and significant increase of cereals production (El-Sadek, 2009; H. Yang & Zehnder, 2002). Considering the crop water requirements and yield, it has been noted that Egypt showed highest cereal yield (7.5 ton/ha) among NA countries. This yield is more than two times of world average yield. On the other hand, the crop water requirements for cereal production in Egypt is more than the cereals water requirements of Libya, Morocco, and the world average (Table 4).

Table (3): Global water save (10^6 m^3) achieved by North Africa net trade of cereals crops, average 2003-2007

	Barley	Wheat	Maize	Rice	Sorghum	Others	Total	%
Algeria	24.05	18016.17	17853.83	286.94	2.11	16.72	36199.82	46.90
Egypt	-0.76	-3461.73	296.51	29.41	NR	26.50	-3110.07	-4.03
Libya	720.32	4402.52	3360.12	707.19	NR	1251.46	10441.61	13.53
Morocco	897.34	2597.46	16206.03	-0.93	NR	85.74	19785.64	25.64
Sudan	NR	2990.04	485.28	239.28	2033.75	12.89	5761.24	7.46
Tunisia	913.36	975.85	5857.74	22.07	292.63	40.02	8101.67	10.50
region	2554.31	25520.31	44059.51	1283.95	2328.49	1433.33	77179.90	

Note: % is the percentage of global water saving achieved by each country to the total saving achieved by the NA region.NR refers that such crop is not relevant in this country

With respect to the global water saving achieved by individual cereal crop trade in NA, it is obvious that maize trading produces 44.06 billion m3/year representing about 57.09% of the global water saving achieved by the region cereal trade. In the same context, Wheat Trading achieves 25.52

billion m^3 /year representing about 33.07%. Therefore, only maize and wheat trading are representing 90.18% of all total global water saving.

Table (4): Crop water requirements, crop yields and the specific water demand of cereals in North Africa countries and in the world, average 2003-2007.

	Crop water requirement (m^3 ha^{-1})	Yield (ton ha^{-1})	Specific water demand (m^3 ton^{-1})
Algeria	8498	1.4	6007
Egypt	4495	7.5	598
Libya	3808	0.6	6123
Morocco	6617	1.2	5611
Sudan	3036	0.6	4775
Tunisia	6034	1.5	4094
World	3574	3.3	1088

5.3 Analysis of available water resources and Cereal trade relation

In this section, we investigate the over-all relation between available water resources and the cereal imports in NA region. Accordingly, a double-log regression model that pools all the observations in the regression without considering the country effect has been adopted. In order to smoothing the yearly fluctuations of trade caused by weather variations and market price volatiles, three years averages is calculated for the period 1985 to 2007. Consequently, eight observations have been generated for each country and then 48 observations are generated for all countries and for the conducted model as well. The selection of the exogenous variables is based on the results of correlation matrix followed by omitting variables that correlate significantly with other exogenous variables to overcome the multicollinearity in the regression. The variables omitted are yield in kg/ha and fertilizers in kg/ha.

The data shows that the net imports of the cereal crops in all countries are negative implying that all countries in the NA region are net importers. The model results show statistically significant coefficients of log-water availability, log-irrigated area, and log-arable land. Such variables explain about 82 percent of the total variance occurred in the log of the cereal trade. After investigating the Durbin-Watson value, it could be concluded that there is no auto-serial correlation.

The negative sign available water resources indicates that the importing of intensive water cereals is not optional policy but due to the lack of available water resources availability. Such fact is statistically proven at significance level of 0.01. Negative signs on irrigated area and of arable land are consistent indicating that the increasing of the irrigated area and the arable land will intuitively reduce the importing of cereals.

Table (5): Regression coefficients of net cereal trade of cereal crops on some selected exogenous variables during the period 1985-2007.

	coefficient	t	F	R^2	D.W
available water resources	-0.963**	-13.24			
Irrigated area	-0.209*	-2.10			
Arable lands	-0.292**	-3.66	38.92**	0.82	1.65
Real gross domestic product	-0.064	-1.09			
Time	-0.186	-1.68			
Intercept	10.47**	14.82			

*** and ** Refer to significant levels at 0.05 and 0.01 respectively**

Conclusion

Although water scarcity is not the main driver of cereals trade on the global level, it plays an essential role in cereal trade between North Africa and the other trade partner countries in the world. At the national level, all North Africa countries achieve water saves to the extent that exceed the total fresh water resources in some cases. Trading of maize and wheat is the most important player of the national water saving among the cereal crops trade.

At the global level, reductions in global water use occur if production by the exporter is more water efficient than by the importer. All countries in the North Africa region achieve a global water save except Egypt. The global water losing achieved by Egypt reveals a relatively high water productivity of cereal crops.

The results of the regression model show negative sign on water availability indicates that the importing of intensive water cereals is not optional policy but due to the lack of available water resources . Negative signs of irrigated area and of arable land are consistent indicating that the increasing of the irrigated area and the arable land will intuitively reduce the importing of cereals.

In this paper, we investigate the positive impact of virtual water trade on national and global water saving. But there is an important side needed to be studied which is the additional pressure occurred on the exporter countries. Accordingly, for example, economic studies are needed to estimate the opportunity cost and negative environmental externalities in exporter countries.

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ندرة المياه و الأمن الغذائي:
دور التجارة الافتراضية لمياه محاصيل الحبوب في دول الشمال الأفريقي

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تعد منطقة شمال افريقيا من اكثر مناطق العالم التي تعاني من ندرة المياه. و لذلك تعتمد معظم هذه الدول على استيراد الغذاء لتحقيق الأمن الغذائي. لذا تهدف هذه الدراسة الى تقدير ما تم توفيره من المياه المتاحة دولياً (لدول شمال افريقيا) و المتاحةعالمياً من خلال تطبيق مفهوم التجارة الإفتراضية للمياه على التجارة الخارجية للحبوب في دول شمال افريقيا. و من ثم تم تقدير الاحتياجات المائية لكل محصول في كل دولة في منطقة الدراسة. كما تهدف الدراسة ايضاً الي تقدير العلاقة بين نصيب الفرد من كميات الحبوب المستوردة كمتغير تابع ، و حجم الموارد المائية المتاحة بكل دولة بالإضافة الى عوامل اخرى هامة كمتغيرات مستقلة.

و اوضحت النتائج ان جميع دول المنطقة قد حققت توفيراً للمياه عن طريق استيراد محاصيل الحبوب الى الحد الذي فاق مقدار الموارد المائية المتاحة لدى بعض الدول مثل ليبيا و الجزائر و تونس. و لقد كان لاستيراد القمح و الذرة االنصيب الأكبر في هذا التوفير. اما بالنسبة للمتاح عالمياً من المياه فقد وجد أن استيراد الحبوب في كل دول الدراسة قد أدي إلى توفير مياه فيما عدا مصر. و يرجع ذلك الى زيادة متوسط انتاجية الهكتار للحبوب في مصر عن المتوسط العالمي.

كما اكدت نتائج نموذج الإنحدار على المعنوية الإحصائية لتأثير نصيب الفرد من كل من الموارد المائية و مساحة الإراضي المروية و مساحة الأراضي القابلة للإستزراع على نصيب الفرد من اجمالي واردات محاصيل الحبوب. و دلت الإشارة السالبة لمعامل الإنحدار لنصيب الفرد من الموارد المائية الى ان استيراد هذه الدول للحبوب كثيفة الإحتياج للمياه لم يكن قراراً اختيارياً و انما يرجع الى انخفاض نصيب الفرد من الموارد المائية المتاحة في هذه الدول. كما دلت الإشارة السالبة لباقي العوامل المستقلة و التي كانت متسقة مع المنطق الاقتصادي على ان زيادة نصيب الفرد من مساحات الأراضي المروية و الأراضي المستصلحة تؤدي الى انخفاض واردات الحبوب في هذه الدول و ذلك عن طريق رفع كفاءة استخدام المورد المائي.

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