Evaluation of Economical aspects of virtual water trade in Egypt

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ملخص البحث:

في الآونة الأخيرة ، في بُلدان الشرق الأوسط المتقدمة النمو ، يجري وضع سياسات للمياه وتدابير مختلفة للحد من ندرة المياه ، مع تزايد عدد السكان وزيادة الطلب على الغذاء ومياه الشرب مع استقرار الموارد المائية القائمة. ومن ثَم ، فإن الحاجة إلى سياسات فعالة ضرورية لإدارة الطلب على المياه. وفي هذا البحث ، تناقش القيمة العملية لمفهوم المياه الافتراضية فضلاً عن إمكانية تطبيقه على الصعيدين الإقليمي والوطني. وتسلط البحوث الضوء على تطبيق المياه الافتراضية في المنتجات الزراعية وكذلك على التجارة الواضحة في المياه في هذه المنتجات. وأشار هذا البحث إلى أنه يمكن تطبيق مفهوم المياه الافتراضية على الصعيدين الوطني والمحلي ، عن طريق النظر في المياه المتاحة وغيرها من الظروف الاقتصادية الطبيعية والاجتماعية المحيطة بالبلد. في نهاية المطاف ، يمكن استنتاج أن تجارة المياه الافتراضية فعالة جداً في توفير المياه وهي أداة حقيقية لتخفيف الضغط على موارد المياه في مصر.

Abstract:

Recently, in the developed middle east countries, water policies and various measures are being developed to reduce the scarcity of water, as the population increases and the demand for food and drinking water increases with the stability of existing water resources. Hence, the need for effective policies is necessary to manage the water demand. In this research, the practical value of the concept of virtual water is discussed as well as its potential to apply the concept at the regional and national levels. Research highlights the application of virtual water in agricultural products as well as the apparent water trade of these products. This research suggested that the virtual water concept can be applied at the national and local levels, by considering the available water and other natural as well asocial economic conditions surrounding the country. Eventually, it can be concluded that virtual water trade is very effective in saving water and it's a real tool to relieve pressure on Egypt's water resources.

Keywords: Virtual Water; Economical aspects; water save ;water resources; water scarcity; Policy Option.

1- Introduction

We can call the twenty-first century the "century of water" because water scarcity has significant negative effects, including poverty, disease, and thus has a direct impact on life in those areas. In addition, at the same time, the expected increase in population density has negative effects on the increased demand for clean water, irrigation water for crop production and increased crop consumption. Egypt can be classified as a water-deficit country to the extent that it affects economic growth and threatens social stability. The purpose of the study is to clarify the key issues that policymakers will face at the strategic level when looking at virtual water as a national policy (Fakhry 2009).

One strong pointer of water shortages and scarcity in affected countries is the value of food imports, as the amount of water used in the agricultural sector exceeds 10 times that used in the combined industrial and social sectors(Allan1997). It should be noted that water is the main indicator determining the type and size of any economic activity. The main challenge to development in Egypt is limited or scarce water resources. The availability of water for irrigation is essential for agricultural development. Water consumption in Egypt from the agricultural sector is estimated at 85%, so trends on how fitting the virtual water trade is as a policy option must be assessed and decision-making supported before conclusions can be reached(AlaaEl-Sadek2010). The virtual water is usually denoting for the embodied water in the product and implicitly included in it, not in the real sense, but in the apparent sense. The positive outcome of the virtual water trade is the water savings it achieves in product importing countries. This influence has been observed in the recent studies related to virtual water (Allan, 1999; Hoekstra, 2003). The national water saving represents the outcome of multiplying the volume of imports in the quantities of water required to produce goods locally. In this regard, the net effect of the global virtual water trade among two countries depends on the volume of actual water used by the exporting countries compared to the volume of water required. (Hoekstra and Hung (2002, 2005)) suggested three levels of water efficiency and detected the most important level highlighted recently is the global water efficiency, which is the global trade in virtual water. The mean global volume of virtual water flows associated with international trade in agricultural products has been estimated as 1263 Gm3 /yr between 1997 and 2001 (Chapagain and Hoekstra, 2004). Based on the importing countries, (Zimmer and Renault (2003)) estimated this as1340 Gm3 /yr, and suggested a partial view of national savings. On the other hand, (Oki et al. (2003)) and (Oki and Kanae (2004)) determined virtual water trade and the resulting global water saved, the total global exports of virtual water for products in exporting countries were (683 Gm3 /yr). and the total global imports of products from importing countries were(1138 Gm3 /yr), This saves 455 Gm3 /yr as a result of food trade. Bearing in mind that their studies are very limited in terms of the methodology used in the assessment.

The objectives of the study can be more fully summarized by clarifying the following points, first present an integrated view for the position of Egypt from the water-scarcity border and consequently, the impact of that condition on water consumption, to determine the suitability of Virtual Water concept to be applied in Egypt, to determine the economic feasibility resulted of application of virtual water concept on the main crops in

Egypt, finally to evaluate foot-prints and impacts of applying the strategic plans based on the virtual water concept in Egypt.

2. Methodology of work.

2.1Calculation of specific water demand per crop type(SWD).

The average specific water demand (***SWD)***per crop type was calculated individually for each appropriate nation on the basis of the Food and Agriculture Organization (FAO) data concerning crop water requirements and crop yields.

$$SWD[e,c] = \frac{CWR\ (e.c)}{CY\ (e.c)} \quad (1)$$

where: -

SWD [e, c]: of specific water demand per croptype (m3/ ton).

CWR [e, c]: the crop water requirement of crop c in country e (m3/fed) (from CropWat model).

CY [e, c]: the crop yield (ton/fed) (from Egyptian Ministry of Agriculture).

The crop water requirement **CWR** (in m3/fed) is calculated from the collected crop evapotranspiration amount Etc (in mm/day) by using **CropWat** software over the complete growing period. The crop evapotranspiration Etc results of multiplying the 'reference crop evapotranspiration' ETo by the crop coefficient Kc:

$$CWR\ [e, c] = \sum ETc \quad (2)$$

$$ETc = Kc \times ETo \quad (3)$$

where: -

ET[c]: summation of crop evapotranspiration amount over the complete growing period of crop c (mm/day).

K[c]: crop coefficient from study crop to reference crop c.

ETo[c]: reference crop evapotranspiration of crop c with ideal condition.

FAO has clarified the concept of "reference crop evapotranspiration " to illustrate evaporative demand for the atmosphere independently of crop type and the popular progress in crops and regulatory methods. The only factors affecting ETO are climate parameters. ETO evaporation is defined as the rate of evaporation from an assumed reference crop with an assumed crop height of 12 cm, a constant crop surface resistance of (70 s/m) and an albedo of 0.23. This reference to evaporation of crops is quite similar to evaporation from a large surface of single-height green grass cover, which grows considerably, completely permeating the ground and with satisfactory water. The reference crop evapotranspiration is calculated on the basis of the FAO Penman-Monteith equation (Ouda S, Noreldin T (2017)).

$$ET_o = \frac{0.408\ \Delta(Rn - G) + \gamma \frac{900}{(T+273)}(U2 * (ea - ed))}{\Delta + \gamma(1 + 0.34U_2)} \quad \text{(FAO Penman-Monteith equation)(4)}$$

where:

ETo: reference crop evapotranspiration [mm/d]. G: soil heat flux [MJ/ m2/d]. U2: wind speed measured at 2m height [m/sec]. Δ: slope vapour pressure curve [kPa/ □C]. γ: psychometric constant [kPa /□C].	Rn: net radiation at crop surface [MJ /m2/d]. T: average air temperature [C]. (ea = saturation vapour pressure;ed = actual vapour pressure) (ea-ed): vapor pressure deficit [kPa]. 900: conversion factor.

The crop coefficient accounts for the actual crop canopy and aerodynamic opposition relative to the theoretical reference crop. The crop coefficient aids as admixture of the physical and physiological differences between a certain crop and the reference crop.

2.2 Calculation of virtual water trade flows and the national virtual water trade balance.

For the most important and necessary definition of economic scheduling, virtual trade flows of water between States, it can be inferred by multiplying international trade flows of crops into the virtual content of those crops. The last depends on the specific demand for water for the crop in the source country of the crop.

-Virtual water trade is thus calculated by:

$$VWT\left[c,\, t\right]=CT\left[c,\, t\right]\times SWD\left[c\right] \quad (5)$$

where:

VWT: the virtual water trade (m3/year) in year t as a result of trade in crop c.

CT: the crop trade (ton/year) in year t for crop c.

SWD: the specific water demand (m3/ton) of crop c.

2.3 Calculation of net virtual water import, gross virtual water imports and exports.

-The gross virtual water import to a country is the sum of all imports:

$$GVWI\left[t\right]=\sum VWT\left[c,t\right] \quad (6)$$

where:

GVWI: The gross virtual water import (m3/year) in year t for crop c.

-The gross virtual water export from a country is the sum of all exports:

$$GVWE\left[t\right]=\sum VWT\left[c,t\right] \quad (7)$$

where:

GVWE: The gross virtual water import (m3/year) in year t for crop c.

-The net virtual water import of a country is equal to the gross virtual water import minus the gross virtual water export. The virtual water trade balance of country x for year t can thus be written as:

$$NVWI\left[x,t\right]=GVWI\left[x,t\right]-GVWE\left[x,t\right] \quad (8)$$

Where:

NVWI: The net virtual water import (m3/year) 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.

2.4 Calculation of a nation's water footprint.

The water footprint of a country (expressed as a volume of water per year) is defined as:

$$Water\ footprint = WU + NVWI \quad (9)$$

Where: NVWI: The net virtual water import (m3/year) to the country.

WU: Total domestic water use WU should ideally refer to the sum of blue water and green water use.

2.5 Calculation of national water scarcity, water dependency and water self-sufficiency.

Countries with abundant water resources can be determined to earn high profits by exporting water in their virtual form, but before that, indicators of water scarcity and the degree of dependence on the import of virtual water must be available. As an indicator of national water scarcity, we use the ratio of total water use to water availability, because it makes sense to assume that a country with high water scarcity will seek to benefit from the net import of virtual water. As an index of national water scarcity we use the ratio of total water use to water availability:

$$WS = (WU / WA) * 100 \quad (10)$$

where

WS: national water scarcity (%).

WU: the total water use in the country (m3/year), (from Ministry of Irrigation and Water Resources).

WA: the national water availability (m3/year), (Ministry of Irrigation and Water Resources Periodical Bulletin).

-A country's water dependence (WD) is estimated as the ratio of net import of virtual water into a country to the total national allocation of water.:

$$WD=\begin{cases} \frac{NVWI}{WU+NVWI} * 100 \end{cases} \quad (11)$$

The water value varied between zero and 100%.

-The water self-sufficiency index is presented below:

$$WSS=\begin{cases} \frac{WU}{WU+NVWI} * 100 \end{cases} \quad (12)$$

The water self-sufficiency level (WSS) represents the national ability of the water supplying system.

2.6 Virtual water imports produce real water saving

The best honest effect of virtual water is the provision of water to countries or regions that import food products. This effect is commonly mentioned in virtual water studies (Allan, 1999). Direct savings as a result of the quantity of imports are multiplied by the estimated virtual water value using the marginal gain principle.

$$\textit{Water savings } (m^3) = \textit{Imports (ton)} \times \textit{V.W (local site)} \quad (13)$$

Where: V.W: virtual water (m3/ton

The overall procedure for the calculation of specific water demand and virtual water is given in Figure (1) **(**at separated file**)**. This chart shows the steps for estimation of the virtual water trade flows for Egypt.

2.7 Evaluation of Economical Aspects of Virtual Water in Egypt

The overall procedure for the Evaluation of Economical Aspects of Virtual Water is given in Figure (2) (at attached file). This chart shows the steps to get the optimum benefits of application the virtual water trade concept for Egypt.

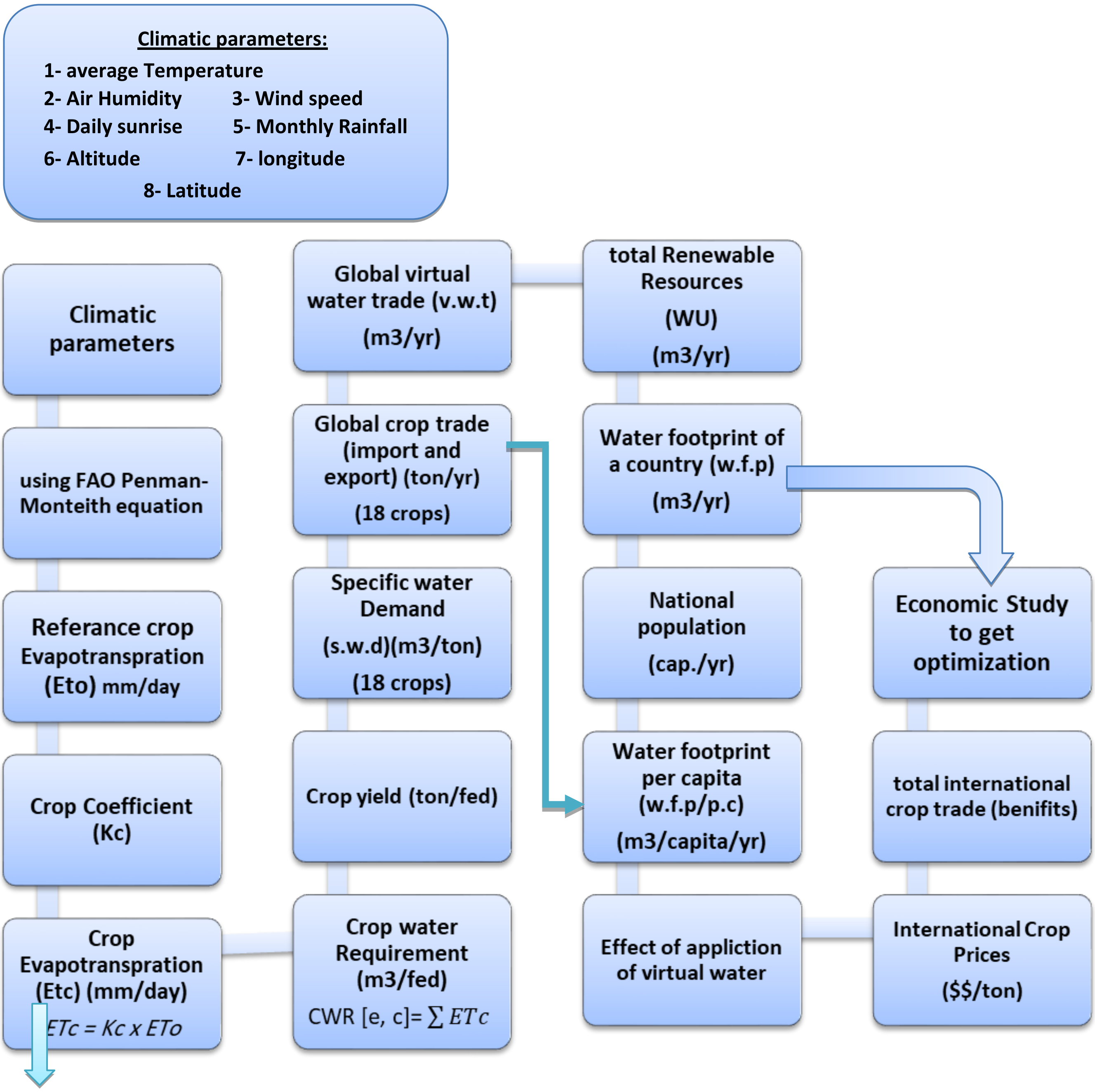


Figure (1)

Figure (1): Flowchart showing the detailed steps of how to calculate the volume of virtual water, as well as the total global volume of Egypt, and clarifies the comprehensive scheme to clarify the effect of virtual water and the course of the research point.

(Source: Calculations, clarification, and authorization of the author based on what will be proven and concluded (Virtual water model).**).**

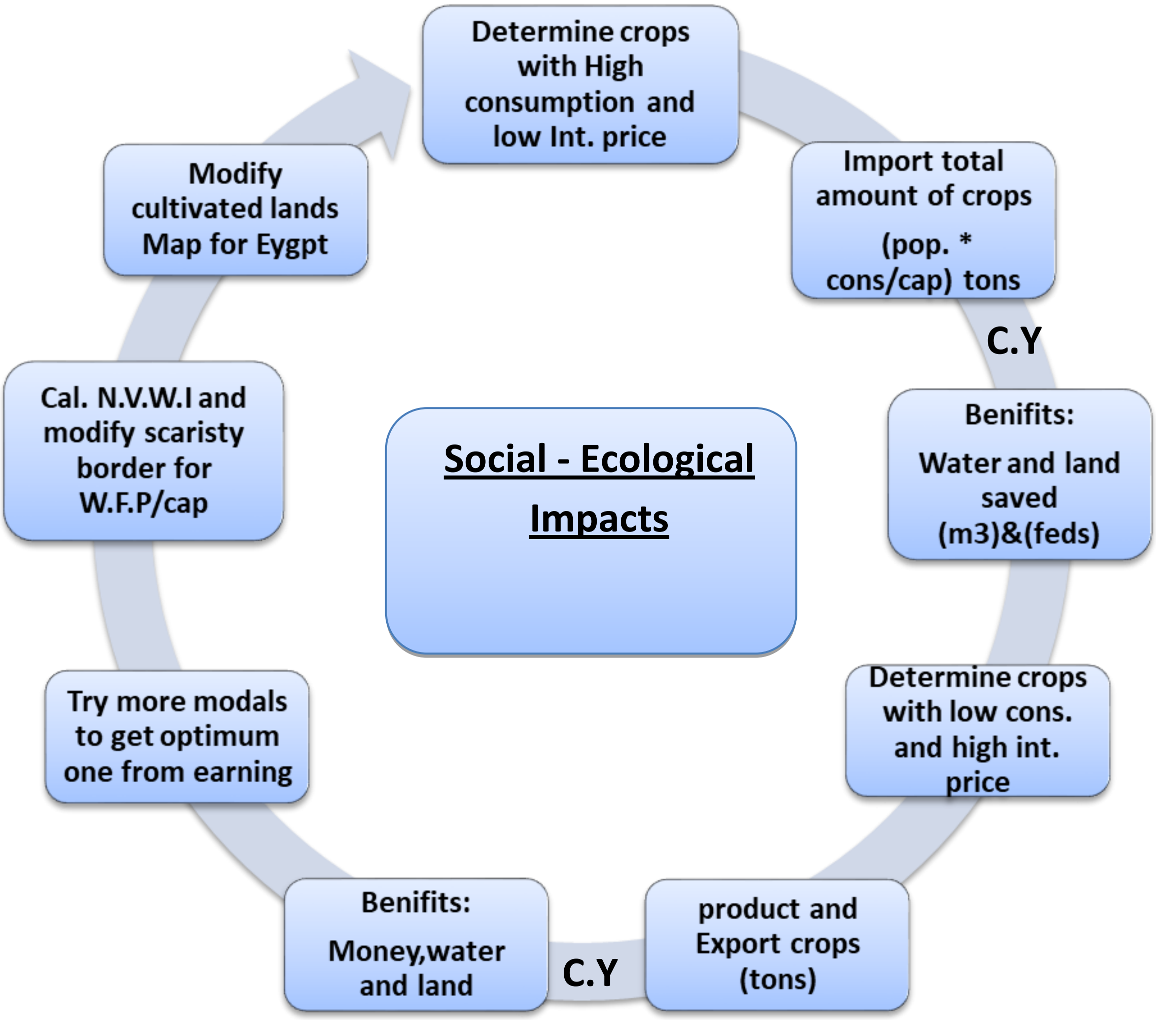


Figure (2)

Figure (2): The detailed chart to clarify the steps to confirm the economic feasibility of applying the hypothetical water theory and that it is valid and can be considered as a source of water resources that cannot be ignored (Source: Author's schemes to prove the findings of the research point).

3.Methodology of the program used (CROPWAT 8.0, CLIMWAT 2.0).

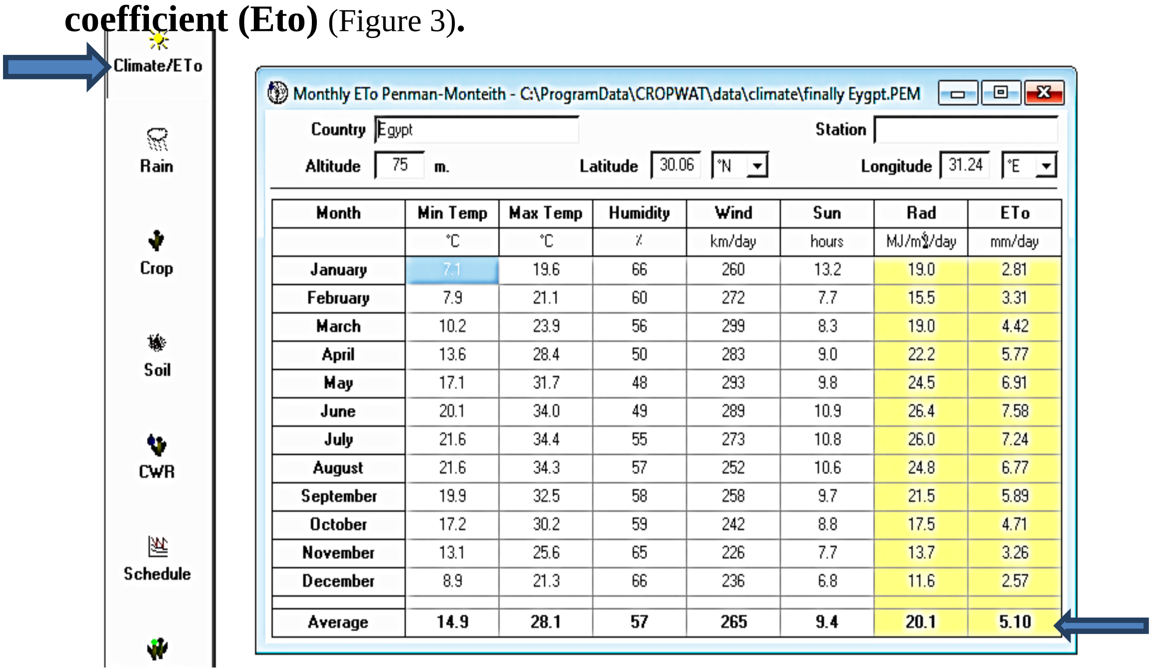
For CropWat Windows used in the calculations, it can be defined as an (FAO) auxiliary software (1992) to calculate the evaporation of reference crops and use the Penman-Monteith method, it is a method approved among many that are inputs to the software, such as climate, rainfall, soil files, crop pattern and others, as well as extensive use of graphics, including the graphs of inputs and results as a whole. The main objective of the software after calculating the evaporation of crops is to calculate crop water requirements and schedule irrigation.

software version: CROPWAT versions 5.7, 7.0 and 8.

used version: CROPWAT 8.

3.1 **The following elements are the successive steps of the program to calculate crop water requirements and attach live forms of results from the program as a result of appropriate inputs for Egypt in the separate attached file.**

3.1.1 For climate input and output it is the reference evapotranspiration coefficient (Eto) (Figure 3).

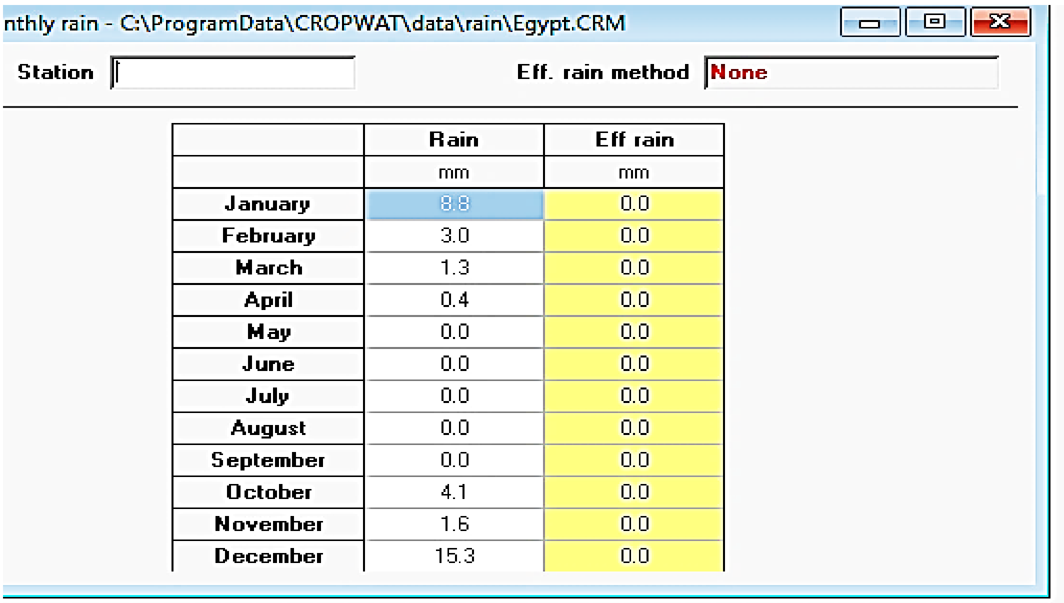


Month	Min Temp	Max Temp	Humidity	Wind	Sun	Rad	ETo
	°C	°C	%	km/day	hours	MJ/m²/day	mm/day
January	7.1	19.6	66	260	13.2	19.0	2.81
February	7.9	21.1	60	272	7.7	15.5	3.31
March	10.2	23.9	56	299	8.3	19.0	4.42
April	13.6	28.4	50	283	9.0	22.2	5.77
May	17.1	31.7	48	293	9.8	24.5	6.91
June	20.1	34.0	49	289	10.9	26.4	7.58
July	21.6	34.4	55	273	10.8	26.0	7.24
August	21.6	34.3	57	252	10.6	24.8	6.77
September	19.9	32.5	58	258	9.7	21.5	5.89
October	17.2	30.2	59	242	8.8	17.5	4.71
November	13.1	25.6	65	226	7.7	13.7	3.26
December	8.9	21.3	66	236	6.8	11.6	2.57
Average	14.9	28.1	57	265	9.4	20.1	5.10

Figure (3)

Fig.3:It shows the results of the program approved by the FAO for averages of the evapotranspiration coefficient for Egypt during the months of the year as an output (average value 5.3 mm)Source: Director of the approved program(Author result).

3.1.2 for input of Rain on program (neglected) (Figure 4).



	Rain	Eff rain
	mm	mm
January	8.8	0.0
February	3.0	0.0
March	1.3	0.0
April	0.4	0.0
May	0.0	0.0
June	0.0	0.0
July	0.0	0.0
August	0.0	0.0
September	0.0	0.0
October	4.1	0.0
November	1.6	0.0
December	15.3	0.0

Figure (4)

Fig.4: It shows the averages of effective rainfall values that were deliberately neglected as a result of Egypt being a non-rainy country and to separate the variables and simulate reality. Source: Director of the approved program(Author result).

3.1.3 for crop(c) and crop coefficient (kc) (the following table).

Table 1, Values of the crop factor (kc) for various crop and growth stages.

Crop	Initial stage	Crop dev. Stage	Mid-season stage	Late season stage
Barely/Oats/Wheat	0.35	0.75	1.15	0.45
Bean. Green	0.35	0.70	1.10	0.90
Bean, dry	0.35	0.70	1.10	0.30
Cabbage/Carrot	0.45	0.75	1.05	0.90
Cotton/flax	0.45	0.75	1.15	0.75
Cucumber/Squash	0.45	0.70	0.90	0.75
Tomato	0.45	0.75	1.15	0.80
Grain/small	0.35	0.75	1.10	0.65
Lentil/pulses	0.45	0.75	1.10	0.50
Lettuce/spinach	0.45	0.60	1	0.90
Maize, Sweet	0.40	0.80	1.15	1.00

(Source: FAO (official web site), 2010).

3.1.4 for soil data input.

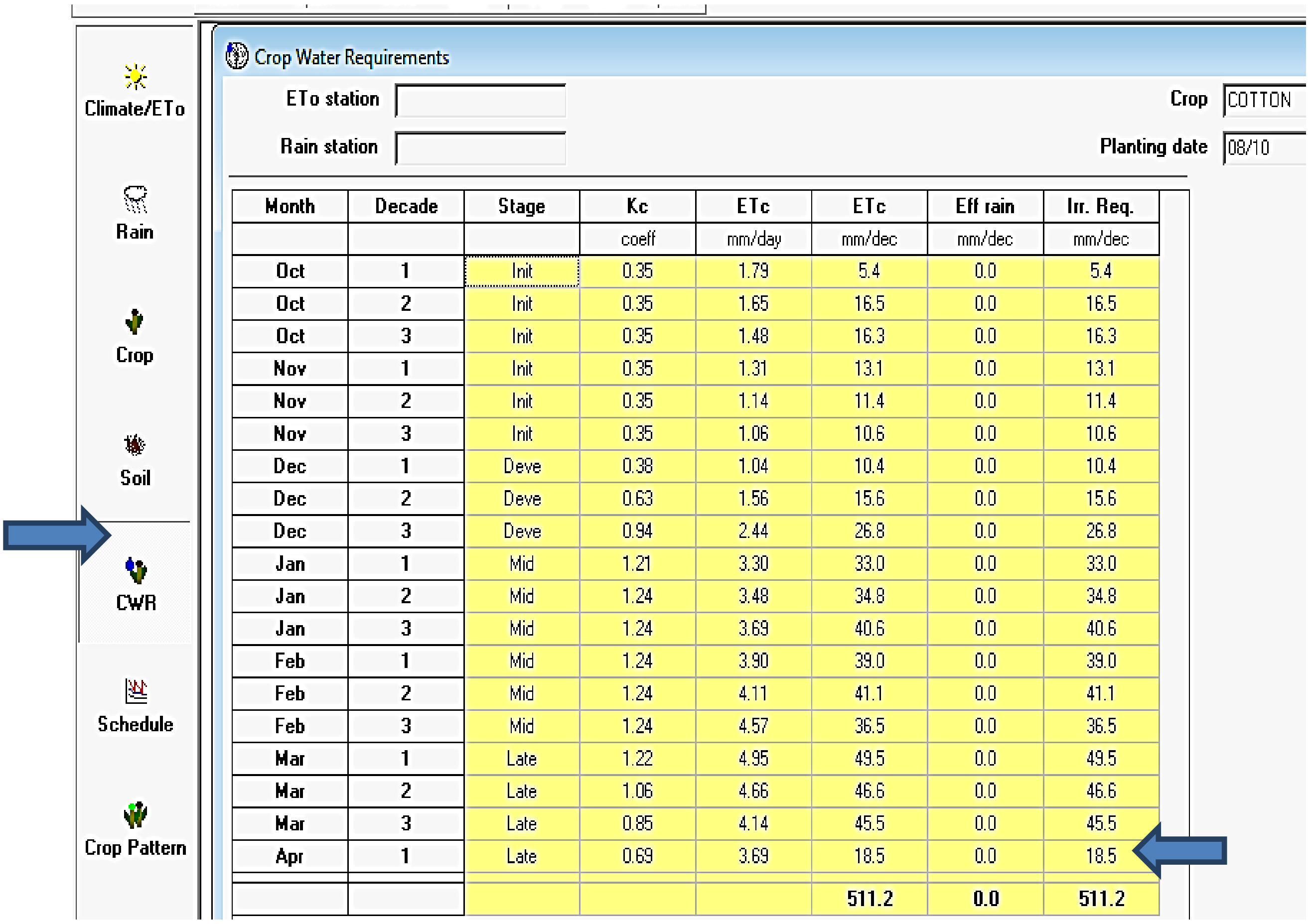
Table2,Soil water holding capacity and available water prevailed in each governorate.

State	Water capacity (m/m)	Existing water (m/m)
Nile Delta		
Alexandria	0.372	0.205
Domiatte	0.375	0.222
Kafr El-Sheik	0.402	0.171
EL-Dakahlia	0.397	0.196
El-Behira	0.406	0.231
EL-Gharbia	0.378	0.220
EL-Monofia	0.417	0.231
EL-Sharkia	0.418	0.210
EL-Kalubia	0.401	0.219
Middle Egypt		
Giza	0.362	0.209
Fayoum	0.425	0.195
Beni-sweif	0.428	0.245
AL-Menia	0.433	0.238
Upper Egypt		
Assuit	0.437	0.235
Suhag	0445	0.245
Qena	0.455	0.293
Asswan	0.447	0.256

(Source**:-**Water and Environment Research Institute, AgriculturalResearch Center, Egypt).

3.1.5. Output data crop water requirement (C.W.R) (Figure 5).

According to the figure 6, the important output was calculated, which is the water yield requirement, which is necessary for the calculation of specfic water demand (s.w.d).



Month	Decade	Stage	Kc	ETc	ETc	Eff rain	Irr. Req.
			coeff	mm/day	mm/dec	mm/dec	mm/dec
Oct	1	Init	0.35	1.79	5.4	0.0	5.4
Oct	2	Init	0.35	1.65	16.5	0.0	16.5
Oct	3	Init	0.35	1.48	16.3	0.0	16.3
Nov	1	Init	0.35	1.31	13.1	0.0	13.1
Nov	2	Init	0.35	1.14	11.4	0.0	11.4
Nov	3	Init	0.35	1.06	10.6	0.0	10.6
Dec	1	Deve	0.38	1.04	10.4	0.0	10.4
Dec	2	Deve	0.63	1.56	15.6	0.0	15.6
Dec	3	Deve	0.94	2.44	26.8	0.0	26.8
Jan	1	Mid	1.21	3.30	33.0	0.0	33.0
Jan	2	Mid	1.24	3.48	34.8	0.0	34.8
Jan	3	Mid	1.24	3.69	40.6	0.0	40.6
Feb	1	Mid	1.24	3.90	39.0	0.0	39.0
Feb	2	Mid	1.24	4.11	41.1	0.0	41.1
Feb	3	Mid	1.24	4.57	36.5	0.0	36.5
Mar	1	Late	1.22	4.95	49.5	0.0	49.5
Mar	2	Late	1.06	4.66	46.6	0.0	46.6
Mar	3	Late	0.85	4.14	45.5	0.0	45.5
Apr	1	Late	0.69	3.69	18.5	0.0	18.5
					511.2	0.0	511.2

Figure (5)

Fig.5: Shows the main result of the program, which is the requirements for the crop of water(CWR), which is necessary to calculate the quantities of water used to clarify the water footprint (example: cotton).

Source: Director of the approved program(Author result).

4.RESULTS AND DISCUSSION.

4.1 The crop water requirement, Comparession between FAO and specific water demand.

Table.3crop water requirement and Specific Water Demand per Crop Type (CropWat model).

Crop	CropWat (m3 / ha)	F.A.O Result (m3 /ha)	Crop Yield (Ton/ha)	Specific water demand (S.W.D) (M3/ton)
Bananas 1year	14382	9680	37.5	384
Barley	5515	5620	2.1	2627
Beans green	4445	4520	12.5	356
Beans dry	4171	4200	2.6	1605
Groundnuts	7664	6930	3.5	2190
Maize	6841	4490	8.9	769
Potatoes	3297	4730	21.5	154
Rice	9560	9600	8.75	1093
Sorghum	6060	4790	5.8	1045
Soybeans	8647	7790	2.6	3326
Sugar beet	8647	7790	47.4	183
Sunflower seed	6716	7380	2.3	2920
Tomatoes	4734	5890	36.9	129
Wheat	5991	6380	6.3	951
CABBAGE Crucifers	9905	–	29.2	340
MANGO	17263	–	9.8	1762
MILLET	3128	–	0.9	3476
Tobacco	4182	–	1.2	3485

(Source: Author calculation and F.A.O official web site).

4.2 Import and Export crops (ton/year).

By obtaining the quantities of water needed to irrigate any crop (s.w.d – c.w.r) and by obtaining the export and import values of that crop during the year, so we can know the consumed quantity of the crop as volume (in tons), as well asvirtual water content (cubic meter) and the costs of importing the imported quantity during the year or growing it locally are compared. Thus, we have achieved the economic aspect of this study by introducing virtual water into the Egyptian water resources plan. Therefore, the quantities of crops (in tons) that were imported and exported for Egypt during the period will be listed and illustrated, which can be translated into virtual quantities of water (cubic meters).

Table.4Import, Export and virtual water for potatoes(for Example)from 1991 to 2050.

Year	Export(ton)	Import(ton)	Net(ton)	S.W.D (m3/ton)	V.W(m3)	v.w(Exp)m3	v.w(Imp)m3
1991	217837	12989	204848	155	31751440	33764735	2013295
1992	209365	22452	186913	155	28971515	32451575	3480060
1993	175470	25786	149684	155	23201020	27197850	3996830
1994	131865	34903	96962	155	15029110	20439075	5409965
1995	418744	74108	344636	155	53418580	64905320	11486740
1996	411173	48644	362529	155	56191995	63731815	7539820
1997	232963	78311	154652	155	23971060	36109265	12138205
1998	228467	48193	180274	155	27942470	35412385	7469915
1999	255569	65377	190192	155	29479760	39613195	10133435
2000	156630	66759	89871	155	13930005	24277650	10347645
2001	185505	34585	150920	155	23392600	28753275	5360675
2002	229382	55463	173919	155	26957445	35554210	8596765
2003	296287	69480	226807	155	35155085	45924485	10769400
2004	381510	23220	358290	155	55534950	59134050	3599100
2005	392178	72908	319270	155	49486850	60787590	11300740
2006	367134	58012	309122	155	47913910	56905770	8991860
2007	389698	69227	320471	155	49673005	60403190	10730185
2008	397944	81665	316279	155	49023245	61681320	12658075
2009	215078	52908	162170	155	25136350	33337090	8200740
2010	298557	146787	151770	155	23524350	46276335	22751985
2011	637434	143638	493796	155	76538380	98802270	22263890
2012	262985	120250	142735	155	22123925	40762675	18638750
2013	427907	184477	243430	155	37731650	66325585	28593935
2014	599540	154978	444562	155	68907110	92928700	24021590
2015	554891	141049	413842	155	64145510	86008105	21862595
2016	407974	164039	243935	155	37809925	63235970	25426045
2020	-	-	-	-	-	74228959.62	23308976.9
2025	-	-	-	-	-	75981750.12	24130205.27
2030	-	-	-	-	-	77734540.62	24951433.64
2035	-	-	-	-	-	79487331.12	25772662.01
2040	-	-	-	-	-	81240121.62	26593890.38
2045	-	-	-	-	-	82992912.12	27415118.75
2050	-	-	-	-	-	84745702.62	28236347.12

(Source: Author calculation, Ministry of Agr and F.A.O official web site).

Where: -

S.W.D: - specfic water demand m3/ton.

V.W: - Virtual water (Exported or Imported) m3/year.

Table 5. total amount of Exported, imported crops (18 crops) and their virtual water for Egypt at 2020.

	Imported (1000 ton)	*Exported (1000ton)*	*G.V.W.I (m3)*	*G.V.W.E (m3)*	*Net (m3)*	*Footprint (m3)*	*Footprint /capita(m 3)*
2020	*15979683*	*722054*	*23290043045*	*657129516.8*	*22632913528*	*1.03633E+11*	*1037*

(source: - FAO wed site and Author cal.).

4.3Analysis of the current state.

The total volume of water used for the production of main crops and the total volume of the imported and exported national water through the trade of main crops in year 2020, where year 2020 is considered as the current state due to the available data, are calculated based on the total quantity of produced, imported, and exported crops in this year and their corresponding virtual water content. Moreover, the national water saving and the total water foot print are estimated for the same year.

As shown in Figure (6) he total volume of Water Used (WU) for the production of the main agricultural crops (for consumption locally and export) is calculated as 81 BCM in year 2020. The imported national water through agricultural crops, Virtual Water Import (VWI), of Egypt for year 2020 is calculated as 23.5 BCM. While, the total volume of the exported national water, Virtual Water Export (VWE), is calculates as .657 BCM. the national water saving (ΔS) of Egypt for year 2020 as a result of trade of agricultural crops is calculated as 22.6 BCM (figures 6&7).

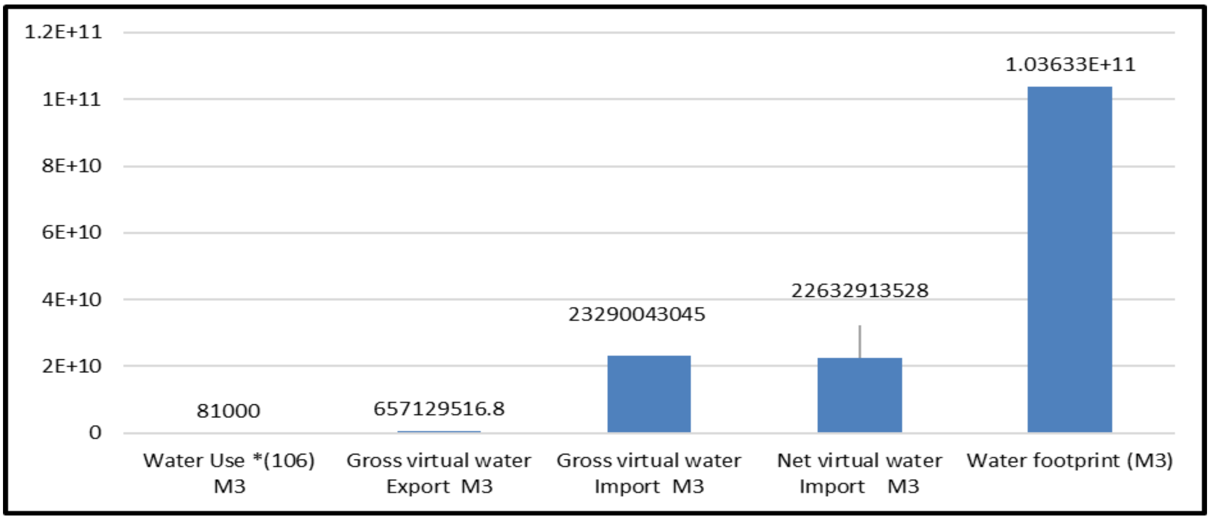


Figure (6)

Figure 6: It shows the total volume of water used, the volume of virtual water that was exported, the volume of imported virtual water, the net volume and the water footprint of Egypt in a year (2019 – 2020) as a review analysis of the current situation.

Source: FAO(official website), (Egyptian Ministry of Trade and Industry), (Central Organization for Export Development), (World Trade Bank) and Author Analysis.

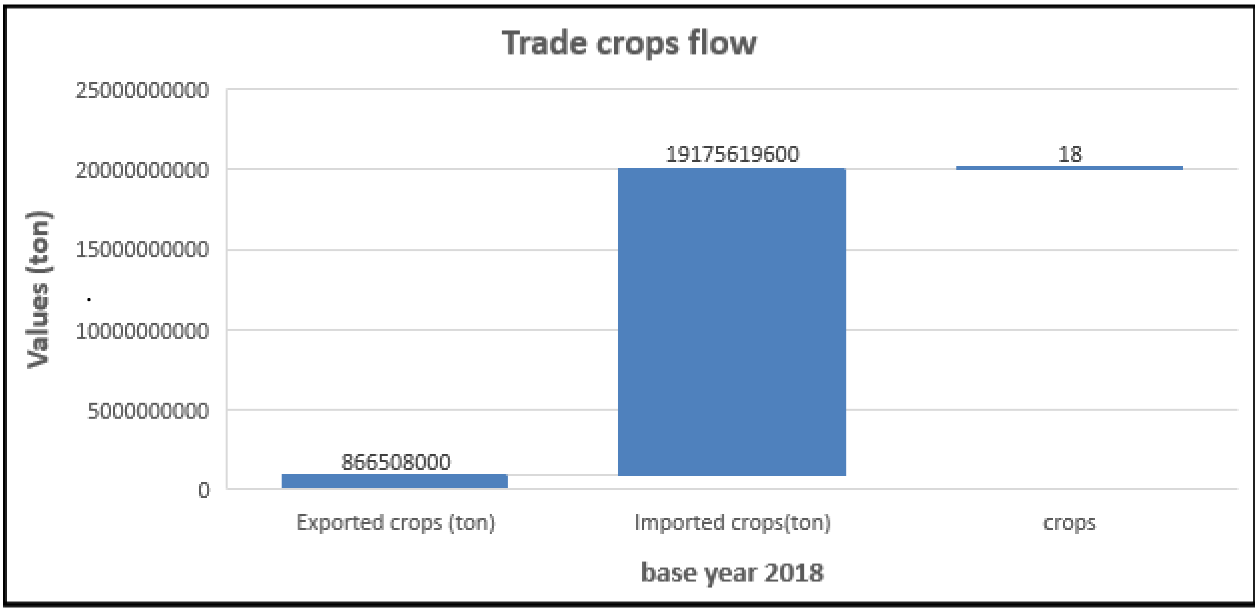


Figure (7)

Figure7: Shows the total flow of Egyptian crop trade, which is represented in the volume of exports of crops (in tons) and the volume of crops that have been imported (in tons) to know the flow of virtual water.

Source: FAO (official website), (Egyptian Ministry of Trade and Industry), (Central Organization for Export Development) and (World Trade Bank).

4.4 **Annual Total Water Demand and Area required for Food Consumption for Egypt.**

Table (6), lists the composition of an average diet for a society in Egypt and the amount of water needed for its cultivation. In this table, the equivalent value of water needed for cultivation of food consumption per capita from each crop is determined. This was given in column No. 5 "water demand" by the aid of the values of water requirement that have been determined from the constructed model.

Table (6). Composition of an Average Diet for a Society in Egypt and the Amount of Water Needed to Produce it.

`	*Crops*	*Food Consumption (kg/capita/yr)*	*Water Requirement (From model) (m^3/ton)*	*Water Demand (m^3/capita/yr)*
1	*Apples*	*8.00*	*665*	*5.3*
2	*Bananas*	*12.12*	*258*	*3.1*
3	*Barley*	*2.30*	*2146*	*4.9*
4	*Beans green*	*3.30*	*475*	*1.6*
5	*Beans dry*	*0.70*	*1565*	*1.1*
6	*Cottonseed*	*4.80*	*9911*	*47.6*

7	*Dates*	*16.00*	*393*	*6.3*
8	*Grapefruit*	*0.10*	*680*	*0.1*
9	*Grapes*	*18.00*	*420*	*7.6*
10	*Groundnuts*	*2.00*	*2350*	*4.7*
11	*Lemons*	*4.50*	*492*	*2.2*
12	*Maize*	*182.00*	*627*	*114.1*
13	*Nuts*	*0.10*	*5452*	*0.5*
14	*Oilseeds*	*1.00*	*7134*	*7.1*
15	*Olives*	*4.00*	*1821*	*7.3*
16	*Onions*	*13.30*	*195*	*2.6*
17	*Oranges*	*18.00*	*552*	*9.9*
18	*Peas, dry*	*0.10*	*2790*	*0.3*
19	*Peas, green*	*4.00*	*478*	*1.9*
20	*Pepper*	*0.10*	*2500*	*0.3*
21	*Potatoes*	*32.00*	*151*	*4.8*
22	*Rice*	*45.00*	*945*	*61.4*
23	*Sorghum*	*12.00*	*864*	*10.4*
24	*Soybeans*	*25.00*	*2453*	*61.3*
25	*Spices*	*0.10*	*2363*	*0.2*
26	*Sugar beet*	*35.00*	*179*	*6.3*
27	*Sugar Cane*	*308.00*	*146*	*45.0*
28	*Sunflower seed*	*8.30*	*2634*	*21.9*
29	*Sweet potatoes*	*4.00*	*232*	*0.9*
30	*Tomatoes*	*105.00*	*137*	*14.4*
31	*Vegetables*	*6.00*	*318*	*1.9*
32	*Watermelons*	*21.00*	*257*	*5.4*
33	*Wheat*	*215.00*	*970*	*208.6*
Total		*700 m^3/capita/yr + Personal Use($\pm$300)= 1000 m^3/capita/yr*		

(Source; - Author cal. And FAO website).

Then, Table (6) shows the composition of an average diet for a society in Egypt

"food consumption" (kg/capita/yr), water requirement(m^3/ton) needed to produce it and water demand (m^3/capita/yr). From the table, it can be concluded that, the annual total water demand per capita from food consumption is 700$\pm$300 m^3/capita/yr.

Table (7) shows the composition of an average diet for a society in Egypt "food consumption" (kg/capita/yr), "crop yield" from one hectare (ton/ha) and the "required area" needed to produce it in (ha). From the table, it can be concluded that the total annual required area per capita from food consumption 0.09372ha/capita.

Table (7). Composition of an Average Diet for a Society in Egypt and the Required Area Needed to Produce it.

	Crops	*Food Consumption (kg/capita)*	*Crop Yield (ton/ha)*	*Required Area (ha)*
1	*Apples*	*8.00*	*21.20*	*0.00038*
2	*Bananas*	*12.12*	*41.90*	*0.00029*
3	*Barley*	*2.30*	*2.93*	*0.00079*
4	*Beans green*	*3.30*	*10.09*	*0.00033*
5	*Beans dry*	*0.70*	*2.62*	*0.00027*
6	*Cottonseed*	*4.80*	*2.33*	*0.00206*
7	*Dates*	*16.00*	*33.73*	*0.00047*
8	*Grapefruit*	*0.10*	*16.00*	*0.00001*
9	*Grapes*	*18.00*	*21.55*	*0.00084*
10	*Groundnuts*	*2.00*	*3.36*	*0.00059*
11	*Lemons*	*4.50*	*22.33*	*0.00020*
12	*Maize*	*182.00*	*8.12*	*0.02242*
13	*Nuts*	*0.10*	*2.91*	*0.00003*
14	*Oilseeds*	*1.00*	*0.90*	*0.00111*
15	*Olives*	*4.00*	*6.36*	*0.00063*
16	*Onions*	*13.30*	*30.00*	*0.00044*
17	*Oranges*	*18.00*	*21.18*	*0.00085*
18	*Peas, dry*	*0.10*	*1.75*	*0.00006*
19	*Peas, green*	*4.00*	*10.37*	*0.00039*
20	*Pepper*	*0.10*	*1.50*	*0.00007*
21	*Potatoes*	*32.00*	*24.76*	*0.00129*
22	*Rice*	*65.00*	*9.97*	*0.00652*
23	*Sorghum*	*12.00*	*5.68*	*0.00211*
24	*Soybeans*	*25.00*	*3.30*	*0.00757*
25	*Spices*	*0.10*	*3.50*	*0.00003*
26	*Sugar beet*	*35.00*	*48.70*	*0.00072*
27	*Sugar Cane*	*308.00*	*119.56*	*0.00258*
28	*Sunflower seed*	*8.30*	*2.38*	*0.00349*
29	*Sweet potatoes*	*4.00*	*29.55*	*0.00014*
30	*Tomatoes*	*105.00*	*38.92*	*0.00270*
31	*Vegetables*	*6.00*	*18.13*	*0.00033*
32	*Watermelons*	*21.00*	*24.70*	*0.00085*
33	*Wheat*	*215.00*	*6.48*	*0.03319*
Total		*0.09372 ha/capita*		

(Source; - Author cal., Ministry of Agriculture and FAO website).

5. Economic studies.

5.1 Food - water Security and Economy Implications for Trade of Virtual Water under the two scenarios.

5.1.1 Scenario (1): The required volume of water, water trade balance and water footprint under achieving food security by striving for water and food self-sufficiency.

The total volume of water required to produce the previous quantities of crops, as shown in table (8), is estimated at 110BCM in year 2050. The expected imported national water through agricultural crops, Virtual Water Import (VWI), of Egypt for year 2050 is calculated as 26.9 BCM. While, the total volume of the expected exported national water, virtual water export (VWE), is calculates as 4.89 BCM., the expected total water footprint (WFP) of Egypt for year 2050 is calculated as 133 BCM. From previous it could have said that the expected per capita water conception for food security in year 2050 is 886 m3 less than value of standard international of border sacristy (1000 m3/capita).

5.1.1.1Water footprints, water scarcity, water self-sufficiency and water dependency.

Through the previous explanation, data and under the prediction of scenario No 1., according to Table No 7. the following was calculated as shown**: -**

Table (8) Water footprints, water scarcity, water self-sufficiency, water dependency and total water availability per capita in Egypt for years from 1990 to 2050.

Year	*population*	*Water withdrawal (10^6)m3*	*Water availability (10^6)m3*	*Water scarcity (%)*	*Gross virtual water import m3*	*Gross virtual water export m3*	*Net virtual water import*	*Water footprint (10^6) m3*	*Water self-Sufficiency (%)*	*Water dependency(%)*	*Total Water Amount per cap*	
											Water Amount 3 (m /yr/cap)	*Water Amount including Virtual Water*
1991	55210277	56000	55500	100	6870170138	335188270	6534981868	62034981868	90	10	1006	1124
1992	56258434	56500	55500	101	6697569308	419457671	6278111637	62278111637	90	10	996	1108
1993	57382040	57000	55500	103	5965651656	321720157	5643931499	62643931499	91	9	994	1092
1994	57800000	57800	55500	104	8470668204	502429510	7968238694	65268238694	88	12	992	1130
1995	58400000	58871	55500	105	7362781021	380772726	6982008295	64982008295	90	10	994	1113
1996	59313000	61228	55500	111	8368480461	696064491	7672415970	68900415970	89	11	1033	1162
1997	59441000	63585	55500	115	9711387441	440844119	9270543322	72855543322	88	12	1070	1226
1998	60706000	65942	55500	119	8130807867	848761018	7282046849	73224046849	91	9	1087	1207
1999	61993000	68300	55500	124	8232852154	626593813	7606258341	75906258341	90	10	1102	1225
2000	63305000	68300	55500	124	9360485051	825856042	8534629009	76834629009	89	11	1079	1214
2001	64652000	68700	55500	124	9527776664	1288573247	8239203417	76939203417	90	10	1063	1191
2002	65986000	69100	55500	125	10316914064	956966244	9359947820	78459947820	89	11	1048	1190
2003	67313000	69500	55500	126	8366399707	1170986867	7195412840	76695412840	91	9	1033	1140
2004	68648000	69900	55500	126	7074334608	1666536285	5407798323	75307798323	93	7	1019	1098
2005	69997000	70300	55500	127	11519295322	2190473089	9328822233	79628822233	89	11	1005	1138

2006	71384000	70700	55500	128	12921200155	1961936692	10959263463	81659263463	87	13	991	1144
2007	72940000	71100	55500	129	16185253870	2440684995	13744568875	84844568875	84	16	975	1164
2008	74439000	71500	55500	129	15399252187	724739456	14674512731	86174512731	83	17	961	1158
2009	76099000	71900	55500	130	17901714474	1480848634	16420865840	88320865840	82	18	945	1161
2010	77840000	72000	55500	130	21199430530	1315384627	19884045903	91884045903	79	21	925	1181
2011	79618000	72200	55500	131	21009302082	305682048	20703620034	92903620034	78	22	907	1167
2012	81567000	72300	55500	131	22726734925	493565849	22233169076	94533169076	77	23	887	1159
2013	83667000	73800	55500	133	19969009255	845613999	19123395256	92923395256	80	20	883	1111
2014	85783000	75300	55500	136	23577232694	523052028	23054180666	98354180666	77	23	878	1147
2015	87963000	76800	55500	139	22799204013	591998197	22207205816	99007205816	78	22	874	1126
2016	90086000	77500	55500	140	16507005766	461677615	16045328151	93545328151	83	17	861	1039
2020	100000000	80000	55500	146	23290043045	657129516.8	22632913528	1.03633E+11	79	21	810	1037
2025	110526293	85000	55500	152	24026070067	682730173.3	23343339894	1.07343E+11	79	21	761	972
2030	118663956	90000	55500	159	24762097089	708330829.7	24053766259	1.12054E+11	79	21	742	945
2035	126801619	95000	55500	166	25498124111	733931486.1	24764192624	1.16764E+11	79	21	726	921
2040	134939282	100000	55500	173	26234151132	759532142.5	25474618990	1.21475E+11	80	20	712	901
2045	143076945	105000	55500	184	26970178154	785132798.9	26185045355	1.28185E+11	80	20	713	896
2050	151214608	110000	55500	193	27706205176	810733455.4	26895471721	1.33895E+11	80	20	708	886

(Source: Author Calculation).

5.1.1.2 Comment about above Results.

Table (9) shows The total amount of water required ($10^9 m^3$) for food consumption (kg/capita/yr) and the remaining amount of water (10^9 m^3), if the irrigation of crops for the food consumption of all Egypt's quota of the River Nile water is 55.5×10^9 m3. It can also be seen that the total area required for self-sufficiency of cultivated crops is 3.5×10^6 ha, which is equal to 8.5×10^6 Feddans.

Table (9). Annual Total Water Demand and Area required for Food Consumption.

Year	*Population*	*Total Amount of Water Required(10^9 m^3)*	*Remaining Amount of water (10^9 m^3)*	*Total Area Required (10^6 ha)*	*Additional cultivated Area Needed to Cover the Requirements (10^6 ha)*
1991	55210277	38.7	16.8	5.2	1.7
1992	56258434	39.4	16.1	5.3	1.8
1993	57382040	40.2	15.3	5.4	1.9
1994	57800000	40.5	15	5.5	2
1995	58400000	40.9	14.6	5.5	2
1996	59313000	41.6	13.9	5.6	2.1
1997	59441000	41.7	13.8	5.6	2.1
1998	60706000	42.5	13	5.7	2.2
1999	61993000	43.4	12.1	5.9	2.4
2000	63305000	44.4	11.1	6	2.5
2001	64652000	45.3	10.2	6.1	2.6
2002	65986000	46.2	9.3	6.2	2.7
2003	67313000	47.2	8.3	6.4	2.9
2004	68648000	48.1	7.4	6.5	3
2005	69997000	49	6.5	6.6	3.1
2006	71384000	50	5.5	6.7	3.2
2007	72940000	51.1	4.4	6.9	3.4
2008	74439000	52.2	3.3	7	3.5
2009	76099000	53.3	2.2	7.2	3.7
2010	77840000	54.5	1	7.3	3.8
2011	79618000	55.8	-0.3	7.5	4
2012	81567000	57.1	-1.6	7.7	4.2
2013	83667000	58.6	-3.1	7.9	4.4

2014	85783000	60.1	-4.6	8.1	4.6
2015	87963000	61.6	-6.1	8.3	4.8
2016	90086000	63.1	-7.6	8.5	5
2020	100000000	70	-14.5	9.4	5.9
2025	110526293	77.4	-21.9	10.4	6.9
2030	118663956	83.1	-27.6	11.2	7.7
2035	126801619	88.8	-33.3	11.9	8.4
2040	134939282	94.5	-39	12.7	9.2
2045	143076945	100.2	-44.7	13.5	10
2050	151214608	100.6	-50.5	14.2	10.7

(Source: Author Cal., Ministry of Agriculture and FAO website).

It can be concluded that, Egypt's quota from the River Nile water ($55.5\times10^9 m^3$) is self-sufficient to produce crops for the food consumption up to year 2011. Meanwhile, the present cultivated land(3.5×10^6ha) is not self-sufficient to produce crops that satisfy food consumption from the year 1990 to year 2050. According to table (9).

5.1.2 Scenario (2): achieving food, Economic and water security by change the old strategy and make a combination of domestic production and food imports and Exports.

5.1.2.1Defects from Scenario no.1 Which make problem.

Table 10 show the shortage on water and lands according to the old strategy.

Year	Needs from water (109 m3)	Available water from Scenario (1) (109 m3)	Shortage in water Δw (109 m3)	Needs from lands. (106 ha)	Available lands (106 ha)	Shortage in lands ΔL (106 ha)	Decision
2050	100.6	55.5	-50.5	10.7	3.5	-7.2	Need to change strategy

(Source: Author Calculation).

Classification crops according to C.W.R and International Price According to what was presented to clarify the economic feasibility, the previously existing crops will be classified into crops with maximum water consumption, with a minimum global price, and they are imported. In addition to crops that have less water consumption and a high global price, they will be cultivated and exported, According to table 11,12

Table 11 International Prices for crops in Egypt according to (FAOSTAT), (USD/ton).

Crop	CropWat (m3 / ha)	International Price (Export=Import) (USD/ton)
Bananas 1year	14382	315
Barley	5515	335
Beans green	4445	306.1
Beans dry	4171	700
Groundnuts	7664	500
Maize	6841	225
Potatoes	3297	166.3
Rice	9560	235
Sorghum	6060	175
Soybeans	8647	371
Sugar beet	8647	39.2
Sunflower seed	6716	390
Tomatoes	4734	120
Wheat	5991	250
CABBAGE Crucifers	9905	78.5
MANGO	17263	270
MILLET	3128	-
Tobacco	4182	-

(Source: Food and Agriculture Organization of the United Nations (official website)).

Table 12. Classification of crops according to water requirements and prices

High Price	*Group (B)* *Peas, green - Beans green – Grapes – Dates-Beans-Dry-Potatoes-Tomatoes- Barley-Groundnuts.*	*Group (D)* *Coffee – Tea - Nuts - Pepper – Barley Sunflower seed -Groundnuts.*
Low Price	*Group (A)* *Grapefruit – Apples – Maize – Oranges – Lemons - Vegetables –– Watermelons - Sweet potatoes – Onions - Sugar Cane -*	*Group (C)* *Cottonseed – Oilseeds -Peas, dry - Sunflower seed – Soybeans- Spices – Olives - Beans dry – Wheat – Rice –Sorghum-Sugar beet-Bananas-Mango.-CABBAGE*
	Low Crop Water Requirements	*High Crop Water Requirements*

(Source: Author Calculation).

5.1.2.2Now, let us review the economic application of scenario No. (2) regarding importing crops that consume more water and their global price is rela

tively low, according to what is shown in Table 13.

Table 13. The feasibility of importing crops with a higher share of domestic water consumption rather than cultivating it (base year 2050)

Crops	*S.W.D (M3/t)*	*CROP YIELD (C.Y) t/ha*	*Quantity from needs (1000 ton)*	*Virtual water import 1000M3/year*	*Water saved 1000M3/yr.*	*Land saved 1000(ha)*	*Foot print 1000(M3)*	*Cash out (1000$) USD*
Rice	*1091*	*8.76*	*6750*	*7364250*	*7364250*	*771*	*77364250*	*1329750*
Mango	*1762*	*9.8*	*2250*	*3964500*	*3964500*	*230*	*73964500*	*443250*
Bananas	*384*	*37.5*	*1800*	*691200*	*691200*	*48*	*70691200*	*354600*
Soybeans	*3326*	*2.6*	*3750*	*12472500*	*12472500*	*1443*	*67972500*	*738750*
Sorghum	*1045*	*5.8*	*1800*	*1881000*	*1881000*	*311*	*57381000*	*354600*
Sugar beet	*183*	*47.4*	*5250*	*960750*	*960750*	*111*	*56460750*	*1034250*
CABBAGE	*340*	*29.2*	*2250*	*765000*	*765000*	*78*	*56265000*	*443250*
Cottonseed	*4811*	*2.4*	*750*	*3608250*	*3608250*	*313*	*59108250*	*147750*
Wheat	*951*	*6.3*	*32250*	*30669750*	*30669750*	*5120*	*86169750*	*6353250*
SUM.	-	-	-	*62377200*	*62377200*	*8425*	*605377200*	*11199450*

(source: Author Calculation).

5.1.4.4 Likewise, the feasibility of cultivating and exporting crops with local consumption of little water and their global price is very high is explained, which benefits Egypt.

Table 14 shows the crops that were locally grown and exported and the interest yielded**.**

Crops	*S.W.D (M3/t)*	*CROP YIELD (C.Y) t/ha*	*Quantity from production (1000 ton)*	*Virtual water Export 1000M3/year*	*Water loss 1000M3/yr*	*Land losses 1000(ha)*	*Cash IN (1000 $) USD*
Beans dry	*1605*	*2.6*	*1950*	*3129750*	*3129750*	*750*	*1365000*
Beans green	*356*	*12.5*	*9375*	*3337500*	*3337500*	*750*	*2869687.5*
Potatoes	*155*	*21.5*	*16125*	*2499375*	*2499375*	*750*	*2676750*
Tomatoes	*130*	*36.9*	*27675*	*3597750*	*3597750*	*750*	*3321000*
Barley	*2626*	*2.1*	*1575*	*4135950*	*4135950*	*750*	*559125*
Groundnuts	*2190*	*3.5*	*2625*	*5748750*	*5748750*	*750*	*1312500*
Grapes	*533*	*19.2*	*14400*	*7675200*	*7675200*	*750*	*3600000*
Maize	*770*	*8.9*	*6675*	*5139750*	*5139750*	*750*	*1501875*
.SUM				*35264025*		*6000*	*17205937.5*

(source: Author Calculation).

Commenting on the results of scenario (2), which is a guiding model and subject to change and amendment according to the needs of the country or decision makers, From the previous data, numbers and comparisons revealed using other alternatives affecting the Egyptian agricultural map, we found the following: when importing(9)crops are only voracious for water consumption out of (18) crops from scenario (1) as well as cultivation and export (8) crops with fair consumption of water and their competitive price is high and after making calculations for each case it shows the following: 1- Egypt's water footprint from importing those crops increased to 140 billion cubic meters at 2050 instead of 133 billion cubic meters from scenario (1), although the number of crops of scenario (2) is half of the number of crops of scenario (1), which confirms the success of the study.2- The value of the water footprint per person increased from 886 liters / person / year to 927 liters / person / year, with an increase of 5%, while preserving the number of crops used. 3- The net financial return after deduction of imports was estimated at about six billion dollars, equivalent to about 90 million Egyptian pounds. **From the above and according to the fig. (10) we conclude that changing the policy followed and searching for other alternatives is very suitable for Egypt's water conditions.**

Table 15Real gains from applying Scenario (2).

Value From Scen. (2)	Available water from resource (10^6m3)	Virtual water import (10^6m3)	Virtual water Export (10^6m3)	Water save(Net) (10^6m3)	Water footprint (10^6m3)	Water footprint /cap M3/cap/yr	Cash Save (10^6$) USD
2050	76000	63000	35000	28000	139000	927	6033

(source: Author Calculation).

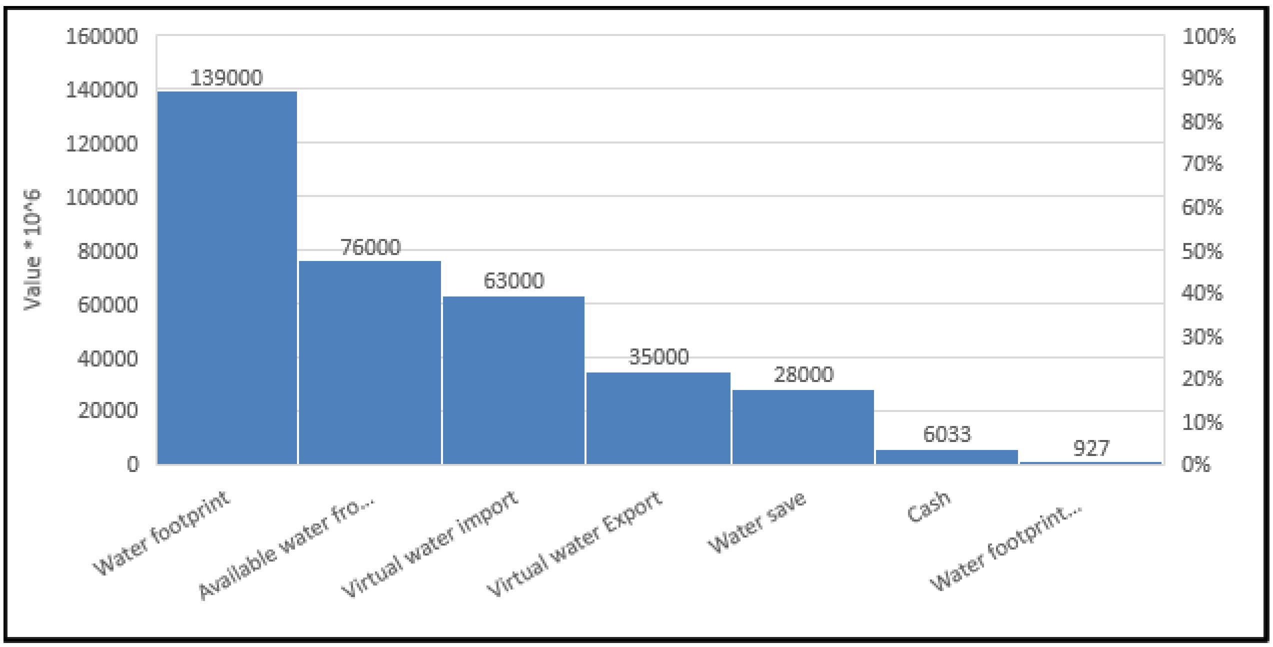


Figure (8)

Figure8 It represents the best economic benefits and feasibility resulting from applying the principle of virtual water trade as a viable and strong alternative to relieve pressure on available water resources according to the scenarios described in the theoretical explanation to prove the research argument to achieve the normal water policy in 2050 in Egypt.

Source: Author Analysis and table 14).

6. Conclusion

Understanding the concept and strategy of virtual water trade is important for countries to develop enlightened policies to improve water efficiency at various levels. The concept of virtual water is still needed as a political option in Egypt for large-scale investigations, research and feasibility assessments, virtual water can be considered an alternative source of water. Governments can use virtual imports of water as a way to reduce pressure on their domestic water resources, and there is a need to understand Egypt's water-efficiency agricultural policies to improve the use of irrigation water to increase crop yields.

Arab and regional countries in the Middle East and North Africa should plan to increase the exchange of crops and to import virtual water. Each country should focus on crops with low water needs, increase the water footprint and increase the amount of crops for domestic consumption by importing high-water crops and lowering their global price. This would help to improve trade balance and create new jobs because importing virtual water from foreign countries is a grave danger, if virtual water trade cannot be used within the region's own countries, and then it would be better to choose independence from water rather than self-sufficiency. The program implemented for this study helps to identify actual water needs for different agricultural crops.

As has been recommended in advance, the participation of politicians and decision makers is required so that the correct scientific approach to virtual water theory can be developed in a systematic and scientific manner that will allow the concept of virtual water to be applied at the national and global levels. Water policy can be summarized as the process of enrolling a constitution that will deal with the conscious and effective use of internal and external water resources in order to reduce water scarcity in Arab regions. There is no doubt that there is a need to balance both supply and demand aspects of water management policy. The main argument is that a virtual water strategy must be an integral part of the whole integrated water resources management framework. Today, as a result of the shortage of fresh water and the ever-increasing water needs of the Arab countries, which are poor, underwater, scarce and even scarce, the problem in these countries is that it is not a problem of affordability in the implementation of the virtual water policy, but a problem of priority and independence in terms of food security. It is therefore necessary before this new concept can be applied as a political option in the Arab world that, there is a need for more researches and understanding of the local social, economic and environmental impacts. From the previous analysis, it is important to point out several points:

1. For countries to have a more transparent picture of the comparative advantage of the concept of virtual water policy as a competitive advantage, the concept of using food imports as a complementary factor in the national food security formula should not be opposed because the concept of virtual water is justified. Food imports must therefore continue, as well as compensation for the shortage of water resources in the Arab region.

2. For sources that call into question the fundamental, economic, social and cultural dimensions of the virtual water trade, planners must address and identify those sources, including by emphasizing that cultural and behavioral changes are necessary to adapt to the current state of water scarcity and to enable regional integration before presenting the idea as a political option, but that the cultural mix will benefit the international community.

Through current research, Egypt can make use of large amounts of water in its imported waters rather than exporting water to agricultural goods; Egypt imports large quantities of water through food commodities as long as 85% of imported water is for grain goods. Egypt's agricultural sector must substantially modify water use to achieve significant water savings, save water for food security, and the path of environmental sustainability.

In conclusion, it can be said that the concept of actual water, together with the water footprint, links a wide range of sectors and issues, providing an appropriate framework to better support water management. Therefore, the virtual water approach to water footprint must be implemented through the development of Egypt's future water policies. But in-depth calculations must be made at the state level, including the use of water at home and in industry, to develop long-term water policies in Egypt. Furthermore, the availability of land for producing the required food security production should be considered under different scenarios.

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