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The Economic Efficiency 0f Water Irrigation Usage and Restructuring Cultivation of Agricultural Crops

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Abstract: Utilizing and the allocation of irrigation water resources is considered crucial for Egyptian agriculture given the country's limited water resources, and the low efficiency of use due to the high losses resulting from surface and flood irrigation systems, in addition to the wasteful use of irrigation water. The research mainly aimed to reallocate the cultivation of agricultural crops on the basis of raising the efficiency of irrigation water resources' use through rationalizing water consumption as a highly important resource that should be carefully used. The research relied on some descriptive statistical methods, in addition to estimating some relevant economic indicators like cost per water unit, net revenue per water unit, water application rate per ton, cost of water application rate per ton, and net return on water application rate per ton. Main results obtained from applying minimum cost and maximum net revenue per water unit revealed that adopting the proposed cropping patterns shall lead to raising production of all the study crops, which in turn will lead to reducing imports of various agricultural crops, thus deficit in the balance of payments and the national dept. Finding also revealed that applying minimum cost and maximum revenue per water unit resulted in increased quantities of various agricultural crops and higher percents of decline in Egyptian imports, where declines increased by 51.59% and 49.78%, respectively. As a result, the research highly recommended adopting the proposed cropping patterns using minimum cost per water unit given the positive impacts it demonstrated on crop production and imports volume compared to the results obtained from using maximum net return per water unit.
Key words:- Economic Efficiency - Irrigation Water - Restructuring Cultivation - AgriculturalCrops.

Introduction

Agriculture occupies a distinguished position in Egypt's economy. The importance of land and water resources stems from the fact that both represent the basic elements for any agricultural activity. It is worth mentioning that Egypt's dependency rate on water from the Nile Rivers amounts to 97%. Unfortunately, while total rainfall on Egypt amounts to 51 billion m^3 per annum, most of which falls during the fall and winter seasons, only 1.6 billion cubic meters is benefited from [1]. In 1959, Egypt and Sudan signed the Nile Waters Treaty, by virtue of which 55.5 billion m^3 is Egypt's annual share of the Nile water.

Generally speaking, Egypt depends on four main groundwater aquifers; these are the Nile Valley Aquifer; the Nubian Sandstone Aquifer; Moghra Aquifer (west of the Cairo-Alexandria Desert road and covers a vast area of the Western Desert between the Nile Delta and the Qattara Depression); and the Coastal Aquifer.

The Nile Valley, Moghra, and the Coastal Aquifers are renewable groundwater resources, whereas the Nubian Sandstone Aquifer, which contains about 150000 billion m^3 of freshwater, i.e., about 3000 times the annual flow of the Nile, is a non-renewable resource. Non-traditional water resources in Egypt include agricultural drainage water, desalination of sea water, desalination of brackish water, and reuse of municipal drainage water [2]. Since scarcity of water resources is a difficult problem, maximizing the benefit of available water resources is vital to maximize benefits to the society. Optimum cropping pattern is considered the mean to achieving compatibility between several goals in one time in order to reach the most efficient cropping pattern and rationalize the use of available water resources under a set of production constraints, with the final aim of increasing farmer's income and saving the largest possible amount of irrigation water, which can be benefited from in horizontal expansions.

Research Problem

Utilizing and the allocation of irrigation water resources is considered crucial for Egyptian agriculture given the limited resources of water, and the low efficiency of water use due to the high losses resulting from surface and flood irrigation systems, in addition to the wasteful use of irrigation water. Therefore, the current research investigates the problem of the weak efficiency in using irrigation water and the noticeable increase in water losses, which both lead to negative impacts on the agricultural sector in specific, and the national economy as a whole.

Research Objective

The research mainly aims to reallocate the cultivation of agricultural crops on the basis of raising the efficiency of using irrigation water resources through rationalizing its consumption as a highly important resource that should be carefully used. In order to achieve such objective, the research focused on studying a set of economic indicators, the most important of which is the net revenue to water unit, and net return per LE invested in irrigation cost.

Methodology and Sources of Data

To achieve its objectives, the research extracted data from the electronic Websites of the Central Agency for Public Mobilization and Statistics (CAPMAS), the United Nations, Food and Agriculture Organization of the United Nations, in addition to the annual statistical bulletins published by the Ministry of Agriculture and Land Reclamation, and some other studies and websites relevant to the study subject. As regards the methodology, the research applied some descriptive statistical methods, in addition to estimating some relevant economic indicators like cost per water unit, net revenue per water unit, water application rate per ton, cost of water application rate per ton, and net return on water application rate per ton.

Cost per Water Unit = Total Cost per Feddan/Water Application Rate per Feddan[3]
Net Revenue on Water Unit = Net Revenue per Feddan/Water Application Rate per Feddan[4]
Water Application Rate per Ton = Water Application Rate per Feddan/Yield Feddan[5]
Cost of Water Application Rate per Ton = Cost per Water Unit * Water Application Rate per Ton[3]
Net Revenue on Water Application Rate per Ton = Net Revenue on Water Unit * Water Application Rate per Ton[6]

Results and Discussion

First: Reallocation of Winter and Summer Crops over Various Governorates

The following reallocation of winter and summer crops is based on some of the estimated economic efficiency indicators for irrigation water; these are minimum cost per unit of irrigation water/ton and maximum net revenue per unit of irrigation water/ton. Governorates producing the study crops have been ranked in ascending order according to minimum cost per unit of irrigation water, and ranked in descending order according to maximum net revenue per unit of irrigation water, as shown in Table (1).

Table (1): Allocation of Winter Crops' Cultivations according to Minimum Cost and Maximum Revenue per Unit of Irrigation Water/ton

Crop	*Minimum Cost per Unit of Irrigation Water/ton*		*Maximum Net Return per Unit of Irrigation Water/ton*	
Wheat	***Governorate***	***Cost (LE)***	***Governorate***	***Revenue (LE)***
	Aswan	1393	Aswan	1800
	Menia	1447	Qena	1713
	Dakahlia	1560	Damietta	1680
	Damietta	1560	Menia	1633
	Behera	1607	Dakahlia	1567
Barley	Behera	1825	Behera	2183
	Sharkia	2092	Sharkia	2067
	Port Said	2100	Aswan	2058
	Aswan	2117	Giza	1983
	Giza	2208	Alexandria	1917
Broad Beans	Dakahlia	678	Aswan	2865
	Sharkia	813	Alexandria	2535
	Damietta	832	Dakahlia	2529
	Alexandria	865	Behera	2290
	Behera	871	Sharkia	2168
Lentils	Sharkia	3894	Sharkia	4131
	Assiut	4750	Assiut	3388
Chickpeas	Menia	3720	Assiut	1340
	Assiut	5220	Menia	846
Lupines	Ismailia	4060	Ismailia	2040
	Sharkia	5007	Sharkia	1153
Fenugreek	Sohag	2239	Sohag	2639
	Qena	2516	Qena	2529
	Assiut	2858	BeniSuef	2110
	Ismailia	2968	Ismailia	2058
	BeniSuef	3032	Assiut	2052
Sugar beet	Assiut	136	Damietta	326
	Dakahlia	155	Assiut	270
	Menia	171	Menia	245
	Gharbia	187	Sharkia	228
	BeniSuef	189	Fayoum	228
Flax	Kafr-El Sheikh	6418	Dakahlia	7197
	Dakahlia	7197	Kafr-El Sheikh	5926
	Gharbia	7557	Sharkia	5025
	Sharkia	9918	Behera	4098
	Damietta	9926	Gharbia	3975
Onions	Behera	198	Aswan	751
	Gharbia	199	Behera	685
	Aswan	202	Gharbia	666
	Assiut	220	Assiut	654
	Dakahlia	235	Dakahlia	637
Garlic	Sohag	269	Aswan	1237
	Aswan	316	Assiut	1168
	Assiut	377	Sohag	1164
	Qena	467	Qena	1092
	Giza	533	Giza	1010
Tomatoes	Sohag	172	Qena	2211
	Ismailia	207	BeniSuef	1327
	Menofia	249	Sohag	1307
	Qena	251	Ismailia	1259
	Assiut	258	Menofia	1251

Source: Calculated based on Data Collected from:

- Bulletins of Agricultural Economics, issued by the Economic Affairs Sector, Ministry of Agriculture and Land Reclamation [7]
- The Central Agency for Public mobilization and Statistics[8]
- Ministry of Irrigation and Water Resources, Annual Bulletin of Irrigation and Water Resources Statistics, 2012[9]

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It is clear from Table (1) that a number of Governorates are distinguished in terms of crop production under both minimum cost and maximum revenue per unit of irrigation water. For winter crops, Aswan came on top of the such Governorates, with wheat production cost estimated at LE 1393/ton and net revenue estimated at LE 1800/ton; followed by Behera, with barley production cost estimated at LE 1825/ton and net revenue estimated at LE 2183/ton; Sharkia, with lentils production cost estimated at LE 3894/ton and net revenue estimated at LE 4131/ton; Ismailia, with lupine production cost estimated at LE 4060/ton and net revenue estimated at LE 2040/ton; and finally Sohag, with fenugreek production cost estimated at LE 2239/ton and net revenue estimated at LE 2639/ton.

As for summer crops, Dakahlia came on top of the distinguished Governorates, with rice production cost estimated at LE 1069/ton and net revenue estimated at LE 1801/ton, and corn production cost estimated at LE 1013/ton and net revenue estimated at LE 1452/ton. Aswan followed with sorghum production cost estimated at LE 1091/ton and net revenue estimated at LE 1623/ton. Giza ranked third with sesame production cost estimated at LE 3862/ton and net revenue estimated at LE 8085/ton, and potato production cost estimated at LE 507/ton and net revenue estimated at LE 684/ton, as shown in Table (2).

Table (2): Allocation of Summer Crops' Cultivations according to Minimum Cost and Maximum Revenue per Unit of Irrigation Water/ton

Crop	Minimum Cost per Unit of Irrigation Water/ton		Maximum Net Return per Unit of Irrigation Water/ton	
	Governorate	Cost (LE)	Governorate	Revenue (LE)
Rice	Dakahlia	1069	Dakahlia	1081
	Behera	1162	Behera	995
	Damietta	1247	Damietta	940
	Alexandria	1307	Alexandria	898
	Port Said	1314	Sharkia	880
Corn	Dakahlia	1013	Dakahlia	1452
	Behera	1161	Behera	1207
	Damietta	1249	Damietta	1195
	Menia	1249	Menia	1029
	Fayoum	1304	Fayoum	926
Sorghum	Aswan	1091	Aswan	1623
	Sohag	1136	Menia	1259
	Menia	1215	Sohag	1243
	Giza	1440	Qena	1102
	Qena	1491	Giza	1077
Soybeans	Assiut	1747	Menia	2475
	Menia	2102	Assiut	1563
	BeniSuef	3227	BeniSuef	1468
Peanuts	Sohag	2127	Behera	6361
	Giza	2409	Sohag	6286
	Behera	2498	BeniSuef	6211
	Ismailia	2569	Giza	5834
	Menia	2611	Ismailia	5626
Sesame	Giza	3862	Giza	8085
	Qena	4261	Qena	7631
	Menia	4364	Menia	7512
	Aswan	4881	Sohag	7468
	Sohag	5061	Aswan	7342
Sunflower	Giza	1257	Assiut	3105
	Alexandria	1377	Giza	2587
	Sohag	1724	BeniSuef	1898
	BeniSuef	2038	Behera	1876
	Menia	2280	Sohag	1843
Cotton	Assiut	4276	Behera	5223
	Dakahlia	4717	Sharkia	5016
	Port Said	5368	Ismailia	4771
	Gharbia	5398	Gharbia	4757
	Fayoum	5498	Menofia	4373
Tomatoes	Ismailia	245	Behera	1250
	Giza	248	BeniSuef	1242
	Sohag	248	Menia	1231

	Gharbia	256	Ismailia	1230
	Qena	272	Qena	1218
Eggplants	Menofia	241	Menia	570
	Assiut	248	Menofia	553
	Kafr-El Sheikh	412	Kafr-El Sheikh	501
	Luxor	424	Ismailia	476
	Menia	432	Behera	426
Squash	Sharkia	451	Alexandria	869
	Qalyoubia	595	Qalyoubia	812
	Giza	641	Behera	791
	Behera	718	Giza	770
	Alexandria	767	Sharkia	709
Okra	Aswan	658	Sharkia	2431
	Giza	682	Aswan	2262
	Assiut	970	Giza	2196
	Sharkia	987	Assiut	1933
	Behera	1014	Behera	1734
Cucumber	Menia	389	Assiut	1056
	Sohag	430	Menofia	1054
	Menofia	438	Menia	893
	Behera	494	Ismailia	729
	Kafr-El Sheikh	580	Kafr-El Sheikh	716
Watermelon	Dakahlia	285	Behera	690
	Ismailia	315	Dakahlia	605
	Alexandria	316	Alexandria	568
	Behera	323	Aswan	566
	Sharkia	334	Fayoum	550
Potatoes	Giza	507	Giza	684
	Ismailia	635	Ismailia	560
	Damietta	731	Damietta	490
	BeniSuef	761	BeniSuef	479
	Assiut	775	Assiut	425

Source: Calculated based on Data Collected from:

- Bulletins of Agricultural Economics, issued by the Economic Affairs Sector, Ministry of Agriculture and Land Reclamation [7]
- Ministry of Irrigation and Water Resources, Annual Bulletin of Irrigation and Water Resources Statistics, 2012 [9]

Second: Proposed Cropping Pattern

Implementing the proposed cropping patterns requires specialization in crop production for different regions based on comparative advantage in the production of such crops, reflected in the form of low cost per unit of irrigation water per ton, in addition to those regions that are distinguished in yielding higher net revenues per unit of irrigation water per ton. Tables (3) and (4), which present the proposed winter and summer cropping patterns, indicate that the areas specialized in the production of wheat, barley, broad beans, onions, flax, sugar beet, garlic, fenugreek and chickpeas in Lower Egypt include Alexandria, Behera, Kafr El-Sheikh, Gharbia, Dakahlia, Sharkia, Port Said, Ismailia, Damietta and Menofia; whereas areas specialized in the production of wheat, barley, broad beans, onions, flax, sugar beet, garlic, fenugreek, and chickpeas in Lower Egypt include Alexandria, Behera, Kafr El-Sheikh, Gharbia, Dakahlia, Sharkia, Port Said, Ismailia, Damietta, and Menofia; and finally, areas specialized in the production of wheat, sugar beet, lentils, chickpeas, fenugreek, garlic, onions, and tomatoes in Upper Egypt include Assiut, Qena, Sohag and Aswan.

Table (3): Proposed Cropping Pattern for Winter Crops According to Minimum Cost per Unit of Irrigation Water/ton

Governorate	Main Crops
Alexandria	Faba Beans
Behera	Wheat - Barley – Faba beans - Onions
Kafr-El Sheikh	Flax
Gharbia	Sugar beet - Flax - Onions
Dakahlia	Wheat - Faba beans - Sugar beet - Flax - Onions
Sharkia	Barley - Faba bean - Flax - Lentils - Thermos
Port Said	Barley
Ismailia	Fenugreek - Lupines - Tomatoes
Damietta	Wheat - Faba bean - Flax
Menofia	Tomatoes
Giza	Barley - Garlic
BeniSuef	Fenugreek - Sugar beet
Menia	Wheat - Sugar beet - Chickpeas
Assiut	Fenugreek - Sugar beet - Lentils - Chickpeas - Onions - Garlic - Tomatoes
Qena	Fenugreek - Garlic - Tomatoes
Sohag	Fenugreek - Garlic - Tomatoes
Aswan	Wheat - Barley - Onions - Garlic

Source: Table (1)

Table (4): Proposed Cropping Pattern for Winter Crops According to Maximum Revenue per Unit of Irrigation Water/ton

Governorate	Main Crops
Alexandria	Barley - Faba bean
Behera	Faba bean - Flax - Onions - Barley
Kafr-El Sheikh	Flax
Gharbia	Flax - Onions
Dakahlia	Wheat - Faba bean - Flax - Onions
Sharkia	Faba bean - Beet sugar - Flax - Lentils - Lupine
Ismailia	Fenugreek - Lupine - Tomatoes
Damietta	Wheat - Sugar beet
Menofia	Tomatoes
Giza	Barley - Garlic
Fayoum	Sugar beet
BeniSuef	Fenugreek - Tomatoes
Menia	Wheat - Sugar beet - Chickpeas
Assiut	Fenugreek - Lentils - Lupine - Sugar beet - Onions - Garlic
Qena	Wheat - Fenugreek - Garlic - Tomatoes
Sohag	Fenugreek - Garlic - Tomatoes
Aswan	Wheat - Barley - Faba bean - Onions - Garlic

Source: Table (1)

Tables (5) and (6), which present the proposed summer cropping patterns, indicate that the areas specialized in the production of rice, corn, cotton, peanuts, sunflower, potatoes, tomatoes and other vegetable crops like squash, okra, cucumber and eggplants in Lower Egypt include Dakahlia, Behera, Damietta, Alexandria, Port Said, Gharbia, Menofia, Kafr El-Sheikh, Ismailia, Sharkia, and Qalyoubia; whereas areas specialized in the production of peanuts, sesame, sunflower, soybeans, sorghum, tomatoes, potatoes, cucumber and eggplants in Middle Egypt include Giza, BeniSuef and Menia; and finally, areas specialized in the

production of sorghum, sesame, peanuts, sunflower, soybeans, cotton, potatoes, tomatoes, okra and cucumber in Upper Egypt include Assiut, Qena, Sohag and Aswan.

Table (5): Proposed Cropping Pattern for Summer Crops According to Minimum Cost per Unit of Irrigation Water/ton

Governorate	**Main Crops**							
Dakahlia	Rice		Cotton	Watermelon				
Behera	Rice	Corn	Peanuts	Squash	Okra	Cucumber	Watermelon	
Damietta	Rice	Corn	Potatoes					
Alexandria	Rice	Sunflower	Squash	Watermelon				
Port Said	Rice	Cotton						
Menia	Corn	Sorghum	Soybeans	Peanuts	Sesame	Sunflower	Eggplant	Cucumber
Fayoum	Corn	Cotton						
Aswan	Sorghum	Sesame	Okra					
Sohag	Sorghum	Peanuts	Sesame	Sunflower	Tomatoes	Cucumber		
Giza	Sorghum	Peanuts	Sesame	Sunflower	Tomatoes	Squash	Okra	Potatoes
Qena	Sorghum	الSesame	Tomatoes					
Assiut	Soybeans	Cotton	Eggplant	Okra				Potatoes
BeniSuef	Soybeans	Sunflower						Potatoes
Ismailia	Peanuts	Tomatoes	Watermelon					Potatoes
Gharbia	Tomatoes	Cotton						
Menofia	Eggplant	Cucumber						
Kafr-El Sheikh	Eggplant	Cucumber						
Luxor	Eggplant							
Sharkia	Squash	Okra						
Qalyoubia	Squash							

Source: Table (2)

Table (6): Proposed Cropping Pattern for Summer Crops According to Maximum Revenue per Unit of Irrigation Water/ton

Governorate	**Main Crops**										
Dakahlia	Rice	Corn	Watermelon								
Behera	Rice	Corn	Peanuts	Cotton		Tomatoes	Squash	Watermelon	Sunflower	Okra	Eggplant
Damietta	Rice	Corn	Potatoes								
Aswan	Sorghum	Okra	Watermelon	Sesame							
Menia	Sorghum	Soybeans	Sesame	Tomatoes	Eggplant	Cucumber					
Sohag	Sorghum	Peanuts	Sesame	Sunflower							
Assiut	Soybeans	Sunflower	Okra	Potatoes	Cucumber						
BeniSuef	Soybeans	Peanuts	Sunflower	Tomatoes	Potatoes						
Giza	Sunflower	lSesame	Okra	Peanuts	Squash	Sorghum	Potatoes				
Qena	Sesame	Sorghum	Tomatoes								
Sharkia	Cotton	Okra	Rice	Squash							
Ismailia	Cotton	Tomatoes	Cucumber	Corn	Peanuts	Eggplant	Potatoes				
Menofia	Eggplant	Cucumber	Cotton								
Qalyoubia	Squash										
Alexandria	Watermelon	Rice	Corn	Squash							
Gharbia	Cotton										
Kafr-El Sheikh	Eggplant	Cucumber									
Fayoum	Watermelon										

Source: Table (2)

Third: Economic Impacts Resulting from the Proposed Cropping Pattern

- Impact on Production

The proposed cropping pattern is expected to result in raising the produced quantities of different crops. Such increases have been calculated by estimating the cropped area for each Governorate and the area under each of the study crops. Total area of crops produced under each cropping pattern was then subtracted from the total cropped area, after which percentage increase in planted area has been estimated on the basis of percent imported of each crop. Figures in Table (7) indicate that increases in the produced quantities of winter crops, namely Wheat, Barley, Faba beans, Chickpeas, Fenugreek, Lentils, Lupine, Sugar beet and Flax reached 1.5,0.012,0.104,0.002,0.006,0.009,0.003,0.306 and0.147million tons, respectively, based on minimum cost per unit of irrigation water; whilst reached0.901,0.009,0.127,0.002,0.005,0.008,0.003,0.243 and0.188 million tons, respectively, based on maximum revenue per unit of irrigation water.

On the other hand, increases in production quantities of summer crops, namely Corn,Sorghum,Peanuts,Soybeans Oil,Sunflower OilandSesame Oil, reached 2.2, 0.012,0.090,0.102 and0.211million tons, and about 0.002 thousand tons,respectively, based on minimum cost per unit of irrigation water; whilst reached2.5,0.015,0.099,0.110,0.242 and0.005million tons, respectively, based on maximum revenue per unit of irrigation water, as shown in Table (7).

Table (7): Percentage Decline in Imported Quantities of Main Crops Due to Applying the Proposed Cropping Pattern based on Minimum Cost and Maximum Revenue per Unit of Irrigation Water

Crop		Increases in Production Quantities (1000 tons)		Imports (1000 tons)	Percent Decline in Imports	
		Minimum Cost/Unit of Irrigation Water	Max. Revenue/Unit of Irrigation Water		Minimum Cost/Unit of Irrigation Water	Max. Revenue/Unit of Irrigation Water
Winter	Wheat	1465.14	900.60	3392.31	43.2	26.5
	Barley	11.77	8.99	13.36	88.1	67.3
	Bean	103.70	127.14	237.26	43.7	53.6
	Chickpeas	1.79	1.85	18.37	9.7	10.1
	Fenugreek	5.62	5.42	24.00	23.4	22.6
	Lentils	8.81	8.45	66.68	13.2	12.7
	Lupine	2.78	2.62	20.00	13.9	13.1
	Sugar	305.83	242.89	641.1	47.7	37.9
	Flax	147.05	187.87	784.00	18.6	23.9
Summer	Corn	2203.04	2456.25	3082.00	28.5	20.3
	Sorghum	12.26	14.99	46.3	73.5	58.43
	Peanuts*	89.75	98.9	6.89	-	-
	Soybeans Oil	102.47	110.25	182.88	43.9	39.71
	Sunflower Oil	210.54	241.62	538.12	60.9	55.09
	Sesame Oil	0.0022	0.0048	0.04	94.5	88.00

Source: Calculated based on Data Collected from:

- Bulletins of Agricultural Economics issued by the Economic Affairs Sector, Ministry of Agriculture and Land Reclamation[7]
- www.fao.org[10]
- The Central Agency for Public mobilization and Statistics, Annual Bulletin of Statistics, 2014 [8]

* Peanuts' Shell represents 33% of the produced quantity [11]

- Impact on Imports

The proposed cropping patterns are expected to reduce imported quantities of Wheat, Barley, Beans, Chickpeas, Fenugreek, Lentils, Lupine, Sugar, Flax, Corn, Sorghum, Soybeans Oil, Sunflower Oil and Sesame Oil by 43.2%,88.1%,43.7%,9.7%,23.4%,13.2%,13.9%,47.7%,18.6%,28.5%,73.5%,43.9%,60.9% and94.5%, respectively, based on minimum cost per unit of irrigation water; and by 26.5%,67.3%,53.6%,10.1%,22.6%,12.7%,13.1%,37.9%,23.9%,20.3%,58.43%,39.71%,55.09% and88%, respectively, based on maximum revenue per unit of irrigation water.

Findings also revealed that the proposed cropping patterns shall contribute to transforming Egypt from importing to exporting pealed peanuts, with a quantity estimated at 53.24 thousand tons based on minimum cost

per unit of irrigation water, and 59.37 thousand tons based on maximum revenue per unit of irrigation water, as shown in Table (7).

Main Results and Recommendations

Main results indicate that the proposed cropping patterns are expected to raise the produced quantities of all the study crops under both minimum cost and maximum revenue per unit of irrigation water, which will consequently lead to reducing imports of different crops, hence deficit in the balance of payments and the Country's national debt, in addition to increasing total production of peanuts to the extent that Egypt can be transformed from a peanuts importing country to a peanuts exporting country. Results also indicate increases in crop production and percentage decline in imports volume under both minimum cost and maximum revenue per unit of irrigation water, which amounted to 51.59% and 49.78%, respectively. Therefore, the research highly recommends adopting the proposed cropping patterns based on minimum cost per unit of irrigation water given the better positive impacts it demonstrated, i.e., increases in production quantities and reduced imports, in comparison to the impacts obtained from applying maximum revenue per unit of irrigation water.

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