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An Economic Study of Various Irrigation Systems Implementation Impact on Some Field Crops Production in Fayoum Governorate

Dr. Noha Ezzat Tawfiq, Dr. Yasmin Ahmed Abuseif, and Dr. Gamal Ali Abo Elela

Agricultural Economics Research Institute, Agricultural Research Center, Egypt
Nohaezzat39@yahoo.com

Abstract: The agricultural sector is considered one of the most important economic sectors that use water resources, as it consumes about 59.3 billion m3, representing about 85.1% of the total actual annual water consumption. The results showed that the transformation from traditional surface irrigation to modern irrigation techniques resulted in saving a large amount of space, as the available area per feddan reached 19% for tomato crop, 17% for maize crop, 15% for alfalfa crop, 20% for onion crop, 18% for wheat crop. According to the results of the study, it results in an increase in the agricultural area and a significant increase in the total revenue and the net return of the water unit, leading to an increase in the national agricultural income. The study recommended several recommendations, the most important of which are: Establishing policies and mechanisms by the state in order to fully transform the cultivated area for improved irrigation in order to benefit from the reduction The amount of irrigation water used and increasing the productivity of various crops, and obliging farmers to switch to modern irrigation by enacting a law and imposing penalties and fines for violators.
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Key Words: Irrigation Systems - Indicators of Economic Efficiency - Analysis Of Variance - Revenues And Costs - Net Return.

1. Introduction:

The issue of developing water resources, maximizing their utilization and rationalizing their use is one of the most important challenges facing Egypt at the present time and the social and political future of Egypt as well, considering that water is the most important pillar currently "to support development plans. With the stability of Egypt's share of the Nile water, And its limitations compared to the steady population increase and the requirements of development plans, as that average decreased to the level that introduced Egypt to what is known as the countries of the water poverty belt, which amounted to about 1000 cubic meters of water, as it necessitated changing perceptions about the importance and rationalization of water, especially as it represents the most important resource. In Egypt, the agricultural sector is considered one of the most important economic sectors that use water resources, as it consumes about 59.3 billion m3, representing about 85.1% of the total actual water consumption annually. The agricultural sector is also considered one of the most important productive sectors on which a large proportion of the population depends as a source of income. In addition to providing the foreign exchange needed to achieve the comprehensive economic and social development of the country, and to adopt an increase in agricultural production over a period of time, and in providing the largest possible amount of food and clothing. The abundance of land resources on the one hand and their suitability for agricultural use on the other hand, and improvement and maintenance of agricultural lands are of great importance due to the deterioration and loss of fertility to agricultural soils as a result of poor drainage and the practice of continuous productive processes on them. Therefore, soil improvement and maintenance is considered one of the most important National goals for the advancement of agricultural production, by rationalizing the use of irrigation water and raising the efficiency and effectiveness of drainage operations, through the implementation of covered drainage projects, which is necessary to prevent the deterioration of the properties of agricultural soil as a result of salinity or alkalinity or because of the high level of ground water resulting from excessive use of water Irrigation, which leads to poor drainage.

Problem of the study:

Egypt faces a set of water-related challenges, as the increasing population growth and the high standard of living are among the main challenges that lead to an increase in the water needs of all

sectors, and the increase in population leads to a widening of the food gap, which requires an increase in the agricultural area, and the achievement of Egyptian food security is the strategic goal of the state. Therefore, a set of water plans and programs have been developed with the aim of rationalizing irrigation water and maximizing the return from the water unit, at the forefront of those plans is to raise the efficiency of the use of water resources by developing field irrigation networks and reducing losses in irrigation water in order to increase agricultural productivity, and the governorate of Fayoum is considered one of the governorates most affected From the shortage of irrigation water due to its geographical nature and the nature of its irrigation systems, as Fayoum governorate suffers from a deficit in the water balance estimated at about 179.3 million cubic meters according to 2019 statistics, so the state rationalized irrigation water and implemented the field irrigation development project in the governorate, so the results achieved were studied. To apply modern irrigation systems, compare them with old irrigation systems, and study the economic effects of applying those systems in the governorate.

Objectives of the study:

The study aims, in general, to study the economic impact resulting from the application of different irrigation systems in Fayoum Governorate, through a set of sub-goals that are:

1- Study the effect of applying different irrigation systems on the cost and revenue items and the net return of the study crops.
2- Study the effect of applying different irrigation systems on the feddan productivity of the study crops.
3- Study the most important indicators of economic and productivity efficiency of the different irrigation systems for the study crops.

2. Methodology and data sources:

The research relied on the descriptive and quantitative method in analyzing the economic variables of the different irrigation systems in Fayoum Governorate, in addition to using some statistical methods such as One-Way Analysis of Variance. The research relied on two sources of data. The first source is the primary data of the field study that was conducted in Fayoum Governorate. During the 2019/2020 season, the second source is the published and unpublished data obtained from various authorities such as the Ministry of Agriculture and Land Reclamation and its affiliated agencies, and some specialized data sites in addition to some references and studies concerned with the research topic.

The study sample:

Due to the difficulty of conducting a comprehensive inventory of all lands applied to modern irrigation methods in Fayoum Governorate, in addition to the presence of a large number of lands that apply to these systems affiliated with agencies and companies that do not belong to the agricultural cooperatives of the Directorate of Agriculture, and the lack of sufficient data on these lands and the difficulty of conducting a questionnaire on them based on the data of the Directorate of Agriculture In Fayoum, and the Irrigation Directorate in Fayoum, an intentional phased sample was selected in its first stage in selecting the villages of Sila of the Fayoum Center, and the village of the Republic affiliated with the Tamiya Center, (due to the presence of a large number of farmers applying the modern irrigation systems in the two villages), and randomly in its second phase by selecting 100 farmers from Each village, so that the total number of the study sample reaches 200 individuals, focusing on farmers who apply different irrigation systems for different crops and make a comparison between them.

3. Results and Discussions:

Water balance for Fayoum Governorate.

The data in Table (1) showed the water balance of Fayoum Governorate according to the administrative centers during the year 2019, as it appears that the total available irrigation water for the governorate is estimated at 2733.48 million cubic meters, while the total needs of the governorate are estimated at 2912.78 million cubic meters of which This means that there is a deficit in the water balance that was estimated at 179.3 million cubic meters. In addition, the governorate's needs for water use (drinking) were estimated at 21.6 million cubic meters, and the industrial use was estimated at 1.55 million cubic meters.

Table (1): The water balance of Fayoum Governorate according to the administrative centers during the year 2019.

Governorate centers	Total availability of irrigation water		The total needs of the governorate		water balance
	Million m3 / year	%	Million m3 / year	%	Million m3 / year
Fayoum	457.28	16.72	493.18	16.93	35.9-
Tamiya	462.41	16.92	501.37	17.21	38.96-
Snores	435.85	15.94	467.22	16.04	31.37-
Etsa	478.14	17.5	512.14	17.58	34-
Yousif Al-Sideeq	407.26	14.9	421.26	14.46	14-
Upshway	492.54	18.02	517.61	17.78	25.07-
Total province	2733.48	100	2912.78	100	179.3-

Source: Ministry of Water Resources and Irrigation, General Authority for Irrigation Projects, records of levels and disposals, 2019.

Firstly: The effect of using different irrigation systems on the costs of producing a feddan, its revenues and the net return of the study crops for the 2019/2020 season in Fayoum Governorate:

1- The effect of using different irrigation systems on the items of tomato feddan production costs, revenues, and net revenue:

By studying the effect of using different irrigation systems on the items of costs of producing an acre of tomatoes for a comparison between the two irrigation methods under study, it was found that, as shown in Table (2), when using drip irrigation, the product achieves a reduction in the production costs items represented in human labor costs, irrigation costs, and nitrogen fertilizer, Phosphate fertilizer, potassium fertilizer, municipal fertilizer, seeds, and pesticides, it was estimated at about 500, 170, 450, 75, 500, 660, 400,500 pounds, respectively, it was estimated at 25%, 28.3%, 25%, 18.7%. 31.3%, 33%, 16.63%, 17.8% of the total previous cost items. The savings in the total variable costs and the total costs of the tomato crop were also 19.7% and 15% for each, respectively, while the use of the sprinkler irrigation method leads to an increase in the fixed cost value per feddan of tomatoes by about 25%. This increase is represented in an increase in the value of the feddan rent and the season's share of the cost of the sprinkler irrigation network.

Table (2): The effect of using different irrigation systems on costs and production per feddan and the net yield of tomatoes

Items Costs (pound)	Irrigation systems		The difference in cost items	
	Drip irrigation	Flood %irrigation	Drip irrigation	%Flood irrigation
Human labor	2000	1500	500	25
Irrigation	600	430	170	28,3
Nitrogen fertilizer	1800	1350	450	25
Phosphate fertilizer	400	375	75	18,7
Potassium fertilizer	450	310	500	31,3
Municipal manure	2000	1340	660	33
Seeds	2400	2000	400	16,6
Pesticides	2800	2300	500	17,8
Variable costs	12450	9515	2545	19,7
Fixed costs	4000	5000	(1000)	25
Total costs	16450	14515	2475	15
Total revenue	60750	76500	15750	25,9
Net return	44500	61958	17485	39,2

Source: The questionnaire was collected and calculated from the 2019-2020 season.

One-way analysis of variance to analyze the impact of different irrigation systems on total costs, total revenues, and net yield of tomatoes:

The data of Table (3) refer to the results of analyzing the one-way Analysis of Variance between the total costs, the total revenue, and the net yield of the tomato crop, as the results showed that there are significant differences between the total and net returns in the lands irrigated by the old irrigation system (flooding) and the lands that are irrigated. With the modern irrigation system (drip irrigation), where the calculated value of (F) reached 144,317 and 60.31, respectively, while the significant differences between the total costs were not proven in both systems.

Table (3): Analysis of variance of the total costs, total revenue, and net yield of tomatoes in the study sample for the 2019/2020 season.

		Sum of Squares	DF	Mean Square	F
Total costs	**Between Groups**	2257675.225	1	2257675.225	1.175
	Within Groups	73033189.55	38	1921926.270	
	Total	75290873.78	39		
Total revenue	**Between Groups**	2195138560	1	2195138560	144.317
	Within Groups	577998392.4	38	15210484.01	
	Total	2773136952	39		
The net return	**Between Groups**	2989994306	1	2989994306	60.316
	Within Groups	1883745499	38	49572249.97	
	Total	4873739804	39		

Source: collected and calculated from the questionnaire data.

2- The impact of using different irrigation systems on the items of production costs, revenues, and net returns of the corn crop:

By studying the impact of the used irrigation method on the items of costs of producing feddan of maize, for a comparison between the two irrigation methods under study, it was found that, as showed in Table (4), when using sprinkler irrigation, the product achieves a reduction in the production costs items represented in human labor costs, irrigation costs, and nitrogen fertilizer, Phosphate fertilizer, potassium fertilizer, municipal fertilizer, seeds, and pesticides, it was estimated at about 580, 180, 130, 90, 110, 180, 70, 180, pounds, respectively, it was estimated at 30.3%, 13.3%, 32.5. 22.5%, 18.3%, 32.1%, 11.6%, 21.6% of the total previous cost items, and the savings in the total variable costs and the total costs of the maize crop also amounted to 1160,340 pounds on It represents 24.8% and 3.5%, respectively, for each of them, respectively, while the use of the sprinkler irrigation method leads to an increase in the value of the fixed costs per feddan of maize by about 50%. This increase is represented by an increase in the value of the feddan rent and the season's share of the cost of the sprinkler irrigation network.

Table (4): The effect of using different irrigation systems on the costs and production of the feddan and the net yield of the maize crop.

Cost items (pound)	Irrigation systems		The difference in cost items	
	Flood Irrigation	Sprinkler Irrigation	Sprinkler Irrigation	Flood Irrigation %
Human labor	1920	1340	580	30,3
Irrigation	1350	1170	180	13,3
Nitrogen fertilizer	400	270	130	32,5
Phosphate fertilizer	400	310	90	22,5
Potassium fertilizer	600	490	110	18,3
Municipal manure	560	740	180	32,1
Seeds	600	530	70	11,6
Pesticides	830	650	180	21,6
Variable costs	6660	5500	1160	24,8
Fixed costs	3000	4500	(1500)	(50)
Total costs	9660	10000	340	3,5
Total revenue	15000	18000	3000	20
Net return	5340	8000	2660	33.2

Source: collected and calculated from the questionnaire data.

One-way analysis of variance to analyze the impact of different irrigation systems on total costs, total revenues, and net yield of maize:

The data of Table (5) refer to the results of the analysis of the one-way analysis of variance between the total costs, the total revenue, and the net yield of the maize crop, as the results showed that there are significant differences between the total and net returns in the lands irrigated by the old irrigation system (flooding) and the lands that are irrigated by the old irrigation system. It is narrated with the modern irrigation system (sprinkler irrigation), where the calculated value (F) reached 123.765 and 26.125 respectively, while the significant differences between the total costs in both systems were not proven.

Table (5): Analysis of variance of the total costs, total revenue, and net yield of the maize crop in the study sample for the 2019/2020 season.

		Sum of Squares	DF	Mean Square	F
Total costs	Between Groups	31696.900	1	31696.900	0.014
	Within Groups	83294889.50	38	2191970.776	
	Total	83326586.40	39		
Total revenue	Between Groups	84584997.23	1	84584997.23	123.765
	Within Groups	25970380.55	38	683431.067	
	Total	110555377.8	39		
The net return	Between Groups	87891496.23	1	87891496.23	26.125
	Within Groups	127843594.8	38	3364305.125	
	Total	215735091	39		

Source: collected and calculated from the questionnaire data.

3- The impact of using different irrigation systems on the items of onion production costs, revenues and net revenue:

By studying the impact of the used irrigation method on the items of costs of producing a feddan of onions to compare the two irrigation methods under study, it was found that, as shown in Table (6), when using drip irrigation, the product achieved a reduction in the production costs items represented by human labor costs, irrigation costs, and nitrogen fertilizer. And phosphate fertilizer, potassium fertilizer, municipal fertilizer, seeds, and pesticides, it was estimated at about 200, 260, 130, 50, 40, 170, 300 and 180 pounds, respectively, it was estimated at 9.2%, 21.6%, 28.8% 11.6%, 7.5%, 24.2%, 23.7, 17.1% of the total previous cost items. The savings in the total variable costs and the total costs of the onion crop also amounted to EGP, respectively, representing 24.8%, 3.5% While the use of the sprinkler irrigation method leads to an increase in the fixed costs per feddan of onions by 16.7%, this increase is represented by an increase in the value of the feddan rent and the season's share of the cost of the drip irrigation network.

Table (6): The effect of using different irrigation systems on the costs and production of the feddan and the net yield of the onion crop

Cost items (pound)	Irrigation systems		The difference in cost items	
	Flood Irrigation	Drip Irrigation	drip Irrigation	Flood Irrigation %
Human labor	2100	1900	200	9,2
Irrigation	1200	940	260	21,6
Nitrogen fertilizer	450	320	130	28,8
Phosphate fertilizer	430	290	50	11,6
Potassium fertilizer	530	490	40	7,5
Municipal manure	700	530	170	24,2
Seeds	1300	1000	300	23,07
Pesticides	1050	870	180	17,1
Variable costs	7760	6340	1420	18,2
Fixed costs	3340	3900	560	16,7
Total costs	11100	10240	860	7,7
Total revenue	63000	70000	7000	11,1
Net return	51900	59760	7860	15,1

Source: collected and calculated from the questionnaire data.

One-way analysis of variance to analyze the impact of different irrigation systems on total costs, total revenues, and net yield of onions:

Data of Table (7) refer to the results of the analysis of the one-way analysis of variance between the total costs, the total revenue and the net yield of the onion crop, as the results showed that there are significant differences between the total costs, the total income and the net return in the lands irrigated by the old irrigation system (flooding) and lands Which is narrated with the modern irrigation system (drip irrigation), where the calculated value of (F) was about 15,911, 262,285, and 284,760, respectively.

Table (7): Analysis of variance of the total costs, total revenue, and net yield of onions in the study sample for the 2019/2020 season.

		Sum of Squares	DF	Mean Square	F
Total costs	Between Groups	6169317.025	1	6169317.025	15.911
	Within Groups	14734211.95	38	387742.420	
	Total	20903528.98	39		
Total revenue	Between Groups	543906250	1	543906250	262.485
	Within Groups	78641500	38	2072144.73	
	Total	622647750	39		
The net return	Between Groups	665929442	1	665929442	284.760
	Within Groups	88865571.95	38	2338567. 683	
	Total	754795014	39		

Source: collected and calculated from the questionnaire data.

4- The effect of using different irrigation systems on the items of alfalfa production costs, revenues, and net revenue:

By studying the impact of the used irrigation method on the items of costs of producing an acre of alfalfa to compare the two irrigation methods under study, it was found that, as shown in Table (8), when using sprinkler irrigation, the product achieves a reduction in the production costs items represented in human labor costs, irrigation costs, and nitrogen fertilizer. And phosphate fertilizer, potassium fertilizer, municipal fertilizer, seeds, and pesticides, it was estimated at about 1200, 530, 50, 60, 60, 150,120 and 180 pounds, respectively, and it was estimated at 48%, 38.8%, 14.2%, 14, 6%, 13.9%, 25%, 24%, 25.7% of the total items of previous costs, and the savings in the total variable costs and the total costs of the alfalfa crop also reached, respectively, which represent% and% for each, respectively. The use of the sprinkler irrigation method leads to an increase in the fixed costs per feddan of alfalfa by about 22.8%. This increase is represented in an increase in the value of the feddan rent and the season's share of the cost of the drip irrigation network.

Table (8): The effect of using different irrigation systems on the costs and production of the feddan and the net yield of the alfalfa crop

Cost items (pound)	Irrigation Systems		The difference in cost items	
	Flood Irrigation	Sprinkler Irrigation	Sprinkler Irrigation	Flood Irrigation %
Human labor	2500	1300	1200	48
Irrigation	1400	870	530	37,8
Nitrogen fertilizer	350	300	50	14,2
Phosphate fertilizer	410	350	60	14,6
Potassium fertilizer	430	490	60	13,9
Municipal manure	600	450	150	25
Seeds	500	380	120	24
Pesticides	700	520	180	25,7
Variable costs	6800	4660	2140	31,4
Fixed costs	3500	4300	800	22,8
Total costs	10300	8960	1340	13
Total revenue	20000	25000	5000	25
Net return	9700	16040	6340	65,3

Source: collected and calculated from the questionnaire data.

One-way analysis of variance to analyze the impact of different irrigation systems on total costs, total revenues, and net yield of alfalfa:

The data of Table (9) refer to the results of the analysis of the one-way analysis of variance between the total costs, the total revenue and the net yield of the alfalfa crop. Which is irrigated by the modern irrigation system (sprinkler irrigation), 364,419, and 177,726, respectively. where the calculated value of (F) reached about 4.305.

Table (9): Analysis of variance of the total costs, total revenue, and net yield of alfalfa yield in the study sample 2019/2020 season.

		Sum of Squares	DF	Mean Square	F
Total costs	Between Groups	1782528.400	1	1782528.400	4.305
	Within Groups	157325152	38	414013.558	
	Total	17515043.60	39		
Total revenue	Between Groups	264453062.5	1	264453062.5	364.419
	Within Groups	27575957.00	38	725683.553	
	Total	292029037.5	39		
The net return	Between Groups	309658860.9	1	309658860.9	177.726
	Within Groups	66208900.20	38	1742339.479	
	Total	375867761.1	39		

Source: collected and calculated from the questionnaire data.

5- The impact of using different irrigation systems on the items of wheat crop production costs, revenues and net revenue:

By studying the impact of the irrigation method used on the items of costs of producing an acre of wheat to compare the two irrigation methods under study, it was found that, as shown in Table (10), when using sprinkler irrigation, the product achieves a reduction in the items of production costs represented in human labor costs, irrigation costs and nitrogen fertilizers And phosphate fertilizer, potassium fertilizer, municipal fertilizer, seeds, and pesticides, it was estimated at about 520, 160, 50, 70, 55, 105, 75 and 120 pounds, respectively, it was estimated at 21.4%, 14.5%, 14.2%. 15,5%, 12,7%, 15,4%, 11,1% and 18,6% of the total previous cost items. The savings in the total variable costs and the total costs of the wheat crop also amounted to 17%, 6.7% respectively. While the use of the sprinkler irrigation method leads to an increase in the fixed costs per acre of wheat by about one percent, this increase is represented by an increase in the value of the feddan rent and the season's share of the cost of the sprinkler irrigation network.

Table (10): The effect of using different irrigation systems on the costs and production of the feddan and the net yield of the wheat crop

Cost items (pound)	Irrigation Systems		The difference in cost items	
	Flood Irrigation	Sprinkler Irrigation	Sprinkler Irrigation	Flood Irrigation %
Human labor	2420	1900	520	21,4
Irrigation	1100	940	160	14,5
Nitrogen fertilizer	350	300	50	14,2
Phosphate fertilizer	450	380	70	15,5
Potassium fertilizer	430	375	55	12,7
Municipal manure	680	575	105	15,4
Seeds	675	600	75	11,1
Pesticides	650	530	120	18,6
Variable costs	6755	5600	1155	17
Fixed costs	3000	3500	(1500)	50
Total costs	9755	9100	655	6,7
Total revenue	12600	13300	700	5,5
Net return	2845	4200	1355	47,6

Source: collected and calculated from the questionnaire data.

One-way analysis of variance to analyze the impact of different irrigation systems on total costs, total revenues and net yield of wheat:

The data of Table (11) refer to the results of the analysis of the one-way analysis of variance between the total costs, the total revenue, and the net yield of wheat crop, as the results showed that there were no significant differences between the total costs, the total income and the net return in the lands irrigated by the old irrigation system (flooding). And the lands that are irrigated with the modern irrigation system (sprinkler irrigation), where the calculated value of (F) is about 1.372, 0.812, and 1.964, respectively.

Table (11): Analysis of variance of the total costs, total revenue, and net yield of wheat crop in the study sample for the 2019/2020 season.

		Sum of Squares	DF	Mean Square	F
Total costs	Between Groups	2649675.625	1	2649675.625	1.372
	Within Groups	73385866.75	38	1931207.020	
	Total	76035542.38	39		
Total revenue	Between Groups	351562.500	1	351562.500	0.812
	Within Groups	16446335	38	432798.289	
	Total	16797897.5	39		
The net return	Between Groups	883575.625	1	883575.625	1.964
	Within Groups	17093051.75	38	449817.151	
	Total	17976627.38	39		

Source: collected and calculated from the questionnaire data.

Secondly: The effect of using different irrigation systems on the feddan productivity and the use of irrigation water for the study crops for the 2019/2020 season in Fayoum Governorate:

Table (12) showed that when using sprinkler irrigation, the tomato production achieved a saving in productivity and the amount used for irrigation water per feddan is estimated at 5.2 tons, 1542 cubic meters, respectively. This saving represents 19.2% and 29.4% of the average productivity per feddan and used of irrigation water from tomato crops in the case of flood irrigation, which amounts to about 27 tons and 3701 cubic meters, respectively. Table (12) also showed that when using sprinkler irrigation, the maize production achieved a saving in productivity and the amount of irrigation water used per feddan is estimated at 2.3 ardab, 879 cubic meters, respectively, this saving represents 9.2%, 20% of the average productivity per feddan and used of the irrigation water from maize crop in the case of flood irrigation, which amounts to about 25 tons and 4394 cubic meters, respectively. Table (12) showed that when using drip irrigation, the onion production achieves a saving in productivity and the amount used for irrigation water per feddan is estimated at 4 tons, 1750 cubic meters, respectively. This saving represents 22.2% and 29.4% of the average productivity per feddan and the used from The irrigation water from the onion crop in the case of flood irrigation is about 18 tons and 5948 cubic meters, respectively.

Table (12) showed that when using sprinkler irrigation, the alfalfa production achieved a saving in the productivity and the quantity of irrigation water used per feddan was estimated at about 5.4 tons and 753 cubic meters, respectively. This saving represents 14.5% and 20.1% of the average productivity per feddan and the used from The irrigation water from the alfalfa crop in the case of flood irrigation is about 37 tons and 3762 cubic meters, respectively. Table (12) showed that when using sprinkler irrigation, the wheat product achieves a saving in productivity and the amount used from irrigation water per feddan is estimated at 3.6 tons, 504 cubic meters. Accordingly, this saving represents 25.5% and 20% of the average productivity per feddan and used for irrigation water from the wheat crop in the case of flood irrigation, which amounts to about 18 tons and 2517 cubic meters, respectively.

Table (12): The effect of using different irrigation systems on the feddan productivity and the use of irrigation water for the study crops for the 2019/2020 season

crop	Variables	flooding	Sprinkler /drip	saving	%
tomatoes	Productivity per faddan (tonnes)	27	32,2	5,2	19,2
	Irrigation water used (cubic meters)	5243	3701	1542	29,4
Maize	Feddan Productivity (Ardab)	25	27,3	2,3	9,2
	Irrigation water used (cubic meters)	4394	3515	879	20
Onions	Productivity per faddan (tonnes)	18	22	4	22,2
	Irrigation water used (cubic meters)	5948	4198	1750	29,4
Alfalfa	Productivity per faddan (tonnes)	37	42,4	5,4	14,5
	Irrigation water used (cubic meters)	3762	3009	357	20,1
Wheat	Feddan Productivity (Ardab)	18	22,6	3,6	25,5
	Irrigation water used (cubic meters)	2517	2013	504	20

Source: collected and calculated from the questionnaire data.

Variance analysis of the effect of different irrigation systems on the feddan yield of the study crops:

Table (13) data refer to the results of a one-way analysis of variance to analyze the impact of different irrigation systems on the feddan productivity of the study crops for the 2019/2020 agricultural season, as the results showed the presence of significant differences in feddan productivity between lands irrigated by the old irrigation system (flooding) and lands which irrigated by modern irrigation system (sprinkling or drip) for alfalfa, onions, maize, and tomatoes, where the calculated value of (F) was about 363.77, 182.40, 129.0, 136.04, respectively, at a significant level (0.01), while the significant differences were not proven for wheat yield in both systems.

Table 13): Analysis of variance in feddan productivity of study crops for the 2019/2020 season

		Sum of Squares	DF	Mean Square	F
Alfalfa	Between Groups	1050.625	1	1050.625	363.770
	Within Groups	109.750	38	2.888	
	Total	1160.375	39		
Onions	Between Groups	57.600	1	57.600	182.400
	Within Groups	12.000	38	0.316	
	Total	69.600	39		
Maize Levantine	Between Groups	129.600	1	129.600	129.00
	Within Groups	38.000	38	1.000	
	Total	167.600	39		
	Between Groups	330.625	1	330.625	136.045
	Within Groups	92.350	38	2.430	
	Total	422.975	39		
tomatoes	Between Groups	1.600	1	1.600	1.652
	Within Groups	36.800	38	0.968	
	Total	38.400	39		

Source: collected and calculated from the questionnaire data.

Thirdly: Indicators of productive and economic efficiency of the different water unit in irrigation of study crops in Fayoum Governorate:

1- The effect of the irrigation method on the most important indicators of economic efficiency and productivity of the water unit used to irrigate the tomato crop:

By measuring the impact of the irrigation method on the most important indicators of economic efficiency and productivity of the tomato crop, it became clear from Table (14) that the total costs per ton, the variable costs per ton, the net return per ton, the return of the pound from the cost of irrigation, the return of the cubic meter of the unit of water per ton, the net return of the water unit amounted to About 906, 461, 1684, 101.2, 11.5, 8.4 pounds, and the productivity of a cubic meter of the water unit reached 5.1 tons for flood irrigation, while the value of these variables amounted to 453, 297, 1936, 177, 20.6, 16 The productivity of a cubic meter of the water unit reached 7 pounds, when the drip irrigation system was followed.

Table (14): The effect of irrigation method on the most important indicators of economic efficiency and productivity of the unit of water used to irrigate the tomato crop.

Crop	Efficiency indicators	Flood irrigation	Drip irrigation
Tomatoes	Total costs per ton	609	453
	Variable costs per ton	461	297
	Net yield per ton	1684	1936
	The pound's return from the cost of irrigation	101,2	177
	Yield per cubic meter per unit of water	11,5	20.6
	Net water unit yield	8,4	16.7
	The productivity of the cubic meter of the water unit	5,1	8,6

Source: The questionnaire was collected and calculated from the 2019-2020 season.

The effect of irrigation method on the most important indicators of economic efficiency and productivity of the water unit used to irrigate the maize crop:

By measuring the effect of the irrigation method on the most important indicators of economic efficiency and productivity of the maize crop, it is clear from Table (15) that the total costs

per ton, the variable costs per ton, the net return per ton, the return of the pound from the cost of irrigation, the return of the cubic meter of the unit of water per ton, the net return of the water unit It amounted to about 386.4, 226,4, 213,6, 11.1, 5,6, 1,2, pounds, and the productivity of a cubic meter of the water unit reached 3,4 tons for flood irrigation, while the value of these variables reached 366, 201,4, 293, 3, 15,1,5, 2,2 pounds, and the productivity of a cubic meter of water unit reached 7.7 tons when using the sprinkler irrigation system.

Table (15): the effect of irrigation method on the most important indicators of economic efficiency and productivity for the water unit used to irrigate the maize crop

crop	Efficiency indicators	Flood irrigation	Drip irrigation
Tomatoes	Total costs per ton	386,4	366
	Variable costs per ton	266,4	201,4
	Net yield per ton	213,6	293,4
	The pound's return from the cost of irrigation	11,3	15,3
	Yield per cubic meter per unit of water	3,4	5,1
	Net water unit yield	1,2	2,2
	The productivity of the cubic meter of the water unit	5,6	7,7

Source: The questionnaire was collected and calculated from the 2019-2020 season.

3- The effect of irrigation method on the most important indicators of economic and productivity efficiency of the water unit used to irrigate the onion crop

By measuring the effect of the irrigation method on the most important indicators of economic efficiency and productivity of the onion crop, it became clear from Table (16) that the total costs per ton, the variable costs per ton, the net return per ton, the return of the pound from the cost of irrigation, the return per cubic meter of the unit of water per ton, the net return of the water unit amounted About 611, 431, 2883, 2, 52.2, 10.5, 8.7, 3.2 pounds, and the productivity of a cubic meter of the water unit reached 3.2 tons for flood irrigation, while the value of these variables amounted to 465, 288, 2716, 74.4, 16.6, 14.2. The productivity of a cubic meter of the water unit reached 14.2 tons when using the drip irrigation system.

Table (16): The effect of irrigation method on the most important indicators of economic efficiency and productivity for the water unit used to irrigate the onion

crop	Efficiency indicators	Flood irrigation	Drip irrigation
Onoin	Total costs per ton	611	465
	Variable costs per ton	431	288
	Net yield per ton	2883	2716
	The pound's return from the cost of irrigation	52,5	74,4
	Yield per cubic meter per unit of water	10,5	16,6
	Net water unit yield	8,7	14,2
	The productivity of the cubic meter of the water unit	3.2	5,2

Source: The questionnaire was collected and calculated from the 2019-2020 season.

4- The effect of irrigation method on the most important indicators of economic efficiency and productivity of the water unit used to irrigate the alfalfa crop:

By measuring the effect of the irrigation method on the most important indicators of economic efficiency and productivity of the alfalfa crop, it became clear from Table (17) that the total costs per ton, the variable costs per ton, the net return per ton, the return of the pound from the cost of irrigation, the return of the cubic meter of the unit of water per ton, the net return of the water unit amounted to About 515, 340, 485, 14.2, 5.3, 2.5 pounds, and the productivity of a cubic meter of the water unit reached 6.6 tons for flood irrigation, while the value of these variables amounted to 358.4, 168.4, 641.6, 28.7, 8.3, 5.3 The productivity of a cubic meter of the water unit reached 8.3 tons, when the sprinkler irrigation system was followed.

Table (17): The effect of irrigation method on the most important indicators of economic efficiency and productivity for the water unit used to irrigate the alfalfa crop

Crop	Efficiency indicators	Flood irrigation	Drip irrigation
Alfalfa	Total costs per ton	515	358,4
	Variable costs per ton	340	186,4
	Net yield per ton	485	641,6
	The pound's return from the cost of irrigation	14,2	28,7
	Yield per cubic meter per unit of water	5.3	8,3
	Net water unit yield	2.5	5,3
	The productivity of the cubic meter of the water unit	**6.6**	8,3

Source: The questionnaire was collected and calculated from the 2019-2020 season.

The effect of irrigation method on the most important indicators of economic efficiency and productivity of the water unit used to irrigate the wheat crop:

By measuring the effect of the irrigation method on the most important indicators of economic efficiency and productivity of the wheat crop, it became clear from Table (18) that the total costs per ton, the variable costs per ton, the net return per ton, the return of the pound from the cost of irrigation, the return per cubic meter of the unit of water per ton, the net return of the water unit amounted About 541, 375, 158, 11.4, 5, 1.1, pounds, and the productivity of a cubic meter of the water unit reached 7.1 tons for flood irrigation, while the value of these variables amounted to 421, 259, 194, 14,1, 6,6, 2.8 pounds The productivity of a cubic meter of a water unit was 8 pounds, and the productivity of a cubic meter was 10.7 tons, when the sprinkler irrigation system was followed.

Table (18): The effect of irrigation method on the most important indicators of economic efficiency and productivity for the unit of water used to irrigate the wheat crop

Crop	Efficiency indicators	Flood irrigation	Drip irrigation
Weat	Total costs per ton	541	421
	Variable costs per ton	375	259
	Net yield per ton	158	194
	The pound's return from the cost of irrigation	11,4	14,1
	Yield per cubic meter per unit of water	5	2,8
	Net water unit yield	1,1	6,6
	The productivity of the cubic meter of the water unit	7,1	10,7

Source: The questionnaire was collected and calculated from the 2019-2020 season.

Impact of irrigation systems on increasing the cultivated area:

The process of switching from traditional surface irrigation to modern irrigation techniques results in the provision of a large amount of space as a result of removing the canals and petun. This area can be used to increase agricultural production, whether from study crops or other agricultural crops. The available area per feddan has reached 19% for tomato crop, 17% For maize crop, 15% for alfalfa crop, 20% for onion crop, 18% for wheat crop, according to the results of the study, which leads to an increase in the agricultural area, and a significant increase in the total revenue and net return of the water unit, which leads to an increase in the national agricultural income.

Summary:

The agricultural sector is considered one of the most important economic sectors that use water resources, as it consumes about 59.3 billion m3, representing about 85.1% of the total annual water consumption, and Egypt faces a set of water-related challenges, and the Fayoum governorate is considered one of the governorates most affected by the lack of irrigation water due to its geographical nature and nature. Irrigation systems in them, as Fayoum governorate suffers from a deficit in the water balance estimated at about 179.3 million cubic meters, according to 2019 statistics, so the state rationalized irrigation water and implemented the field irrigation development project in the governorate. Therefore, the results achieved for the application of modern irrigation systems were studied and compared to the old irrigation systems and studied. The economic implications of implementing these systems in the

governorate, and the study aimed to study the effect of applying different irrigation systems on the items of costs, revenues, net yield per feddan and the most important indicators of economic and productive efficiency of the different irrigation systems for the study crops.

The study reached many results, the most important of which are:

The results of the analysis of variance between costs, revenues and the net return of the study crops showed that there are significant differences between them and the old and modern irrigation systems in alfalfa and onion crops, the absence of significant differences between them in the wheat crop, and the presence of significant differences in feddan productivity between lands irrigated by the irrigation system. Old (flooding) and lands irrigated by modern irrigation system (sprinkler or drip) for alfalfa, onion, maize, and tomato crops, where the calculated value of (F) was about 363.77, 182.40, 129.0, 136.04, respectively, at a significant level (0.01), in when the significance of the differences between the productivity of the wheat crop in both systems was not proven, the results also showed that the process of shifting from traditional surface irrigation to modern irrigation techniques entails saving a large amount of space as a result of removing the channels and petuns, and that area can be used to increase agricultural production, whether from crops The study or other agricultural crops, as the available area per acre reached 19% for tomato crop, 17% for maize crop, 15% for alfalfa crop, 20% for onion crop, 18% for wheat crop, according to the results of the study, which results from it increasing the agricultural area, and a significant increase in the total income and the net return of the water unit, which leads to an increase in the national agricultural income.

Recommendations:

Through the results, the study reached the following recommendations:

1- Establishing policies and mechanisms by the state for the complete transformation of the cultivated area for improved irrigation to benefit from reducing the amount of irrigation water used and increasing the productivity of various crops.

2- Providing financial and technical support to farmers and training them to shift from surface irrigation to improved irrigation, and the state's adoption of projects for developing surface irrigation.

3- Providing all facilities and soft and long-term loans to implement the developed surface irrigation programs.

4- Activating the role of extension agencies and the media in educating farmers about the importance of using modern methods of irrigation.

5- Opening new specializations in the Faculties of Agriculture for water extension, and organizing irrigation networks for the graduation of specialized human cadres.

6- Forcing farmers to switch to modern irrigation by enacting a law and imposing penalties and fines for violators.

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