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An analytical study of the possibility of increasing rice production in Egypt

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Abstract: The research aims to increase the local production of rice crop because it is considered one of the main cereal crops and the important strategy in Egypt, and the method of two-way analysis of variance and the Harry Eyre model - Edward Shaw were used, and linear programming was used using WinQSB program. The research found that there are significant differences of statistical significance for the impact of cultivated rice species on fed productivity, and using the Harry- Eyre and Edwar coefficients, after replacing high-productivity species with low-productivity species, increasing the productivity per fedden to about 3.990 tons / fedden and increasing the transfer coefficients in the supply function of the species Giza 179, Sakha 104, Sakha 101, Giza 177, Giza 178, Super 300, Sakha 108, Sakha 102, Sakha 103 with a transfer coefficient of about 0.4%, 2.9%, 5.6%, 3.5%, 6.3%, 0.21%, 0.7%, 0.4% and 0.07% each respectively, for the same cultivated areas. It led to an increase in production achieved from about 4.829 million tons to about 4.950 million tons, an increase of about 120.3 thousand tons, equivalent to about 2.5% of actual production. From the results of the linear programming of most of the net return, it was found that the most best net return amounted to about 5.1 billion pounds, an increase of about 1.3 billion pounds over the current net return, and the most best production reached about 4959 thousand tons, an increase of about 221 thousand tons over the current production.

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Key Words: linear programming, Harry- Eyre and Edwar coefficient ,production, rice.

Introduction:

The rice crop is one of the main cereal crops and important strategy in Egypt, and comes after the wheat crop in second place in terms of its nutritional importance because it contains many salts, minerals and nutritional vitamins, and its secondary product enters the concentrated feed industry for animal production, in addition to that it still achieves a surplus directed to export after meeting the requirements of the local market [(6)]. In recent years, the rice crop has taken a general decreasing trend, as it is considered one of the crops that consume the most irrigation water, as it needs about 9.6 billion m3 [(2)], and because of the state's keenness to rationalize irrigation water after the Renaissance Dam crisis, the target area for it in the crop composition has been determined by about 724 thousand fedden only [(11)], whose production is sufficient for local consumption and export requirements[(8)].

In light of the limited land and water resources available to Egypt, and with the increase in investments necessary for the reclamation of new lands, the importance of using varietal technology to increase rice production through the development of new improved species has emerged, leading to higher self-sufficiency of this crop[(7)].

Problem:

Despite the importance of the rice crop as the main food of the Egyptian people, the state has adopted a policy of determining the area planted with rice due to its large water needs, which resulted in a decrease in the amount of production and exports of rice crop as well as export revenues, and this policy also affected the percentage of self-sufficiency from it. It was necessary for the state to pay attention to varietal technology and develop exceptional methods and solutions to address the shortage of cultivated area of rice due to water scarcity, and its desire to save hard

currency, by choosing the highest productive species and expanding their cultivation in place of other less productive species to increase the productivity of the ground unit and the unit of water used. And Thanks to the research conducted in this field by the Ministry of Agriculture and the specialized research institutes of the Agricultural Research Center, many species with high productivity, resistance to diseases and short-lived have been developed, and the question posed by the research paper is whether the development of new species of rice and the application of the varietal composition of the rice crop for each governorate achieve maximum production and optimal use of resources.

Objective:

The main objective of the research is to increase the local production of rice crop. This is done by achieving the following sub-objectives:

1- Studying the development of the most important productive and economic variables of the rice crop during the period (2010-2020).
2- Measuring the impact of species technology on the productivity the fedden of rice crop.
3- Measuring the impact of the cultivation of modern species on the transmission of rice crop supply function.
4- Access to the class map of the rice crop, which achieves the maximum possible production under the available resources.

Method and Data Sources:

The research relied on the method of descriptive and quantitative analysis to study the evolution of rice variables through the use of some statistical and mathematical methods such as averages and percentages, and the method of regression analysis to estimate the general time trend, and the method of analysis of variance in two directions to clarify the differences in productivity between species and governorates, and in the case of the significance of the calculated value - F, the averages are compared using the LSD test to determine which of these species causes morality, and the Harry Eyre - Edward Shaw model was used to estimate the coefficients of The transfer of the supply function for different species of rice crops, linear programming was used to determine the most appropriate distribution of rice species and also used the WinQSB programme.

As for the data sources, the research was based on many available sources, including agricultural statistics bulletins, and food security bulletins issued by the Economic Affairs Sector at the Ministry of Agriculture and Land Reclamation, in addition to the data available in previous studies related to the subject.

Results and Discussion

First: The development of the most important productive variables of the rice crop in Egypt:

The evolution of the area of the rice crop:

It is clear from the data of Table (1) in the appendix that the area of the rice crop in Egypt during the period (2010-2020) ranged between 858.7 thousand feddens in 2018 as a minimum, after the decision of the Minister of Water Resources to reduce the areas of the rice crop in order to reduce water consumption [(11)] and about 1472.1 thousand feddens in 2012 as a maximum, and by estimating the equation of the general time trend of the area of the rice crop during the study period, it was found that the statistical significance was not proven at different significance levels, and this means that it is characterized by the relative stability around the annual average for the period indicated.

Evolution of rice crop productivity:

It is clear from the data of Table (1) in the appendix that the average productivity of rice crop in Egypt amounted to about 3.886 tons / fedden during the study period and ranged between 3.635 tons / fedden in 2018 as a minimum and about 4.028 tons / fedden in 2014 as a maximum, and by estimating the equation of the general time trend of rice crop productivity during the study period, it was found that the linear functions the best mathematical function suitable for the data, as the results indicated that the productivity of the rice crop increased at a significant annual rate. Statistically estimated at about 0.037 tons / fedden per year, representing about 0.95% of the annual average productivity of the rice crop, which is about 3.886 tons / fedden, and the significance of the model as a whole. was proven and the results showed that about 72% of the changes in the productivity of the rice crop during the study period are due to time factor.

The development of rice production:

It is clear from the data of Table (1) in the appendix that the average production of rice crop in Egypt amounted to about 4955.6 thousand tons during the study period and ranged between 3121.9 thousand tons as a minimum in 2018, and about 5896.6 thousand tons in 2012 as a maximum, and by estimating the equation of the general time trend for rice production, it was found that statistical significance was not proven at different significance levels, and this means that it is characterized by relative stability around the annual average for the period referred to.

The evolution of the farm price of rice crop:

It is clear from the data of Table (1) in the appendix that the average farm price of rice crop was about 2611.7 pounds / fedden during the period (2010-2020) and ranged between 1837 pounds / fedden in 2010 as a minimum and about 2565 pounds / fedden in 2020 as

a maximum, and by estimating the equation of the general time trend of the farm price of the rice crop during the study period, the results showed that the exponential function is the best mathematical function suitable for the data, and it was found that the agricultural price of the rice crop increases at a rate of About 7.5% per year, and the significance of the model as a whole was proven and the results indicated that about 83% of the changes in the farm price of rice crop are due to time factor.

Table (1): General Time Trend of the Most Important Rice Crop Productivity Variables (2010-2020)

Statement		Function	General trend equation	T_{testb1}	R^2	F	Rate of change(%)
Productivity	Ton/fed	Linear	$\hat{Y}i = 4.111 + 0.037Xi$	4.81	0.72	23.13	0.95
Farm price	EGP/Fed	Exponential	$ln\hat{Y}i = 1603.2 + 0.075Xi$	6.65	0.83	44.25	**7.5**
Total Revenue	EGP/Fed	Exponential	$ln\hat{Y}i = 6841.6 + 0.065Xi$	6.75	0.84	45.57	6.5
Total costs	EGP/Fed	Exponential	$ln\hat{Y}i = 3714.53 + 0.089Xi$	7.52	0.86	56.58	8.9

where : $\hat{Y}_i = \ln\hat{Y}_i$ = estimated value of the study variables, X_i = time variable ,where i =1,2…….19.

Source: Calculated and collected from data of the Ministry of Agriculture and Land Reclamation, Economic Affairs Sector, Central Administration for Agricultural Economy, Bulletin of Agricultural Statistics, during the period (2010-2020).

The evolution of the total revenue of the rice crop:

It is clear from the data of Table (1) in the appendix that the average total revenue of the rice crop amounted to about 10355.5 pounds / fedden during the study period and ranged between 7503 pounds / fedden in 2010 as a minimum and about 13682 pounds / fedden in 2020 as a maximum, and by estimating the equation of the general time trend The total revenue of the rice crop during the study period showed that the exponential function is the best mathematical function suitable for the data, and it was found that the total revenue of the rice crop increases at a rate of About 6.5% per year, and the significance of the model as a whole was proven and the results indicated that about 84% of the changes in the total revenue of the rice crop are due to the time factor.

The evolution of the total costs of the rice crop:

It is clear from the data of Table (1) in the appendix that the average total costs of the rice crop amounted to about 6639.4 pounds / fedden during the study period and ranged between 4073 pounds / fedden in 2010 as a minimum and about 10475 pounds / fedden in 2018 as a maximum, and by estimating the equation of the general time trend of the total costs of the rice crop during the study period, the results showed that the exponential function is the best mathematical function suitable for the data, and it was found that the total costs of the rice crop increase at a rate of About 8.9% per annum. The results indicated that about 86% of the changes in the total costs of rice crop are due to the time factor.

Evolution of net return:

It is clear from the data of Table (1) in the appendix that the average net yield of the rice crop amounted to about 3478.5 pounds / fedden during the study period and ranged between 2391 pounds / fedden in 2016 as a minimum and about 5221 pounds / fedden in 2017 as a maximum, and by estimating the equation of the general time trend of the net yield of the rice crop during the study period, the results showed that the statistical significance was not proven at different significance levels, and this means that it is characterized by relative stability around the annual average for the period referred to.

Second: Geographical Distribution of Rice Crop in Egypt:

Table (2) shows the geographical distribution of rice crop during the period (2016-2020) and shows the following:

- The governorates of Lower Egypt are considered one of the most cultivated governorates for the rice crop, with an average area of about 1196 thousand feddens, which represents about 95.5% of the total area of rice in Egypt, which is estimated at about 1202 thousand feddens, and the average productivity of an fedden is about 3.755 tons / fedden and an average production of about 4504.8 thousand tons during the mentioned period. Rice production was concentrated in five governorates: (Dakahlia, Sharqia, Kafr El-Sheikh, Beheira, and Gharbia).

Third: The relative importance of rice species during the period from (2016-2020):

One of the most important objectives of the National Rice Research Program is to develop new species with high productivity, resistance to pests and diseases and tolerating unfavorable environmental conditions, especially alkalinity and salinity of the soil, as well as with high quality qualities of cereals to suit local and international consumption.

Table (3) shows the most important species of rice crop in Egypt during the average period (2016-2020), where the Giza 178 specie is the most cultivated rice crop in Egypt with an area estimated at about 377.3 thousand feddens during the mentioned period, representing about 31.4% of the total area of rice crop in Egypt, which is about 1202.2 thousand feddens, and the productivity of this variety was about 3.726 tons / fedden, and its average production was about 1410.4 thousand tons and represents about 31.2% of the total rice production in Egypt. By studying the geographical distribution of the population on the governorates of the Republic, it is clear from Appendix (2) that Dakahlia Governorate is the most cultivated governorate for the rice crop Giza 178 in terms of area for this specie, followed by Kafr El-Sheikh Governorate, then Sharkia Governorate by representing about 46%, 20%, 18%, respectively, of the total cultivated area of this specie in Egypt, with a productivity of about 4.151, 3.875, 3.439 tons / fedden for each of them, respectively.

Table (2): Geographical Distribution of Area, Productivity and Production of Rice Crop in Egypt Governorates during the Period Average (2016-2020)

Governorate	Area Fed	% Area	Productivity Ton/Fed	%Productivity	Production Ton	%Production
Dakahlia	345803	28.8	3.959	**105.5**	1380501	**30.5**
Sharqia	248642	20.7	3.470	**92.4**	864819	**19.1**
Kafr El-Sheikh	248505	20.7	3.977	**105.9**	987870	**21.8**
Beheira	165121	13.7	3.672	**97.8**	606003	**13.4**
Gharbia	99228	8.3	3.688	**98.3**	365385	**8.1**
Lower Egypt Total	1196414	99.5	3.755	**100.0**	4504802	**99.5**
Upper Egypt Total	7	0.0	3.413	**90.9**	24	**0.001**
Total Middle Egypt	3692	0.3	3.582	**95.4**	13514	**0.3**
Total Country	**1202227**	**28.8**	**3.754**	**100**	**4525386**	**100.0**

Source: Collected and calculated by the Ministry of Agriculture and Land Reclamation, Economic Affairs Sector, Bulletin of Agricultural Statistics, Miscellaneous Issues

Table (3): Relative Importance of the Most Important Rice Crop species in Descending Order by Area during the Period (2016-2020)

varieties	Area (k fed)	%	Productivity (ton/fed)	%	Production (k tons)	%
Giza 178	377.3	31.4	3.726	98.97	1410.4	31.2
Sakha 101	308.1	25.6	3.763	99.98	1160.6	25.6
Giza 177	193.1	16.1	3.756	99.79	725.6	16.0
Sakha 104	188.9	15.7	3.772	100.21	713.0	15.8
Sakha 108	44.7	3.7	3.809	101.20	170.6	3.8
Sakha 106	30.6	2.5	3.816	101.38	116.9	2.6
Giza 179	24.8	2.1	3.905	103.74	99.2	2.2
Sakha 105	24.0	2.0	3.833	101.84	91.4	2.0
Super 300	13.1	1.1	3.809	101.20	48.1	1.1
Sakha 102	9.2	0.8	3.520	93.51	34.0	0.8
Sakha 107	6.9	0.6	4.017	106.73	25.6	0.6
Sakha 103	1.9	0.2	3.668	97.44	7.0	0.2
Giza 171	1.9	0.2	3.351	89.02	6.3	0.1
Mongrel 1	0.9	0.1	4.064	107.97	3.3	0.1
Giza 170	0.1	0.01	3.265	86.75	0.2	0.01
Other Species	14.0	1.2	3.640	96.69	54.4	1.2
Total Country	**1202.2**	**100**	**3.764**	**100**	**4525.4**	**100**

Source: Collected and calculated by the Ministry of Agriculture and Land Reclamation, Economic Affairs Sector, Agricultural Statistics Bulletins, during the period (2016-2020).

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The Sakha 101 specie ranks second in terms of area, which is estimated at about 308.1 thousand feddens, representing about 25.6% of the total area of the rice crop in Egypt, with an average productivity of about 3.763 tons / feddens during the average period (2016-2020).

By studying the class distribution of the specie Sakha 101, it is clear that the Sharkia Governorate comes in the first place in terms of the cultivated area of this specie, followed by Dakahlia and then Gharbia with percentages representing 29%, 28%, 16% for each of them, respectively, with a productivity of about 3.86, 4.097, 3.66 tons per fedden.

Fourth: Measuring the impact of the application of verities technology on the productivity of rice crop in Egypt:

To illustrate the effect of species technology on Rice crop productivity, analysis of variance and differences between Rice crop productivity was used according to the technological element used namely the species and the governorate. The results of Table (4), which shows the analysis of the variation between the fedden productivity of rice crop species, showed that there are statistically significant differences in the impact of cultivated rice species on the fedden productivity of these species and also the strength of the impact of governorates (geographical location) on this productivity at the probability level of 1%.

The analysis of comparisons [4] between the average fedden productivity of rice crop species was carried out with consideration of the results of the analysis of variance in two directions between the average fedden productivity of the most important rice crop species during the period (2016-2020) by estimating the analysis of the value of the lowest difference in the meaning of LSD, the results of which are shown in Table (5), and it was found that the Sakha 107 specie comes in first place in terms of average productivity per fedden, as its productivity reached about 4.017 tons / fedden during the average period (2016-2020) and it surpasses statistically significant differences over most species where it surpassed the species (Giza 179, Sakha 106, Sakha 105, Sakha 101, Sakha 104, Giza 178, Giza 177, Sakha 102, Sakha 103, Giza 170, Giza 171).

Table (4): Analysis of the variance in two directions between the fedden productivity of rice crop species during the period (2016-2020) to test the impact of the species and governorates.

Source of contrast	Degrees of freedom	Sum Square deviations	Average Square deviations	F calculated
Between the species	14	2.337	0.167	++2.443
Between Governorates	14	20.673	1.477	++21.615
Error	316	21.588	0.068	
Total	345	4631.379		

** Significant at the probability level of 1%.

Source: Results of statistical analysis using SPSS program for data of the Ministry of Agriculture and Land Reclamation, Economic Affairs Sector, Central Administration for Agricultural Economy, Agricultural Statistics Bulletin, Miscellaneous issues.

Table (5): Results of LSD Value Analysis between Average Fedden Productivity in Tons of Cultivated species of Rice Crop during the Period (2016-2020)

species	Creation history	Average	Sakha 107	Super 300	Giza 179	Sakha 106	Sakha 105	Sakha 101	Sakha 104	Giza 178	Giza 177	Sakha 102	Sakha 103	Giza 170	Giza 171
			4.096	3.972	3.918	3.858	3.851	3.844	3.804	3.779	3.747	3.603	3.579	3.450	3.350
Sakha 107	2016	4.096	0												
Super 300	2019	3.972	.3344	0											
Giza 179	2013	3.918	.2334*	-.1010	0										
Sakha 106	2011	3.858	.2857*	-.0487	.0523	0									
Sakha 105	2010	3.851	.2377*	-.0967	.0043	-.048	0								
Sakha 101	2000	3.844	.3137*	-.0207	.0803	.0760	.0760	0							
Sakha 104	2000	3.804	.3400*	.0056	.1066	.1023	.1023	.0263	0						
Giza 178	2000	3.779	.4511*	.1167	.2177*	.2134*	.2134*	.1374*	.1111	0					
Giza 177	2000	3.747	.4408*	.1064	.2074*	.2031*	.2031*	.1271*	.1008	-.010	0				
Sakha 102	2000	3.603	.4545*	.1201	.2211*	.2168*	.2168*	.1408	.1145	.0034	.0137	0			
Sakha 103	2000	3.579	.4899*	.1555	.2565*	.2522*	.2522*	.1762	.1499	.0388	.0491	.0354	0		
Giza 170	2000	3.450	.5574*	.2230	.3240	.3197	.3197	.2437	.2174	.1063	.1166	.1029	.0675	0	
Giza 171	2000	3.350	.6483*	.3139	.4149*	.4106*	.4106*	.3346*	.3084*	.1972*	.2075*	.1938	.1584	.0909	0

- Hagin 1 specie was excluded because the farmer does not accept to grow it due to its low price on the one hand, and its lack of acceptance of the Egyptian taste on the other hand.

Source*:* Results of statistical analysis using SPSS program for data of the Ministry of Agriculture and Land Reclamation, Economic Affairs Sector, Central Administration for Agricultural Economy, Agricultural Statistics Bulletin, (2016-2020).

Fifth: The impact of the cultivation of modern species of rice crop on the transmission of the supply functions during the period (2010-2020):

To study the impact of planting new species of rice crop, the Harry- Eyre and Edwar coefficient [(1)] called the Technological change coefficient was used to measure the transfer of the supply function of agricultural crops resulting from technological change in the introduction of modern species of these crops, and this equation is:

$$\sum \left[\left(1 - \frac{Yu * Fu}{Ya * Fa}\right) * Pa\right] \times 100$$

Where:

K = The amount of relative transition in the resulting supply of the crop.

Yu = Average productivity of old species of the crop under study.

Ya = Average productivity of the species developed for the crop under study.

Fu = Average extraction rate of old species of the crop under study.

Fa = Average extraction rate of the new A specie of the crop under study.

Pa = Relative importance of the modern specie = area of the modern specie / total crop area in Egypt ×100

Where the value of the coefficient of Harry- Eyre and Edwar positive roles indicates the superiority of the modern (or new) specie over the traditional (or old) specie, and this leads to the transfer of the supply function to the right, while if the value of the Harry-Eyre and Edwar coefficient - and negative roles, this means that the modern (or new) specie later than the traditional (or old) specie,

and this leads to the transfer of the supply function to the left. The aim of this laboratory is to monitor the possibility of increasing crop production by replacing low- productivity species with high-productivity species. The highest species were taken into account according to fedden productivity.

Table (6) indicates that before modifying the varietal composition of the rice crop in Egypt, it was found that the species Giza 178, Sakha 101, Giza 177, Sakha 104, achieved the highest relative transmission coefficient to the right by about 5.16%, 5.15%, 3.3%, and 2.7% respectively, due to the high percentage of the area of the specie, which amounted to about 31%, 27%, 17%, and 14% respectively of the total area of rice crop in Egypt during (2010-2020). While after modifying the increasing fedden productivity to about 3.990 Ton / Fedden for the same cultivated areas. As a result, the production of species Giza 179, Sakha 104, Sakha 101, Giza 177, Giza 178, Super 300, Sakha 108, Sakha 102, Sakha 103 with a rate of about 0.01%, 1.7%, 1.9%, 2.8%, 3.0%, 9.0%, 4.5%, 0.8%, and 2.8% respectively. increasing fedden productivity to about 3.990 Ton / Fedden for the same cultivated areas. As a result, the production of species Giza179, Sakha 104, Sakha 101, Giza 177, Giza 178, Super 300, Sakha 108, Sakha 102, Sakha 103 with a rate of about 0.01%, 1.7%, 1.9%, 2.8%, 3.0%, 9.0%, 4.5%, 0.8%, and 2.8% respectively.

Table (6): Relative Transition Coefficients in the Rice specie Supply Function in Egypt during the Average Period (2010-2020).

Items	Average area fed	% of item area	Average productivity of the modern specie (T/f)	Extraction rate of the new specie	Average productivity of the old specie	Extraction rate of the old specie	Transition coefficients in the supply function before modification (%)	Transition coefficients in the supply function after modification (%)
		Pa	Ya	Fa	Yu	Yu	K	K
Giza179	22824.1	2	4.039	0.68	3.258	0.71	0.3	0.4
Sakha 107	6858.6	1	4.017	0.72	3.258	0.71	0.1	0.1
Sakha 105	32113.5	3	4.011	0.72	3.258	0.71	0.5	0.5
Sakha 106	30369.9	2	3.942	0.72	3.258	0.71	0.5	0.5
Sakha 104	179625.3	14	3.926	0.72	3.258	0.71	2.7	2.9
Sakha 101	348188.7	27	3.902	0.72	3.258	0.71	5.15	5.6
Giza177	216391.3	17	3.869	0.73	3.258	0.71	3.3	3.5
Giza178	389220.5	31	3.864	0.71	3.258	0.71	5.16	6.3
Super 300	13130.5	1	3.809	0.75	3.258	0.71	0.19	0.21
Sakha 108	44681.5	4	3.809	0.72	3.258	0.71	0.6	0.7

Sakha 102	**22308.1**	**1.75**	**3.788**	**0.72**	**3.258**	**0.71**	**0.3**	**0.4**
Sakha 103	**4171.2**	**0.33**	**3.734**	**0.72**	**3.258**	**0.71**	**0.05**	**0.07**

- Hybrid 1 specie was excluded because the farmer does not accept to grow it due to its low price on the one hand and its lack of acceptance of the Egyptian taste on the other hand.

- The modern specie represents the average productivity of species (Sakha 107, Sakha 105, Sakha 106) which is 3.990 Ton /fedden.

Source: - Calculated and collected from the Ministry of Agriculture and Land Reclamation, Economic Affairs Sector, Agricultural Statistics Bulletins, Miscellaneous Issues.

- Ministry of Agriculture and Land Reclamation, Agricultural Research Centre, Agricultural Crops Research Institute, Rice Research Department.

Sixth: The impact of species technology on rice production:

Table (8) shows the production and area of rice crop species after replacing high-productivity species with low-productivity species and increasing fedden productivity to about 3.990 Ton / Fedden for the same cultivated areas. As a result, the production of species Giza 179, Sakha 104, Sakha 101, Giza 177, Giza 178, Super 300, Sakha 108, Sakha 102, Sakha 103 with a rate of about 0.01%, 1.7%, 1.9%, 2.8%, 3.0%, 9.0%, 4.5%, 0.8%, and 2.8% respectively. This led to an increase in production achieved from about 4.829 million tons to about 4.950 million tons, an increase estimated at about 120.3 thousand tons, equivalent to about 2.5% of the actual production.

Table (7): Area and Production of the Most Important Species of Rice Crop after Modifying the Varietal Composition during the Period (2010-2020)

Species	Average area	Average productivity	Productivity	Production after modification	Increase in production	Percentage of increase	Available area
	Fedden	Ton/Fedden	Ton	Ton	Ton	%	Fedden
Giza179	**22824.1**	**4.039**	**91065.8**	**91077.18**	**11.4**	**0.01**	**2.8**
Sakha 104	**179625.3**	**3.926**	**704730.3**	**716775.1**	**12044.8**	**1.7**	**3068.3**
Sakha 101	**348188.7**	**3.902**	**1363159.7**	**1389409**	**26249.4**	**1.9**	**6727.6**
Giza177	**216391.3**	**3.869**	**840162.4**	**863485.8**	**23323.4**	**2.8**	**6028.5**
Giza178	**389220.5**	**3.864**	**1507608.5**	**1553142**	**45533.6**	**3.0**	**11785.5**
Super300	**13130.5**	**3.809**	**48072.5**	**52395.83**	**4323.3**	**9.0**	**1134.9**
Sakha 108	**44681.5**	**3.809**	**170638.0**	**178296.7**	**7658.7**	**4.5**	**2010.5**
Sakha 102	**22308.1**	**3.788**	**88331.1**	**89018**	**686.9**	**0.8**	**181.4**
Sakha 103	**4171.2**	**3.734**	**16187.5**	**16644.72**	**457.2**	**2.8**	**122.4**
Total	**1240541.2**	**3.893**	**4829955.8**	**4950245**	**120288.8**	**2.5**	**30895.3**

- Production after modification = average area of the cultivar × average productivity of high- productivity cultivar (Sakha 107, Sakha 105, Sakha 106) 3.99 Ton/Fedden.

- Available area = Increase in production (K tons) ÷ Average fedden productivity (tons/fed).

Source: Collected and calculated from data from the Ministry of Agriculture and Land Reclamation, Economic Affairs Sector, Central Administration for Agricultural Economy, Agricultural Statistics Bulletin, during (2010-2020).

In the case of replacing the highest productivity Species according to the results of the LSD:

Table (8) shows the production and area of rice crop Species after replacing high-productivity Species according to the results of LSD, which is Sakha 107 Species, replacing low-productivity Species and increasing fedden productivity to about 4.017 tons / fedden for the same cultivated areas. As a result, the production of Species Giza 179, Sakha 104, Sakha 101, Giza 177, Giza 178, Super 300, Sakha 108, Sakha 102, Sakha 103 increased by about 0.7%, 2.4%, 2.6%, 3.5%, 3.7%, 9.7%, 5.2%, 1.5% and 3.5% respectively. This led to an increase in production achieved from about 4.829 million tons to about 4.983 million tons, an increase estimated at about 153.86 thousand tons, equivalent to about 3.2% of the actual production.

Seventh: The varietal map of the rice crop, which achieves the maximum possible production in light of the available resources:

To reach the most suitable area planted with different Species of rice crop, linear programming [5] using WinQSB2.0 will be used and consists of:

A- Objective function:

The first model: maximizing the net return:

$$Max \quad \sum_{j=1}^{m} \alpha_j X_j$$

Where: αj refers to the net fedden yield of the rice Specie j, Xj refers to the area planted with different Species of rice crop.

The second model: maximizing production:

$$Max \quad \sum_{j=1}^{m} \gamma_j X_j$$

where: γj refers to the productivity of the rice Specie j.

Table (8): Area and production of the most important species of rice crop after modifying the varietal composition according to the results of LSD during the period (2010-2020)

Species	Average area	Average productivity	Production	Production after modification	Increase in production	Percentage of increase	Available area
	Ton	Ton/Fedden	Ton	Ton	Ton	%	Fedden
Giza179	22824.1	4.039	91065.8	91695	629	0.7	156
Sakha104	179625.3	3.926	704730.3	721636	16906	2.4	4306
Sakha101	348188.7	3.902	1363159.7	1398832	35672	2.6	9142
Giza177	216391.3	3.869	840162.4	869342	29180	3.5	7542
Giza178	389220.5	3.864	1507608.5	1563676	56067	3.7	14510
Super300	13130.5	3.809	48072.5	52751	4679	9.7	1228
Sakha108	44681.5	3.809	170638.0	179506	8868	5.2	2328
Sakha102	22308.1	3.788	88331.1	89622	1291	1.5	341
Sakha103	4171.2	3.734	16187.5	16758	570	3.5	153
Total	**1240541.2**	**3.893**	**4829955.8**	**4983818**	**153862**	**3.2**	**39523**

- Production after modification = average area of the item × average productivity of high- productive items (Sakha 107, Sakha 105, Sakha 106) 3.99 Ton / Fedden.
- Available area = increase in production (thousand tons) ÷ average fedden productivity (Ton / Fedden).

Source: Collected and calculated from data from the Ministry of Agriculture and Land Reclamation, Economic Affairs Sector, Central Administration for Agricultural Economy, Agricultural Statistics Bulletin Miscellaneous Issues.

B- Restrictions:

1- The restriction on the area planted with rice crop: It includes

- The restriction that the area planted with rice crop in different governorates should not fall below the minimum area planted with rice crop in different governorates during the study period.

$$\sum_{i=1}^{n} X_i \geq W_i$$

Where:

i is the province that cultivates rice where i = 1, 2, 3, ... ،8

N Number of provinces that cultivate rice.

Xi refers to the area planted with rice crop in a particular province i.

Wi the minimum area planted with rice crop in different governorates i.

- The restriction on not exceeding the area planted with rice crop in different governorates from the maximum area planted with rice crop in different governorates during the study period.

$$\sum_{i=1}^{n} X_i \leq Y_i$$

Where:

Yi The maximum area planted with wheat crop in different governorates i.

- The restriction on not exceeding the area planted with different Species of rice crop than the maximum area planted with different Species during the study period.

$$\sum_{j=1}^{m} X_j \leq Z_j$$

Where:

j Cultivated rice class where j = 1, 2, 3, ... ،14

M Number of rice species cultivated.

Xj Refers to the area planted with different species of rice crop j.
Zj Minimum area planted with different species of rice crop j.

2- Labor restriction:
It is for not to increase the labor used for what is available

$$\sum_{i=1}^{n} \beta_i X_i \leq U_i$$

Where:
i Rationed rice crop in different governorates of employment per day work / man.
Ui The maximum available rice crop in different governorates of employment per day work/man.

3- The restriction of 33.5% Nitrogen fertilization: It is for not increasing the nitrogen fertilization 33.5% used for what is available.

$$\sum_{i=1}^{n} d_i X_i \leq S_i$$

Where:
Di Rationed rice crop in different provinces of nitrogen fertilization 33.5% per sack.
Si The maximum available limit for rice crop in different governorates from nitrogen fertilizer is 33.5% in Shikara.

4- The restriction of Nitrogen fertilization is 46.5%: It is for not increasing the nitrogen fertilization 46.5% used for what is available.

$$\sum_{i=1}^{n} e_i X_i \leq R_i$$

Where:
Ei Rationed rice crop in different governorates of Nitrogen fertilization 46.5% per sack.
Ri The maximum available yield of rice in different governorates from nitrogen fertilizer is 46.5% in Shikara.

5- The restriction on Phosphate fertilization is 15%: It is for not to increase the phosphate fertilization 15% used for what is available.

$$\sum_{i=1}^{n} f_i X_i \leq Q$$

Where:
Fi Rationed rice crop in different governorates of phosphate fertilization 15% per sack.
Qi The maximum available rice crop in different governorates of phosphate fertilizer is 15% per sack.

6- The restriction on potash fertilization is 48%: It is for not increasing the potash fertilization 48% used for what is available.

$$\sum_{i=1}^{n} g_i X_i \leq V_i$$

Where:
Gi Rationed rice crop in different governorates of potash fertilization 48% per sack.
Vi The maximum available rice crop in different governorates of potash fertilizer is 48% per sack.

7- The restriction of the water rationed: It is for not exceeding the water used than the available

$$\sum_{i=1}^{n} c_i X_i \leq T_i$$

Where:
Ci Rationed rice crop in different governorates of water in cubic meters.
Ti The maximum available rice crop in different governorates of water in cubic meters.

- Maximized net income results:

The first scenario:

Deleting a restriction less than the maximum area:

The number of governorates included in the programming analysis for this scenario reached 8 governorates, while the number of Species reached about 14 Species and the number of activities, which are the Species planted in the different governorates, reached about 76, while the number of restrictions reached about 64.

Table (9) shows that the net return was about 5.1 billion pounds, with increase of about 1.3 billion pounds, with the provision of about an fedden, the provision of about 30.52 working days / man, about 1.33 nitrogen fertilizers 33.5%, about 1.44 nitrogen fertilizers 46.5%, about 1.53 phosphate fertilizers 15%, about 0.53 phosphate fertilizers 49%, and the provision of about 5700 cubic meters of water, and the number of Species planted according to this result about 7 Species (Specie Sakha 101 in Sharkia Governorate, Sakha 104 in Beheira Governorate, Sakha 102 in Kafr El-Sheikh Governorate, Sakha 103 in Damietta Governorate, Giza 179 in Qalyubia Governorate, Giza 177 in Ismailia Governorate, Sakha 107 in Gharbia Governorate, and Dakahlia.

The most successful production according to the most successful area was estimated at about 4749.3 thousand tons, with an increase of about 12.1 thousand tons, representing about 0.3% over the current production, which is estimated at about 4727.1 thousand tons on average for the period (2016-2020).

The second scenario:

Using all restrictions:

The number of governorates included in the programming analysis for this scenario reached 8 governorates, while the number of Species reached about 14 Species, and the number of activities, which are the Species cultivated in the different governorates, reached about 76 Species, while the number of restrictions reached about 140. Table (11) shows that the net return reached about 4.1 billion pounds, an increase of about 165.1 million pounds, with the provision of about an fedden, the provision of

about 30.52 working days / man, about 1.33 nitrogen fertilizers 33.5%, about 1.44 tons of nitrogen fertilizers 46.5%, about 1.53 tons of phosphate fertilizers 15%, about 0.53 cigarettes for potash fertilizers 49%, and the provision of about 5700.36 cubic meters of water, and the number of Species planted according to this result about 13 items, as in Table (10) . The most successful production according to the most successful area was estimated at about 4760.5 thousand tons, with an increase of about 23.3 thousand tons, representing about 0.5% over the current production, which is estimated at about 4737.1 thousand tons on average for the period (2016-2020).

- Maximizing production results:

The first scenario:

Deleting a restriction less than the maximum area:

The number of governorates included in the programming analysis for this scenario reached 8 governorates, while the number of Species reached about 14 Species and the number of activities, which are the Species cultivated in the different governorates, reached about 76 items, while the number of restrictions reached about 64, Table (11) shows that the most successful production reached about 4959 thousand tons, with an increase of about 221 thousand tons, with the provision of about an fedden, and the provision of about 30.52 working days /man, And about 1.33 nitrogen fertilizers 33.5%, about 1.44 nitrogen fertilizers 46.5%, about 1.53 phosphate fertilizers 15%, and about 0.53 sack for potash fertilizers 49%, and provide about 5700 cubic meters of water, and the number of Species planted according to this result about 6 Species .

The second scenario:

Using all restrictions:

The number of governorates included in the programming analysis for this scenario reached 8 governorates, while the number of Species reached about 14 Species and the number of activities, which are the Species cultivated in the different governorates, reached about 76 Species , while the number of restrictions reached about 140, while Table (12) shows that the most successful production amounted to about 4769.8 thousand tons, an increase of about 32.7 thousand tons, with the provision of about an fedden, about 30.52 working days / man, and about 1.33 fertilizer bags Nitrogen 33.5%, about 1.44 tons of nitrogen fertilizers 46.5%, about 1.53 tons of phosphate fertilizers 15%, about 0.53 cigarettes for potash fertilizers 49%, and providing about 5700.36 cubic meters of water, and the number of Species planted according to this result about 14 Species.

Table (9): the first scenario of the results of linear programming and the target function for maximizing the net income of rice crop during the average period (2016-2020).

Statement	Current Area	Ideal Area	Difference	Current Production	Ideal Production	Difference	Current Return	Net Return	Difference	%
	Fedden	Fedden	Fedden	K Ton	K Ton	K Ton	Mil EGP	Mil EGP	Mil EGP	
Giza170	63	-	-63	0.237	0	-0.2	0.046	0	0	-100
Giza171	2674	-	-2674	9.1	0.0	-9.1	4.8	0.0	-4.8	-100
Giza177	187860	4739	-183121	708.8	16.4	-692.4	571.9	11.0	-560.9	-98
Giza178	359819	-	-359819	1353.2	0.0	-1353.2	1152.4	0.0	-1152.4	-100
Giza179	48047	6702	-41345	190.3	23.3	-167.0	121.1	18.7	-102.4	-85
Sakha101	308185	255524	-52661	1160.6	923.0	-237.6	962.2	632.4	-329.7	-34
Sakha102	16416	286873	270457	62.3	1172.1	1109.8	50.9	1103.7	1052.8	2067
Sakha103	3728	59467	55739	13.8	204.6	190.8	12.5	189.0	176.6	1415
Sakha104	188007	174643	-13364	708.5	634.4	-74.1	594.1	627.3	33.2	6
Sakha105	26722	-	-26722	102.2	0.0	-102.2	87.1	0.0	-87.1	-100
Sakha106	33788	-	-33788	129.0	0.0	-129.0	112.2	0.0	-112.2	-100
Sakha107	9177	466741	457564	33.9	1775.4	1741.6	28.1	2560.9	2532.8	9005
Sakha108	57301	-	-57301	217.8	0.0	-217.8	180.5	0.0	-180.5	-100
Super300	12903	-	-12903	47.3	0.0	-47.3	32.8	0.0	-32.8	-100
Total	1254689	1254688	-1	4737.1	4749.3	12.1	3910.7	5143.1	1232.4	32
Ismailia (Giza177)	4739	4739	0.00	15.7	16.4	0.7	9.1	11.0	1.9	21
Beheira Sakha(104)	174643	174643	-0.22	637.3	634.4	-2.9	545.8	627.3	81.5	15
Dakahlia Sakha (107)	356108	356108	-0.10	1421.7	1388.2	-33.5	1490.7	2135.4	644.7	43
Sharqiah Sakha (101)	255524	255524	0.00	887.9	923.0	35.1	542.6	632.4	89.9	17
Gharbiah Sakha(107)	110634	110634	-0.10	410.2	387.3	-23.0	292.6	425.5	132.9	45
Qalyubia)Giza(179	6702	6702	-0.20	22.6	23.3	0.7	6.8	18.7	11.9	175
Damietta)Sakha(103	59467	59467	0.00	201.5	204.6	3.1	116.0	189.0	73.1	63
Kafr El Sheikh)Sakha(102	286873	286873	-0.23	1140.3	1172.1	31.8	907.1	1103.7	196.6	22
Total	1254689	1254688	-1	4737.1	4749.3	12.1	3910.7	5143.1	1232.4	32

Source: Linear programming results using WinQSB2.0

Table (10): The second scenario of the results of linear programming and the objective function for maximizing the net yield of rice crop during the average period (2016-2020)

Statement		*Current Area*	*Ideal Area*	*Difference*	*Current Production*	*Ideal Production*	*Difference*	*Current Return*	*Net Return*	*Difference*	%
		Fed	**Fed**	**Fed**	**K Ton**	**K Ton**	**K Ton**	**Mil EGP**	**Mil EGP**	**Mil EGP**	
Sakha 101	Beheira	45136	69,922	24,786	166.6	258.1	91.5	143.1	221.7	78.6	54.9
	Gharbiah	44401	57,636	13,235	164.5	213.5	49.0	116.7	151.5	34.8	29.8
	Kafr El Sheikh	30738	38,078	7,340	123.2	152.6	29.4	106.6	132.1	25.5	23.9
	Dakahlia	82976	97,230	14,254	330.6	387.4	56.8	346.5	406.0	59.5	17.2
	Damietta	11514	13,477	1,964	39.6	46.4	6.8	23.3	27.3	4.0	17.1
	Sharqiah	89008	104,408	15,400	321.5	377.1	55.6	220.3	258.4	38.1	17.3
	Qalyubia	2687	1,384	-1,303	8.8	4.5	-4.3	2.1	1.1	-1.0	-48.5
	Ismailia	1726	1,799	74	5.8	6.0	0.2	3.5	3.6	0.1	4.3
Sakha 104	Beheira	28249	41,192	12,943	102.6	149.6	47.0	101.5	148.0	46.5	45.8
	Kafr El Sheikh	45599	54,771	9,172	183.5	220.4	36.9	158.2	190.0	31.8	20.1
	Dakahlia	36308	47,266	10,958	147.8	192.5	44.6	161.8	210.6	48.8	30.2
	Damietta	13053	13,552	500	44.8	46.6	1.7	28.1	29.2	1.1	3.8
	Sharqiah	44439	65,196	20,757	156.0	228.8	72.8	95.8	140.5	44.7	46.7
	Ismailia	1754	1,808	54	5.8	6.0	0.2	3.4	3.5	0.1	3.1
	Qalyubia	2399	4,995	2,596	8.6	17.9	9.3	3.7	7.7	4.0	108.2
Sakha 102	Beheira	2903	4,682	1,779	10.6	17.0	6.5	8.3	13.4	5.1	61.3
	Kafr El Sheikh	7842	8,029	188	32.0	32.8	0.8	30.2	30.9	0.7	2.4
	Sharqiah	4282	10,382	6,100	14.7	35.6	20.9	10.0	24.2	14.2	142.5
Sakha 105	Beheira	3438	5,954	2,516	12.7	22.0	9.3	10.3	17.8	7.5	73.2
	Gharbiah	3031	5,516	2,486	11.1	20.2	9.1	8.1	14.8	6.7	82.0
	Kafr El Sheikh	9817	14,806	4,989	39.2	59.1	19.9	32.9	49.6	16.7	50.8
	Dakahlia	4685	6,506	1,821	19.1	26.6	7.4	23.5	32.6	9.1	38.9
	Damietta	480	490	11	1.6	1.7	0.0	1.0	1.0	0.0	2.2
	Sharqiah	5273	14,432	9,159	18.5	50.5	32.1	11.4	31.2	19.8	173.7
Sakha 103	Dakahlia	1523	2,645	1,123	6.4	11.1	4.7	6.7	11.7	4.9	73.7
	Damietta	432	523	92	1.5	1.8	0.3	1.4	1.7	0.3	21.2
Sakha 108	Sharqiah	6395	12,166	5,771	21.3	40.6	19.2	14.2	27.1	12.9	90.2
	Beheira	17821	17,821	0	63.4	63.4	0.0	58.6	58.6	0.0	0.0
	Gharbiah	7419	7,419	0	31.0	31.0	0.0	23.0	23.0	0.0	0.0
Sakha 106	Beheira	7606	9,285	1,679	27.9	34.0	6.2	22.8	27.8	5.0	22.1
	Kafr El Sheikh	8657	10,295	1,639	35.0	41.6	6.6	33.2	39.5	6.3	18.9
	Dakahlia	8915	13,325	4,410	36.1	54.0	17.9	38.6	57.7	19.1	49.5
	Sharqiah	4931	9,616	4,686	17.4	33.9	16.5	11.9	23.1	11.3	95.0
Giza 171	Sharqiah	1626	3,941	2,315	5.5	13.4	7.9	3.4	8.3	4.9	142.3
Giza 178	Beheira	7382	11,340	3,958	26.9	41.3	14.4	22.3	34.3	12.0	53.6
	Gharbiah	7584	10,090	2,506	28.7	38.2	9.5	24.1	32.1	8.0	33.0
	Kafr El Sheikh	73137	104,422	31,285	289.6	413.4	123.9	239.3	341.7	102.4	42.8
	Dakahlia	165963	162,939	-3,024	658.2	646.2	-12.0	686.9	674.3	-12.5	-1.8
	Damietta	28552	26,326	-2,227	95.1	87.7	-7.4	50.7	46.7	-4.0	-7.8
	Sharqiah	76314	6,638	-69,67	251.9	21.9	-230.0	127.9	11.1	-116.8	-91.3
	Ismailia	756	572	-184	2.4	1.8	-0.6	1.0	0.8	-0.3	-24.3
	Qalyubia	131	155	25	0.4	0.5	0.1	0.2	0.2	0.0	18.8
Giza 179	Beheira	2153	3,540	1,388	8.0	13.2	5.2	6.8	11.2	4.4	64.5
	Dakahlia	14110	21,405	7,295	58.7	89.1	30.4	63.6	96.5	32.9	51.7
	Sharqiah	2839	5,617	2,778	10.1	20.1	9.9	5.7	12.8	7.1	123.7
	Gharbiah	849	1,707	858	3.1	6.3	3.2	2.6	5.1	2.6	101.1
	Qalyubia	168	168	0	0.6	0.6	0.0	0.5	0.5	0.0	0.0
Giza 177	Gharbiah	20357	26,902	6,545	73.4	97.0	23.6	54.3	71.7	17.5	32.2
	Kafr El Sheikh	66475	56,472	-10,00	261.3	222.0	-39.3	212.7	180.7	-32.0	-15.0
	Damietta	4413	5,099	686	15.5	17.9	2.4	10.1	11.7	1.6	15.5
	Sharqiah	17917	23,127	5,210	62.7	80.9	18.2	38.5	49.7	11.2	29.1
	Ismailia	504	560	57	1.7	1.9	0.2	1.2	1.3	0.1	11.2
Super 300	Beheira	6589	5,463	-1,126	23.2	19.2	-4.0	18.8	15.6	-3.2	-17.1
Sakha 107	Beheira	2462	5,444	2,982	9.0	19.9	10.9	8.4	18.6	10.2	121.1
	Gharbiah	275	1,364	1,089	1.0	4.8	3.8	1.1	5.2	4.2	395.3
	Dakahlia	1893	4,792	2,899	7.4	18.7	11.3	8.9	28.7	19.9	223.6
Total		1,254,689	1,254,688	1-	4737.1	4760.5	23.3	3910.7	4075.9	165.1	4.2

Source: Linear programming results using WinQSB2.

Table (11): the first scenario of the results of linear programming and the objective function for most rice crop production during the average period (2016-2020)

Statement	*Current Area*	*Ideal Area*	*Difference*	*Current Production*	*Ideal Production*	*Difference*	**%**
	Fedden	**Fedden**	**Fedden**	**K Ton**	**K Ton**	**K Ton**	
Giza170	63	6702	6639	0.24	25	24.8	10496
Giza171	2674	0	-2674	9	0	-9.1	-100
Giza177	187860	4739	-183121	709	16	-692.4	-98
Giza178	359819	0	-359819	1353	0	-1353.2	-100
Giza179	48047	234109	186062	190	861	670.5	352
Sakha101	308185	255524	-52661	1161	923	-237.6	-20
Sakha102	16416	286873	270457	62	1172	1109.8	1782
Sakha103	3728	356108	352380	14	1499	1485.5	10785
Sakha104	188007	0	-188007	709	0	-708.5	-100
Sakha105	26722	0	-26722	102	0	-102.2	-100
Sakha106	33788	0	-33788	129	0	-129.0	-100
Sakha107	9177	0	-9177	34	0	-33.9	-100
Sakha108	57301	110634	53333	218	462	244.1	112
Suprt300	12903	0	-12903	47	0	-47.3	-100
Total	1254689	1254688	-1	4737	4959	221	5

Statement	Governorates	*Current Area*	*Ideal Area*	*Difference*	*Current Production*	*Ideal Production*	*Difference*	**%**
		Fed	**Fed**	**Fed**	**K Ton**	**K Ton**	**K Ton**	
Giza177	Ismailia	4739	4739	0.00	15.7	16.4	0.7	5
Giza179	Beheira	174643	174643	-0.22	637.3	652.1	14.8	2
Sakha103	Dakahlia	356108	356108	-0.10	1421.7	1499.3	77.6	5
Giza179	Sharqiah	255524	255524	0.00	887.9	923.0	35.1	4
Sakha108	Gharbiah	110634	110634	-0.10	410.2	461.9	51.7	13
Giza170	Qalyubia	6702	6702	-0.20	22.6	25.1	2.5	11
Giza179	Damietta	59467	59467	0.00	201.5	208.7	7.2	4
Sakha102	Kafr El Sheikh	286873	286873	-0.23	1140.3	1172.1	31.8	3
Total		1262422	1254689	1-	4737.1	4958.6	221.5	5

Source: Linear programming results using WinQSB2.

Table (12) the second scenario of the results of linear programming and the objective function for maximizing rice crop production during the average period (2016-2020)

Statement		Current Area	Ideal Area	Difference	Current Production	Ideal Production	Difference	%
		K Fedden	**K Fedden**	**K Fedden**	**K Ton**	**K Ton**	**K Ton**	
Sakha101	Beheira	45136	69,922	24,786	166.6	258.1	91.5	54.9
	Gharbiah	44401	61,026	16,625	164.5	226.0	61.6	37.4
	Kafr El Sheikh	30738	38,078	7,340	123.2	152.6	29.4	23.9
	Dakahlia	82976	97,230	14,254	330.6	387.4	56.8	17.2
	Damietta	11514	13,477	1,964	39.6	46.4	6.8	17.1
	Sharqiah	89008	104,408	15,400	321.5	377.1	55.6	17.3
	Qalyubia	2687	1,234	-1,453	8.8	4.0	-4.7	-54.1
	Ismailia	1726	1,799	74	5.8	6.0	0.2	4.3
Sakha104	Beheira	28249	4,455	-23,795	102.6	16.2	-86.4	-84.2
	Gharbiah	16206	14,045	-2,162	59.4	51.4	-7.9	-13.3
	Kafr El Sheikh	45599	54,771	9,172	183.5	220.4	36.9	20.1
	Dakahlia	36308	47,266	10,958	147.8	192.5	44.6	30.2
	Damietta	13053	13,552	500	44.8	46.6	1.7	3.8
	Sharqiah	44439	65,196	20,757	156.0	228.8	72.8	46.7
	Ismailia	1754	1,808	54	5.8	6.0	0.2	3.1
	Qalyubia	2399	4,995	2,596	8.6	17.9	9.3	108.2
Sakha102	Beheira	2903	4,682	1,779	10.6	17.0	6.5	61.3
	Kafr El Sheikh	7842	8,029	188	32.0	32.8	0.8	2.4
	Sharqiah	4282	10,382	6,100	14.7	35.6	20.9	142.5
	Dakahlia	691	691	0	2.9	2.9	0.0	0.0
سخا105	Beheira	3438	5,954	2,516	12.7	22.0	9.3	73.2
	Gharbiah	3031	5,516	2,486	11.1	20.2	9.1	82.0
	Kafr El Sheikh	9817	14,806	4,989	39.2	59.1	19.9	50.8
	Dakahlia	4685	6,506	1,821	19.1	26.6	7.4	38.9
	Damietta	480	490	11	1.6	1.7	0.0	2.2
	Sharqiah	5273	14,432	9,159	18.5	50.5	32.1	173.7
Sakha103	Dakahlia	1523	2,645	1,123	6.4	11.1	4.7	73.7
	Damietta	432	523	92	1.5	1.8	0.3	21.2
Sakha108	Kafr El Sheikh	13797	27,374	13,577	55.3	109.7	54.4	98.4
	Sharqiah	6395	12,166	5,771	21.3	40.6	19.2	90.2
	Gharbiah	7419	7,419	0	31.0	31.0	0.0	0.0
سخا106	Beheira	7606	9,285	1,679	27.9	34.0	6.2	22.1
	Kafr El Sheikh	8657	10,295	1,639	35.0	41.6	6.6	18.9
	Dakahlia	8915	13,325	4,410	36.1	54.0	17.9	49.5
	Sharqiah	4931	9,616	4,686	17.4	33.9	16.5	95.0
Giza171	Sharqiah	1626	3,941	2,315	5.5	13.4	7.9	142.3
Giza178	Beheira	7382	11,340	3,958	26.9	41.3	14.4	53.6
	Gharbiah	7584	10,090	2,506	28.7	38.2	9.5	33.0
	Kafr El Sheikh	73137	104,422	31,285	289.6	413.4	123.9	42.8
	Dakahlia	165963	167,040	1,077	658.2	662.5	4.3	0.6
	Damietta	28552	26,271	-2,282	95.1	87.5	-7.6	-8.0
	Sharqiah	76314	1,646	-74,668	251.9	5.4	-246.5	-97.8
	Ismailia	756	572	-184	2.4	1.8	-0.6	-24.3
	Qalyubia	131	155	25	0.4	0.5	0.1	18.8
Giza179	Beheira	2153	3,540	1,388	8.0	13.2	5.2	64.5
	Dakahlia	14110	21,405	7,295	58.7	89.1	30.4	51.7
	Sharqiah	2839	5,617	2,778	10.1	19.5	9.4	92.5

	Gharbiah	849	1,707	858	3.1	6.3	3.2	101.1
	Qalyubia	168	168	0	0.6	0.6	0.0	0.0
	Damietta	55	55	0	0.2	0.2	0.0	0.0
Giza177	Beheira	50905	60,021	9,117	186.3	219.7	33.4	17.9
	Kafr El Sheikh	66475	25,496	-40,979	261.3	100.2	-161.1	-61.6
	Damietta	4413	5,099	686	15.5	17.9	2.4	15.5
	Sharqiah	17917	23,127	5,210	62.7	80.9	18.2	29.1
	Ismailia	504	560	57	1.7	1.9	0.2	11.2
سوبر 300	Gharbiah	5420	10,831	5,411	20.5	41.0	20.5	99.8
	Kafr El Sheikh	894	1,068	175	3.6	4.3	0.7	19.5
Sakha107	Beheira	2462	5,444	2,982	9.0	19.9	10.9	121.1
	Kafr El Sheikh	2045	2,534	489	8.2	10.1	2.0	23.9
	Sharqiah	2501	4,992	2,491	8.3	16.6	8.3	99.6
Total		1,254,689	1,254,688	-1	4737.1	4769.8	32.7	1

Source: Linear programming results using WinQSB2.0

Conclusions:

Main findings and recommendations:

- The area of rice crop in Egypt ranged between 858.7 thousand Acers in 2018 as a minimum, after the decision of the Minister of Water Resources to reduce the areas of rice crop in order to reduce water consumption and about 1472.1 thousand Acers in 2012 as a maximum. The average productivity of rice crop in Egypt was about 3.886 tons / fedden during the study period and ranged between 3.635 tons / fedden in 2018 as a minimum and about 4.028 tons / fedden in 2014 as a maximum. The average production of rice crop in Egypt amounted to about 4955.6 thousand tons during the study period and ranged between 3121.9 thousand tons as a minimum in 2018, and about 5896.6 thousand tons in 2012 as a maximum.
- The governorates of Lower Egypt are considered one of the most cultivated governorates for the rice crop, which represents about 95.5% of the total area of rice in Egypt, and the average productivity of an fedden is about 3.755 Tons / Fedden with an average production of about 4504.8 thousand tons during (2016-2020). Rice production was concentrated in five governorates: Dakahlia, Sharqia, Kafr El-Sheikh, Beheira, and Gharbia.
- Dakahlia Governorate ranks first in rice production with an area of 345.8 thousand Acers, representing about 28.8% of the total area of rice in Egypt, with an average productivity of about 3.959 tons / Acers.
- The Giza 178 variety is the most cultivated rice crop in Egypt with an area that represents about 31.4% of the total area of the rice crop in Egypt, which is about 1202.2 thousand Acers, and the productivity of this variety is about 3.726 tons / Acers, and its average production represents about 31.2% of the total rice production in Egypt.
- The analysis of the variance between the fedden productivity of rice crop species indicates that there are statistically significant differences in the impact of cultivated rice species on the fedden productivity of these species, and by estimating the analysis of the value of the lowest significant difference LSD, it was found that the Sakha 107 variety comes in first place in terms of average productivity per fedden, as its productivity reached about 4.017 tons / fedden during the average period (2016-2020) and statistically significantly superior to most species.
- Using the Harryair coefficient and Roles, it was found after modifying the class composition and replacing the high-productivity species Sakha 107, Sakha 105, and Sakha 106 with the low-productivity species, as this results in increasing the fedden productivity to about 3.990 tons / fedden using the same cultivated area, which leads to an increase in the transfer coefficients in the supply function of the species Giza 179, Sakha 104, Sakha 101, Giza 177, Giza 178, Super 300, Sakha 108, Sakha 102, and Sakha 103 with a transfer coefficient of about 0.4%, 2.9% , 5.6%, 3.5%, 6.3%, 0.21%, 0.7%, 0.4% and 0.07% each, respectively, led to an increase in production achieved from about 4.829 million tons to about 4.950 million tons, an increase estimated at about 120.3 thousand tons, equivalent to about 2.5% of the actual production.
- One of the results of linear programming for most of the net return is the scenario of deleting a constraint less than the maximum area that the net return reached about 5.1 billion pounds, an increase of about 1.3 billion pounds over the current net return, with the provision of about an fedden, while the scenario of all restrictions reached the net return of about 4.1 billion pounds and an increase estimated at about 165.1 million pounds, with the provision of about an fedden.
- While one of the results of linear programming for most of the production is the scenario of deleting a constraint less than the maximum area, the successful

production reached about 4959 thousand tons, an increase of about 221 thousand tons over the current production, with the provision of an fedden, while the scenario of all restrictions The successful production reached about 4769.8 thousand tons, an increase of about 32.7 thousand tons over the current production, with the provision of an fedden.

Recommendations:

- Work to increase the production of improved seeds of rice species (Sakha 107, Sakha 105, Sakha 106) and replace them with low production species.
- Improving the efficiency of the distribution of seeds of rice species (Sakha 107, Sakha 105, Sakha 106) through the multiplicity of distribution outlets at the level of rice-growing governorates, such as agricultural cooperative societies scattered in villages.
- Activating the role of agricultural extension by communicating with farmers through the work of extension seminars and field work days to educate farmers to cultivate high-productivity species such as (Sakha 107, Sakha 105, Sakha 106), and replace them with low-productivity species in the regions or governorates where the cultivation of these species is good.
- Attention to the work of periodic varietal maps of the rice crop to know the most productive species in order to increase production with the optimal use of resources.

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Appendix (1): Evolution of the most important productivity variables of rice crop during the period (2010-2020)
Years Production Area Farm Price Total Revenue Total Costs Net Return

Years	*Area*	*Production*	*Production*	*Farm Price*	*Total Revenue*	*Total Costs*	*Net Return*
	K Feddens	**Ton/Feddens**	**K Tons**	**Pound/Feddens**	**Pound/Feddens**	**Pound/Feddens**	**Pound/Feddens**
2010	1093.3	3.958	4327.1	1837	7503	4073	3430
2011	1409.2	4.020	5665.4	2008	8340	4423	3917
2012	1472.1	4.005	5896.6	2067	8568	4948	3620
2013	1419.4	4.028	5717.1	2110	8786	5205	3581
2014	1363.8	4.004	5460.8	2130	8829	5465	3364
2015	1215.8	3.963	4818.0	2136	8757	5809	2948
2016	1353.3	3.923	5308.2	2268	9196	6805	2391
2017	1307.1	3.793	4957.6	3500	13580	8359	5221
2018	858.7	3.635	3121.9	3552	13233	10475	2758
2019	1303.6	3.681	4798.3	3556	13437	9678	3759
2020	1188.5	3.737	4441.0	3565.0	13682.0	7793.0	3275.0
Average	**1271.3**	**3.886**	**4955.6**	**2611.7**	**10355.5**	**6639.4**	**3478.5**

Source: Ministry of Agriculture and Land Reclamation, Economic Affairs Sector, Central Administration for Agricultural Economics, Agricultural Statistics Bulletin, Miscellaneous issues.

Appendix (2) : Relative Importance of Area (Thousand feddens) and Productivity (Ton/fedden) of Rice Crop by Governorates during the Period (2016-2020)

Arrange provinces in descending order according to area				Province order in descending order according to productivity				Arrange provinces in descending order according to area				Province order in descending order according to productivity			
vaniti	**Governo**	**Are**	**%**	**vaniti**	**Governo**	**Producti**	**%**	**vaniti**	**Governo**	**Ar**	**%**	**vaniti**	**Governo**	**Producti**	**%**
Giza178	Dakahlia	182	46	**Giza178**	Dakahlia	4.151	10	**Sakha105**	Kafr El-	9.9	30	**Sakha105**	Dakahlia	4.236	11
	Kafr El-	79.	20		Kafr El-	3.875	10		Sharkia	8.5	26		Kafr El-	4.008	10
	Sharkia	70.	18		Sharkia	3.439	89		Dakahlia	6.8	21		Beheira	3.724	97
	Total	**395**	**10**		Total	3.849	10		Beheira	4.7	14		Gharbia	3.589	93
Sakha101	Sharkia	98.	29	**Sakha101**	Dakahlia	4.097	10		Gharbia	4.3	13		Sharkia	3.566	93
	Dakahlia	94.	28		Kafr El-	4.087	10		**Total**	**32.**	**10**		Total	3.844	10
	Gharbia	54.	16		Sharkia	3.863	99	**Sakha102**	Kafr El-	6.9	45	**Sakha102**	Dakahlia	4.194	11
	Beheira	46.	14		Beheira	3.829	99		Beheira	5.6	37		Kafr El-	4.056	11
	Kafr El-	27.	8		Gharbia	3.667	94		Sharkia	4.8	31		Beheira	3.691	10
	Total	**337**	**10**		Total	3.886	10		Al-	0.9	6		Sharkia	3.504	96
Giza177	Kafr El-	76	36	**Sakha177**	Dakahlia	4.040	10		Dakahlia	0.7	5		Al-	3.220	88
	Beheira	52	24		Kafr El-	3.867	10		**Total**	**15.**	**10**		Total	3.644	10
	Dakahlia	32	15		Beheira	3.672	98	**Sakha107**	Beheira	3.6	57	**Sakha107**	Dakahlia	4.333	10
	Gharbia	24	11		Sharkia	3.526	94		Kafr El-	1.9	30		Gharbia	4.165	10
	Sharkia	20	9		Gharbia	3.462	92		Dakahlia	1.6	26		Kafr El-	3.997	96
	Damietta	5	2		Damietta	3.359	90		Gharbia	0.5	7		Beheira	3.949	95
	Total	**212**	**10**		**Total**	3.751	10		**Total**	**6.3**	**10**		Total	4.144	10
Sakha104	Sharkia	43.	23	**Sakha104**	Dakahlia	4.180	10	**Giza171**	Sharkia	2.3	74	**Giza171**	Gharbia	3.531	10
	Kafr El-	41.	22		Kafr El-	4.046	10		Al-	0.6	19		Al-	3.399	10
	Dakahlia	40.	22		Sharkia	3.660	96		Gharbia	0.3	11		Sharkia	3.313	99
	Beheira	24.	13		Beheira	3.634	95		Ismailia	0.3	8		Ismailia	3.000	90
	Gharbia	19.	10		Gharbia	3.519	92		**Total**	**3.2**	**10**		**Total**	3.335	10
	Damietta	12.	6		Damietta	3.321	87	**Sakha103**	Gharbia	1.8	56	**Sakha103**	Dakahlia	3.975	10
	Total	**188**	**10**		Total	3.824	10		Dakahlia	1.3	41		Al-	3.526	97
Sakha106	Dakahlia	12.	29	**Sakha106**	Dakahlia	4.211	10		Beheira	1.1	36		Gharbia	3.389	93
	Kafr El-	10.	26		Kafr El-	4.011	10		Al-	0.5	15		Damietta	3.320	91
	Beheira	7.9	19		Beheira	3.708	96		Damietta	0.2	7		Beheira	3.300	90
	Sharkia	6.2	15		Gharbia	3.637	94		**Total**	**3.1**	**10**		Total	3.652	10
	Gharbia	4.0	9		Sharkia	3.541	91	**Mongrel 1**	Sharkia	0.3	44	**Mongrel 1**	Dakahlia	5.108	11
	Total	**41.**	**10**		Total	3.879	10		Dakahlia	0.2	36		Beheira	4.430	96
Giza179	Kafr El-	21.	56	**Giza179**	Kafr El-	3.908	98		Beheira	0.2	26		Sharkia	4.270	93
	Dakahlia	16.	42		Beheira	3.776	95		Gharbia	0.1	9		Gharbia	4.113	89
	Beheira	5.8	15		Sharkia	3.555	89		**Total**	0.8	10		**Total**	4.601	10
	Sharkia	5.3	14		Al-	3.298	83	**jasmine**	Damietta	0.2	28	**jasmine**	Dakahlia	3.750	10
	Al-	2.7	7.		Damietta	3.298	83		Dakahlia	0.0	7		Damietta	3.502	95
	Damietta	2.70	7.0		**Total**	3.985	100		**Total**	0.08	100		**Total**	3.667	100
		38.9	**100**		Kafr El-Sheikh	3.908	98								

Source: Collected and calculated by the Ministry of Agriculture and Land Reclamation, Economic Affairs Sector, Agricultural Statistics Bulletins, during the period.

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