المجلة المصرية للاقتصاد الزراعي

الآثار الإقتصادية لآليات التأقلم للجفاف بالساحل الشمالي الغربي لمصر

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بيانات البحث	المستخلص

يعد التركيب المحصولي أحد أهم الآليات الرئيسية للتأقلم للجفاف والحد من الآثار الإقتصادية والإجتماعية له، لذا وبإستخدام نموذج البرمجة الخطية للتعرف علي التركيب المحصولي الأمثل للساحل الشمالي الغربي بوجه عام ولمحافظة مطروح علي وجه التحديد في ظل هدفي تدني الموارد المائية المتاحة، وتعظيم العائد من المحاصيل المنزرعة وجد أن:

1. التركيب المحصولي المقترح في ظل ظروف تدني الموارد المائية المتاحة يؤدي لإنخفاض كمية مياه الري اللازمة للتركيب المحصولي المقترح بمقدار 5.94 مليون م^3، ويحقق إجمالي عائد قدر بنحو 1270.48 مليون جنيه، ويحتاج إلي حوالي 2157 ألف عامل زراعي.

2. التركيب المحصولي المقترح في ظل هدف تعظيم العائد من المحاصيل يحقق زيادة في العائد بمقدار 55.98 مليون جنيه ويحتاج إلي حوالي 450.95 مليون م^3 من مياه الري، ونحو 2157 ألف عامل زراعي.

وبإفتراض سيناريوهات التركيب المحصولي الأمثل عند حدوث الجفاف وجد أن:

1. التركيب المحصولي المقترح في ظل هدف تعظيم العائد من المحاصيل وبإفتراض نقص الموارد المائية المتاحة بنسبة 10% يحقق زيادة في العائد بمقدار 55.94 مليون جنيه، ويحتاج إلي حوالي 405.85 مليون م^3 من مياه الري، ونحو 2157 ألف عامل زراعي.

2. التركيب المحصولي المقترح في ظل هدف تعظيم العائد من المحاصيل وبإفتراض نقص الموارد المائية المتاحة بنسبة 20% يحقق زيادة في العائد بمقدار 55.81 مليون جنيه ويحتاج إلي حوالي 360.76 مليون م^3 من مياه الري، ونحو 2157 ألف عامل زراعي.

وتوصي الدراسة بإعادة النظر في التركيب المحصولي لمحافظة مطروح وفقاً للسيناريوهات المقترحة في حالة حدوث الجفاف وفقاً لما توصلت إليه الدراسة.

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The Economic Impacts of Drought Mitigation Mechanisms in the Northwestern Coast of Egypt

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A R T I C L E I N F O

A B S T R A C T

The crop pattern is one of the most important mechanisms for drought mitigation and limitation of its economic and social effects. Therefore, using the linear programming model is an excellent option in order to identify the optimal crop pattern for the Northwestern Coast in general and in particular for Matrouh Governorate, where irrigation water scarcity is dominant, and maximizing the revenues from crops. Results indicated that:

1. The proposed cropping pattern under conditions of irrigation water scarcity led to a decrease in the required amount of irrigation water for the proposed agricultural pattern by 5.94 million m^3, to achieve a total return estimated at 1270.48 million Egyptian pounds using 2157 thousand agricultural manpower unit in the productivity process.
2. The proposed cropping pattern, in light of the objective of maximizing the revenue of crops, achieves an increase in revenue by 55.98 million LE and requires 450.95 million m^3 of irrigation water, and each needs 2157 thousand agricultural manpower unit.

 Assuming the most appropriate cropping pattern scenarios when drought occurs, it was found that:
1. The proposed cropping pattern in light of the objective of maximizing the revenue of crops and assuming a shortage of water resources by 10%, achieves an increase in revenue by 55.94 million LE, and it needs 405.85 million cubic meters of irrigation water, and 2157 thousand agricultural manpower unit in the productivity process
2. The proposed cropping pattern in light of the objective of maximizing the revenue of crops and assuming a shortage of water resources by 20%, achieves an increase in revenue by 55.81 million LE and requires 360.76 million m^3 of irrigation water, and 2157 thousand agricultural manpower unit.

The study recommends reconsidering the cropping pattern of Matrouh Governorate according to the proposed scenarios under the drought disaster existence that the study dealt with.

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Introduction:

Drought is one of the most important environmental challenges for the Arab region, particularly Egypt that is located in the hyper arid and arid regions. Given the fact that all the Arab water resources come from outside the Arab region itself, therefore the negative effects of this phenomenon are magnified.

Drought is defined as a critical state of climate change, and it has successive types in its occurrence, namely climatic drought, water drought, agricultural drought, and economic and social drought. (**Egyptian National Drought Mitigation Plan, 2019**).

The agricultural sector in Egypt is one of the most important sectors in the national economy, as it is the main driver of other economic sectors. Yet the drought phenomenon has direct negative impacts on it, particularly in the desert areas, such as the "Northwestern Coast of Egypt", the phenomenon of drought is severe, consequently the local authorities and farmers have to follow various means of action in order to secure irrigation water resources to be delivered to the agricultural land, as well as follow a national strategy for drought mitigation and ensure the sustainable use of the available environmental resources including the water resources ,targeting minimization of the economic negative effects of the phenomenon besides maximization of the economic revenues from the land unit.

Problem Statement:

Egypt is witnessing a noticeable decrease in the Nile water revenues in recent years by the mean of Hydrological drought. Meanwhile, the northwestern coast is experiencing severe metrological drought, where the most optimistic precipitation average ranges between 105 mm^3/year in El-Salloum and 199.6 mm^3/year in Alexandria.

These conditions are lower than the 40% of the historical percent of normal index for this region, and by 56% of the global average, which starts at 250 cubic mm/ year. These challenging conditions are negatively affecting the availability of many agricultural commodities.

Objectives of the study:

The study mainly aimed to study and identify mechanisms and develop some potential economic scenarios for drought crisis mitigation, by identifying the optimal cropping pattern in the northwestern coast in general and in Matrouh Governorate in particular, in light of: a. Decreased water resources used to irrigate crops, b. Maximizing the revenue of crops by crop pattern.

Materials and Method:

The research relied on the use of the descriptive analysis method, such as arithmetic mean and percentages, in addition to some operations research tools represented in the linear programming method to reach the optimal crop pattern that achieves the economic use of agricultural resources available in Matrouh Governorate, to achieve two objectives during the period (2015 – 2019); The first: the optimal crop pattern under the unavailability (or minimizing) of irrigation water resources; The second: maximizing the revenue from crops under these severe conditions; assuming two scenarios for the crises as irrigation water scarcity by 10% and 20%, respectively and in the light of the default determinants of the linear programming.

Components of a linear programming model. (Raihan, 2021).

First: The unavailability of irrigation water resources:

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

When:

W:	The total amount of irrigation water available.
$W_1, W_2, \ldots, W_n$:	The total amount of irrigation water for each of the crops included in the model.
$X_1, X_2, \ldots, X_n$:	The total activities included in the model that determine the value or amount of W, which is not negative, and whose value is required to be obtained under the following constraints:

$$C_1 \rightarrow X_1 + X_2 + \ldots + X_n \geq L$$

When:

C_1:	The first constraint represents the total cropped area in feddan.
$X_1, X_2, \ldots, X_n$:	Total crops included in the model.
L:	The agricultural area available for cultivated crops.

$$C_2 \rightarrow a_1 X_1 + a_2 X_2 + \ldots + a_n X_n \geq R$$

When:

C_2:	The second constraint represents the expected total revenue.
$a_1, a_2, \ldots, a_n$:	The revenue of each of the crops included in the model.
$X_1, X_2, \ldots, X_n$:	Total crops included in the model.
R:	Total revenue.

$$C_3 \rightarrow b_1 X_1 + b_2 X_2 + \ldots + b_n X_n \geq E$$

When:

C_3:	The third constraint is related to the activities' needs of agricultural Employment.
$b_1, b_2, \ldots, b_n$:	Employment needs for each of the crops included in the model.
$X_1, X_2, \ldots, X_n$:	Total crops included in the model.
E:	Available from agricultural Employment.

$$C_4 \rightarrow X_1, X_2, \ldots, X_n \geq \text{Zero} \rightarrow \text{Non-negative constraint.}$$

Second: The objective of maximizing the revenue of crops:

$$\text{Max} \sum_{i=1}^{n} Z_i X_i$$

When:

Z_i:	Total expected revenue.
$Z_1, Z_2, \ldots, Z_n$:	The total expected net revenue of the crops in the model.
$X_1, X_2, \ldots, X_n$:	The total crops included in the model, which determine the value or amount of Z, which is not negative, and whose value is required under the following constraints:

$$C_1 \rightarrow X_1 + X_2 + \ldots + X_n \leq L$$

When:

C_1:	The first constraint represents the total cropped area in feddan.
$X_1, X_2, \ldots, X_n$:	Total crops included in the model.
L:	The agricultural area available for cultivated crops.

$$C_2 \rightarrow a_1 X_1 + a_2 X_2 + \ldots + a_n X_n \leq W$$

When:

C_2:	The second constraint is related to the irrigation water needs of crops
$a_1, a_2, \ldots, a_n$:	Water requirements for each of the crops included in the model.
$X_1, X_2, \ldots, X_n$:	Total crops included in the model.
W:	Available water resources.

$C_3 \rightarrow b_1X_1 + b_2X_2 + \ldots + b_nX_n \geq E$

When:

C_3:	The third constraint is related to the activities' needs of agricultural Employment.
$b_1, b_2, \ldots, b_n$:	Employment needs for each of the crops included in the model.
$X_1, X_2, \ldots, X_n$:	Total crops included in the model.
E:	Available from agricultural Employment.

$C_4 \rightarrow X_1, X_2, \ldots, X_n \geq$ Zero $\rightarrow$ Non-negative constraint.

Data sources:

The study relied on published and unpublished secondary data issued by some governmental agencies to obtain the necessary statistical data for the study, such as the Central Agency for Public Mobilization and Statistics, the Economic Affairs Sector, and the Ministry of Agriculture and Land Reclamation.

Results and Discussion

First: Getting to know the existing "actual" crop pattern:

Table (1) shows the cultivated area, the average revenue for each crop, the total revenue for the cultivated area, the water ration, and the Employment needed for crops of the crop pattern. From the table it is clear that:

- **The total area cultivated with the crop pattern is 176604 feddan, divided into:**

    A. The area of the winter crops reached 45696.40 feddan. Wheat ranked first with an area of 15992.80 feddan with a percentage of 9.02%, while barley ranked last with an area of 365.20 feddan with a percentage of 0.21%.
    B. The area of summer crops reached 30020.60 feddan, in which tomato ranked first with an area of 18462 feddan with a rate of 10.45%, while pepper ranked last with an area of 983.80 feddan with a percentage of 0.56%.
    C. The area of date palms and fruit trees reached 100887 feddan, where fig trees ranked first with an area of 60236.40 feddan with a rate of 34.11%, while date Palms ranked last with an area of 8671 feddan with a percentage of 4.91%.

- **The total revenue from the crop pattern is 1270.45 million LE, divided into:**

    A. The revenue from winter crops reached 496.09 million LE, in which the revenue from tomato ranked first with 257.18 million LE, while the revenue from barley ranked last with 760 thousand LE with a rate of 0.01%.
    B. The revenue of summer crops reached 69.97 million LE, in which the revenue from tomato ranked first with 37.60 million LE, while the revenue from peppers ranked last with 5.42 million LE.
    C. The revenue from date palms and fruit trees amounted to 704.42 million LE, in which the revenue from date palms ranked first with 258.89 million LE, while the revenue from figs ranked last with 205.04 million LE.

- **The irrigation water requirements classified by crop pattern is 450.95 million m³ divided into:**

A. 97.61 million m^3 to irrigate winter crops, in which sustainable alfalfa ranked the first with 30.44 million m^3, while barley ranked the last with 520 thousand m^3.

B. 115.23 million m^3 to irrigate summer crops, in which tomato ranked the first with 77.08 million m^3, while the potatoes ranked last with 2.87 million m^3.

C. 238.10 million m^3 to irrigate date palms and fruit trees, in which olive trees ranked the first with 143.91 million m^3, while figs trees ranked the last with 42.16 million m^3.

- **The total manpower classified by the crop pattern is 2157 thousand agricultural workers, divided into:**

A. 1159 thousand workers for winter crops, in which perennial clover ranked first with 545 thousand workers, while barley ranked last with 21 thousand workers.

B. 695 thousand workers for summer crops, in which tomato ranked the first with 369 thousand workers, and peppers ranked the last with 20 thousand workers.

C. 303 thousand workers for date palms and fruit trees, in which figs ranked the first with 181 thousand workers, while Date Palms ranked the last with 26 thousand workers.

Table (1): The average cultivated area, the average and total revenue, the water rate, and the Employment needed for the "actual" existing crop pattern in Matrouh Governorate for the average period (2015 – 2019).

Crop	A. Cultivated Area (Feddan)[1]	%	A. Revenue (LE/Feddan)[2]	T. Revenue (Million LE)	Rated Water (m3/Feddan)[3]	T. rated water (million m^3)	Employment (worker/Feddan)[4]	T. Manpower (thousand workers)
Wheat (X_1)	15922.80	9.02	3208.40	51.09	1897.80	30.22	20	318
Barley (X_2)	365.20	0.21	2079.40	0.76	1401.60	0.52	19	6
Faba Beans (X_3)	4124.80	2.34	4207.60	17.36	1575.20	6.49	5	21
Perennial Clover (X_4)	11837.60	6.70	13225.20	156.55	2571.80	30.44	46	545
Tomato (X_5)	11671.20	6.61	22035.40	257.18	2260	26.38	20	233
Potato (X_6)	1775	0.99	7414.20	13.16	2008	3.56	20	36
Total Winter Season	**45696.40**	**25.87**	**52170.20**	**496.09**	**11714.40**	**97.61**	**130**	**1159**
Maize (X_7)	9443	5.35	2147	20.27	3312	31.27	30	283
Tomato (X_8)	18462	10.45	2036.60	37.60	4175	77.08	20	369
Potato (X_9)	1131.80	0.65	5893.80	6.67	2541	2.87	20	23
Pepper (X_{10})	983.80	0.56	5511.20	5.42	4071	4.01	20	20
Total Summer Season	**30020.60**	**17**	**15588.60**	**69.97**	**14099**	**115.23**	**90**	**695**
Date Palms (X_{11})	8671	4.91	29856.60	258.89	6000	52.03	3	26
Olive Trees (X_{12})	31979.60	18.11	7520	240.49	4500	143.91	3	96
Fig Trees (X_{13})	60236.40	34.11	3404	205.04	700	42.16	3	181
Total Date Palms and Fruit Trees	**100887**	**57.13**	**40780.60**	**704.42**	**11200**	**238.10**	**9**	**303**
Total Amount	**176604**	**100**	**108539.40**	**1270.48**	**37013.40**	**450.95**	**229**	**2157**

Source: Compiled and calculated from:

1. Data of the annual bulletin for the statistics of crop areas and plant production, the Central Agency for Public Mobilization and Statistics, miscellaneous issues.
2. Data of the annual bulletin of income estimates from agricultural production, the Central Agency for Public Mobilization and Statistics, miscellaneous issues.
3. Data of the Annual Bulletin of Irrigation and Water Resources Statistics, Central Agency for Public Mobilization and Statistics, miscellaneous issues.
4. Data of the annual bulletin of agricultural employment, the economic affairs sector, the Ministry of Agriculture and Land Reclamation, miscellaneous issues.

Second: The proposed cropping pattern under water scarcity conditions:

Table (2) shows the proposed cropping pattern under water scarcity conditions, where observations indicated that:

A. Winter season:

1. Decreasing in each of:

- Wheat cultivated area reached 2211.02 feddan with percent of decrease reached 1.26%, where the area cultivated with the existing pattern was 15992.80 feddan by 9.02%, while it became in the proposed pattern 13711.78 feddan by 7.76%.

- Perennial clover cultivated area reached 167.98 feddan with percent of decreases by 0.09%, where the cultivated area in the current pattern was (11837.60 feddan with percent 6.70%, while it became in the proposed pattern 11669.62 feddan with percent 6.61%.

2. Increase in each of:

- Barley cultivated area reached 414.80 feddan with percent of decreases by 0.23%, where the cultivated area was in the existing pattern was 365.20 feddan by 0.21%, while it became in the proposed pattern 780 feddan by 0.44%.

- Faba beans cultivated area reached 1123.20 feddan with percent of decreases by 0.63%, where the cultivated area in the existing pattern was 4124.80 feddan by 2.34%, while it became in the proposed pattern 5248 feddan by 2.97%.

- Tomato cultivated area reached 578.80 feddan with percent of decreases by 0.33%, where the cultivated area with the existing pattern was 1167.20 feddan by 6.61%, while it became in the proposed pattern 12250 feddan by 6.94%.

- Potato cultivated area reached 262 feddan with percent of decreases by 0.14%, where the planted area with the existing pattern was 1775 feddan by 1.01%, while it became in the proposed pattern 2037 feddan by 1.15%.

B. Summer season:

1. Decrease the area of tomato by 2313 feddan with a percent of 1.31%, where the planted area with the existing pattern was 18462 feddan by 10.45%, while it became in the proposed pattern 16149 feddan by 9.14%.

2. Increase the area of:

- Maize to reach 2160 feddan by 1.22%, where the planted area with the existing pattern was 9443 feddan by 5.35%, while it became in the proposed pattern 11603 feddan by 6.57%.

- Potato to reach 78.20 feddan by 0.32%, where the planted area with the existing pattern was 1131.80 feddan by 0.64%, while it became in the proposed pattern 1210 feddan by 0.69%.

- Pepper to reach 74.80 feddan by 0.04%, where the planted area with the existing pattern was 938.80 feddan by 0.56%, while it became in the proposed pattern 1058.60 feddan by 0.60%.

C. **Date Palms and Fruit Trees:**

1. **Decrease in the area of:**
   - Date palms by 385.45 feddan by 0.22%, where the planted area with the existing pattern was 8671 feddan by 4.91%, while it became in the proposed pattern 8285.52 feddan by 4.69%.
   - Olive trees by 382.12 feddan by 0.22%, where the planted area with the existing pattern was 31979.60 feddan by 18.11%, while it became 31597.48 feddan by 17.89%.

2. **Increase in the area of** fig trees by 767.60 feddan by 0.44%, where the planted area with the existing pattern was 60236.40 feddan by 34.11%, while it became in the proposed pattern 61004 feddan by 34.54%.

Table (2): The existing crop pattern and the proposed cropping pattern in light of the low available water resources resulting from the basic model for the average period (2015 – 2019) in Matrouh Governorate.

Crop	Current Pattern		Proposed Pattern		Amount of change (Feddan)	percentage change (%)
	Area (Feddan)	%	Area (Feddan)	%		
Wheat (X_1)	15922.80	9.02	13711.78	7.76	-2211.02	-1.26
Barley (X_2)	365.20	0.21	780	0.44	414.80	0.23
Faba Beans (X_3)	4124.80	2.34	5248	2.97	1123.20	0.63
Perennial Clover (X_4)	11837.60	6.70	11669.62	6.61	-167.98	-0.09
Tomato (X_5)	11671.20	6.61	12250	6.94	578.80	0.33
Potato (X_6)	1775	1.01	2037	1.15	262	0.14
Total Winter Season	**45696.40**	**25.87**	**45696.40**	**25.87**	**-**	**-**
Maize (X_7)	9443	5.35	11603	6.57	2160	1.22
Tomato (X_8)	18462	10.45	16149	9.14	-2313	-1.31
Potato (X_9)	1131.80	0.64	1210	0.69	78.20	0.32
Pepper (X_{10})	983.80	0.56	1058.60	0.60	74.80	0.04
Total Summer Season	**30020.60**	**17**	**30020.60**	**17**	**-**	**-**
Date Palms (X_{11})	8671	4.91	8285.52	4.69	-385.48	-0.22
Olive trees (X_{12})	31979.60	18.11	31597.48	17.89	-382.12	-0.22
Fig trees (X_{13})	60236.40	34.11	61004	34.54	767.6	0.44
Total Date Palms and Fruit Trees	**100887**	**57.13**	**100887**	**57.13**	**-**	**-**
Total Amount	**176604**	**100**	**176604**	**100**	**-**	**-**

Source: Computer Results Using LINDO.

Each of the amounts of irrigation water, Revenue and Employment for the proposed pattern and their comparison with each of the amount of irrigation water, Revenue and Employment for the existing pattern has been calculated and the results were as shown in Table (3), where it was clear that:

- A decrease in the irrigation water requirements for the proposed cropping pattern by 5.94 million m^3 to become 445.01 million m^3 compared to the existing pattern 450.95 million m^3, as a result of:

  A. **Winter season:**
  1. Water consumption of wheat decreased to 26.02 million m^3 compared to 30.22 million m^3, and the perennial clover became 30.01 million m^3 compared to 30.44 million m^3 according to / as of the existing pattern or as referred to in the aforementioned / aforesaid pattern.
  2. Increase the water ration for barley to 1.09 million m^3 compared to 520 thousand m^3, tomato to 27.68 million m^3 compared to 26.38 million m^3,

and potato 4.09 million m^3 compared to 3.56 million m^3 (according to / as of) the existing pattern or as referred to in the (aforementioned / aforesaid) pattern.

B. Summer season:
1. Water rate of tomato decreased to 67.42 million m^3 compared to 77.08 million m^3 (according to / as of) the existing pattern or as referred to in the (aforementioned / aforesaid) pattern.
2. Increase the water rate of Maize to 38.43 million m^3 compared to 31.27 million m^3, potato to 3.07 million m^3 compared to 2.87 million m^3, and pepper to 4.31 million m^3 compared to 4.01 million m^3 (according to / as of) the existing pattern or as referred to in the (aforementioned / aforesaid) pattern

C. Date Palms and Fruit Trees:
1. Decrease in water rate of date palms to 49.71 million m^3 compared to 52.03 million m^3, and olive trees to 142.19 million m^3 compared to 143.91 million m^3 (according to / as of) the existing pattern or as referred to in the (aforementioned / aforesaid) pattern.
2. Increase in water rate for fig trees to become 42.71 million m^3 compared to 42.16 million m^3 (according to / as of) the existing pattern or as referred to in the (aforementioned / aforesaid) pattern

- Both the current pattern and proposed pattern achieved total revenue estimated at 1270.48 million LE.

- Both the current and proposed pattern requires 2157 thousand manpower / labor / workforce.

Table (3): Crop area, water ration, total Revenue and employment for different crops with the current crop pattern and proposed pattern, resulting from the basic model since lack of water resources during (2015 – 2019) in Matrouh Governorate.

Crop	Current Pattern					Proposed Pattern				
	Area (Feddan)	%	Revenue (M. LE)	Water Rate (M. m³)	Employment (thousand workers)	Area (Feddan)	%	Revenue (M. LE)	Water Rate (M. m³)	Employment (thousand workers)
Wheat (X₁)	15922.80	9.02	51.09	30.22	318	13711.78	7.76	43.99	26.02	274
Barley (X₂)	365.20	0.21	0.76	0.52	6	780	0.44	1.62	1.09	15
Faba Beans (X₃)	4124.80	2.34	17.36	6.49	21	5248	2.97	22.08	8.27	26
Perennial Clover (X₄)	11837.60	6.70	156.55	30.44	545	11669.62	6.61	154.33	30.01	537
Tomato (X₅)	11671.20	6.61	257.18	26.38	233	12250	6.94	269.93	27.68	245
Potato (X₆)	1775	0.99	13.16	3.56	36	2037	1.15	15.10	4.09	41
Total Winter Season	**45696.40**	**25.87**	**496.09**	**97.61**	**1159**	**45696.40**	**25.87**	**507.07**	**97.17**	**1138**
Maize (X₇)	9443	5.35	20.27	31.27	283	11603	6.57	24.91	38.43	348
Tomato (X₈)	18462	10.45	37.60	77.08	369	16149	9.14	32.89	67.42	323
Potato (X₉)	1131.80	0.65	6.67	2.87	23	1210	0.69	7.13	3.07	24
Pepper (X₁₀)	983.80	0.56	5.42	4.01	20	1058.60	0.60	5.83	4.31	21
Total Summer Season	**30020.60**	**17**	**69.97**	**115.23**	**695**	**30020.60**	**17**	**70.77**	**113.23**	**716**
Date Palms (X₁₁)	8671	4.91	258.89	52.03	26	8285.52	4.69	247.38	49.71	25
Olive Trees (X₁₂)	31979.60	18.11	240.49	143.91	96	31597.48	17.89	237.61	142.19	95
Fig Trees (X₁₃)	60236.40	34.11	205.04	42.16	181	61004	34.54	207.66	42.70	183
Total Date Palms and Fruit Trees	**100887**	**57.13**	**704.42**	**238.10**	**303**	**100887**	**57.13**	**692.65**	**234.61**	**303**
Total Amount	**176604**	**100**	**1270.48**	**450.95**	**2157**	**176604**	**100**	**1270.48**	**445.01**	**2157**

Source: Tables (1), (2).

The results obtained for the cropping pattern can be summarized in light of the low available water resources, as shown in Table (4):

Table (4): Results from comparing the current crop pattern and proposed crop pattern in light of the low availability of water resources.

Report	Current	Proposed	Change Amount
Crop area (feddan)	**176604**	**176604**	**-**
Quantity of water used to irrigate The cultivated area (million m³)	**450.95**	**445.01**	**5.94**
Net revenue on cultivated area (million LE)	**1270.48**	**1270.48**	**-**
Total employment in the cultivated area (thousand workers)	**2157**	**2157**	**-**

Source: Computer Results Using LINDO.

Third: The proposed crop pattern in light of the objective of maximizing the revenue of crops:

Table (5) shows the proposed crop pattern under the objective of maximizing the revenue of crops, as it was discovered / noticed that:

A. Regarding winter season :

1. **Decrease in** wheat area by 3203.28 feddan with 1.81% change rate, where the planted area with the current pattern was 15992.80 feddan with 9.02% change rate, while it became in the proposed pattern 12719.52 feddan with 7.20% change rate.

2. **Increasing the planted area regarding:**
   - Barley, by 414.80 feddan with 0.23%, where the cultivated area was in the current pattern 365.20 feddan with 0.21% change rate, while it became in the proposed pattern 780 feddan with 0.44% change rate.
   - Faba beans, by 1123.20 feddan with 0.63% change rate, where the planted area with the current pattern was 4124.80 feddan with 2.34% change rate, while it became in the proposed pattern 5248 feddan with 2.97% change rate.
   - Perennial clover, by 824.28 feddan with 0.47% change rate, where the cultivated area in the current pattern was 11837.60 feddan with 6.70% change rate, while it became in the proposed pattern 1661.88 feddan with 7.17% change rate.
   - Tomato, by 578.80 feddan with 0.33% change rate, where the planted area with the current pattern was 1167.20 feddan with 6.61% change rate, while it became in the proposed pattern 12250 feddan with 6.94% change rate.
   - Potato, by 262 feddan with 0.15% change rate, where the planted area with the current pattern was 1775 feddan with 1.01% change rate, while it became in the proposed pattern 2037 feddan with 1.15% change rate.

B. Regarding summer season :

1. The area of Maize decreased by 419.88 feddan with 0.24% change rate, where the planted area with the current pattern was 9443 feddan with 5.35% change rate, while it became in the proposed pattern 9023.12 feddan with 5.11% change rate.

2. **Increasing the planted area regarding:**
   - Tomato, by 65.48 feddan with 0.04% change rate, where the planted area with the current pattern was 18462 feddan with 10.45% change rate, while it became in the proposed pattern 18,527.48 feddan with 10.49% change rate.

- Potato, by 78.20 feddan with 0.04% change rate, where the planted area with the current pattern was 1131.80 feddan with 0.64% change rate, while it became in the proposed pattern 1210 feddan with 0.69% change rate.
- Pepper, by 767.60 feddan with 0.16% change rate, where the planted area with the current pattern was 938.80 feddan with 0.56% change rate, while it became in the proposed pattern 1260 feddan with 0.71% change rate.

C. Date Palms and Fruit Trees:
1. A decrease in the area of olive trees by 2424.60 feddan with 1.37% change rate, where the planted area with the current pattern was 31979.60 feddan with 18.11% change rate, while it became 29555 feddan with 16.73% change rate.

2. **Increasing the planted area regarding:**
- Date Palms, by 1657 feddan with 0.94% change rate, where the planted area with the current pattern was 8671 feddan with 4.91%, while it became in the proposed pattern 103282 feddan with 5.85% change rate.
- Fig trees, by 767.60 feddan with 0.43% change rate, where the planted area with the current pattern was 60236.40 feddan with 34.11%, while it became in the proposed pattern 61004 feddan with 34.54% change rate.

Table (5): The current crop pattern and the proposed crop pattern in light of maximizing the revenue of crops resulting from the basic model during the period of (2015 – 2019) in Matrouh Governorate.

Crop	Current Pattern		Proposed Pattern		Amount of change (Feddan)	percentage change (%)
	Area (Feddan)	%	Area (Feddan)	%		
Wheat (X_1)	15922.80	9.02	12719.52	7.20	-3203.28	-1.81
Barley (X_2)	365.20	0.21	780	0.44	414.80	0.23
Faba Beans (X_3)	4124.80	2.34	5248	2.97	1123.20	0.63
Perennial Clover (X_4)	11837.60	6.70	12661.88	7.17	824.28	0.47
Tomato (X_5)	11671.20	6.61	12250	6.94	578.80	0.33
Potato (X_6)	1775	1.01	2037	1.15	262	0.15
Total Winter Season	**45696.40**	**25.87**	**45696.40**	**25.87**	**-**	**-**
Maize (X_7)	9443	5.35	9023.12	5.11	-419.88	-0.24
Tomato (X_8)	18462	10.45	18527.48	10.49	65.48	0.04
Potato (X_9)	1131.80	0.64	1210	0.69	78.20	0.04
Pepper (X_{10})	983.80	0.56	1260	0.71	276.20	0.16
Total Summer Season	**30020.60**	**17**	**30020.60**	**17**	**-**	**-**
Date Palms (X_{11})	8671	4.91	10328	5.85	1657	0.94
Olive Trees (X_{12})	31979.60	18.11	29555	16.73	-2424.60	-1.37
Fig Trees (X_{13})	60236.40	34.11	61004	34.54	767.60	0.43
Total Date Palms and Fruit Trees	**100887**	**57.13**	**100887**	**57.13**	**-**	**-**
Total Amount	**176604**	**100**	**176604**	**100**	**-**	**-**

Source: Computer Results Using LINDO.

Each amount of irrigation water, Revenue and Employment for the proposed pattern and their comparison with each amount of irrigation water, Revenue and Employment for the current pattern has been calculated, the results were as referred to in Table (6), where it states:

- Increasing the revenue from crops for the proposed cropping pattern by 55.98 million LE to 1326.46 million LE, comparing to the current pattern by 1270.48 million LE, where:

A. Regarding winter season:

1. Increasing the revenues regarding :
- Barley, reached 1.09 million LE compared to 520 thousand LE with the current pattern.
- Faba beans, reached 22.08 million LE compared to 17.36 million LE with the current pattern.
- Perennial clover, reached 167.45 million LE compared to 156.55 million LE with the current pattern.
- Tomato, reached 269.93 million LE compared to 257.18 million LE with the current pattern.
- Potato, reached 15.10 million LE compared to 13.16 million LE with the current pattern.

2. Decrease the revenues of wheat to 40.81 million LE compared to 51.09 million LE with the current Pattern.

B. Regarding summer season:

1. Increasing the revenues regarding:
- Tomato, reached 37.73 million LE compared to 37.60 million LE with the current pattern.
- Potato, reached 7.13 million LE compared to 6.67 million LE with the current pattern.
- Pepper, reached 6.94 million LE compared to 5.42 million LE with the current pattern.

2. Decrease the revenues from Maize to become 19.37 million LE compared to 20.27 million LE with the current pattern.

C. Date Palms and Fruit Trees:

1. Increasing the revenues regarding:
- Date palms, reached 308.36 million LE compared to 258.89 million LE with the current pattern.
- Fig trees, reached 207.66 million LE compared to 205.04 million LE with the current pattern.

2. Decrease the revenue from Olive trees to reach 222.25 million LE compared to 240.49 million LE with the current pattern.

- Both the current pattern and the proposed pattern require 450.95 million m³ of irrigation water.

- Both the current and the proposed pattern require 2157 thousand manpower / labor / workforce.

Table (6): Crop area, water ration, total Revenue and employment for different crops with the current crop pattern and the proposed pattern resulting from the basic model in light of the goal of maximizing the revenue of crops during the period of (2015 – 2019) in Matrouh Governorate.

Crop	Current Pattern					Proposed Pattern				
	Area (Feddan)	%	Revenue (M. LE)	Water Rate (M. m³)	Employment (thousand workers)	Area (Feddan)	%	Revenue (M. LE)	Water Rate (M. m³)	Employment (thousand workers)
Wheat (X_1)	15922.80	9.02	51.09	30.22	318	12719.52	7.20	40.81	24.14	254
Barley (X_2)	365.20	0.21	0.76	0.52	6	780	0.44	1.62	1.09	15
Faba Beans (X_3)	4124.80	2.34	17.36	6.49	21	5248	2.97	22.08	8.27	26
Perennial Clover (X_4)	11837.60	6.70	156.55	30.44	545	12661.88	7.17	167.45	32.56	583
Tomato (X_5)	11671.20	6.61	257.18	26.38	233	12250	6.94	269.93	27.68	245
Potato (X_6)	1775	0.99	13.16	3.56	36	2037	1.15	15.10	4.10	41
Total Winter Season	**45696.40**	**25.87**	**496.09**	**97.61**	**1159**	**45696.40**	**25.87**	**517.01**	**97.84**	**1164**
Maize (X_7)	9443	5.35	20.27	31.27	283	9023.12	5.11	19.37	29.88	271
Tomato (X_8)	18462	10.45	37.60	77.08	369	18527.48	10.49	37.73	77.35	371
Potato (X_9)	1131.80	0.65	6.67	2.87	23	1210	0.69	7.13	3.08	24
Pepper (X_{10})	983.80	0.56	5.42	4.01	20	1260	0.71	6.94	5.13	25
Total Summer Season	**30020.60**	**17**	**69.97**	**115.23**	**695**	**30020.60**	**17**	**71.18**	**115.44**	**691**
Date Palms (X_{11})	8671	4.91	258.89	52.03	26	10328	5.85	308.36	61.97	31
Olive Trees (X_{12})	31979.60	18.11	240.49	143.91	96	29555	16.73	222.25	133	89
Fig Trees (X_{13})	60236.40	34.11	205.04	42.16	181	61004	34.54	207.66	42.70	183
Total Date Palms and Fruit Trees	**100887**	**57.13**	**704.42**	**238.10**	**303**	**100887**	**57.13**	**738.27**	**237.67**	**303**
Total Amount	**176604**	**100**	**1270.48**	**450.95**	**2157**	**176604**	**100**	**1326.46**	**450.95**	**2157**

Source: Tables (1), (5).

The results obtained for the crop pattern can be summarized in light of The goal of maximizing the revenues of crops, as referred to in Table (7):

Table (7): Results of comparing the current crop pattern and the proposed crop pattern in light of the goal of maximizing the revenues of crops.

Report	Current	Proposed	Change Amount
Crop area (feddan)	176604	176604	-
Quantity of water used to irrigate The cultivated area (million m³)	450.95	450.95	-
Net revenue on cultivated area (million LE)	1270.48	1326.46	55.98
Total employment in the cultivated area (thousand workers)	2157	2157	-

Source: Computer Results Using LINDO.

Fourth: Scenarios of optimal crop pattern when drought occurs:

i. **The proposed crop pattern under the objective of maximizing the revenues of crops and assuming a shortage of water resources by 10%:**

Table (8) shows the proposed crop pattern in light of the goal of maximizing the revenues of crops, assuming a shortage of water resources by 10%, i.e. 45.10 million m³, where it was found that:

A. **Regarding Winter season:**
1. **Decrease in** wheat area by 3203.28 feddan with 1.81% change rate, where the planted area with the existing pattern was 15992.80 feddan with 9.02% change rate, while it became in the proposed pattern 12719.52 feddan with 7.20% change rate.

2. Increasing in the area regarding:

- Barley, by 414.80 feddan with 0.23% change rate, where the cultivated area was in the current pattern 365.20 feddan with 0.21% change rate, while it became in the proposed pattern 780 feddan with 0.44% change rate.
- Faba beans, by 1123.20 feddan with 0.63% change rate, where the planted area with the current pattern was 4124.80 feddan with 2.34% change rate, while it became in the proposed pattern 5248 feddan with 2.97% change rate.
- Perennial clover, by 824.28 feddan with 0.47% change rate, where the cultivated area in the current pattern was 11837.60 feddan with 6.70% change rate, while it became in the proposed pattern 1661.88 feddan with 7.17% change rate.
- Tomato, by 578.80 feddan with 0.33% change rate, where the planted area with the current pattern was 1167.20 feddan with 6.61% change rate, while it became in the proposed pattern 12250 feddan with 6.94% change rate.
- Potato, by 262 feddan with 0.15% change rate, where the planted area with the existing pattern was 1775 feddan with 1.01% change rate, while it became in the proposed pattern 2037 feddan with 1.15% change rate.

B. Regarding Summer season:

1. Decrease the area of Maize by 419.88 feddan with 0.24% change rate, where the planted area with the existing pattern was 9443 feddan with 5.35% change rate, while it became in the proposed pattern 9023.12 feddan with 5.11% change rate.

2. Increasing in the area regarding:

- Tomato, by 65.48 feddan with 0.04% change rate, where the planted area with the current pattern was 18462 feddan with 10.45% change rate, while it became in the proposed pattern 18,527.48 feddan with 10.49% change rate.
- Potato, by 78.20 feddan with 0.0.04% change rate, where the planted area with the current pattern was 1131.80 feddan with 0.64% change rate, while it became in the proposed pattern 1210 feddan with 0.69% change rate.
- Pepper, by 267.20 feddan with 0.15% change rate, where the planted area with the current pattern was 938.80 feddan with 0.56% change rate, while it became in the proposed pattern 1260 feddan with 0.71% change rate.

C. Date Palms and Fruit Trees:

1. Decrease the area of olive trees by 2424.60 feddan with 1.37% change rate, where the planted area with the existing pattern was 31979.60 feddan with 18.11% change rate, while it became 29555 feddan with 16.73% change rate.

2. Increasing in the area regarding:
- Date palms, by 1657 feddan with 0.94% change rate, where the planted area with the current pattern was 8671 feddan with 4.91% change rate, while it became in the proposed pattern 103282 feddan with 5.85% change rate.
- Fig trees, by 767.60 feddan with 0.43% change rate, where the planted area with the current pattern was 60236.40 feddan with 34.11% change rate, while it became in the proposed pattern 61004 feddan with 34.54% change rate.

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Table (8): The current crop pattern and the proposed cropping pattern in light of maximizing the revenues of crops resulting from the basic model and assuming a shortage of water resources by 10% for the period of (2015 – 2019) in Matrouh Governorate.

Crop	Current Pattern		Proposed Pattern		Amount of change (Feddan)	percentage change (%)
	Area (Feddan)	%	Area (Feddan)	%		
Wheat (X_1)	15922.80	9.02	12719.52	7.20	-3203.28	-1.81
Barley (X_2)	365.20	0.21	780	0.44	414.80	0.23
Faba Beans (X_3)	4124.80	2.34	5248	2.97	1123.20	0.63
Perennial Clover (X_4)	11837.60	6.70	12661.88	7.17	824.28	0.47
Tomato (X_5)	11671.20	6.61	12250	6.94	578.80	0.33
Potato (X_6)	1775	1.01	2037	1.15	262	0.14
Total Winter Season	**45696.40**	**25.87**	**45696.40**	**25.87**	**-**	**-**
Maize (X_7)	9443	5.35	9023.12	5.11	-419.88	-0.24
Tomato (X_8)	18462	10.45	18527.48	10.49	65.48	0.04
Potato (X_9)	1131.80	0.64	1210	0.69	78.20	0.05
Pepper (X_{10})	983.80	0.56	1260	0.71	276.20	0.15
Total Summer Season	**30020.60**	**17**	**30020.60**	**17**	**-**	**-**
Date Palm (X_{11})	8671	4.91	10328	5.85	1657	0.94
Olive Trees (X_{12})	31979.60	18.11	29555	16.74	-2424.60	-1.37
Fig Trees (X_{13})	60236.40	34.11	61004	34.54	767.60	0.43
Total Date Palms and Fruit Trees	**100887**	**57.13**	**100887**	**57.13**	**-**	**-**
Total Amount	**176604**	**100**	**176604**	**100**	**-**	**-**

Source: Computer Results Using LINDO.

Each amount of irrigation water, Revenue and Employment for the proposed pattern and their comparison with each amount of irrigation water, Revenue and Employment for the current pattern has been calculated and the results were referred to in Table (9), where it states:

- Increasing the revenues from crops for the proposed crop pattern by 55.94 million LE to 1326.42 million LE, while it was with the current pattern 1270.48 million LE, where:

A. **Regarding Winter season:**

1. **Increasing the revenues regarding:**

   - Barley, to 1.62 million LE compared to 520 thousand LE with the current pattern.
   - Faba beans, to 22.08 million LE compared to 17.36 million LE with the current pattern.
   - Perennial Clover, to 167.45 million LE compared to 156.55 million LE with the current pattern.
   - Tomato, to 269.93 million LE compared to 257.18 million LE with the current pattern.
   - Potato, to 15.09 million LE compared to 13.16 million LE with the current pattern.

2. **Decrease the revenue from** wheat to 40.81 million LE compared to 51.09 million LE with the current Pattern.

B. **Regarding Summer season:**

1. **Increasing the revenues regarding:**

- Tomato, to 37.73 million LE compared to 37.60 million LE with the current pattern.
- Potato, to 7.13 million LE compared to 6.67 million LE with the current pattern.
- Pepper, to 6.94 million LE compared to 5.42 million LE with the current pattern.

2. **Decrease the revenue from** Maize to become 19.37 million LE compared to 20.27 million LE with the current pattern.

C. **Date Palms and Fruit Trees:**

1. **Increasing the revenues regarding:**

- Date palms, to 308.36 million LE compared to 258.89 million LE with the current pattern.
- Fig trees, to 207.66 million LE compared to 205.04 million LE with the current pattern.

2. **Decrease the revenues from** olive trees to reach 222.25 million LE compared to (240.49 million LE) with the current pattern.

- The proposed pattern needs 405.85 million m^3 of irrigation water compared to 450.95 million m^3 the current pattern's need of irrigation water.

- Both the current pattern and the proposed pattern require 2157 thousand manpower / labor / workforce.

- A decrease in the revenues from the crops with the proposed crop pattern in this scenario (10% decreases in water resources) compared to the revenues from the proposed crop pattern in light of the goal of maximizing the revenues before the water resource shortage occurs by 40 thousand LE.

Table (9): Crop area, water ration, total revenues and employment for different crops with the current crop pattern and the proposed pattern in light of the objective of maximizing the revenues of crops resulting from the basic model assuming a shortage of water resources by 10% for the e period of (2015 – 2019) in Matrouh Governorate.

Crop	Current Pattern					Proposed Pattern				
	Area (Feddan)	%	Revenue (M. LE)	Water Rate (M. m³)	Employment (thousand workers)	Area (Feddan)	%	Revenue (M. LE)	Water Rate (M. m³)	Employment (thousand workers)
Wheat (X_1)	15922.80	9.02	51.09	30.22	318	12719.52	7.20	40.81	21.73	254
Barley (X_2)	365.20	0.21	0.76	0.52	6	780	0.44	1.62	0.98	15
Faba Beans (X_3)	4124.80	2.34	17.36	6.49	21	5248	2.97	22.08	7.42	26
Perennial Clover (X_4)	11837.60	6.70	156.55	30.44	545	12661.88	7.17	167.45	29.31	583
Tomato (X_5)	11671.20	6.61	257.18	26.38	233	12250	6.94	269.93	24.92	245
Potato (X_6)	1775	0.99	13.16	3.56	36	2037	1.15	15.09	3.68	41
Total Winter Season	**45696.40**	**25.87**	**496.09**	**97.61**	**1159**	**45696.40**	**25.87**	**516.98**	**88.05**	**1164**
Maize (X_7)	9443	5.35	20.27	31.27	283	9023.12	5.11	19.37	26.90	271
Tomato (X_8)	18462	10.45	37.60	77.08	369	18527.48	10.49	37.73	69.62	371
Potato (X_9)	1131.80	0.65	6.67	2.87	23	1210	0.69	7.13	2.77	24
Pepper (X_{10})	983.80	0.56	5.42	4.01	20	1260	0.71	6.94	4.62	25
Total Summer Season	**30020.60**	**17**	**69.97**	**115.23**	**695**	**30020.60**	**17**	**71.17**	**103.90**	**691**
Date Palms (X_{11})	8671	4.91	258.89	52.03	26	10328	5.85	308.36	55.77	31
Olive trees (X_{12})	31979.60	18.11	240.49	143.91	96	29555	16.74	222.25	119.70	89
Fig trees (X_{13})	60236.40	34.11	205.04	42.16	181	61004	34.54	207.66	38.43	183
Total Date Palms and Fruit Trees	**100887**	**57.13**	**704.42**	**238.10**	**303**	**100887**	**57.13**	**738.27**	**213.90**	**303**
Total Amount	**176604**	**100**	**1270.48**	**450.95**	**2157**	**176604**	**100**	**1326.42**	**405.85**	**2157**

Source: Tables (1), (8).

The results obtained for the crop pattern can be summarized under the objective of maximizing the revenue of crops and assuming a decrease in water resources by 10% as referred to in Table (10):

Table (10): The results of comparing the existing crop pattern and the proposed cropping pattern under the objective of maximizing the revenue of crops and assuming a decrease in water resources by 10%.

Report	Current	Proposed	Change Amount
Crop area (feddan)	176604	176604	-
Quantity of water used to irrigate The cultivated area (million m^3)	450.95	405.85	-45.10
Net revenue on cultivated area (million LE)	1270.48	1326.42	55.94
Total employment in the cultivated area (thousand workers)	2157	2157	-

Source: Computer Results Using LINDO.

ii. **The proposed crop pattern under the objective of maximizing the revenues of crops and assuming a shortage of water resources by 20%:**

Table (11) shows the proposed crop pattern in light of the goal of maximizing the revenues of crops, assuming a shortage of water resources by 20%, i.e. 90.19 million m^3, where it states:

A. **Regarding Winter season:**

1. **Decrease in** Wheat area by 3186.20 feddan with 1.80% change rate, where the planted area with the current pattern was 15992.80 feddan with 9.02% change rate, while it became in the proposed pattern 12736.20 feddan with 7.21% change rate.

2. **Increasing the revenues regarding:**

   ▪ Barley, by 414.80 feddan with 0.23% change rate, where the cultivated area was in the current pattern 365.20 feddan with 0.21% change rate, while it became in the proposed pattern 780 feddan with 0.44% change rate.

   ▪ Faba beans, by 1123.20 feddan with 0.63% change rate, where the planted area with the current pattern was 4124.80 feddan with 2.34% change rate, while it became in the proposed pattern 5248 feddan with 2.97% change rate.

   ▪ Perennial clover, by 807.20 feddan with 0.46% change rate, where the cultivated area in the current pattern was 11837.60 feddan with 6.70% change rate, while it became in the proposed pattern 12664.01 feddan with 7.16% change rate.

   ▪ Tomato, by 578.80 feddan with 0.33% change rate, where the planted area with the current pattern was 1167.20 feddan with 6.61% change rate, while it became in the proposed pattern 12250 feddan with 6.94% change rate.

   ▪ Potato, by 262 feddan with 0.14% change rate, where the planted area with the current pattern was 1775 feddan with 1.01% change rate, while it became in the proposed pattern 2037 feddan with 1.15% change rate.

B. Regarding Summer season:

1. **Decrease the area of** Maize by 375.49 feddan with 0.21% change rate, where the planted area with the current pattern was 9443 feddan with 5.35% change rate, while it became in the proposed pattern 9067.51 feddan with 5.13% change rate.

2. **Increasing the revenues regarding:**
   - Tomato, by 21.09 feddan with 0.01% change rate, where the planted area with the current pattern was 18462 feddan with 10.45% change rate, while it became in the proposed pattern 18483.09 feddan with 10.47% change rate.
   - Potato, by 78.20 feddan with 0.04% change rate, where the planted area with the current pattern was 1131.80 feddan with 0.64% change rate, while it became in the proposed pattern 1210 feddan with 0.69% change rate.
   - Pepper, by 267.20 feddan with 0.15% change rate, where the planted area with the current pattern was 938.80 feddan with 0.56% change rate, while it became in the proposed pattern 1260 feddan with 0.71% change rate.

C. Date Palms and Fruit Trees:

1. **Decrease the area of** Olive trees by 2424.60 feddan with 1.37% change rate, where the planted area with the current pattern was 31979.60 feddan with 18.11% change rate, while it became 29555 feddan with 16.74% change rate.

2. **Increasing the area regarding:**
   - Palm trees, by 1657 feddan by 0.94%, where the planted area with the current pattern was 8671 feddan with 4.91% change rate, while it became in the proposed pattern 103282 feddan with 5.85% change rate.
   - Fig trees, by 767.60 feddan with 0.43% change rate, where the planted area with the current pattern was 60236.40 feddan with 34.11% change rate, while it became in the proposed pattern 61004 feddan with 34.54% change rate.

Table (11): The current crop pattern and proposed crop pattern in light of maximizing the revenues of crops resulting from the basic model and assuming a shortage of water resources by 20% for the period of (2015 – 2019) in Matrouh Governorate.

Crop	Current Pattern		Proposed Pattern		Amount of change (Feddan)	percentage change (%)
	Area (Feddan)	%	Area (Feddan)	%		
Wheat (X_1)	15922.80	9.02	12736.60	7.21	-3186.20	-1.80
Barley (X_2)	365.20	0.21	780	0.44	414.80	0.24
Faba Beans (X_3)	4124.80	2.34	5248	2.97	1123.20	0.63
Perennial Clover (X_4)	11837.60	6.70	12644.80	7.16	807.20	0.46
Tomato (X_5)	11671.20	6.61	12250	6.94	578.80	0.33
Potato (X_6)	1775	1.01	2037	1.15	262	0.14
Total Winter Season	**45696.40**	**25.87**	**45696.40**	**25.87**	**-**	**-**
Maize (X_7)	9443	5.35	9067.51	5.13	-375.49	-0.21
Tomato (X_8)	18462	10.45	18483.09	10.47	21.09	0.01
Potato (X_9)	1131.80	0.64	1210	0.69	78.20	0.05
Pepper (X_{10})	983.80	0.56	1260	0.71	276.20	0.15
Total Summer Season	**30020.60**	**17**	**30020.60**	**17**	**-**	**-**
Date Palms (X_{11})	8671	4.91	10328	5.85	1657	0.94
Olive Trees (X_{12})	31979.60	18.11	29555	16.74	-2424.60	-1.37
Fig Trees (X_{13})	60236.40	34.11	61004	34.54	767.60	0.43
Total Date Palms and Fruit Trees	**100887**	**57.13**	**100887**	**57.13**	**-**	**-**
Total Amount	**176604**	**100**	**176604**	**100**	**-**	**-**

Source: Computer Results Using LINDO.

Each amount of irrigation water, Revenue and Employment for the proposed pattern and their comparison with each amount of irrigation water, Revenue and Employment for the current pattern has been calculated and the results were referred to in Table (12), where it states:

- Increasing the revenues from crops for the proposed crop pattern by 55.81 million LE to 1326.29 million LE, while the current pattern 1270.48 million LE, where:

  A. Regarding Winter season:

  1. Increasing the revenues regarding:

  - Barley, to 1.62 million LE compared to 520 thousand LE with the current pattern.
  - Faba beans, to 22.08 million LE compared to 17.36 million LE with the current pattern.
  - Perennial clover, 167.23 million LE compared to 156.55 million LE with the current pattern.
  - Tomato, to 269.93 million LE compared to 257.18 million LE with the current pattern.
  - Potato, to 15.09 million LE compared to 13.16 million LE with the current pattern.

  2. Decrease the revenues from wheat to 40.86 million LE compared to 51.09 million LE with the current Pattern.

  B. Regarding Summer season:

  1. Increasing the revenues regarding:

  - Tomato, to 37.64 million LE compared to 37.60 million LE with the current pattern.
  - Potato, to 7.13 million LE compared to 6.67 million LE with the current pattern.
  - Pepper, to 6.94 million LE compared to 5.42 million LE with the current pattern.

  2. Decrease the revenue from Maize to become 19.47 million LE compared to 20.27 million LE with the current pattern.

  C. Date Palms and Fruit Trees:

  1. Increasing the revenues regarding:

  - Date palms, to 308.36 million LE compared to 258.89 million LE with the current pattern.
  - Fig, to 207.66 million LE compared to 205.04 million LE with the current pattern.

  2. Decrease the revenue from olive trees to reach 222.25 million LE compared to 240.49 million LE with the current pattern.

- The proposed pattern needs 360.76 million m^3 of irrigation water compared to 450.95 million m^3 the current pattern's need of irrigation water.

- Both the existing pattern and proposed pattern require 2157 thousand man power / labor / workforce.

- A decrease in the revenues from the crops with the proposed crop pattern in this scenario (20% decreases in water resources) compared to the revenues from the

proposed crop pattern in light of the goal of maximizing the revenues before the water resource shortage occurs by 170 thousand LE.

- A decrease in the revenue of crops with the proposed crop structure in this scenario (20% decreases in water resources) compared to the revenues from the proposed crop structure in each of the first scenarios (10% decrease in water resources) by 130 thousand LE.

Table (12): Crop area, water ration, total revenues and employment for different crops with the current crop pattern and proposed pattern in light of the objective of maximizing the revenues of crops resulting from the basic model assuming a shortage of water resources by 20% for the period of (2015 – 2019) in Matrouh Governorate.

Crop	Current Pattern					Proposed Pattern				
	Area (Feddan)	%	Revenue (M. LE)	Water Rate (M. m³)	Employment (thousand workers)	Area (Feddan)	%	Revenue (M. LE)	Water Rate (M. m³)	Employment (thousand workers)
Wheat (X_1)	15922.80	9.02	51.09	30.22	318	12736.60	7.21	40.86	19.34	255
Barley (X_2)	365.20	0.21	0.76	0.52	6	780	0.44	1.62	0.88	15
Faba Beans (X_3)	4124.80	2.34	17.36	6.49	21	5248	2.97	22.08	6.62	26
Perennial Clover (X_4)	11837.60	6.70	156.55	30.44	545	12644.80	7.16	167.23	26.02	581
Tomato (X_5)	11671.20	6.61	257.18	26.38	233	12250	6.94	269.93	22.16	245
Potato (X_6)	1775	0.99	13.16	3.56	36	2037	1.15	15.10	3.27	41
Total Winter Season	**45696.40**	**25.87**	**496.09**	**97.61**	**1159**	**45696.40**	**25.87**	**516.83**	**78.29**	**1163**
Maize (X_7)	9443	5.35	20.27	31.27	283	9067.51	5.13	19.47	24.03	272
Tomato (X_8)	18462	10.45	37.60	77.08	369	18483.09	10.47	37.64	61.73	370
Potato (X_9)	1131.80	0.65	6.67	2.87	23	1210	0.69	7.13	2.46	24
Pepper (X_{10})	983.80	0.56	5.42	4.01	20	1260	0.71	6.94	4.11	25
Total Summer Season	**30020.60**	**17**	**69.97**	**115.23**	**695**	**30020.60**	**17**	**71.19**	**92.33**	**691**
Date Palms (X_{11})	8671	4.91	258.89	52.03	26	10328	5.85	308.36	49.57	31
Olive Trees (X_{12})	31979.60	18.11	240.49	143.91	96	29555	16.74	222.25	106.40	89
Fig Trees (X_{13})	60236.40	34.11	205.04	42.16	181	61004	34.54	207.66	34.17	183
Total Date Palms and Fruit Trees	**100887**	**57.13**	**704.42**	**238.10**	**303**	**100887**	**57.13**	**738.27**	**190.14**	**303**
Total Amount	**176604**	**100**	**1270.48**	**450.95**	**2157**	**176604**	**100**	**1326.29**	**360.76**	**2157**

Source: Tables (1), (10).

The results obtained for the cropping pattern can be summarized under the objective of maximizing the revenue of crops and assuming a decrease in water resources by 10% as shown in Table (13):

Table (13): The results of comparing the existing crop pattern and the proposed cropping pattern under the objective of maximizing the revenue of crops and assuming a decrease in water resources by 20%.

Report	Current	Proposed	Change Amount
Crop area (feddan)	176604	176604	-
Quantity of water used to irrigate The cultivated area (million m³)	450.95	360.76	-90.19
Net revenue on cultivated area (million LE)	1270.48	1326.29	55.81
Total employment in the cultivated area (thousand workers)	2157	2157	-

Source: Computer Results Using LINDO.

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