DOI: 10.21608/alexja.2024.326967.1097

Efficiency Analysis of Tomato Crop in Egypt: A Case Study

Abdel-Rahman Sameh Abdel-Aal Abdullah*, Abdullah Mahmoud Abdel-Maqsoud, Ibrahim Ali Mohammed

Department of Agricultural Economics, Faculty of Agriculture, Ain Shams University

*Corresponding author: abdelrahman234@agr.asu.edu.eg

ARTICLE INFO

Article History

Received: 26/8/2024

Revised: 13/10/2024

Accepted: 18/10/2024

Key words: Data Envelopment Analysis Program (DEAP), Technical Efficiency, Allocative Efficiency, Economic Efficiency, Tomato Crop.

ABSTRACT

Tomatoes are one of the primary vegetable crops in Egypt in terms of cultivated area and are among the most important food commodities. Therefore, it is essential to focus on improving economic and productive efficiency, stabilizing the crop supply, and enhancing its quality. and ensure fair pricing for both producers and consumers.

This has necessitated the focus on estimating the efficiency of selected tomato farms. This objective was achieved using the Data Envelopment Analysis (DEAP) method to estimate the technical, allocative, and economic efficiency of the farms in the study sample, which included 66 farms, divided into three categories based on farm size. The results of the study indicated that the technical efficiency indicators, under both constant and variable returns to scale, were higher in the second category of farm size compared to the first and third categories, with the average scale efficiency of the second category reaching 91%, while the averages for the first and third categories were approximately 76% and 77%, respectively. Additionally, economic efficiency in the third category outperformed the first, suggesting that as the cultivated area increases, economic efficiency also improves.

The study recommends guiding farmers to follow technical recommendations for tomato production to reduce costs and increase profits. It also suggests investigating the factors that contributed to achieving the highest economic efficiency in some tomato farms and adopting these as practical models for less efficient farms to achieve the highest possible efficiency. Furthermore, it encourages farmers to expand the cultivated areas for tomato production.

INTRODUCTION

Tomatoes are one of the primary vegetable crops in Egypt in terms of cultivated area and are among the most important food commodities, accounting for approximately a quarter of the total vegetable cultivated area annually. over half of which are in newly reclaimed lands with potential for higher productivity and quality, provided that the marketing system is developed and improved. Enhancing marketing efficiency is expected to positively impact farmers' returns (Rehan Attia and Mahmoud El-Sayed 2023). As a widely consumed product in Egypt, efficient production stabilizes market supply and limits price fluctuations, ensuring better quality and fair prices for both producers and consumers (Amal Eid, Rasha Mohammed and Wael Izzat 2014). Moreover, tomatoes have considerable potential for industrial processing, and improvements in their marketing efficiency can serve as a model for other horticultural products in Egypt. Despite the surplus production in certain seasons, Egyptian tomato exports remain limited. A well-developed marketing system could facilitate the export of these surpluses.

Research problem:

Numerous studies, reports, empirical evidence, and expert opinions indicate significant shortcomings in the overall performance of Egypt's tomato marketing system, there is considerable scope for improvement and enhancement to elevate the efficiency of this system and optimize its overall performance, through some of the key indicators of these shortcomings include:

- **Market volatility:** Fluctuations in both prices and production.
- **A multiplicity of intermediaries:** This leads to increased or inflated margins for intermediaries at the expense of both producers and consumers, given the limited value-added marketing services provided and the low farm-gate prices.
- **Insufficient and inadequate levels of basic marketing services:** Such as sorting, grading, packaging, etc.
- **Producers not receiving fair and remunerative prices for their sales.**
- **High levels of losses and waste throughout the various stages and links of the tomato marketing system.**

Research objectives:

This study aims to estimate the efficiency of resource utilization in tomato production to optimize resource allocation, reduce production costs, increase profitability for tomato producers, and identify the optimal combination of production

inputs. To achieve these goals, the study will:

- Measuring the scale efficiency of tomato farms within the study sample.
- Estimating the technical, allocative, and economic efficiencies of resources used in tomato production within the study sample.
- Determining the quantity of production inputs required for economic efficiency and, consequently, estimate the quantity of wasted production inputs in tomato farms, thereby identifying the necessary improvement level.

Methodology and data sources:

- **Research Methodology**: The research primarily depends on a quantitative approach using the **Data Envelopment Analysis Program (DEAP)**, which applies linear programming to measure the technical, allocative, and economic efficiencies of tomato farms under both constant returns to scale (CRS) and variable returns to scale (VRS) assumptions.
- **Data Sources**: The study depends on two types of data:
  - Secondary data published by the Economic Affairs Sector of the Ministry of Agriculture and Land Reclamation, as well as related research on the subject.
  - Primary data was collected during the 2022/2023 season through a questionnaire administered to a case study of 66 tomato farms in some governorates of Upper and Lower Egypt.

Case study description:

A purposive sampling technique was employed in this case study, utilizing 66 survey questionnaires distributed across select governorates in both Upper and Lower Egypt for the 2022/2023 agricultural season. Specifically, 29 questionnaires were distributed in the Upper Egypt governorates of Beheira, Qalyubiya, and Menoufia, while 37 were distributed in the Lower Egypt governorates of Beni Suef, Minya, and Fayoum. Tomato farms were categorized into three groups based on their size: Group 1 comprised farms with an area less than 5 feddans, Group 2 included farms with an area between 5 and 10 feddans, and Group 3 encompassed farms with an area exceeding 10 feddans.

The relationship between output (Y), which represents the total production of tomato crop for each farm, and the study inputs is defined as follows: The cultivated area in feddans (X_1), the quantity of seedlings (X_2), the amount of chemical fertilizer (nitrogen) in effective units (X_3), the quantity of fuel in liters (X_4), the size of labor in man-days (X_5), the amount of irrigation water in cubic meters per feddan (X_6), and the quantity of organic fertilizer in cubic meters (X_7).

The theoretical framework of Data Envelopment Analysis Program (DEAP):

Data Envelopment Analysis (DEA), as developed by Coelli (1996), is a quantitative methodology employed for benchmarking, performance evaluation, and measuring the relative efficiency of Decision-Making Units (DMUs), such as farms, that share similar objectives and operational activities. The term "Data Envelopment Analysis" is derived from the concept that efficient DMUs form an envelope around less efficient units, enabling the analysis of data within this efficient frontier.

Farrell (1957) initially explored measuring technical efficiency using a single-input, single-output model. Subsequently, Charnes, Cooper, and Rhodes (1978) extended this model to accommodate multiple inputs and outputs. Efficiency can be measured using either input-oriented or output-oriented models. This research will focus on the input-oriented model, given farmers' greater control over inputs compared to their ability to increase output.

The DEAP software provides a numerical measure of relative efficiency for each DMU. Fully efficient units (operating at scale efficiency) achieve a score of one, while inefficient units (operating below scale efficiency) obtain a score less than one. Consequently, relative efficiency scores range between zero and one.

Scale Efficiency:

It refers to the ratio of the average output of a production unit operating at a certain point to the average output of a production unit operating at its optimal scale. If the value of scale efficiency equals 1, it indicates that the production unit is operating at optimal capacity. However, if the value is less than 1, it implies that the unit is operating with lower scale efficiency. Scale efficiency can be calculated by:

$$\textit{Scale Efficiency} = \frac{\textit{Technical Efficiency (CRS)}}{\textit{Technical Efficiency (VRS)}}$$

This measure (program) deals with two fundamental models:

1. Constant Returns to Scale (CRS) Model
2. Variable Returns to Scale (VRS) Model

The CRS model assumes that farms operate at their maximum capacity. However, in reality, various constraints, such as imperfect competition and financing constraints, prevent production units from achieving such scales. This means that an increase in inputs does not necessarily lead to a proportional increase in outputs. Therefore, the VRS model was developed to be applied when production units are not operating at optimal levels (below maximum capacity).

Economic Efficiency:

Economic efficiency is achieved through the combination of resources used to maximize production with the least possible cost or minimal quantities of resources.

Economic efficiency is divided into two components:

1. **Technical Efficiency (TE)**: This refers to the ability of a firm to produce the maximum possible output from a given set of inputs.
2. **Allocative Efficiency (AE)**: This reflects a farm's ability to utilize the optimum combination of inputs to produce a specific quantity of output at the lowest possible cost, considering input prices.

Economic efficiency (EE) for a farm is calculated as the product of technical efficiency (TE) and allocative efficiency (AE), represented by the formula:

$EE = TE \times AE$

This equation expresses the total cost reduction without affecting the level of production.

RESULTS AND DISCUSSION

First: Development of the Cultivated Area, Yield per Feddan, and Total Production of the Summer Tomato Crop in Egypt During the Period (2005-2022):

1. Development of the Cultivated Area for the Tomato Crop (summer season) in Egypt:

The data from Table(1) indicate that the cultivated area for tomatoes during the study period ranged from a minimum of approximately 166.03 thousand feddans in 2021 to a maximum of about 284.98 thousand feddans in 2008, with an annual average of approximately 231.09 thousand feddans during the period (2005-2022).

2. Development of Tomato Yield per Feddan (summer season) in Egypt:

The data from Table (1) indicate that the yield of tomato crop during the study period ranged from a minimum of approximately 14.48 tons per feddan in 2007 to a maximum of about 16.53 tons per feddan in 2022, with an annual average of approximately 15.75 tons per feddan during the period (2005-2022).

Table 1: Development of the Area, Yield per Feddan, and Total Production of the Tomato Crop (summer season) in Egypt During the Period (2005-2022)

Years	Summer season		
	Cultivated Area (thousand feddans)	Yield per Feddan (tons/feddan)	Total Production (thousand tons)
2005	215.46	15.26	3288.92
2006	241.31	14.86	3586.79
2007	266.96	14.48	3865.06
2008	284.98	14.86	4233.95
2009	270.32	15.66	4233.98
2010	262.05	15.73	4121.07
Average	256.85	15.14	3888.30
2011	246.36	15.40	3793.66
2012	258.74	15.89	4111.75
2013	238.38	16.17	3853.34
2014	265.98	15.65	4161.07
2015	242.10	15.91	3850.77
2016	224.84	15.78	3547.18
Average	246.07	15.80	3886.30
2017	197.61	16.29	3218.28
2018	218.85	16.06	3514.85
2019	197.12	16.33	3218.46
2020	171.58	16.45	2823.06
2021	166.03	16.16	2683.82
2022	190.90	16.53	3155.29
Average	190.35	16.30	3102.29
Overall Average	231.09	15.75	3625.63
Minimum	166.03	14.48	2683.82
Maximum	284.98	16.53	4233.98

Source: Compiled and calculated from the data of the Ministry of Agriculture and Land Reclamation, Economic Affairs Sector, Agricultural Statistics Bulletin, various issues.

3. Development of Total Tomato Production (summer season) in Egypt:

The data from Table (1) indicate that the total tomato production during the study period ranged from a minimum of approximately 2,683.82 thousand tons in 2021 to a maximum of about 4,233.98 thousand tons in 2009, with an annual average of approximately 3,625.63 thousand tons during the period (2005-2022).

Second: The relative importance of selected governorates in the study sample in terms of cultivated area, yield per feddan, and total production of the tomato crop during the summer season for the period (2018-2022):

Table(2) shows that some of the selected governorates in the study sample accounted for approximately 40% of the average total cultivated area of summer tomato crop during the period (2018-2022). Beheira ranked first in terms of tomato cultivation area, with an average of approximately 23.14 thousand feddans, representing about 13% of the total summer tomato crop area. It was followed by the governorates of Matrouh, Minya, Giza, Beni Suef, and Fayoum, with averages of 16 thousand feddans, 11.94 thousand feddans, 7.31 thousand feddans, 4.92 thousand feddans, and 4.57 thousand feddans, respectively, representing for about 9%, 7%, 4%, 3%, and 3% of the total summer tomato crop area, respectively.

Table (2) also highlights the relative importance of the average yield per feddan in some of the governorates included in the study sample. Minya ranked first in terms of productivity, with an average yield of approximately 18.55 tons per feddan, representing 113.7% of the average total yield per feddan for summer tomato crops. It was followed by the governorates of Giza, Beni Suef, Beheira, Matrouh, and Fayoum, with average yields of approximately 17.50 tons per feddan, 16.58 tons per feddan, 16.43 tons per feddan, 14.59 tons per feddan, and 12.42 tons per feddan, respectively. These yields represent 107.3%, 101.7%, 100.7%, 89.5%, and 76.1%, respectively, of the average total yield per feddan for summer tomato crops.

The same table highlights the relative importance of the average total production in some of the governorates included in the study sample. Beheira ranked first in terms of total summer tomato production, with an average of approximately 378.12 thousand tons, representing 13% of the total average production of summer tomatoes. It was followed by the governorates of Matrouh, Minya, Giza, Beni Suef, and Fayoum, with averages of approximately 233.11 thousand tons, 221.57 thousand tons, 128.05 thousand tons, 81.90 thousand tons, and 56.86 thousand tons, respectively. These figures account for 8%, 7%, 4%, 3%, and 2%, respectively, of the total average summer tomato production.

It is evident from the above that the previously mentioned governorates contributed approximately 40% of the total average summer tomato production nationwide during the period (2018-2022). Additionally, the governorates that ranked first in terms of cultivated area for tomato crops are the same ones that ranked first in terms of total production, indicating that increased production is primarily the result of an increase in cultivated area.

Third: Estimation of Technical Efficiency of Tomato Crop According to the Concepts of Constant and Variable Returns to Scale:

Technical efficiency indicators were estimated based on the concepts of Constant and Variable Returns to Scale, in addition to the scale efficiency indicator. Technical efficiency refers to the ability of a firm to achieve the maximum possible output from the (previously mentioned) set of available inputs. The following are the estimates of the study sample divided into three categories to compare the technical efficiency of farms within each category.

1. First Category of Farms (Less than 5 Feddans):

This category includes 29 farms with areas ranging from 1 to 4 feddans. As shown in Table 3, only 5 farms in this category achieved technical efficiency according to the concept of constant returns to scale, while the remaining farms did not attain this efficiency. According to the constant returns to scale assumption, which assumes that the farm operates at its maximum capacity, technical efficiency ranged between a minimum of approximately 43% and a maximum of 100%, with an average of around 74%. This indicates that the same level of production could be achieved using only 74% of the resources currently utilized, meaning that 26% of the resources could be saved without affecting production levels.

In contrast, under the variable returns to scale assumption, which suggests that these farms do not operate at maximum capacity, technical efficiency was achieved in 16 farms within this category. The average technical efficiency index related to the concept of variable returns to scale was 97%, indicating that these farms could achieve the same level of production using only 97% of the resources employed, thus allowing for a 3% resource savings without impacting production levels. The technical efficiency under variable returns to scale indicates that farm activities are operating at levels below maximum capacity, leading to higher technical efficiency indicators compared to the constant returns to scale scenario.

Scale efficiency was achieved in farms 6, 7, 8, 20, and 29, which exhibited constant returns to scale (indicating that no changes in resource quantities are necessary to maintain the same level of production).

Conversely, scale efficiency was not achieved in 24 farms with increasing returns to scale (which requires a rise in production levels using fewer resources). The average scale efficiency index for the tomato farms in the first category was approximately 76%.

Table 2: The Relative Importance of Area, Yield per Feddan, and Total Production of the Tomato Crop in Selected Governorates of the Study Sample (Summer Season) During the Average Period (2018-2022)

Items / Governorates	Years	Area (thousand feddans)	%	Yield per Feddan (tons/ feddan)	%	Total Production (thousand tons)	%
Beheira	2018	45.72		16.08		735.17	
	2019	18.22		16.94		308.52	
	2020	14.31		16.89		241.65	
	2021	14.97		15.93		238.47	
	2022	22.47		16.32		366.79	
	Average	23.14	13	16.43	100.7	378.12	13
Matrouh	2018	16.149		12.85		207.52	
	2019	17.41		14.30		249.09	
	2020	15.42		14.37		221.59	
	2021	15.59		15.55		242.51	
	2022	15.43		15.86		244.83	
	Average	16.00	9	14.59	89.5	233.11	8
Minya	2018	9.61		18.18		174.61	
	2019	11.08		18.50		205.08	
	2020	8.95		19.54		174.93	
	2021	12.04		17.52		210.94	
	2022	18.00		19.01		342.26	
	Average	11.94	7	18.55	113.7	221.57	7
Giza	2018	7.89		17.19		135.56	
	2019	6.73		17.37		116.96	
	2020	4.52		17.46		78.84	
	2021	6.95		17.73		123.21	
	2022	10.47		17.74		185.71	
	Average	7.31	4	17.50	107.3	128.05	4
Beni Suef	2018	3.25		16.38		53.20	
	2019	3.37		16.57		55.89	
	2020	4.95		16.34		80.82	
	2021	4.80		16.59		79.66	
	2022	8.22		17.03		139.93	
	Average	4.92	3	16.58	101.7	81.90	3
Fayoum	2018	2.66		12.04		32.06	
	2019	4.22		12.17		51.33	
	2020	8.97		12.22		109.54	
	2021	1.89		12.41		23.50	
	2022	5.11		13.28		67.865	
	Average	4.57	3	12.42	76.1	56.86	2
Average Total of the Summer Season (2018-2022)		188.90	100	16.31	100	3079.10	100

Source: Compiled and calculated from the data of the Ministry of Agriculture and Land Reclamation, Economic Affairs Sector, Agricultural Statistics Bulletin, various issues.

Table 3: Results of the Technical Efficiency Estimation of Tomato Crop and Scale Returns for the First Category of Sample Farms

Farm Number	Farm area (feddans)	Technical Efficiency(CRS)	Technical Efficiency (VRS)	Scale Efficiency	Returns to scale
1	1	0.842	1.000	0.842	Increasing
2	1	0.833	1.000	0.833	Increasing
3	1	0.758	1.000	0.758	Increasing
4	1	0.926	1.000	0.926	Increasing
5	1	0.801	1.000	0.801	Increasing
6	1	1.000	1.000	1.000	Constant
7	1	1.000	1.000	1.000	Constant
8	1	1.000	1.000	1.000	Constant
9	1	0.667	1.000	0.667	Increasing
10	1	0.667	1.000	0.667	Increasing
11	1	0.543	1.000	0.543	Increasing
12	1	0.429	1.000	0.429	Increasing
13	1.5	0.541	1.000	0.541	Increasing
14	2	0.500	0.806	0.620	Increasing
15	2	0.513	0.928	0.553	Increasing
16	2	0.884	0.939	0.941	Increasing
17	2	0.507	0.958	0.529	Increasing
18	2	0.541	0.988	0.548	Increasing
19	2	0.667	0.993	0.672	Increasing
20	3	1.000	1.000	1.000	Constant
21	3	0.552	0.921	0.599	Increasing
22	3	0.846	0.934	0.906	Increasing
23	3	0.556	1.000	0.556	Increasing
24	3	0.838	0.916	0.915	Increasing
25	3	0.604	0.988	0.611	Increasing
26	4	0.789	0.894	0.883	Increasing
27	4	0.806	0.991	0.813	Increasing
28	4	0.846	0.935	0.905	Increasing
29	4	1.000	1.000	1.000	Constant
Average	2.052	0.740	0.972	0.761	
Maximum	4	1.000	1.000	1.000	
Minimum	1	0.429	0.806	0.429	

Source: Results of the Data Analysis from the Survey Questionnaires Using the Data Envelopment Analysis Program (DEAP).

2. Second Category of Farms (5-10 Feddans):

This category includes 24 farms. As shown in Table 4, only 8 farms in this category achieved technical efficiency under the assumption of constant returns to scale, with efficiency ranging from a minimum of 55% to a maximum of 100%, and an average of approximately 90%. This indicates that the same level of production could be achieved using only 90% of the resources currently employed, meaning that this category could save 10% of the production resources without affecting the production level.

Technical efficiency was achieved under the variable returns to scale assumption in 16 farms within this category, with efficiency ranging from a minimum of 91% to a maximum of 100%, and an average of about 98%.

Scale efficiency was achieved in farms 2, 8, 13, 15, 16, 18, 21, and 24, which operated under constant returns to scale, indicating that the combination of resources used was optimal for production. However, scale efficiency was not achieved in 16 farms with increasing returns to scale, suggesting that production levels could be increased by using fewer resources. The average scale efficiency for tomato farms in the second category was approximately 91%.

Table 4: Results of the Technical Efficiency Estimation of Tomato Crop and Scale Returns for the Second Category of Sample Farms

Farm Number	Farm Area (feddans)	Technical Efficiency (CRS)	Technical Efficiency (VRS)	Scale Efficiency	Returns to Scale
1	5	0.948	1.000	0.948	
2	5	1.000	1.000	1.000	Constant
3	5	0.940	1.000	0.940	Increasing
4	5	0.898	1.000	0.898	Increasing
5	5	0.883	1.000	0.883	Increasing
6	6	0.946	0.989	0.957	Increasing
7	6	0.697	0.908	0.768	Increasing
8	6	1.000	1.000	1.000	Constant
9	6	0.954	1.000	0.954	Increasing
10	6	0.920	1.000	0.920	Increasing
11	6	0.811	0.953	0.851	Increasing
12	7	0.759	0.961	0.790	Increasing
13	7	1.000	1.000	1.000	Constant
14	7	0.871	1.000	0.871	Increasing
15	7	1.000	1.000	1.000	Constant
16	7	1.000	1.000	1.000	Constant
17	7	0.854	0.972	0.879	Increasing
18	7	1.000	1.000	1.000	Constant
19	7	0.747	0.960	0.778	Increasing
20	7	0.553	0.975	0.567	Increasing
21	8	1.000	1.000	1.000	Constant
22	10	0.854	0.961	0.889	Increasing
23	10	0.945	1.000	0.945	Increasing
24	10	1.000	1.000	1.000	Constant
Average	6.750	0.899	0.987	0.910	
Maximum	10	1.000	1.000	1.000	
Minimum	5	0.553	0.908	0.567	

Source: Results of the Data Analysis from the Survey Questionnaires Using the Data Envelopment Analysis Program (DEAP)

3. Third Category of Farms (More than 10 Feddans):

This category includes 13 farms. As shown in Table 5, only 2 farms in this category achieved technical efficiency under the assumption of constant returns to scale, with efficiency ranging from a minimum of approximately 42% to a maximum of 100%. The average technical efficiency index under constant returns was around 74%, indicating that the same level of production could be achieved using only 74% of the resources currently utilized. This implies that this category could save 26% of the production resources without affecting output levels.

Additionally, the table shows that 8 farms in this category achieved technical efficiency under the concept of variable returns to scale, while the remaining farms did not attain this efficiency. The efficiency index in this case ranged from a minimum of approximately 86% to a maximum of 100%, with an average of about 97%. This suggests that these farms could achieve the same level of production using only 97% of the production resources, allowing for a potential saving of 3% without impacting output levels.

The table also indicates that scale efficiency was achieved in farms 4 and 13, which exhibited constant returns to scale, suggesting that the combination of resources used is optimal for production. In contrast, scale efficiency was not achieved in 11 farms with increasing returns to scale, indicating the need to increase production levels using fewer production resources. The average scale efficiency index for tomato farms in the third category was approximately 77%.

Table 5: Results of the Technical Efficiency Estimation of Tomato Crop and Scale Returns for the third Category of Sample Farms

Farm Number	Farm Area (feddans)	Technical Efficiency(CRS)	Technical Efficiency(VRS)	Scale Efficiency	Returns to Scale
1	11	0.767	1.000	0.767	Increasing
2	11	0.772	1.000	0.772	Increasing
3	11	0.416	1.000	0.416	Increasing
4	11	1.000	1.000	1.000	Constant
5	11	0.516	1.000	0.516	Increasing
6	15	0.585	0.856	0.683	Increasing
7	15	0.648	1.000	0.648	Increasing
8	17	0.872	0.882	0.989	Increasing
9	20	0.906	0.960	0.944	Increasing
10	20	0.616	0.923	0.667	Increasing
11	22	0.653	0.923	0.707	Increasing
12	25	0.847	1.000	0.847	Increasing
13	25	1.000	1.000	1.000	Constant
Average	16.462	0.738	0.965	0.766	
Maximum	25	1.000	1.000	1.000	
Minimum	11	0.416	0.856	0.416	

Source: Results of the Data Analysis from the Survey Questionnaires Using the Data Envelopment Analysis Program (DEAP)

It is evident from the above that the technical efficiency indicators based on both constant and variable returns to scale in the second category outperform those in the first and third categories, with the average scale efficiency for the second category being approximately 91%, compared to 76% and 77% for the first and third categories, respectively. This underscores the need to prioritize agricultural extension programs for these categories to enhance their scale efficiency. The overall average technical efficiency index for the entire sample was 79% under constant returns to scale and 97% under variable returns to scale, respectively.

Fourth: Estimation of Allocative Efficiency of Tomato Crop According to the Concepts of Constant and Variable Returns to Scale:

1. First Category of Farms (Less than 5 Feddans):

As shown in Table 6, the allocative efficiency index for the production resources in this category, under the concept of constant returns to scale, ranged from a minimum of approximately 56% to a maximum of 100%, with an average of about 71%. This indicates that redistributing the production resources used could reduce the cost of tomato production in this category by approximately 29%.

Table 6: Results of the Allocative Efficiency Estimation of Tomato Crop

Categories	Number of Farms	Assessment Categories	Farm Area (feddans)	Allocative Efficiency	
				Under CRS	Under VRS
Category 1	29	Average	2.052	0.713	0.695
		Maximum	٤	1.000	1.000
		Minimum	١	0.562	0.421
Category 2	24	Average	6.750	0.931	0.913
		Maximum	10	1.000	1.000
		Minimum	5	0.719	0.686
Category 3	13	Average	16.462	0.813	0.853
		Maximum	25	1.000	1.000
		Minimum	11	0.615	0.588
Overall Study*	66	Average	6.598	0.814	0.815
		Maximum	25	1.000	1.000
		Minimum	1	0.562	0.421

Source: Results of the Data Analysis from the Survey Questionnaires Using the Data Envelopment Analysis Program (DEAP)

* The overall study average was calculated using the geometric mean.

Under the concept of variable returns to scale, the allocative efficiency index ranged from a minimum of 42% to a maximum of 100%, with an average of about 70%. This suggests that redistributing the resources could reduce the cost of tomato production in this category by approximately 30%.

2. Second Category of Farms (5-10 Feddans):

As shown in Table 6, the allocative efficiency index for the production resources in this category, under the concept of constant returns to scale, ranged from a minimum of approximately 72% to a maximum of 100%, with an average of about 93%. This indicates that redistributing the production resources used could reduce the cost of tomato production in this category by approximately 7%.

Under the concept of variable returns to scale, the allocative efficiency index ranged from a minimum of 69% to a maximum of 100%, with an average of about 91%. This suggests that redistributing the resources could reduce the cost of tomato production in this category by approximately 9%.

3. Third Category of Farms (More than 10 Feddans):

The results in Table 6 show that the allocative efficiency index for the production resources in this category, under the concept of constant returns to scale, ranged from a minimum of approximately 62% to a maximum of 100%, with an average of about 81%. This indicates that redistributing the production resources used could reduce the cost of tomato production in this category by approximately 19%.

Under the concept of variable returns to scale, the allocative efficiency index ranged from a minimum of 59% to a maximum of 100%, with an average of about 85%. This suggests that redistributing the resources could reduce the cost of tomato production in this category by approximately 15%.

The results indicate that the allocative efficiency of resources used in the third category outperformed the first category under both constant and variable returns to scale. This suggests that as the cultivated area increases, the efficiency in resource utilization also improves. However, it is noteworthy that the second category surpassed both the first and third categories under both constant and variable returns to scale, indicating that the cultivated area is not the primary factor affecting allocative efficiency. Instead, it is the combination of resources used in production as a whole that plays a crucial role.

Fifth: Estimation of Economic Efficiency of the Tomato Crop According to the Concepts of Constant and Variable Returns to Scale:

1. First Category of Farms (Less than 5 Feddans):

The results in Table 7 show that the economic efficiency index for this category, under the concept of constant returns to scale, ranged from a minimum of approximately 32% to a maximum of 100%, with an average of about 53%. This indicates that the same level of production could be achieved by reducing production costs by 47%.

Under the concept of variable returns to scale, the economic efficiency index ranged from a minimum of 42% to a maximum of 100%, with an average of about 68%. This suggests that the same level of production could be achieved by reducing production costs by 32% for tomato production in this category.

Table 7: Results of the Economic Efficiency Estimation of Tomato Crop

Categories	Number of Farms	Assessment Categories	Farm Area (feddans)	Allocative Efficiency	
				Under CRS	Under VRS
Category 1	29	Average	2.052	0.528	0.679
		Maximum	4	1.000	1.000
		Minimum	1	0.324	0.416
Category 2	24	Average	6.750	0.837	0.901
		Maximum	10	1.000	1.000
		Minimum	5	0.518	0.686
Category 3	13	Average	16.462	0.592	0.826
		Maximum	25	1.000	1.000
		Minimum	11	0.395	0.558
Overall Study*	66	Average	6.598	0.640	0.797
		Maximum	25	1.000	1.000
		Minimum	1	0.324	0.416

Source: Results of the Data Analysis from the Survey Questionnaires Using the Data Envelopment Analysis Program (DEAP)

* The overall study average was calculated using the geometric mean.

2. Second Category of Farms (5-10 Feddans):

The results in Table 7 show that the economic efficiency index for this category, under the concept of constant returns to scale, ranged from a minimum of approximately 52% to a maximum of 100%, with an average of about 84%. This indicates that the same level of production could be achieved by reducing production costs by 16%.

Under the concept of variable returns to scale, the economic efficiency index ranged from a minimum of 69% to a maximum of 100%, with an average of about 90%. This suggests that the same level of production could be achieved by reducing production costs by 10% for tomato production in this category.

3. Third Category of Farms (More than 10 Feddans):

The results in Table 7 show that the economic efficiency index for this category, under the concept of constant returns to scale, ranged from a minimum of approximately 40% to a maximum of 100%, with an average of about 59%. This indicates that the same level of production could be achieved by reducing production costs by 41%.

Under the concept of variable returns to scale, the economic efficiency index ranged from a minimum of 56% to a maximum of 100%, with an average of about 83%. This suggests that the same level of production could be achieved by reducing production costs by 17% for tomato production in this category.

The results indicate that the economic efficiency in the third category outperformed that in the first category under both constant and variable returns to scale. This suggests that as the cultivated area increases, economic efficiency also improves. However, it is noteworthy that the second category surpassed both the first and third categories under both constant and variable returns to scale. This indicates that the cultivated area is not the primary factor influencing economic efficiency; rather, it is the overall combination of resources utilized in production that plays a crucial role.

In light of the study results, the recommendations of the research are the next:

1- Guide farmers to adhere to the technical recommendations related to tomato production to enhance resource utilization efficiency and reduce waste, leading to decreased production costs and increased profits.
2- Investigate the factors that contributed to achieving higher economic efficiency in certain tomato production farms and consider adopting these as practical models for less efficient farms to attain the highest possible efficiency.
3- Rationalize the use of available production elements to increase the economic efficiency of tomato farms in Egypt.
4- Organize training courses to improve the efficiency of tomato producers.
5- Encourage farmers to expand the cultivated areas of tomato crops.

REFERENCES

Afriat, P. (**1972**). Efficiency Estimation of Production Functions. International Economic Review, **13**, 568-598.

Abu Saif, Yasmin Ahmed, and Mona Abbas Darwish. (**2019**). "Estimating the Economic Efficiency of Wheat Production in Newly Reclaimed Lands in Fayoum Governorate." The Egyptian Journal of Agricultural Economics, Vol. **29**, No. **3**. (Arabic)

Attia, Rehan Mohamed, and Mahmoud Mowad El-Sayed (**2023**). Economic Efficiency of Summer Tomato Production in the Nubaria Region, The Egyptian Journal of Agricultural Economics, Vol. **33**, No. 1. (Arabic)

Coelli, T. J. (**1996**). A Guide to DEAP Version 2.1: A Data Envelopment Analysis (Computer) Program, Center for Efficiency and Productivity Analysis Working Paper 96/08, Department of Econometrics. University of New England, Armidale.

Charnes, A., Cooper, W. W., & Rhodes, E. (**1978**). Measuring the efficiency of decision-making units, European Journal of Operational Research.

Eid, Amal Kamel, et al. (**2014**). Estimating the Technical and Economic Efficiency of Sesame Production in Fayoum Governorate. Agricultural Economics Research Institute. (Arabic)

Farrell M.J. (**1957**). The measurement of productive efficiency, J. of the Royal Statistical Society, Vol (**120**), No (**3**).

Izzat, Wael Ahmed, and Hala Hassan Abdel-Meguid. (**2023**). Estimating the Technical and Economic Efficiency of Resources Used for Cotton Production in Kafr El-Sheikh Governorate. Alexandria Journal of Scientific Exchange, Vol. **44**, No. **3**. (Arabic)

Mohammed, Ahmed Mahmoud. (**2016**). Estimating the Efficiency of Fish Production in Egypt Using Data Envelopment Analysis. The Egyptian Journal of Agricultural Economics, Vol. **26**, No. **2**. (Arabic).

Muaz, Said Hassan Ali, Abdel Hamid, Ahmed Fawzy. (**2020**). Technical and Economic Efficiency of Date Processing in New Valley Governorate. The Egyptian Journal of Agricultural Economics, Vol. **30**, No. (Arabic).

Ministry of Agriculture and Land Reclamation, Economic Affairs Sector. Agricultural Statistics Bulletin, Various Issues. (Arabic).

Seiford, L.M., (**1996**). Data Envelopment Analysis: The Evolution of the state of the Art (1978 – 1995), Journal of productivity Analysis.

الملخص العربي

تحليل الكفاءة لمحصول الطماطم في مصر (دراسة حالة)

عبد الرحمن سامح عبد العال عبدالله، عبد الله محمود عبد المقصود، إبراهيم على محمد

قسم الاقتصاد الزراعى – كلية الزراعة– جامعة عين شمس.

يعتبر محصول الطماطم من محاصيل الخضر الرئيسية في مصر من حيث المساحة، كما أنه من أهم السلع الغذائية، لذلك يجب الاهتمام بتحسين الكفاءة الاقتصادية والإنتاجية والعمل على استقرار عرض المحصول وتحسين جودته، بالإضافة إلى توفير المنتج وفق أسعار عادلة لكل من المنتج والمستهلك، مما استدعى الاهتمام بتقدير الكفاءة لبعض مزارع الطماطم، وتحقق هذا الهدف بالاعتماد على أسلوب تحليل مغلف البيانات DEAP لتقدير الكفاءة التقنية والفنية والاقتصادية لمزارع عينة الدراسة التي شملت ٦٦ مزرعة، حيث تم تقسيمها لثلاث فئات وفقاً للمساحة، كما أوضحت نتائج الدراسة تفوق مؤشرات الكفاءة التقنية وفقاً لكل من مفهومي ثبات وتغير العائد للسعة بالفئة الحيازية الثانية مقارنةً بالفئتين الأولى والثالثة حيث بلغ متوسط كفاءة السعة للفئة الحيازية الثانية نحو ٩١٪، بينما بلغ المتوسط للفئتين الأولى والثالثة نحو ٧٦٪ ، ٧٧٪ على الترتيب، كما تبين أن الكفاءة الاقتصادية في الفئة الثالثة قد تفوقت على الفئة الأولى، مما يدل على أنه كلما زادت المساحة المزروعة زادت الكفاءة الاقتصادية، ويوصي البحث بضرورة إرشاد المزارعين إلى اتباع التوصيات الفنية المتعلقة بإنتاج محصول الطماطم، مما يؤدي إلى خفض التكاليف الإنتاجية وبالتالي زيادة الأرباح، ودراسة الأسباب التي حققت أعلى كفاءة اقتصادية في بعض مزارع إنتاج محصول الطماطم ومحاولة اتخاذها كنماذج تطبيقية للمزارع غير الكفؤة للوصول إلى أعلى كفاءة ممكنة، بالإضافة إلى تشجيع المزارعين على زيادة المساحات المزروعة من محصول الطماطم.

الكلمات الاسترشادية: برنامج تحليل مغلف البيانات، الكفاءة التقنية، الكفاءة التوزيعية، الكفاءة الاقتصادية، محصول الطماطم.