Journal of Agricultural Sciences and Sustainable Development

Open Access Journal
https://jassd.journals.ekb.eg/

ISSN (Print): 3009-6375; ISSN (Online): 3009-6219

AN ANALYTICAL STUDY OF PRODUCTION EFFICIENCY AND USE OF ECONOMIC RESOURCES IN CROP WHEAT FARMS IN SALAH AL-DIN GOVERNORATE

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Abstract
Wheat is considered one of the most important strategic crops, as the ability to produce it has become a key factor in achieving economic stability for many countries. This highlights the significance of the current study, which focuses on analyzing the production efficiency of agricultural crops—particularly wheat—as a crucial step toward improving efficiency in the agricultural sector. Salah al-Din Governorate, the focus of this study, holds particular importance due to its prominent role among Iraq's governorates in terms of cultivated area and wheat production. Therefore, this research explores the extent to which wheat farms in Salah al-Din achieve technical efficiency in their production, as well as how efficiently they utilize available economic resources. The study aimed to assess production efficiency and resource-use efficiency in wheat farms in Salah al-Din Governorate by estimating technical efficiency (TE) based on the concepts of constant returns to scale (CRS) and variable returns to scale (VRS). This analysis was conducted across the main categories of wheat-producing farms during the 2022–2023 production seasons. The findings revealed that the average technical efficiency under CRS for the sample of 60 farms was approximately 87.4%, while under VRS, it was about 92.3%. Additionally, the average scale efficiency was around 94.8%. At the scale level, the results showed that 30 out of the 60 sampled farms exhibited increasing returns to scale, indicating that these farms could increase their production while using fewer resources.

Manuscript Information:
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Received: 23/05/2025
Revised: 18/06/2025
Accepted: 27/06/2025
Published: 08/07/2025
DOI: **10.21608/JASSD.2025.388312.1062**

Keywords: Technical efficiency, capacity efficiency, data envelope

مجلة العلوم الزراعية والتنمية المستدامة

Open Access Journal
https://jassd.journals.ekb.eg/

الترقيم الدولي (مطبوع): 3009-6375 الترقيم الدولي (أونلاين): 3009-6219

دراسة تحليلية لكفاءة الإنتاج واستخدام الموارد الاقتصادية في مزارع محصول الحنطة بمحافظة صلاح الدين

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الملخص العربي:

يُعدّ الحنطة من أهم المحاصيل الاستراتيجية، إذ أصبحت القدرة على إنتاجه عاملاً أساسياً في تحقيق الاستقرار الاقتصادي للعديد من الدول، ومن هنا تبرز أهمية الدراسة الحالية، التي تُركّز على تحليل كفاءة إنتاج المحاصيل الزراعية وخاصةً الحنطة، كخطوة رئيسية نحو تحسين كفاءة القطاع الزراعي، وتحظى محافظة صلاح الدين حالة هذه الدراسة، بأهمية خاصة نظرًا لدورها البارز بين محافظات العراق من حيث المساحة المزروعة وإنتاج الحنطة، لذا إهتم البحث بدراسة مدى تحقيق مزارع الحنطة في صلاح الدين للكفاءة الفنية في إنتاجها، بالإضافة إلى مدى كفاءة استخدامها للموارد الاقتصادية المتاحة، وقد استهدفت الدراسة تقييم كفاءة الإنتاج وكفاءة استخدام الموارد في مزارع الحنطة في محافظة صلاح الدين من خلال تقدير الكفاءة الفنية (TE) استنادًا إلى مفهومي العائد الثابت للسعة (CRS) والعائد المتغير للسعة (VRS) ، وقد أُجري هذا التحليل على الفئات الرئيسية لمزارع إنتاج الحنطة خلال موسم الإنتاج 2022–2023. وأظهرت النتائج أن متوسط الكفاءة الفنية وفقا للعائد الثابت للسعة CRS على مستوى إجمالي عدد مزارع العينة والبالغ (60 مزرعة) بلغ حوالي 87.4%، بينما بلغ وفقا للعائد المتغير للسعة VRS حوالي 92.3 %، أما بالنسبة لمتوسط مؤشر كفاءة السعة فقد بلغ نحو 94.8%، وعلى مستوى العائد للسعة اتضح من نتائج التحليل أن 30 مزرعة من إجمالي مزارع العينة ذات عائد متزايد للسعة، مما يشير إلى إمكانية زيادة إنتاجها باستخدام موارد أقل، وبناءً على هذه النتائج، اقترحت الدراسة مجموعة من التوصيات التي تهدف إلى تحسين كفاءة الإنتاج وتحسين استخدام الموارد المتاحة في زراعة الحنطة.

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تاريخ استلام البحث: 2025/05/23م
تاريخ إجراء التعديلات: 2025/06/18م
تاريخ القبول: 2025/06/27م
تاريخ النشر: 2025/07/08م
معرف الوثيقة:
DOI: **10.21608/JASSD.2025.388312.1062**

الكلمات المفتاحية: الكفاءة الفنية، كفاءة السعة، مغلف البيانات.

INTRODUCTION:

Wheat is regarded as a strategic crop due to its status as a fundamental component of human nutrition, indispensable in both developing and developed countries. The ability to produce wheat has become a key factor in ensuring economic stability for nations (Al-Naimi & Al-Saour, 2008). Wheat is one of the most important cash crops and holds a significant position in the economies of developing countries, including Iraq. It plays a key role not only in foreign trade and numerous domestic industries but also due to its nutritional value and its vital contribution to economic and social development (Ghazal, Mona Ahmed, 2012). Iraq has been renowned for wheat cultivation since ancient times, often referred to as the "Land of the Two Rivers," the "Land of Blackness," and the "Land of Wheat." It is widely believed that Iraq is the original birthplace of wheat, first cultivated near the Sulaymaniyah region before spreading across the globe.

Wheat cultivation is widespread throughout Iraq, with areas planted often exceeding one million hectares—and even surpassing two million hectares in some years. However, production fluctuates from year to year due to the country's heavy reliance on rainfall and its seasonal distribution. Despite wheat's dominance as the most important cereal crop in Iraq, the country remains unable to achieve self-sufficiency and depends on large imports to meet local consumption needs (Al-Shammari et al., 2019).

Although Iraq possesses substantial financial and human resources, along with abundant water, fertile soil, and a favorable climate for agriculture, the sector remains one of the most underdeveloped among productive sectors in Iraq and neighboring countries. Addressing the challenges of the agricultural sector is thus crucial for achieving sustainable agricultural development, particularly in light of rising food security concerns (Laura Al-Saour, 2010).

Against this backdrop, the importance of this research lies in the study and analysis of productive efficiency in agricultural crop production as a key means to improving overall efficiency in the agricultural sector (Aziz, Hussein, 2023). The choice of Salah al-Din Governorate as a case study is due to its status as one of Iraq's leading regions in terms of cultivated area and wheat production. Therefore, this research seeks to evaluate the efficiency of production and the use of resources on wheat farms in Salah al-Din Governorate.

The research problem is framed by two central questions:

(1) To what extent do wheat farms in Salah al-Din Governorate achieve technical efficiency in crop production?

(2) To what extent do these farms utilize economic resources efficiently?

The main objective of the study is to evaluate the efficiency of production and resource use in wheat farms in Salah al-Din Governorate. To achieve this, several sub-objectives were pursued:

- Assessing the relative importance of wheat among total grain production in Iraq generally and in Salah al-Din specifically.
- Analyzing the optimal farm size for efficient wheat production.
- Determining the optimal quantities of resources needed to achieve technical efficiency.

- Investigating the extent to which economic resources are utilized in a technically efficient manner.

The study concludes with a set of recommendations aimed at enhancing wheat production, reinforcing its role as one of the most essential cereal crops cultivated in Salah al-Din Governorate.

MATERIALS AND METHODS:

To achieve the objectives of the study, the descriptive method and quantitative statistical analysis were used to estimate the economic efficiency of production and use of economic resources in wheat crop farms in Salah al-Din Governorate. By applying the data envelopment analysis method Data Envelopment Analysis (DEA) to estimate technical efficiency (TE) on The level of the most important categories of wheat production farms in Salah al-Din Governorate for the production season (2022-2023) According to the following assumptions:

(1) Constant Returns to Scale (CRS).

(2) Variable return to scale (VRS).

This is done by solving the model data using a statistical program or package known as: DEAP (Coelli, 1996), under the condition that the number of variables (inputs) is less than the number of observations (farms), and thus it was possible to apply the concepts of (CRS) and (VRS), and thus the technical efficiency and capacity efficiency were estimated and the capacity form was determined as “fixed, increasing, decreasing” (Mona Ali, 2013).

The study was based on both secondary and primary data sources. Secondary data—both published and unpublished—were obtained from the website of the Arab Organization for Agricultural Development, as well as from the records and statistical reports of the Ministry of Planning, the Department of Agricultural Statistics, and the agricultural statistics divisions within the Ministry of Agriculture in Salah al-Din Governorate. Primary data were collected through a structured questionnaire administered to a sample of wheat farmers during the 2022–2023 agricultural season in Salah al-Din Governorate. The study sample was categorized into three groups based on farm size. The first category comprised farmers whose wheat-cultivated areas ranged from 4 dunums (equivalent to one hectare) up to 40 dunums (10 hectares). The second category included farms with areas between more than 40 dunums and up to 80 dunums, while the third category consisted of farms ranging from more than 80 dunums to 120 dunums.

It is worth noting that technical efficiency means the farm’s ability to use the optimal mix of available resources to obtain the greatest amount of production, and it also reflects the farmer’s ability to obtain the maximum production capacity from the set of inputs and available technology (Al-Warfali, et al.,2019), and from this standpoint, there are several methods (strategies) through which this efficiency can be improved at the level of each farm, and the choice of any of them depends on the result of the diagnosis of the elements responsible for the defect, in addition to the external environmental restrictions that each farm is subject to and that are sometimes difficult to change. These strategies are represented in four approaches, which are as follows:

- The first is the stability of outputs while reducing inputs. This means getting rid of excess and unused input elements, the abandonment of which will not affect the amount of outputs achieved. The first approach is usually called the input-direction model.

- The second approach involves increasing outputs while keeping inputs constant. This means using all administrative, supervisory, and control methods that work to make the best use of resources and prevent or minimize waste. This approach is called the output guidance model.

- The third is to increase outputs and increase inputs, provided that the percentage of increase in outputs is higher.

- The fourth is increasing outputs while reducing inputs. This is considered the best approach, as it is achieved by achieving greater outputs with a smaller amount of inputs. This is done by replacing the labor element with machines and technology. However, this may not be possible in some cases, at least in the short term, as there may be social and political restrictions that limit the reduction of the labor element (Abdul Qader, 2012).

The current research has settled on adopting the first and second approaches in analysis and achieving its goal.

The research also relied on estimating efficiency according to the specific boundary approach. The Deterministic Frontier Approach using Data Envelopment Analysis. It is worth noting that Farrell (1957) was the first to establish a methodology for analyzing and calculating efficiencies in 1957. It is a specific, non-standard methodology, and this methodology is based on the fact that each farm represents a point on the isoquant production curve.

It is worth noting that the difference between DEA and SAF is that DEA is used in the case of non-parametric deterministic models that can be solved using mathematical programming, while SAF is used in the case of parametric stochastic models that can be solved using econometric methods.

DEA It is based on a simple concept: any organization that uses fewer inputs than others to produce the same level of output is considered more efficient. According to this concept, the frontier efficiency curve covers all the studied observations - it is the best combination of observations for the ratio of outputs to inputs.

MODEL USED:

The data composing the model were entered in the form of a matrix with dimensions:

(1) Number of rows = Number of observations (Number of farms) =60 farms.

(2) Number of columns = Number of inputs =5 inputs.

Thus, the condition for applying the data envelopment analysis method is achieved, as the number of inputs or columns is less than the number of observations or rows (Mona Ali,2013).

In general, data envelopment analysis Data Envelopment Analysis (DEA) relies on the use of linear programming to create an envelope or field containing data in what is known as a non-parametric piecewise surface, so that farm efficiency can be estimated according to the relationship of the combination of resources used from this field (envelope). There are three trends in analyzing this type of data that can be summarized as follows (Mona Ali, 2013):

A - Constant return model of capacity (CRS): The Constant Returns to Scale Model:

Assuming there are a number of economic units (N) produces a number of goods (Y) using a set of resources (X), and thus the goal of applying DEA becomes to determine the envelope (range) of production on which we seek the data of the economic unit to fall, and thus it is necessary to estimate the ratio of products to resources for all economic units, (UY/VX), where U represents the production weighting vector (MX1), while V represents the input weighting vector (KX1), and thus to choose the optimal weighting it is necessary to estimate the following linear programming model (Coelli, 1996):

$$Max_{\ U,V} \qquad (U'Y_j/V'X_j)$$

$$st \quad U'Y_j/V'X_j \leq 1 \quad j = 1,2 \ldots, N,$$

$$u, v \geq 0$$

Here we must continue to appreciate the values U, V are used as efficiency criteria, with the sum of these criteria ranging from zero to one. However, practical experience with this method has shown that it yields an infinite number of solutions. Therefore, it has been modified in the following form by introducing a new determinant: $v'x_i = 1$ (Coelli, 1996), and it became as follows:

$$Max_{\ \mu,v} \qquad (\mu' y_j),$$

$$st \quad v'x_i = 1$$

$$\mu' y_j - v'x_i \leq 0, j = 1,2 \ldots, N,$$

$$\mu, v \geq 0$$

Binary image is usually used.Dual instead of the previous multiplier image and it is in the following image:

$$min_{\ \theta\ ,\ \lambda}$$

$$st \quad - \quad y_i + y\,\lambda \geq 0,$$

$$\theta\, x_i \quad - x\,\lambda \geq 0,$$

$$\lambda \geq 0$$

b - Variable return model of capacity (VRS) and capacity efficiency (SE):

The Variable Returns to Scale Model and Scale Efficiency:

The Constant Returns to Scale (CRS) concept assumes that an economic unit operates at its optimal production capacity (Optimal Scale), implying a horizontal long-run average cost curve (Coelli, 1996). However, this assumption does not hold true for most agricultural units due to several influencing factors, such as imperfect market competition and the technical and economic constraints these units face. Consequently, agricultural units are often unable to operate at their optimal production scale.

To account for these deviations, the standard linear programming model used in Data Envelopment Analysis (DEA) was extended to incorporate the Variable Returns to Scale (VRS) hypothesis. This adjustment enables the estimation of scale efficiency (SE) by distinguishing between technical efficiency and scale efficiency—particularly in situations where the CRS assumption does not apply. As a result, applying the VRS model facilitates the separation of technical production efficiency from the scale efficiency of each economic unit.

Coelli (1996) proposed a modification to the CRS-based linear programming model to reflect the VRS assumption. This is achieved by introducing an additional constraint that ensures convexity of the production frontier, thereby allowing for a more accurate representation of real-world agricultural production environments. The modified model is formulated as follows:

$$min_{\ \theta\ ,\ \lambda} \quad \theta,$$

$$st \quad -y_i + y\,\lambda \geq 0,$$

$$\theta\, x_i - x\,\lambda \geq 0,$$

$$N\ 1'\lambda \leq 1$$

$$\lambda \geq 0$$

Input surplus Slack Inputs: It is clear from the shape (1) Point A' can be moved to point C (the farm, i.e. the nearest point) at the same level of unit output, but by providing an amount of X2 (Coelli, 1996), i.e. using a smaller amount, and this is considered a surplus of inputs, which is shown by the programming results in the form of (IS) Inputs Slack, i.e. the concept of surplus means an increase in the use of production inputs, and this means that it is possible to reduce or provide the amount of inputs in excess of use and obtain the same production and technical efficiency.

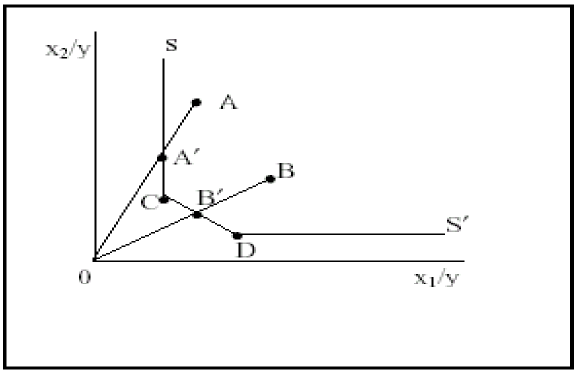

Figure (1) Efficiency scale and input surplus

$$min_{\lambda,OS,IS} -(MI'OS + KI'IS),$$

$$st \quad -y_i + Y\lambda - OS = 0,$$

$$\theta x_i - X\lambda - IS = 0,$$

$$\lambda \geq 0, OS \geq 0, IS \geq 0,$$

Where OS is the Mx1 vector for outputs, IS is the Kx1 vector for inputs. Note thatθUnchanged in the second stage (Coelli, 1996).

RESULTS AND DISCUSSION:

(1) The relative importance of wheat crops in Iraq:

Studying the relative importance of wheat production in Iraq during the period ((2018-2022) Based on data available from the Arab Organization for Agricultural Development, the following is shown:

- The Relative Importance of Wheat Area to the Total Cereal Area in Iraq:

An analysis of the relative importance of wheat cultivation area in relation to the total cereal area in Iraq during the period 2018–2022 reveals significant insights. According to the data presented in Table (1), the average area cultivated with wheat reached approximately 1,420.8 thousand hectares, accounting for about 67.6% of the total cereal area in the country over the study period. The cultivated wheat area fluctuated during these years, with a minimum of approximately 788.5 thousand hectares recorded in 2018 and a maximum of around 2,143.4 thousand hectares in 2020.

- The relative importance of wheat productivity and production in Iraq:

It is important to note that agricultural productivity is influenced by the interaction of various factors. These include soil quality and fertility, the types of crop varieties and agricultural treatments used, as well as environmental and climatic conditions—most notably, the consistent availability of irrigation water throughout the growing season, which plays a crucial role in ensuring optimal crop development.

By analyzing the data presented in Table (2), it was found that the average wheat productivity in Iraq during the period 2018–2022 was approximately 2,769.6 kg per hectare. This figure represents around 106.7% of the overall average cereal productivity in Iraq during the same period. Wheat productivity varied during the study years, reaching a minimum of about 2,659.7 kg/hectare in 2021 and peaking at approximately 2,771.4 kg/hectare in 2022.

Table (1) the relative importance of wheat area in thousand hectares to the total grain area in Iraq during the period (2018-2022)

Year/Statement	Wheat area	Total grain area	relative importance
2018	788.5	1137.5	69.3
2019	1582.8	2772.9	57.1
2020	2143.4	3482.0	61.6
2021	1591.8	1945.1	81.8
2022	997.6	1179.0	84.6
Overall average for the period	1420.8	2103.3	67.6
Relative importance of the period	**67.6**		

Source: Collected and calculated from data:

- Arab Organization for Agricultural Development, Statistical Yearbook, various issues.

Table (2) the relative importance of wheat productivity and production in Iraq during the period (2018-2022)

Year/Statement	yield		Productivity level	Production		Relative importance of production
	Wheat (kg/hectare)	Cereals (kg/hectare)		wheat (thousand tons)	grains (thousand tons)	
2018	2762.1	2303.6	119.9	2177.9	2620.4	83.1
2019	2744.2	2491.5	110.1	4343.5	6908.6	62.9
2020	2910.5	2550.8	114.1	6238.4	8881.9	70.2
2021	2659.7	2727.0	97.5	4233.7	5304.3	79.8
2022	2771.4	2902.1	95.5	2764.7	3421.7	80.8
Overall average for the period	**2769.6**	**2595.0**	**106.7**	**3951.6**	**5427.4**	**72.8**
Productivity rate for the period	**106.7**					
Relative importance of production for the period	**72.8**					

Source: Collected and calculated from data:

- Arab Organization for Agricultural Development, Statistical Yearbook, various issues.

As for the level of wheat production, it should be noted that the total production of wheat is determined in light of the area planted with it and the productivity, meaning that it is considered the sum of the variables of the area planted with it and the productivity, and the data in Table (2) The average wheat production in Iraq during the period (2018-2022) was about 3951.6 thousand tons, representing about 72.8% of the average grain production in Iraq for that period. Wheat production during that period ranged between a minimum of about 2177.9 thousand tons in 2018, and a maximum of about 6238.4 thousand tons in 2020.

(2) The relative importance of the area, productivity and production of wheat crops in Salah al-Din Governorate

Reviewing the area of wheat harvested in Salah al-Din Governorate during the period ((2019-2023) in Table (3) shows that its average during that period was 655.1 thousand dunums, representing about 12.5% of the average total harvested area at the level of Iraq for that period, which amounted to about 5464.0 thousand dunums. Table (1 in the appendix) also shows that Salah al-Din Governorate ranks third among the governorates of Iraq in terms of the harvested area of wheat crops, with an average of about 678.5 thousand dunums during the period (2021-2023).

Table (3) the relative importance of the area, productivity and production of wheat crops in Salah al-Din Governorate during the period (2019-2023)

Year / Statement	*Wheat area in Salah al-Din Governorate (one thousand acres)	*Wheat area in Iraq (one thousand acres)	relative importance	*Wheat productivity in Salah al-Din Governorate (kg/dunum)	*Wheat productivity in Iraq (kg/dunum)	Productivity level	Wheat production in Salah al-Din Governorate (1000 tons)	Wheat production in Iraq (thousand tons)	relative importance
2019	550.7	4338.3	12.7	816.1	782.9	104.2	449.4	3396.4	13.2
2020	689.5	5951.9	11.6	873.1	841.4	103.8	602.1	5007.8	12.0
2021	667.3	6367.2	10.5	625.1	664.9	94.0	417.1	4233.7	9.9
2022	719.0	3990.3	18.0	751.5	692.8	108.5	540.3	2764.7	19.5
2023	649.2	6672.3	9.7	859.6	636.6	135.0	558.1	4247.7	13.1
Average	**655.1**	**5464.0**	**12.5**	**785.1**	**723.7**	**109.1**	**513.4**	**3930.1**	**13.6**

* Area here refers to the harvested area, not the total area. Productivity here refers to the productivity of the harvested area.

Source Collected and calculated from data:

- Ministry of Planning, Central Statistical Agency, Agricultural Statistics Directorate, Wheat and Barley Production Report, various issues.

Regarding the level of wheat crop productivity in Salah al-Din Governorate, the average productivity during the period 2019–2023 was approximately 785.1 kg per dunum, which represents about 109.1% of the national average wheat productivity in Iraq during the same period. Productivity in the governorate ranged from a minimum of approximately 625.1 kg/dunum in 2021 to a maximum of about 873.1 kg/dunum in 2020.

As for wheat production in Salah al-Din Governorate, the data presented in Table (3) indicate that the average production during the study period was around 513.4 thousand tons, accounting for approximately 13.6% of Iraq's total average wheat production for that timeframe. Wheat production in the governorate peaked at about 602.1 thousand tons in 2020 and reached its lowest level at approximately 417.1 thousand tons in 2021.

Furthermore, Table (1) in the appendix reveals that Salah al-Din Governorate ranked second among all Iraqi governorates in terms of wheat production, with an average output of about 505.18 thousand tons during the period 2021–2023.

(3) Estimating the technical and capacity efficiency of wheat crops according to the concepts of fixed and variable capacity returns:

First: Indicators of technical efficiency and capacity efficiency of the wheat crop at the first category level:

The data in Table (4) The technical efficiency index, according to the concept of constant return on capacity, which assumes that these farms operate at their maximum efficiency, ranged between a minimum of about 72.0% and a maximum of about 90.3%, while the average technical efficiency index, according to the concept of constant return on capacity, for the first category was about 80.3%. This indicates that these farms can achieve the same level of production using only 80.3% of the combination of productive resources used in production, represented by (seeds, fertilizers, pesticides, machine labor, human labor "family"), which means that about 19.7% of these resources can be provided without affecting the volume of production, meaning that these farms use these resources at a rate that exceeds the plant's need for them (Emad, et al., 2023).

According to the concept of variable return on capacity, which assumes that these farms do not operate at their maximum capacity, the data in Table (4) Technical efficiency was achieved according to the concept of variable return on capacity in 5 farms in this category, which are farms (first to fifth), while the average technical efficiency index according to the variable return on capacity for farms in this category reached about 88.1%, which indicates that these farms can achieve the same production capacity using 88.1% of the combination of resources used in production, which means that about 11.9% of these resources can be saved without affecting the production volume, and since technical efficiency according to the concept of variable return on capacity refers to farm activity at capacities less than the maximum capacity, we find that the technical efficiency index in this case is higher than in the case of the concept of fixed return on capacity.

Table (4) Indicators of technical and capacity efficiency of the first category of wheat farms according to the concepts of fixed and variable capacity returns.

Technical efficiency indicators for the first category of wheat farms				
Return on capacity (RS)	**Capacity efficiency (Se_i)**	**Technical efficiency according to variable return on capacity (TE_i^{CRS})**	**Technical efficiency according to constant return on capacity (TE_i^{VRS})**	**Farm number**
irs	0.729	1	0.729	1
irs	0.820	1	0.820	2
irs	0.843	1	0.843	3
irs	0.802	1	0.802	4
irs	0.898	1	0.898	5
irs	0.900	0.885	0.797	6
irs	0.906	0.932	0.845	7
irs	0.927	0.939	0.870	8
irs	0.916	0.833	0.763	9
irs	0.908	0.871	0.791	10
irs	0.950	0.786	0.746	11
irs	0.961	0.939	0.903	12
irs	0.954	0.772	0.736	13
irs	0.968	0.745	0.721	14
irs	0.966	0.745	0.720	15
irs	0.975	0.893	0.871	16
irs	0.973	0.775	0.754	17
irs	0.962	0.846	0.814	18
irs	0.986	0.823	0.812	19
irs	0.986	0.838	0.826	20
	0.917	**0.881**	**0.803**	**First class average**

Source: Results of analysis of study sample data using the program DEAP.

As for capacity efficiency, the data in Table (4) Capacity efficiency was not achieved in any of the farms in this category. The average capacity efficiency index for this category was about 91.7%, and ranged between a minimum of about 72.9% and a maximum of about 98.6%. It can be noted from the analysis results for the first category, shown in Table (4), that the farms in this category are farms with an increasing return on capacity, "which requires increasing the level of production by using a smaller amount of resources".

Second: Indicators of technical efficiency and capacity efficiency of the wheat crop at the second category level:

This category included22 farms, and the estimation results in Table (5) indicate that 9 farms achieved technical efficiency according to the concept of constant return to capacity, while the rest of the farms did not achieve efficiency and ranged between a minimum of about 81.9% and a maximum of about 97.6%. The average technical efficiency index for farms in this category according to the concept of constant return to capacity reached about 95.3%, meaning that these farms can achieve the same amount of production using 95.3% of the combination of resources used in production.

According to the concept of variable return on capacity, the data in Table (5) Technical efficiency was achieved according to the concept of variable return on capacity in 10 farms in this category, while the average technical efficiency index according to the variable return on capacity for farms in this category was about 95.7%, which indicates that these farms can achieve the same amount of production using 95.7% of the combination of resources used in production, which means that about 4.3% of these resources can be saved without affecting the production volume. "The technical efficiency of farms in this category according to the concept of variable return on capacity ranged between a minimum of about 83.0% and a maximum of about 97.6%

Table (5) Indicators of technical and capacity efficiency of the second category of wheat farms according to the concepts of fixed and variable capacity returns.

Technical efficiency indicators for the second category of wheat farms				
Return on capacity (RS)	**Capacity efficiency (Se_i)**	**Technical efficiency according to variable return on capacity (TE_i^{CRS})**	**Technical efficiency according to constant return on capacity (TE_i^{VRS})**	**Farm number**
irs	0.988	0.885	0.875	21
irs	0.987	0.891	0.879	22
irs	0.990	0.910	0.901	23
irs	0.992	0.924	0.917	24
-	1	1	1	25
irs	0.993	0.914	0.908	26
irs	0.994	0.869	0.864	27
irs	0.986	0.830	0.819	28
-	1	1	1	29
irs	0.997	0.974	0.971	30
irs	0.999	0.960	0.959	31
irs	0.999	0.976	0.975	32
-	1	1	1	33
-	1	1	1	34
-	1	1	1	35
-	1	1	1	36
drs	0.997	0.958	0.955	37
-	1	1	1	38
-	1	1	1	39
-	1	1	1	40
drs	0.976	1	0.976	41
-	1	0.964	0.964	42
	0.995	**0.957**	**0.953**	**Second class average**

SourceResults of analysis of study sample data using the program:DEAP.

As for the capacity efficiency level, the analysis results indicated in Table (5) Capacity efficiency was achieved in 10 farms in this category, which are farms with a constant return to capacity (meaning that the amount of resources used does not change to maintain the same level of production), while capacity efficiency was not achieved in 12 farms, including 10 farms with an increasing return to capacity (meaning that the production level can be increased using fewer resources used), while 2 farms achieved capacity efficiency and had a decreasing return (meaning that increasing production requires the use of a greater amount of resources). According to the analysis results, the average capacity efficiency index for this category reached approximately 99.5%.

Third: Indicators of technical efficiency and capacity efficiency of the wheat crop at the third category level:

This category included18 farms, and the analysis results in Table (6) show that the technical efficiency index according to the concept of fixed return on capacity reached an average of about 85.7%, which indicates that these farms can achieve the same amount of production using only 85.7% of the combination of production resources used, which means that about 4.3% of these resources can be saved without affecting the production volume. The technical efficiency index according to the concept of fixed return on capacity for this category ranged between a minimum of about 77.1% and a maximum of about 96.1%.

Table (6) Indicators of technical and capacity efficiency for the third category of wheat farms according to the concepts of fixed and variable capacity returns.

Technical efficiency indicators for the third category of wheat farms				
Return on capacity (RS)	**Capacity efficiency (Se_i)**	**Technical efficiency according to variable return on capacity (TE_i^{CRS})**	**Technical efficiency according to constant return on capacity (TE_i^{VRS})**	**Farm number**
drs	0.962	0.927	0.891	43
drs	0.946	0.901	0.853	44
drs	0.932	0.948	0.884	45
drs	0.955	1	0.955	46
drs	0.931	1	0.931	47
drs	0.961	1	0.961	48
drs	0.947	0.875	0.828	49
drs	0.963	0.848	0.816	50
drs	0.948	0.863	0.818	51
drs	0.967	0.797	0.771	52
drs	0.989	0.791	0.782	53
drs	0.925	0.855	0.791	54
drs	0.911	0.889	0.809	55
drs	0.883	1	0.883	56
drs	0.901	1	0.901	57
drs	0.896	1	0.896	58
drs	0.844	1	0.844	59
drs	0.818	1	0.818	60
	0.927	**0.927**	**0.857**	**Third class average**

Source: Results of analysis of study sample data using the program:DEAP.

As the analysis results indicate in Table (6) Eight farms in this category achieved technical efficiency according to the change in return to capacity, while the rest of the farms did not achieve technical efficiency, as the technical efficiency index for the rest of the farms in this category ranged between a minimum of about 79.1% and a maximum of about 94.8%. The average technical efficiency index according to the change in return to capacity in this category reached about 92.7%.That is, these farms use production resources at a rate that exceeds the plant's need for them.(Emad, et al., 2023),This means that farms in this category can achieve the same level of production using92.7% of the total productive resources used, meaning that 7.3% of these productive resources can be saved without affecting production volume.

As for the capacity efficiency level of the third category farms, the analysis results were shown in Table (6) That farms in this category did not achieve capacity efficiency, and the results indicated that farms in this category are farms with decreasing return on capacity (i.e., to increase the level of production, it is necessary to use a greater amount of production resources). The capacity efficiency index for farms in the third category ranged between a minimum of about 81.8%, a maximum of about 98.9%, and an average of about 92.7%.

Fourth: Technical efficiency indicators at the level of the total study sample of wheat farmers:

The table shows (7) The most important indicators of technical efficiency at the level of the total study sample, which amounted to 60 farms, which shows that the average technical efficiency index according to the fixed return on capacity at the level of the total number of sample farms amounted to about 87.4%, while the average technical efficiency index according to the variable return on capacity at the level of the total number of sample farms amounted to about 92.3%, while the average capacity efficiency index at the level of the total number of sample farms amounted to about 94.8%.

Table (7) Indicators of technical efficiency and capacity efficiency at the level of the total study sample of wheat farms according to the concepts of fixed and variable capacity returns.

Statement	Technical efficiency according to constant return on capacity (TE_i^{VRS})	Technical efficiency according to variable return on capacity (TE_i^{CRS})	Capacity efficiency (Se_i)	Return on capacity (RS)		
				Its type	Number of farms	% number of farms to the total sample
Sample mean	0.874	0.923	0.948	**increasing**	30	50.0
minimum	0.720	0.745	0.729	**fixed**	10	16.7
maximum	1	1	1	**decreasing**	20	33.3

Source: Results of analysis of study sample data using the program: DEAP.

As for the level of return to capacity, it became clear from the analysis results shown in Table (7) 30 farms out of the total sample farms had an increasing return to capacity, indicating that production levels could be increased by using fewer resources. The analysis results also indicated that 10 farms had a constant return to capacity, while the number of farms with a decreasing return to capacity was 20 farms, indicating that increasing production requires the use of a greater amount of production resources.

Fifth: Estimating the surplus in productive resources used at the level of the study sample for wheat farms:

Data from Table (8) To the quantities of surplus in productive resources used in wheat farms at the level of the study sample, which indicates that the average quantities of surplus at the level of the total sample amounted to about 35.9 kg, 12.9 kg, 6.9 liters, 8.1 hours, 25.3 hours for each of (seeds, quantity of fertilizers, pesticides, machine labor, human or family labor) respectively. The results also indicated that the average quantity of surplus in productive resources at the level of the first category farms amounted to about 23.6 kg, 2.8 kg, 1.1 liters, 3.4 hours, 8.1 hours for each of (seeds, quantity of fertilizers, pesticides, machine labor, human or family labor) respectively. As for the level of the second category farms, the results of the analysis showed that the average quantities of surplus of productive resources amounted to about 14.1 kg, 1.0 kg, 14.9 liters, 6.4 hours, 39.8 hours respectively for each of (Seeds, quantity of fertilizers, pesticides, machine labor, human or family labor).

At the level of third-class farms, it was found that the average amount of surplus production resources amounted to approximately76.3 kg, 38.6 kg, 0.7 L, 15.5 hours, 26.7 hours for each of (seeds, fertilizer quantity, pesticides, machine labor, human or family labor) respectively.

Table (8) Average quantities of surplus production resources used at the level of the study sample for wheat farmers in Salah al-Din Governorate.

Statement	Quantity of seeds	Amount of fertilizer	amount of pesticides	Mechanized work	Human and family work
First category	23.6	2.8	1.1	3.4	8.1
Second category	14.1	1	14.9	6.4	39.8
Third Category	76.3	38.6	3.7	15.5	26.7
Overall average of the total sample	35.9	12.9	6.9	8.1	25.3

Source: Results of analysis of study sample data using the program:DEAP.

RECOMMENDATIONS:

Based on the results of the study, some recommendations can be formulated that may contribute to increasing wheat production as one of the most important grain crops produced in Salah al-Din Governorate, which are as follows:

(1) The importance of having a specialized agricultural advisory and technical cadre that guides farmers to follow technical recommendations for wheat production, which is reflected in increased efficiency in the use of production resources and improved wheat crop productivity.

(2) The study results showed that a number of farms achieved technical efficiency, which makes it important to study these cases and generalize them to the same area category. On the other hand, it is important to study the obstacles that prevented the remaining farms from achieving technical efficiency in their crop production.

(3) The importance of adopting modern methods in farm management to increase production efficiency and achieve optimal use of available resources. This will improve food security, increase self-sufficiency, and reduce the food gap in wheat production.

CONCLUSIONS:

Studying and analyzing the production efficiency of agricultural crops, particularly wheat, is a primary goal for achieving efficiency in the agricultural sector. Therefore, the study focused on measuring the extent to which wheat farms in Salah al-Din Governorate (a case study) achieved technical efficiency in their crop production, and the extent to which wheat farms achieved efficiency in their use of economic resources. The results indicated that the average technical efficiency index, based on the fixed return to capacity, across the total number of sample farms (60 farms) was approximately 87.4%. This is due to numerous obstacles that prevented farmers from achieving technical efficiency in their crop production. Hence, the importance of adopting modern methods in farm management to raise their production efficiency and achieve optimal use of available resources. This will improve food security, increase self-sufficiency, and reduce the food gap from wheat.

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