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Article

# Evaluation of Efficiency of Tomato Producing Farms in Afghanistan

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**Abstract:** Efficiency is one of the most important factors in productivity growth, especially in the agricultural economies of developing countries. The use of inputs in the production of agricultural products can improve the quantity and quality of these products and move towards food security. Tomatoes are considered the second-most important agricultural product. Tomatoes are primarily produced in greater quantities in the eastern and southern regions of the country. In the current research, Nangarhar province in eastern Afghanistan is an important tomato-growing area with the aim of evaluating the efficiency of agricultural units in the province and examining the reasons for inefficiency. However, the current study, conducted in 2024, selected 102 tomato producers from 16 districts of this province using a random sampling method and measured their efficiency using Data Envelopment Analysis (DEA). The data used in this research included yield per unit, pesticide use rate in liters, chemical fertilizer consumption rate (Urea, DAP) in Kg, seed consumption rate in Kg, number of hours of machinery use, and energy use rate. Work is in man-days, cultivated area in hectares, water consumption in cubic meters, and production in Kilograms. The results show that, in terms of Variable Return to Scale, there is an average of 98.6% technical efficiency, 49.9% allocation efficiency, and 49.3% economic efficiency. In this regard, it is recommended that the government of Afghanistan subsidize expensive items such as pesticides. In addition, regular and frequent visits are recommended to disseminate the latest methods of tomato cultivation, reduce losses, and educate and promote the practices of more productive farmers.

**Keywords:** data envelopment analysis; returns to scale; efficiency and food security

## 1. Introduction

Agriculture in Afghanistan is the main economic pillar and backbone of the country's economy. There are two main reasons for the importance of agriculture in a country like Afghanistan: the first reason is the importance of agriculture in people's employment; thus, 44% of the workforce is directly involved in agricultural activities, and 80% of the workforce is indirectly related to agricultural and animal husbandry for earnings. For this reason, we can say that the problem of agriculture in Afghanistan has a livelihood aspect (NSIA, 2020). The Second, more than 25 percent of Afghanistan's GDP is provided through this sector.

Globally, tomatoes (*Solanum lycopersicum* L.) is one of the most widely grown vegetables, with an annual production of 182.3 million tonnes obtained from 4.85 million ha annually (FAO, 2018). It is ranked sixth among the most consumed crops worldwide (Ntonifor et al., 2013; Ddamulira et al., 2021). Asia accounts for 61.1% of global tomato production, with 13.5%, 13.4%, and 11.8% coming from Europe, North America, and Africa, respectively. Tomato consumption per capita ranges from 61.9 to 198.9 kg, with the majority of tomato consumption occurring in China, India, North Africa, the Middle East, the US, and Brazil (Quinet et al., 2019). This product is both fresh and processed. In the year 2020, approximately 20,000 hectares of tomatoes were planted in Afghanistan, and the production level was reported at about 356,000, so that more than 16% of the garden products of Afghanistan constituted (Ministry of Agriculture Irrigation and Livestock of Afghanistan (MAIL), 2021).

Increasing the exports of agricultural products is one of Afghanistan's economic development programs. With Afghanistan's membership in the World Trade Organization and its presence in the world of economic competition, the importance of production, replacement, and development of exports has become more important. Based on this, the government adopted different regional support policies to expand and diversify the production and export of agricultural products. Supportive policies are the most important economic policies in the agricultural sector of Afghanistan, if the reason is the low elasticity of products supply in this sector, Perishable and limited storage capacity of products, increased competitiveness in export markets and improved income of farmers (Nikzad et al., 2021). The excellent natural and geographical conditions of this region for the production and export of tomatoes and their products make the province one of the main production centers of this product. According to the latest statement issued by the Ministry of Finance of Afghanistan, the export of tomatoes from Afghanistan to Europe was approved in 2023, which is an important achievement for this country. According to the latest statistics published on the site (FAO) in 2022, the export of this product is equal to 210485.5 tons, and the value is reported to be US$ 31,980,000. Thus, it ranks 10th in the world among 125 tomato exporters in the aforementioned year. To increase tomato production and improve competitiveness in global markets, at least three areas of improvement are necessary: (1) improvement in the environmental factors that farmers produce such as correct pricing, (2) improvement in the technologies used, and (3) more efficient producers. Therefore, it is necessary to determine the performance status of the producers of the product; conducting scientific research on the production of this product can have a positive effect on the evaluation. Considering the geographical location and climatic conditions of the southern and eastern provinces of Afghanistan, the production and processing of this product are of great importance in these areas. Based on this, the population under statistical investigation was the Nangarhar province of tomato growers in Eastern Kishor, Afghanistan.

Efficiency refers to the allocation of optimal resources and the use of maximum available resources; if any economic country has efficient production abroad, it will increase the costs and waste of resources (Yousefi et al., 2020). Considering scarcity and limited production resources, one of the most effective and efficient ways to achieve growth and prosperity in the agricultural sector is to examine the efficiency of agricultural units. Increased efficiency in the production of agricultural products will help direct resources and production possibilities to improve poor economic infrastructure and revive the competitive position of these products (Tajik et al., 2012).

To date, many researchers have focused on measuring the efficiency.

Alem et al. (2018) employed stochastic frontier analysis to evaluate the economic performance of Norwegian crop farms. The study utilized a translog cost function and an unbalanced panel data set covering the period from 1991 to 2013, comprising data from 455 farms located in the eastern and central regions of Norway. The analysis revealed that the average cost efficiency ranged between 78% and 81%. Furthermore, the study found that farm management practices and socioeconomic factors had a significant impact on the economic efficiency of these crop farms.

Singh et al. (2019) estimated the technical efficiency (TE) of firms and its determining factors within the Indian manufacturing sector. Building upon this, the present study assesses the TE of firms using a stochastic frontier production function approach. Subsequently, it investigates the influence of science and technology (S&T) as well as intellectual property rights (IPRs)-related factors on the estimated TE through a linear regression model. The findings reveal that the average TE of firms is approximately 94%, indicating a high level of efficiency in surplus production within the manufacturing sector. These results suggest that firms can further enhance their production capabilities through increased technological upgrades and innovation-driven advancements.

Nomani and Sen (2019) evaluated technical efficiency and factors affecting 115 small manufacturing industries in India using Data Envelopment Analysis. The results indicate that the average technical efficiency of enterprises is low, indicating a high level of technical inefficiency in the production process. High productivity in companies is mostly due to the conversion of inefficient inputs to outputs, instead of an inefficient scale. Additionally, using the Tobit regression model, the positive effects of labor expertise, age, company size, entrepreneur's experience, and entrepreneur's gender on performance were described.

Yu and Huang (2020) present an economic framework and empirical analysis to examine the impact of non-economic outputs and social value-relevant variables on the efficiency of farmer cooperatives. Utilizing survey data from 164 farmer cooperatives in Fujian Province, China, the authors estimate a multi-output translog production function that incorporates non-economic societal output, measured by the number of beneficiary farmers. The study finds that the average technical efficiency of the cooperatives is 0.747, suggesting that efficiency could be improved by approximately 25.3% on average without additional input resources, based on current production conditions.

Gulab et al. (2020) conducted a field survey in the eastern region of Afghanistan to assess tomato production, trade, and post-harvest handling practices. Data were collected through structured questionnaires administered to agricultural organizations, producers, traders, consumers, and university professors. The primary objective of the study was to evaluate the current state of tomato production and the associated supply chain processes in the region. The findings indicated that access to quality inputs, such as hybrid seeds and fertilizers, significantly influenced both yield and fruit quality. Additionally, the use of appropriate post-harvest technologies played a critical role in reducing fruit losses. Based on the results, a SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis was developed to summarize key insights.

Asfaw (2021) analyzed the technical efficiency of tomato producers in Ethiopia. Accordingly, a total of 160 farmers were surveyed. The results showed that the average efficiency of technical tomato farmers is 60%, and approximately 6480 kg of production per hectare will be lost due to inefficient factors. Finally, it was suggested that to improve the efficiency and equitable distribution of water and supply, the opportunity should be considered.

Shirzai et al. (2022) assessed delves deeper into investigating the factors influencing consumers' choice of tomato paste and the quality of the tomato paste products. In this study through descriptive, cross sectional method 384 individuals responsible for purchasing food items for their households were selected from across the Kabul city using the convenience sampling method. The results of the study of tomato paste quality show that the majority of products available in the country markets are of low quality and are contrary to the accepted and expected standards. This issue leads to the loss of one of the most important pillars of food safety and security in the country.

Kazemi Heydarloo and Molaei (2023) discuss to compare the technical efficiency of wheat production between the provinces implementing the new agricultural extension system and other provinces in Iran. The required data were obtained from the Ministry of Agriculture's website for the period of 2015–2019 and their analysis was performed using data envelopment analysis method. The results showed that the mean of input oriented technical efficiency under constant and variable efficiency in the provinces implementing the new agricultural extension system was 0.59 and 0.75 and in other provinces was 0.56 and 0.72, respectively. Also, the amount of technical efficiency under constant and variable efficiency in the provinces implementing the new agricultural extension system is 0.58 and 0.66 and in other provinces was 0.55 and 0.62, respectively.

Kouriati et al. (2023) conducted an objective assessment of farmers' technical efficiency using the Data Envelopment Analysis (DEA) method. The study aimed to demonstrate the application of DEA in a sample of farms located in the regional unit of Pieria. Data were collected through a structured survey involving 40 participating farms. The output variable was defined as the total sales of each farm, while the input variables represented key production factors: (1) land (in acres), (2) labor (in hours), and (3) variable costs (in euros). The findings indicated that, under the Constant Returns to Scale (CRS) model, the farms could improve efficiency by reducing input usage by an average of 34.6%.

Previous studies have indicated that tomatoes have very good properties and benefits for the body and have a high nutritional value (Shirzai et al., 2022). In the discussion of tomato production, it is correct if the level of harvest has a high effect on the production, but it will be clear if high-level cultivation does not necessarily lead to improved production; if the production is high and the guaranteed quality is high, the price is low, or exports will not last. Despite the importance of tomato production in Afghanistan, the efficiency of Afghan tomato growers has not been evaluated. In this study, the efficiency of the manufacturers of this product was assessed for the first time. The difference between the present study and the above-mentioned studies is that it includes different types of efficiency, including technical efficiency, scale efficiency, allocative efficiency, and economic efficiency are compared while in most studies, such as the article Kouriati et al. (2023), Kazemi Heydarloo & Molaei (2023) only the efficiency of technical agricultural products has been calculated. In addition, in this study, the causes of inefficiency and the strengths and weaknesses of tomato producers are identified in allocating resources, and at the end, successful farmers are introduced as models for other farmers.

## 2. Research Methodology

To evaluate the performance and efficiency of decision-making units (DMUs), a variety of methods are employed, which are generally classified into two main categories: parametric and nonparametric approaches (Mohammadi & Sadrolashrafi, 2005). Parametric models estimate a specific production function using statistical techniques, and efficiency is then measured based on this estimated function. In contrast, nonparametric methods do not require any assumptions about the functional form or statistical distribution of the data (Battese, 1991; Coelli, 1996; Rahimi Soreh & Sadeghi, 2004). One of the earliest applications of nonparametric methods was conducted by Farrell in 1957, who measured the efficiency of the U.S. agricultural sector using economic theory. He introduced five foundational principles to define a production possibility set, where the frontier represents an estimate of the production function. Any DMU located on this frontier is considered efficient; otherwise, it is deemed inefficient (Farrell, 1957). However, due to challenges in measurement and methodological limitations, Farrell's approach saw limited practical application and remained underutilized until 1978. That year, Charnes, Cooper, and Rhodes (CCR) (Charnes et al., 1978) addressed these shortcomings by developing Data Envelopment Analysis (DEA), which extended Farrell's model to accommodate multiple inputs and outputs. DEA does not require a predefined functional form and measures the efficiency of each DMU relative to others (Cooper et al., 2000; Zamanian & Hassani, 2016; Yong & Chunweki, 2003). DEA has become one of the most widely used nonparametric methods. It is a linear programming-based technique designed to calculate the relative efficiency of comparable DMUs. In essence, DEA is a quantitative tool for assessing the performance of organizations or units engaged in similar activities (Yong & Chunweki, 2003). In this study, an input-oriented Data Envelopment Analysis (DEA) model was employed to assess the efficiency of tomato-producing farms in Afghanistan. The selection of this model is particularly appropriate given the country's agro-economic context, where most farmers operate under low-income conditions and face rising costs for essential agricultural inputs. Afghanistan experiences persistent shortages of critical resources such as irrigation infrastructure, quality seeds, chemical fertilizers, and modern farming equipment. Additionally, due to challenges in market access, inadequate infrastructure, and external factors such as weather variability, farmers often have limited control over outputs. Under these constraints, minimizing input use while maintaining current output levels presents a more feasible and realistic approach than attempting to increase outputs (Cooper et al., 2007). The input-oriented DEA model facilitates the identification of inefficiencies in input utilization by comparing each farm against a best-practice frontier. This approach enables the determination of the extent to which inputs can be proportionally reduced without adversely affecting output, thereby enhancing resource efficiency (Cooper et al., 2007). From an environmental perspective, excessive input use contributes to soil degradation, water scarcity, and pollution. Consequently, the input-oriented approach supports sustainable agricultural practices by highlighting where and to what extent resource overuse occurs. Moreover, in the Afghan context, input data—such as land area, labor, fertilizer usage, and pesticide application—is generally more accessible and reliable than output data, especially in rural and remote areas, further supporting the suitability of the input-oriented DEA model for this study (Ministry of Agriculture Irrigation and Livestock of Afghanistan (MAIL), 2021).

In this model, the quantity θ representing the measurement efficiency is one unit, and the numerical quantity has a zero and one place between them. In fact, it is scalar, which means that in order to obtain the required efficiency units, this problem is solved i times by formula. Variable λ is a vector consisting of N × 1 numbers and is fixed if it represents the total reference weight. Y is an M × N matrix of outputs and X is a K × N matrix of inputs. Therefore, in relation (1), $y_i$ and $x_i$ are the sequence vectors of the outputs and inputs, respectively.

$$\begin{aligned} & Min\,\theta \\ & s.t \\ & -y_i - Y\lambda \geq 0, \\ & \theta x_i - X\lambda \geq 0 \quad \lambda \geq 0,\ i = 1,2 \ldots N \end{aligned} \tag{1}$$

The first constraint indicates whether the amount of actual output produced by the $i^{th}$ firm or the production factors used can be greater than this. The second constraint indicates that if $i^{th}$ firm uses the production factors, the number of factors used by the producer must be the reference.

In 1984, taking into account the assumption that the efficiency variable return to scale was measured (Banker et al., 1984), the DEA method was simplified, and the BCC model was presented. Relationships (2)–(4) indicate the nature of the return to scale.

$$NI'\lambda = 1 \Rightarrow \text{ Assume constant return to scale} \tag{2}$$

$$NI'\lambda \leq 1 \Rightarrow \text{ Assume decreasing return to scale} \tag{3}$$

$$NI'\lambda \geq 1 \Rightarrow \text{Assume increasing return to scale} \tag{4}$$

The model CCR calculations were scaled with the assumed variable return to scale by adding the convexity constraint ( $NI'\lambda \leq 1$). Therefore, the BBC model determines whether the firm will operate in an area of increasing returns to scale or decreasing returns to scale. In other words, the type of return for a particular enterprise is determined by the quantity of technical efficiency in the case of decreasing return to scale. In this case, if these two are equal, then the firm in question is faced with a decreasing return to scale. Otherwise, the rate of return remains an increasing return to scale.

Data envelopment analysis models can be output-oriented or input-oriented. In the input-oriented approach, efficiency can be achieved by minimizing the use of production factors at a given level of output. Diagram (1) shows the production output (Y) with two factors of production (K) and (L). If the (NV) line is the Iso-cost line and (UU') Iso product curve (Iso-quant), a firm is perfectly efficient under conditions of constant return to scale (CRS) (Figure 1).

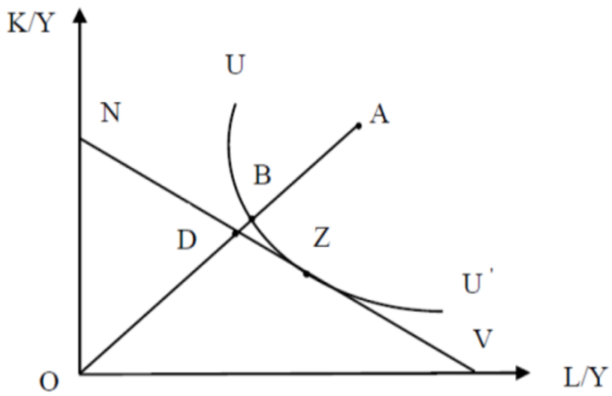


**Figure 1**. Efficiency based on input minimization (Coelli et al., 2005).

In the output-oriented approach, efficiency can be achieved by maximizing output at a given level of production factors. Diagram (2) shows that, in the context of one factor of production (X), two outputs (Y1) and (Y2), the iso-Revenue line (DD'), and the production possibilities curve (ZZ') of a firm in a two-dimensional space and in terms of constant returns to scale. The fixed ratio is the opposite of the scale ratio. In this graph, point A represents an inefficient firm, and point B represents an efficient firm (Coelli et al., 2005) (Figure 2).

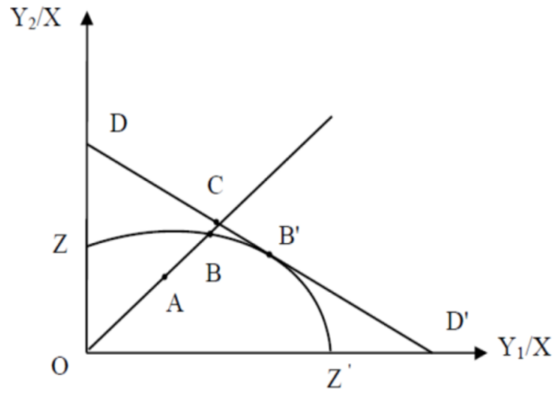


**Figure 2.** Efficiency based on maximizing output (Coelli et al., 2005).

In addition, the data envelopment analysis specifies how the output will change if we change the inputs by a certain ratio; in this case, the concept of efficiency is referred to as scale. In this case, the concept of returning to scale is discussed. A constant return to the scale of production occurs when an increase in the quantity of all factors of production leads to the same increase in the quantity produced. Increasing returns to scale of production occur when an increase in the quantity of all factors of production leads to a larger increase in the quantity produced. Decreasing returns to scale of production occur when an increase in the quantity of all factors of production leads to a smaller increase in the quantity produced. This order leads to two important results: first, the separation of technical efficiency into two parts, managerial efficiency and scale efficiency, and second, the distinction between small and large enterprises. The assumption of a return to scale means that the measuring firm does not consider the relative efficiency of the scale. Therefore, efficiency can be calculated using the DEA technique based on constant returns to scale (CRS) and variable returns to scale (VRS) (Ishizaka & Nemery, 2013). In this order, if s is the number of outputs, *m* is the number of inputs, *k* is the number of companies (DMUs), $y_{rk}$ is the amount of output r produced by DMU *k*, $X_{ik}$ is the amount of input *i* consumed by DMU *k*, $U_r$ is the weight of output *r*, and $v_i$ is the weight of input *i*. For the quantitative efficiency in terms of CRS, and based on the output axis approach is calculated from Equation (5):

$$Minimize \quad \sum_{i=1}^{m} v_i x_{ik} \tag{5}$$

Subject to:

$$\sum_{i=1}^{m} v_i x_{ij} - \sum_{r=1}^{s} u_r y_{rj} \geq 0 , \qquad j = 1, \dots , n$$

$$\sum_{r=1}^{s} u_r y_{rk} = 1$$

$$u_r . v_i > 0 \quad \forall\, r = 1, \dots , s ; \quad i = 1, \dots , m$$

The quantity of efficiency in terms of VRS and based on the output-axis approach is calculated using Equation (6):

$$Minimize \ \textstyle\sum_{i=1}^{m} v_i x_{ik} - c_k \tag{6}$$

Subject to:

$$\sum_{i=1}^{m} v_i x_{ij} - \sum_{r=1}^{s} u_r y_{rj} - c_k \geq 0 , \qquad j = 1, \dots , n$$

$$\sum_{r=1}^{s} u_r y_{rk} = 1$$

$$u_r . v_i > 0 \quad \forall\, r = 1, \dots, s\,; \quad i = 1, \dots, m$$

The quantity of efficiency in the condition of CRS and based on the input-oriented approach is calculated using Equation (7):

$$Maximize \sum_{r=1}^{s} u_r y_{rk} \tag{7}$$

Subject to:

$$\sum_{i=1}^{m} v_i x_{ij} - \sum_{r=1}^{s} u_r y_{rj} \geq 0\,, \qquad j = 1, \dots, n$$

$$\sum_{i=1}^{m} v_i x_{ik} = 1$$

$$u_r . v_i > 0 \quad \forall\, r = 1, \dots, s\,; \quad i = 1, \dots, m$$

In addition, the quantity of efficiency in terms of VRS and based on the input-oriented approach is calculated using Equation (8):

$$Maximize \sum_{r=1}^{s} u_r y_{rk} + c_k \tag{8}$$

Subject to:

$$\sum_{i=1}^{m} v_i x_{ij} - \sum_{r=1}^{s} u_r y_{rj} - c_k \geq 0\,, \qquad j = 1, \dots, n$$

$$\sum_{i=1}^{m} v_i x_{ik} = 1$$

$$u_r . v_i > 0 \quad \forall\, r = 1, \dots, s\,; \quad i = 1, \dots, m$$

In the data envelopment analysis method for measuring relative efficiency, there is a set of homogeneous units with similar inputs and outputs. In addition, in this method, the selection of correct inputs and outputs is an important principle if the system should be observed by managers and programmers in such a way that all the effective factors include the efficient or inefficient yield of a unit. The number of inputs and outputs is also very important. As a large number of variables, in addition to reducing the accuracy of the analysis, it has caused a decrease in the difference between the efficiency units and placed a larger number of units in the category of efficient units. Generally, the number of units under investigation must be greater than or equal to three times the sum of inputs and outputs. According to this study, to compare the efficiency of producers in the production process, the consumption of inputs includes (1) chemical fertilizers, (2) agricultural Pesticides, (3) seeds, (4) labor, (5) machinery, (6) water, and (7) cultivation area, and the amount of product is considered as an output. In the present study, the quantity of efficiency is measured using the DEA method and is based on two approaches based on the minimization of production factors (input oriented approach), considering the variable return to scale. It should be mentioned that in the present study, efficiency measurements will be performed using DEAP2.1 software.

## 3. Result and Discussion

Descriptive statistics of the inputs and outputs of tomato producers in Nangarhar Province, Afghanistan, are as follows (Table 1):

**Table 1.** Descriptive statistics of tomato producers in Nangarhar province during the year studied.

| Number | Description | Mean | Number | Description | Mean |
|---|---|---|---|---|---|
| 1 | Income (Afg/ha) | 305,251 | 7 | Seed(gr) | 390 |
| 2 | Cost (Afg/ha) | 131,279 | 8 | Labor(man) | 100 |
| 3 | Profit (Afg/ha) | 173,972 | 9 | Machinery cost (Afg/ha) | 23,390 |
| 4 | Yield (Kg/ha) | 27,247 | 10 | Irrigation frequency | 14 |
| 5 | Chemical Fertilizers (Kg) | 496 | 11 | Land(ha) | 0.63 |
| 6 | Agricultural pesticides (Lit) | 7 | 12 | | |

Source: Research findings.

The constant return to scale model is suitable for times when farmers operate at an optimal scale, and the efficiency of tomato products will be investigated in the producing districts of Nangarhar province in 2021 under conditions of variable return to scale.

As Table 2 shows, out of 16 districts, the lowest technical efficiency with 85.6% is Rodat district and the highest technical efficiency with 100 % is 11 districts: Khewa, Kama, Sarkhrod, Behsud, Achin, Spinghar, Dara Noor, and Ghanikhel., Lalpur, Pachiragam, and Kot. In addition, the average efficiency of tomato-producing districts in the state of variable returns to scale is 98% (Research findings, 2024) (Figure 3).

**Table 2.** The efficiency of tomato producing districts in the state of variable return to scale.

| Districts | Technical Efficiency | Allocative efficiency | Economic Efficiency | District | Technical efficieny | Allocative efficiency | Economic Efficiency |
|---|---|---|---|---|---|---|---|
| Khewa | 1 | 0.591 | 0.591 | Spinghar | 1 | 0.493 | 0.493 |
| Kama | 1 | 0.557 | 0.557 | Rodat | 0.856 | 0.402 | 0.340 |
| Surkhrod | 1 | 0.784 | 0.784 | Darenoor | 1 | 0.409 | 0.409 |
| Behsood | 1 | 0.642 | 0.642 | Ghanikhel | 1 | 0.357 | 0.357 |
| Goshta | 0.987 | 0.532 | 0.528 | Lalpoora | 1 | 0.458 | 0.458 |
| Bati Kot | 0.919 | 0.517 | 0.481 | Pachiragam | 1 | 0.404 | 0.404 |
| Momandara | 0.974 | 0.491 | 0.484 | Kot | 1 | 0.493 | 0.493 |
| Achine | 1 | 0.495 | 0.495 | Khogani | 0.949 | 0.542 | 0.514 |

Source: Research findings.

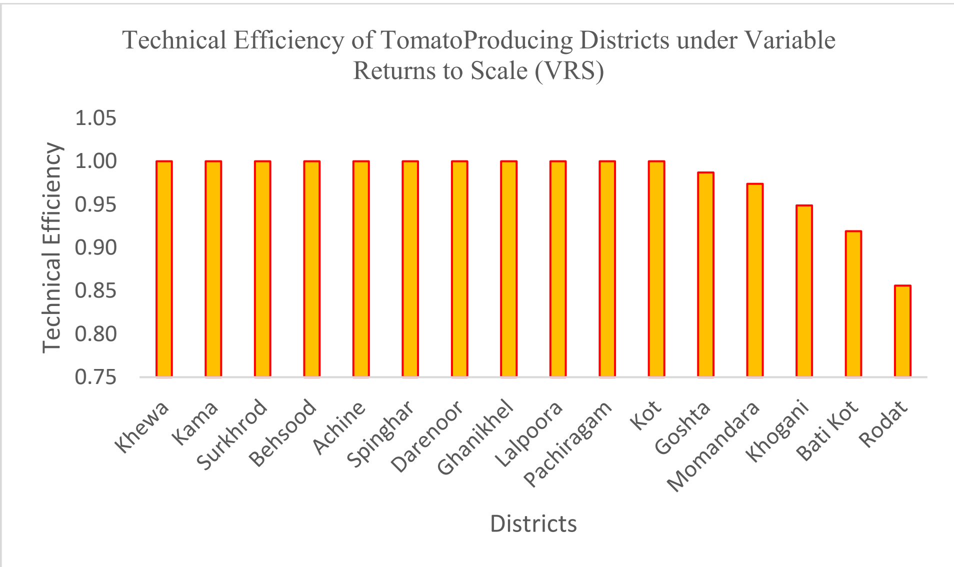


**Figure 3.** Technical Efficiency of Tomato Producing Districts. (Research findings, 2024)

In addition, the results in Table 2 show that, among the 16 districts, Ghanikhel had the lowest allocation efficiency (35.7%) and Surkhrod had the highest allocation efficiency (78.4%). In addition, the average allocation efficiency of tomato-producing districts in the case of variable returns to scale is equal to 51% (Figure 4).

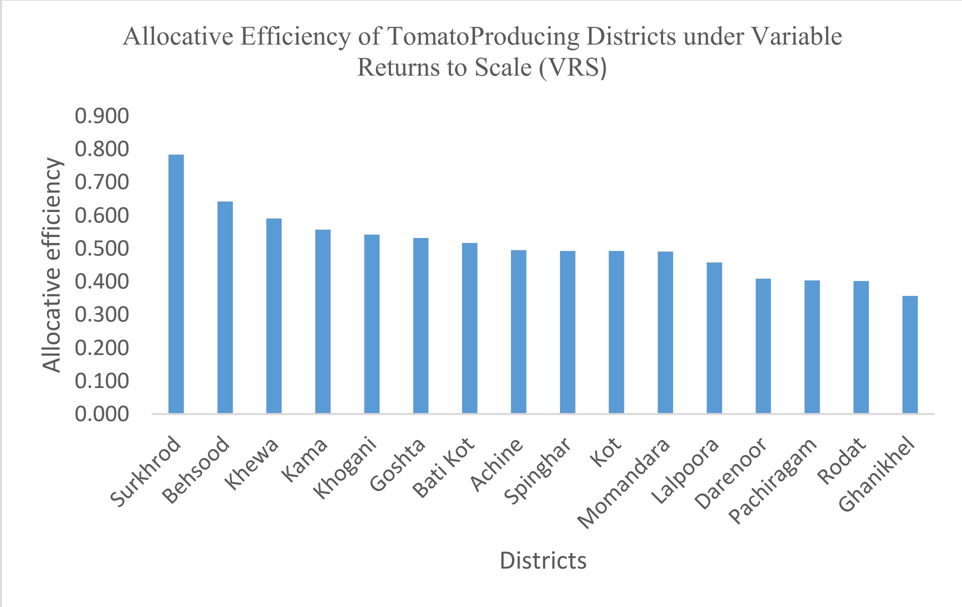


**Figure 4.** Allocative Efficiency of Tomato Producing Districts (Research findings, 2024)

In addition, the results in Table 2 show that among the 16 districts, the Rodat district has the lowest economic efficiency (34.00%) and the Surkhrod district has the highest level of economic efficiency (78.4%). In addition, the average economic efficiency of tomato-producing districts in the case of variable returns to scale is equal to 50.2% (Figure 5).

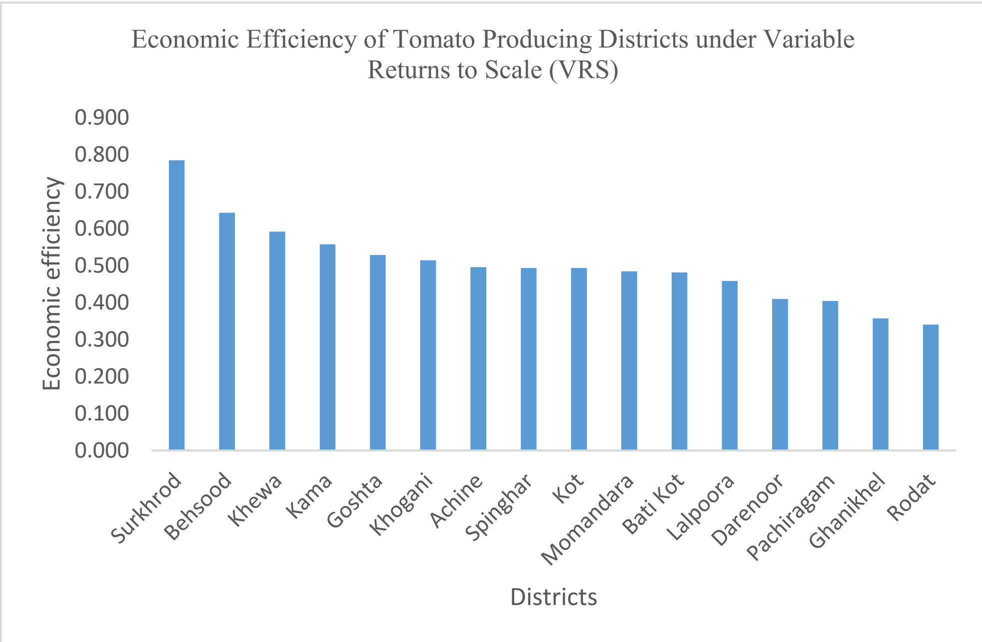


**Figure 5.** Economic Efficiency of Tomato Producing Districts (Research findings, 2024)

In the following distribution, the technical, allocative, and economic efficiency of 102 tomato producers are presented along with a statistical description in terms of VRS in Table 3.

The results in Table 3 show that the highest frequency of technical efficiency is 93.14% in areas of more than 90%. In addition, allocative efficiency and economic efficiency were 33.33 and 36.27%, respectively, and less than 40% was allocated. Table 3 shows the average, minimum, and maximum efficiencies of the three types of VRS.

As Table 4 shows, the average technical efficiency in the case of VRS is 98.6 percent, indicating that tomato production farms are facing an inefficiency scale. In this case, high technical efficiency means that if the planning and management are correct, the border will be able to achieve efficient production.

**Table 3.** Distribution of technical, allocative and economic efficiency of tomato producers in terms of variable return to scale.

| Technical Efficiency Level | Number | Percent | Allocative Efficiency Level | Number | Percent | Economic Efficiency Level | Number | Percent |
|---|---|---|---|---|---|---|---|---|
| $X \leq 40$ | 0 | 0 | $X \leq 40$ | 34 | 33.33 | $X \leq 40$ | 37 | 36.27 |
| $40 < X \leq 50$ | 0 | 0 | $40 < X \leq 50$ | 24 | 23.53 | $40 < X \leq 50$ | 22 | 21.57 |
| $50 < X \leq 60$ | 0 | 0 | $50 < X \leq 60$ | 17 | 16.67 | $50 < X \leq 60$ | 16 | 15.69 |
| $60 < X \leq 70$ | 0 | 0 | $60 < X \leq 70$ | 15 | 14.71 | $60 < X \leq 70$ | 15 | 14.71 |
| $70 < X \leq 80$ | 4 | 3.92 | $70 < X \leq 80$ | 7 | 6.86 | $70 < X \leq 80$ | 7 | 6.86 |
| $80 < X \leq 90$ | 3 | 2.94 | $80 < X \leq 90$ | 3 | 2.94 | $80 < X \leq 90$ | 3 | 2.94 |
| $90 < X \leq 100$ | 95 | 93.14 | $90 < X \leq 100$ | 2 | 1.96 | $90 < X \leq 100$ | 2 | 1.96 |
| Total | 102 | 100 | Total | 102 | 100 | Total | 102 | 100 |

Source: Research Findings.

**Table 4.** Descriptive statistics of technical, allocative and economic efficiency of tomato producers in terms of yield variable ratio to scale (percentage).

| Types of Efficiency | Technical Efficiency | Allocative Efficiency | Economics Efficiency | Scale Efficiency |
|---|---|---|---|---|
| Mean | 98.6 | 49.9 | 49.3 | 70.9 |
| Minimum | 74.5 | 23.6 | 23.0 | 34.6 |
| Maximum | 100 | 100 | 100 | 100 |

Source: Research findings.

Allocative efficiency also shows the situation for the producers to minimize the cost, if for the tomato producers, the VRS varies between 23.6 and 100%.

The economic efficiency of tomato producers in Nangarhar Province is also calculated to be 49.3% on average. There is also much potential for increasing the economic efficiency of tomato growers. Next, the average consumption of actual and optimal inputs, as well as the average level of shortage of each input in terms of VRS, for 102 tomato producers are presented in Table 5.

**Table 5.** Comparative average consumption of actual and optimal inputs used per hectare of tomato production (percentage).

| Input | Average Actual Consumption | Average Surplus Consumption (Input Slacks) | Average Optimal Consumption (Input Target) | Inefficiency Input Consumption (%) |
|---|---|---|---|---|
| Chemical fertilizer (Kg) | 488.35 | 164.59 | 323.75 | 33.7 |
| Pesticides (Lit) | 6.65 | 2.40 | 4.26 | 36.00 |
| Seed (Kg) | 0.39 | 0.10 | 0.28 | 26.2 |
| Labor (man-days) | 98.84 | 14.76 | 84.08 | 14.9 |
| Machinery (hour) | 145.52 | 22.81 | 122.71 | 15.7 |
| Water ($m^3$) | 10.77 | 4.25 | 6.52 | 39.5 |
| Cultivation area (ha) | 63.2 | 3.60 | 59.6 | 5.7 |

Source: Research findings.

The inefficiency in the use of inputs in tomato production is obtained by dividing the amount of surplus inputs by the actual consumption of inputs. It can be seen that the highest levels of inefficiency with 39.5 and 36% are in the consumption of water and water, respectively.

According to previous studies conducted (Unggul Heriqbaldi et al., 2015; Pradhan, 2018; Yu & Huang, 2020; Koye et al. 2022; Kazemi Heydarloo & Molaei, 2023 and Kouriati et al., 2023) in separate studies in Indonesia, India, China, Ethiopia, Iran and Greece showed that the average technical efficiency will be around 77, 79.10, 74.7, 60, 75, 65.4 percent respectively, and a significant amount of the investigated agricultural units are inefficient. Therefore, the results of this study were inconsistent with those of the aforementioned studies. On the other hand, a study (Alem et al., 2018) in Norway showed that the investigated units are efficient (average efficiency 81%), so the results of the study confirm the findings of the present research. It should be mentioned that efficiency is conceptually dynamic and relative, and the comparison between actual yield and ideal yield is of units; therefore, a census and survey of the total population can produce more accurate results. However, it is not possible to collect statistics and information from all tomato growers because of their cost and time. However, access to magazines and information banks in Afghanistan is not easy, and the aforementioned problems are the most important limitations of this study.

## 4. Conclusions

Farmers face many problems during the various stages of securing input, planting, harvesting, and selling the product. In this regard, identifying obstacles and the causes of inefficiency in order production can help producers. Accordingly, in this study shows that being technically efficient does not always mean being economically efficient. When input prices are affected by subsidies, taxes, or market failures, farmers may not use resources in the best way, leading to reduced allocative efficiency (Coelli et al., 2005). Poor access to markets, limited credit, and inaccurate price information also prevent farmers from choosing the most cost-effective input combinations (Farrell, 1957; Bravo-Ureta & Pinheiro, 1997). Even if they understand the ideal input use, financial and knowledge barriers may stop them from applying it in practice (Ali & Flinn, 1989). In some cases, environmental regulations require farmers to use more expensive, eco-friendly inputs, further lowering economic efficiency (Battese & Coelli, 1995). To improve overall efficiency, it is important to address market distortions, improve access to credit and information, and promote sustainable and efficient farming practices.

The results indicate that 102 tomato producers are not similar in terms of scale, and the average of scale efficiency is 70.9%; thus, 86 producers have an increasing return to scale, and through expansion of production activity, they can reduce the cost of production and increase the optimal output. The remaining producers have a constant return to the scale of production. The findings also show that although producers' technical efficiency is optimal (average 98.6), allocative and economic conditions are not favorable. The results show that in the agricultural sector of Afghanistan, there is an average of 98.6% technical efficiency, 49.9% allocative efficiency of 49.3% economic efficiency. In this regard, it is recommended that the government of Afghanistan subsidize expensive items such as pesticides. Additionally, regular and frequent visits are recommended to disseminate the latest methods of tomato cultivation, reduce casualties, and educate and extend the practices of productive farmers.

### *4.1. Recommendations*

Based on the findings of this research, the following recommendations are recommended:

The concept of efficiency is relative, and the yield method of each producer is compared to a similar producer at a particular time; therefore, in the presentation of the results, it is necessary for the manufacturers to confirm whether the results of this study are acceptable only for their practical conditions, and they must also seek to increase their efficiency and improve their yield. It is suggested that inefficient districts benefit from the experience of the reference district. One advantage of this method is that it identifies the most efficient firm on the frontier of efficiency for each inefficient unit. These districts are known to be the optimum. If an inefficient district wants to improve its yield, it should focus on its best-yield peers and set it as a model or reference. Based on the results of this study, the districts of Kama, Surkhrud, and Behsud can be used as references.

Reducing the cost of production and, consequently, the level of inefficiency with the optimal use of water and agricultural fertilizers is recommended.

### *4.2. Limitations and Future Scope of the Research*

The selection of input and output variables plays a critical role in efficiency evaluation. It is recommended that future studies utilize methods such as regression analysis, correlation analysis, or hierarchical analysis to identify appropriate variables. In the present study, actual data will be cross-sectional and definitive, corresponding to the agricultural year 2024. Future research should consider the effects of time and the use of fuzzy data in the analysis.

This study adopts an input-oriented approach. However, it is recommended that future studies also apply an output-oriented approach to offer a more comprehensive evaluation. In terms of methodology, Data Envelopment Analysis (DEA) does not accommodate zero or negative values among inputs and outputs. Although zero values can be replaced with very small positive values (e.g., 0.01), when zero values are observed in the collected data, alternative methods for measuring efficiency are advised.

Furthermore, it is suggested that future research go beyond measuring efficiency alone. Other performance indicators—such as effectiveness, value, and productivity—should be incorporated when comparing performance across districts.

## Author Contributions

Z.U.R.R. performed the data analysis and prepared the full manuscript. A.R. reviewed and edited the manuscript and provided valuable feedback. A.K.N. administered the questionnaires to respondents and collected the data for the study. All authors have read and approved the final version of the manuscript.

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## Informed Consent Statement

Not applicable

## Data Availability Statement

The datasets generated during the current study are available from the corresponding author upon reasonable request.

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## Conflicts of Interest

The authors declare no conflict of interest.

## Use of AI and AI-Assisted Technologies

No AI tools were utilized for this paper.

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