Agricultural Marketing and Commercialization Journal
6(2), 175-193, 2022, ISSN Print: 2676640X, ISSN online: 2676-7570

Study of Management Metrics Affecting Greenhouse Efficiency (Greenhouse Estate of Savojbolagh County)

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Received: 19 August 2022/ Revised: 13 October 2022/ Accepted: 05 December 2022/ Published: 31 December 2022

Abstract

The agricultural sector heavily relies on energy to meet the ever-increasing food demands of the growing population of the planet and to provide sufficient and proper nutrients. Assessment of energy-use patterns in the agricultural sector seems to be critical due to the limited natural resources and the adverse impacts of improper utilization of various energy resources on human health and the environment. Therefore, this study aims to investigate the management indicators affecting greenhouse efficiency. Efficiency is the production of goods with higher quality in the shortest possible time, which is categorized into three types: technical, allocative, and economical. Technical efficiency can determine the ability to produce the maximum possible output from a certain bundle of inputs. In this study, the Stochastic Frontier Analysis (SFA) and Data Envelopment Analysis (DEA) were used to determine the technical efficiency of greenhouses, and Eviews, SPSS, and Frontier software were also used for data analysis. In the present study with a sample of 38 greenhouses among the greenhouses of Savojbolagh County, it was concluded that the production increased by 14.5%, 41.1%, and 1.5%, with 1% more use of chemical fertilizers, pesticides, area, and irrigation, respectively; also factors such as education and applying modern knowledge affect the technical efficiency of greenhouses.

Keywords: Greenhouse, Management indicators, Savojbolagh County, Technical efficiency.

Introduction

In today's world, the production level in a country, particularly the production of agricultural commodities, can be counted among the most important factors in establishing authority and sustainability at the national and international levels. Therefore, the agricultural policies will focus on the quantitative analysis of production and the optimal use of agricultural production resources, seeking to increase domestic production through the optimal use of resources (Diaz et al., 2004).

Given the growing population and the subsequent increase in demand for agricultural products, as well as the limited resources and crop seasonality, strategies should be considered to meet people's needs for both increasing the yield and possibility of producing crops out of season (Naieni, 2012).

Water deficiency is the most limiting factor for the economic development of the country. Population growth and limited extractable water pose a major challenge to the agricultural sector, which must produce more agricultural products with less water

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consumption to ensure food security (Muosanejad et al., 1999). The agricultural sector is known as the largest water user in the world, and Iran is no exception to this, as approximately 82 Bm^3 (94%) of the total extracted water in Iran (87.5 Bm^3) is currently allocated to the agricultural sector. Thus, optimal exploitation and water use reduction can play an effective role in solving the constraints of water resources (Dehghanisanij et al., 2007).

Saving water use is a good solution in this regard, as in traditional cultivation, almost 20 t of cucumber are obtained for 14,000-18,000 m^3/ha of water, while in greenhouse cultivation, approximately 250 t of cucumber are produced for 7500 m^3/ha of water (Yilmaz et al., 2007).

The increase in efficiency can contribute as an appropriate complement to a set of policies to simulate production or preserve resources. Furthermore, it can play a pivotal role in the allocation of inputs and production factors and provide grounds for improvement to develop balanced and sustainable agricultural growth. Given the constraints facing the agricultural sector to increase production through the development of production factors and major modifications in available technology, the most appropriate solution to establish the required growth rate in the agricultural sector is most likely to improve technical efficiency, i.e., obtaining more production from a fixed set of production inputs (Mehrabi Bashirabadi, 2007).

The development of commercial greenhouse units is an appropriate option for the commercialization and competitiveness of the agricultural sector and its active presence in global markets.

The origin of greenhouse crops goes back to 1600 AD. The greenhouse industry is a product of modern sciences and technologies, which is the result of combining the findings of various sciences, including mechanics, electronics, agricultural and horticultural sciences, water and soil engineering, chemistry, etc. (Speelman et al., 2009).

In post-World War II, the greenhouse crop industry underwent a big transformation. Although the rapid growth of greenhouse production technology remained behind Iran's borders for a long time, the discussion of greenhouse crops entered the Iranian agricultural system in the years after the Iraq-Iran war. Climatic diversity, abundant labor force, technical knowledge for production, and availability of inexpensive energy are proper grounds for the development of greenhouse production units in Iran (Raju & Kumar, 2006).

The greenhouse can effectively improve crop yield and quality due to the ability to increase the duration of land exploitation to 12 months instead of a cropping season, as well as the ability to better control environmental uncertainties such as climatic factors required by the plant and remove restrictions. Greenhouse cultivation has significantly grown in recent years in Iran (Thanassoulis, 2000).

The yield in greenhouse cultivation is significantly higher than in outdoor cultivation. This provides sufficient income for farmers who have small lands and limited water resources. The crops produced in the greenhouse have higher quality due to the control of effective factors during production. Adverse weather conditions, diseases, and pests can be managed more easily in the greenhouse than outdoors. Tomato, cucumber, eggplant, strawberry, radish, pepper, and various types of leafy vegetables are among the crops that can be produced in a greenhouse simple and hassle-free, most of which are produced by the hydroponic method (Yilmaz et al., 2007).

The land occupation in outdoor cultivation is about ten times, and the water use is around twelve times that of greenhouse cultivation, while the annual yield from greenhouse cultivation is about ten times that of outdoor cultivation, making it possible to achieve higher yields by using newer techniques. Greenhouse crop production is considered to be quite economical all over the world because it increases financial efficiency, first with off-season production and second by increasing water-use efficiency by up to 90% due to the use of artificial soil (Jos & Oliveira, 2003).

According to these features, it is very important to determine the efficiency of greenhouse units and to identify the effective factors, as it provides the possibility to pay attention to the position of greenhouse production units, the existing potential to increase efficiency, and the use of existing resources, along with economic analysis (Daneshvar & Alavi, 2005).

Given these details, it can be acknowledged that this study aims to investigate the management indicators affecting greenhouse efficiency with a case study of the greenhouse estate located in Savojbolagh County.

Literature Review

(Najafi & Shajari, 1997) estimated the technical efficiency of wheat farmers in Fars province by using three methods (modified ordinary least squares, linear programming, and maximum likelihood). Their study results showed that there is a relatively significant difference in the efficiency of wheat farmers so that the production can be increased through training methods applied in advanced farms and expanding management knowledge among other farmers.

Kerami and Zibaie (2000) calculated the technical efficiency of rice growers using the maximum likelihood method and the estimation of the stochastic frontier logarithmic-linear production function and investigated the factors affecting it. According to the results of the frontier production function estimation, the technical efficiency and socioeconomic factors in Fars province are significantly interrelated, while the technical efficiency of farmers in Gilan province is positively correlated with their age but negatively correlated with their family size. In Mazandaran province, efficiency had a negative relationship with family size and farm size and a positive relationship with education level.

(Diaz et al., 2004), evaluated the efficiency of irrigation basins in Spain by using the data envelopment analysis (DEA) technique. (Raju & Kumar, 2006) also studied irrigation scheme ranking in India using the multi-criteria decision-making method and DEA model.

Ceyhan and Bozoğlu (2007) studied the technical efficiency of vegetable farms in

Samsun province, Turkey, during 2002-2003. Their results showed that the technical efficiency among farmers ranged from 0.56 to 0.95 with an average efficiency of 0.82, which can increase the efficiency of these farmers up to 18%, and the variables of education, credit, women's participation, and the amount of information negatively affect inefficiency.

(Speelman et al., 2009), analyzed the irrigation water use efficiency in South African farms and the factors affecting it using the DEA method. According to their results, the average water efficiency in constant and variable efficiency compared to the scale was 43% and 67%, respectively. Factors such as irrigation methods, land ownership, land size, and crop selection were effective in irrigation water efficiency.

(Yilmaz et al., 2007), studied the water use efficiency in the Menderes basin in Turkey using the DEA method. In this study, the efficiency of the decision-making units was evaluated according to the weight limitations specified by value judgments.

Methodology

The present study is applied research for its orientation according to its objective, field research in data collection, and correlational research for the relationships among the variables. This study was performed in a greenhouse estate located in Hashtgerd New City in Savojbolagh County, where the first and largest hydroponic greenhouse project in Iran has been implemented with an area of 170 ha, and currently, more than 50 greenhouses in the Hashtgerd greenhouse estate grow all kinds of summer plants, flowers, and ornamental plants and strawberries (Anonymous, 2007, p. 12). To assess the condition of greenhouses and determine management indicators and technical efficiency of greenhouse units in the greenhouse estate of Alborz province, Savojbolagh County, the sample size was estimated at 38 greenhouse units based on Cochran's formula, which was selected by random cluster sampling.

$$n = \frac{P(1-P) * Z^2}{d^2}$$

Where,

Z: The confidence coefficient (α-1) % to generalize the results of the sample to the population;

P: A presumption of the relative frequency of the studied trait in the population;

d : Optimal accuracy to generalize the results of the sample to the population.

This study was conducted in steps as follows: (i) the library resources were first reviewed for the literature review, and the sources and experiences were searched through the Internet, (ii) after summarizing and formulating the framework, the variables related to the research objectives were identified, and (iii) in the next step, a questionnaire tailored to the studied population was designed and used to complete and collect information. The required data was related to the profile of the greenhouse unit manager, the greenhouse unit management, how to buy and sell, the status of the greenhouse location, the status of applied inputs, and the status of personnel and production. To estimate the efficiency of the beneficiaries studied by Eviews software, a proper and optimal functional form should first be determined, followed by the estimation of the efficiency function based on it and with the Frontier software.

Two types of Cap Douglas functions (representative of inflexible functions) and Transendenthal (representative of flexible functions) were estimated in this study. The general mathematical form of these functions is as follows:

(1) Cap Douglas function:

$$\ln(y) = \alpha + \sum_{i=1}^{n} \beta_i \ln(X_i) + u_i$$

(2) Translog production function:

$$\ln(y) = \alpha + \sum_{i=1}^{n} \beta_i \ln(X_i) + (\frac{1}{2})\sum_{i=1}^{n} \gamma_{ii} (\ln X_i)^2 + \sum_{i=1}^{n}\sum_{j=2}^{n} \gamma_{ij} (\ln X_i)(\ln X_j) + u_i$$

Where, α, γ, and β are the parameters; Y is the yield; X_i is the input values, including chemical fertilizer (Kg/ha), pesticides (L/ha), number of plants (n), the labor force (l), irrigation period (ab), and cultivated area (sz).

u_i is the function residual term that consists of the following two components:

$$u_i = e_i + v_i$$

Where, v_i is the random variations caused by factors beyond the beneficiaries' control, and e_i indicates the inefficiency of the units.

In this study, the factors affecting inefficiency (e_i) are considered as follows:

$$e_i = \alpha_0 + \alpha_1 z_1 + \alpha_2 z_2 + \alpha_3 z_3 + \alpha_4 z_4 + \alpha_5 z_5 + \alpha_6 z_6$$

Where, z_1 is the education level, z_2 is the existence of insurance, z_3 is the gender, z_4 is the management, z_5 is the ownership, and z_6 is the soil leaching for salinity control. The data applied in the estimation of these functions include the data related to 38 beneficiaries in Savojbolagh County in 2013. LR statistic was used in the study and comparison of Translog and Cap Douglas models. This statistic is calculated as follows:

$$LR = -2Ln\lambda = -2(Ln(L_R) - Ln(L_U))$$

$$L_R = \log - likelihood\ \ function = 16.6$$

$$L_U = \log - likelihood\ \ function = 3.9$$

The degree of freedom of the test statistic is equal to the number of restrictions imposed on the Translog model to reach the Cap Douglas model. With the assumption of a normal distribution for the error component, the likelihood level test compares the maximum value of the likelihood function under the hypothesis that the null hypothesis is true with the maximum value of the likelihood function in the unrestricted mode. If both values do not differ much, then the two restricted and unrestricted forms are not different from each other; while if the difference is large, the probability of rejecting the null hypothesis is increased, and the unrestricted form is preferred over the restricted, and in other words, the Translog function is preferable to the Douglas Cup.

Conceptual Model

The conceptual model of the studied variables is as follows (Figure 1):

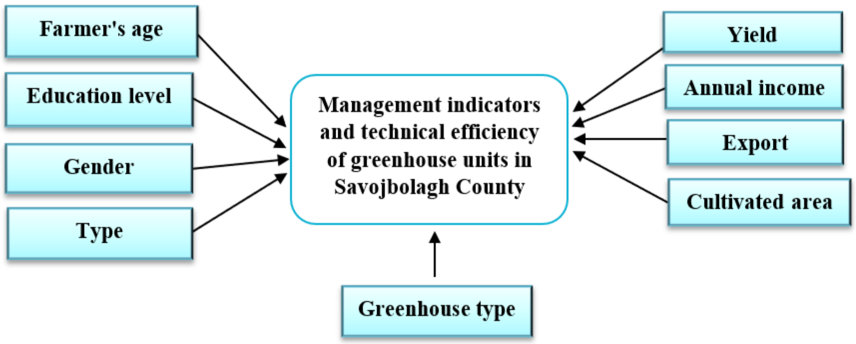

Figure 1. Conceptual model of variables

Results

Production function estimation results

According to (Table 1), the maximum likelihood statistic is lower than the chi-square value of the table; as a result, the null hypothesis, i.e., the Cab Douglass function, is accepted, and this function is selected as the best functional form. The null hypothesis on the normality of the error term is accepted in this model according to the P-value of Jarque-Bera's statistic.

Table 1. Comparison of Cab Douglass and Translog functions based on the likelihood ratio test

Estimated model	likelihood function value	Parameter number	Calculated LR
Translog	101.8	6	0.26
Cab Daglass	116.6	17	

Source: Research findings

The results of the Cab Douglass model estimation are reported in (Table 2), which are as follows:

C: It is an intercept, and it does not matter whether its level is accepted or not. Regarding the positive or negative (Figure 2) and (Table 2), it can be indicated that if it is positive, it has a greater and positive effect on production, while if it is negative, it has an inverse and negative effect on production.

According to (Table 2) on the extracted parameters and (Figure 2), if 1% is added to the plant number, 14.5% will be added to the production, i.e., the efficiency of more plants is positive. On the other hand, if 1% is added to the labor, 8.4% of the product will decrease, i.e., the efficiency of the labor is negative.

Table 2. Cab Douglas model estimation results

Dependent Variable: LNY				
Method: Least Squares				
Sample (adjusted): 1 37				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-54.8943	37.74698	-1.45427	0.1578
LNBOTE	14.55046	2.843029	5.117941	0
LNL	-8.44079	5.05469	-1.66989	0.1069
LNKOOD	42.19572	2.761031	15.28259	0
LNSAM	-6.01391	3.325019	-1.80868	0.0821
LNSZ	-33.3366	6.287174	-5.30231	0
LNAB	1.592843	7.634138	0.208647	0.8363
R-squared	0.939266	Mean dependent var		-21.5523
Adjusted R-squared	0.92525	S.D. dependent var		34.1439
S.E. of regression	9.335103	Akaike info criterion		7.491272
Sum squared resid	2265.748	Schwarz criterion		7.808713
Log likelihood	116.606	Hannan-Quinn criter.		7.598081
F-statistic	67.01548	Durbin-Watson stat		2.217796
Prob(F-statistic)		0		

(Source: Research findings)

In the case of another parameter, such as fertilizer, it can be concluded that with a 1% increase in fertilizer, production will increase by 42.1%, and the efficiency of using fertilizer is positive.

Furthermore, if 1% is added to the pesticide parameter, 6.01% of the production will be reduced; that is, the efficiency of using the pesticide is negative. In addition, with a 1% addition to the cultivated area, 33.3% of the production will be reduced, i.e., the efficiency of using the cultivated area is also negative. According to the extraction of (Figure 2), with a 1% increase in water use, we have a 1.5% increase in production, so the water use efficiency is also positive.

According to the study results, it can be concluded that with the existing area, the cultivated area in the current situation to increase the production, plant inputs-fertilizer and water use is increased, and on the contrary, it reduced other inputs such as pesticide-labor. Each of these coefficients is the concept of elasticity of production with respect to production inputs, which is based on the following equation:

$$\frac{dlny}{dlnx} = \frac{\frac{dy}{y}}{\frac{dx}{x}} = \frac{dy}{dx} = \frac{x}{y} = \text{xyx}$$

The elasticity of y with respect to x

F-Statistic: If the calculated F is greater than F in the table, the hypothesis H_0 is rejected, i.e., all parameters of "β" in the model are statistically acceptable.

According to the calculated F, all parameters are accepted at the 99% probability level "with an error level of <0.01".

Durbin-Watson Statistic: This statistic assesses the autocorrelation hypothesis of the model. If the Durbin-Watson Statistic is "approximate" between 1.9 and 2.3, it indicates that there is no autocorrelation in the model. When a model is auto correlated, there is a correlation between the residuals of the model (Ui) (Figure 2).

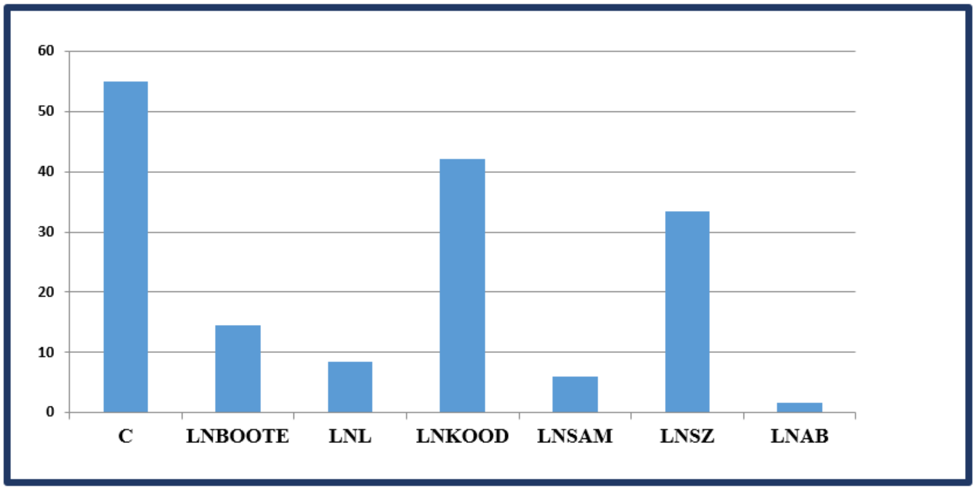

Figure 2. Cab Daglass model estimation results (Source: Research findings)

The results of the Translog model estimation in (Table 3) are as follows:

C: It is an intercept, and it does not matter whether its level is accepted or not. Regarding the positive or negative (Figure 3) and (Table 3), it can be indicated that if they are positive, it has a greater and positive effect on production, while if they are negative, it has a negative and less effect on production.

Table 3. Translog model estimation results

Dependent Variable: LNY				
Method: Least Squares				
Sample (adjusted): 137				
Included observations: 33 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-8857.2	10634.39	-0.83288	0.4172
LNBOTE	33.97841	95.66474	0.355182	0.7271
LNL	-57.752	67.71427	-0.85288	0.4063
LNKOOD	-1708.16	2448.644	-0.69759	0.4954
LNSAM	-3.87701	109.534	-0.0354	0.9722
LNSZ	5321.355	6805.356	0.781936	0.4457
LNAB	-4289.67	5503.267	-0.77948	0.4471
LNKOOD*LNAB	-9.52325	21.63674	-0.44014	0.6657
LNBOTE*LNKOOD	3.356618	8.279435	0.405416	0.6905
LNKOOD*LNSAM	8.394971	10.15328	0.826824	0.4205
LNKOOD*LNSZ	224.2623	308.7191	0.726428	0.4781
LNBOTE*LNBOTE	-6.84685	6.694474	-1.02276	0.3216
LNL*LNL	14.3254	25.02182	0.572516	0.5749
LNKOOD*LNKOOD	-3.7676	3.735472	-1.0086	0.3282
LNSAM*LNSAM	-7.96133	7.684487	-1.03603	0.3156
LNSZ*LNSZ	-536.55	688.7798	-0.77899	0.4474
LNSZ*LNAB	546.8056	685.5676	0.797595	0.4368
Regression statistics				
R-squared	0.975118	Mean dependent var	-21.5523	
Adjusted R-squared	0.950236	S.D. dependent var	34.1439	
S.E. of regression	7.616784	Akaike info criterion	7.20497	
Sum squared resid	928.2465	Schwarz criterion	7.975898	
Log likelihood	101.882	Hannan-Quinn criter.	7.464364	
F-statistic	39.18953	Durbin-Watson stat	1.99629	
Prob(F-statistic)		0		

(Source: Research findings)

According to the Translog table:

- If 1% is added to the plant numbers, 33.9% will be added to the production, which means that the efficiency of more plants is positive.
- If 1% is added to the labor force, 57.7% of the production will decrease, i.e., the efficiency of using more labor force is negative.
- If 1% is added to the fertilizer, 1708.1% of the production will decrease, which means that the efficiency of using more fertilizer is negative.

- If 1% is added to the pesticide, 3.8% of the product will decrease, i.e., the efficiency of using more pesticides is negative.
- If 1% is added to the cultivated area, 5321.3% is added to the production, i.e., the efficiency of using more cultivated area is positive.
- If 1% is added to water use, 4289.6% of production will decrease, which means that the efficiency of using more water is negative.
- If 1% is added to fertilizer and water use, 9.5% of production will decrease, i.e., the efficiency of increasing fertilizer and water use is negative.
- If 1% is added to the plants and fertilizer, 3.3% will be added to production, i.e., the efficiency of increasing fertilizer and plants is positive.
- If 1% is added to fertilizers and pesticides, there is an 8.3% increase in production, i.e., the efficiency of increasing fertilizers and pesticide is positive.
- If 1% of fertilizer and the cultivated area is added, there is a 224.2% increase in production, i.e., the efficiency of increasing fertilizer and the cultivated area is positive.

F-Statistics

If the calculated F is greater than the F in the table, hypothesis H_0 is rejected, i.e., all the model parameters are statistically acceptable. According to the calculated F, all parameters are accepted at the 99% probability level "with an error level of <0.01".

Durbin-Watson Statistic

This statistic evaluates the autocorrelation hypothesis of the model. If the Durbin-Watson Statistic is "approximate" between 1.9 and 2.3, it indicates that there is no autocorrelation in the model. When a model is auto correlated, there is a correlation between the residuals of the model (Ui).

Inefficiency occurs when the actual production is not equal to the potential production, and there is no efficiency (Figure 3).

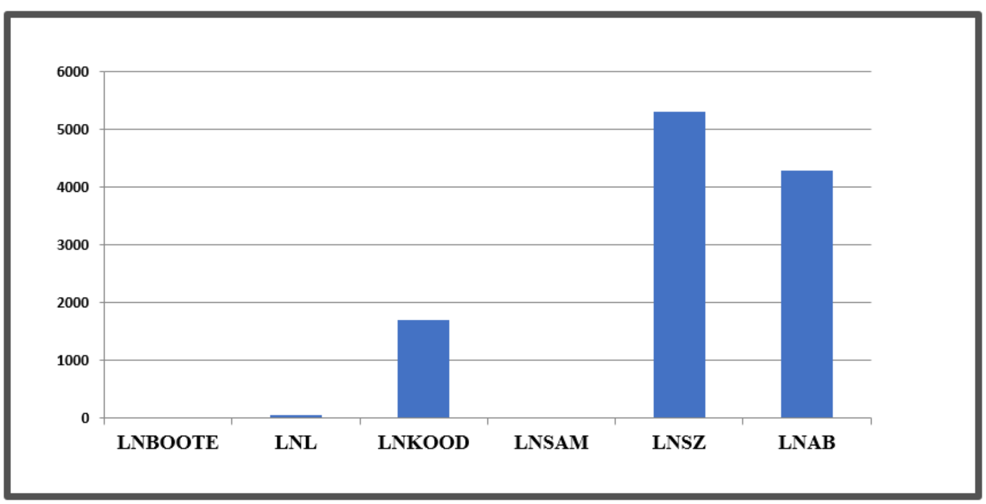

Figure 3. Translog model estimation results (Source: Research findings)

The elasticity of input production shows that if production inputs increase by 1%, several percent will be added to production.

Table 4. Elasticity values of production variables

Input	Elasticity value in mean inputs
Plant number	14.55
Labor	-8.44
Fertilizer	42.19
Pesticide	-6.01
Cultivated area	-33.33
Irrigation	1.59

(Source: Research findings)

According to (Table 4), among the factors affecting growth, the production elasticity of chemical fertilizers, the number of plants, and irrigation are positive, i.e., with 1% more use of chemical fertilizers, pesticides, and irrigation, production increases by 14.5% 42.1%, and 1.5% respectively. The (Figure 4) -8.44, -6.01, and -33.33 obtained for labor, pesticide, and cultivated area, respectively, indicate that these inputs had a negative production elasticity due to unknown reasons, and not only has production not improved with their increase, but it has also experienced a negative growth. These values can be observed in a better way in (Figure 4).

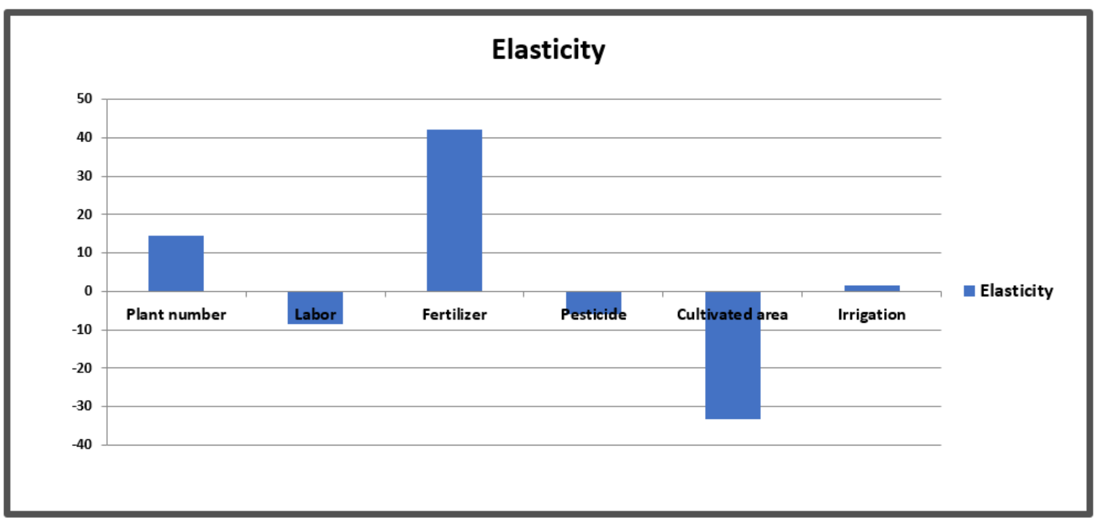

Figure 4. Values of elasticity of production variables (Source: Research findings)

The results of the frontier function estimation of the maximum likelihood value

Following the estimation and selection of the appropriate production function, the SFA model and the OLS regression model were estimated using Eviews software. In this model, *J* represents gender, *BIME* represents insurance, *AMOZ* represents training, *TAH* represents education level, *TAJ* represents experience, *RAVESH* represents cultivation method, and *MA* represents ownership.

Table 5. Estimation results using least squares

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.809379	0.728303	1.111321	0.277
J	-0.042289	0.117833	-0.358887	0.7227
BIME	-0.306764	0.154906	-1.980329	0.0588
AMOZ	-0.00561	0.012435	-0.451153	0.6558
TAH	0.074036	0.188456	0.392854	0.6978
TAJ	-0.002632	0.004149	-0.63443	0.5316
RAVESH	-0.054993	0.200347	-0.274488	0.786
R-squared	0.122544	Mean dependent var		0.265844
Adjusted R-squared	-0.088046	S.D. dependent var		0.23217
S.E. of regression	0.242175	Akaike info criterion		0.192329
Sum squared resid	1.46622	Schwarz criterion		0.512958
Log likelihood	3.922743	Hannan-Quinn criter.		0.298608
F-statistic	0.581908	Durbin-Watson stat		1.867073
Prob(F-statistic)	0.741261			

(Source: Research findings)

The estimation results of the least squares model in (Table 5) are as follows:

- Gender is not accepted at the probability level of 28%, and statistically, it is not a factor affecting inefficiency, but the negative sign of the coefficient obtained for the gender variable (male) causes a decrease in inefficiency in greenhouse units, i.e., the gender (male) causes more efficiency of the production units in greenhouses.
- In addition, the insurance is accepted at the probability level of 95%, and statistically, it significantly affects the inefficiency, but the minus sign of the coefficient obtained for the insurance variable reduces the inefficiency in the greenhouse units, i.e., the insurance makes the production greenhouse units more efficient.
- Training is not accepted at the probability level of 35%, and it is not a statistically significant factor affecting inefficiency, but the negative coefficient obtained for the variable of training decreased inefficiency in greenhouse units, i.e., training increases the efficiency of production greenhouse units.
- Education level is not accepted at the probability level of 31%, and it is

statistically insignificant on the inefficiency, but the positive coefficient obtained for the variable of education level indicates that the presence of low education level results in more inefficiency in greenhouse units. Therefore, a low education level leads to a decrease in efficiency.

- Experience is not accepted at the probability level of 47%, and it statistically affects inefficiency insignificantly, but the negative coefficient value obtained for the experience variable decreased inefficiency in greenhouse units, i.e., experience increases efficiency in production greenhouse units.
- Cultivation method is not accepted at the probability level of 22%, and it does not statistically have a significant effect on inefficiency, but the negative coefficient value obtained for the variable of cultivation method decreases inefficiency in greenhouse units, i.e., the cultivation method results in more efficiency in production greenhouse units.

F-Statistics:

If the calculated F is greater than the F value in the table, hypothesis H_0 is rejected, indicating that all the parameters of the model are statistically acceptable. As the number of questionnaires was small, this affected the results. According to the calculated F, all parameters are not accepted at the probability level of 42%.

The technical efficiency function showed the relationship between the studied variables and technical inefficiency. If a variable has a negative relationship with inefficiency, it indicates that the variable in question has increased technical efficiency; and if the variable has a positive relationship with inefficiency, meaning that the mentioned variable decreases technical efficiency. According to the study of coefficients of the variables included in the technical inefficiency function of producers, the variables of gender, insurance, training, experience, and cultivation method have a negative relationship with the technical inefficiency of production units. While the education level variable is not such, i.e., these variables do not have a significant relationship with inefficiency (Figure 5).

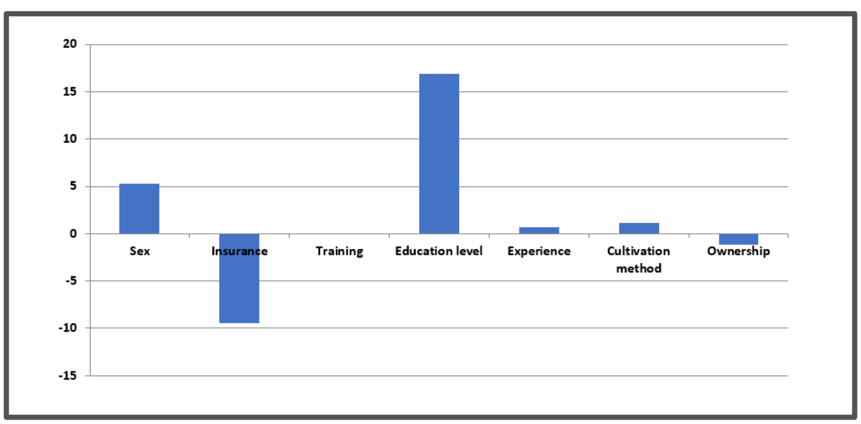

Figure 5. Estimation results using least squares

Study of technical efficiency values of beneficiaries

For each of the studied beneficiaries, the value of the technical efficiency index was obtained through Frontier software. The technical efficiency estimation results are summarized in (Table 6).

Table 6. Descriptive statistics of technical efficiency scores from Stochastic Frontier Analysis (SFA)

Sample No.	Mean	S.D.	Variance	Min.	Max.
38	0.68	0.22	0.048	0.07	1

(Source: Research findings)

As shown in (Table 6), the mean technical efficiency of beneficiaries in Savojbolagh County is 0.68, while this efficiency ranged between 0.07 and 1 with a variance of 0.048. In other words, in a greenhouse unit with minimum efficiency, the production can increase up to about 90% by extension of the inputs' values and the application method in the efficient units. Otherwise, the maximum production rate will not be achieved. The minimum and maximum technical efficiency of producers were calculated as 0.07 and 1, respectively, indicating a significant difference between the minimum and maximum technical efficiency of producers.

Table 7. The range of technical efficiency of the units by the SFA method

Range	Frequency	Percentage
<60	13	34
60-70	8	21
70-80	6	15
80-90	3	7
90-100	8	21

(Source: Research findings)

According to the results provided in (Table 7), the efficiency of 21% of beneficiaries is more than 90%. Fifteen percent (15%) of the beneficiaries are in the efficiency range between 70% and 80%, and the efficiency of 34% of the beneficiaries is contrarily calculated in the lowest efficiency range (<60%), which is very significant in terms of the amount and number of production units. Accordingly, more attention should be paid to increasing efficiency (Figure 6).

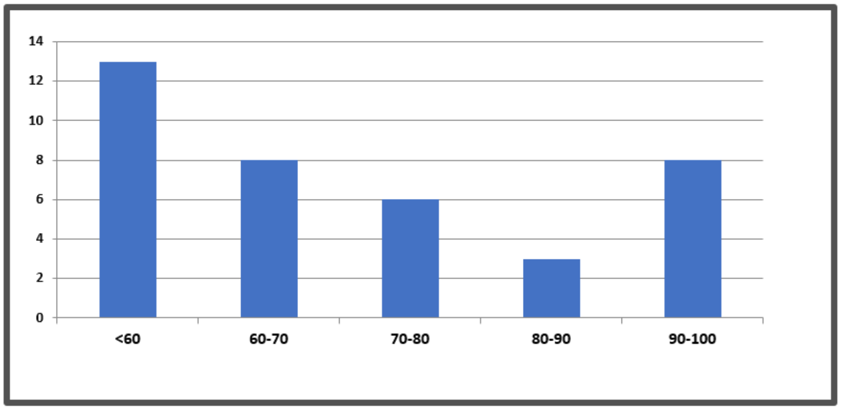

Figure 6. Technical efficiency range of units by SFA method (Source: Research findings)

Efficiency analysis of greenhouse units

The efficiency of each greenhouse unit is extracted using Deap software and listed in (Table 8).

The results of greenhouse efficiency in (Table 8) are as follows:

- The technical efficiency of a production unit 1; if production unit 1 wants to increase its technical efficiency to 100 with a constant assumption, it should increase its inputs by 0.444 (1-0.556). In addition, in other production units of the table, like unit 1, their inputs varied considering the technical efficiency of the table, and therefore they increased.
- The scale efficiency of a production unit 1; if it wants to increase its technical efficiency assuming a change in the ratio of using inputs to 100, it should increase the inputs by 0.444 (1-0.556), i.e., by changing the ratio of using inputs, it is possible to reach 913% with the initial fixed level (0.556).
- According to the data in the table, under the CRS hypothesis, among the studied units, 36 units had acceptable technical efficiency, and only 1 unit did not have an acceptable efficiency, the inefficiency of which can have various reasons. Nevertheless, according to the VRS hypothesis, all the studied greenhouses have acceptable efficiency (Figure 7).

Table 8. Efficiency of greenhouses using Deap software

Production units	Under the CRS hypothesis	Under the VRS hypothesis	
	Technical efficiency	Scale efficiency	Net technical efficiency (management efficiency)
1	0.556	0.556	1.000
2	0.558	0.913	0.913
3	0.500	0.836	0.836
4	0.500	0.834	0.834
5	0.556	0.896	0.896
6	0.883	1.000	1.000
7	0.739	0.994	0.994
8	1.000	1.000	1.000
9	0.667	1.000	1.000
10	0.510	1.000	1.000
11	0.868	1.000	1.000
12	0.672	1.000	1.000
13	0.769	1.000	1.000
14	0.769	1.000	1.000
15	0.833	1.000	1.000
16	0.771	0.964	0.964
17	0.982	1.000	1.000
18	0.656	0.943	0.943
19	0.884	0.988	0.988
20	0.864	1.000	1.000
21	0.900	1.000	1.000
22	1.000	1.000	1.000
23	1.000	1.000	1.000
24	0.680	1.000	1.000
25	0.500	1.000	1.000
26	1.000	1.000	1.000
27	0.578	0.940	0.940
28	0.578	0.940	0.940
29	0.490	0.757	0.757
30	0.716	0.738	0.738
31	1.000	1.000	1.000
32	0.656	0.943	0.943
33	0.522	0.994	0.994
34	1.000	1.000	1.000
35	0.578	0.940	0.940
36	1.000	1.000	1.000
37	0.672	1.000	1.000
38	0.308	1.000	1.000
Mean	0.713	0.952	0.964

(Sources: research findings)

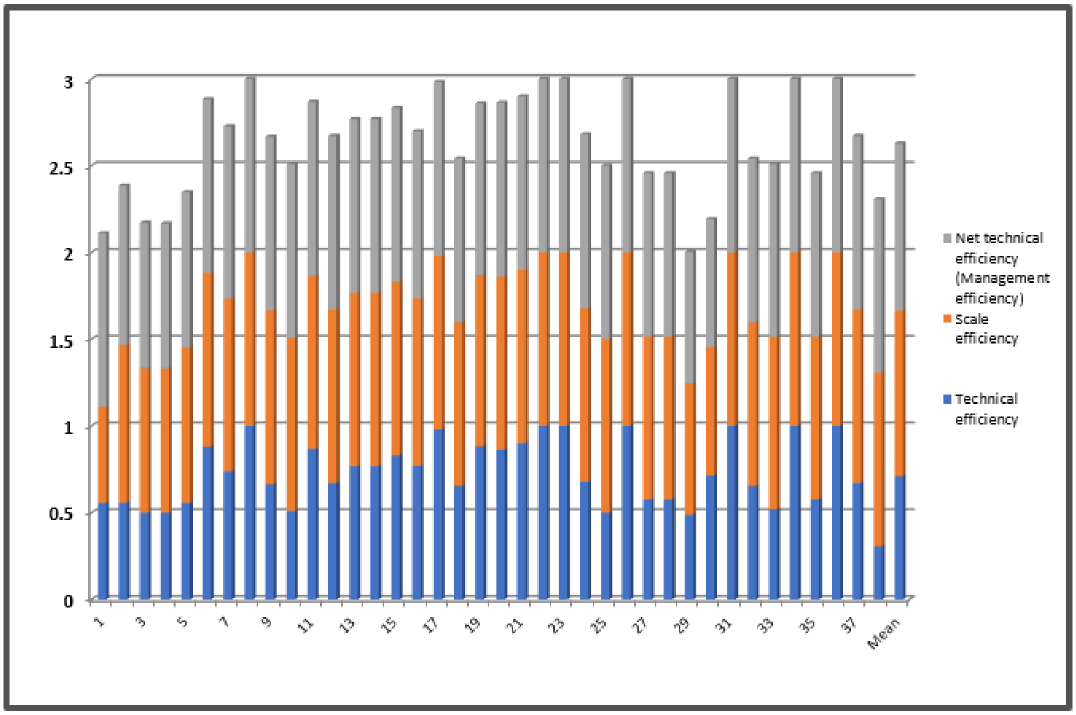

Figure 7. Efficiency of greenhouses using Deap software (Source: Research findings)

Discussion

The technical efficiency of the studied greenhouses is low.

According to the mean of 0.68 for the measured units, it is concluded that the technical efficiency of the studied greenhouses is not low, and this hypothesis is rejected.

There is a direct, significant relationship between technical efficiency and the cultivated area of greenhouses.

According to the correlation coefficient of 0.192, there is no significant relationship between these two variables, i.e., there is no significant relationship between the cultivated area and the technical efficiency of greenhouses.

There is a direct relationship between technical efficiency and farmers' education level.

According to the correlation coefficient of 0.332 at the 0.05 level, there is a significant relationship between technical efficiency and farmers' education level.

There is a direct relationship between technical efficiency and the farmers' age.

According to the correlation coefficient of 0.22, there is no significant relationship between the two variables of efficiency and farmers' age.

There is a direct relationship between technical efficiency and farmers' experience.

There is no significant correlation between these two variables, according to the results obtained from the correlation analysis. In other words, there is no significant relationship between technical efficiency and farmers' experience.

According to the obtained results, with an average of 0.68 for the measured units, the technical efficiency of the studied greenhouses is not low, and this hypothesis is rejected. This can be due to the existence of relatively appropriate facilities, the accessibility to current knowledge of greenhouse cultivation, and the average young age of the people.

This research finding that the technical efficiency of greenhouses had no significant relationship with the cultivated area in the studied sample indicates the difference in quantity and quality. In other words, the farmers with smaller greenhouses got better outcomes due to more attention and consideration of the greenhouse requirements.

Since the results of the analysis show a significant relationship between education level as an independent variable and efficiency as a dependent variable, it can be claimed that education level is a determinant in greenhouse farming. People with a higher education level can better use modern knowledge and science and new tools to improve greenhouse efficiency, so being equipped with modern science plays a decisive role in improving the technical efficiency of greenhouses.

Conclusion

According to the results of the data analysis, it can be concluded that there was no significant relationship between the farmers' age (an independent variable) and technical efficiency (a dependent variable). This could be due to the fact that although older people have more experience, younger farmers have more energy and also use more agricultural knowledge, so the experience of older farmers is compensated by the more energy of younger farmers.

According to the results of the data analysis, there is no significant relationship between the two variables of technical greenhouse efficiency and farmers' experience, i.e., experience is not a determinant for the technical efficiency of greenhouses due to the ever-increasing growth of greenhouse technology and knowledge, and young and inexperienced farmers have been able to compensate for their inexperience with more energy and equipping themselves with modern science.

Suggestions and recommendations

It is suggested that required measures be taken regarding the continuous training of farmers and equipping them with modern knowledge.

Since there are questions related to government support to farmers in the questionnaire and the fact that the vast majority of farmers have expressed their dissatisfaction with government support, it is recommended to provide more support in the field of economic and educational policies in this field.

According to the response of the applicants regarding the water purchase, it is suggested to dig a special well for the construction of a greenhouse estate.

Since the water well privilege is used for agriculture, all bills, including water, electricity, and gas, will be calculated with the agricultural tariff so that the applicants do not have any problems.

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