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TECHNICAL AND ECONOMIC EFFICIENCY ANALYSIS OF CAYENNE PEPPER FARMING IN MAGELANG REGENCY, CENTRAL JAVA

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Abstract

Background: A common issue in cayenne pepper farming is the effective optimization of production factors. The inappropriate and inefficient use of production factors leads to a decline in output, resulting in lower farm income. The problem that often occurs in cayenne pepper farming is the maximization of the use of production factors. This is certainly the focus for cayenne pepper farmers in using production factors efficiently to increase their farming income.
Purpose: This study aims to analyze the influence of production and cost factors in the cultivation of cayenne pepper, to determine the technical efficiency of the use of production factors, and to determine the economic efficiency of the use of cost factors in cayenne pepper cultivation in Magelang Regency, Central Java.
Design/methodology/approach: This study was conducted from October to November 2025. The method employed in this study was a survey. The data analysis in this study was conducted using stochastic frontier production function analysis and stochastic frontier cost function analysis, processed with Frontier 4.1 software.
Findings/Results: The analysis results show that the production factors that significantly influence the output of cayenne pepper farming include land area (m^2), fertilizer (kg), pesticides (liters), and labor (HOK), while seedlings (units) do not have a significant effect. Similarly, with respect to total production costs, profit sharing and land tax (IDR), cost of seeds (IDR), cost of fertilizer (IDR), cost of pesticides (IDR), and cost of labor (IDR) have a significant influence, while cayenne pepper production (kg) does not have a significant effect. Based on the level of efficiency, 60.19% of the cayenne pepper farmers obtained technical efficiency scores above the average, while 69.19% achieved economic efficiency scores above the average.
Conclusion: Based on the levels of technical and economic efficiency, most cayenne pepper farmers in Magelang Regency have achieved technical and economic efficiency in the use of production inputs.
Originality/value (State of the art): This study provides evidence of the influence of production factors and costs on the total production and total production costs of cayenne pepper farming. Furthermore, this study determined the technical and economic efficiency of cayenne pepper farming in Magelang Regency

Keywords: cayenne pepper, cost function, efficiency, farmers, production function, stochastic frontier

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INTRODUCTION

Chili is one of the horticultural crops widely cultivated by Indonesian farmers. The primary reasons for its extensive cultivation are its high economic value, status as a leading national and regional commodity, important role in the food menu, and use as a raw material for industry (Sardianti, 2020). Chili has become one of the leading national commodities, as evidenced by the continuously increasing annual demand. The average per capita weekly consumption of cayenne pepper increased from 32 to 42 ounces between 2020 and 2023 (Badan Pusat Statistik, 2024c).

The demand for cayenne pepper continues to increase annually. The rising demand for chilli is directly proportional to its production (Maemunah et al. 2019). The continuously increasing demand for cayenne pepper has become a primary focus of efforts to maintain and further enhance cayenne pepper production each year. Cayenne pepper production in Indonesia from 2020 to 2023 showed an increase for red chili; however, cayenne pepper production experienced fluctuations, with declines recorded in 2021 and 2023 (Badan Pusat Statistik, 2024b). This situation poses a challenge for chili farmers to continuously enhance the productivity of their farming operations to meet the steadily increasing demand for cayenne peppers. An increase in production is accompanied by optimal utilization of inputs, including labor and land use (Rahayu et al. 2019).

The inappropriate and inefficient use of production factors leads to a decline in output, resulting in lower farm income. The optimal use of production factors can generate maximum revenue or profit (Yanuarti et al. 2019). The efficient use of production factors in farming encompasses both technical and economic efficiency. Technical efficiency focuses on how existing production inputs are optimally used to produce maximum output (Chaniago et al. 2025). A production process is economically efficient at a given output level if no other process can produce a similar output at a lower cost (Chotimah et al. 2019).

A common issue in cayenne pepper farming is the need to maximize the utilization of production factors. Production in large quantities or volumes is not always influenced by the use of inputs in large amounts (Sumiratin, 2025). The large number of production factors utilized leads to an increase in the production costs borne by farmers (Putri et al. 2022). This issue has become a primary concern for cayenne pepper farmers in ensuring the efficient utilization of production factors to increase their farm income.

Central Java Province ranks second in Indonesia for total cayenne pepper production. From 2021 to 2023, the total cayenne pepper production in Central Java was 670.798 tons, compared to 1.788.439 tons in East Java (Badan Pusat Statistik, 2024b). Magelang Regency is one of the major contributors to the high total cayenne pepper production in Central Java. Magelang Regency is a national horticultural commodity production center (Maemunah et al. 2019). This can be seen from the total cayenne pepper production in Magelang Regency in 2023, which reached 53.155 tons (Badan Pusat Statistik, 2025). Grabag District and Secang District are among the leading producers of cayenne pepper in Magelang Regency. From 2021 to 2023, Grabag District ranked third in Magelang Regency in terms of the largest cayenne pepper harvested area, with a total of 1.715 hectares, while Secang District ranked ninth with a total harvested area of 386 hectares (Badan Pusat Statistik, 2024a).

Maemunah et al. (2019) conducted research on cayenne pepper farming, focusing on analyzing the efficiency of using cayenne pepper production factors in Girikulon Village, Secang District, Magelang Regency. This research gap focuses more on analyzing the technical and economic efficiency of cayenne pepper farming using the Maximum Likelihood Estimation (MLE) method, as well as a broader research scope, namely taking more research samples from Secang District and Grabag District, Magelang Regency. The use of the Maximum Likelihood Estimation (MLE) method, which is different from before, is expected to explain in more detail the influence of production factors on production results and total production costs.

The technical and economic efficiency or inefficiency of production input use is influenced by the appropriate quantity or dosage of land, seeds, fertilizers, pesticides, and labor (Lutfi & Baladina, 2018). The analysis of technical and economic efficiency enables farmers to determine whether the use of production input factors is efficient, serving as a step toward maximizing farm income. To overcome these problems, it is necessary to conduct a technical and economic efficiency analysis that will enable farmers to know whether the use of production input factors is efficient as a step in

maximizing their farming income. This research is expected to help cayenne pepper farmers in Magelang Regency maximize their farming efforts through an analysis of farming production factors, farming costs, technical efficiency, and economic efficiency, as well as being a consideration or reference for other chili farmers in cultivating cayenne pepper. This study aimed to analyze the production factors, farming costs, technical efficiency, and economic efficiency of cayenne pepper farming in Magelang Regency.

METHODS

This study was conducted between October and November 2025. This study employed a survey method. The survey method was carried out through structured interviews using questionnaires administered directly to cayenne pepper farmers in Grabag and Secang Districts, Magelang Regency, Central Java. A survey is a type of research that collects information about the characteristics, behaviors, or opinions of a representative group of respondents considered to be the population (Sudaryo et al. 2019). A survey provides a quantitative or numerical description of trends, attitudes, or opinions of a population by studying a sample of that population (Creswell & Creswell, 2017). The research location was selected using the purposive method based on various considerations. The purposive method selects data source locations based on specific considerations (Sugiyono, 2024). The research was conducted in Grabag and Secang Districts of the Magelang Regency, based on the consideration that both districts have high cayenne pepper production.

The sampling method involved selecting 10% of the total population of cayenne pepper farmers in Grabag and Secang Districts, Magelang Regency. When the population is less than 100 individuals, it is recommended to include all of them; if the population is large, a sample of 10–15% or 20–25% may be taken (Arikunto, 2010). The population of cayenne pepper farmers in Grabag District is 1,360 people; therefore, the sample taken is 10% of the population, which is 136 people. The population of cayenne pepper farmers in Secang District is 750; therefore, the sample taken is 10% of the population, which is 75 people. The sample size in this study consisted of 211 cayenne pepper farmers from Grabag and Secang Districts of the Magelang Regency.

This study employed a probability sampling method. Probability Sampling is a sampling technique that gives each element (member) of the population an equal chance of being selected as a sample member (Sugiyono, 2024). The sample was selected using simple random sampling by conducting a random draw of all active farmers who regularly engage in cayenne pepper farming.

The data analysis used to determine the influence of production factors in cayenne pepper farming in Magelang Regency was conducted using the stochastic frontier production analysis with the Cobb-Douglas model. Stochastic frontier analysis is a parametric model used to measure the level of efficiency (Dewi et al. 2017). Stochastic models allow for the estimation of panel data, making it possible to search for observations (between farmers/companies) and inter-temporal efficiency (Fatmawati, 2019). An analysis of technical and economic efficiency is required to determine the efficiency of production factor usage in cayenne pepper farming in Grabag and Secang districts.

The data analysis used to determine the influence of production factors in cayenne pepper farming in Magelang Regency was the stochastic frontier production analysis using Frontier 4.1 software. The production function model used in this study is the Cobb-Douglas stochastic frontier model. The Cobb-Douglas stochastic frontier production function equation was transformed into a linear equation form through a natural logarithm (Ln) transformation with the following formulation (Rosidah et al. 2023):

$$LnY = \beta_0 + \beta_1 lnX_1 + \beta_2 lnX_2 + \beta_3 lnX_3 + \beta_4 lnX_4 + \beta_5 lnX_5 + (v_i - u_i)$$

Note: LnY (cayenne pepper production); β_0 (constant); $\boldsymbol{\beta}_{1\text{-}5}$ (regression coefficient); X_1-X_5 (land size, seeds, fertilizer, pesticide, and labor); $v_{i\,(noise);\,and}\,u_i$(inefficiency). The data analysis used to determine the influence of cost factors in cayenne pepper farming in Magelang Regency was conducted using the stochastic frontier production analysis with the Frontier 4.1 software. The production function model employed in this study is the Cobb-Douglas stochastic frontier model. The Cobb-Douglas stochastic frontier cost function equation is transformed into a linear equation form through a natural logarithm (Ln) transformation with the following formulation (Rosidah et al. 2023):

$LnC = \alpha + \beta_0 lnY + \beta_1 lnP_1 + \beta_2 lnP_2 + \beta_3 lnP_3 + \beta_4 lnP_4 + \beta_5 lnP_5 + (v_i - u_i)$

Note: LnC (total production costs); α (constant); β_{0-5} (regression coefficient); Y (cayenne pepper production); P_1-P_5 (profit sharing and land tax, cost of seeds, cost of fertilizer, cost of pesticide, and cost of labor); v_i (noise); u_i (inefficiency).

The t-test was used to determine whether each independent variable (land size, seeds, fertilizer, pesticide, and labor) partially had a significant effect on production results and whether the independent variables (land tax and rent cost, cost of seeds, cost of fertilizer, cost of pesticide, and cost of labor) partially had a significant effect on the total production costs of cayenne pepper farming.

The technical efficiency of cayenne pepper farming in Magelang Regency was obtained from data processing using Frontier 4.1 software. The technical efficiency analysis of cayenne pepper farming can be measured using the following formula (Ogundari & Ojo, 2006):

$TE = Yi/Yi^* = E(Yi \mid ui,Xi) / E(Yi \mid ui = 0,Xi) = E [exp(-ui)/\text{Ɛ}i]$

Note: TE (Technical Efficiency); Yi (observed output); Yi* (corresponding frontier output).

The criterion used was the economic efficiency value ($0 \leq ET \leq 1$). The closer the value is to 1, the more economically efficient the farm is.

The economic efficiency of cayenne pepper farming in Magelang Regency was obtained from the data processing results using Frontier 4.1 software. The economic efficiency analysis of cayenne pepper farming can be measured using the following formula (Ogundari & Ojo, 2006):

$EE = C^* / C = E (Ci \mid ui = 0,Yi,Pi) / E (Ci \mid ui,Yi,Pi) = E [exp(Ui)/\text{Ɛ}i]$

Note: EE (Economic Efficiency); C* (minimum observed total production cost); and C (actual total production costs).

The criterion used was the economic efficiency value ($0 \leq EE \leq 1$). The closer the value is to 1, the more economically efficient the farm is.

The analysis used to determine the factors that influence the production and costs of cayenne pepper farming in Magelang Regency, Central Java, is using the stochastic frontier production and cost function regression with the MLE method. The analysis used to determine the level of efficiency of the use of production factors for cayenne pepper farming in Magelang Regency, Central Java, is a technical and economic efficiency analysis. The level of technical efficiency can be analyzed using the technical efficiency level measurement with Frontier 4.1 software. The level of economic efficiency can be analyzed using the economic efficiency level measurement with Frontier 4.1 software. Research framework in Figure 1.

RESULTS

Respondent Profile

Based on Table 1, it can be seen that as many as 174 farmers, or 82% of the total respondents, are male farmers, while the remaining 37 farmers, or 18% of the total respondents, are female farmers. These differences can occur due to several factors, one of which is the workload that involves physical activity by farmers. Physical strength is widely used in running a farming business, where men's physical strength is greater than that of women (Permatasari and Rondhi, 2022). Male respondents are more flexible in choosing jobs because they try various types of jobs to seek profits that aim to meet their personal and family needs (Pratiwi et al. 2024).

The majority of cayenne pepper farmers in Magelang Regency are aged 50-56 years. These results illustrate that the cayenne pepper farmers in Magelang Regency are of productive age. The productive age is divided into three classifications, namely, 0-14 years is said to be an unproductive age, 15-64 years is said to be a productive age, and 65 years and above is said to be unproductive (Rusydi and Rusli, 2022). The older the farmer, the more experience he has, but the increasing age of the farmer is not accompanied by an increase in physical ability (Kirana, 2023).

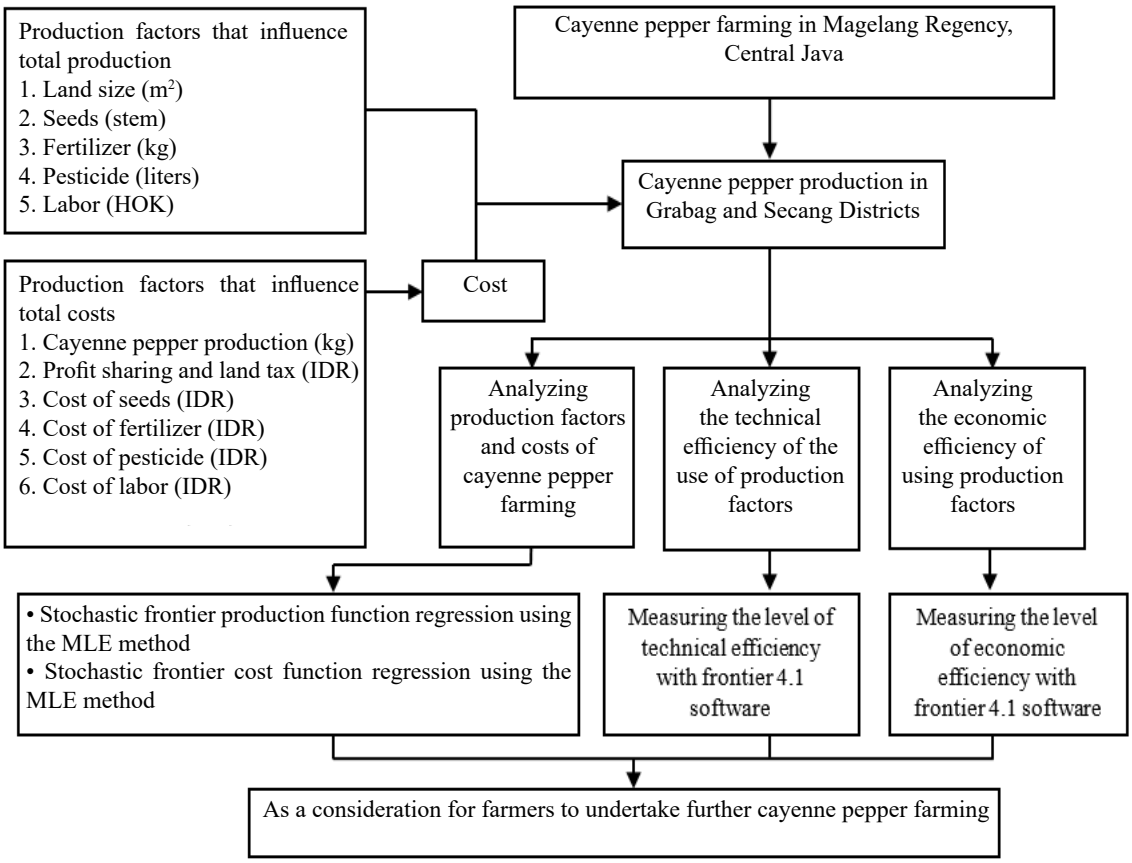

Figure 1. Research framework

The majority of cayenne pepper farmers in Magelang Regency have 8-13 years of experience in cayenne pepper farming. Experience in farming impacts how farmers manage their farming businesses. Farming experience is the length of time a farmer has worked or tried to manage his farming business, which is calculated based on years (Kirana, 2023). The more experienced a person is in farming, the easier it will be to apply methods and face obstacles in their farming business (Sayugyaningsih et al. 2022).

Based on education level, it is known that the cayenne pepper farmers in Grabag and Secang Districts with elementary school (SD) graduates are the most, namely 123 farmers or 58% of the total population. One of the causes of the low level of education of farmers is family economic problems. The agricultural cultivation sector is currently still dominated by elementary school graduates because they come from underprivileged families, so school or education is not yet a primary need for them (Yulistiono, 2019). Education is one of the factors that can influence farmers' thinking in carrying out farming. Farmers with higher levels of education tend to have a more advanced mindset than those with lower levels of education (Gusti et al. 2022). These results illustrate that most cayenne pepper farmers in Grabag and Secang Districts are small-scale farmers. Farmers are categorized based on land area as follows: small-scale farmers with a farm area of <0.5 ha, medium-scale farmers with a farm area of 0.5-1.0 ha, and large-scale farmers with a farm area of >1.0 ha (Mandang et al. 2020).

Stochastic Frontier Production Function Analysis of Cayenne Peppers

The production function model used in this study is the Cobb-Douglas stochastic frontier production function, which aims to analyze the factors that influence the production of cayenne pepper. The maximum likelihood estimation (MLE) method with Frontier 4.1 software was used to estimate the parameters. The results of the estimation using the maximum likelihood estimation (MLE) method can be seen from the LR test value of the one-sided error of 96.615, which is greater than the value of X^2_R with the number of restrictions (2) (Kodde & Palm, 1986) (Table 2), which is 12.810 (α=1%). This means that the stochastic frontier production function

can explain the problem of technical inefficiency among cayenne pepper farmers in Magelang. A Generalized Likelihood Ratio (LR) value for the Stochastic Frontier production function greater than that in the Kodde and Palm table indicates a technical inefficiency problem among farmers (Rachmawati et al. 2022).

The results of the stochastic frontier function regression show that the sigma squared value (σ^2) of 1.008 is significant at the error level (α=10%, 5%, and 1%), meaning that there is a variation in the error or error term due to technical inefficiency. The sigma square value indicates the distribution of the technical inefficiency error term (Ui) (Mutiarasari et al. 2019). The gamma value (Ɣ) is significant at the error level (α=10%, 5%, and 1%), indicating that the error term is caused by technical inefficiency (Ui). This can be seen from the regression coefficient value of 0.991, which means that 99.1% of the error term is caused by technical inefficiency (Ui), and the remaining 0.9% is caused by noise (Vi). The significant gamma value, which is more than the t-table, explains that 81.9% of the error term is caused by technical inefficiency problems (Ui), while the remainder is caused by noise (Vi) (Rachmawati et al. 2022).

Table 1. Characteristics of gender, age, experience, education, and land size of Chili Farmers in Magelang Regency

Farmer's Characteristics	Caretogy	%
Farmer's gender	Male	82
	Female	18
Farmer's age (year)	22-28	2
	29-35	2
	36-42	9
	43-49	23
	50-56	36
	57-63	19
	64-70	7
	71-77	1
	78-84	0
Farmer's experience (year)	2-7	24
	8-13	32
	14-19	20
	20-25	18
	26-31	3
	32-37	1
	38-43	1
	44-49	0
	50-55	1
Farmer education	Failed school	1
	Elementary school	58
	Junior high school	30
	Senior high school	9
	Bachelor	0
Farmer's land size (m^2)	<5.000	91
	5.000-10.000	9
	>10.000	0

Table 2. Regression Analysis result of the stochastic frontier production function of cayenne pepper farming in Magelang Regency

Variabel	Regression Coefficient	t-Ratio
Constant	0.450	3.007
X1 (land size) (m2)	0.717	15.074***
X2 (seeds) (stems)	-0.027	-0.998^{ns}
X3 (fertilizer) (kg)	0.147	3.561***
X4 (pesticide) (liters)	0.091	5.470***
X5 (labor) (HOK)	0.056	1.847*
Sigma squared (σ2)	1.008	2.827***
Gamma (Ɣ)	0.991	252.668***
log likelihood function	114.623	
LR test of the one-sided error	96.615	
number of restrictions	2	

Note: ***) significant at the 1% level; **) significant at the 5% level; *) significant at the 10% level; ^{ns}) insignificant; X^2_R significant at α = 1% (Kodde & Palm, 1986).

Land size (m^2) significantly influenced the production results of cayenne pepper farming, with a positive regression coefficient (0.717). The frontier elasticity of the land area variable has a significant and positive effect on chili production (Adhiana et al. 2022). These results can be interpreted as follows: if the land area increases by 1%, then the production of cayenne pepper farming will increase by 0.717%, assuming other inputs are constant. The land area variable has a positive effect on cayenne-pepper production (Agustina et al. 2023). The wider the land, the greater the production results, and vice versa, the narrower the land, the less production is obtained (Piri et al. 2022).

Seeds (stems) did not significantly influence the production results of cayenne pepper farming. In contrast to cayenne pepper production in Mirit District, chili seeds have a significant impact on chili production (Saridewi, 2022). The seed variable had a significant and positive effect on cayenne pepper production, indicating that if seeds are added, it will increase cayenne pepper production (Agustina et al. 2023). Field findings indicate that farmers purchase cayenne pepper seedlings in bamboo trays rather than individually. Purchasing seeds in trays requires cayenne-pepper farmers to buy 400 seeds in a tray. The price per tray containing approximately 416 seeds was IDR80.000 (Alif, 2017). This condition makes it impossible for cayenne pepper farmers to decide whether to buy seeds in the desired quantities. Many farmers buy cayenne pepper seeds rather than sowing their own seeds from fresh chilies, which are open-pollinated (OP) seeds, because of the type and quality of the seeds. Research conducted by Nugrahapsari et al. (2021) stated that although they are more expensive than OP seeds, packaged seeds are preferred by farmers because packaged seeds are generally hybrid seeds that have higher productivity than OP seeds. According to Astina et al. (2022), purchasing seeds is more practical, allowing farmers to use them without effort. Meanwhile, procuring seeds by making them is quite complicated.

Fertilizer (kg) significantly influenced the production results of cayenne pepper farming, with a positive regression coefficient (0.147). This result means that a 1% increase in fertilizer will increase cayenne pepper farming yields by 0.147%, assuming that other inputs remain constant. Fertilizer has a significant positive effect on cayenne pepper production (Agustina et al. 2023). There is a positive relationship between NPK fertilizer and chili production results, which shows that every addition of NPK fertilizer in chili farming activities can increase chili production (Salsabilah et al. 2023).

Pesticide use (liters) significantly influenced the production results of cayenne pepper farming, with a positive regression coefficient (0.091). This result means that a 1% increase in pesticides will increase cayenne pepper farming production by 0.091%, assuming that other inputs remain constant. Pesticide variables have a significant influence on cayenne pepper production (Alda et al. 2025).

Labor (HOK) significantly influenced the production results of cayenne pepper farming, with a positive regression coefficient (0.056). This result indicates

that a 1% increase in labor will increase cayenne pepper farming output by 0.056%, assuming that other inputs remain constant. Labor has a significant and positive effect on chili production (Adhiana et al. 2022). Increasing the number of workers increases the production of cayenne pepper (Agustina et al. 2023).

Stochastic Frontier Cost Function Analysis of Cayenne Peppers

The cost function model used in this study is the Cobb-Douglas stochastic frontier cost function, which aims to analyze the factors that influence the total cost of cayenne pepper production. The estimation parameters used are the maximum likelihood estimation (MLE) method with Frontier 4.1 software. The results of the estimation using the maximum likelihood estimation (MLE) method can be seen from the LR test value of X^2_R the one-sided error of 31.452, which is greater than the value of with the number of restrictions (2) (Kodde and Palm, 1986) (Table 3), which is 12.810 (α=1%). This means that the stochastic frontier production function can explain the problem of technical inefficiency among cayenne pepper farmers in Magelang Regency.

The results of the stochastic forntier function regression show that the sigma squared value (σ^2) of 1.645 is significant at the error level (α=10%, 5%, and 1%), meaning that there is a variation in the error or error term due to technical inefficiency. sigma square (σ^2) shows the total variance of two components, namely the inefficiency effect (Ui) and the noise effect (Vi) (Nurjati et al. 2018). The gamma value (Ɣ) is significant at the error level (α=10%, 5%, and 1%), indicating that the error term is caused by technical inefficiency (Ui). This can be seen from the regression coefficient value of 0.994, which means that 99.4% of the error term is caused by technical inefficiency (Ui), and the remaining 0.6% is caused by noise (Vi).

The production results of cayenne pepper did not significantly affect the total production costs of cayenne pepper farming. Increasing cayenne pepper production yields does not increase the total production costs of cayenne pepper farming. An increase in cayenne pepper production does not result in an increase in the total production costs of cayenne pepper farming. This is different from the research conducted by Rosdiantini (2020), which states that the amount of production has a positive effect on total farming costs. Research conducted by Rosidah et al. (2023) also stated that production variables have a significantly positive effect on total production costs. Production results are said to have no effect on total costs if production costs are fixed or if variable costs do not increase with increased production, so that total costs remain relatively stable even though output increases. Increased production output is not always accompanied by an increase in total production costs because increased production output can be influenced by inefficiency and noise (external) factors, such as weather, temperature, and humidity. Differences in planting height affect the yield of cayenne pepper plants, as shown in the parameters of the number of fruits, fruit weight per plant, average fruit weight, fruit length, and fruit diameter (Aryani et al. 2022).

Table 3. Regression analysis result of the stochastic frontier production function of cayenne pepper farming in Magelang Regency

Variabel	Regression Coefficient	t-Ratio
Constant	1.929	6.325***
Y (cayenne pepper production) (kg)	-0.053	-0.763^{ns}
P1 (profit sharing and land tax) (IDR)	0.315	3.757***
P2 (cost of seeds) (IDR)	0.245	6.601***
P3 (cost of fertilizer) (IDR)	0.116	3.712***
P4 (cost of pesticide) (IDR)	0.354	12.104***
P5 (cost of labor) (IDR)	0.431	12.426***
Sigma squared (σ2)	1.645	10.274***
Gamma (Ɣ)	0.994	169.473***
log likelihood function	84.966	
LR test of the one-sided error	31.452	
number of restrictions	2	

Note: ***) significant at the 1% level; **) significant at the 5% level; *) significant at the 10% level; ^{ns}) insignificant; X^2_R significant at α = 1% (Kodde & Palm, 1986).

Profit sharing and land tax significantly influence the total production costs of cayenne pepper farming, with a positive regression coefficient (0.315). This result indicates that a 1% increase in land tax costs will increase the total production costs of cayenne pepper farming by 0.315%, assuming that other inputs remain constant. Profit sharing and land tax (IDR) variables have a significant positive effect on total production costs (Rosidah et al. 2023). Profit-sharing costs are one of the major expenses for sharecroppers because the sharecropper costs are divided 1:3 or 25% of the total income. In the profit-sharing system, farm income is obtained through a profit-sharing mechanism between landowners and cultivators (Tamimi et al. 2025).

Seed costs significantly influenced the total production costs of cayenne pepper farming, with a positive regression coefficient (0.245). These results can be interpreted as a 1% increase in pesticide costs, then the total production costs of cayenne pepper farming will increase by 0.245%, assuming other inputs are constant. Seedling cost variable (IDR) has a significantly positive effect, indicating that if there is an increase in seedling costs, it will increase total costs (Rosidah et al. 2023). Fertilizer costs significantly influenced the total production costs of cayenne pepper farming, with a positive regression coefficient (0.116). These results indicate that a 1% increase in pesticide costs will increase the total production costs of cayenne pepper farming by 0.116%, assuming that other inputs remain constant. The organic fertilizer cost variable (IDR) has a significant positive effect on total production costs; however, the coefficient value of this variable is very small, so the effect of increasing organic fertilizer costs is very small on total production costs (Rosidah et al. 2023). Most farmers with small land holdings buy cheaper, lower-quality fertilizers to reduce production costs. When the price of chemical fertilizers rises, farmers may increase the use of substitutes such as organic fertilizers, minimize the use of chemical fertilizers, and switch to cheap and low-quality chemical fertilizers (Sun and Li, 2021).

Pesticide costs significantly influenced the total production costs of cayenne pepper farming, with a positive regression coefficient (0.354). These results can be interpreted as a 1% increase in pesticide costs, then the total production costs of cayenne pepper farming will increase by 0.354%, assuming other inputs are constant. The price of solid insecticides has a positive effect on total production costs, whereas the price of liquid insecticides has no significant effect on production costs. The effect of pesticide prices on total production costs (Rosdiantini, 2020).

Labor costs significantly influenced the total production costs of cayenne pepper farming, with a positive regression coefficient (0.431). Labor cost factors significantly impact farming profits (Putri et al. 2020). These results can be interpreted as a 1% increase in pesticide costs, then the total production costs of cayenne pepper farming will increase by 0.431%, assuming other inputs are constant. Cultivation labor costs (IDR) have a significant positive influence on total costs (Rosidah et al. 2023). Labor wage variables have a positive or significant influence on total agricultural costs (Rosdiantini, 2020).

Technical and Economic Efficiency Level

Based on the analysis results, the average technical efficiency value for cayenne pepper farming in Magelang Regency was 0.889, with the highest technical efficiency value being 0.978 and the lowest being 0.198 (Table 4). The technical efficiency distribution table shows that 40% of cayenne pepper farmers received technical efficiency scores below the average (0.899), and the remaining 60% of cayenne pepper farmers received technical efficiency scores above the average (0.899). This indicates that most cayenne pepper farmers in Magelang Regency are technically efficient in their use of production inputs. Technically, a producer is said to be efficient if it has a technical efficiency rating of ≥ 0.70 (Darmawan, 2016; Parwiti et al. 2019). Research conducted by Putri et al. (2020) showed that cayenne pepper farming in South Lampung Regency can be classified as profitable based on the average level of technical efficiency.

Based on the analysis results, the average economic efficiency value for cayenne pepper farming in Magelang Regency was 0.865, with the highest economic efficiency value being 0.978 and the lowest being 0.462. The distribution of economic efficiency shows that 31% of the cayenne pepper farmers received economic efficiency scores below the average (0.865), and the remaining 69% of cayenne pepper farmers received economic efficiency scores above the average (0.865). This indicates that the majority of cayenne pepper farmers in Magelang Regency are economically efficient in their use of production inputs. Technically, a producer is said to be efficient if it has an economic

efficiency rating of ≥ 0.70 (Darmawan, 2016; Parwiti et al. 2019). The level of economic efficiency is influenced by high production costs in farming, such as fertilizer input costs, labor wages, and nursery costs (Zainuddin & Wibowo, 2018).

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The research conducted with the title "Analysis of Technical and Economic Efficiency of Cayenne Pepper Farming in Magelang Regency, Central Java" can be concluded that the production factors that significantly influence the production results of cayenne pepper farming are land area (m^2), fertilizer (kg), pesticides (liters), and labor (HOK), while the factors that do not have a significant influence are seeds (stem). The factors that significantly influenced the total cost of cayenne pepper production were land area (m^2), fertilizer (kg), pesticides (liters), and labor (HOK), while the factors that did not significantly influence the total cost were seeds (stems).

Based on the level of technical efficiency, the majority of cayenne pepper farmers in Magelang Regency are technically efficient in their use of the production inputs. Based on the level of economic efficiency, the majority of cayenne pepper farmers in Magelang Regency are economically efficient in their use of the production inputs.

Recommendations

For cayenne pepper farmers, increasing cayenne pepper production in Magelang Regency can be achieved by increasing the land area, adding fertilizer, pesticides, and labor. Farmers with low efficiency can increase the use of production inputs, namely, fertilizers, pesticides, and labor, which are already used by farmers with high efficiency. Farmers need to participate in and actively participate in training, counseling, and mentoring provided by the Agricultural Extension Agency (BPP) to improve their cayenne pepper cultivation skills. For the government, providing and improving facilities in the form of subsidies for fertilizers, pesticides, and other supporting equipment can ease the burden on farmers in carrying out their activities. Further research is recommended to examine the influence of production factors and costs on production results and total production costs of cayenne pepper farming, as well as the level of efficiency of cayenne pepper farming, including technical, economic, and allocative efficiency.

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Table 4. Distribution of technical and economic efficiency of cayenne pepper farmers in Magelang Regency

Range	Efficiency (%)	
	Technical	Economic
≤ 0.50	1	1
0.51 – 0.60	0	4
0.61 – 0.70	1	4
0.71 – 0.80	0	9
0.81 – 0.90	37	30
0.91 – 1.00	60	52
Amount	100	100
Average	0.899	0.865
Maximum	0.978	0.978
Minimum	0.198	0.462

DISCLAIMER ABOUT GENERATIVE AI: During the preparation of this work, the authors used ChatGPT as a tool to enhance clarity, refine academic word choice, and improve the overall readability of the manuscript. Following this use, the authors conducted a thorough review, validated, and edited the content to ensure scientific accuracy and integrity, and took full responsibility for the final published version of the article.

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