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The determinant factors of technical efficiency of hybrid corn (*Zea Mays* L) farming in Majalengka Regency, Indonesia: Stochastic frontier approach

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Abstract

This research was conducted in Gununglarang Village, Bantarujeg District, Majalengka Regency, West Java Province, Indonesia in August - September 2024. This study aims to analyze production factors that have a significant effect on corn production levels and to assess how technically efficient corn farming is in using production factors. A quantitative descriptive approach is the research methodology employed, along with a method for identifying respondents, namely, cluster sampling, with the number of respondents being 55. Primary and secondary data are the types and sources of data used in this study. The Stochastic Frontier Analysis production function using the MLE approach is the research model that is employed. According to the study's findings, corn production in Gununglarang Village, Bantarujeg District, Majalengka Regency, is significantly impacted by the production factors of labor, seeds, fertilizer, pesticides, and land area. Meanwhile, the technical efficiency level shows an average technical efficiency value of 0.688 or 68 percent. The number of farmers included in the quite efficient category (> 0.7) was 29 people (52.73%). This shows that there are still many farmers in Gununglarang Village who are not technically efficient. Farmers can accomplish this by raising their educational attainment, or they can participate in informal education through seminars, training, group discussions, etc. that can give them new information to increase their technical efficiency and corn farming.

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Introduction

In Indonesia's development, the agricultural sector is crucial to the country's economy. The subsectors of horticulture, forestry, plantations, livestock, and food crops make up the agricultural sector. The food crop subsector is one of the agricultural subsectors that contributes to development and the economy because it can support the lives of the Indonesian population.

Rice farming and secondary crop farming are the two main categories of food crop farming. Enhancing food security and reducing poverty are two more goals of secondary crop development. In Indonesia, hybrid corn is one of the secondary crops that farmers grow extensively (Chotimah et al., 2019). Corn plants are one of the food crops that have a strategic role because the availability of corn plants has a multipurpose function (4F), which contributes to providing the need for food, animal feed, fuel, and industrial raw materials (fiber) (Amandasari et al., 2014; Melati & Mayninda, 2020; Zhou et al., 2021).

One of the areas that is a corn commodity development area in West Java Province is Majalengka Regency with a total production of 144,141 tons in 2022. Majalengka Regency is one of the second largest corn-producing centers in West Java after Garut Regency. Bantarujeg sub-district has the potential to develop hybrid corn commodities because it has quite high market demand, one of which is fulfilling animal feed.

Bantarujeg sub-district is a large corn-producing district in Majalengka Regency. However, according to Central Bureau statistics data from Majalengka Regency in 2018–2021, a significant decline in corn production occurred from 27,042 tons in 2020, to 23,323 tons in 2021. This can be caused by environmental factors, poor cultivation techniques, or inefficient use of production factors.

In efforts to increase the productivity of corn from each land, farmers are faced with a problem, namely, limitations in utilizing production factors in the corn production process, and this results in the production results not being maximized. So, it requires a combination of using production factors such as land area, seeds, capital, fertilizer, pesticides, and appropriate labor (Adzawla & Alhassan, 2021; Amaliyah, 2018; Arifin et al., 2021; Edison, 2022).

Gununglarang Village is one of the villages with potential agricultural land for corn farming because the land it owns includes dry land with a total area of non- rice fields or what is usually called moorland, covering an area of 64,550 Ha. Generally, corn farmers in Gununglarang Village utilize labor, seeds, fertilizer, pesticides, and land area as production factors. The variety of corn seeds used by farmers is hybrid corn, which makes it possible for higher production than with local corn. Hybrid corn is capable of producing 10–12 tonnes/ha (Dang, 2017; Hasnah et al., 2024; Payang et al., 2019; Sir et al., 2024).

However, the reality in the field is that the average corn production in Gununglarang Village still reaches 5–7 tons/ha, which is due to limited use of seeds due to fluctuating seed prices, relatively limited land owned by farmers, lack of business capital due to input prices. expensive production, pest and plant disease attacks, and soil fertility levels that are starting to decline. According to the explanation above, it is essential to know the technical efficiency of hybrid corn farming. Thus, an analysis was carried out on corn farming in Gununglarang Village, Bantarujeg District, Majalengka Regency. The aim of this research is to analyze production factors that have a significant effect on hybrid corn production levels and to assess the level of technical efficiency in using hybrid corn farming production factors.

Theoretical Background

According to Debertin (2002) the demand for production input demand can be derived through the production function and profit function. The technical relationship between input and output is indicated by the production function. The function of production simply describes the transformation process from inputs such as labor, capital, raw materials to output. The relationship between input and output is $f(x,y) = 0$. The production function indicates the output level that can be produced for a particular technology and input level. In the production graph, how possible the output level is can be traced by changing the input level. Mathematically, the general form of the production function can be formulated as follows:

$$Y = f(K,L,F) \quad (1)$$

where y is the amount of production or output produced from a number of inputs used while K, L, F are production factors or inputs used to produce output of one of the input credits (K).

There are three stages of production that describe geographically various technical functions, namely, the first stage of conditions where the average product increases; this area is called an irrational area, an area that is not or has not been efficient because in this area additional inputs can still be carried out to increase output. The second stage is the condition where the average product rises and reaches the peak. In this condition, it is a rational or efficient area in carrying out farming, that is, when the percentage of output change due to

input changes has a value of 1, or the average product is equal to the additional product (marginal product/MP), namely, AP = MP. In this second stage, marginal products decreased but still had a positive value. The third stage is the condition where marginal products are decreasing and negative in nature, this area is no longer rational and is inefficient.

Efficiency in production is called economic efficiency or productive efficiency. Dilawar developed the literature to perform empirical estimates for technical efficiency. The ability of farmers to produce maximum production output by using optimal production inputs is reflected in technical efficiency. Allocative efficiency uses the minimum cost criterion to produce a certain amount of output on an isoquant. At the same level of production technology, if a farmer can produce more output than other farmers, then the farmer is said to be more efficient than other farmers. Farmers at the same level of production technology produce the same output, but fewer inputs are used, so this condition also illustrates that the farmer is more efficient than other farmers. This explains the relative concept of technical efficiency (Khan et al., 2021).

Coelli et al. (2005) state that the frontier production function is a production function that describes the maximum output that can be achieved from each level of input use. If a farm is at a point in the frontier production function, it means that the farm is technically efficient. If the production function of the frontier is known, then the technical inefficiency can be estimated through a comparison of the actual position relative to the frontier. Technical efficiency can be illustrated by isoquan and isocost curves. The isoquant curve describes the possible combination of inputs used to produce the same amount of output. Technical efficiency describes the ability to produce along the isoquant frontier. The isocost curve describes a combination of inputs used at the same cost.

Efficiency measurement can use panel data and cross-sectional data. According to Kumbhakar et al. (2015), in some economic theories of production economics theory several forms of production functions are known, namely, Cobb-Douglas, translog (transcendental logarithmic), CES (Constant Elasticity of Substitution) and quadratic functions, each of which has different characteristics. The production functions that are widely used to measure efficiency are the Cobb-Douglas production function and the translog production function. Some characteristics of the Cobb-Douglas production function are (1) Assumption of perfect competition market; (2) The production elasticity of each parameter is fixed; (3) The production technology used is the same; (4) The production factors used in the production process interact with each other. The advantages of the Cobb-Douglas production function are homogeneous, the estimation can be used with OLS (ordinary least square), the calculation is simple available in many software, return to scale, and the amount of elasticity of one. Some of the weaknesses of the Cobb-Douglas production function are that there is no maximum production, production increases along the expansion path, causing bias towards managerial aspects, the assumption of technology is considered the same even though the technology in one area is different from another and the possibility of multicollinearity.

Stochastic Frontier Analysis (SFA) and Data Envelopment Analysis (DEA)

In order to seek technical efficiency, such is carried out using two approaches, namely: (1) Frontier Stochastic Analysis (SFA) and (2) Data Envelopment Analysis (DEA). In the operational SFA approach, the production function in this study refers to the approach of Aigner et al. (1977). The production function used is in the form of the Cobb Douglas function.

$$ln\ Yi = \beta 0 + \sum^{4} \quad \beta jlnXij + vi - ui \qquad (2)$$

where Y is the amount of rice production in the sample of farmers to i, Xij is the input vector of type j in farmers to i, which includes seeds, fertilizers, pesticides, labor. βj presents the parameters to be estimated. V is a random variable assumed to be N~(0, δ2V), indicating an error factor of a stochastic effect that the farmer cannot control. U random variable is a non-negative random that indicates the technical inefficiency of farming (Coelli et al., 2005). U assumed independent from V. The parameters γ are located from 0 to 1. Value 1 indicates that all carnena deviations are purely a factor of technical efficiency between farmers.

$$\sigma_u^2\sigma_v^2\sigma_u^2 + \sigma_v^2 = \sigma^2\gamma =: \sigma_u^2 - (\sigma_u^2 + \sigma_v^2)\ ;\ \lambda = \sigma_u / \sigma_v\ (> 0).$$

Parameter estimation is carried out using the MLE (Maximum Likelihood Estimate) estimation method. The measurement of the level of technical efficiency (TE) in this study was carried out through the following calculations:

$$TE_i = \frac{y_i}{y_i^*} = \frac{exp(x_i\beta + v_i - u_i)}{exp(x_i\beta + v_i)} = exp(-u_i) \qquad (3)$$

where *yi,* is the actual production of observation, y^* is the alleged frontier production obtained from the stochastic frontier production function.

The analysis uses Data Envelopment Analysis (DEA). used to look at efficiency between farmers and also to look at efficiency across companies. To determine the technical

efficiency for farmers to i, the liner program used is as follows:

Maximize θλ θ Subject to:
-θyi + Yλ ≥ 0 *Xi – Xλ ≥ 0* N1'λ=1
λ ≥ 0

where θ is the technical efficiency score (TE), yi is the amount of rice production from farmers to I, xi is the vector Nx1 of the number of production inputs for farmers to i, Y is the vector 1xM for production, N is the NxM matrix of the number of production inputs used, λ is the Mx1 vector of the weighter and θ is scalar.

Technical efficiency is known with the CRS (constant return to scale) approach, and VRS variable return to scale (VRS) will be known as business scale efficiency. Meanwhile, business efficiency (SU) is obtained from:

$$S_iUi = \theta^{CRS} / \theta^{VRS} \quad (4)$$

Factors affecting the technical efficiency obtained through SFA and DEA were analyzed by regression estimated with the Tobit regression.

In the economics literature, efficiency is often measured by frontier methods, which are: (i) non-parametric, for example, data envelopment analysis (DEA); and (ii) parametric, i.e., stochastic frontier analysis (SFA). DEA applications are quite widely used due to their flexibility and simplicity. DEA can handle a variety of outputs and inputs more simply and does not require as many assumptions. However, as a deterministic approach, the DEA assumes that all deviations from the frontier (or most efficient entity) are due to inefficiency. This means that the DEA does not distinguish inefficiencies from other factors, such as statistical noise, so the level of inefficiency is often overestimated. In contrast, in the SFA method, such shortcomings can be avoided because SFA distinguishes deviations as inefficiency and statistical noise. In addition, as a parametric approach, researchers can observe how the input affects the output. SFA's ability to analyze panel data adds to the list of advantages of using SFA compared to DEA.

Cobb-Douglas Production Function

The production functions of CDs are given as follows: $y = f(x) = A \prod N x^{\beta i}$, (1) where logarithmic form would be: $\ln y = \beta 0 + \sum N \beta i \ln xi$, (2) where $\beta 0 = \ln A$. A CD function with an output-oriented perspective would be $y = f(x)e^{-u}$, where u is the inefficiency. In logarithmic form it will be $y = \ln y^{-u}$. The function of a CD with an input-oriented perspective would be $y = f(xe^{-u})$, and in logarithmic form would be: $\ln y = \beta 0 + \sum N \beta i \ln xi - (\sum N \beta i)u$. (3) Since the function of the CD is homogeneous, there is no significant difference between the two perspectives.

Translog Production Function

The production function of the translog is given as follows (Obalola et al., 2025):

$$\ln y = \beta_0 + \sum_{i=1}^{N} \beta_i \ln x_i + \frac{1}{2}\sum_{i=1}^{N}\sum_{j=1}^{N} \beta_{ij} \ln x_i \ln x_j \quad (5)$$

where βij = βji. The production function of the translog is not homogeneous, except when $\sum N \beta ij = 0 \ \forall i$. For perspective output-oriented, then only add –u to equation (4).

For an input-oriented perspective it is a bit tricky:

$$\ln y = \beta_0 + \sum_{i=1}^{N} \beta_i (\ln x_i - u) + \frac{1}{2}\sum_{i=1}^{N}\sum_{j=1}^{N} \beta_{ij} (\ln x_i - u)(\ln x_j - u)$$
$$= \beta_0 + \sum_{i=1}^{N} \beta_i \ln x_i + \frac{1}{2}\sum_{i=1}^{N}\sum_{j=1}^{N} \beta_{ij} \ln x_i \ln x_j - u\sum_{i=1}^{N} \beta_i + \frac{1}{2}\left(\sum_{i=1}^{N}\sum_{j=1}^{N} \beta_{ij}\right)u^2 - \left[\sum_{i=1}^{N}\left(\sum_{j=1}^{N} \beta_{ij} \ln x_j\right)\right]u \quad (6)$$

If the function is homogeneous, then:

$$\ln y = \beta_0 + \sum_{i=1}^{N} \beta_i \ln x_i + \frac{1}{2}\sum_{i=1}^{N}\sum_{j=1}^{N} \beta_{ij} \ln x_i \ln x_j - u\sum_{i=1}^{N} \beta_i \quad (7)$$

Some previous research has been carried out in analyzing technical efficiency of corn and hybrid corn. According to Kurnia et al. (2024) who conducted research not only on technical efficiency special in hybrid corn seed farming in Randublatung, Blora Regency, but also in allocative and economic efficiency, the result showed that on average, means of technical efficiency was .878 and categorized in efficient level (Kurnia et al., 2024). Ashari et al. (2023) through Cobb-Douglas function analysis assessed allocative efficiency in hybrid corn in sigi Regency. They claimed that the production of corn was significantly impacted by all factors at once, including labor, urea and potassium fertilizers, seeds, and land area size (Ashari et al., 2023). At international level, some research on maize or hybrid maize has already been released, such as in Pakistan (Ali et al., 2019; Memon et al., 2016), in China (Wu et al., 2022), in Vietnam (Dang, 2017), in the central African republic.

The uniqueness of this research is that it focuses particularly on hybrid corn, while another research was not specific to hybrid corn, but local corn. There has been some research on hybrid corn, but in the seed of hybrid corn and using Cobb-Douglas and econometric tests for analysis. A focus on hybrid corn, and the stochastic frontier model is presented in this

research. Another difference is that this research tries to delve more deeply into the characteristics of respondents and their influence on technical efficiency. It is certain that this is the first research on technical efficiency in hybrid corn in Majalengka regency as one of the centers of agricultural regions in West Java Province.

Methodology

This study was conducted in Gununglarang Village, Bantarujeg District, Majalengka Regency. This location's potential for hybrid corn farming was taken into consideration when it was chosen purposefully. The research period covers from August to September 2024. Quantitative descriptive research is the methodology employed for all research objectives. Primary and secondary data make up the data gathered for this study.

The research technique uses quantitative descriptive methods. Research that describes variables as they are, backed up by numerical data derived from real-world situations, is known as quantitative descriptive research; methods for gathering data via surveys, interviews, and observation.

The method used in sampling for this research is Purposive sampling, a sampling technique that involves selecting one group to be used as samples. The chosen group, a corn farmer group used as a sample of respondents, consisted of 55 members from the Pasir Panjang Farmers Group, and this study also chose complete enumeration, which is all members of the farmer group became samples of the research.

Both primary and secondary data types are utilized. Direct field observations and interviews with corn farmers and Farmer Group Leaders using a pre-made questionnaire were used to gather primary data. Meanwhile, secondary data was obtained from journals, theses, and various agencies related to this research. The definition of variables are explained in Table 1.

Table 1 Definition of variables

Variable	Indicators	Definition
Land size	Planting area	Planted area (ha)
Seed	Number of seedlings	Number of seedlings used for the 2022/2023 planting season (ku)
	Seed price	Seed Expansion Price (Rp/ku)
	Seed cost	Cost of seeds for the 2022/2023 planting season (Rp)
Fertilizer	Types of Fertilizers	Type or brand of fertilizer used (organic/inorganic)
	Number of Fertilizers	The amount of fertilizer planted as much as the area of the cultivated land (kg/liter)
	Fertilizer price	Fertilizer price paid by farmers (Rp)
	Fertilizer cost	The amount of fertilizer used is multiplied by the price of fertilizer (Rp)
Workforce/Labor	Number of Workforce	Number of people who are able to do work in farming (people)
	Labor prices	Total salary per day (Rp)
	Cost of Work	Total cultivation cost (Rp)
	Cost of felling	Total felling fee (Rp)
	Mechanization costs	Total mechanization cost (Rp)
Herbicide	Types of herbicides	Brand or type of herbicide used (organic/inorganic)
	Herbicide price	Herbicide purchase price (Rp/liter)
	Amount of Pesticides	Volume of herbicide used to expand planting (liters)
Control of pest and disease	Pests, diseases, weeds	Types of pests, diseases and weeds that interfere with the growth of sugarcane plants
Characteristics of Farmers	Farmer age	Number of years that respondents have lived (Years)
	Education	Official learning process activities to acquire knowledge and skills (Elementary, Junior High, High School, Bachelor)
	Experience	The length of time farmers carry out rice farming activities
	Number of family dependents	Number of family members who are still dependents (year)
Output	Production quantity	Total harvest of the growing season (ku)
	Price	Selling price per kg of corn received by farmers (Rp)
	Acceptance	Production quantity multiplied by price (Rp)

To answer the first and second objectives, researchers used the Stochastic Frontier Analysis production function because it involves a disturbance term which represents disturbances, measurement errors and exogenous factors that are outside the control of the production unit. Meanwhile, the analysis tool used is the Maximum Likelihood Estimator (MLE) because it maximizes the Likelihood function.

The purpose of this production function is to ascertain production factors that are thought to have a real influence on corn farming production. The production factors used in corn farming production activities in this research are based on a framework that influences corn production results, namely, land area, seeds, fertilizer, pesticides and labor. The Stochastic Frontier production function can be systematically written as follows:

$$Y = \beta^0 + X_1^{\beta 1} X_2^{\beta 2} X_3^{\beta 3} X_4^{\beta 4} X_5^{\beta 5} e^{(vi-ui)} \quad (8)$$

Subsequently, natural logarithms are used to transform the equation into linear form.

$$LnY = Ln\beta_0 + \beta_1 LnX_1 + \beta_2 LnX_2 + \beta_3 LnX_3 + \beta_4 LnX_4 + \beta_5 LnX_5(V_i - U_i) \quad (9)$$

Information:
Y = production function (Kg)
e = natural logarithms
β_0 = constant
β_1 = corn elasticity (I = 1,2,3,4…..)
X_1 = land size (Ha)
X_2 = seed (Kg)
X_3 = Fertilizer (Kg)
X_4 = Pesticides (l)
X_5 = Labor (HOK)
Vi = error of random model
Ui = one side error term

Solving the Frontier stochastic production function using Frontier 4.1 software with the Maximum Likelihood Estimation (MLE) method. To find out which independent variables have a significant impact on the dependent variable, the t test can be used in this model. The purpose of this test is to determine whether or not the suggested hypothesis is accepted.

The second research objective is to analyze technical efficiency which can be evaluated through the comparison of potential production (Yii) and actual production (Yi) obtained using frontier software; mathematically it can be calculated using the formula:

$$TEi = \frac{yi}{yii} = \frac{exp(xi\beta + vi - ui)}{exp\ (xi\beta + vi)} = exp\ (-ui) \quad (10)$$

Information:
TE = Technical efficiency n-i
Yi = Actual Production n-i (Kg)
Yii = Potential production n-i (Kg)
x = *input*
β = Coefficient
vi = Error of model
ui = Random of change
$(0 \leq TE \leq 1)$

Measuring the level of efficiency uses Frontier 4.1 Software. Through this software, the technical efficiency value is achieved by each corn farmer. It is possible to say that technical efficiency is increasing or becoming more efficient if the TE value is approaching 1, and vice versa. If the TE value gets closer to 0, then the level of technical efficiency is lower or more inefficient.

This study uses Cobb-Douglass Function. This function is :

- more simplicity and interpretability.
- When assuming constant elasticity of substitution (CES = 1).
- When believe returns to scale are constant or easy to specify.
- When assume inputs are not very substitutable beyond a point.

Translog production function is used when:

- more flexible functional form.
- analyzing substitution possibilities between inputs.
- testing for non-constant returns to scale or interactions.
- working in a context like cost functions or efficiency analysis.

Results and Discussion

General Condition

Majalengka Regency is one of the regions included in the West Java Province today and during the period of the Indian Colonial Government. The Dutch Majalengka Regency is included in the Cirebon Residency. Currently, based on the coordinates, Majalengka is located to the west of 108° 03′ – 108° 19 East Longitude, East 108° 12′ – 108° 25 East Longitude, Side North 6° 36′ – 5°58 South Latitude and South 6° 43′ – 7°44. Based on these coordinate points, Majalengka

Regency has a subtropical climate. With a natural expanse that extends from Mount Ciremai to the north to the direction of Indramayu Regency, Majalengka Regency is crossed by the Cimanuk River.

Majalengka regency area from the 1900s until now has not changed. In the north it borders the Indramayu Regency and the city of Cirebon, and to the east, it borders two districts, Cirebon Regency and Kuningan Regency. In the south the Regency of Majalengka borders Ciamis Regency and Tasikmalaya Regency, and the west borders directly with Sumedang Regency.

Gununglarang Village is one of 13 villages in Bantarujeg District, Majalengka Regency. Overall, Gununglarang Village has an area of approximately 1,200,1400 (Ha) and is divided into 6 Hamlets/Blocks, consisting of 31 RTs and 8 RWs. The distance from the Village office to the District center is 2 km, while the distance to the Regency capital is around 32 km, and to the Provincial capital it is 82 km.

Characteristics of Respondents

Respondents age

The oldest age group was in the 36–51 age interval, namely, 21 people or 38.18% of the total number of respondent farmers. Most of the corn farmers in Gununglarang Village are of productive age. The population belonging to the productive age ranges between 15–59 years. So overall, the respondent farmers are still in the productive age group, which means that at this productive age, farmers will have high enthusiasm and will find it easier to innovate in running their farming business. Description of ages are shown in Table 2.

Table 2 Number of respondents based on age

Interval of age (year)	Frequency	Percentage
20–35	8	14.55
36–51	21	38.18
52–66	20	36.36
>67	6	10.91
Total	55	100

Note: Data processed in 2024

Respondents Education

The majority of respondent farmers have education levels up to elementary school (Table 3), namely, 150 people (90.91%), followed by farmers with education levels up to high school and D3/S1 with the respective numbers being 4 people (7.27%) and 1 person (1.82%).

Table 3 Number of respondents based on education

No	Level of education	Frequency	Percentage
1	SD (Elementary school)	50	90.91
2	SLTP (Junior high school)	0	0.00
3	SLTA (Senior high school)	4	7.27
4	D3/S1 (Bachelor)	1	1.82
	Total	55	100

Note: Data processed in 2024

Family Members (Dependents)

Respondent farmer family members varied between 1–5 people. For farmers who have 2 and 3 family members, the percentages are 40 percent and 30.91 percent, respectively. Then farmers with 4 and 1 family member(s) have percentages of 14.55 percent and 10.91 percent, respectively (Table 4). The smallest percentage of farmer family members is farmers who have 5 family dependents, which is 3.64 percent of all respondent farmers. Based on Appendix 3, there are typically two members among farmers. This number of families will influence the decision-making process and expenditures in corn farming and influence the technical efficiency level.

Table 4 Number of respondents based on family dependents

Number of family members	Frequency	Percentage
1	6	10.91
2	22	40.00
3	17	30.91
4	8	14.55
5	2	3.63
Total	55	100

Note: Data processed in 2024

Land Size

According to Table 5, the number of respondent farmers is dominated by farmers with the land area used for corn farming ranging from .20–.56 ha or 65.45 percent, 36 of the total respondent farmers. Corn farmers with a land area range of between .56–.93 ha or 27.28 percent total 15 people, and a land area range of between .93–1.30 ha at 7.27 percent, or 4 people from the total number of respondent farmers. This number illustrates that the majority of corn farmers in the research area have low/small land areas, however, it is hoped that corn farming carried out by these farmers will provide high income.

Table 5 Number of respondents based on land size

No	Interval of land size (Ha)	Frequency	Percentage
1	.20–.56	36	65.45
2	.56–.93	15	27.28
3	.93–1.30	4	7.27
	Total	55	100

Note: Data processed in 2024

Farmer Experience

Table 6 shows that 11 corn farmer respondents in Gununglarang Village, Bantarujeg District have farming experience of 2–14 years, or 20 percent of the total number of respondent farmers. Respondent farmers who have farming experience of 14–26 years number 22 people or 40 percent of the total number of corn respondent farmers, and the remaining farmers who have farming experience of 26–38 years and 38–50 years respectively both number 11 people or 20 percent, of the total number of respondent farmers.

Table 6 Farmer's experience

No	Farmer Experience (year)	Frequency	Percentage (%)
1	2–14	11	20
2	14–26	22	40
3	26–38	11	20
4	38–50	11	20
	Total	55	100

Source: Data processed in 2024

Factors Affecting Corn Production

Table 7 indicates the outcomes of utilizing the MLE approach to estimate the Stochastic Frontier production function.

According to Table 7, the stochastic frontier production function analysis's findings demonstrate that the following equation represents how labor (X5), seeds (X2), fertilizer (X3), pesticides (X4), and land area input (X1) affect corn production output (Y):

$$LnY = Ln\ 0.119 + 0.001\ Ln\ X1 + 0.799\ Ln\ X2 + -0.076\ Ln\ X3 + 0.307\ Ln\ X4 + -0.005\ Ln\ X5\ (2.014\ –17.110) \quad (11)$$

Based on the stochastic frontier production function equation above, since the dependent variable is regarded as fixed, it is evident that the constant value is .119, and production results increase by .119. The land area coefficient is .001. Thus, for each land area raised by one percent, production results increase by .001. With a coefficient of .799 for the seed variable, an increase of one percent in the number of seeds, the amount of production will increase by .799; it can be assumed that other variables are constant. The coefficient value of the fertilizer variable is -.076, meaning that if the amount of fertilizer increases by one percent, the amount of production will decrease by .076. The pesticide coefficient value is .307, which illustrates that each additional dose of pesticide will raise production yields by .307. For labor, the coefficient value is -.005, which indicates that increasing the number of workers can reduce production output by .005.

Table 7 Stochastic Frontier estimation results using the MLE approach

Variable	Coefficient	SE	*t*-ratio
Constant	.119	.614	1.936
Land Area (X1)	.001	.001	6.417*
Seed (X2)	.799	.200	3.981*
Fertilizer (X3)	-.076	.065	-1.729*
Pesticide (X4)	.307	.117	2.624*
Labor (X5)	-.005	.001	-4.663*
Sigma-squared	.175	.058	3.009
Gamma (y)	.999	.015	66.152
Log Likelihood Function OLS		-8.377	
Log Likelihood Function		.177	
MLE		17.110	
LR test of the one-sided error		2.014	
T table (α = 5%)			

Source: Primary data processed in 2024

Based on Table 7, explaining the estimation using the MLE model, it is evident that the production factors of land area, seeds, fertilizer, pesticides, and labor are the ones that affect the amount of corn produced at the 95 percent confidence level.

In the land area production factor, as can be observed, the coefficient value is .001, meaning that corn production will rise by .001 percent for every 1 percent increase in the land area variable. In the seed production factor, it can be seen that the coefficient value of the seed production factor is .799, which shows that every 1 percent raise in seed use increases corn production by .799 percent. Respondent farmers use superior seeds with the variety names NK212 and Bisi 18. In the fertilizer production factor, the value can be seen. The negative coefficient is -.076, this shows that every 1 percent rise in fertilizer use reduces corn production by .076 percent. Farmers generally use two types of fertilizer, namely, chemical fertilizers such as urea, phonska, and organic fertilizers such as kohe (chicken and goat). In the pesticide production factor, as shown, the coefficient value is .307, indicating that corn production will increase by .307 percent for every 1 percent rise in pesticide use. The pesticides used by farmers are herbicides.

In the labor production factor, it can be seen that the negative coefficient value is -.005, which implies that corn production will decrease by .005 percent for every 1 percent increase in labor use. In the field, one day of work yields a wage of IDR 50,000/day for female workers and IDR 75,000/day for male.

Value of *t*-table for df 50 is 1.676. Therefore, all of the variables are significant at .05 probability. However, the most significant factor is the fertilizer among others. It is in line with the result of the econometric test.

From Table 8 below, it is seen that the most significant factor is fertilizer. It is a little bit different from the result from SFA, which shows that all variables have a significant effect on the production. The difference implies that the result from SFA is deeper than an econometric test.

Table 8 Result of econometric test

Model		Unstandardized Coefficients		Standardized Coefficients	*t*	Sig.
		B	Std. Error	Beta		
1	(Constant)	-8.176	5.764		-1.418	.163
	Landsize	-.006	.086	-.004	-.069	.945
	Pesticides	2.994E-6	.000	.057	.613	.543
	Capital	2.677E-6	.000	.283	1.697	.096
	Fertilizer	8.192E-6	.000	.564	3.747	.000
	Seed	.031	.137	.016	.227	.821
	Labor	.216	.384	.048	.564	.575

Note: Primary data processed in 2024

Technical Efficiency of Corn Farming

Table 9 implies the approximate technical efficiency level of corn farming in Gununglarang Village, Bantarujeg District, Majalengka Regency.

Table 9 Interval of number and percentage of respondent farmers based on technical efficiency category

No.	Technical Efficiency Level Interval	Category	Number of Farmers (people)	Percentage (%)
1	.227–.484	Low	7	12.73
2	.484–.740	Medium	24	43.64
3	.740–.996	high	24	43.64
Amount			55	100
Average			.688	
Maximum			.996	
Minimum			.227	

Note: Primary data processed in 2024

Table 9 shows that corn farmers' technical efficiency falls between the high (.740–.996) and medium (.484–.740) intervals, namely, 24 people each with a percentage of 43.64 percent of the 55 respondents. Meanwhile, the efficiency level of the low interval (.227–.484) was 7 people.

This shows that there are differences in the use of input allocation used by farmers. Of the total 55 respondents in this study, the highest technical efficiency value was .996, this means that farmers can still become more technically proficient by .4 percent. Furthermore, the lowest technical efficiency value is .227, which means that the farmer can still increase his technical efficiency value by 77.3 percent. The mean technical efficiency of corn producers in Gununglarang Village is .688 or 68.8 percent. Farmers can increase their production by 31.2 percent to achieve optimal production by using production factors efficiently.

Distribution of Technical Efficiency based on Average Value

It is evident from the analysis's findings in the earlier discussion that the average value of technical efficiency for respondent farmers is .688. In Figure 1, technical efficiency values have been grouped based on average values. If the technical efficiency value is above the average value, then the value is positive, whereas if the technical efficiency value is below the average value, then it is negative. This was done to determine the number of respondents who had technical efficiency values that were above/below the average value. A total of 55 farmer respondents were divided into 26 people who had an efficiency level below the average value and 29 people who had an efficiency level above the average value.

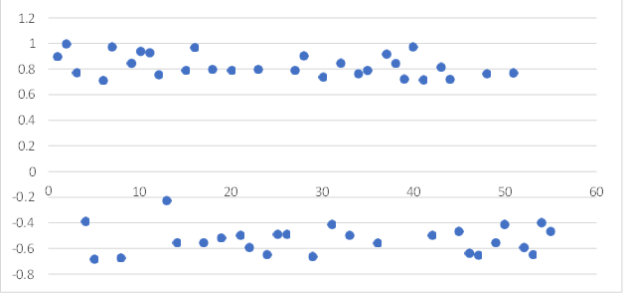


Figure 1 Distribution of technical efficiency

According to the analysis's findings, such demonstrates that the number of respondent farmers who are efficient in running their farming businesses are farmers who use production factors such as land area, seeds, fertilizers, pesticides and labor optimally or effectively. For example, having a large enough land area and good land management, using good and superior (Certified) seeds supported by

sufficient capital to run a farming business, as well as good fertilizer such as the right type, dose, time and method. Then, in using chemicals such as pesticides in the right dosage and type, as well as using sufficient labor. Meanwhile, farmers in the inefficient category are farmers whose use of production factors is not optimal due to having a small land area, using unsuitable seeds, lack of capital sources for corn farming, fertilization that is not done at the right time and dose, and the use of labor that is still not effective. However, in fact, externally it is assumed that other factors also have an effect on production, such as government program or assistance, but such could be effective or not effective (Sulaksana, 2024).

Technical Efficiency based on Education Level

Figure 2 shows that 7 farmer respondents with an education period of 0–6 years are in the low technical efficiency category, 21 people are in the medium technical efficiency category, and 22 people are in the high technical efficiency category. Meanwhile, there was 1 respondent farmer with 7–15 years of education in the low technical efficiency category, 2 people in the medium technical efficiency category and 2 people in the high technical efficiency category.

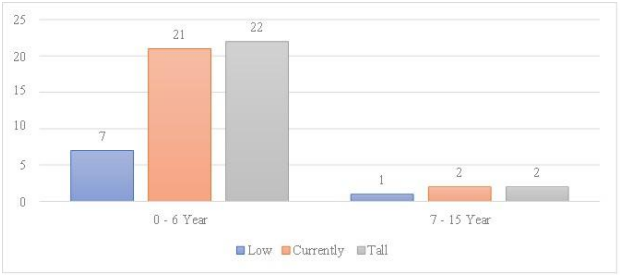


Figure 2 Level of technical efficiency based on education level

Technical Efficiency based on Age

Figure 3 shows that there are 8 respondents in the productive age category (15–64 years) in the low technical efficiency category, 21 people in the medium technical efficiency category and 19 people in the high technical efficiency category. Meanwhile, there were no farmer respondents in the unproductive age category (>65 years) in the low technical efficiency category, 2 people in the medium efficiency category and 5 people in the high technical efficiency category.



Figure 3 Level of technical efficiency by age

Technical Efficiency based on Number of Family Dependents

Figure 4 shows that 7 respondents with family members with 1–3 family members are in the low technical efficiency category, 20 people are in the medium technical efficiency category, and 18 people are in the high technical efficiency category. Meanwhile, farmers with 4–5 family members fall into the low technical efficiency category, 1 person, 3 people in medium efficiency, and 6 people in high efficiency.

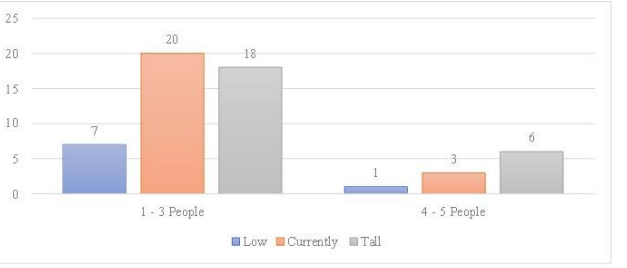


Figure 4 Level of technical efficiency based on number of family dependents

Conclusion and Recommendation

Conclusion

In Gununglarang Village, Bantarujeg District, Majalengka Regency, the variables of land area, seeds, and pesticides significantly increase corn production levels, whereas fertilizer and labor significantly decrease corn production levels.

Corn farming in Gununglarang Village, Bantarujeg District, Majalengka Regency using the stochastic frontier approach shows an average technical efficiency value of .688 or 68 percent. The number of farmers included in the quite efficient category (>.7) was 29 people (52.73%). This shows that there

are still many farmers in Gununglarang Village who are not technically efficient.

Recommendation

Corn farmers are expected to improve their skills in allocating production factors such as land area utilization, use of seeds, fertilizers, pesticides and labor in accordance with recommended recommendations to produce optimal corn production.

The technical efficiency values of 47.27 percent of the farmers in this study's sample were less than .7. By optimizing the use of production factors through recommendations, this technical efficiency value can still be raised. Farmers can also accomplish this by raising their educational attainment, but since they are no longer able to do so, they can participate in informal education through seminars, training, group discussions, etc., that can give them new information to increase their technical efficiency and corn farming.

Future research that can be recommended includes a study on the sustainability of farming, such as sustainability efficiency or a sustainability index, to conduct a comprehensive study on corn farming.

Conflict of Interest

All of the authors declare that there is no conflict of interest.

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