



Efficiency of Hybrid Maize Farming at the Household Scale in Drylands

Yohanes Fischer Tallo^{1*}, Agnes Quartina Pudjiastuti², Jatmiko Setiaji³

Universitas Tribhuwana Tunggaladewi, Indonesia¹

Universitas Tribhuwana Tunggaladewi, Indonesia²

Universitas Tribhuwana Tunggaladewi, Indonesia³

Email : yohanesfischertallo@gmail.com*

Received: 02-08-2025

Reviewed: 03-09-2025

Accepted: 17-10-2025

Abstract

Corn as a pillar of the household-scale farmer economy not only serves as a source of food, but also as animal feed and industrial raw material. However, the productivity of hybrid corn in the drylands of Jetak Village (4-7 tons/ha) is still much lower than in other areas (8-10 tons/ha), indicating inefficient use of inputs. This study measured technical, allocative, and economic efficiency among 96 farmers using the Cobb-Douglas production function with stratified random sampling: <0.5 ha (n=33), 0.5-1 ha (n=30), and >1 ha (n=33). NPK fertilizer consistently dominated productivity (elasticity 0.318-0.394; $p < 0.01$) at all scales. Technical efficiency increased from 0.846 (small land) to 0.879 (large land), indicating a productivity gap of 12-15%. Economic efficiency remains suboptimal (0.619-0.688) with a potential for improvement of 31.2%. Allocative analysis shows the highest NPM/Px ratio for urea fertilizer (5.81) on large-scale land, while labor is over-utilized (NPM/Px=0.80). Contribution of the study: identification of scale-based efficiency thresholds for dryland—expansion of critical land for small farmers (NPM/Px=14.17), nitrogen intensification for medium-sized land, and labor restructuring for large land areas. Interventions should focus on NPK optimization and precision fertilization.

Keywords: Production efficiency, hybrid corn, small-scale farmers, drylands.

Introduction

Food crops are an important foundation for all living things in ensuring global survival and prosperity (Erenstein, 2022; Johansson et al., 2024; Saccone et al., 2025; Purba et al., 2025; Mavroeidis et al., 2022). As a basic necessity, food crops not only serve as a primary source of nutrition, but also as an economic pillar that supports the lives of millions of people around the world (Ali & Bhattacharjee, 2023; Ojuederie et al., 2024; Kasmini, 2024). Today, with the continuing growth of the population and the challenges of climate change, the need for efficient and sustainable food production is becoming increasingly urgent.

The Food and Agriculture Organization (FAO) estimates that food demand in developing countries will increase by 60% by 2030 and double by 2050, equivalent to a 42% increase in global production by 2030 and a 70% increase by 2050. Food demand will continue to rise in line with significant population growth (FAO, IFAD, WHO, UNICEF, 2024). This is related to increased consumption, especially in developing countries such as Indonesia, which will have a population of 284,4 million by 2025. This population is expected to continue to grow (BPS, 2025).

Seeing the continuous population growth, the Indonesian government is currently facing serious challenges in ensuring national food security, especially in relation to the suboptimal utilization of dry land. Based on data from the National Food Agency, not all strategic food in Indonesia can be fulfilled by domestic production, so a number of staple foods still have to be fulfilled through imports (BPN, 2024). This situation is exacerbated by the shrinking area of productive agricultural land, especially on the island of Java, as a result of ongoing land conversion. Recognizing this situation, in 2025 President Prabowo Subianto established the national food estate program as one of the priority strategies for achieving food self-sufficiency outside of Java.

East Java has been designated as one of the largest corn food estates with significant production growth of 21.9% from 2024 to 2025 (BPS, 2025), with a focus on development in Tuban Regency, specifically for corn crops. This designation is based on the potential of the land and agroclimatic conditions that support corn development in the region.

Corn is a strategic commodity that plays a multifunctional role as an alternative food source, livestock feed, and industrial raw material. Globally, around 60% of world corn production is used for animal feed, 24% for industrial purposes, and 16% for direct human consumption (Prasetyo et al., 2024; Beding et al., 2023; Erenstein et al., 2022). Given this strategic role, efforts to increase corn productivity continue to be made to meet the surplus needs of food, animal feed, and industrial needs both domestically and to meet export demand. However, climate change and water limitations on dry land can significantly affect the productivity of corn and other food crops, resulting in a decline in production. This condition needs to be prioritized by the government regarding corn crops on dry land. Dry land refers to agricultural land without a technical irrigation system that is highly dependent on rainfall. Generally, dry land has limited water reserves, low organic matter content, high acidity, and is prone to erosion, which can reduce corn productivity if not addressed through the selection of adaptive varieties, water-saving irrigation technology, and effective input management (Rejekiingrum, 2022; Albahari et al., 2023).

Based on data from the Central Statistics Agency, 2025, the corn harvest area reached 0.66 million hectares, a decrease of 0.01 million hectares or 2.17% (BPS, 2025). The decline in production is a particular concern in the agricultural sector, especially for small-scale farmers and large-scale farmers who own dry land with a high level of difficulty in developing productivity. This condition is clearly experienced by corn farmers in Jetak Village, with an average corn production of 4-7 tons/ha compared to other regions with an average productivity of 8-10 tons/ha (Bahtiar et al., 2020). Given this reality, corn farmers in Jetak Village, which

is one of the areas in the East Java food barn region, have strategic potential but face technical and economic constraints in developing efficient corn farming.

Farming efficiency is the key to increasing corn productivity. Efficiency is not only related to the optimization of production inputs but also includes the ability of farmers to produce maximum output with minimum production costs (Ruzhani & Mushunje, 2025). Along with the development of agricultural technology, hybrid corn has become the main choice for corn farmers in Jetak Village and corn farmers in general because it has advantages in terms of productivity, resistance to pests and diseases, and adaptability to various environmental conditions, especially in dry land ecosystems (Zebua et al., 2024; Dewi et al., 2022).

Literature Review

Adaptation of Hybrid Corn to Dry Land Conditions

Hybrid corn is the result of crossing two or more pure lines that have heterosis advantages with a potential yield of 8-12 tons/ha, higher than composite or local varieties. The advantage of hybrid corn lies in its adaptability to various agroclimatic conditions, including dry land with limited water availability, varying levels of fertility, and high dependence on rainfall (Zein, 2024; Li et al., 2024; Konate et al., 2023; Singamsetti et al., 2023). Although productivity in drylands tends to be lower than in paddy fields due to drought stress, hybrid corn responds well to fertilization and can provide optimal yields when managed with appropriate cultivation practices according to the land conditions in Jetak Village.

The Concept of Farming Efficiency

Production efficiency in corn farming is constructed through three conceptually integrated dimensions. Technical efficiency refers to farmers' capacity to optimize input utilization in order to achieve maximum output within the constraints of available technology, reflecting technical and managerial capabilities in the production process. Allocative efficiency indicates the economic rationality of farmers in determining the optimal composition and proportion of inputs based on the prevailing input-output price structure, with the aim of minimizing production costs or maximizing business surplus. Meanwhile, economic efficiency represents a holistic measure that combines these two dimensions of efficiency, describing the overall productive and economic performance of farmers in allocating limited resources to achieve an optimal level of welfare (Palus et al., 2025; Tumuri et al., 2024; Alemu et al., 2022).

This study focuses on the efficiency of hybrid corn farming, which is formed from the interaction of production factors and the socio-economic characteristics of farmers on dry land. Production factors include land area, seeds, fertilizers, pesticides, and labor. Socio-economic factors include age, education, and farming experience. All these factors work simultaneously and influence each other in shaping the level of technical, allocative, and economic efficiency in household-scale hybrid corn farming in drylands.

Efficiency of Household-Scale Farming

Achieving efficiency in hybrid corn farming on dry land is influenced by complex interactions between production factors and farmers' socioeconomic characteristics. Production factors include land availability and quality, seed varieties used, fertilizer intensity and pest control, labor allocation, and business capital availability. Meanwhile, socioeconomic characteristics such as farmers' managerial capacity (which is influenced by age and education), accumulated knowledge from farming experience, and security of land rights also determine the level of efficiency that can be achieved. Household-scale farms generally have limited land area (<2 hectares), labor use dominated by family members, limited capital, and a subsistence to semi-commercial orientation, which are important characteristics in efficiency analysis (Lowder et al., 2025; Purnawan et al., 2021).

Research Method

This study uses a quantitative approach by applying the Cobb–Douglas production function to measure technical, allocative, and economic efficiency in hybrid corn farming on dry land in Jetak Village. The analysis was conducted using a modern econometric approach that integrates parametric and nonparametric methods (Dong & Gao, 2025). This approach provides greater flexibility in modeling the relationship between input and output variables under various agroecological conditions. The research sample consisted of 96 farmers selected by stratified random sampling based on land area, comprising 33 smallholder farmers (<0.5 ha), 30 medium-scale farmers (0.5-1 ha), and 33 large-scale farmers (>1 ha). Primary data were collected through structured interviews using questionnaires covering variables such as land area, seeds, fertilizers, pesticides, labor, and production costs.

Data analysis began with classical assumption tests (normality, multicollinearity) to validate the regression model. Next, the Cobb-Douglas production function is estimated through natural logarithm transformation. Hypothesis testing uses the F test (simultaneous) and t test (partial) at a 5% significance level, with the coefficient of determination (R^2) to measure the explanatory power of the model. Technical efficiency is measured by comparing actual output to maximum potential output. Allocative efficiency is calculated through the ratio of marginal product value (NPM) to input price. Economic efficiency is the product of the two. Comparative analysis is conducted to compare efficiency levels between land scale levels.

Results and Discussion

Farmer Characteristics

Farmer characteristics are an important aspect that influences the success of hybrid corn farming in drylands. Farmer profiles include age, education level, and farming experience, which are the basic capital in farm management. Understanding these characteristics provides an overview of farmers' capacity to make production decisions and manage available resources.

The characteristics of the farmers who responded to this study are presented in the following table:

Table 1. Characteristics of corn farmers based on land area scale in Jetak Village.

No.	Characteristics	Category	Land Area Category					
			Small	%	Medium	%	Large	%
		Year/Level	Quantity		Quantity		Quantity	
1	Age	30-50	17	52	13	41	17	55
		>50	16	48	19	59	14	45
2	Education	Elementary school	16	48	14	44	13	42
		Junior high school	11	33	13	41	13	42
		Senior high school	5	15	4	13	5	16
		Bachelor's Degree	1	3	1	3	0	0
3	Farming experience	<20	6	18	4	13	6	19
		20-30	11	33	11	34	14	45
		>30	16	48	17	53	11	35
Total			33	100	32	100	31	100

Source: Processed Primary Data (2025)

Based on Table 1, farmers with medium-sized plots are predominantly aged over 50 (59%), reflecting established farmers without expansion. In contrast, farmers with large plots are more likely to be of productive age (30-50 years old) (55%), indicating business expansion by younger generations. The level of education is low in all categories, with the majority having only elementary school (42-48%) and junior high school/MTs (33-42%) education. However, low education does not hinder land expansion, proving that the scale of business is more determined by capital and experience than formal education. Farming experience shows that medium-scale farmers are the most experienced (53% >30 years), while large-scale farmers are dominated by those with 20-30 years of experience (45%). This confirms that expansion occurs when farmers have sufficient experience but are still productive and growing.

Characteristics of Farming

The characteristics of farming describe the patterns of production input use and output produced on each scale of land. This information forms the basis for understanding the level of intensification of hybrid corn farming on dry land before conducting an efficiency analysis. The average use of inputs and production outputs is presented in the following table:

Table 2. Characteristics of Hybrid Corn Farming in Jetak Village Based on Scale

Variable	Unit	Land Area Category		
X1-X7 (Y)	Hectare/Liter/ Person-days	Small	Medium	Large
Land Area	Ha	0,32	0,60	1,28
Seeds	Kg	3,53	6,56	14,09
Manure	Kg	25,46	47,78	102,68
Urea Fertilizer	Kg	79,52	149,31	320,84
NPK Fertilizer	Kg	105,76	179,06	374,10
Pesticides	L	0,08	1,5	2,5
Labor	PD	2,64	4,84	10,07
Production	Kg	1.717	3.307	6.281
Total Farmers		33	32	31

Source: Processed Primary Data (2025)

Table 2 shows the pattern of input use proportional to land scale. The larger the cultivated land area, the greater the need for seeds, fertilizers, and labor. Productivity per hectare is relatively consistent across all scales. This productivity is calculated by dividing the total production by the land area of each category. Small plots produce 1,717 kg from 0.32 ha. Medium-sized land produces 3,307 kg from 0.60 ha. Meanwhile, large land produces 6,281 kg from 1.28 ha. This consistency indicates the application of uniform cultivation techniques, both by small and large farmers. This consistency indicates the application of uniform cultivation techniques, both by small and large farmers. The most striking difference is seen in the use of pesticides. Small plots only use 0.08 liters, which is much lower than medium plots at 1.5 liters and large plots at 2.5 liters. On small plots, farmers are still able to control pests manually because of their limited size. Conversely, larger plots make manual control inefficient, so pesticide application becomes a rational choice. The average land area, input use, and labor distribution indicate that farmers on dry land tend to optimize available resources. These results support the findings of Lowder et al. (2025), which state that an increase in land scale is positively related to productivity and input use efficiency in the sustainable agriculture sector.

Classical Assumption Test

Before interpreting the results of the Cobb-Douglas production function estimation, classical assumption testing was conducted to ensure that the regression model met the requirements of the Best Linear Unbiased Estimator (BLUE) as described by Hansen (2022). The classical assumption tests conducted included normality, multicollinearity, and heteroscedasticity tests. Fulfilling these assumptions ensures that the resulting estimators are unbiased, consistent, and efficient, so that the analysis results can be used as a basis for valid decision making. The normality test can be presented in the following table:

Table 3. Kolmogorov-Smirnov Classical Assumption Test

Model	Land Area Category		
	Small	Medium	Large
Asymp.Sig. (2-tailed)	0.142	0.178	0.193
Criteria	Normal Distribution	Normal Distribution	Normal Distribution

Source: Processed Primary Data (2025)

Table 3 shows the results of the normality test using the Kolmogorov-Smirnov method for the three land categories. The Asymp.Sig. (2-tailed) values for large land areas are 0.193, medium land areas 0.178, and small land areas 0.142. All three values are greater than the significance level of 0.05, which means that the residuals in all models are normally distributed. The fulfillment of the normality assumption indicates that the regression model is suitable for further analysis, because the resulting parameter estimates are unbiased and efficient.

Multicollinearity Test

The multicollinearity test aims to detect the presence or absence of high correlation between independent variables in a regression model. Multicollinearity can cause coefficient estimates to become unstable and standard errors to increase, thereby reducing the accuracy of the analysis. The test uses the Variance Inflation Factor (VIF) and Tolerance values, with

criteria of $VIF < 10$ and $Tolerance > 0.10$ indicating that the model is free from multicollinearity. The multicollinearity test data can be seen in the following table;

Table 4. Multicollinearity Test Based on Land Area Category

Variable	Land Area Category					
	Small		Medium		Large	
	Collinearity Statistics					
	X1-X7	Tolerance	VIF	Tolerance	VIF	Tolerance
X1 (Land Area)	3.421	0.292	3.876	0.258	4.123	0.243
X2 (Seeds)	2.987	0.335	3.234	0.309	3.567	0.280
X3 (Manure)	2.654	0.377	2.987	0.335	3.234	0.309
X4 (Urea Fertilizer)	4.123	0.243	4.567	0.219	4.876	0.205
X5 (NPK Fertilizer)	3.876	0.258	4.234	0.236	4.567	0.219
X6 (Pesticides)	2.234	0.448	2.456	0.407	2.789	0.359
X7 (Labor)	2.891	0.346	3.123	0.320	3.456	0.289

Source: Processed Primary Data (2025)

Table 4 shows the results of the multicollinearity test for the three land categories using the Variance Inflation Factor (VIF) and Tolerance values. All variables for small, medium, and large plots have VIF values < 10 . This indicates that there is no high correlation between the independent variables in the model. This regression model is free from multicollinearity issues, and each input variable can be interpreted independently of its effect on hybrid corn production.

Model Fit (Model Goodness Fit)

The suitability of the model is measured by the coefficient of determination, which describes the proportion of production variation that can be explained by the input variables in the model. The higher the value, the stronger the model's ability to represent the actual conditions of hybrid corn farming at the research site. The results of the model suitability test are presented in Table 5 below.

Table 5. Coefficient of Determination (R^2)

Land Area Category	Model			
	R	R Square	Adjusted R Square	Std. Error Of Estimate
Small	0.865	0.748	0.678	0.432
Medium	0.877	0.769	0.702	0.517
Large	0.885	0.782	0.716	0.623

Source: Processed Primary Data (2025)

The results of model feasibility testing show that all three land categories have a good level of suitability, with R Square values ranging from 0.748 to 0.782. This means that the input variables in the model are able to explain around 75-78% of the variation in hybrid corn production, while the rest is influenced by other factors outside the model. The R Square value shows an upward trend as the land scale increases, with large land areas having the highest value (0.782), followed by medium land areas (0.769), and small land areas (0.748). This pattern indicates that larger-scale hybrid corn farms tend to have more systematic and measurable input management, so that the relationship between production inputs and outputs

is more consistent and predictable compared to small farms, which may be more influenced by the variability of individual farmers' management.

Hybrid Corn Production Function Analysis

Production function analysis was conducted to understand the relationship between the use of production inputs and the output produced in hybrid corn farming. Using the Cobb-Douglas production function approach, this study identified the influence of various input factors on corn productivity in three land area categories, namely small, medium, and large. The results of the analysis are presented in the following table;

Table 6. Production Function Based on Land Area Category

Model	Land Area Category								
	Small			Medium			Large		
Variable	B	Std.Error	Sig.	B	Std.Error	Sig.	B	Std.Error	Sig.
Constant	3.854	0.682	0.211	2.967	0.745	0.121	3.245	0.812	0.301
Ln-X1	0.412	0.118	0.002	0.187	0.134	0.175	0.156	0.142	0.283
Ln-X2	0.089	0.145	0.544	0.094	0.156	0.552	0.082	0.168	0.630
Ln-X3	0.067	0.098	0.500	0.078	0.112	0.493	0.071	0.125	0.575
Ln-X4	0.124	0.156	0.434	0.289	0.128	0.033	0.183	0.152	0.241
Ln-X5	0.318	0.089	0.001	0.394	0.115	0.002	0.367	0.108	0.002
Ln-X6	0.045	0.067	0.508	0.063	0.089	0.486	0.074	0.098	0.458
Ln-X7	0.118	0.132	0.379	0.142	0.145	0.337	0.298	0.134	0.036
F- Count	10.687			11.452			11.856		
Sig.Simultaneous	0.000			0.000			0.000		
F-Table	3.54			3.59			3.64		
T-Table	2.787			2.797			2.807		

Source: Processed Primary Data (2025)

Based on Table 6, the results of the Cobb-Douglas production function analysis show that the model as a whole is feasible and significant for all three land categories, as evidenced by the calculated F-value being much greater than the F-table at a significance level of 1%. This indicates that the input variables collectively have a significant effect on hybrid corn production. NPK fertilizer (X5) is the most consistent and dominant production factor that has a very significant effect on production in all land scales with the highest elasticity coefficient in medium land (0.394), followed by large land (0.367) and small land (0.318). This means that every 1% increase in NPK fertilizer will increase production by around 0.32-0.39%, with the best response on medium-sized land. These findings indicate that NPK fertilizer is a strategic input that must be prioritized in the allocation of hybrid corn farming resources.

The pattern of influence of production factors differs according to land scale. For small land areas, land area (0.412) is a very significant determining factor, indicating that land expansion still has a major impact on increasing production. For medium-sized land areas, urea fertilizer (0.289) has a significant effect, indicating the importance of nitrogen availability in supporting plant growth. Meanwhile, on large farms, labor (0.298) is a significant factor, reflecting the importance of good human resource management in large-scale farming. Other production factors such as seeds, manure, and pesticides do not show a statistically significant effect, indicating that farmers are already using these inputs in sufficient doses or have not yet

optimized their application. The results of the Cobb-Douglas production function analysis show that land area and fertilizer have a significant effect on corn production, while labor and pesticides have no significant effect. These findings are consistent with the research by Tumuri et al. (2022), which reports that land area and fertilizer use are the main factors affecting corn output in drylands in East Africa.

Allocative Efficiency

Allocative efficiency measures the accuracy of production input allocation based on a comparison of Marginal Product Value (MPV) with input prices. An MPV/Px ratio of 1 indicates optimal allocation, >1 indicates that inputs need to be increased, while < 1 indicates overuse. The results of the analysis are presented in the following table:

Table 7. Allocative Efficiency Allocative Efficiency Based On Land Area Comparison

Input	Land Area Category					
	Small		Medium		Large	
	Elasticity	NPM/Px	Elasticity	NPM/Px	Elasticity	NPM/Px
Land Area	0,412	14,17	0,187	8,66	0,156	8,87
Seeds	0,089	1,08	0,094	1,98	0,082	3,53
Manure	0,067	1,13	0,078	2,26	0,071	4,74
Urea Fertilizer	0,124	1,34	0,289	2,68	0,183	5,81
NPK Fertilizer	0,318	1,41	0,394	1,66	0,367	3,24
Pesticides	0,045	1,00	0,063	1,00	0,074	1,00
Labor	0,118	1,00	0,142	0,97	0,298	0,80

Source: Processed Primary Data (2025)

Criteria: NPM/Px = 1 (Efficient); NPM/Px > 1 (Not yet optimal, need to add input); NPM/Px < 1 (Inefficient, need to reduce input).

The analysis results show that on small plots of land, land area has the highest NPM/Px ratio of 14.17, indicating that land expansion is very profitable. NPK fertilizer shows a ratio of 1.41, so its use needs to be increased. Pesticides and labor with a ratio of 1.00 have reached an efficient allocation, indicating an optimal balance between costs and benefits. On medium-sized land, urea fertilizer shows a ratio of 2.68, indicating that it needs to be increased, while labor with a ratio of 0.97 is close to optimal. Pesticides remain efficient with a ratio of 1.00. Large land area, urea fertilizer has the highest ratio of 5.81, indicating that its use is still far from optimal and needs to be increased significantly. Pesticides remain efficient on all land scales, but labor shows inefficiency with a ratio of 0.80, indicating excessive labor use and the need for reduction in large-scale farming.

Overall, almost all inputs have not been optimally allocated with an NPM/Px ratio greater than 1, indicating that farmers can still improve efficiency by increasing the use of NPK fertilizer, urea fertilizer, manure, and seeds. Pesticides are a consistently efficient input across all land scales, while labor shows a different pattern, being efficient on small plots but inefficient on large plots, reflecting the need to adjust labor management according to the scale of the business. The results of the allocative efficiency analysis show that most farmers have not yet achieved optimal efficiency, as indicated by the NPM/Px ratio, which is still far from one. This condition is in line with the theory proposed by Ruzhani & Mushunje (2025), that

allocative efficiency is achieved when the marginal product value of each input is equal to its cost of use, which indicates optimal resource allocation.

Technical Efficiency

Technical efficiency measures farmers' ability to optimize the use of production inputs to achieve maximum output in hybrid corn farming on dry land. Technical efficiency values range from 0 to 1, where values close to 1 indicate that farmers are approaching optimal production levels at the household scale. The results of the technical efficiency analysis based on land area categories are presented in Table 8:

Table 8. Technical Efficiency Levels Based on Land Area Categories

Category	Average ET	Std.Dev	Technical Efficiency Criteria							Total	%
			Efficient	%	Fairly Efficient	%	Less Efficient	%			
			(>0,90)		(0,80-0,90)		(< 0,80)				
			Total		Total		Total				
			Farmers		Farmers		Farmers				
Small	0,846	0,078	8	24	14	42	11	34	33	100	
Medium	0,863	0,072	9	28	15	47	8	25	32	100	
Large	0,879	0,068	10	32	14	45	7	23	31	100	
Average	0,862	0,073							96	100	

Source: Processed Primary Data (2025)

Explanation:

The Technical Efficiency (TE) values in the table above are the average results of calculations of individual farmers' technical efficiency in each land area category. These values describe farmers' ability to maximize output from the combination of inputs available at a given level of technology. The higher the TE value (approaching 1), the more efficient farmers are in utilizing their production inputs. The standard deviation (Std.Dev) value indicates the level of diversity in efficiency among farmers in that category; the smaller the value, the more uniform the efficiency of farmers in that land category.

The results show that technical efficiency increases with increasing land area. The average technical efficiency value for small land areas is 0.846, increasing to 0.863 for medium land areas and reaching 0.879 for large land areas. This increase indicates that farmers with larger land areas tend to be more efficient in optimizing the use of their production factors. The standard deviation value decreased from 0.078 on small farms to 0.068 on large farms, indicating that the level of efficiency among farmers is more uniform on large-scale farms. This means that farmers in the large farm group have relatively less variation in efficiency, which may reflect the application of more homogeneous technologies and cultivation practices.

The majority of farmers are in the moderately efficient category, with the highest proportion on medium-sized farms at 46.88%. The proportion of farmers classified as efficient also increased from 24.24% on small farms to 32.26% on large farms, while the proportion of inefficient farmers decreased from 33.33% to 22.58%. This pattern indicates a positive shift towards higher levels of efficiency. However, with the highest average technical efficiency of

0.879, there is still potential for a 12–15% increase in production if all farmers are able to achieve full technical efficiency (ET value = 1). This shows that some farmers still face constraints in the use of production inputs, either due to limited capital, knowledge, or the suboptimal application of cultivation technology.

The level of technical efficiency in hybrid corn farming on dry land shows an increase as the scale of land increases. These results reinforce the findings of Abate (2023), who found that land scale and farmer experience are important factors in improving the technical efficiency of corn farming in Africa. Furthermore, these findings are also in line with Erenstein et al. (2022), who emphasize that corn is a strategic global commodity that contributes significantly to food security and the welfare of smallholder farmers.

Economic Efficiency

Economic efficiency is a combination of technical efficiency and allocative efficiency that measures farmers' ability to allocate inputs optimally by considering technical aspects of production and input-output prices. The economic efficiency value ranges from 0 to 1, where a value close to 1 indicates that farmers are able to maximize profits through the proper use and allocation of inputs in hybrid corn farming on dry land. The results of the economic efficiency analysis based on land area categories are presented in Table 9:

Table 9. Economic Efficiency Levels Based on Land Area Categories

Criteria for economic efficiency										
Category	Average EE	Std.Dev.	Efficient		Fairly Efficient		Less Efficient		Total l	%
			(>0,70)	%	(0,50-0,70)	%	t (< 0,50)	%		
			Total Farmers		Total Farmers		Total Farmers			
Small	0,619	0,098	12	36	16	49	5	15	33	100
Medium	0,654	0,103	14	43	13	41	5	16	32	100
Large	0,688	0,095	16	52	11	35	4	13	31	100
Average	0.053	0.099							96	100

Source: Processed Primary Data (2025)

Explanation:

The Economic Efficiency (EE) values in the table above are the average results of calculations of the economic efficiency of individual farmers in each land area category.

Table 9 shows that the level of economic efficiency of corn farming increases with increasing land area. The average economic efficiency value for small land areas is 0.619, increasing to 0.654 for medium land areas, and reaching 0.688 for large land areas. This increase shows that farmers with larger land areas are able to combine technical efficiency and allocative efficiency more optimally than small-scale farmers. The proportion of farmers

classified as efficient also increased from 36.36% in the small land group to 51.61% in the large land group. Conversely, the percentage of farmers in the moderately efficient category decreased from 48.48% to 35.48%. This decline is a positive indication because it reflects a shift from the moderately efficient category to the efficient category, rather than a decline in performance. However, the highest average economic efficiency only reached 0.688, which means that there is still potential for a 31.2% increase in efficiency if farmers can optimally allocate all production inputs in accordance with prevailing prices and technology. This indicates that most corn farmers in Jetak Village still face limitations in the efficient use of production inputs, whether due to technical factors, capital constraints, or knowledge about the efficient use of inputs. Therefore, efforts are needed to increase farmer capacity through extension services, access to production technology, and strengthening business management so that economic efficiency can be improved in a sustainable manner.

Overall, the results of the study indicate that the technical and allocative efficiency of hybrid corn farming on dry land can still be improved through the optimization of key inputs such as land and fertilizer. This confirms the importance of land management strategies and increasing farmer capacity in supporting sustainable productivity (Abate, 2023; Erenstein et al., 2022; Ruzhani & Mushunje, 2025).

Conclusion

The results of the analysis show that the factors that significantly affect economic efficiency vary between land area categories. For small land areas, the variables that significantly affect economic efficiency are land area and NPK fertilizer. This shows that increasing the scale of land and using the right compound fertilizer can improve the economic efficiency of farmers with small land areas. Land limitations require small farmers to maximize productivity through fertilizer input optimization and efficient land use. For medium-sized land, the variables that have a significant effect are urea fertilizer and NPK fertilizer. These findings indicate that the combination of nitrogen fertilization (urea) and complete macro nutrients (NPK) plays an important role in increasing production and input allocation efficiency. Meanwhile, on large plots of land, the significant variables are NPK fertilizer and labor. This means that on a larger scale, economic efficiency is determined by the farmer's ability to manage labor requirements in balance with the size of the land and the optimal use of NPK fertilizer. Overall, the results of this study confirm that NPK fertilizer is the most consistent factor influencing economic efficiency across all land area categories, making the management of dosage and application timing key to improving corn farming efficiency in Jetak Village.

References

Abate, T. (2023). Determinants of technical efficiency of maize production in Africa: A meta-analysis. *Heliyon*, 9(3), e14689. <https://doi.org/10.1016/j.heliyon.2023.e14689>.

- Ali, A., & Bhattacharjee, B. (2023). *Nutrition security, constraints, and agro-diversification strategies of neglected and underutilized crops to fight global hidden hunger*. *Frontiers in Nutrition*, 10, 1144439. <https://doi.org/10.3389/fnut.2023.1144439>.
- Alemu, G., Angasu, B., & Sime, N. (2022). *Economic Efficiency Of Smallholder Farmers In Maize Production: The Case Of Arsi Negelle District, Oromia National Regional State, Ethiopia*. 11 (2)(August), 98–104. <https://doi.org/10.11648/j.jwer.20221102.14>.
- Albahri, G., Alyamani, A. A., Badran, A., Hijazi, A., Nasser, M., Maresca, M., & Baydoun, E. (2023). Enhancing essential grains yield for sustainable food security and bio-safe agriculture through latest innovative approaches. *Agronomy*, 13(7), 1709. <https://doi.org/10.3390/agronomy13071709>.
- Badan Pusat Statistik. (2025). *Mid year population (thousand people), 1960–2025*. Badan Pusat Statistik. <https://www.bps.go.id/en/statistics-table/2/MTk3NSMy/mid-year-population--thousand-people-.html>.
- Badan Pusat Statistik. (2025). *Luas panen dan produksi jagung di Indonesia (hasil KSA amatan April 2025)*. Badan Pusat Statistik. <https://assets.dataindonesia.id/2025/08/07/1754529970455-49-6.-Berita-Resmi-Statistik-Luas-Panen-dan-Produksi-Jagung-Juni-2025.pdf>.
- Bahtiar, B., Zanuuddin, B., & Azrai, M. (2020). Advantages of Hybrid Corn Seed Production Compared to Corn Grain. *International Journal of Agriculture System*, 8(1), 44. <https://doi.org/10.20956/ijas.v8i1.2327>.
- Beding, P. A., Lewaherilla, N. E., Lestari, R. H., & Tirajoh, S. (2023). Analisis Potensi Pengembangan Komoditas Jagung Di Wilayah Perbatasan Nkri – Png Kabupaten Keerom Papua. *SEPA: Jurnal Sosial Ekonomi Pertanian dan Agribisnis*, 20(2), 162. <https://doi.org/10.20961/sepa.v20i2.52339>.
- Badan Pangan Nasional. (2024). *Rencana aksi Badan Pangan Nasional*. Badan Pangan Nasional. https://esakip.badanpangan.go.id/dok/pk/dok_202411753451491.pdf.
- Dewi, R. S., Hidayatullah, M., & Suryani, E. (2022). Potensi dan pengembangan jagung hibrida di Indonesia. *Jurnal Agronomi Indonesia*, 50(1), 45–58. <https://doi.org/10.47701/sintech.v3i1.2518>.
- Dong, C., & Gao, J. (2025). *Modern series methods in econometrics and statistics*. Springer Singapore. <https://doi.org/10.1007/978-981-96-2822-3>.
- Erenstein, O., Jaleta, M., Sonder, K., Mottaleb, K., & Prasanna, B. M. (2022). Global maize production, consumption and trade: Trends and R&D implications. *Food Security*, 14(5), 1295–1319. <https://doi.org/10.1007/s12571-022-01288-7>.
- Erenstein, O. (2022). Role of staple cereals in human nutrition: Sustainably and diversely agri-food systems and diets. *Food Research International*, 156, 111264. <https://doi.org/10.1016/j.foodres.2022.111264>.
- FAO, IFAD, UNICEF, WFP, & WHO. (2024). *The state of food security and nutrition in the world 2024: Financing to end hunger, food insecurity and malnutrition in all its forms*. Food and Agriculture Organization of the United Nations (FAO). <https://doi.org/10.4060/cd1254en>.
- Hansen, B. E. (2022). *Econometrics*. Princeton University Press. ISBN 978-0691235899.

- Johansson, E., Prieto-Linde, M. L., & Östman, A. (2024). Wheat – Current contribution to food security, human nutrition and food products, and needs for improvement. *Frontiers in Nutrition*, 11, 1393357. <https://doi.org/10.3389/fnut.2024.1393357>.
- Kasmini, L. (2024). Identifikasi Jenis Tumbuhan Sebagai Sumber Kehidupan Berdasarkan Dari Variasi Gizi Dan Nutrisi: Discovery Learning Pada Sekolah Dasar. *Journal Visipena Special Issue*, 12–18. <https://doi.org/10.46244/visipena.vi.2536>.
- Konate, L., Badu-Apraku, B., Coulibaly, M., Menkir, A., Nasser Laouali, M., Meseka, S., & Mengesha, W. (2023). Agronomic performance and yield stability of extra-early maturing maize hybrids in multiple environments in the Sahel. *Heliyon*, 9(11), e21659. <https://doi.org/10.1016/j.heliyon.2023.e21659>.
- Li, Z., Zhang, J., & Song, X. (2024). Breeding Maize Hybrids with Improved Drought Tolerance Using Genetic Transformation. *International Journal of Molecular Sciences*, 25(19). <https://doi.org/10.3390/ijms251910630>.
- Lowder, S. K., Bhalla, G., & Davis, B. (2025). Decreasing farm sizes and the viability of smallholder farmers: Implications for resilient and inclusive rural transformation. *Global Food Security*, 45, 100854. <https://doi.org/10.1016/j.gfs.2025.100854>.
- Mavroeidis, A., Roussis, I., & Kakabouki, I. (2022). The role of alternative crops in an upcoming global food crisis: A concise review. *Foods*, 11(22), 3584. <https://doi.org/10.3390/foods11223584>
- Ojuederie, O. B., et al. (2024). *Editorial: Neglected and underutilized crop species for sustainable food and nutritional security: Prospects and hidden potential*. *Frontiers in Plant Science*, 15, 1358220. <https://doi.org/10.3389/fpls.2023.1358220>.
- Palus, F. T., Pudjiastuti, A. Q., & Yoga, T. (2025). Allocation of input use in dryland chili farming of Kelompok Tani Hutan Panderman, Batu City. *Journal of Business Management and Economic Development*, 3(3), 945–957. <https://doi.org/10.59653/jbmed.v3i03.1869>.
- Purba, N. H., & Krishnaswamy, K. (2025). Exploring the potentials of neglected underutilized crops (NUCs): an integrative review for developing a sustainable food system model. *npj Science of Food*, 9(1), 199. <https://pmc.ncbi.nlm.nih.gov/articles/PMC12485001>.
- Purnawan, E., Brunori, G., & Prosperi, P. (2021). Financial support program for small farmers, and its impact on local food security: Evidence from Indonesia. *Horticulturae*, 7(12), 546. <https://doi.org/10.3390/horticulturae7120546>.
- Prasetyo, R., Sari, M. K., & Lestari, Y. K. (2024). Penguatan ekosistem jagung: Isu, tantangan, dan kebijakan. *Policy Brief Pertanian, Kelautan, dan Biosains Tropika*, 6(1), 749-753. <https://doi.org/10.29244/agro-maritim.0601.749-753>.
- Rejekiningrum, P., Apriyana, Y., Sutardi, Estiningtyas, W., Sosiawan, H., Susilawati, H. L., Hervani, A., & Alifia, A. D. (2022). Optimising water management in drylands to increase crop productivity and anticipate climate change in Indonesia. *Sustainability*, 14(18), 11672. <https://doi.org/10.3390/su141811672>.
- Ruzhani, F., & Mushunje, A. (2025). Technical efficiency in agriculture: A decade-long meta-analysis of global research. *Journal of Agriculture and Food Research*, 19, 101667. <https://doi.org/10.1016/j.jafr.2025.101667>.

- Saccone, D., Mazzocchi, M., & Corsi, S. (2025). Global food security in a turbulent world: Reviewing the role of cereals in food systems. *Agricultural & Food Economics*, 13(1), Article 3. <https://doi.org/10.1186/s40100-025-00388-0>.
- Singamsetti, A., Zaidi, P. H., Seetharam, K., Vinayan, M. T., Olivoto, T., Mahato, A., Madankar, K., Kumar, M., & Shikha, K. (2023). Genetic gains in tropical maize hybrids across moisture regimes with multi-trait-based index selection. *Frontiers in Plant Science*, 14, 1147424. <https://doi.org/10.3389/fpls.2023.1147424>.
- Tumuri, A., Geleta, D., & Sime, G. (2024). Technical efficiency of maize production and their determinants among smallholder farmers in Ethiopia: A case study in Sidama Region. *Cogent Food and Agriculture*, 10(1), 2392045. <https://doi.org/10.1080/23311932.2024.2392045>.
- Zebua, A., Waruwu, H., Telaumbanua, A., & Laoli, A. (2023). Analisis pertumbuhan tanaman jagung hibrida sebagai pakan ternak di Desa Olora Kota Gunungsitoli. *Habitat*, 2(2), 1–10. <https://doi.org/10.62951/habitat.v2i2.50>.