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Allocation of Input Use in Dryland Chili Farming of Kelompok Tani Hutan Panderman, Batu City

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Abstract

Chili cultivation in dryland areas faces significant challenges, including limited water availability, low soil fertility, and the risk of land degradation. Under such conditions, the efficient use of inputs becomes a critical factor in enhancing both productivity and the sustainability of farming practices. This study aims to examine the influence of production factors on chili yield and to assess the levels of technical, allocative, and economic efficiency among chili farmers in Kelompok Tani Hutan Panderman. A quantitative approach with a descriptive-analytical method was employed. Primary data were gathered through questionnaires administered to 32 farmers selected via a census method and analyzed using multiple linear regression within a Cobb-Douglas production function framework. The results indicate that land area, labor, and farming experience have a significant positive impact on production, whereas excessive use of urea fertilizer and pesticides exerts a negative effect. While technical efficiency was largely achieved, allocative and economic efficiencies remain suboptimal. These findings highlight the importance of optimizing input allocation, adopting water-saving technologies, and implementing balanced fertilization strategies. The study's implications point toward strengthening agricultural extension services, promoting appropriate technology adoption, and enhancing farmers' managerial capacities to achieve sustainable productivity and efficiency.

Keywords: Allocative Efficiency, Chili Cultivation, Dry Land, Economic Efficiency, Technical Efficiency

Introduction

Chili *(Capsicum spp.)* cultivation represents a vital subsector of horticultural agriculture in Indonesia due to its high economic value, stable market demand, and significant contribution to farmers' income. As a strategic commodity, chili plays a role not only in meeting household consumption needs but also in influencing national food price stability. Price fluctuations, particularly during specific periods such as the month of Ramadan, ahead of major religious celebrations, and throughout the rainy season, are frequently identified as key contributors to national inflation (Azwina & Syahbudi, 2022; Royun Nuha et al., 2023).

The success of chili farming is highly dependent on the efficiency of input allocation. The primary inputs include labor, capital, and production materials such as seeds, fertilizers, pesticides, and water. Labor is required at various stages of production, ranging from planting and maintenance to harvesting. Capital is allocated for the provision of production facilities, while production materials directly support plant growth. Efficient input utilization aims to maximize output at minimal cost, prevent resource wastage, and enhance farmers' competitiveness (Wati et al., 2020; Azhari et al., 2025).

Nevertheless, the continuous addition of inputs does not always correspond proportionally to increased yields. The theory of diminishing returns in production economics explains that beyond a certain threshold, additional inputs result in progressively smaller increases in output and may even lead to a decline in technical efficiency (Liang, 2023). Several studies have indicated that the appropriate allocation of inputs can substantially enhance technical efficiency. Among these inputs, labor and seeds often emerge as the dominant factors, while effective capital management plays a crucial role in supporting overall productivity (Khomsah et al., 2022; Ahmed et al., 2024). These findings are consistent with the study by (Yoga et al., 2024), which employed the Stochastic Frontier Analysis approach on rice farming in Ponorogo Regency. The study revealed that land area and seed utilization had a positive and significant effect on production, whereas fertilizer application could negatively impact yields if not managed in accordance with recommended dosages. This highlights the importance of selecting appropriate inputs both in quantity and quality to prevent resource wastage and ensure optimal productivity.

Dryland refers to agricultural land without a technical irrigation system, relying heavily on rainfall, which makes chili cultivation increasingly challenging. Such land typically has limited water reserves, low organic matter content, high soil acidity, and is prone to erosion. These conditions can lead to reduced productivity if not addressed through the selection of suitable varieties, the adoption of water-efficient irrigation technologies, and effective input management (Rejekiningrum et al., 2022). The following section presents chili production data for East Java Province from 2021 to 2022.

Tabel 1. Chilli Production in East Java Province

Regency/City	Big Chili Pepper		Cayenne pepper		Curly Chili	
	2021	2022	2021	2022	2021	2022
Kediri	135.675	34.863	599.068	811.942	9.686	25.365
Malang	287.625	15.892	836.625	874.337	110.538	11.563
Banyuwangi	9.097	104.833	169.059	1.042.988	-	-
Probolinggo	89.642	120.378	649.266	354.006	-	-
Gresik	48.554	4.924	229.568	208.456	-	-

Source: BPS (Central Statistical Agency), 2024

The table illustrates a notable variation in chili production across East Java Province during the 2021–2022 period. Kediri, Malang, and Probolinggo emerged as the primary production centers for various chili varieties, while regions such as Banyuwangi and Gresik also contributed, albeit with smaller volumes. These differences reflect variations in agroclimatic conditions, cultivation practices, and the efficiency levels of input utilization in each region.

Given these conditions, optimizing input allocation in dryland farming has become an urgent necessity to enhance production and improve farmers' incomes. Inefficient use of inputs can lead to high costs coupled with low productivity. Therefore, this study aims to analyze the allocation of input use in chili cultivation in dryland areas managed by the Kelompok Tani Hutan Panderman in Batu City. The findings are expected to provide strategic recommendations for farmers to optimize resource utilization, increase productivity, and promote farmers' welfare.

Literature Review

Agricultural Production Efficiency

In farming systems, efficiency is generally classified into three dimensions: technical efficiency, allocative efficiency, and economic efficiency. Technical efficiency refers to the ability of farmers to produce the maximum possible output from a given combination of inputs with the available technology. Allocative efficiency relates to the ability to select an optimal combination of inputs that minimizes costs or maximizes profits under prevailing input and output prices. Economic efficiency represents the combined outcome of both technical and allocative efficiency.

This study conceptualizes technical, allocative, and economic efficiency as the result of interactions between production factors and socio-economic factors. The production factors analyzed include land area, seed quantity and quality, fertilizer and pesticide use, labor, and capital. The socio-economic factors encompass farmers' age, education level, farming experience, and land ownership status.

The Theory of Diminishing Returns

The theory of diminishing returns explains that the addition of one unit of a variable input while keeping other inputs constant will increase marginal output up to a certain point. Once this threshold is surpassed, further increases in input will yield progressively smaller output gains and may even reduce total yield. Input application beyond the optimal level does not result in proportional yield improvements and can, in fact, lower efficiency. In the context of dryland farming, limited water availability and soil conditions act as primary constraints influencing crop responses to input use

Dryland Agriculture

Dryland agriculture refers to farming systems that rely entirely on rainfall without the support of technical irrigation. Such systems typically face limited water availability, low organic matter content, high soil acidity, and susceptibility to erosion. Alizadeh et al., (2023), note that dryland productivity can be enhanced through the adoption of water conservation technologies, the selection of drought-tolerant crop varieties, and the application of balanced fertilization.

Research Method

This study employed a quantitative approach with a descriptive-analytical design to examine the effects of input factors on chili production and to measure the efficiency of their utilization in dryland farming. The analysis combined multiple linear regression with the Cobb–Douglas production function, enabling estimation of the relationships between input and output variables while simultaneously calculating technical, allocative, and economic efficiency. The research population comprised all chili farmers who are members of the Kelompok Tani Hutan Panderman cultivating on dryland. A census sampling method was applied, involving all 32 farmers as respondents. Primary data were collected through structured questionnaires that had undergone validity and reliability testing to ensure the quality of the research instrument.

Prior to analysis, the data were tested using classical assumption tests including normality, multicollinearity, heteroscedasticity, autocorrelation, and linearity to confirm the validity of the regression model. The effects of the independent variables on chili production were evaluated using an F-test for simultaneous significance and a t-test for partial significance at a 5% significance level, while the coefficient of determination (R^2) was employed to assess the model's explanatory power. Technical efficiency was measured to evaluate the farmers' ability to maximize output at a given input level, allocative efficiency to assess optimal input use based on prevailing prices, and economic efficiency as the combined measure of both. The variables analyzed included land area, labor, fertilizer, pesticides, seeds, and working capital.

Result

Characteristics of Chili Farmers in KTH Panderman

The chili farmers of Kelompok Tani Hutan (KTH) Panderman exhibit diverse characteristics, which in turn influence variations in their behavioral patterns under different conditions. This study examined key characteristics, including age, gender, educational background, and farming experience, as summarized in the following table.

Table 2. Characteristics of KTH Panderman Chili Farmers

No	Age (Years)	Number	Percentage %
	30-65	13	40,625
1	>65	19	59,375
	Amount	32	100
2	Gender	Number	Percentage %
	Male	27	84,375
	Female	5	15,625
	Amount	32	100

3	Education	Number	Percentage %
	Elementary School	27	84,375
	Junior High School	4	12,5
	High School	1	3,125
	Diploma	0	0
	Amount	32	100
4	Farming Experience (Years)	Number	Percentage %
	30-50	13	40,625
	51-70	19	59,375
	Amount	32	100

Source: Processed Data (2025)

Based on Table 2, the majority of chili farmers in Kelompok Tani Hutan (KTH) Panderman are over 65 years old (59.38%), followed by those aged 30–65 years (40.63%). This demographic profile suggests a potential challenge in generational renewal within the agricultural workforce. While older farmers generally possess extensive farming experience, they tend to be less adaptable to modern technology, which may affect efficiency and productivity levels. Most respondents are male (84.38%), reflecting a gender-based division of labor in which women are typically involved in post-harvest handling and marketing activities. In terms of education, the majority completed only primary school (84.38%), followed by junior high school (12.5%) and senior high school (3.13%). The relatively low formal education level indicates the need for extension approaches that are practical and grounded in field experience. All respondents have more than 30 years of farming experience, which represents a strong foundation of local knowledge. Nevertheless, issues related to age structure, education, and gender roles should be considered in designing strategies to improve chili farming productivity.

Validity and Reliability Testing

The validity test was conducted to ensure the accuracy of the instrument in measuring the research variables, while the reliability test aimed to evaluate the internal consistency of the instrument. The results of these tests are presented in Table 3.

Table 3. Validity and Reliability Test Results

Variables	*Sig, (2-tailed)*	*Pearson Correlation*	Validity Statement
Constants	0,000	0,682	Valid
Land Area	0,000	0,811	Valid
Labor	0,020	0,410	Valid
Seeds	0,000	0,811	Valid
Urea Fertilizer	0,008	0,463	Valid
Manure	0,003	0,502	Valid
NPK Fertilizer	0,005	0,486	Valid
Phonska Fertilizer	0,000	0,712	Valid
Pesticides	0,002	0,524	Valid
Farming Experience	0,002	0,520	Valid
r-table		0,2960	
Cronbach alpha		0,819	

Source: Processed Data (2025)

The validity test results in Table 3 indicate that all variables have Pearson correlation values exceeding the r-table threshold (0.2960) with significance levels below 0.05, confirming that all instrument items are valid. The reliability test yielded a Cronbach's alpha value of 0.819, which is higher than the minimum criterion of 0.60, indicating that the research instrument possesses a high level of internal consistency.

Classical Assumption Test

Prior to conducting the regression analysis, a classical assumption test was performed to ensure the model's appropriateness. The normality test was applied to assess whether the data followed a normal distribution, while the multicollinearity test aimed to detect any high linear correlations among the independent variables. The results of these tests are presented in Tables 4 and 5.

Normality

Table 4. Normality Test Results

One-Sample Kolmogorov-Smirnov Test		
		Unstandardized Residual
N		32
Normal Parameters[a,b]	Mean	0,0000000
	Std. Deviation	.18647878
Most Extreme Differences	Absolute	.092
	Positive	.062
	Negative	-.092
Kolmogorov-Smirnov Z		0,921
Asymp. Sig. (2-tailed)		0,949

a. Test distribution is Normal.

b. Calculated from data.

Source: Processed Data (2025)

The data in Table 4, derived from the Kolmogorov–Smirnov normality test, indicate an Asymp. Sig. value of 0.949 (>0.05), confirming that the dataset follows a normal distribution.

Multicollinearity Test

Table 5. Results of Multicollinearity Test and Heteroscedasticity Test

Model	Collinearity Statistics		Sig.
	Tolerance	VIF	
Constants			0,737
Land Area	0,212	4,707	0,317
Labor	0,431	2,321	0,993
Seeds	0,415	2.408	0,918

Urea Fertilizer	0,461	2,171	0,615
Manure	0,678	1,475	0,799
NPK Fertilizer	0,558	1,793	0,937
Phonska Fertilizer	0,311	3,217	0,187
Pesticides	0,577	1,733	0,118
Farming Experience	0,577	1,734	0,173

Source: Processed Data (2025)

The results of the multicollinearity test indicate no evidence of multicollinearity among the independent variables. This is supported by the absence of tolerance values below 0.10 and Variance Inflation Factor (VIF) values exceeding 10. Therefore, all independent variables in this analysis can be considered free from severe multicollinearity. Furthermore, the heteroscedasticity test shows that the significance values for all examined variables are greater than 0.05, suggesting that the regression model does not exhibit heteroscedasticity.

Model Fit (Model Goodness Fit)

The model's adequacy can be evaluated using the coefficient of determination. In this context, conclusions are drawn based on the adjusted R-squared value, where a value closer to 1 indicates a better fit of the regression model.

Table 6. Coefficient of Determination (R^2)

R	R *Square*	*Adjusted R Square*	*Std. Error of the Estimate*
0,896[a]	0,803	0,722	0,2509184

Source: Processed Data (2025)

Based on the analysis results presented in Table 4.8, the adjusted R-squared value is 0.722, indicating that variables such as land area, labor, seeds, urea fertilizer, organic fertilizer, NPK fertilizer, Phonska fertilizer, pesticides, and farming experience collectively explain 72.2% of the variation in chili production. The remaining variation is attributed to other factors not included in this study.

Chili Production Function Analysis

The analytical model applied to estimate the chili farming production function employs the Cobb-Douglas production function. The production factors considered in this model include land area, labor, seeds, urea fertilizer, organic fertilizer, NPK fertilizer, Phonska fertilizer, pesticides, and farming experience.

Table 7. Regression Test Results

Variable	β	T	Sig.
Constant	-0,218	-0,094	0,926
Country	0,534	2,550	0,018
Labor	1.480	3.239	0,004
Seed	0,112	0,813	0,425
Urea Fertilizer	-0,486	-3,104	0,005
Fertilizer	-0,109	-0,772	0,448
NPK Fertilizer	0,253	1,524	0,142

Phonska Fertilizer	0,315	1,632	0,117
Pesticide	-0,280	-2,646	0,015
Farming Experience	1,234	3,087	0,005
F-Count		9,934	
Sig. Simultaneous.		0,000b	
F Table		2,40	
T Table		1,71714	

Source: Processed Data (2025)

Based on the regression analysis of the Cobb-Douglas production function presented in Table 7, the variables that exhibit a positive and statistically significant effect on chili production are land area (β = 0.534; p = 0.018), labor (β = 1.480; p = 0.004), and farming experience (β = 1.234; p = 0.005). In contrast, urea fertilizer (β = –0.486; p = 0.005) and pesticides (β = –0.280; p = 0.015) show a significant negative effect, indicating that excessive use can reduce yields. Meanwhile, seeds, organic fertilizer, NPK fertilizer, and Phonska fertilizer have no significant influence on production. The F-test produced a value of 9.934 with a significance level of 0.000 (< 0.05), confirming that the independent variables collectively have a significant impact on chili production.

Allocation and Economic Efficiency

The analysis of allocation efficiency and economic efficiency was conducted to assess the extent to which the use of production factors in dryland chili farming aligns with the principles of cost and profit optimization. Allocation efficiency measures the appropriateness of input proportions based on input and output prices, while economic efficiency represents the combined effect of technical and allocation efficiency. The results of this analysis are presented in Tables 8 and 9.

Tabel 8. Analisis Efisiensi Alokasi Cabai

Variables	β	$\bar{Y}$	Py	$\bar{X}_i$	P_{Xi}	$b.\bar{Y}.P_Y$	$\bar{X}_i.P_{Xi}$	$\frac{b.\bar{Y}.P_Y}{\bar{X}.P_{Xi}}$
Land Area	0.534	2895.313	35000	0.190938	500	5411	95.46875	566817.8396
Labor	1.480	2895.313	35000	24.5	60000	1.4998	1470000	102025.2976
Seeds	0.112	2895.313	35000	172.5	35.000	113496	6037500	1.879855072
Urea Fertilizer	-0.486	2895.313	35000	54.40625	2.450	-4.925	133295.3	-369.4748503
Manure	-0.109	2895.313	35000	87.96875	2.500	-11046	219921.9	-50.2251865
NPK Fertilizer	0.253	2895.313	35000	68.90625	2.500	25637992	172265.6	148.828254
Phonska Fertilizer	0.315	2895.313	35000	58.4375	2.500	31920820	146093.8	218.4954545
Pesticides	-0.28	2895.313	35000	47.84375	20.000	-2,837	956875	-29.65284128
Farming Experience	1.234	2895.313	35000	51.09375	500	1.25049	25546.88	4894866.667

Source: Processed Data (2025)

F-test was conducted to examine the simultaneous effect of production factors on chili production. The analysis revealed that all independent variables including land area, labor, seeds, urea fertilizer, organic fertilizer, NPK fertilizer, Phonska fertilizer, pesticides, and farming experience had a significant influence on chili production. With a significance value of 0.000 and an F-count of 9.934, exceeding the F-table value of 2.40, it can be concluded that the combined use of these inputs significantly affects chili yield. Further analysis indicated that not all production factors contributed positively to output. Land area and labor had positive effects, with coefficients of 0.534 and 1.480, respectively, suggesting that increasing these inputs could enhance chili production. In contrast, the use of urea fertilizer and organic fertilizer showed negative effects, with coefficients of -0.486 and -0.109, indicating that excessive application could reduce yield. Meanwhile, seeds, NPK fertilizer, and Phonska fertilizer had no significant impact on production, highlighting the need for greater attention to input quality and dosage.

The analysis also emphasized that several factors, such as land area, labor, and farming experience, had yet to achieve optimal efficiency. Farmers are advised to allocate inputs more carefully, considering appropriate fertilizer doses and labor utilization, while adopting more innovative farming practices. Although farming experience remains a valuable asset, continuous learning and adaptation to new techniques are essential for improving efficiency and productivity in chili cultivation

Table 9. Economic Efficiency Analysis

Variables	ET	Justification	EH	Justification	EE	Justification
Land Area	0.534	Efficient	566817.8396	Not Yet Efficient	302680.7264	Not Yet Efficient
Labor	1.480	Not Yet Efficient	102025.2976	Not Yet Efficient	150997440.5	Not Yet Efficient
Seeds	0.112	Efficient	1.879855072	Not Yet Efficient	0.210543768	Not Yet Efficient
Urea Fertilizer	-0.486	Inefficient	-369.4748503	Inefficient	179.5647772	Not Yet Efficient
Manure	-0.109	Inefficient	-50.2251865	Inefficient	5.474545329	Not Yet Efficient
NPK Fertilizer	0.253	Efficient	148.828254	Not Yet Efficient	37.65354825	Not Yet Efficient
Phonska Fertilizer	0.315	Efficient	218.4954545	Not Yet Efficient	68.82606818	Not Yet Efficient
Pesticides	-0.28	Inefficient	-29.65284128	Inefficient	8.302795558	Justification
Farming Experience	1.234	Not Yet Efficient	4894866.667	Not Yet Efficient	6040265467	Not Yet Efficient

Source: Processed Data (2025)

Based on the economic efficiency calculation, three possible conditions can be identified. First, if the economic efficiency value is greater than one, the farming operation is considered economically inefficient, indicating that the use of production factors should be increased to achieve maximum profit. Second, if the efficiency value is less than one, it implies that the farming activity is inefficient, meaning that the quantity of production factors should be reduced to reach efficiency. Third, if the efficiency value equals one, it indicates that the farming operation has achieved an optimal level of efficiency, thereby generating maximum profit.

Discussion

Technical Efficiency

The findings indicate that land area, labor, and farming experience play a crucial role in enhancing the technical efficiency of chili cultivation in dryland areas. These results align with production theory, which emphasizes that technical efficiency is achieved when farmers are able to produce maximum output from a specific combination of inputs (Gaviglio et al., 2021; Sharma & Sekhon, 2021; Radlińska, 2023). Adequate land area allows for diversified cropping patterns and more effective crop management, while sufficient labor ensures proper crop maintenance.

The positive influence of farming experience supports the findings of Stringer et al., (2020), which suggest that the knowledge and skills acquired through years of practice enable farmers to adapt to climate risks, pest attacks, and market dynamics. In the context of dryland farming, such experience is a valuable asset in determining appropriate irrigation and fertilization strategies. Conversely, excessive use of urea fertilizer and pesticides was found to reduce technical efficiency, consistent with the principle of diminishing returns (Othuon & Oyugi, 2023; Nakachew et al., 2024), which asserts that adding inputs beyond the optimal threshold decreases marginal productivity.

Allocative Efficiency

The analysis of allocative efficiency indicates that most production factors have not yet been allocated optimally. This suggests that farmers have not fully adjusted their input use based on both price and its contribution to output. As highlighted by Nurul C et al., (2018), allocative efficiency is closely related to a farmer’s ability to manage resources rationally in order to minimize production costs at a given output level.

The insignificant effect of NPK and Phonska fertilizers on yield points to opportunities for improvement in determining both the dosage and timing of application. These results are consistent with the findings of Yakup et al., (2024), which emphasize the importance of balanced fertilization in optimizing plant growth and yield in dryland farming systems. Implementing fertilizer strategies based on soil analysis could serve as an effective solution to enhance allocative efficiency which emphasize the importance of balanced fertilization in optimizing plant growth and yield in dryland farming systems. Implementing fertilizer strategies based on soil analysis could serve as an effective solution to enhance allocative efficiency.

Economic Efficiency

The majority of production factors have not yet achieved economic efficiency, indicating that the combination of technical and allocative efficiency has not been fully realized. As noted by Okello et al., (2019), this situation suggests that while farmers are able to utilize inputs to generate output, the management of those inputs has not yielded maximum profit under prevailing market prices.

These findings are consistent with the studies of Gitaningtyas, (2022) and Penuelas et al., (2023), which reveal that inappropriate fertilizer dosage and disproportionate labor use are key contributors to low economic efficiency in horticultural farming. In the context of this study, improving economic efficiency can be achieved through controlling variable costs, adopting input-saving technologies, and enhancing farmers' managerial skills.

Conclusion

This study reveals that land area, labor, and farming experience are significant positive determinants of chili production in dryland areas, whereas excessive use of urea fertilizer and pesticides exerts a negative impact. Overall, technical, allocative, and economic efficiency in dryland chili farming have not yet been achieved optimally. This suggests that, although farmers are able to utilize inputs to generate output, the management of these input combinations has not resulted in maximum profit under prevailing market prices. These findings underscore the importance of implementing appropriate input management strategies covering quantity, quality, and timing of application to enhance productivity, efficiency, and the sustainability of chili farming in regions with limited water resources.

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