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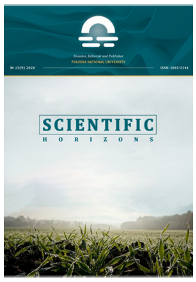

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Analysis of cassava farming efficiency as a supporter of post-COVID-19 rural economic changes in wonogiri regency

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Abstract. Cassava farming, as an important commodity in agriculture in Wonogiri Regency, is necessary for structural changes in the rural economy of Wonogiri Regency in post-COVID-19 conditions. This study aims to determine the level of efficiency and analyse the elasticity of cassava farming. The Data Envelopment Analysis is used in analysing the efficiency of cassava farming, while multiple linear regression analysis is used in analysing production elasticity. The results of Data Envelopment Analysis with an input-oriented model in the study show that farmers have a level of technical efficiency of 64.6%, allocative efficiency of 47.1%, and economic efficiency of 30%. Farmers who are not efficient can increase their efficiency value by using cassava farming inputs. The elasticity of the production of seedlings, manure, SP36 fertilizer, Phonska fertilizer, urea fertilizer, pesticides, and labour is positive. The scale of business results show that farming is in a condition of increasing returns to scale. The addition of production factors has a positive effect on cassava production. However, if production factors are not considered, it will result in additional inputs, decreasing yields. Optimal use of inputs can increase the production scale of cassava farming and increase efficiency. This study can be helpful for the farmers to increase the efficiency level through the efficient use of inputs. They can be helpful for the government in the formulation of rural development plans with farming development and implementing policies to increase the efficiency

Keywords: input; elasticity; rural development; Cobb-Douglas; Data Envelopment Analysis

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INTRODUCTION

The structure of agricultural businesses in Indonesia is dominated by small-scale agriculture in rural areas. Rural change or transformation in rural areas is not only from the agricultural side but needs to pay attention to the aspirations of rural communities, which play an important role in shaping their desires. Therefore, to develop a rural economy, it must start from the community's aspirations through production, distribution, consumption, and investment activities. In the current conditions, transformation is needed because most small-scale (subsistence) agriculture can no longer meet the community's economic needs, especially food needs. Understanding rural dynamics is one of the main keys to formulating agricultural development policies and regional economic development. In line with the ongoing development process, the rural economy is experiencing dynamic structural changes post-COVID-19. The impact of Covid-19 has deepened the vulnerability of small producers, including in the agricultural sector (FAO, 2020).

In agriculture, economic production is closely related to natural processes. Hence, the restrictive measures imposed during the COVID-19, in particular, negatively impacted farmers' productive employment, rural household budgets, and the functioning of the rural social environment. area, etc. The background of this research is that cassava is a leading commodity in Wonogiri Regency and in Central Java. The production of cassava in Wonogiri Regency is 857,432 tons/year, but the productivity is low compared to other regions. They always increase natural resources while maintaining sustainability and the rural economy. The level of productivity can be seen from the use of inputs as a resource in farming (Badan Pusat Statistik, 2022). Based on the concept of resilience, M. Meuwissen *et al.* (2019) define it as the ability of an agricultural to be able to adapt to all impacts that occur, be able to study the conditions that occur, and be able to transform to change the agricultural system. For some local farmers in research by I. Scoones *et al.* (2020), transformation is related to resistance to development forces to achieve sustainability.

A research study in the first year of E. Rahayu *et al.* (2021) found that cassava agribusiness impacts the economy of Wonogiri Regency from the dynamic cassava supply chain, which was able to increase revenue by Rp. 7,972,155.03/Ha compared to COVID-19, which was only 4,909,935.52/Ha. Although there was an increase in costs by 17.79%, there was an increase in revenue by 62.36%, so it still gave a positive increase. The results of P. Mugabe *et al.* research (2022) also show that COVID-19 has had an impact on agriculture, where as many as 45% of farmers have experienced a decrease in agricultural output, and among them, as many as 60% have experienced a decrease of 25% while the rest (40% of farmers) have experienced a decrease of 50%.

Cassava in Wonogiri Regency is used as a supplier of raw materials for tapioca factories, with a proportion of more than 50% of the total raw materials needed, and this has caused the demand for cassava raw materials to continue to increase. Unlike the previous decades, where cassava was only consumed directly, direct consumption will continue to decrease, and F. Rozi *et al.* (2023) said that it will be offset by increased demand for cassava as an industrial raw material for processed industries, as well as new and renewable energy material. Cassava can be processed into various kinds of derivative products, which are produced in small-scale and large-scale industries, both in terms of production and the technology used, including in Wonogiri Regency. In Wonogiri Regency, cassava is widely cultivated by the community and used as raw material for the flour industry (Banowati *et al.*, 2020). In Wonogiri Regency, there have been two units of tapioca flour industry, and it is estimated that in the future, it will increase. Farmers prefer to sell cassava to wholesalers and contract systems with factories or processing industries because the prices offered by wholesalers are greater than those offered by the market, increasing the competitiveness of cassava at the farmer level.

Post-COVID-19, the economy of cassava is used as a reference in changing the rural economy. Post-COVID-19 conditions provide an opportunity to think about all actions in making decisions regarding the agricultural system that will be developed, including decisions on how to use optimal inputs (Lioutas & Charatsari, 2021). In cassava production conditions, it has not been balanced with farmers' knowledge of using the right production factors. Farmers do not understand the principles of the relationship between inputs and outputs, so farmers often use inputs that do not follow recommendations. The use of inputs that are not optimal results in the production produced is also not optimal. Therefore, T. Luttiyana & Y. Hariyati (2019) stated that knowing what factors can affect a farm to be used as efficiently as possible is necessary.

There is a need for studies on economic activities, especially from cassava production and farming in Wonogiri Regency based on cassava agribusiness, where cassava is the dominant commodity that develops as a rapidly growing and productive economic sector. Cassava agribusiness activities, it is expected to be a trigger in the rural economy that is balanced and develop into the industry, both cassava product development industries and non-cassava impacts on rural economic development, namely the increase in income levels and welfare of cassava agribusiness. Revenue from the cassava agribusiness affects the economic dynamics in rural areas in terms of food consumption and non-food consumption (education, health, quality of labour, etc.). Therefore, the purpose of this study was to determine the efficiency and elasticity of cassava production in the Wonogiri region.

MATERIALS AND METHODS

This research survey was conducted from May to June 2022 in three districts with high cassava production, namely Ngadirojo District, Tirtomoyo District, and Jatiroto District. The research method in this study is a closed survey method. The survey was conducted offline through direct interviews with cassava farmers related to data on the use of cassava farming inputs consisting of the use of cassava seeds, manure, SP36 fertilizer, urea fertilizer, pesticides, and labour use, with the price of each input. As well as questions about output in the form of production from cassava farming. In the interview, farmers are willing to voluntarily become respondents with prior permission and ensure the protection of respondents' data by not misusing data obtained from respondents.

The selection of districts and villages as research samples (in Fig.1) was carried out by multi-stage stratify random sampling. The population data of cassava farmers in Wonogiri Regency is unknown, so the determination of the number of samples uses the formula of P. Levy and S. Lemeshow (2013):

$$n = \frac{Z^2 1-\alpha/2 P(1-P)}{d^2}, \quad (1)$$

where n is the number of samples; Z is the z score at 95% level of confidence = 1.96; P is the maximum estimate = 0.5; and d is alpha (0.10) or sampling error = 10%. Through the formula above, the number of samples to be used is:

$$n = \frac{Z^2 1-\alpha/2 P(1-P)}{d^2};$$
$$n = \frac{1{,}96^2 - 0.5/(1-0.5)}{0.01}; \quad (2)$$
$$n = 96.04,$$

The risk of data loss is often faced by researchers, one of which is because there is a chance that respondents do not answer ranging from 5-25% of the total respondents. If respondents do not answer a maximum of 25% of the total sample (96 farmers), then the total sample that does not respond is 24 farmers. For the total sample to be optimal, the risk of unresponsive samples is added to the total sample of the initial calculation, thus the total sample used in this study amounted to 120 cassava farmers who were divided proportionally into 3 sub-districts, namely each sub-district consisting of 40 cassava farmers as research samples.

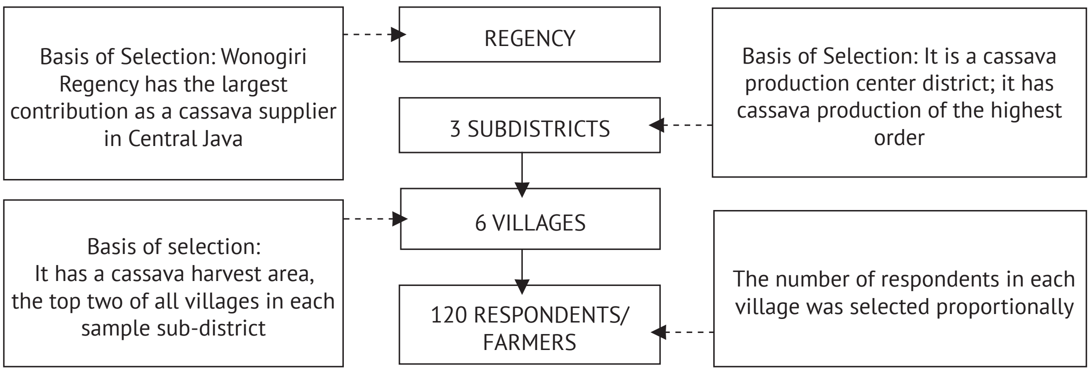

Figure 1. *Research Sample Determination Scheme*

Source: *formed by authors*

The data analysis method to determine the level of efficiency uses the Data Envelopment Analysis (DEA). The concept of efficiency used in this study refers to efficiency proposed by T.J. Coelli *et al.* (2005), where efficiency is classified into technical, allocative, and economic efficiency. The DEA model used in this study is input-oriented because farmers can control input variables more easily than the output produced. Technical efficiency relates to the managerial ability of farmers in allocating production inputs. In calculating technical efficiency, it is assumed that there are K inputs and M outputs for each period N and at the i moment will be represented by factors xi and yi. The input matrix, X, and output matrix, Y, represent data for the entire period N. The formulation of input orientation and assumption of Variable Returns to Scale (VRS) can be formulated:

$$\begin{gathered} \mathrm{Min}_{\theta,\lambda}, \theta \\ \text{Subject to:} -yi + Y\lambda \geq 0; \\ \theta\, xi - X\lambda \geq 0; \\ N1\lambda = 1; \\ \lambda \geq 0, \end{gathered} \quad (3)$$

where θ is the technical efficiency score, yi is the vector of the amount of cassava production. xi is the vector of the input, Y is the output of the production in kilogram, X is the input (the use of cassava seeds (X1), manure (X2), SP36 fertilizer (X3), Phonska fertilizer (X4), urea fertilizer (X5), pesticides (X6) and labour (X7)), and λ is the Nx1 vector of the weightier. An efficiency score of ≤1 with a value of 1 indicates an efficient Decision-Making Unit (DMU). An efficiency score of 1 indicates a point on the frontier where a farmer run by a cassava farmer

(DMU) is already efficient, while an efficiency score of <1 indicates a point where a farmer run by a farmer has not been efficient. Allocative efficiency measurement can be done with input price information and cost minimization assumptions. Assuming VRS and cost minimization, the equation becomes as follows:

$$\begin{gathered} \text{Min } \lambda, \text{xi Pixi*} \\ \text{Subject to - yi + Y } \lambda \geqslant 0; \\ \theta \text{ xi - X } \lambda \geqslant 0; \\ \text{N 1 } \lambda = 1; \\ \lambda \geqslant 0, \end{gathered} \tag{4}$$

where, Pi is the input price vector for the i time and xi* is the cost minimization vector of the input quantity for the i time, with the output rate yi. According to Soekartawi (2003), economic efficiency (EE) is the product between all price efficiency (allocative) of all input factors or between technical efficiency (TE) and allocative efficiency (AE). The economi efficiency can be expressed as EE = TE×AE, with criteria if EE = 1, then the use of input is efficient, and if EE < 1, then the use of input is inefficient. The data analysis method of the production elasticity is multiple linear regression analysis based on the Cobb-Douglas production function as follows:

$$Y = a\, X_1^{\beta 1}\, X_2^{\beta 2}\, X_3^{\beta 3}\, X_4^{\beta 4}\, X_5^{\beta 5}\, X_6^{\beta 6}\, X_7^{\beta 7}\, e, \tag{5}$$

where Y is cassava production (kg), a is the constant value. X_1 is the use of cassava seedlings (stems), while X_2 is the use of manure (kg). X_3 is the fertilizer SP36 (kg), X_4 is the fertilizer Phonska (kg), and X_5 is the urea fertilizer (kg). X_6 is using pesticides for cassava farming (litres) and X7 is using labour(man-day). While β_1, β_2, β_3, β_4, β_5, β_6, and β_7 are estimated parameters, which output the elasticity of each input used, and e are error terms.

After the data is logarithm, it is possible to use multiple linear regression analysis to find the next equation. The results of the equation are then transformed into a natural logarithm equation (Ln) so that the equation becomes:

$$\text{LnY} = \text{Ln a} + \beta 1\text{LnX}_1 + \beta 2\text{LnX}_2 + \beta 3\text{LnX}_3 + \beta 4\text{LnX}_4 + \beta 5\text{LnX}_5 + \beta 6\text{LnX}_6 + \beta 7\text{LnX}_7 + e \tag{6}$$

The elasticity of output towards the input used can be seen from the coefficient value of each input (βi).

RESULTS AND DISCUSSION

Efficiency analysis is carried out to determine how cassava farming management is managed efficiently. The results of DEA Variable Return to Scale (VRS) in Table 1. show that the average farmer has a technical efficiency level of 0.646 or 64.6%, therefore there are 35.4% technically inefficient uses of input. The percentage of farmers who are fully efficient (1,000) on the VRSTE assumption is 29 farmers (24.2%), and the majority of farmers, namely 34.2%, have an efficiency value in the range of 0.250-0.499, which shows that they have a low-efficiency value.

Table 1. *Distribution of Technical, Allocative, and Economic Efficiency of Cassava Farming*

Range	Technical Efficiency		Allocative Efficiency		Economic Efficiency	
	Freq	%	Freq	%	Freq	%
0.250-0.499	41	34.2	57	47.5	96	80.0
0.500-0.749	34	28.3	50	41.7	21	17.5
0.750-0.999	16	13.3	12	10.0	2	1.7
1,000	29	24.2	1	0.8	1	0.8
Total	120	100	120	100	120	100
Mean	0.646		0.471		0.30	
Min. Efficiency	0,118		0		0	
Max. Efficiency	1		1		1	

Source: *compiled by authors using Data Envelopment Analysis (2023)*

The results of DEA with an input-oriented model in research show that farmers who are not yet efficient. Technical efficiency levels range from 11.8% to 100%, which implies an opportunity to improve technical efficiency. A. Akpaeti and N. Frank (2021), B. Sherzod *et al.* (2018) research that farmers can increase the technical efficiency with the current production resources. Increasing agricultural productivity ranks highly as a path to poverty alleviation and reducing vulnerability to poverty for changes towards improving the economy of rural communities, which in T. Mallawaarachchi & D. Rahut's research (2023) can be approached with technical changes in agricultural systems supported by knowledge transfer.

Cassava farmers in Wonogiri Regency have an allocative efficiency rate of 0.471 or 47.1% (in Table 14), which shows that farmers can reduce current average production costs by 52.9% to achieve potential minimum production costs. The allocative efficiency shows that only 0.8% of farmers are fully allocative efficient, while most farmers (47.5%) have low or inefficient efficiency. Allocative efficiency relates to the price level of each input issued by farmers. The majority of farmers do not make purchases of seedlings. The need for seedlings is obtained from stem cuttings from previous cassava plants. The problem mainly occurs in the price of NPK Phonska fertilizer and urea, which affects the input costs incurred by farmers because there is a price difference between subsidized and non-subsidized fertilizers. Not all cassava farmers can access subsidized fertilizers for cassava farming. The availability of subsidized fertilizer does not follow when the fertilizer is needed for cassava farming, so it requires farmers to buy non-subsidized fertilizer so that farming continues to run by meeting the nutrient needs of cassava plants.

There is a need for adequate support in the form of agricultural subsistence, because, according to S. Singh *et al.* (2020), the agricultural sector can contribute to the recovery and strengthening of countries, stimulate rural development, increase food security, and influence price stabilization on global markets. E. Nchanji *et al.* (2021) proposed subsidy provisions for agricultural inputs as post-COVID-19 policy recommendations in their research. Subsidies for agricultural inputs can affect the amount of expenditure or costs incurred by farmers so that the use of inputs can be carried out optimally without any availability restrictions and price limits. The economic efficiency rate of cassava farming is 30% and almost all cassava farmers in Wonogiri Regency have not been efficient because only 0.8% of farmers have just achieved economic efficiency with a value of 1,000. W. Kaye-Blake (2022) states that resilience cannot develop without supporting resources. Therefore, achieving resilience depends on how resources can be used efficiently.

Good management of agricultural systems and natural resources can increase sustainability towards a sustainable agricultural system (Piñeiro *et al.,* 2020). The availability of natural resources is very meaningful for the sustainability of production activities to the consumption of rural communities. Natural resources as factors of production must be used efficiently to produce optimal production output (Ajayi & Olutumise, 2018). A good understanding of the relationship/interaction of production activities and their efficiency drives changes in rural economic dynamics that broadly impact the life sector of farmers and the surrounding community. The mechanism is expected to improve the farmer's economy and more dynamic rural economic dynamics after COVID-19. In line with the ongoing development process in Wonogiri Regency, the rural economy is undergoing dynamic structural changes after COVID-19. The pandemic of COVID-19 has changed rural life, including agricultural and food conditions (Mayuzumi, 2023), where the existence of COVID-19 as a whole affects agricultural output.

Cassava farming inputs include seeds, fertilizers, and pesticides. Seeds are needed in farming so that cultivation can be carried out. Fertilizer aims to provide nutrients to plants to meet the nutritional needs of plants. Fertilizers used in cassava farming consist of manure, SP36 fertilizer, Phonska fertilizer, and urea fertilizer.

Table 2. *Average Cost of Production Facilities in Cassava Farming in Wonogiri Regency in 2022*

Description	Average Usage/MT	Average Cost/MT (Rp)
Seed	393.38 stem	2,083.33
Fertilizer		
a. Manure	271.92 kg	0
b. SP36 Fertilizer	7.73 kg	26,229.17
c. Phonska Fertilizer	27.83 kg	100,416.67
d. Urea Fertilizer	57.12 kg	161,933.33
Pesticides	0.02 litres	1,916.67
Total	292,579.17	

Source: *compiled by authors based on the survey data results*

Based on the average use of cassava farming inputs, an analysis of the elasticity of cassava production can be carried out. In business activities, producing production activities aims to maximize profits. This condition is achieved by utilizing some inputs at the optimum level. Two conditions are needed to achieve maximum profit: necessary and sufficient. The necessary condition is objective in that it is fulfilled when there is no longer the possibility of achieving greater production using the same inputs or when the elasticity of production is between zero and one ($0 \leqslant \varepsilon p \leqslant 1$). The level of production elasticity of each input used can be seen from the results of multiple linear regression analysis to analyse the influence of inputs or production factors.

Tests with multiple linear regression models must meet the rules of classical assumptions to show whether there is bias in the research data results used in multiple linear regression tests. Classical assumptions are assumptions that are met to meet the criteria of BLUE (Best Linear Unbiased Estimator). Classical assumption testing consists of Normality, Multicollinearity, and Heteroscedasticity Tests. The normality test is needed to test the dependent variable and independent variables, whether the residuals are normally distributed or not. In this study, the normality test was carried out by looking at the histogram and normal probability plot graphs. Based on the results in Figure 2, it gives a pattern that does not deviate left or right, and the data spread following the direction of the histogram graph, thus meeting the normality test. Based on the normal probability plot test results in Figure 3, the points or data are near or following the diagonal line, so the residual values are normally distributed.

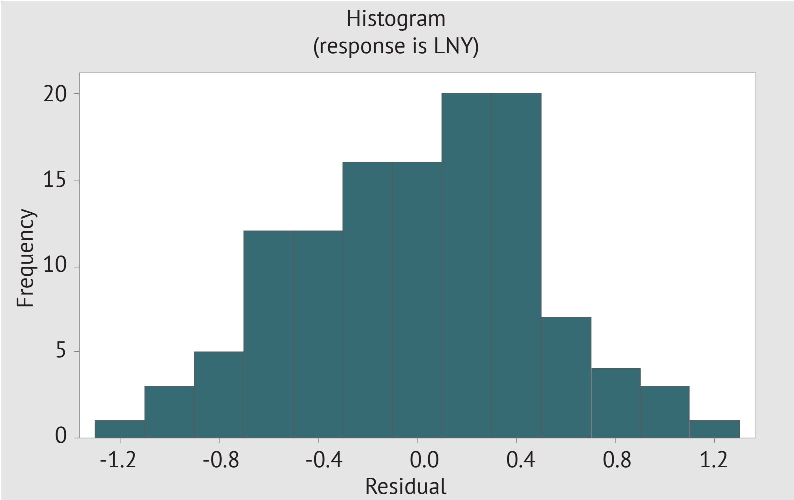

Figure 2. *Histogram Graph*

Source: *regression output with Minitab based on survey data results*

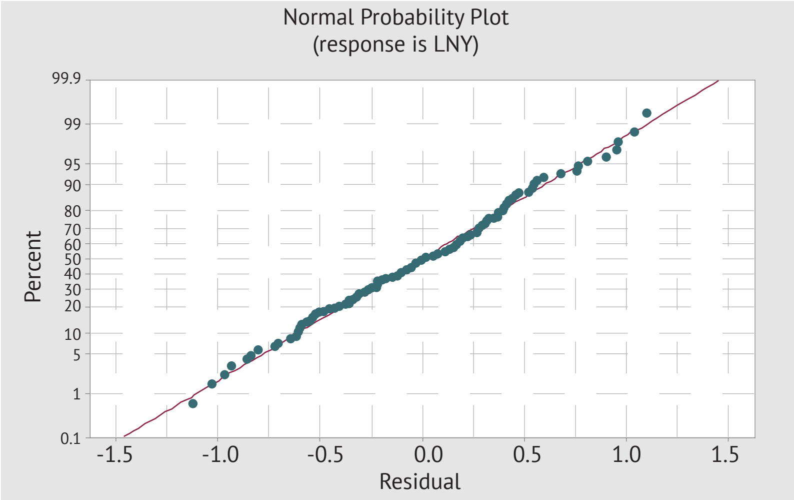

Figure 3. *Normal Probability Plot Graph*

Source: *regression output with Minitab based on survey data results*

Multicollinearity is a condition with a linear relationship between two or more independent variables (Chan *et al.*, 2022). The method used is seen from the Variance Inflation Factors (VIF). The VIF limit is 10, so multicollinearity does not occur if the VIF value ≤10 per independent variable. Based on Table 3, the VIF value of each independent variable (seedlings, manure, SP36 fertilizer, Phonska fertilizer, urea fertilizer, pesticides, and labour) is less than 10. It can be concluded that each variable has been free from the problem of multicollinearity or multicollinearity has not occurred.

Table 3. *VIF Value*

Term	VIF
Constant	
LNX1 (Seed)	1.78
LNX2 (Manure)	1.93
LNX3 (SP36 Fertilizer)	1.33
LNX4 (Phonska Fertilizer)	1.18

Table 3, Continued

Term	VIF
LNX5 (Urea Fertilizer)	1.46
LNX6 (Pesticide)	1.20
LNX7 (Labour)	1.20

Source: *compiled by authors using Minitab based on survey data results*

The heteroscedasticity test is used to test whether there is an imbalance of variance in a regression model. If the variance of one observation is different from other observations, this indicates heteroscedasticity is occurring. Based on the scatterplot diagram, it is known that the pattern of dots does not form a specific pattern. These points are distributed randomly and spread above or below the number 0 on the Y-axis, so there is no heteroscedasticity and the regression model can be used to predict. The coefficient of determination (R2) measures how far a model can explain the independent or dependent variables (Table 4).

Table 4. *Test Results of Coefficient of Determination (R^2)*

Model Summary			
S	R-sq	R-sq(adj)	R-sq(pred)
0.485897	72.25%	70.51%	68.44%

Source: *compiled by authors using Minitab based on survey data results*

The coefficient of determination test shows that the value of the coefficient of determination or R Squared is 72.25%, which shows that the variation of independent variables (seeds, manure, SP36 fertilizer, Phonska fertilizer, urea fertilizer, pesticides, and labour) used in the model can explain 72.25% of the variation in the dependent variable (cassava production). While 27.75% was influenced by other variables not included in the regression model. The F test is used to test whether the independent variable) together affect the dependent variable (cassava production). The results of the F test can be seen in Table 5.

Table 5. *F-test Result*

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	7	68, 8312	9.8330	41,65	0,000
Error	112	26, 4427	0.2361		
Total	119	95, 2739			

Source: *compiled by authors using Minitab based on survey data results*

The probability value (P-Value) is 0.000, less than α ($\alpha = 0.05$). The independent variables; seeds, manure, SP36 fertilizer, Phonska fertilizer, urea fertilizer, pesticides, and labour, significantly affect the dependent variable, namely cassava production in Wonogiri Regency. The statistical test t is used to determine how far the influence of the free variables of seedlings, manure, SP36 fertilizer, Phonska fertilizer, urea fertilizer, pesticides, and individual labour can explain the variation of the dependent variable in the form of cassava production. The P-value of seed input was obtained at $0.052 < \alpha = 0.1$. Seed input (X1) individually affects cassava production in Wonogiri Regency (Y). Manure and Phonska fertilizer inputs affect cassava production, with a P-Value of $0.000 < \alpha = 0.01$ for manure and a P-Value of $0.028 < \alpha = 0.05$ for Phonska fertilizer. Pesticide input has a P-Value of $0.000 < \alpha = 0.01$, which shows that pesticides significantly affect cassava production in Wonogiri Regency. The labour variable has a P-value of $0.029 < \alpha = 0.05$, meaning that labour input significantly affects cassava production in the Wonogiri Regency. Based on Table 6, the cassava production function in Wonogiri Regency can be written:

$$LnY = 3.924 + 0.1533\ LnX_1 + 0.4305\ LnX_2 + 0.0496\ LnX_3 + 0.0527\ LnX_4 + 0.0273\ LnX_5 + 1.004\ LnX_6 + 0.1749\ LnX_7$$

Table 6. *t-Test Results from Factors Affecting Cassava Production*

Term	Coef	SE Coef.	T-Value	P-Value
Constant	3,924	0,439	8,95	0,000
LnX1 (Seed)	0,1533*	0,0782	1,96	0,052
LnX2 (Manure)	0,4305***	0,0635	6,78	0,000
LnX3 (SP36 Fertilizer)	0,0496ns	0,0321	1,54	0,125
LnX4 (Phonska Fertilizer)	0,0527**	0,0236	2,23	0,028

Table 6, Continued

Term	Coef	SE Coef.	T-Value	P-Value
LnX5 (Urea Fertilizer)	0.0273[ns]	0.0251	1.09	0.279
LnX6 (Pesticides)	1.004[***]	0.227	4.42	0.000
LnX7 (Labour)	0.1749[**]	0.0792	2.21	0.029

Note: ** Significant at the level of 10%; ** Significant at the level of 5%; *** Significant at the level of 1%; ns: non-significant*
Source: *compiled by authors using Minitab based on survey data results*

Based on the cassava production function, the production factor that has the greatest influence on cassava production is pesticides (X6), with a regression coefficient of 1.004. The value of the regression coefficient of pesticide use shows that every addition of pesticides by 1% will increase cassava production by 1.004%. The production factor that has the least influence on cassava production is urea fertilizer (X5), with a regression coefficient of 0.0273. The value of the regression coefficient of urea fertilizer shows that every addition of 1% will increase cassava production, although it is not significant because it only increases by 0.0273%.

Cassava seeds (X1) have a production elasticity of 0.1533 and positively affect cassava production in Wonogiri Regency. Adding seed production factors by 1% will increase cassava production by 0.1533%, with other factors considered fixed (ceteris paribus). Manure (X2) has a production elasticity of 0.4305, indicating that increasing the use of manure production factors by 1% will increase cassava production by 0.4305%, with other factors considered fixed (ceteris paribus). SP36 fertilizer (X3) has an elasticity value of 0.0496, meaning that if there is an addition of SP36 fertilizer production factors by 1%, it will increase cassava production but not significantly because it only increases by 0.0496% with other factors considered fixed (ceteris paribus). Similarly, Phonska fertilizer (X4) has a positive regression coefficient value with a production elasticity of 0.0527. Increasing Phonska fertilizer production factors by 1% will increase cassava production by 0.0527%, with other factors considered fixed (ceteris paribus). The factor of labour production (X7) significantly affects the confidence level of 95%. The value of the elasticity of labour production factors is 0.1749, which means that every increase in labour use by 1% will increase cassava production by 0.1749%.

While the production factor, in the form of pesticides, has a production elasticity value of 1.004. Production elasticity in area I is greater than one (Ep>1), meaning that adding pesticide production factors as much as 1% will cause an increase in cassava production, which is always greater than 1%. This area is said to be increasing returns to scale area because each addition of production factors will increase the amount of production, which increases more and more. In this area, maximum profit has not been achieved because production can still always be increased by adding inputs (factors of production). Thus, this area is irrational. According to D. Debertin (2012), the production function is divided into three areas, distinguished based on the production elasticity of the production factors used. Area I is a production area with a production elasticity greater than one (Ep>1), area II is a production area with an elasticity between zero and one (0<Ep<1), and area III is a production area with a production elasticity smaller than one (Ep<1).

The elasticity value, except for pesticides, has an elasticity value greater than zero but smaller than 1 (0<Ep<1) (in production area II). The results of research by I. Ansah *et al.* (2023) also showed that labour, planting materials, and pesticides affect the level of cassava production, with the difference that planting materials and pesticides have a negative elasticity value, whereas, in this study, the value was positive. The research of S.E. Esheya (2022) showed positive elasticity results for cassava cutting and labour. Still, fertilizer input has a negative elasticity, indicating that the input allocation and utilization are at an irrational production stage (stage III) due to excessive use.

Every additional 1% of production factors can increase production by between zero and 1%. At a certain level, the use of input will provide maximum benefits. This shows that the production elasticity value for each input in the form of seeds, manure, SP36 fertilizer, Phonska fertilizer, urea fertilizer, and labour is in the rational area, meaning that its use has provided benefits and advantages. The sum of the elasticity values for each input can be used to see the condition of the agricultural business scale. The results of this research show that the elasticity amount is 1.8923, which means that adding one percent of each production will increase production by 1.89%. The total production elasticity value is greater than one, this is in line with the research results of E. Widyastiara *et al.* (2023), so that cassava farming is in a condition of increasing returns to scale. Cassava farmers have not used inputs efficiently in conditions of increasing returns to scale because in these conditions maximum profits have not been achieved, so inputs are underutilized by cassava farmers. Cassava farmers can increase the optimal use of inputs as resources (Gbigbi, 2021; Mwebaze *et al.,* 2022).

Cassava is a commodity for rural development (FAO, 2018). Hence, the production process in cassava farming is the main activity of rural communities in meeting their and their families' living needs. Cassava farming provides a significant multiplier effect by developing employment and business opportunities from cassava production activities, resulting in changes in the dynamics of the rural economy based on cassava production agribusiness. The production elasticities of inputs and labour were the greatest in the rural extension (Freitas *et al*., 2021). Facilitating rural economic transformation can be focused on relative comparative advantage across diverse conditions. The utilization of local advantages owned by each region can be adjusted to the needs of each community. According to A. Kolapo & E. Abimbola (2020), increasing agricultural productivity through the use of inputs and utilizing local resources can reduce poverty through increasing farmer's income. According to E. Ikuemonisan *et al*. (2020), interventions to increase cassava production have resulted in increased output and stimulated the rural economy.

Cassava farming in Wonogiri Regency is not yet efficient technically, allocative, and economically. There is an opportunity to increase efficiency by optimizing input use and limiting minimum costs to reach an efficient level. Based on the overall level of input used in cassava farming, the elasticity of cassava production is in a condition of increasing returns to scale, which shows that the maximum level of profit can still be achieved by farmers by adding input in a fixed proportion. Utilizing local resources as input in farming is an effort to use input efficiently, where maintaining local advantages can be taken from existing natural attributes. Natural conditions following the growth of a plant, with the availability of agricultural production factors, can encourage the economic development of an area, especially rural areas. Rural dependence on natural conditions can be utilized by optimizing resources in efficiency to increase productivity, as factors needed in cassava farming.

CONCLUSIONS

This study analyses the efficiency and elasticity of cassava farming in Wonogiri Regency. The Data Envelopment Analysis (DEA) analysis results obtained an average technical efficiency level of 0.646 or 64.6%. The results of DEA with an input-oriented model show that farmers who are not yet efficient can increase the level of efficiency value by using cassava farming inputs. Cassava farmers in Wonogiri Regency have an allocative efficiency rate of 0.471 or 47.1%, which shows that farmers can reduce current average production costs by 52.9% to achieve potential minimum production costs. In terms of economic efficiency, cassava farmers have not yet reached an efficient level. Allocative efficiency relates to the price level of each input issued by farmers. This shows that the most important role in increasing the efficiency is the optimal allocation of input use with consideration of the right price.

The results of production elasticity show that all production factors in the form of seeds, manure, SP36 fertilizer, Phonska fertilizer, urea fertilizer, and labour are of positive value. All factors of production except pesticides are in the rational area. The production elasticity value of each of these inputs is at the rational stage, meaning that its use has provided benefits and advantages in rural development efforts in post-covid 19 conditions. The capacity of a farm to achieve maximum production levels with a certain set of inputs refers to efficiency results. Evaluation of the level of agricultural efficiency allows decision-making for farmers. The use of inputs as a resource in farming plays an important role in the level of production and productivity of farming, so the farmer's decision in determining the level of input use is very important. The price factor for each input influences the level of allocative efficiency or cost efficiency, so farmers must try to use inputs as optimally as possible at the minimum cost level to produce the maximum possible output or level of cassava farming production.

The addition of production factors has a positive effect on cassava production. However, if farmers do not consider the right input decisions, it will result in additional input, reducing production. Increasing the production scale can be done by giving attention to using inputs as resources. From the results, there is an opportunity to improve the efficiency of cassava farming. Such conditions encourage increasing efficiency to accelerate rural development to increase the distribution of economic activities and farmers' income. This research can still be developed for future research using other methods, such as Stochastic Frontier Analysis (SFA), in analysing the efficiency of cassava farming. Other variables as input in farming can be included in the model to explore determinants of efficiency. Study development can be done by analysing off-farm cassava with a wider scope.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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Аналіз ефективності вирощування маніоки як підтримки економічних змін у сільській місцевості після Covid-19 у князівстві Воногірі

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Анотація. Вирощування маніоки, як важливого товару в сільському господарстві графства Воногірі, є необхідним для структурних змін у сільській економіці графства Воногірі в умовах пост-COVID-19. Це дослідження має на меті визначити рівень ефективності та проаналізувати еластичність вирощування маніоки. Для аналізу ефективності вирощування маніоки було використано метод Data Envelopment Analysis, а для аналізу еластичності виробництва – множинний лінійний регресійний аналіз. Результати Data Envelopment Analysis з використанням моделі, орієнтованої на вхідні ресурси, показують, що фермери мають рівень технічної ефективності 64,6 %, ефективності розподілу 47,1 % та економічної ефективності 30 %. Фермери, які не є ефективними, можуть підвищити свою ефективність, використовуючи фактори виробництва маніоки. Еластичність виробництва розсади, гною, добрива SP36, добрива Фонська, карбаміду, пестицидів та робочої сили є позитивною. Масштаб бізнес-результатів показує, що фермерське господарство перебуває в стані зростаючої віддачі від масштабу. Додавання факторів виробництва має позитивний вплив на виробництво маніоки. Однак, якщо не враховувати фактори виробництва, це призведе до додаткових витрат, що знизить врожайність. Оптимальне використання факторів виробництва може збільшити масштаби виробництва маніоки та підвищити ефективність. Це дослідження може бути корисним для фермерів для підвищення рівня ефективності за рахунок ефективного використання факторів виробництва. Воно може бути корисним для уряду при розробці планів розвитку сільських територій, що включають розвиток фермерства та реалізацію політики підвищення ефективності

Ключові слова: фактори виробництва; еластичність; сільський розвиток; Кобб-Дуглас; аналіз оболонки даних