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An Analysis of Factors Influencing Sweet Potato Production

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Abstract: Karanganyar Regency is one of the sweet potato producers in Central Java Province, which often utilizes sweet potatoes for processing into traditional foods and industrial raw materials. The availability of sweet potato production is important to meet the raw material needs of these food products. This study aims to determine the factors that influence sweet potato farming production in Karanganyar Regency. The study was conducted through a survey using an interview method using a questionnaire to 50 sweet potato farmers in Karanganyar Regency in 2020, with snowball sampling. The method used was *Ordinary Least Squares* (OLS) with *Cobb-Douglas* production function. The results showed that input production factors that significantly influence sweet potato farming production are land area, seedlings, and labor, while fertilizers have no significant effect on sweet potato farming in Karanganyar Regency. Furthermore, sweet potato production farming in Karanganyar shows that there is *Decreasing Return to Scale*, as indicated by a return to scale value is 0,978. Optimizing land use for sweet potato farming in Karanganyar Regency by using superior seeds is a priority for farmers to increase sweet potato farming production, followed by efficient labor allocation with mentoring and training from agricultural extension workers for farmers.

Keywords: Input factors, production, sweet potato

1. Introduction

The agricultural sectors, as one of the key contributors to the national economy and meeting the community's basic food needs, also plays a role in providing raw materials for industry. As the population increases, the need for food and industrial raw materials also increases (Rojun & Nadziroh, 2020). This raises challenges in the agricultural sector, including improving the welfare of farmers as agricultural producers. Sweet potato is one of the twenty types of food that has a source of carbohydrates after rice, corn and cassava. It is based on the consideration that sweet potato has high productivity compared to rice and cassava. Sweet potatoes have the potential for market demand, which continues to increase, especially in Indonesia that can be a local food that is easy to process and becomes a community favorite. It also has the potential for quite diverse product diversification and nutritional content (Suharyono & Edi, 2020).

Sweet potato has high nutritional value and one of strategic role in food security in many tropical countries, including Indonesia. Sweet potato production productivity are influenced by a variety of complex biotic and abiotic factors, such as soil nutrient, characteristic of varieties, environmental conditional and also farm management. Farmers are expected to understand various factors so that they can increase productivity and production of sweet potatoes, so that they can meet consumption needs and improve the welfare of farmers.

Other studies have shown that production factors such as land area, seedlings, fertilizer, pest control can play a significant role in determining sweet potato yields. In Sukaperna village, found that land area and seedlings variables had a significant positive effect on sweet potato production (Widyastuti, et al., 2023). Furthermore, other research revelaed that organic fertilizer dosage only significantly affected certain components of sweet potato production (Harahap, et al., 2025). Several studies have identified factors influencing sweet potato production, but other researchers can also conduct similar research, as responses vary across locations, varieties and production management. Analyzing production factors for sweet potato can give a recommendatins to formulating each inputs to use for production to increase production and farmers income. Therefore, this study aims to analyze the key factors influencing sweet potato production for developing more effective cultivation strategies.

2. Literature Review

2.1 Cobb Douglas Production Function

The production function is a fundamental in economic theory that describes the quantitative relationship between production factors (inputs) and production (output) in production process. One of the most frequently models that researchers usually used is Cobb-Douglas production function that relates output to combination of factors inputs such as labor, capital, and other inputs that usually used in agricultural production through a econometrically functional form (Gautam, 2024). This model was widely adopted in economic analysis because of its advantages in estimating the elasticity of output and input factors, also has the ability to assess return to scale.

The Cobb-Douglas production function analysis is used to determine the effect of changes in independent variables for dependent vaiables (Moonik, et al., 2020) which is then analyze with regression analysis. Data analysis using the Cobb-Douglas production function often referred to as an exponential production function where the production function model needed to be transformed first into a linear form using the natural logarithm (ln), so that it can be processed using regression analysis (Tinah, et al., 2022). Further, mathematic models regarding Cobb-Douglas production function model will be explained in the methodology.

2.2 Return to Scale

In economic theory, a basic assumption of production utility is the law of diminishing returns. Its describes the relationship between production factors and overall production results. When input factors is still small, output will increases significantly, but if other productions factors to be added without paying attention to other production factors, the resultas will be decreased. Production elasticity is defined as the percentage change in the results of the percentage change in the result of the percentage change in production factors (Tinah, et al. 2022).

This function makes it possible to understand how variations in input levels impact output in terms of scale efficiency and helps farmers or researchers to understanding of different farming operational scale. Return to scale used to estimate whether agricultural production exhibits increasing, decreasing or constant returns to scale (Gautam, 2024). Increasing return to scale happened when an increase in all inputs more than the increasing in ouput. It shows that scale of production are more efficient. Decreasing return to scale occurs, when an increase in all input factors less than the output, it indicates that larger scale production are not efficient. Constant return to scale occurs, when an increasing all input factors equal in increasing output, this proportionally increases indicating constant scale efficiency.

3. Methodology

This research was conducted in Ngargoyoso District, Karanganyar Regency, Central Java Province. This area was selected purposively because it is an area with high sweet potato productivity in Central Java Province, particularly in Ngargoyoso District, which is a sweet potato production center in Karanganyar Regency. This research was conducted from February to May 2020, with a sample of 50 sweet potato farmers.

This study uses quantitative descriptive approach with data collection techniques using questionnaires using a question format as a data collection tool, interviews to access nformation from farmer respondents regarding the data needed in the study, observations by observing the conditions of respondents and documentation (Sugiyono, 2024). The results of the respondent data collection were then analyzed. The following variables were used in the research analysis, including :

- Production yield, the final output of a production process that uses various inputs. Production is measured based on the number of sweet potatoes produces by farmers, measured in kilograms (kg)
- Land area, the total area used by farmers to grow sweet potatoes, measured in square meters (m^2)
- Seedlings, the number of seeds in the form of stem cuttings used in a single harvest, measured in units (units)
- Fertilizers, The amount of fertilizer used by farmers, both organic and chemical, during a single harvest, measured in kilograms (kg)
- Labor, the amount of labor used in the production process during a single planting period, both family and non-family labor, measured in Man-Days (Man-Days)

The research data analysis caried out, includes:

3.1 Cobb Douglas Production Function

Data analysis using the Cobb-Douglas production function often refreed to as an exponential production function where the production function model needed to be transformed first into a linear form using the natural logarithm (ln), so that it can be processed using regression analysis (Tinah, *et al*., 2022). This analysis using IBM SPSS Statistics. The Cobb-Douglass Production Function which is expressed in logarithmic form with the following equation:

$$\ln Y = \alpha + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + e$$

Where:

$\ln Y$ = ln sweet potato production variable
α = constant
$\beta_1, \beta_2, \beta_3, \beta_4$ = regression coefficient independent variable
$\ln X_1$ = ln land area variable
$\ln X_2$ = ln seedlings variable
$\ln X_3$ = ln fertilizers variable

lnX_4 = ln labor variable
e = error term

A linearized and regressed production function model is considered a good model if it meets the BLUE (*Best Linear Unbiased Estimator*) assumptions and meets the following classical assumptions test: (Hamid, et al., 2020)

- Normality Test, to determine whether the regression model is normally distributed by analysing the Residual Histogram and Normal P-Plot graph;
- Multicollinearity Test, to test for correlation between independent variables, then analyzed using partial correlation;
- Autocorrelation Test, to determine the correlation between residuals (errors) in the regression model from one time period to the previous period using the Durbin-Watson test;
- Heteroscedasticity Test, to determine whether the variable variance is constant using the Glejser method.

Once, the regression model has been tested for classical assumptions, the next step is to analyze the following regression coefficients:

- The F-test, to determine the magnitude of simultaneous influence of the independent variables. If the Sig. value is less than 0,05, it means the independent variables simultaneously influence of the dependent variable.
- The t-test, to determine the magnitude of the partial influence of the independent variables. If the Sig. value is less than 0,05, it means every independent variable influences the dependent variable.
- The coefficient of determination test or R-square Test, to test the feasibility of the model and the extent to which the independent variables can explain the dependent variable by looking at the Adj R^2 value.

3.2. Return to scale

After the Cobb-Douglas test, an efficiency analysis is performed, which, in this case, sums all the regression coefficients' values. If the regression coefficient value is more than 1, it means it is in a condition of increasing returns to scale. If the regression coefficient value is equal to 1, it means it is in a condition of constant return to scale. If the regression coefficient value is less than 1, it means the production is in a condition of decreasing returns to scale (Indrianti, *et al.*, 2024).

4. Results and Discussion

Analysis of factors influencing sweet potato production was measured using the Cobb-Douglas production function. This analysis was calculated by linear regression with estimation using variables such as land area, seedlings, fertilizers, and labor as independent variables and production as the dependent variable with IBM SPSS Statistics 22.

Table 1: Results of estimation summary model and regression coefficient cobb-douglas production

Variable	Coefficient	t	Sig.	Correlations Partial
Dependent Variable (ln Y)				
Constant	0.879	3.331	0.002	
Land Area (ln X_1)	0.423	4.652	0.000	0.570
Seedlings (ln X_2)	0.498	4.814	0.000	0.583
Fertilizers (ln X_3)	-0.017	-0.299	0.767	-0.044
Labor (ln X_4)	0.074	2.216	0.032	0.314
R^2	0.991			
Adj R^2	0.990			
F-value	1176,738			
Sig. F	0,000			
Durbin Watson	1.730			
Dependent Variable (ABSRES)				
Constant	0.316	1.723	0.092	
Land Area (ln X_1)	-0.027	-0.433	0.667	
Seedlings (ln X_2)	-0.044	-0.619	0.539	
Fertilizers (ln X_3)	0.042	1.051	0.299	
Labor (ln X_4)	0.020	0.859	0.395	

Source: *Processed Data*, 2025

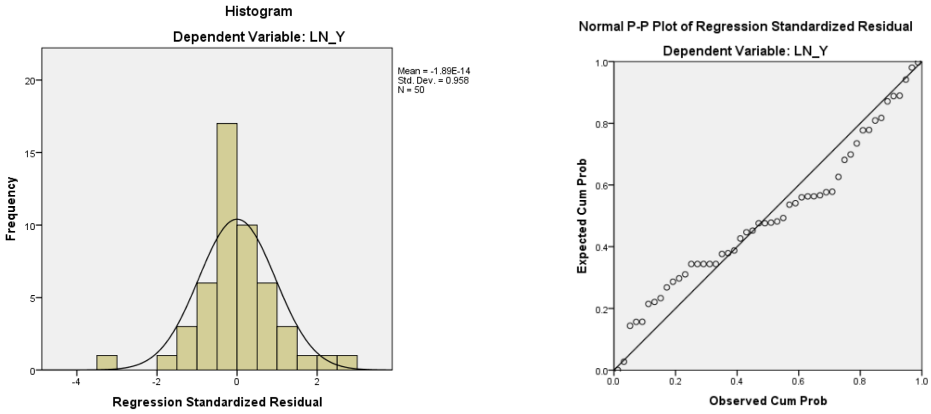

Fig. 1: (a) Histogram Residual; (b) Normal P-Plot

Estimation of factors influencing sweet potato production with multiple regression linear analysis using the Cobb-Douglas production function model resulted in regression coefficients for all factors influencing sweet potato production. Cobb-Douglas production function of sweet potato farming can be formulated using the following model, based on analysis in Table 1:

$$\ln Y = 0.879 + 0.423 \ln X_1 + 0.498 \ln X_2 - 0.017 \ln X_3 + 0.074 \ln X_{4} + e$$

Based on this production function model, we can analyze the factors influencing sweet potato production. However, the model needs to be analyzed using the classical assumption test to determine whether the production function model is BLUE (*Best Linear Unbiased Estimator*). First, the normality test was conducted to determine whether the data was normally distributed or not. Based on Figure 1, it is known that the data is normally distributed as shown by the bell-shaped curve and the data points (plots) align closely with the straight diagonal line, which meets the assumption of normality. It is consistent with Mutiara, *et al*. (2025) study, where the data distribution of sweet potato farming also showed normality.

Besides normality test, there is a multicollinearity test to analyze the correlation between the independent variables in the data. Based on Table 1, the correlation partial value for land area (0,570), seedlings (0,583), fertilizers (-0,044), and labor (0,314) are lower than the R^2 value (0,991). It means the data does not have multicollinearity. Another test is the heteroscedasticity test. It shows in Table 1, that the Sig. value of land area (0,667), seedlings (0,539), fertilizers (0,299), and labor (0,395) with dependent variable ABSRES are more than 0,05. It shows that there is no heteroscedasticity or the variance variables is constant. The autocorrelation test can also be seen in Table 1, where the Durbin Watson value is 1,730 (1,7214 < DW < 2,2786) which shows that there is no autocorrelation. Based on this results, the regression model is in BLUE (*Best Linear Unbiased Estimator*) condition.

The F test is used to determine the significance of the contribution of production factors (inputs) and production (Wulan, *et al*., 2022). Based on Table 1, Sig. F value is 0,000 that means all production factors such as land area, seedlings, fertilizers and labor simultaneously influence the sweet potato production.The results of production function model estimation provide the coefficient of determination value (R^2). Based on Table 1, the coefficient of determination value is 0,990 which we can know from the Adj R^2 value. It shows that 99% of the variance in sweet potato production diversity can be explained by the variance in production function in the model. In other words, 99% collectively influences production and the remaining 1 % is explained by other factors outside the model or influenced by other factors that have not been calculated.

The t test is used to analyzed every factors that influencing sweet potato production from land area, seedlings, fertilizers and labor, which we can know based on Table 1. Based on the analysis, the Sig. value of land area is 0,000 or less than 0,05, which shows that the land area variable has an effect on sweet potato production. The coefficient value is 0,423 means that each additional 1% of land area will increase sweet potato production by 0,423 kg. This results are in line with Mutiara, *et al*. (2025) that most farmers in Karanganyar cultivate small-scale plots of land that are spread across multiple locations. So, farmers need to optimalize the land use with efficiency land management to increase the production. However, increasing land area can provides farmers the opportunity to increase the crops with increasing input use, so the production can also increases (Sari, *et al.*, 2023).

The Sig. value of seedlings is 0,000 or less than 0,05, it means that the seedlings variable can affect sweet potato production. The coefficient value of seedlings is 0,498, which shows that each additional 1 unit of sweet potato seedlings will increase sweet potato production by 0,498 kg. This results is in line with Andriani et al. (2015), whixh showed that seedlings can affecting sweet potato production. Increasing the number of seedlings with appropriate planting spacing also can increase sweet potato production (Simanjuntak, *et al.,* 2019).

The Sig. value of fertlizer is 0,767 or more than 0,05. It shows that fertilizer variable does not have affect of sweet potato production. This can caused by high rainfall, extreme temperatures, or poor soil physical properties that can limit the development of sweet potato root or tuber, so making the effect of fertilizer minimal (Kristanto, *et al.*, 2019). The Sig. value of labor is 0,032 or less than 0,05, it means that labor variable can affect sweet potato production. The coefficient value of labor is 0,074, which shows that each additional 1 day of work per labor will increase sweet potato production by 0,074 kg. This results are not in line with Mutiara, *et al*. (2025) studies that has a negative impact on increasing sweet potato production.

Based on Table 1, of the regression coefficient sum, it is known that the return to scale value of sweet potato production is 0,978, which indicates that sweet potato production in Karanganyar Regency is in a condition of decreasing returns to scale because the number of regression coefficients is less than 1. This indicates that the addition of disproportionate production inputs will reduce the production results of sweet potato farming. The addition of proportional production inputs is necessary to limit the use of production inputs, especially seedlings, fertilizers, and labor. Return to scale usually shows how output changes when all inputs factors are increased proportionally in the long run. This result is different from the study of Mutiara, *et al*. (2025) which shows that sweet potato farming is in a condition of increasing returns to scale of 1,240. The adoption of appropriate technology, mechanization, or effective agronomic practices will tend to boost the return to scale because output increases more with efficiency-enhancing technology (Zhang, 2025).

5. Conclusion

Based on the results, it is known that the factors influencing sweet potato production, especially in Karangayar Regency, are land area, seedlings and labor, where the regression model used fulfilled all classical assumption tests (multicollinearity, autocorrelation, and heteroscedasticity). The scale of sweet potato farming is in a condition of decreasing returns to scale, which shows that adding excessive inputs no longer increases production optimally. Suggestions that can be given are optimizing the use of production inputs, not only by increasing their quantity but also by using quality inputs, such as the use of quality seedlings. Optimizing land use for planting sweet potatoes and the use of organic and chemical fertilizers, including efficient labor management, are really needed. In addition, encourage the development of innovation and technology by providing assistance and training related to the efficiency of sweet potato farming.

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Conflict of Interest

The authors declare no conflicts of interest.

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