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Estimation Of Cassava Production in Central Buton Using the Mean Absolute Error (MAE) Method in the Multiple Linear Regression Algorithm

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ABSTRACT
This research has the potential to offer new contributions in the application of statistical methods in agriculture. The aim is to provide a stronger basis for farmers and the government in increasing cassava production in the future based on planting distance and land area. The method used is the Mean Absolute Error (MAE) in the Multiple Linear Regression Algorithm. The result partial test show that planting distance has a real and positive effect on cassava production in Central Buton, as evidenced by the value of $T_{value} = 2.320 > T_{table} = 1.997$, with a significance value of $0.023 < 0.05$. Likewise, the partial test results show that land area has a real and positive effect on cassava production, as indicated by the value of $T_{value} = 7.095 > T_{table} = 1.997$, with a significance value of $0.000 < 0.05$. Meanwhile, the simultaneous test results show that planting distance and land area have a real and positive effect on cassava production, as indicated by the value of $F_{value} = 56.087 > F_{table} = 3.986$, with a significance value of $0.000 < 0.05$. The magnitude of the combined effect, based on the coefficient of determination test, is 62.2%. Thus, the Mean Absolute Error (MAE) method, the average prediction error of the Multiple Linear Regression model obtained obtained very good or acceptable results, namely 111 or around 0.3% of the average error compared to the actual value.

KEYWORDS
Planting Distance, Land Area, Mean Absolute Error (MAE), Cassava Production, Multiple Linear Regression.

1. INTRODUCTION

As an agrarian country, Indonesia's economy relies heavily on agriculture. Particularly in rural areas, the agricultural sector plays a strategic role in the framework of national economic development. The national economy remains highly dependent on, and strategically influenced by, the agricultural sector [1]. In this context, cassava represents one of the major food commodities in Indonesia, including in Southeast Sulawesi Province. In 2019, the province produced 144,752 tons of cassava, which increased significantly to 260,916 tons in 2020 [2]. Efforts to improve agricultural productivity require careful consideration of resource management, particularly planting distance and land area.

Land area and planting distance are significant factors that influence crop growth and yield [2]. Planting distance affects leaf area, plant dry weight, root system development, the amount of sunlight received, and the level of nutrients absorbed from the soil. Meanwhile, land area directly impacts production capacity, as larger farmland typically leads to higher yields, provided that proper agricultural management is applied. Furthermore, algorithmic approaches allow for the measurement of the influence of independent variables in research using multiple linear regression analysis [2].

This study is motivated by the need to provide concrete solutions to address uncertainties in cassava production and to

ensure the sustainability of cassava yields in the future through accurate data-driven approaches. By using the Mean Absolute Error (MAE) method in the multiple linear regression algorithm, it is hoped that it can produce more accurate and reliable cassava production forecasts. Such predictive tools will enable farmers to make better-informed decisions regarding optimal planting distance and the extent to which land area contributes to cassava productivity. With more effective prediction models, farmers can maximize yields, reduce losses due to unmet expectations, and improve overall welfare. Additionally, this study is expected to make a significant contribution to enhancing farmers' livelihoods and strengthening food security in Buton Tengah Regency, while also providing a replicable model for other regions.

Overall, this research is of great importance, considering that Buton Tengah is one of the largest cassava-producing regions in Southeast Sulawesi and has the potential to contribute substantially to the application of statistical methods in agriculture. The findings are also expected to provide a stronger foundation for farmers, policymakers, and the Buton Tengah local government in planning and improving cassava production in the future.

2. LITERATURE REVIEW

Cassava (Manihot utilissima or Manihot esculenta Crantz) is a tropical and subtropical perennial tree belonging to the Euphorbiaceae family, also known as cassava. Its leaves are used as vegetables, and its tubers are widely known as a staple source of carbohydrates. After being brought to the Indonesian archipelago by the Portuguese in the 16th century from Brazil via the Bogor Botanical Gardens, cassava was first commercially cultivated in Indonesia in 1810 [3]. The plant is rich in nutrients and is very good for human health [4].



(a) Raw Cassava **(b)** Peeled Cassava

Figure 1. Cassava

In Indonesia, cassava is widely cultivated in various environmental conditions. Cassava plants have a dicotyledonous root system, or taproot. The circular, serrated cassava stem begins near the base of the leaf stalk. Cassava is a tall plant with a hollow center. With approximately three to eight leaves per stalk, cassava leaves have long stalks and leaf blades that resemble eight palms. Additionally, cassava leaves only last for a few months before falling off. The veins of the leaves are finger-like, and the edges of the leaves are smooth [3].

2.1 Cassava Production

Buton Regency produced 23,181 tons of cassava, Muna Regency 19,010 tons, West Muna 12,822 tons, North Buton 12,547 tons, Konawe Islands 7,595 tons, and Kolaka 6,815 tons. Kendari City produced 3,294 tons, Bau-Bau City 914 tons, North Konawe 864 tons, Bombana 715 tons, Konawe 5,930 tons, East Kolaka 4,592 tons, and North Kolaka 559 tons. One of the regional foods in Southeast Sulawesi known as "Kasuami" and "Kabuto" is cassava, which can be eaten raw in its tuber form with a planting area of 1,296 hectares and a highest yield of 355 quintals per hectare, Central Buton Regency is the largest contributor to cassava production in Southeast Sulawesi, amounting to 46,086 tons. South Konawe Regency is the third-largest cassava producer with 42,040 tons, followed by South Buton Regency with 40,171 tons and Wakatobi Regency with 33,753 tons [5].

2.2 Land Area And Planting Distance

Land area is where farmers carry out their farming activities. With land, farmers can utilize all production variables in accordance with the commodities they intend to cultivate. One of the key determinants of the harvest yield that farmers will obtain is the land area they own or use for production. In other words, harvest yields increase in tandem with land area [6].

In essence, one strategy for improving agricultural yields in a given area is to select the planting distance. In order for plants to make optimal use of their growing environment, nutrients, light, and water, yields can be increased by increasing the planting distance per unit area within a certain range [7].

This study was conducted with farmers in Central Buton by applying an average planting distance of 1.3 m x 1.3 m with an intercropping pattern between cassava and corn. The planting distance arrangement has a significant impact on the success of the intercropping system. One way to maximize the utilization of existing environmental factors and produce the elements needed by plants is by adjusting the planting distance [8].

Although reducing plant density per hectare can cause microclimate changes that affect growth and yield, increasing plant density per unit area to a certain point can increase crop yield.

2.3 Multiple Linear Regression Model

In determining the area and quantity of land that influences cassava production, In general, the multiple linear regression model for sample data is as follows:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_p X_p + \varepsilon \tag{1}$$

Description:
Y =dependent variable
β_0 = intercept
$X_1, X_2, \cdots, X_p$ = independent variables
ε = random error term

A linear regression model is considered superior if it meets a number of assumptions known as “classical assumptions,” including multicollinearity tests and residual assumption tests, which include heteroscedasticity and normality tests.

2.4 Mean Absolute Error (MAE) Method

Mean absolute error (MAE) is a simple but powerful metric used to measure the accuracy of regression models. MAE measures the average absolute difference between the predicted and actual values, providing an estimate of the magnitude of inaccuracy, but not the direction (e.g., predictions that are too high or too low) [9].

The advantage of the MAE method over other regression error evaluation methods is that MAE provides easy-to-understand results because it measures the average error in the same units as the dependent variable. The error is calculated absolutely, making it very intuitive [10].

MAE is more resistant to outliers than mean squared error (MSE) or root mean squared error (RMSE). The MSE method assigns a higher weight to large errors because they are squared. In contrast, MAE does not affect the calculation based on the magnitude of the error, so MAE provides a more stable and fair assessment in cases of data with outliers because each error is calculated linearly, with no magnification or difference in influence between small and large errors. MAE allows for a more balanced assessment of errors, especially when wanting to avoid excessive penalties for large errors, as occurs with MSE [11].

Here is the MAE method formula:

$$MAE = \frac{1}{n} \sum_{i=1}^{n} | Y_i - \hat{Y}_i | \tag{2}$$

Description:
Y_i = true value
$\hat{Y}_i$ = forecast value
n = amount of data

Based on the MAE formula, the component $| Y_i - \hat{Y}_i |$ shows the error value, or the difference between the predicted value and the actual value. The smallest error is the expected difference (error). The results of the consistency and reliability of the forecast are used to measure its accuracy. If the forecast is too high or too low compared to the actual event, the forecast is considered biased. If the forecast error is sufficiently minimal, the forecast results are considered consistent [12]. Several analyses of variations in the average absolute error percentage [1].

Table 1. Variations in the Average Absolute Error Percentage

No.	Percentage of Average Absolute Error	Criteria
1	$< 10\%$	Very Good
2	$10\% - 20\%$	Good
3	$20\% - 50\%$	Worthy
4	$> 50\%$	Bad

The average absolute error percentage value can still be used if it does not exceed 50%.

3. METHODOLOGY

The research design is descriptive quantitative and correlational quantitative, where descriptive quantitative is used to determine the development of the variables of planting distance (X_1), land area (X_2), and cassava production (Y). Correlational quantitative analysis is used to determine the effect of planting distance (X_1), and land area (X_2), on cassava production (Y), both partially and simultaneously, as well as to test the hypothesis parameters to determine whether they are rejected or accepted. The population in this study was all cassava farmers in Central Buton Regency in 2024-2025, specifically in Mawasangka Subdistrict, with a saturated sample technique of 68 farmers, because the population is relatively small (less than 100), so that all members of the population can be sampled, or to minimize sampling errors and obtain a perfect representation of the population as a whole.

3.1 Analysis Procedure

Before conducting multiple linear regression tests accompanied by calculations of the accuracy of the results using the mean absolute error (MAE) approach, a simple assumption test was first conducted.

3.2 Normality Test

The approach used to determine the normality of the data is the Kolmogorov-Smirnov method. The Kolmogorov-Smirnov test is performed by matching D_{value} and D_{table}

$$D_{value} = maks|F_0(x) - S_n(x)| \tag{3}$$

Description:
$F_0(x)$ = theoretical cumulative frequency distribution
$S_n(x)$ = cumulative frequency distribution of scores

3.3 Heteroscedasticity Test

The purpose of the heteroscedasticity test is to determine whether the residual variance in the regression model varies unevenly in an observation. Hypothesis testing is:
H_0 : There is no heteroscedasticity
H_1 : There is heteroscedasticity.

The variance function of the residuals is:

$$\sigma_i^2 = f\ (\alpha_0 + \alpha_1 Z_{1i}) \tag{4}$$

σ_i^2 is non-stochastic variable Z function, and it is assumed that:

$$\sigma_i^2 = \alpha_0 + \alpha_1 Z_{1i} \tag{5}$$

σ_i^2 is a linear function of variable Z. If $\alpha_1 = 0$ then $\sigma_i^2 = \alpha_0$then it has a fixed value. Decision to reject H_0 if the absolute value T_{value} and T_table atau p-value $< \alpha$. It can be concluded that the resulting model has a heteroscedasticity problem if H_0 is rejected for each parameter [13].

3.4 Partial Test (T)

To determine how much each independent variable contributes to explaining the dependent variable, T-test is used. The partial test statistical hypothesis in this study can be stated as follows:

1. The effect of planting distance (X_1) on cassava production (Y)
   H_0: $\beta_1 = 0$
   H_1: $\beta_1 \neq 0$

2. The effect of land area (X_2) on cassava production (Y) H_0: $\beta_2 = 0$
   H_1: $\beta_2 \neq 0$

The following criteria are applied when deciding whether to accept or reject the hypothesis [13]:
H_0 rejected and H_a accepted, if $t_{value} \geq t_{table}$
H_0 accepted and H_a rejected, if $t_{value} < t_{table}$

3.5 Simultaneous Test (F)

To determine whether independent factors simultaneously influence the dependent variable, an F test is used. The calculated F and table F are compared to perform the F test. The following criteria are applied when deciding whether to accept or reject the hypothesis [13]:
The statistical hypothesis of the simultaneous test in this study can be stated as follows:
The effect of planting distance (X_1) and land area (X_2) on cassava production (Y) $H_0 \ : \ \beta_i = 0, \ \ i = \{1,2\}$
$H_1 \ : \ \exists_i, \ \beta_i \neq 0, \ \ i = \{1,2\}$

The following criteria are applied when deciding whether to accept or reject the hypothesis follows:
H_0 rejected and accepted H_a, so $F_{value} \geq F_{table}$
H_0 accepted dan H_a rejected, so $F_{value} < F_{table}$

3.6 Determination Coefficient Test (R^2)

The purpose of this test is to measure how much influence the independent variable has on the dependent variable. The following formula can be used to calculate the coefficient of determination [13]:

$$R^2 = \frac{\hat{b}_1 \ (\sum X_1 Y) + \hat{b}_2 \ (X_2 Y)}{\sum Y^2} \tag{6}$$

Description:
R^2 = Coefficient of determination
$\hat{b}_1$ = estimation of variable coefficients X_1
$\hat{b}_2$ = estimation of variable coefficients X_2
X_1 = Planting Distance
X_2 = Land Area
Y = Cassava Production

3.7 Multiple Linear Regression Test

The technique used to determine whether land area and quantity affect cassava production is multiple linear regression testing. For sample data, the multiple linear regression model generally looks like this: Multiple Linear Regression Test The technique used to determine whether land area and quantity affect cassava production is multiple linear regression testing. For sample data, the multiple linear regression model generally looks like this:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_p X_p + \varepsilon \tag{7}$$

Description:
Y = Cassava Production
β_0 = Constanta
X_1 = Planting distance
X_1 = Land Area
β_1 = Planting distance regression coefficient
β_2 = land area regression coefficient
ε = random error term

3.8 Mean Absolute Error Test (MAE)

Mean absolute error (MAE) as in equation (2) is a simple yet powerful measure for evaluating the accuracy of regression models. MAE measures the average absolute difference between predicted and actual values, providing an estimate of the magnitude of inaccuracy, but does not provide direction (e.g., predictions that are too high or too low) [9].

4. RESULT & DISCUSSION

4.1 Profile Data

The data used in this study was obtained from direct field observations and interviews with cassava farmers. **Figure 2** shows the land area, planting distance, and cassava production volume. Planting distance was measured in square meters, land area in square meters, and production in kilograms. There were 68 farmer respondents, consisting of 55 men and 13 women aged between 28 and 54 years old.

4.2 Assumption Test Results

4.2.1 Normality Test

The Kolmogorov-Smirnov normality test with p-p plot can be seen in the following table. **Table 2** shows a significance value for

Table 2. One-Sample Kolmogorov-Smirnov Test

		Unstandardized Residual
N		68
Normal Parameters[a,b]	Mean	0.0000000
	Std. Deviation	9738.98481619
Most Extreme Differences	Absolute	0.105
	Positive	0.085
	Negative	-0.105
Kolmogorov-Smirnov Z		0.865
Asymp. Sig. (2-tailed)		0.446

a. Test distribution is Normal.
b. Calculated from data.

the normality test using a one-sample Kolmogorov-Smirnov test of $0.446 > 0.05$, indicating that the data is normally distributed.

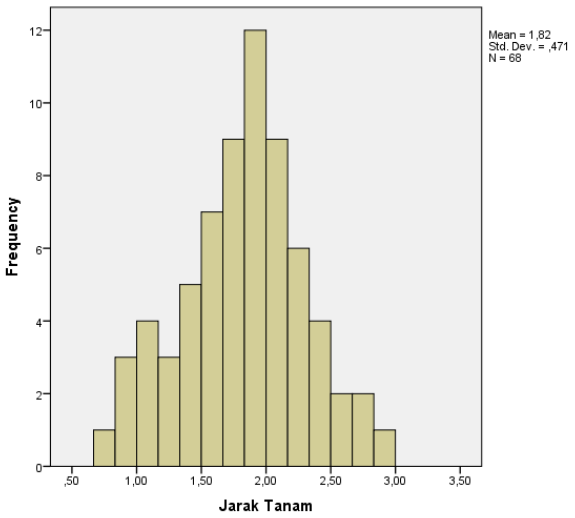
4.2.2 Heteroscedasticity Test

The results of the heteroscedasticity test are shown in the **Figure 3**. The points in the **Figure 3** are scattered on the Y-axis around the number 0 and do not follow a specific pattern. Thus, it can be said that there is homoscedasticity, or the absence of heteroscedasticity.

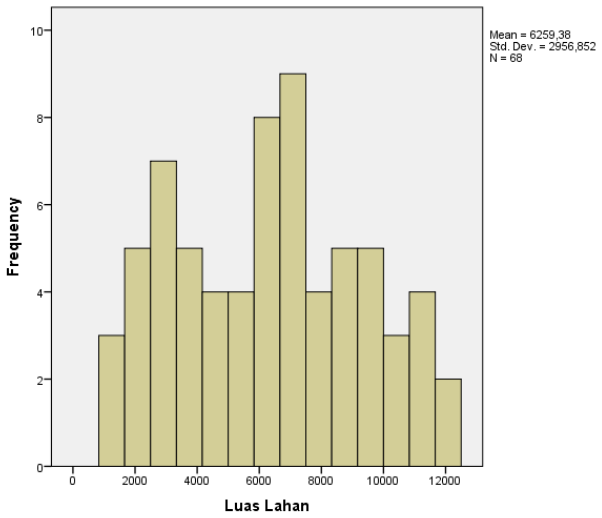
4.2.3 Partial Test Results (t-Test)

The t-test results are shown in **Table 3**. This table is explained as follows:

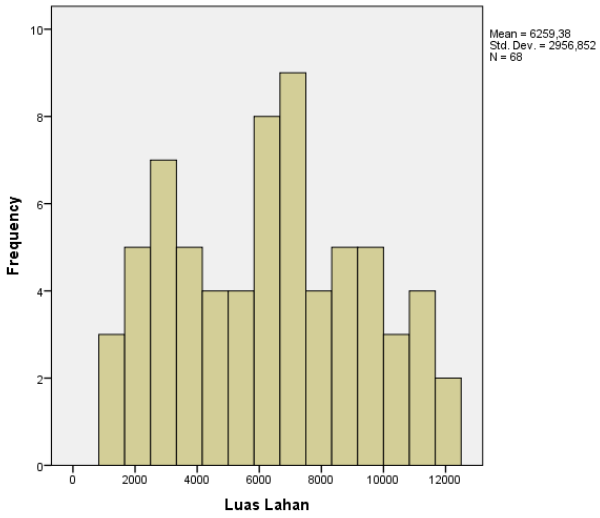
1. The T-test results obtained a coefficient value for planting distance of 7293.313 and a calculated T_{value} of $2.320 > T_{table}$ of 1.997, while the significance value was $0.023 < 0.05$, so it can be said that there is a significant effect of planting distance on cassava production in Central Buton.



(a) Histogram Chart of Planting Distance



(b) Histogram Chart of Land Area



(c) Histogram Chart of Production Cassava

Figure 2. Histogram of planting distance, land area, and the volume of cassava production

Source: Output from SPSS

Table 3. Partial Test Results (t-test)

Model	Variable	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	728.676	4833.478		0.151	0.881
	Planting Distance	7293.313	3143.004	0.214	2.320	0.023
	Land Area	3.551	0.500	0.653	7.095	0.000

a. Dependent Variable: Amount of Production

2. The T-test result for the land area variable coefficient is 3.551 and T_{value} is 7.095 $>$ T_{table} 1.997 with a significance value of 0.000 $<$ 0.05, so it can be said that there is a very significant effect of land area on cassava production in Central Buton.

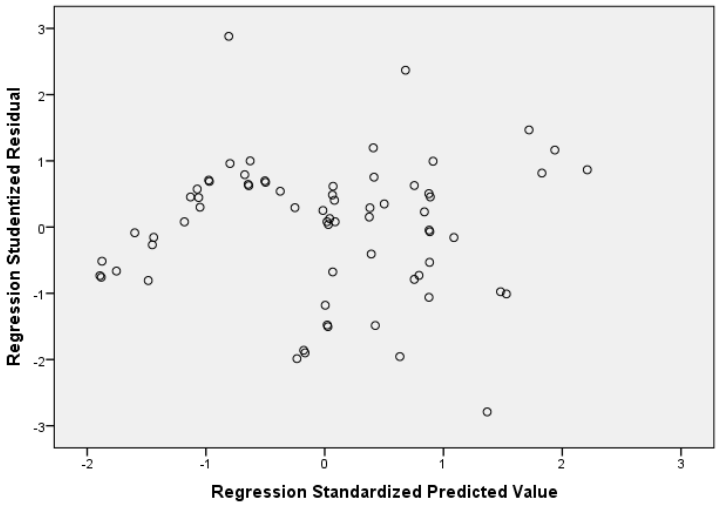


Figure 3. Heteroscedasticity Test Results with Scatterplot

4.2.4 Simultaneous Test Results (F Test)

The F-test results can be seen in **Table 4**. It can be seen that the value of $F_{value} = 56,087 > F_{table} = 3,986$ and the significance

Table 4. Simultaneous Test Results (F-test)

Model	Source	Sum of Squares	df	Mean Square	F	Sig.
1	Regression	10966744192.878	2	5483372096.439	56.087	< 0.001
	Residual	6354804291.755	65	97766219.873		
	Total	17321548484.632	67			

a. Dependent Variable: Amount of Production

value is $0.000 < 0.05$, then planting distance and land area simultaneously have a significant effect on cassava production in Central Buton.

4.3 Results of the Coefficient of Determination Test (R^2 Test)

The coefficient of determination measures the influence of independent variables on dependent variables. Consider **Table 5**.

Table 5. Determination Test Results

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.796^a	0.633	0.622	9887.680

a. Predictors: (Constant), Land Area, Planting Distance

Based on **Table 5**, it can be seen that the proportion of planting distance and land area variables to cassava production is 62.2%. This means that planting distance and land area in Central Buton have an influence of 62.2%, while the remaining 37.8% is influenced by other variables.

4.4 Multiple Linear Regression Analysis Results

The **Table 6**shows the results of Multiple Linear Regression Analysis. From this table, the multiple linear regression equation is obtained as follows:

$$Y = 728.676 + 7,293.313X_1 + 3.551X_2$$

The interpretation of the equation is as follows:
If X_1 and $X_2 = 0$, then the estimated value of Y is 728.676. This is the baseline value of Y before being influenced by X_1 and X_2.

Table 6. Multiple Linear Regression Test Results

Model	Variable	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	728.676	4833.478		0.151	0.881
	Planting Distance	7293.313	3143.004	0.214	2.320	0.023
	Land Area	3.551	0.500	0.653	7.095	< 0.001

a. Dependent Variable: Amount of Production

The regression coefficient of variable X_1 (planting distance) of 7,293.313 indicates that every 1 unit increase in planting distance will increase cassava production by 7,293.313 units, assuming other variables are constant. Based on the t-test results, the calculated t-value was 2.320, which is greater than the t-table value of 1.997 at a 5% significance level. Furthermore, the p-value of 0.05 indicates that variable X_1 is significant at the 95% confidence level. Therefore, it can be concluded that planting distance has a positive and significant effect on cassava production. The X_2 regression coefficient of 3.551 indicates that every 1-unit increase in X_2 will increase cassava production by 3.551 units, assuming other variables remain constant.

The t-test results show that the calculated t-value of 7.095 is significantly greater than the t-table value of 1.997. Furthermore, the p-value of 0.000 (< 0.05) indicates that X_2 has a positive and significant effect on cassava production. The relatively large calculated t-value indicates that X_2 has a more dominant influence than X_1 in explaining variations in cassava production.

4.5 Mean Absolute Error (MAE) Results

The purpose of using Mean Absolute Error (MAE) in this study is to measure the effectiveness of the regression model in predicting cassava production. The lower the MAE value, the smaller the prediction error and the better the model fit. The average error value calculated using the MAE method in this study is 111, or 0,3% of the actual value, which is smaller than the accuracy value calculated using another regression method, Root Mean Squared Error (RMSE), which is 9668 and much smaller than the actual average value of 36255. so that the predicted value of cassava production in Central Buton can be said to be very good

5. CONCLUSION

The partial test results show that the planting distance variable has a positive value because T_{value} of 2.320, while the significance is 0.023 in relation to production volume. These results indicate that the planting distance variable has a positive and significant effect, meaning that when the planting distance increases along the interval of 1.5 x 1 meters to 3 x 1.5 meters, cassava production in Central Buton will increase. Meanwhile, the land area variable has a positive value because T_{value} is 7.095 and its significance value is 0.000 in relation to production volume. These results show that the land area variable has a positive and highly significant effect, meaning that even a slight increase in the value of the land area variable will have a significant effect on cassava production in Central Buton. In addition, the results of the simultaneous test of both variables were also positive with a significance value of 0.000 for production volume. The findings show that land area and planting distance factors work together positively and significantly to influence the variable of production quantity. The previous hypothesis that planting distance and land area have a significant impact on cassava yield in Central Buton was simultaneously accepted. Meanwhile, the results of the multiple linear regression algorithm showed that production was significantly influenced by partial planting distance (significant value 0.023), partial planting area (significant value 0.000), and planting distance and land area simultaneously (significant value 0.000) with an average absolute error prediction accuracy (MAE) value of 111, or 0,3% of the average prediction error from the actual value.

REFERENCES

[1] S. Maulida and A. Yunani, "Peluang dan tantangan pengembangan usaha mikro kecil menengah (umkm) dari berbagai aspek ekonomi," *Jurnal Ilmiah Manajemen Dan Bisnis*, vol. 2, no. 1, pp. 181–197, 2017.

[2] N. Jamil, H. B. Setyawan, S. Hartatik, S. Soeparjono, and S. Avivi, "Aplikasi pupuk organik (kompos) dan jarak tanam terhadap pertumbuhan dan produksi singkong (crantz) varietas cimanggu di lahan kering berpasir," *Jurnal Nasional Perhimpunan Ilmu Pemuliaan Indonesia*, pp. 238–239, October 2017.

[3] W. Endah and S. Dyah, *Buku Budidaya dan Aneka Olahan Singkong*, 1st ed. Lembaga Penelitian dan Pengabdian Kepada Masyarakat, 2021.

[4] L. Fajriyah, S. Sa'diah, K. Mulamawarni, A. Merlina, M. Ridwan, B. Febriyanti, and R. O. Khastini, "Manajemen ketahanan pangan melalui program diversifikasi pangan di sumatera utara dalam rangka mendukung pertahanan negara," *Jurnal Ilmu Pertanian*, vol. 12, no. 1, pp. 8–16, 2024.

[5] Dinas Tanaman Pangan dan Peternakan Provinsi Sulawesi Tenggara (Distanak Sultra), "Produksi ubi kayu sultra 260.916 ton," 2021, diakses pada: 2026.

[6] H. Zulfani, "Analisis usahatani dan pemasaran stroberi (studi kasus: Desa dolat rayat dusun iii tongkoh kecamatan berastagi kabupaten karo)," Undergraduate Thesis, Universitas Muhammadiyah Sumatera Utara Medan, 2017.

[7] A. Pithaloka, Sunyoto, M. Kamal, and K. F. Hidayat, "Pengaruh kerapatan tanaman terhadap pertumbuhan dan hasil beberapa varietas sorgum (sorghum bicolor (l.) moench)," *Jurnal Agrotek Tropika (JAT)*, vol. 3, no. 1, pp. 56–63, 2015.

[8] G. Raditya and K. Kristiana, "Mengkaji sistem tanam tumpangsari tanaman semusim," *Jurnal Proceeding Biology Education Conference*, vol. 15, no. 1, pp. 791–794, 2018.

[9] M. W. Ahmed, "Understanding mean absolute error (mae) in regression: A practical guide," 2023, blog post.

[10] R. Hyndman and G. Athanasopoulos, *Forecasting: Principles and Practice*, 2nd ed. OTexts, 2018.

[11] G. James, D. Witten, and R. T. Tibshirani, *An Introduction to Statistical Learning*, 1st ed. New York, Amerika Serikat: Springer, 2017.

[12] S. Meyyappan, "Improving forecasting accuracy using machine learning algorithms," *Journal on Electronic and Automation Engineering*, vol. 2, no. 4, pp. 9–18, 2023.

[13] I. Ghozali, *Aplikasi analisis multivariate dengan program IBM SPSS 25*, 9th ed. Universitas Diponegoro, 2018.