Application of Linear Regression to The Factors Affecting The Rice Production Level in Langsa City

Penerapan Regresi Linier Terhadap Faktor–Faktor yang Mempengaruhi Tingkat Produksi Padi di Kota Langsa

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ABSTRAK

Padi merupakan bahan pangan penghasil beras yang menjadi makanan pokok bagi sebagian besar penduduk Indonesia. Penduduk Indonesia berpendapat bahwa beras merupakan makanan pokok utama yang dapat tergantikan, hal ini mengakibatkan tingginya kebutuhan konsumsi beras di Indonesia. Masyarakat Indonesia masih sangat bergantung pada beras sebagai makanan pokok yang menyebabkan pemerintah harus melakukan cara agar dapat mengontrol ketersediaan beras dengan baik. Penelitian ini bertujuan untuk mengetahui faktor – faktor yang mempegaruhi produksi padi dan mengetahui seberapa besar pengaruh hubungan atau korelasi antara faktor – faktor terhadap hasil produksi. Metode yang digunakan dalam penelitian ini adalah regresi linier berganda, analisis ini digunakan untuk mengetahui hubungan dari variabel terikat dengan variabel bebas apakah masing - masing variabel berhubungan positif atau negatif dan melihat berapa persentase pengaruh variabel bebas terhadap variabel terikat yaitu luas panen, curah hujan dan produktifitas terhadap produksi padi di Kota Langsa. Berdasarkan hasil penelitian diperoleh hasil analisis korelasi yang kuat antara produksi padi (y) dengan luas panen (x_2) yaitu 0.973 dan pada hasil uji linier berganda didapatkan nilai sebesar $54 \geq F_{0,05\ 3,4} = 6,59$ dengan taraf signifikan $\alpha = 0,05$, maka dapat disimpulkan bahwa H_0 ditolak dan H_1 diterima.
Kata kunci: Padi, Luas Panen, Curah Hujan, Produktivitas, Regresi Linier Berganda

ABSTRACT

Rice is a food that produces rice which is the staple food for most of the Indonesian population. Indonesian people think that rice is a staple food that cannot be replaced, this causes the high demand for rice consumption in Indonesia. The Indonesian people, who are still very dependent on rice as a staple food, have forced the government to take steps to control the availability of rice properly. This study aims to determine the factors that influence rice production and to find out how much influence the relationship or correlation between factors has on production results. The method used in this study is multiple linear regression, this analysis is used to determine the relationship between the dependent variable and the independent variable whether each variable is positively or negatively related and see what percentage of the influence of the independent variable on the dependent variable, namely harvested area, rainfall and productivity. on rice production in Langsa City. Based on the results of the study, the results of the analysis of a strong correlation between rice production (y) and harvested area (x2) were 0.937 and results of the multiple linear test obtained a value of with a significant level of, it can be concluded that is rejected and is accepted.$54 \geq F_{0,05\ 3,4} = 6,59$ $\alpha = 0,05$$H_0$$H_1$.

PRELIMINARY

Rice or with the Latin name Oryza Sativa is a plant or cultivated plant that is preserved in Indonesia. Rice is a rice-producing food which is the staple food for most of the Indonesian population (Gamayanti & Junaidi, 2021). The Indonesian population believes that rice is the main staple food that cannot be replaced, this results in the high demand for rice consumption in Indonesia. The increasing population in Indonesia, the higher the availability of rice from consumer demand. Indonesian people who are still very dependent on rice as a staple food cause the government to take steps to control the availability of rice properly (Aziz & Sukmono, 2018).

Due to unstable rice production, it is necessary to investigate the factors that affect rice production in Langsa City (BPS, 2021). Several factors that influence the demand for rice are the price of rice itself, the income per capita of the community and the population. If the price of an item is getting cheaper, the demand for that item will increase, and vice versa (Samsul & Rizal, 2022). One method that can be used to determine the factors that affect rice production is linear regression, then the demand for these goods increases, and vice versa (Samsul & Rizal, 2022). One method that can be used to determine the factors that affect rice production is linear regression. then the demand for these goods increases, and vice versa (Samsul & Rizal, 2022). One method that can be used to determine the factors that affect rice production is linear regression.

Linear regression is a method to determine one or more dependent and independent variables. Multiple linear regression was conducted to determine how much influence the independent variable had on the dependent variable. Variables that affect are called independent variables or independent variables. The variable that is affected is called the dependent variable or the dependent variable (Ningsih & Dukalang, 2019). This study aims to determine the factors-factors that affect rice production and determine how much influence the relationship or correlation between factors - factors on production results.

One thing that distinguishes this researcher from previous researchers is that in previous studies, land area greatly affects rice production and labor greatly affects rice production.

METHOD

Multiple Linear Regression Equation

Multiple linear regression is a regression modeling that is used to explain the relationship between the number of independent variables more than one and the dependent variable. With the increase in independent variables, the general form of the multiple linear regression equation that includes two or more independent variables is as follows (Aziz & Sukmono, 2018):

$$y = b_0 + b_1 x_1 + b_2 x_2 + b_3 x_3 + \cdots + b_n x_n + e$$

Y = Dependent Variable

X = Independent Variable

b_0 = Regression constant

b_n = Independent variable regression coefficient x_n

To do the modeling of the factors that affect the production of paddy, then first look for parameter estimates b_0, b_1, b_2, b_3. So that the estimation of the multiple linear equation is as follows:

$$\hat{y} = \hat{b}_0 + \hat{b}_1 x_1 + \hat{b}_2 x_2 + \hat{b}_3 x_3$$

Estimation Standard Error

To find out the accuracy of the estimation of the linear equation, you can see the standard error of estimation. The size of the standard error of estimation shows the accuracy of the true value equation for the dependent variable. The smaller the standard value of the estimate, the higher the accuracy of the estimation equation produced by the true value of the dependent variable. The greater the value of the estimation standard error, the lower the accuracy of the estimation equation produced by the true value of the dependent variable (Tumangger, 2019).

Then the formula for calculating the standard error of estimation is as follows:

$$s_{y.123}^2 = \frac{\Sigma(Y - \hat{Y})^2}{n - k - 1}$$

yi = actual data value

$\hat{y}$ = estimated value

n = sample size

k = size of independent variable

Coefficient of Determination

The coefficient of determination explains the variation in the effect of the independent variables on the dependent variable. Score R^2 is between 0 and 1, the value of R^2 meansif the value is closer to 1, then the relationship is getting stronger, and vice versa if the value is close to 0 then the relationship is getting weaker (Munthe, 2019).

So R^2 can be calculated using the following formula:

$$R^2 = \frac{\Sigma(\hat{y}_i - \bar{y})^2}{\Sigma(y_i - \bar{y})^2}$$

Correlation Coefficient Test

Correlation coefficient is usually symbolized by r. The value of the correlation coefficient is the value used to measure the strength of a linear relationship between variables. The value of r is between -1 to 1. If $r < 0$ then there is a negative relationship between X and Y which means that if X gets bigger, then Y gets smaller and if X gets smaller, then Y gets bigger. If $r > 0$ then there is a positive relationship between X and Y, meaning that if X gets bigger then Y will also get bigger and if X gets smaller then Y will also get smaller (Zuhri, 2020).

The relationship between variables can be grouped into three types, namely:

1. Positive Correlation

   Positive correlation is where there is a positive correlation if the change between one variable is followed by another variable in the same direction. This means that one variable increases, it will be followed by an increase in other variables. The results of the calculation of the correlation are close to +1 or $0 < r < 1$.

2. Negative Correlation

   Negative correlation is where a negative correlation occurs when changes between one variable are followed by other variables in the opposite direction. This means that if one variable increases, the other variables tend to decrease. The result of the correlation calculation is close to -1 or $-1 < r < 0$.

3. Zero Correlation

   Zero correlation is where there is no correlation between variables. The closeness of correlation can be grouped as follows:

   1. 0.00 - 0.20 correlation has a very weak correlation.
   2. 0.21 - 0.40 correlation has a weak correlation.
   3. 0.41 - 0.70 correlation has a strong closeness.
   4. 0.41 - 0.90 correlation has a very strong correlation.

5. 0.91 - 0.99 correlation has a very strong correlation

6. 1 correlation has perfect closeness.

Multiple Linear Regression Test

H_0 : there is no significant relationship between harvested area, amount of rainfall, and productivity to the level of lowland rice production.

H_1: there is a significant relationship between harvested area, the amount of rainfall and productivity on the level of lowland rice production.

With a significant degree $\alpha = 0,05$

$$F = \frac{\frac{JK_{reg}}{k}}{\frac{JK_{res}}{(n-k-1)}}$$

Multiple Linear Regression Coefficient Test

$\hat{y} = 556,943 - 3,929x_1 + 4,804x_2 + 0,108x_3$

$H_0 : b_i = 0$ where i = 1,2,…, k (the independent variable X has no effect on Y)

$H_1: b_i \neq 0$ where i = 1,2,…, k (the independent variable X affects Y)

Testing Criteria:

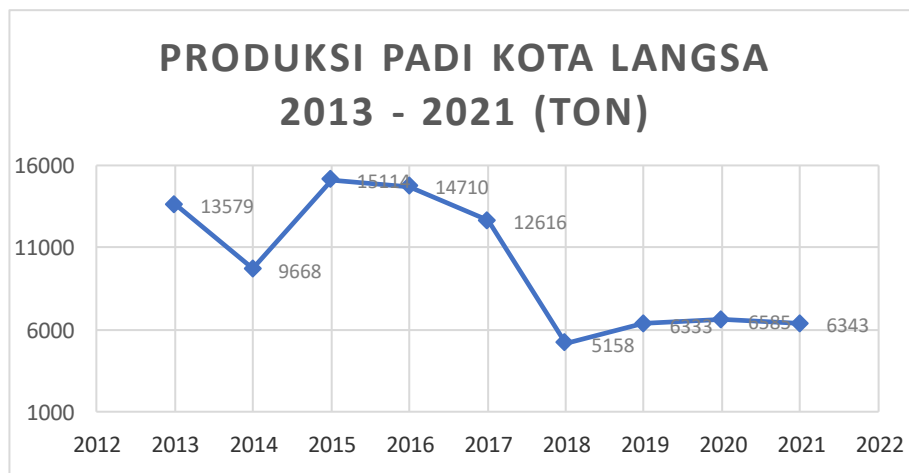Accept H_0 if $t_{hitung} < t_{tabel}$

Reject H_0 if $t_{hitung} > t_{tabel}$

RESULT AND DISCUSSION

Data Description

Figure 1 shows the amount of rice production in Langsa City in 2013 – 2021. The highest rice production in 2015 was 15,114 tons and the least in 2018 was 5,158.

Figure 1. Graph of Rice Production in Langsa City 2013 -2021 (Tons)

Multiple Linear Regression Equation

To model the factors that affect rice production, first look for parameter estimates b_0, b_1, b_2, b_3. So that the estimation of the multiple linear equation is as follows:

$$\hat{y} = \hat{b}_0 + \hat{b}_1 x_1 + \hat{b}_2 x_2 + \hat{b}_3 x_3$$

Y = Rice Production

x_1 = Productivity

x_2 = Harvest Area

x_3 = Rainfall

Table 1. Results of parameter estimation and parameter testing of multiple linear regression equations

Parameter	Estimate $\hat{b}$	Std. Error	Significant Value
Constant	556,943	2088,353	0,800
X1	-3.929	2,791	0,218
X2	4,804	0,479	0,000
X3	0,108	0,379	0,787

Then the multiple linear regression equation is:

$$\hat{y} = \hat{b}_0 + \hat{b}_1 x_1 + \hat{b}_2 x_2 + \hat{b}_3 x_3$$
$$\hat{y} = 556{,}943 - 3{,}929 x_1 + 4{,}804 x_2 + 0{,}108 x_3$$

Based on the table, the constant value is obtained which states that if there is harvested area, rice productivity, and rainfall, the level of rice production is 556.943. Regression coefficient value x_1 states that for every 1 ha/ton reduction in rice productivity, there will be a decrease in rice production of 3,929 tons. Regression coefficient value x_2 states that if every 1 hectare of harvested area is added, there will be an increase in the production of total rice production of 4,804 tons. Regression coefficient value x_3 states that if every 1 mm increase in the amount of rainfall, there is an increase in rice production of 0,108 tons.

Estimation Standard Error

Then the formula for calculating the standard error of estimation is as follows:

$$s_{y.123}^2 = \frac{\Sigma(Y - \hat{Y})^2}{n - k - 1}$$

yi = actual data value

$\hat{y}$ = estimated value

n   = sample size

k   = size of independent variable

Table 2. Estimated values obtained from multiple linear regression equations to calculate the standard error of estimation

Year	Y	$\hat{y}$	$(y - \hat{y})$	$(y - \hat{y})^2$
2013	13579	16654,05	-3075,05	9455932,5
2014	9668	11862,2	-2194,2	4814513,64
2015	15114	14916,94	197,06	38832,6
2016	14710	15563,5	-853,5	728462,3
2017	12616	13468,5	-852,5	726756,3
2018	5158	6561,6	-1403,6	1970092,96
2019	6333	8119,98	-1786,98	3193297,52
2020	6568	8387,2	-1819,2	3309488,64
2021	6343	8116,9	-1773,9	3146721,21
Σ	**90089**	**103650,9**	**-13561,9**	**27384097,17**

$$s^2_{y.123} = \frac{\Sigma(Y - \hat{Y})^2}{n - k - 1}$$

$$s^2_{y.123} = \frac{27384097,17}{8 - 3 - 1} = 6846024,3$$

With the standard error of estimation obtained, it states that the actual average rice production will deviate from the estimated rice production of $6846024,3$.

Coefficient of Determination

So R^2 can be calculated using the following formula:

$$R^2 = \frac{\Sigma(\hat{y}_i - \bar{y})^2}{\Sigma(y_i - \bar{y})^2}$$

Table 3. Calculation $\hat{y}$ Determinant Coefficient

R	R Square	*Adjusted R Square*	*Std. Error*
0,981	0,963	0,940	987,46

Then the value of the coefficient of determination is obtained R^2 is as follows:

$$R^2 = 0,963$$

Obtained value R^2 between harvested area, amount of rainfall, and rice productivity is 0,963. It is stated that through multiple linear regression about 96% of rice production can be determined by harvested area, amount of rainfall, and area of productivity.

And for the multiple correlation coefficient values are as follows:

$$R = \sqrt{R^2}$$
$$R = 0,981$$

From the calculation results obtained correlation (R) between harvested area, amount of rainfall, and rice productivity is 0,981. It is stated that 98% of production is influenced by the 3 factors analyzed, and the remaining 2% is influenced by other factors.

Correlation coefficient

Table 4. Calculation Correlation coefficient

	Y	X1	X2	X3
Y	1,000	-0,363	0,973	-0,274
X1	-0,363	1,000	-0,248	-0,017
X2	0,973	-0,248	1,000	-0,318
X3	-0,274	-0,17	-0,318	1,000

To calculate the correlation coefficient between the dependent variable y with each of the three independent variables X_1, X_2, dan X_3 that is:

1. Correlation coefficient between rice production (y) and productivity (X_1)

$$r_{yx_1} = \frac{n \, \Sigma x_{1i} y_i - \Sigma x_{1i} \Sigma y_i}{\sqrt{\{n \, \Sigma x_{1i}^2 - (\Sigma x_{1i})^2\}\{n \, \Sigma y_i^2 - (\Sigma y_i)^2\}}}$$

$$= -0,363$$

The correlation coefficient between rice production (y) and productivity (X_1) is -0.363 indicating a negative correlation. The higher the productivity, the lower the amount of rice production. On the other hand, the lower the productivity, the higher the rice production.

2. The correlation coefficient between rice production (y) and harvested area (X_2).

$$r_{yx_2} = \frac{n \, \Sigma x_{2i} y_i - \Sigma x_{2i} \Sigma y_i}{\sqrt{\{n \, \Sigma x_{2i}^2 - (\Sigma x_{2i})^2\}\{n \, \Sigma y_i^2 - (\Sigma y_i)^2\}}}$$

$$= 0,973$$

The correlation coefficient between rice production (y) and harvested area (X_2) is 0.973 indicating a positive correlation and has a very strong relationship. If the harvested area is increased, it will increase rice production. Conversely, if the harvested area decreases, the level of rice production also decreases.

3. The correlation coefficient between production (y) and rainfall (X_3).

$$r_{yx_3} = \frac{n \, \Sigma x_{3i} y_i - \Sigma x_{3i} \Sigma y_i}{\sqrt{\{n \, \Sigma x_{3i}^2 - (\Sigma x_{3i})^2\}\{n \, \Sigma y_i^2 - (\Sigma y_i)^2\}}}$$

$$= -0{,}274$$

Correlation coefficient between rice production (y) andrainfall (X_3)is -0.274 indicating a negative correlation. The higher the rainfall, the lower the amount of rice production. On the other hand, the lower the rainfall, the higher the rice production.

Calculation of Correlation between Independent Variables

1. The correlation coefficient between productivity (X_1) with harvested area (X_2).

$$r_{x_1 x_2} = \frac{n \, \Sigma x_{1i} x_{2i} - \Sigma x_{1i} \Sigma x_{2i}}{\sqrt{\{n \, \Sigma x_{1i}^2 - (\Sigma x_{1i})^2\}\{n \, \Sigma x_{2i}^2 - (\Sigma x_{2i})^2\}}}$$

$$= -0{,}248$$

2. The correlation coefficient between productivity (X_1) with rainfall (X_3).

$$r_{x_1 x_3} = \frac{n \, \Sigma x_{1i} x_{3i} - \Sigma x_{1i} \Sigma x_{3i}}{\sqrt{\{n \, \Sigma x_{1i}^2 - (\Sigma x_{1i})^2\}\{n \, \Sigma x_{3i}^2 - (\Sigma x_{3i})^2\}}}$$

$$= -0{,}017$$

3. The correlation coefficient between harvested area (X_2) with rainfall (X_3).

$$r_{x_2 x_3} = \frac{n \, \Sigma x_{2i} x_{3i} - \Sigma x_{2i} \Sigma x_{3i}}{\sqrt{\{n \, \Sigma x_{2i}^2 - (\Sigma x_{2i})^2\}\{n \, \Sigma x_{3i}^2 - (\Sigma x_{3i})^2\}}}$$

$$= -0{,}318$$

Multiple Linear Regression Test

With a significant degree$\alpha = 0{,}05$

$$F = \frac{\dfrac{JK_{reg}}{k}}{\dfrac{JK_{res}}{(n - k - 1)}}$$

$$= \frac{\dfrac{1.108.716.828,1}{3}}{\dfrac{27.384.097,2}{(9-3-1)}}$$

$$= \frac{369.572.276}{6.846.024,3} = 54$$

Test criteria: H_0 rejected when $F \geq F_{\alpha\,3,4}$

Because $54 \geq F_{0,05\,3,4} = 6{,}59$ so H_0 rejected and H_1 received. This means that there is a significant relationship between harvested area, amount of rainfall and productivity on rice production.

Multiple Linear Regression Coefficient Test

From the previous calculations obtained:

$s^2_{y.123} = 6846024{,}3$ $\Sigma x_1^2 = 175{,}66$ $\Sigma x_2^2 = 50289302$

$\Sigma x_3^2 = 43762318$ $r_{x_1 x_2} = -0{,}248$ $r_{x_1 x_3} = -0{,}017$

$r_{x_2 x_3} = -0{,}318$

Then the estimate error is: b_i

$$Sb_i = \sqrt{\frac{s^2_{y.12...k}}{(\Sigma x_1^2)(1 - R_1^2)}}$$

$$= \sqrt{\frac{6846024{,}3}{(175{,}66)(1 - 0{,}061504)}}$$

$$= 203{,}78$$

$$Sb_2 = \sqrt{\frac{s^2_{y.12...k}}{(\Sigma x_2^2)(1 - R_2^2)}}$$

$$= \sqrt{\frac{6846024{,}3}{(50289302)(1 - 0{,}000289)}}$$

$$= 0{,}369$$

$$Sb_3 = \sqrt{\frac{s^2_{y.12...k}}{(\Sigma x_3^2)(1 - R_3^2)}}$$

$$= \sqrt{\frac{6846024{,}3}{(43762318)(1 - 0{,}101124)}}$$

$$= 1{,}32$$

So that the distribution is obtained as follows : t_i

$$t_1 = \frac{b_1}{sb_1}$$

$$= \frac{-3,929}{203,78}$$

$$= -0,02$$

$$t_2 = \frac{b_2}{sb_2}$$

$$= \frac{4,804}{0,369}$$

$$= 12,13$$

$$t_3 = \frac{b_3}{sb_3}$$

$$= \frac{0,108}{1,32}$$

$$= 0,081$$

From the above calculation results obtained: 2.776

1. $t_1 = -0,02 < t_{tabel} = 2,776$
2. $t_2 = 12,13 > t_{tabel} = 2,776$
3. $t_1 = 0,081 < t_{tabel} = 2,776$

So that obtained from the three coefficients (Productivity) has no effect on the level of rice production, (Harvest Area) has an effect on the level of rice production, and (Rainfall) has no effect on the level of rice production $X_1 X_2 X_3$.

Classic assumption test

Multicollinearity Test

Multicollinearity test is used to determine the correlation between variables using VIF. If the VIF value is < 10, then it is free from multicollinearity problems and if the VIF is > 10, there will be multicollinearity problems (Mahdiana and Amin, 2020).

Table 5. Multicollinearity Test

Model		Unstandardized Coefficients		Standardized Coefficients				Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Tolerance	VIF
1	(Constant)	-468,941	3705.502		-127	.904		
	x1	-4.051	2,753	-130	-1.472	.201	.937	1.067
	x2	4.696	.473	.928	9.937	.000	.843	1.186
	x3	.959	2,303	.038	.416	.694	.897	1.115

a. Dependent Variable: y

Based on the results of the multicollinearity test, the VIF value of the variable productivity, harvested area and rainfall < 10 with a value of $1.067 < 10$; $1.186 < 10$; $1.115 < 10$. It can be concluded that there is no multicollinearity in this study.

Heteroscedasticity Test

Heteroscedasticity test to determine whether there are deviations in the classical assumptions. Heteroscedasticity test in this study uses the scatter plot method by observing the points on the image pattern. If the points in the image spread on the number 0 on the Y axis and do not form a certain pattern, it can be said that there is no heteroscedasticity in the regression model. To strengthen the results, the Spearman's rho test was carried out by looking at the significance value (Sig.) > 0.05 to state that there were no symptoms of heteroscedasticity in the regression model.
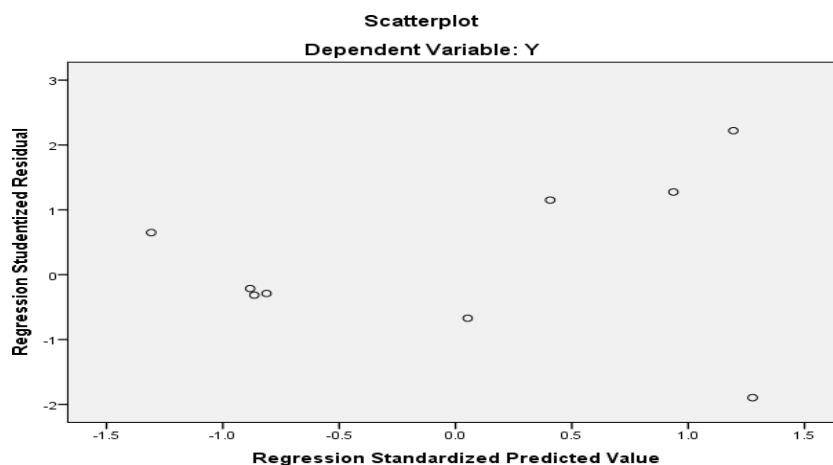
Figure 2. Heteroscedasticity Test

From the results of the scatterplot image above, the points spread below and above the Y axis, do not have a regular pattern. So it can be concluded that the independent variable above does not occur heteroscedasticity or homoscedasticity.

Autocorrelation Test

Autocorrelation test aims to find out whether there is a correlation between the independent variable and the dependent variable. To see the presence of autocorrelation, the Durbin Watson test was used by looking at the location of the regression value between dU and 4-dU, so it can be stated that there is no autocorrelation in the regression model.

Table 6. **Autocorrelation Test**

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.981[a]	.963	.940	987.46381	.579

a. Predictors: (Constant), X3, X1, X2
b. Dependent Variable: Y

From the results above, it can be concluded that there is no autocorrelation of this regression model because the value of Durbin-Watson is 0.579 > -2.

Normality test

Normality test using the Kolmogolov-Smirnov method with sig > 0.05 where the results can be declared normally distributed or not.

Table 7. **Normality test**

One-Sample Kolmogorov-Smirnov Test		
		Y
N		9
Normal Parameters[a,b]	mean	10009.89
	Std. Deviation	4033,349
Most Extreme	Absolute	.248
Differences	Positive	.248
	negative	-.185
Test Statistics		.248
asymp. Sig. (2-tailed)		.118[c]

a. Test distribution is Normal.

b. Calculated from data.

c. Lilliefors Significance Correction.

From the normality test data using the Kormogolov-Smirnov method, it is known that the sig. (2-tailed) of 0.118 > 0.05. So it can be stated that the data in this study is normally distributed or distributed.

CONCLUSION

Based on the results of the above processing, it can be concluded as follows:

1. From the results of calculations using the formula, the equation for the values of the regression coefficients is obtained as follows:

   $b_0 = 556,943, b_1 = -3,929, b_2 = 4,804, b_3 = 0,108$

   So that the linear regression equation obtained is:

   $\hat{y} = 556,943 - 3,929x_1 + 4,804x_2 + 0,108x_3$

2. In the standard error test, the estimation obtained states that the actual average rice production will deviate from the estimated rice production of .6846024,3

3. The coefficient of determination R between harvested area, amount of rainfall and rice productivity is0.981. This shows that 98% of production is influenced by the 3 factors analyzed and the remaining 2% is influenced by other factors. Due to the very large percentage of the influence of harvested area, rainfall and productivity on rice production, it can be stated that the instability of rice production in the last nine years in Langsa City is caused by these three factors.

4. In the correlation analysis between the independent variables and the dependent variable, a strong correlation occurs between rice production (y) and harvested area (₂) is 0.973. Therefore, it can be stated that harvested area affects rice production.

5. On the results of the multiple linear test with a significant level obtained, it can be concluded that$\alpha = 0,0554 \geq F_{0,05\ 3,4} = 6,59 H_0$ rejected and H_1 received. This means that there is a significant relationship between harvested area, amount of rainfall and productivity on rice production.

6. In the test of multiple linear regression coefficients obtained from three coefficients, namely (Productivity) has no effect on the level of rice production, (Harvest Area) has an effect on the level of rice production, and (Rainfall) has no effect on the level of rice production $X_1 X_2 X_3$.

   The suggestion in this study is that the government must control the price of rice so that there is no significant spike in certain conditions. The government must continue to ensure the availability of rice supplied in Langsa City so that there is no shortage of rice supply considering the demand for rice has increased every year.

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