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Forecasting Palawija Harvest Results In North Aceh Using Multiple Linear Regression Method

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ABSTRACT

The agricultural sector is one sector that is very dominant in people's income in Indonesia because most Indonesians work as farmers. One of the plants that play the most crucial role is the palawija plant. An increase in the amount of production and the harvested area will also increase the amount of harvest produced; therefore, to find out which areas have the potential to become producers of productive secondary crops in North Aceh, one of them is by predicting crop yields using the multiple linear regression method. The dataset used for this research is data on the development of palawija crop intensification in North Aceh Regency from 2017 to 2021, taken from the Department of Agriculture and Food Crops, North Aceh Regency. The multiple linear regression method is implemented by entering actual data. Then the data will be calculated in various stages, starting from determining the value of constants and coefficients using a table helper. After getting the result value, then converted into matrix form A and H to find the determinants A1, A2, A3, and A4. After that, enter it into a linear regression pattern and produce a predictive value of crop yield data for the coming year. Calculations in the linear regression method are taken on soybean yields in the Tanah Jambu Aye sub-district in 2022, ranging from 61.00 tons.

I. Introduction

Indonesia is known as an agrarian country, which means a country that relies on the agricultural sector both as a source of livelihood and as a support for development. Agriculture and plantations in this country are known to be so abundant that they can be exported to several countries. The agricultural sector is one sector that is very dominant in people's income in Indonesia because most Indonesians work as farmers. One of the plants that play the most crucial role is the palawija plant. In general, farmers always cultivate palawija plants as a source of main livelihood and additional livelihood. Palawija is the second agricultural crop after rice which is a staple crop such as beans, tubers, corn, and so on. Palawija plants are also plants that can support the income of the Indonesian people because these plants are plants that are commonly consumed by the wider community. These secondary crops are seasonal crops that wait for the harvest not too long.

North Aceh district is an area suitable for the cultivation of secondary crops with an area of ± 3,296.86 km² and a field area of 22,771 ha, which has the potential to produce very abundant crops. In 2019 corn was the most crop-producing secondary crop in North Aceh, with a total income of 14,647.67 tons, and Nisam sub-district was among the largest producers of crops with a figure of 3,415.83 tons. The second highest yield of secondary crops is occupied by peanuts, with a total yield of 110.63 tons, and the sub-district with the highest yield is still occupied by the Nisam sub-district, with a total income of 38.76 tons. As for the sub-district that produces the minor crop of palawija crops, it is the Paya Bakong sub-district which only produces 5.6 tons with a planting area of 1 hectare (Ha).

Another research was conducted by Fitri Sakinah with the title Forecasting production, harvested area, and price and analysis of spatial integration of peanut markets in Bengkulu province. The result of this study is that the forecasting of peanut production in Bengkulu Province for the future using the most accurate forecasting technique (quadratic trend) has increased every year. Forecasting the

harvested area of peanuts in Bengkulu Province for the future period using the most accurate forecasting technique (quadratic trend) increases yearly. The peanut market in Bengkulu Province has been well integrated into four districts in Bengkulu Province. The districts influencing the price of peanuts are South Bengkulu with North Bengkulu and South Bengkulu with Rejang Lebong..

II. Methods

Research is a testing effort that is carried out carefully and critically to find facts and principles by using systematic steps. Research methods are procedures or steps in obtaining scientific knowledge or science. The research method is a systematic way to organize knowledge. While the research technique is a way to carry out research methods. Research methods usually refer to forms of research.

The steps that the author takes in the process of doing this final project is to use the waterfall method, where the first step is system requirements analysis to system testing.

III. Result and Discussion

In this study, the author will test the Multiple Linear Regression method to predict the yield of secondary crops in the North Aceh district for 2022. This method will calculate crop yield data from 2017 to 2021. The predicted data will be displayed in GIS and later used as knowledge for the Department of Agriculture and Food Crops North Aceh Regency.

For the system to run as expected, the authors collected agricultural data from a survey of the Department of Agriculture and Crops, North Aceh Regency. Obtained data and conclusions as follows:

1. Data on the development of Palawija yields were obtained from 2017 to 2021, namely Soybean, Corn, Peanut, and Green Beans, by calculating planting area (ha), harvested area (ha), productivity (kw/ha), and production (tonnes)).
2. Multiple Linear Regression algorithms will be implemented on data on the development of Palawija crop yields in the North Aceh district.

In this calculation, the author uses data on the yield of Palawija crops from 2017 to 2021. Here the author will take a sample of the yield of one of the secondary crops in 2021.

Table 1. Data on Crop Yields Of Palawija Crops In 2018

No.	Plant Type	Planting Area *(Ha)*	Harvest Area *(Ha)*	Productivity *(Kw/Ha)*	Production *(Ton)*
1	Soya bean	604	222	15,35	340,81
2	Corn	3.281	3.238	51,25	16.596,14
3	Peanuts	84	88	17,56	154,51
4	Mung beans	34	33	15,25	50,31

Table 2. Criteria

Criteria Code	Criteria
X1	Planting Area
X2	Harvest Area
X3	Productivity
Y	Production

To simplify the calculation process, a helper table is used as a reference to determine the value of the constant and multiple linear regression coefficients.

Y	X1	X2	X3	X1Y	X2Y	X3Y	X1X2	X2X3	$X1^2$	$X2^2$	$X3^2$
Σ Y	Σ X1	Σ X2	Σ X3	Σ X1Y	Σ X2Y	Σ X3Y	Σ X1X2	Σ X2X3	$\Sigma X1^2$	$\Sigma X2^2$	$\Sigma X3^2$

Table to find the matrix

$$\begin{Bmatrix} N & \Sigma X1 & \Sigma X2 & \Sigma X3 \\ \Sigma X1 & \Sigma X1^2 & \Sigma X1X2 & \Sigma X1X3 \\ \Sigma X2 & \Sigma X1X2 & \Sigma X2^2 & \Sigma X2X3 \\ \Sigma X3 & \Sigma X1X3 & \Sigma X2X3 & \Sigma X3^2 \end{Bmatrix} \begin{Bmatrix} \Sigma Y \\ \Sigma X1Y \\ \Sigma X2Y \\ \Sigma X3Y \end{Bmatrix}$$

Determination of the parameters of the data processed is planted area (ha), harvested area (ha), productivity (kw/ha), production (tons), percentage of the harvested area (ha), and percentage of production (tonnes). The following is a dataset taken in 2021, which can be seen in the following table:

Table 3. Development Of Green Beans In North Aceh District In 2021

No.	Subdistrict	Planting Area (Ha)	Harvest Area (Ha)	Productivity (Kw/Ha)	Production (Ton)
1	Sawang	3	4	15,26	6,10
2	Nisam	0	0	0	0
3	Nisam Antara	8	7	15,13	10,59
4	Banda Baro	0	0	0	0
5	Kuta Makmur	1	1	15,11	1,51
6	Simpang Keramat	0	0	0	0
7	Syamtalira Bayu	0	0	0	0
8	Geureudong Pase	0	0	0	0
9	Meurah Mulia	0	0	0	0
10	Matangkuli	0	0	0	0
11	Paya Bakong	0	0	0	0
12	Pirak Timu	3	2	15,27	3,05
13	Cot Girek	0	0	0	0
14	Tanah Jambo Aye	0	0	0	0
15	Langkahan	0	0	0	0
16	Seunuddon	0	0	0	0
17	Baktiya	1	1	15,06	1,51
18	Baktiya Barat	0	0	0	0
19	Lhoksukon	0	0	0	0
20	Tanah Luas	0	0	0	0
21	Nibong	0	0	0	0
22	Samudera	0	0	0	0
23	Syamtalira Aron	0	0	0	0
24	Tanah Pasir	0	0	0	0
25	Lapang	0	0	0	0
26	Muara Batu	1	0	0	0
27	Dewantara	0	0	0	0
	Amount	**17**	**15**	**15,18**	**22,77**

Table 4. Of Mung Bean Income Calculation In North Aceh 2021

No.	Subdistrict	Production (TON) Y	Planting Area (Ha) X1	Harvest Area (Ha) X2	Productivity (Kw/Ha) X3	X1Y	X2Y	X3Y	X1X2	X1X3	X2X3	$X1^2$	$X2^2$	$X3^2$
1	Muara Batu	6,10	3	4	15,26	18,31	24,42	93,15	12	45,78	61,04	9	16	232,87
2	Sawang	0,00	0	0	0,00	0,00	0,00	0,00	0	0,00	0,00	0	0	0,00
3	Nisam	10,59	8	7	15,13	84,73	74,14	160,24	56	121,04	105,91	64	49	228,92
4	Nisam Antara	0,00	0	0	0,00	0,00	0,00	0,00	0	0,00	0,00	0	0	0,00
5	Banda Baro	1,51	1	1	15,11	1,51	1,51	22,83	1	15,11	15,11	1	1	228,31
6	Dewantara	0,00	0	0	0,00	0,00	0,00	0,00	0	0,00	0,00	0	0	0,00
7	Kuta Makmur	0,00	0	0	0,00	0,00	0,00	0,00	0	0,00	0,00	0	0	0,00
8	Simpang Kramat	0,00	0	0	0,00	0,00	0,00	0,00	0	0,00	0,00	0	0	0,00
9	Syamtalira Bayu	0,00	0	0	0,00	0,00	0,00	0,00	0	0,00	0,00	0	0	0,00
10	Geureudong Pase	0,00	0	0	0,00	0,00	0,00	0,00	0	0,00	0,00	0	0	0,00
11	Meurah Mulia	0,00	0	0	0,00	0,00	0,00	0,00	0	0,00	0,00	0	0	0,00
12	Samudera	3,05	3	2	15,27	9,16	6,11	46,63	6	45,81	30,54	9	4	233,17
13	Syamtalira Aron	0,00	0	0	0,00	0,00	0,00	0,00	0	0,00	0,00	0	0	0,00
14	Tanah Pasir	0,00	0	0	0,00	0,00	0,00	0,00	0	0,00	0,00	0	0	0,00
15	Lapang	0,00	0	0	0,00	0,00	0,00	0,00	0	0,00	0,00	0	0	0,00
16	Tanah Luas	0,00	0	0	0,00	0,00	0,00	0,00	0	0,00	0,00	0	0	0,00
17	Nibong	1,51	1	1	15,06	1,51	1,51	22,68	1	15,06	15,06	1	1	226,80
18	Matang Kuli	0,00	0	0	0,00	0,00	0,00	0,00	0	0,00	0,00	0	0	0,00
19	Pirak Timu	0,00	0	0	0,00	0,00	0,00	0,00	0	0,00	0,00	0	0	0,00
20	Paya Bakong	0,00	0	0	0,00	0,00	0,00	0,00	0	0,00	0,00	0	0	0,00
21	Lhoksukon	0,00	0	0	0,00	0,00	0,00	0,00	0	0,00	0,00	0	0	0,00
22	Cot Girek	0,00	0	0	0,00	0,00	0,00	0,00	0	0,00	0,00	0	0	0,00
23	Baktiya	0,00	0	0	0,00	0,00	0,00	0,00	0	0,00	0,00	0	0	0,00
24	Baktiya Barat	0,00	0	0	0,00	0,00	0,00	0,00	0	0,00	0,00	0	0	0,00
25	Seunuddon	0,00	0	0	0,00	0,00	0,00	0,00	0	0,00	0,00	0	0	0,00
26	Tanah Jambo Aye	0,00	1	0	0,00	0,00	0,00	0,00	0	0,00	0,00	1	0	0,00
27	Langkahan	0,00	0	0	0,00	0,00	0,00	0,00	0	0,00	0,00	0	0	0,00
	SUM	22,77	17,00	15,00	75,83	115,22	107,68	345,54	76,00	242,80	227,66	85,00	71,00	1150,07

To find (Σ) then we use the helper table as a reference to determine the value of constants and coefficients in multiple linear regression. Then after getting the sum of (Σ) where

ΣY = 22,77
ΣX1 = 17,00
ΣX2 = 15,00
ΣX3 = 75,88
ΣX1Y = 115,22
ΣX2Y = 107,66
ΣX3Y = 345,54
ΣX1X2 = 76,00
ΣX1X3 = 342,80
ΣX2X3 = 227,66
$X1^2$ = 85,00
$X2^2$ = 71,00
$X3^2$ = 1150,07
N =27

When the independent variable is more than 2, the value of the constant and the regression variable of each independent variable can be obtained using the determinant matrix. An example is when there are three equations with three unknown variables, namely Y, X1, X2 & X3; these equations can be expressed in a matrix equation as follows to determine the A and H matrices.

A H

$$\begin{Bmatrix} N & \Sigma X1 & \Sigma X2 & \Sigma X3 \\ \Sigma X1 & \Sigma X1^2 & \Sigma X1X2 & \Sigma X1X3 \\ \Sigma X2 & \Sigma X1X2 & \Sigma X2^2 & \Sigma X2X3 \\ \Sigma X3 & \Sigma X1X3 & \Sigma X2X3 & \Sigma X3^2 \end{Bmatrix} \begin{Bmatrix} \Sigma Y \\ \Sigma X1Y \\ \Sigma X2Y \\ \Sigma X3 \end{Bmatrix}$$

Then the matrices A, A1, A2, A3 and A4 are

DETERMINE MATRIX A H

27	17,00	15,00	75,83	22,77
17,00	85,00	76,00	242,80	115,22
15,00	76,00	71,00	227,66	107,68
75,83	242,80	227,66	1150,07	345,54

Then to determine the A1 matrix, that is by replacing the value of the first column of the A matrix with the H matrix value. While the other column values remain.

DETERMINE MATRIX A1

22,77	17,00	15,00	75,83
115,22	85,00	76,00	242,80
107,68	76,00	71,00	227,66
345,54	242,80	227,66	1150,07

Then to determine the A2 matrix, that is by replacing the value of the second column of the A matrix with the H matrix value. While the other column values remain.

DETERMINE MATRIX A2

27	22,77	15,00	75,83
17,00	115,22	76,00	242,80
15,00	107,68	71,00	227,66
75,83	345,54	227,66	1150,07

Then to determine the A3 matrix, that is by replacing the value of the third column of the A matrix with the H matrix value. While the other column values remain the same.

DETERMINE MATRIX A3

27	17,00	22,77	75,83
17,00	85,00	115,22	242,80
15,00	76,00	107,68	227,66
75,83	242,80	345,54	1150,07

Then to determine the A4 matrix, that is by replacing the value of the fourth column of the A matrix with the H matrix value. While the other column values remain.

DETERMINE MATRIX A4

27	17,00	15,00	22,77
17,00	85,00	76,00	115,22
15,00	76,00	71,00	107,68
75,83	242,80	227,66	345,54

After determining the matrix value of A, A1, A2, A3, and A4, the next step is to determine the determinant of each matrix.

DET A	2362443,072
DET A1	1177,64396
DET A2	-27142,01324
DET A3	3607271,154
DET A4	1370,55915

Then to determine the value of b1 used the formula.

$$b1 = \frac{Det(A1)}{Det(A)}$$

$$b2 = \frac{Det(A2)}{Det(A)}$$

$$b3 = \frac{Det(A3)}{Det(A)}$$

$$b4 = \frac{Det(A4)}{Det(A)}$$

Where b1 = 1177,64396 / 2362443,072 = -0,00515323
b2 = -27142,01324 / 2362443,072 = 0,038957764
b3 = 3607271,154 / 2362443,072 = 1,731493436
b4 = 1370,55915 / 2362443,072 = -0,004049626

from the B value obtained can be processed to obtain a multiple linear regression pattern, the pattern is

Y = b1 + b2 * x1 + b3 * x2 + b4 * x3 or
Y = -0,00515323 + 0,038957764 * X1 + 1,731493436 * X2 + -0,004049626 * X3
Then the pattern obtained will be used to test the yield of the crop in Nisam sub-district with

X1 = 8
X2 = 7
X3 = 15,13

Y = -0,00515323 + 0,038957764 * 8 + 1,731493436 * 7 + -0,004049626 * 15,13
Y = 10,605883 or 10, 61 tons.

Based on the process that has been passed, it can be concluded that the income from the Green Bean crop in 2022 will come in the Nisam sub-district will get an income in the range of 10.61 tons.

IV. Conclusion

The conclusions from the results of the research that the author did are as follows:

1. The multiple linear regression method is implemented by entering actual data. Then the data will be calculated in various stages, starting from determining the value of constants and coefficients using a table helper. After getting the value (Σ) then, converted into matrix form A and H to find the determinants of A1, A2, A3, and A4. linear regression pattern will produce a predictive value for harvest data for the coming year.
2. The calculation in the linear regression method as an example is taken from soybean yields in the Tanah Jambu Aye sub-district in 2021, which ranged from 10.61 tons. Then it is included in the regression calculation, and it is predicted that for the harvest in 2018, the yields will range from 10,605883 tons or 10,61 tons. Based on these data, the accuracy of the linear regression method in Tanah Jambo Aye district is 98.81%.
3. GIS will display the predicted results from the data that has been tested and then will be displayed to find and find out which part of the area produces the most productivity in a calendar year. Based on data that has been predicted using the linear regression method, the largest producer of soybeans in 2018 is in the Nisam sub-district, with a figure of 85.86 tons. As for the results, there are at least 17 sub-districts because the sub-districts did not plant corn that year.

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