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RESEARCH ARTICLE

Application of Cubic Nonlinear Regression on the Effects of Rainfall on Rice Harvest Results

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ABSTRACT

Sukoharjo rice yields fluctuate every year. There is no system used for predicting rice yields in the Sukoharjo region, this results in a lack of information to increase rice production in Sukoharjo Regency.The purpose of this study is to apply the Cubic Nonlinear regression method to predict rice yields in Sukoharjo Regency, taking into account the influence of average rainfall on the prediction of rice yields.The design method uses Unified Model Language (UML), the application is designed with the vb net programming language and sql server database system, testing the functionality using the Black Box Test and testing the validity using MAPE. The calculated data is the 2016 data. The results of the study show predictions in 2017 have a MAPE of $3{,}86565 \times 10^{-12}$. This shows the prediction error rate of $3{,}86565 \times 10^{-10}$ %.Based on the results of the functionality test, 100% of the applications function.

1. INTRODUCTION.

Sukoharjo Regency is one of the food buffer districts in Central Java. There are various food crops produced in Sukoharjo Regency each year. Such as rice, crops, vegetables and fruits. One of the food plants that is continuously being promoted is rice. In 2015 rice productivity reached 75.26 kw/ha, with a production of 374,535 tons and a harvest area of 49,764 ha. Sukoharjo Regency is divided into 12 subdistricts consisting of 167 villages/kelurahan which have 44.60% of paddy fields (20,814 ha) (Abbas,2016).

In an effort to overcome the extreme price increase, it is necessary to have accurate and accurate forecasts about yields in Sukoharjo Regency. there is no system regarding the prediction of rice yields, resulting in no information to increase rice production in Sukoharjo Regency.

In this study prediction of rice yields will be affected by the average rainfall by applying the cubic nonlinear method. Calculation of Mean Absolute Percentage Error (MAPE) becomes a reference for the validity of predictions of rice yields. Making this system is an application that can predict rice yields in Sukoharjo Regency. From this application we can know the prediction of crop yields in the coming year. The results are used as a reference to control the price and stock of rice harvest in Sukoharjo Regency.

2. LITERATURE REVIEW

In a study by Supriyanto (2012) concerning the prediction of harvested area and rice production using the adaptive neuro-fuzzy inference system (ANFIS) method in Banyumas Regency. Based on these studies it can be concluded, harvested area and rice production can be used for forecasting rice production in the following year in Banyumas Regency (Supriyanto, 2012). Another study conducted by Nurudin (2015) used two calculation variables namely rainfall and pests in rice plants. The study was calculated using the Least Square method with prediction results that have a difference that is not adrift far from the original harvest data (Nurudin, 2015). Whereas in a study conducted by Bhuana (2015) rice yields were influenced by three factors namely land area, irrigation and labor (Bhuana, 2015).

Research conducted by Maharani Rositasari in 2015 tested the effect of trust, risk perception, perceived convenience, and perceived benefits on the attitude of purchasing fashion products through an online shop on Facebook. The sampling technique uses Non-Probability Sampling based on Roscoe's opinion, as many as 85 respondents. Multiple linear regression analysis was used to examine the effect of the independent variables on the dependent variable in the study. The results of the study prove that trust, perceived convenience and perceived benefits partially affect the attitude of buying through an online shop. While the perception of risk does not significantly influence the attitude of buying through an online shop. This study has a similarity analysis of the relationship between the dependent variable with the independent variable used with the research to be carried out using multiple linear regression analysis. But the difference lies in the research that will be done is the purchase of an online shop on Instagram social networks while

the previous researchers purchased fashion products on the Facebook social network. In addition, the study conducted by the author uses 35 questionnaire methods.

Azhar Fazhu (2014) conducted a study using five variables influencing the buying decisions of Muslim clothing through online shops, namely consumer perceptions of selling prices, products, services, trust levels, and advertising. The method used is puposive sampling. The analytical tool used is multiple regression. The results showed that all variables together had a significant positive effect on Muslim clothing buying decisions. As for the partial test, only product and advertising variables have a significant positive effect. Variable selling price, service, and level of trust did not significantly influence Muslim buying decisions through online shops. This research has similarities with the theory conducted by the author, but there are differences, namely different research objects and the method used in the study is purposive sampling.

Another research was also conducted by Susilo (2010) which aims to find out the influence of internet technology knowledge on consumer trust, website quality and product quality online shopping motives. The analytical method used is quantitative analysis and qualitative analysis. Hypothesis testing using the t test shows that the four independent variables studied were found to significantly influence the dependent motives of online shopping variables. Then through the F test shows that the four variables are feasible to test the decision of the dependent variable brand displacement. An Adjusted R Square figure of 0.695 indicates that 69.5 percent of the variation in online shopping patterns can be explained by four independent variables in the regression equation. While the rest of 64.9 percent is explained by other variables outside of the four variables used in this study. This research has a difference with the research that the author did, namely the variables used. The author conducts research using price, product, trust, and convenience variables on online shop purchasing decisions.

3. METHODS

3.1 Forecasting

Forecasting is a statement about the future value, of a variable of interest. A good prediction or forecast will be more informative for a decision made. Some types of forecast can be long-term, covering several years or more. While the forecast is short-term forecast is to predict a few weeks or months (Assauri, 2016). Forecasting can be done quantitatively or qualitatively. Quantitative measurement uses statistical methods, while the measurement is qualitatively based on the opinion (judgment) of the forecasters. Forecasting (forecasting) is the art and science of predicting future events (Herjanto, 2015).

3.2 Cubic Nonlinear Regression

Linear analysis is divided into two parts, namely simple regression that only uses one count variable and multiple regression that uses more than one count variable. As for non-linear regression, it can be divided into several parts such as quadratic, cubic, inverse regression (Nawari, 2017). The cubic non linear regression equation model can be described as follows:

$$Y = b_0 + b_1x + b_2x^2 + b_3x^3$$

If the equation is linearized it will be multiple linear with three independent variables, viz

$$Y = b_0 + b_1Z_1 + b_2Z_2 + b_3Z_3$$

with

$$X = Z_1$$
$$X^2 = Z_2$$
$$X^3 = Z_3$$

If expressed in matrix form, the equation will be $Z_tZ_b = Z_tY$.

$$Z = \begin{bmatrix} 1 & Z_{11} & Z_{12} & Z_{13} \\ 1 & Z_{21} & Z_{22} & Z_{23} \\ \dots & \dots & \dots & \dots \\ 1 & Z_{n1} & Z_{n2} & Z_{n3} \end{bmatrix} Y = \begin{bmatrix} Y_1 \\ Y_2 \\ Y_3 \end{bmatrix}$$

With:

N = amount of data

$Z_{11} = X_{11}$ = first rainfall data

$Z_{12} = (X_{11})^2$ = first rainfall data squared

$Z_{13} = (X_{11})^3$ = data of rainfall were first buried

$Z_{n1} = X_{n1}$ = n rainfall data

$Z_{n2} = (X_{n1})^2$ = n rainfall data is squared

$Z_{n3} = (X_{n1})^3$ = n-rainfall datais buried

y = yield data

Thus b can be obtained through the following equation:

$$Z^tZb = Z^tY$$

$$\begin{bmatrix} 1 & 1 & 1 \\ Z_{11}Z_{21}Z_{31} \\ Z_{12}Z_{22}Z_{32} \\ Z_{13}Z_{23}Z_{33} \end{bmatrix} \begin{bmatrix} 1 & Z_{11}Z_{12}Z_{13} \\ 1 & Z_{21}Z_{22}Z_{23} \\ 1 & Z_{31}Z_{32}Z_{33} \end{bmatrix} \begin{bmatrix} b_0 \\ b_1 \\ b_2 \\ b_3 \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 \\ Z_{11}Z_{21}Z_{31} \\ Z_{12}Z_{22}Z_{32} \\ Z_{13}Z_{23}Z_{33} \end{bmatrix} \begin{bmatrix} Y_1 \\ Y_2 \\ Y_3 \end{bmatrix}$$

Variables X, X^2, X^3 which have been changed to Z_1, Z_2, Z_3 are entered into the equation to form the following equation:

$$\begin{bmatrix} 1 & 1 & 1 \\ Z_{11}Z_{21}Z_{31} \\ Z_{12}Z_{22}Z_{32} \\ Z_{13}Z_{23}Z_{33} \end{bmatrix} \begin{bmatrix} 1 & Z_{11}Z_{12}Z_{13} \\ 1 & Z_{21}Z_{22}Z_{23} \\ 1 & Z_{31}Z_{32}Z_{33} \end{bmatrix} \begin{bmatrix} b_0 \\ b_1 \\ b_2 \\ b_3 \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 \\ Z_{11}Z_{21}Z_{31} \\ Z_{12}Z_{22}Z_{32} \\ Z_{13}Z_{23}Z_{33} \end{bmatrix} \begin{bmatrix} Y_1 \\ Y_2 \\ Y_3 \end{bmatrix}$$

Will be obtained:

$$\begin{bmatrix} \sum^n_{Z_{1i}} & \sum Z_{1i} & \sum Z_{2i} & \sum Z_{3i} \\ \sum Z_{2i} & \sum (Z_{1i})^2 & \sum (Z_{2i}Z_{1i}) & \sum (Z_{1i}Z_{1i}) \\ \sum Z_{3i} & \sum (Z_{2i}Z_{1i}) & \sum (Z_{2i})^2 & \sum (Z_{2i}Z_{3i}) \\ & \sum (Z_{3i}Z_{1i}) & \sum (Z_{3i}Z_{2i}) & \sum (Z_{3i})^2 \end{bmatrix} \begin{bmatrix} b_0 \\ b_1 \\ b_2 \\ b_3 \end{bmatrix} = \begin{bmatrix} \sum ZY_i \\ \sum Z_{1i}Y_i \\ \sum Z_{2i}Y_i \\ \sum Z_{3i}Y_i \end{bmatrix}$$

With:

Z: rainfall variable

Y: rice yields

b_0, b_1, b_2, b_3: regression coefficients

3.3 Determination of Methods and Variables

There are various research methods, calculation of prediction of rice yield, such as Trend Least Square, GARCH, Moving Average, Linear and Nonlinear Regression. There are various calculation variables such as the area of agricultural land, the location of the area, the height of the land, fertilizer and so forth. In this study the variables used are irrigation and average rainfall, while the prediction method uses the Cubic Nonlinear method. The method is used because of the nonlinear relationship between the independent and dependent variables.

This happens because the rate of change of the dependent variable is not constant with the rate of change of the independent

variable. this happens for the value of certain independent variables. Therefore the irrigation variable and the average rainfall are chosen to calculate the predicted rice yield, because the higher the average rainfall or the wider irrigation does not necessarily make rice yields increase. The system analysis and design stage determines the system design that will be created, based on the proposed design and system analysis that has been carried out.

3.4 Data Sources, Development, and System Design

The data used in research on the prediction of rice yields is the average rainfall and irrigation data and rice yields obtained from the Agriculture Office of Sukoharjo Regency. System development method used is the waterfall method. The waterfall method has several sequential stages, namely: reqirement (needs analysis), system design (system design), coding (coding) & testing (testing), and maintenance. The system design uses Unified Model Language (UML). UML is a visual language for modeling and communication about a system by using diagrams and supporting texts to specify, describe, construct, and document the software system. UML consists of 4 types of diagrams, namely Use Case Diagrams, Activity Diagrams, Classes Diagrams, and Sequence Diagrams.

4. RESULTS AND DISCUSSION

4.1 Manual Calculation

To calculate the values of b_0, b_1, b_2, b_3can be done by entering Z_1, Z_2, Z_3into the matrix equation. The calculated data is entered into the initial matrix. From this matrix produces the following values b_0, b_1, b_2, b_3

$$\begin{bmatrix} 12 & 142{,}59 & 1748{,}11 & 22164{,}99 \\ 142{,}59 & 1748{,}11 & 22164{,}99 & 291174{,}36 \\ 1748{,}11 & 22164{,}99 & 291174{,}36 & 3965873{,}5 \\ 22164{,}99 & 291174{,}36 & 3965873{,}5 & 55996957{,}59 \end{bmatrix} \begin{bmatrix} b_0 \\ b_1 \\ b_2 \\ b_3 \end{bmatrix} = \begin{bmatrix} 353884 \\ 4306704{,}34 \\ 54570892{,}15 \\ 720794065 \end{bmatrix}$$

A value of b that has been found can be used to calculate predictions of rice yield based on average rainfall with calculations

$$Y = b_0 + b_1 Z_1 + b_2 Z_2 + b_3 Z_3 \quad (1)$$

The following results from calculations are shown in Figure 1

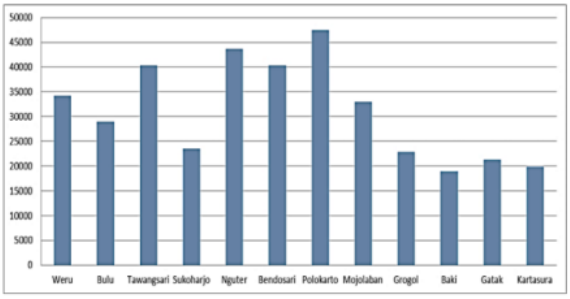

Figure 1. Calculation Results with Average Rainfall Models

By the same calculation, the following results in finding the values of $b_0, b_1, b_2, b_3$with Average Rainfall data.

$$\begin{bmatrix} -4845{,}266533 \\ 47{,}84285097 \\ -0{,}013722152 \\ 8{,}23129\text{E}-07 \end{bmatrix} = \begin{bmatrix} b_0 \\ b_1 \\ b_2 \\ b_3 \end{bmatrix}$$

4.2 Mean Absolute Percentage Error (MAPE)

Expressed in the form of an average absolute percentage of error. The equation used is as follows.

$$MAPE = \frac{1}{n}\sum \frac{(y - \hat{y})}{y} \times 100\% \quad (2)$$

With
y = actual data
$\hat{y}$ = predictive data
n = amount of data

As for the average rainfall model as follows MAPE = $3{,}86565 \times 10^{-12}$

4.3 Implementation

To develop the system a user interface is created. There are five forms in the application of rice harvest prediction. Namely Initial Display, Input Data Display, Calculation Display b_0, b_1, b_2, b_3, Display Prediction Calculation and MSE Error Value Form.

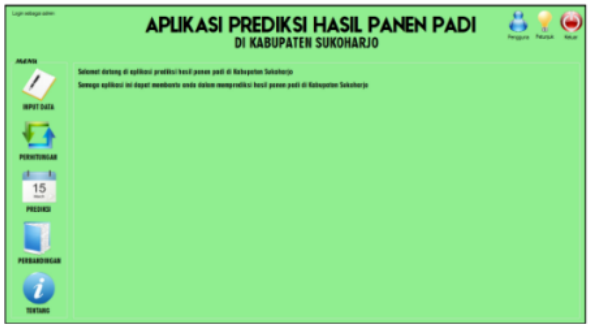

Figure 1. Initial Display

Data Input Display

Figure 2. Initial Data Input

Display Calculation b_0, b_1, b_2, b_3

Figure 3. Calculation of b_0, b_1, b_2, b_3

Prediction Calculation Display

Figure 4 Prediction Calculation Results

Black Box Testing is a test conducted on the software display, and is used to demonstrate the function of the software being operated, whether the input is received correctly, and the output is correct.

Login, When starting the application a login page will appear, only users, both admin and user, can fill out the form containing the user name and password. It will appear like Figure 5.

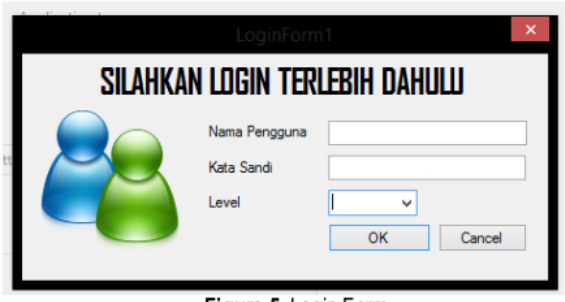

Figure 5. Login Form

If it contains a username and password not filled in, a message box will appear like Figure 6.

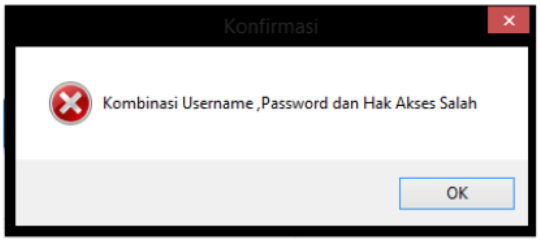

Figure 6. Username Message Box, Incorrect Password

Data Input, When the user saves the data in the initial data input form and one of the data is still empty then a message box will appear as in figure 7

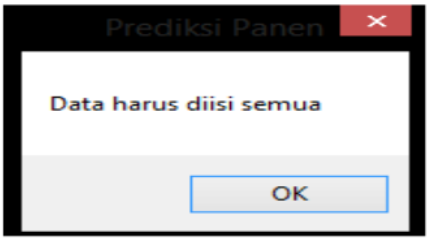

Figure 7. The message box appears if there is empty data

Prediction Calculation, If the user has not entered data to be counted or there is still data blank. A message box will appear as in Figure 8.

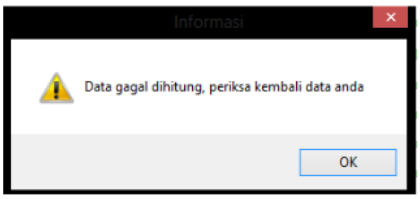

Figure 8. Failure to calculate Data

If the user is correct in entering data. Then the data will appear on the form as shown in Figure 9.

Figure 9. Prediction Data Appears

Error Value, When the user has not calculated the predicted results, a message box will appear as shown in Figure 10.

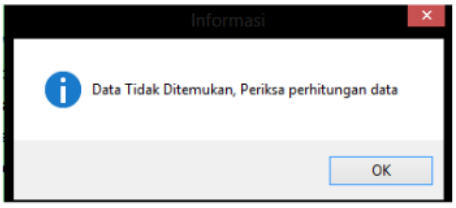

Figure 10. Prediction Results Not Calculated

If the user has calculated the prediction results, then the data will appear in the Error Value form as shown in Figure 11. And will appear suggestions for farmers in each region that has increased or decreased rice yields as shown in Figure 12.

Figure 11. Data Successfully Calculated

Figure 12. Suggestions for farmers

5. CONCLUSION

Based on research that has been done, it can be concluded as follows. The results of the manual calculation and calculation of the application of the Cubic Nonlinear method of irrigation models produce MAPE of $3{,}86565 \times 10^{-10}$ %. The value of the MAPE produced includes a small MAPE value because it is less than 10, so this method is suitable for predicting rice yields. Applications made with the vb net programming language use Cubic Nonlinear calculations. In future studies, we can try to use different variables and methods and with a larger amount of data. The program created is still static which can only compare two kinds of variables

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