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Rainfall Prediction Information System in Jombang Regency Using the Fuzzy Time Series Method

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Abstract

Weather and climate information is very important for some people to support life. In agriculture, for example, climate change has a major effect on changing planting patterns. Fuzzy Time Series (FTS), Rainfall prediction is used to understand the intensity of future rainfall that serves as a reference in making the right decisions and preparing to address future problems. In this study using the Fuzzy Time Series (FTS), this method can be used to solve forecasting problems with linguistic historical data and real numbers by converting the real number data into linguistic variables. The results of this study are a website-based system that can predict rainfall in the coming year by using previous rainfall history data as a reference for prediction calculations.

Keywords: *prediction; rainy; fuzzy time series; website*

INTRODUCTION

Rainfall is one of the biggest factors that affect the climate of a region and affects various sectors of human life. In agriculture, for example, climate change has a major impact on changing cropping patterns. Agricultural production requires good climatic conditions so that the production of crops can produce good results. However, the uncertain climate change resulted in a decrease in agricultural production yields, causing farmers to experience crop failure.

In the series of weather and climate information, the component that plays a very large role is rainfall. Rainfall can be described as rainwater that falls and on a flat place with conditions that do not evaporate, do not seep, and do not flow. In a unit of rainfall as much as 1 mm is referred to as rain water which has a height of 1. mm which falls on a flat area of 1. m2 with conditions that do not evaporate, do not seep, and do not flow. Climatic classification can be done from the comparison between the total average dry month and the number of wet months. It is called a dry month if the average monthly rainfall is less than 60 mm/month, while it is called a wet month if the average monthly rainfall is above 100 mm/month (Manalu, 2016).

The topography of Jombang Regency makes rain a very important thing, especially if the intensity of high rainfall will have an impact that can cause flooding. In estimating rainfall, it really depends on the month, because there are two seasons, namely dry and rainy seasons (Ritha, et al. 2016). But lately, rainfall is increasingly difficult to predict, for this reason it is necessary to estimate rainfall that produces high accuracy based on previous data to prevent this effect by taking preventive measures.

This study has the aim of producing a prediction of monthly rainfall in Jombang district which is obtained through a prediction calculation process using previous (historical) data. In this study, the author uses the FTS (fuzzy time series) method in determining the results of rainfall predictions. There are 5 criteria for rainfall intensity, namely very light, light, moderate, heavy rain and very heavy rain. The data used is Jombang Regency rainfall data from 2014 to 2019.

Wahyuni and Ahda have conducted a rainfall prediction research using the Tsukamoto Fuzzy Inference System (FIS) method. The study used rainfall baseline data as input data. The Root Mean Square Error (RMSE) value obtained in the Junggo area is 9,196, in the Pujon area of 9,407, in the Tinjomulyo area of 8,798, in the Ngujung area of 8,825 (Wahyuni and Ahda, 2018). Another study using the Fuzzy Time Series method was conducted by Lestari et al, regarding the use of the Fuzzy Time Series method to predict the yield of rice production in Majalengka district. The results of the tests in this study showed that the forecasting accuracy value reached 95.76% and the results of forecasting forecasting in 2017 obtained rice production of 677943.6 tons (Lestari et al, 2017). In the calculation of the Fuzzy Time Series method, it is strongly influenced by the amount of data and the number of intervals in dividing the data. From the several studies above, the most accurate method is the Fuzzy Time Series method which has a forecasting accuracy of 95.76% in predicting rice production, therefore by applying the fuzzy time series method to predict rainfall in Jombang district, it is expected to be able to predict rainfall which produces a high level of rainfall. good accuracy.

LITERATURE REVIEW

Prediction

Prediction (forecasting) is an attempt to predict or predict something that will happen in the future by utilizing various relevant information at previous times (historical) through a scientific method. The purpose of prediction is to get information about what

will happen in the future with the greatest probability of occurrence (Wanto and Windarto, 2017). Prediction or forecasting can be done by involving taking historical data and projecting it into the future with a form of mathematical model (Brata, 2016).

Forecasting method is a way of quantitatively forecasting what will happen in the future based on relevant data in the past. The choice of forecasting method is very useful because it will help in conducting an analytical approach to past behavior or patterns, so that it can provide a systematic and pragmatic way of thinking, working or solving problems, and providing a greater level of confidence or accuracy of the results of the forecasts made. . Forecasting is usually classified based on the future time horizon it covers, and time is divided into 3 categories, including (Heizer, 2006).

1. Short-term forecasting where this forecast covers a period of up to 1 year but generally less than 3 months. This short-term forecast is used, among others: to plan the level of production, purchasing, work scheduling, and the number of workers.
2. Medium-term forecasting which generally covers a monthly count of up to 3 years. Medium-term forecasting is commonly used for sales planning, production planning and budgeting, cash budgeting, and analyzing various operating plans.
3. Long-term forecasting is generally for a planning period of 3 years or more. Long-term forecasting is usually used to plan new products or purchases.

Rainfall

Rain is water that falls to the earth because the water droplets that are accommodated in the clouds or in the air exceed the capacity of the clouds. While the notion of rainfall is rainwater that is accommodated and measured on a surface with an area of 1 square meter (m2). Rainfall uses units of millimeters (mm), so 1 mm rainfall means that rainwater collects in an area of 1 m2 with a water depth or height of 1 mm. Rainfall measured less than 0.1 mm will be recorded as 0 (Trianandi et al, 2018). Rain intensity is the amount of rainfall per unit period of time.

The Meteorology, Climatology and Geophysics Agency (BMKG) divides the criteria for rainfall intensity into 5 categories, namely (Carolina, 2019):

a. Very light rain with an intensity of 0-5 mm/day

b. Light rain with an intensity of 5-20 mm/day

c. Moderate rain with an intensity of 20-50 mm/day

d. Heavy rain with an intensity of 50-100 mm/day

e. Very heavy rain with intensity > 100 mm/day

Data Mining

Data Mining is a data processing method to find hidden patterns from the data. The results of data processing with this data mining method can be used to make decisions in the future. Data mining is also known as pattern recognition. Data mining is a large-scale data processing method, therefore data mining has an important role in the fields of industry, finance, weather, science and technology. In general, data mining studies discuss methods such as clustering, classification, regression, variable selection and market basket analysis (Vulandari, 2016).

It can be concluded in general that data mining is an activity of data analysis to look for a certain pattern, with a large amount of data and aims to produce information that can be used and developed further.

Time Series Data

Time Series data or periodic data is data collected from time to time, to describe the development of an activity. Periodic data analysis allows us to know the development of one or more events and their relationship/influence on other events. Data movement patterns or variable values can be followed or known by the presence of periodic data, so that periodic data can be used as a basis for decision making, forecasting future trade and economic conditions, as well as planning future activities (Halimi and Wahyu, 2007). 2018).

Meanwhile, according to Anwary in Fyanda et al, Periodic data (Time Series) is data that is arranged in a time sequence or data collected from time to time. The time used can be in the form of days, weeks, months, years, and so on. Thus, periodic data relates to statistical data recorded and investigated within certain time intervals, such as sales, prices, inventories, labor production, exchange rates (exchange rates), and stock prices (Fyanda et al, 2016).

A time series is a set of observations in which the variables used are measured in order of time periods, such as yearly, monthly, quarterly, and so on. With time series data, data movement patterns or variable values can be followed or known. Thus, time series data can be used as a basis for (Fyanda et al, 2016):

a.Decision making at this point

b. Forecasting the state of trade and the economy in the future.

c. Planning activities for the future.

Fuzzy Time Series

Fuzzy time series can predict product need for the next period and this prediction can be arranged based on time period needed. By integrating fuzzy time series to an information system to calculate ROP score of each product, the error average of ROP score got after being examined by using method of Average Forecasting Error Rate (AFER) was 7.13%. Fuzzy times series can predict the number of stock needed in stock room, report stock availability, and give goods stock information so high economy efficiency is got (Mashuri et al., 2018)

The fuzzy time series method is a forecasting concept proposed by Song and Chissom in 1993 by applying the concept of fuzzy logic to develop the basis of fuzzy time series using time invariant and time variant methods used to model forecasting the number of applicants at the University of Alabama (Lestari et al., 2017). Fuzzy time series can be used to solve forecasting problems with historical data in the form of linguistics and real numbers by converting the real number data into linguistic variables.

FTS is a data forecasting method that uses fuzzy principles as its basis. Roughly, a fuzzy set can be defined as a class of numbers with vague boundaries. If the universe of discourse

(U) is the universal set, U= [u1, u2, u3……up], then a fuzzy set from U with membership degrees is generally stated as follows (Rahmawati et al., 2019):

Ai = Ai (u1) / u1 +…+ Wha (up) /up

where Ai (ui) is the degree of membership from to, ui to Ai where Ai (ui) [0,1] and 1 i p. The membership degree value of Ai (ui) is determined according to the following rules:

Rule 1: If the actual data Xt is included in ui, then the degree of membership for ui is 1, and ui+1 is 0.5 and if not ui and ui+1, it is declared zero.

Rule 2: If the actual data Xt belongs to ui, 1≤ i p then the degree of membership for ui is 1, for ui-1 and ui+1 is 0.5 and if not ui, ui-1, and ui+1 are stated zero.

Rule 3: If the actual data Xt is included in ui , then the degree of membership for ui is 1, and for ui-1 is 0.5 and if not ui and ui-1 it is declared zero.

RESEARCH METHOD

In predicting there are various methods used, the selection of the right method will have a major effect on the results to the accuracy of predictions. One of the prediction methods is Fuzzy Time Series (FTS) which will be used in this research. Fuzzy Time Series aims to be used as a method for forecasting problems with actual data formed into linguistic values. (Sumartini et al, 2017).

The following are the steps for calculating time series data predictions using FTS Cheng (Rahmawati et al, 2019):

a. Calculating the h. universal set (U) of the actual data, namely (Rahmawati et al, 2019):

$$U = [d_{min}, d_{max}]$$

Where d_{min} is the data with the smallest value, d_{max} is the data with the largest value.

b. Use the frequency distribution to determine the width of the interval, with the following steps:

1. Calculate the range (range) with the following formula:

$$R = [d_{max}, d_{min}]$$

Where R is the range value resulting from the reduction of the largest value data d_{max} minus the smallest value data d_{min} .

2. Calculating class intervals with the Sturges equation with the formulafollowing: $K = 1 + 3.322\ x \log n$

K is the number of intervals and n is the number of data.

3. Calculate the width of the interval with the following formula:

$$\text{I} = \frac{Range\ Data\ (R)}{Number\ of\ class\ intervals\ (K)}$$

4. Finding the middle value. The formula is as follows:

$$\text{mi} = \frac{Lower\ Limit + Upper\ Limit}{2}$$

Where i is called the number of fuzzy sets.

c. After getting the range value, class interval value, interval width, and middle value then form a fuzzy group A_i by knowing the number of different frequencies. For the first most frequent frequency it is divided into similar intervals, and the second most frequent frequency is divided into 1 similar interval, at the third most frequent frequency it is divided into 2 similar intervals. Doing so up to an interval with a frequency.i that cannot be subdivided.

d. Next is to define the fuzzy set A_i and fuzzify the actual data. Can be for example A_1, A_2,...,A_p is a fuzzy set that has a linguistic value from a linguistic variable, the definition of a fuzzy set A_1, A_2,...,A_p on U as follows:

$A_1 = 1/u_1 + 0{,}5/u_2 + 0/u_3 + \ldots + 0/u_p$

$A_2 = 0{,}5/u_1 + 1/u_2 + 0{,}5/u_3 + \ldots + 0/u_p$

$A_3 = 0/u_1 + 0{,}5/u_2 + 1/u_3 + \ldots + 0/u_p$

$\vdots$

$A_p = 0/u_1 + 0/u_2 + 0/u_3 + \ldots + 0{,}5/u_{p-1} + 1/u_p$

Where u_i (i = 1, 2, ..., p) is an element of the universal set (U) and any number containing a symbol "/" expresses that the degree of membership is $\mu_{A_i}(u_i)\ terhadap\ A_i$ (i = 1, 2, ..., p) where the result is 0, 0.5 or 1.

e. The next step is to create an FLR column or table based on actual data. The FLR symbol can be described as $A_i \rightarrow A_j$, which means A_i means current state and A_j means next state.

f. Next, determine the Fuzzy Logical Relationship Group (FLRG) and give weights based on the same order of repetition. The current state FLR (A_i) with the same value will be grouped into one group in the form of a weighting matrix.

(t= 1)$A_1 \rightarrow A_1$, . weighted 1

(t= 2)$A_2 \rightarrow A_1$, weighted 1

(t= 3)$A_1 \rightarrow A_1$, given a weight of 2

(t=4)$A_1 \rightarrow A_1$, given a weight of 3

Dimana *t* menyatakan waktu.

g. Then set the defuzzification of the forecast value. To get the predicted value, the standardized weighting matrix (W*) will be multiplied by m_i(middle value). So the prediction calculation becomes:

$F_i = w_{i1} * (m_i) + w_{i1} * (m_i) + \ldots + w_{ip} * (m_p)$

Where F_i is the result of forecasting; with $w_i * = \frac{w_i}{\sum_{j=1}^{p} wi}$

With the explanation that the result of the i-period fuzzification is A_i, and A_i does not sound FLR on FLRG with condition output $A_i \rightarrow$, and where for the maximum value the degree of membership is at u_i, then for the forecast value (F_i) is equal to the mean value of u_i, or can be defined by m_i.

RESULT AND DISCUSSION

The results of the thesis research entitled "Designing Rainfall Prediction Information Systems in Jombang Regency Using the Fuzzy Time Series Method" is an application to predict monthly rainfall in Jimbang Regency which is designed in the form of a website.

Login Page

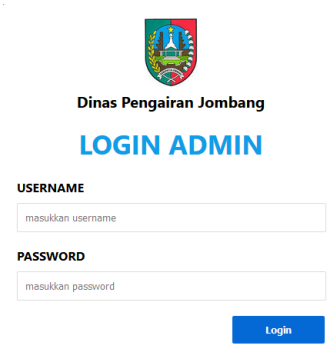


Figure 1. Login Page

When the first admin accesses this rainfall prediction information system, a login page will be displayed to enter the system. To be able to use this system the admin must enter the username and password then login by clicking the Login button, then the system will perform the process of matching the username and password with the existing data. If it matches, the system will display the main admin page.

Admin main page

The admin main menu page is shown as in Figure 2 below which shows the homepage menu, rainfall input menu, calculate monthly rainfall, calculate annual rainfall, view daily rain, view monthly rain, view annual rain, admin input, view admin, operator input, view operators, and calculate predictions.

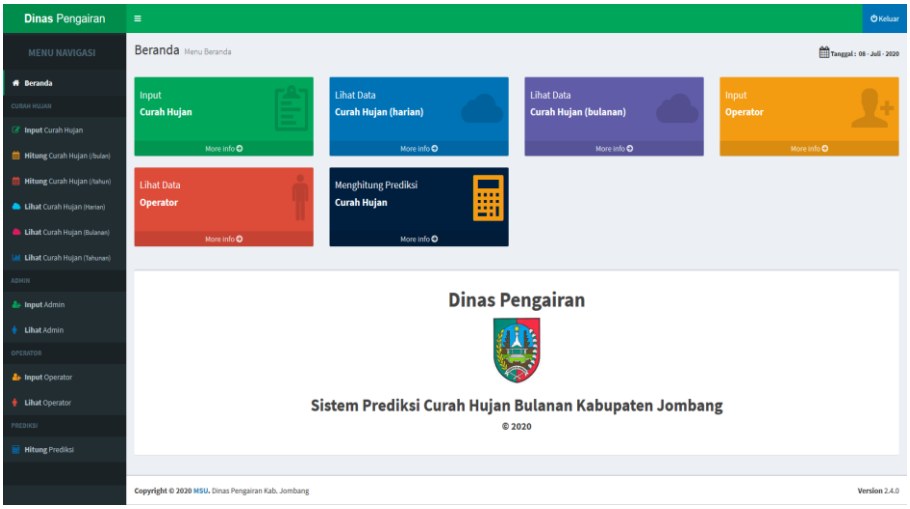


Figure 2. Admin Main Page

Monthly Rainfall Count Page

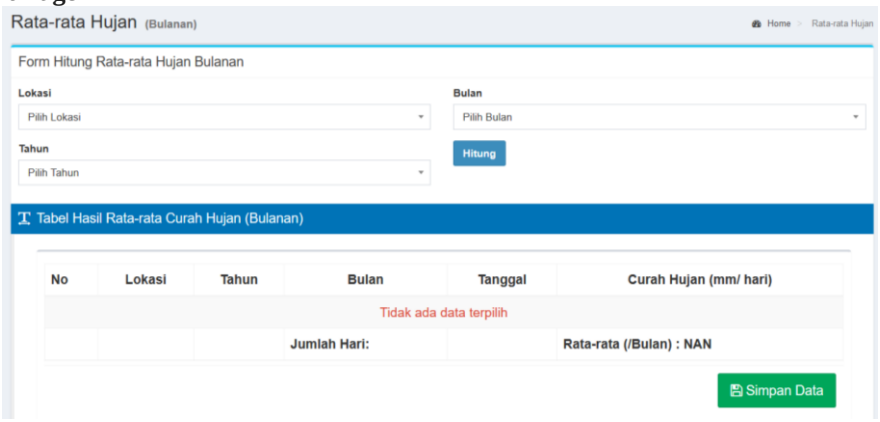
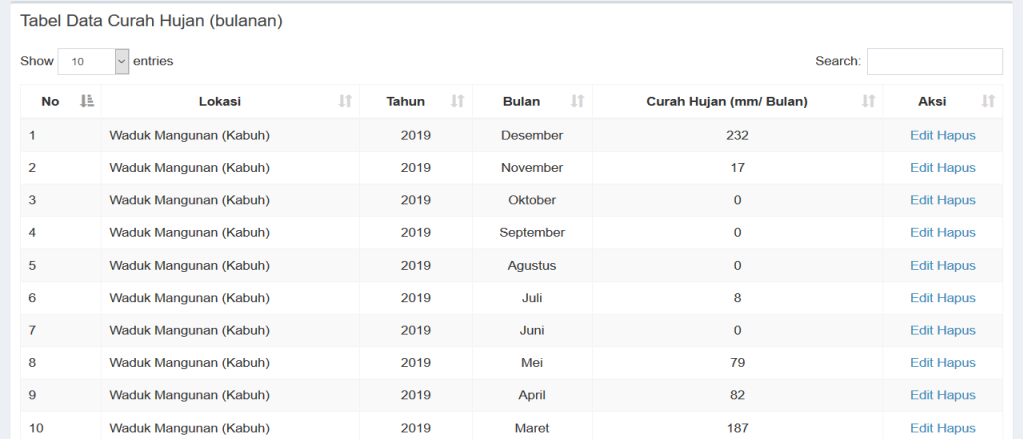


Figure 3. Monthly Rainfall Data Count Page

The monthly rainfall calculation page is used to calculate the monthly rainfall by calculating the average daily rainfall within a month. To calculate monthly rainfall, there are options that must be selected first, namely location, year, and month. There is a calculate button to start the monthly rainfall calculation process and a data save button to save the calculated data. Then after the calculation process is complete, the monthly rainfall data page will appear as shown in Figure 4 below.



No	Lokasi	Tahun	Bulan	Curah Hujan (mm/ Bulan)	Aksi
1	Waduk Mangunan (Kabuh)	2019	Desember	232	Edit Hapus
2	Waduk Mangunan (Kabuh)	2019	November	17	Edit Hapus
3	Waduk Mangunan (Kabuh)	2019	Oktober	0	Edit Hapus
4	Waduk Mangunan (Kabuh)	2019	September	0	Edit Hapus
5	Waduk Mangunan (Kabuh)	2019	Agustus	0	Edit Hapus
6	Waduk Mangunan (Kabuh)	2019	Juli	8	Edit Hapus
7	Waduk Mangunan (Kabuh)	2019	Juni	0	Edit Hapus
8	Waduk Mangunan (Kabuh)	2019	Mei	79	Edit Hapus
9	Waduk Mangunan (Kabuh)	2019	April	82	Edit Hapus
10	Waduk Mangunan (Kabuh)	2019	Maret	187	Edit Hapus

Figure 4. Monthly Rainfall Data Count Page

Prediction Count Page

To calculate predictions there is a choice of locations that must be selected first. There is a process button to start the process of calculating monthly rainfall predictions, then there are two tables, namely the monthly rainfall data table and the rainfall prediction table and there is a graph of the comparison of actual data and predictive data. There is also a show details button to view the details of the prediction calculations using the fuzzy time series method.

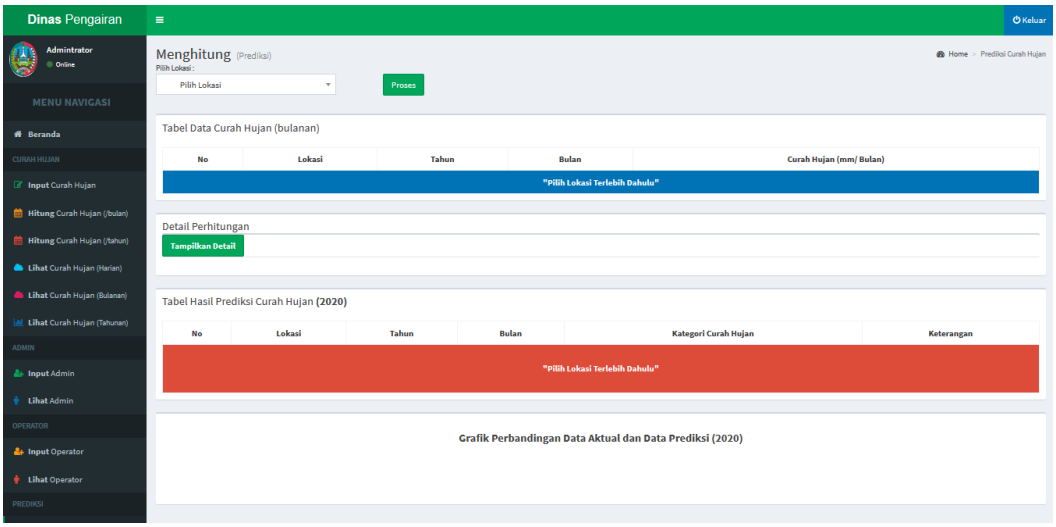


Figure 5. Calculating Rainfall Prediction Page

To display the calculation of the rainfall prediction page after the admin has made a location selection and clicking on the process will display a table which contains the location, year, month category, and information to provide a detailed explanation of the prediction results. Then there is a graph of the comparison of the actual data with the predicted data as shown in Figure 6 below.

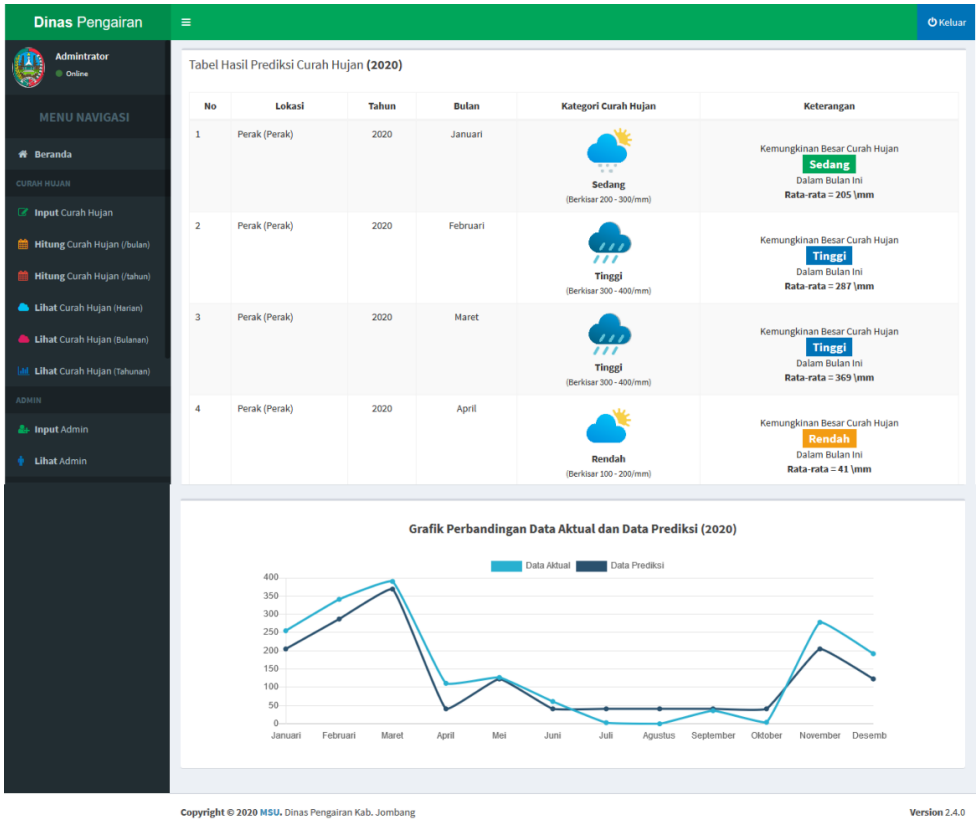
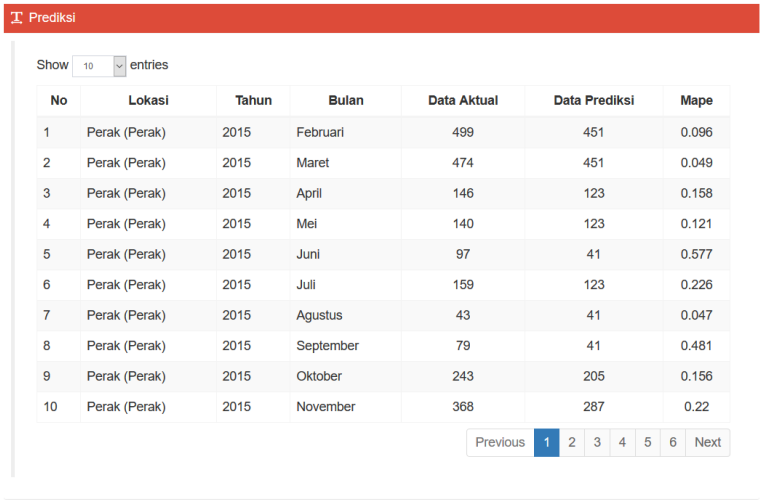


Figure 6. Calculating Rainfall Prediction Page



No	Lokasi	Tahun	Bulan	Data Aktual	Data Prediksi	Mape
1	Perak (Perak)	2015	Februari	499	451	0.096
2	Perak (Perak)	2015	Maret	474	451	0.049
3	Perak (Perak)	2015	April	146	123	0.158
4	Perak (Perak)	2015	Mei	140	123	0.121
5	Perak (Perak)	2015	Juni	97	41	0.577
6	Perak (Perak)	2015	Juli	159	123	0.226
7	Perak (Perak)	2015	Agustus	43	41	0.047
8	Perak (Perak)	2015	September	79	41	0.481
9	Perak (Perak)	2015	Oktober	243	205	0.156
10	Perak (Perak)	2015	November	368	287	0.22

Previous 1 2 3 4 5 6 Next

Figure 7. Calculation Details

In the details of this calculation, as shown in Figure 7, it displays the results of the prediction calculations and then also displays the MAPE value which serves as the accuracy value of the prediction results. The results of the calculations carried out by the system in predicting rainfall using the Fuzzy Time Series method for example in the Perak sub-district resulted in an average MAPE value of 0.90 which means that it has very good performance because it produces an average MAPE value of less than 10.

CONCLUSION

The application program for Rainfall Prediction in Jombang Regency has been produced based on previous rainfall data obtained from the Jombang Regency Public Work and Spatial Planning service using the Fuzzy Time Series (FTS) method. The resulting program has several menu options making it easier for admins, operators, and residents to operate it and is able to produce predictions with very good performance because it produces a MAPE of less than 10, which is 0.90

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