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The forecasting of palm oil based on fuzzy time series-two factor

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ABSTRACT

Palm oil is a vegetable oil obtained from the mesocarp fruit of the palm tree, generally, from the species, Elaeis guineensis, and slightly from the species Elaeis oleifera and Attalea maripa. Palm oil is naturally red due to its high alpha and beta-carotenoid content. Palm kernel oil is different from palm kernel oil produced from the same fruit core. Planning for palm oil production is necessary because it greatly affects to the level of the country's economy. Forecasting can reduce uncertainty in planning. Forecasting used in the palm oil problem is two-factor forecasting using the Kumar method with uama factors in the form of palm oil production and supporting factors in the form of land area. The forecasting is evaluated using AFER and MSE, from the acquisition of AFER value of 1.212% <10%, then the forecasting has very good criteria.

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1. INTRODUCTION

Palmoil Grown only in the tropics, the oil palm tree produces high-quality oil used primarily for cooking in developing countries [1]. It's an edible vegetable oil that comes from the fruit of oil palm trees, the scientific name is Elaeis guineensis [2]. Two types of oil can be produced; crude palm oil comes from squeezing the fleshy fruit, and palm kernel oil which comes from crushing the kernel, or the stone in the middle of the fruit. Palm oil is in nearly everything – it's in close to 50% of the packaged products we find in supermarkets, everything from pizza, doughnuts and chocolate, to deodorant, shampoo, toothpaste and lipstick. It's also used in animal feed and as a biofuel in many parts of the world [3].

Planning, sense of planning can also be defined as an activity or coordinated activity to achieve that particular goal within a certain period. Thus, in a plan there will be activities or activities testing several directions of achievement, assessing uncertainty, measuring capacity, determining the direction of achievement, and also determining steps to achieve it. According to [4] stated that the understanding of this planning is a process of determining what to achieve in the future and also sets the necessary steps to achieve it. In real life not all the sets we encounter in everyday life are firmly defined. In addressing the problem of set with an indecisive boundary Professor Lotfi A. Zadeh, an expert in computer science, University of California, Berkeley attributed the set to a function that expresses the degree of conformity of the elements in its universe to the concept that is a condition of membership of the function [5]. That function is called a membership function and the value of that function is called the degree of membership of an element in the set. A fuzzy set is a set expressed by a membership function, which maps each domain in the fuzzy set to exactly one number

at intervals of zero to one. Time series data forecasting predicts what will happen based on past data. Data consist of a set word and sentence [6]. A probabilistic feature model was generated as a reference for the calculation of the data test classification [7]. A time series is a collection of regular observations on a variable over the same period and successively. By learning how variable changes over time, a relationship between need and time can be formulated and used to predict the level of future needs.

Research using FST has been developed by various researchers, among others, is the use of FST method to solve the problem of forecasting of historical data in the form of Linguistic values [8], [9], research on the use of new methods in interval sharing that is frequency density-based partitioning that produces more accurate forecasting results than using the usual interval sharing method in the fuzzy time series method [10]–[14]. In addition, FST is also used for sales forecasting, stock price forecasting, inflation forecasting to electricity load forecasting. The application of fuzzy forecasting that has been carried out is time series forecasting with various methods implemented in the University of Alabama enrollment data from 1971-1992 to obtain a method that has a small error value [10], [15]–[17]. One-factor forecasting begins to develop into two or more factors forecasting, in contrast to forecasting that uses only one factor, the development of this forecast allows researchers to predict time series data using the main factors by considering the supporting factors that are then referred to as high order factors. Production of land area, the reason for the selection of variables in the form of the land area is a place or container used to cultivate palm oil in units per hectare (Ha). Land (land area) is one of the production factors [18].

2. METHOD

2.1 Fuzzy time series

Definition 1 [19]

Suppose $F(t)$ and $G(t)(t = \cdots,0,1,2,3, \dots)$are two fuzzy time series. If $F(t)$ caused $F(t-1), G(t-1)$, then the FLR is represented by $\big(F(t-1)G(t-1)\big) \rightarrow F(t)$, and called the two-factor FLR, where each $F(t)$ and $G(t)$ is called the main factor and the second factor on $(t = \cdots,0,1,2,3, \dots)$. For those factors k-faktor $(k > 2)$, the FLR can be built. When building a time series fuzzy forecasting model, the number of fuzzy sets $F(t)$ will always be the same for every moment $t(t = \cdots,0,1,2,3, \dots)$. For example, if $F(t-1) = A_t$, $G_1(t-1) = B_j^1$ dan A_r is a fuzzy set, $F(t-1), G_1(t-1) \rightarrow F(t)$ can be written as $A_t B_j^1 \rightarrow A_r$where $A_t B_j^1$ is called the premise and A_r called consequences. If $A_t B_j^1 \rightarrow A_r$ appear v times in the fuzzy time series, it will be written as $A_t B_j^1 \rightarrow A_r(v)$ where v is a positive integer.

This method is used the fuzzy time series model. In this approach, the value of the fuzzy time series is the fuzzy set, and there is a relationship between observation at t time and observation at the previous time. The model has been developed using two fuzzy time series techniques, the Chen-type arithmetic model, and the modified one.

Given fuzzy the main factor in the i year is the $A_i$and no fuzzy group relationships are available, then the forecast of the main factor in the year $i+1$is the middle value of the A_i. with $A_i \rightarrow A_i$, $A_i$have a maximum membership value at U_{Ai} intervals weighted average model. The model developed has been customized and

Definition 2 [20]

Given fuzzy the main factor in the i year is A_i, the relationship of the fuzzy group is expressed with the $A_i \rightarrow A_k$, then the forecast of the main factor in the i year is the average middle value of A_i and A_k. By A_k is a linguistic that has a maximum membership value at U_{An}intervals.

Definition 3.9.2

Given fuzzy the main factor in the i year is the A_i, the fuzzy group relationship is expressed by $A_i \rightarrow A_{k1}, A_i \rightarrow A_{k2}, A_i \rightarrow A_{kp}$, then the forecast value at $i+1$ is in the equation below:

$$\frac{\left(\frac{(m_1 + m_2 + \dots + m_p)}{p} + \frac{(l_1 + l_2 + \dots + l_q)}{q}\right)}{2} \quad (1)$$

with $A_{k1}, A_{k2}, \dots, A_{kp}$ have a maximum membership value at intervals of $U_{Ak1}, U_{Ak2}, \dots, U_{Akp}$and each has a middle interval value of $m_1, m_2, \dots, m_p$and fuzzy supporting factors in the i year are $B_m$and fuzzy group relationships its $B_m \rightarrow [A_{n1}, A_{n2}, \dots, A_{nq}]$ where $A_{n1}, A_{n2}, \dots, A_{nq}$have a maximum membership value at intervals of $U_{An1}, U_{An2}, \dots, U_{Anq}$and each has a middle interval value of $l_1, l_2, \dots, l_q$.

Definition 3 [20].

Given fuzzy the main factor in the i year is the $A_i$and no fuzzy group relationships are available, then the forecast of the main factor in the year $i+1$is the middle value of the A_i. with $A_i \rightarrow A_i$, $A_i$have a maximum membership value at U_{Ai} intervals, shown in Figure 1.

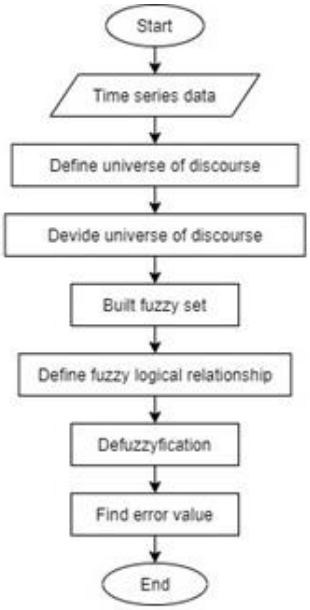


Figure 1. Kumar's method

3. RESULT AND DISCUSSION

The data used in this study relates to the production of palm oil in the form of palm oil production data in tonnes, and palm oil plantation area in hectares from 2000 to 2019.

The palm oil production variable is the dependent variable with a time horizon in the form of a time series which is then referred to as the main factor, namely X

The variable of oil palm plantation area is an independent variable with a time horizon in the form of a time series which is then referred to as a supporting factor, namely Y^i

Step 1: Defines the discussion universe for each factor, using the following definitions:

$$X_{min} = 2991.3 \quad X_{max} = 8688.9 \quad D_{X1} = 391.3 \quad D_{X2} = 211.1$$
$$Y^1{}_{min} = 5094.86 \quad Y^1{}_{max} = 29637.5 \quad D_{Y^1{}_1} = 94.86 \quad D_{Y^1{}_2} = 162.5$$

Suppose that the main factor universe (U) in equation below

$$U = [X_{min} - D_{X1}\ , X_{max} + D_{X2}\ ] = [2600{,}8900\ ] \tag{2}$$

Suppose the universe of supporting factors (W)

$$W = [Y^1{}_{min} - D_{Y^1{}_1}\ , Y^1{}_{max} + D_{Y^1{}_2}\ ] = [5000\ ,29800\ ] \tag{3}$$

Defining the length of the interval for the main factor

$$l_X = \frac{[\,(X_{max}+D_{X2}) - (X_{min}-D_{X1})\,]}{m} = 835 \tag{4}$$

Defining the length of the interval for a contributing factor

$$l_{Y^1} = \frac{\left[\left(Y^1{}_{max}+D_{Y^1{}_2}\right) - \left(Y^1{}_{min}-D_{Y^1{}_1}\right)\right]}{m} = 2480 \tag{5}$$

Steps 2 and 3: Division of the universe into intervals [21] shown in Table 1.

Table 1. Linguistic of main and second factor

Fuzzy			
Second factor	Linguistic	Main factor	Linguistic
[5000 ; 7480]	A1	[2600 ; 3500]	B1
[7480 ; 9960]	A2	[3500 ; 4400]	B2
[9960 ; 12440]	A3	[4400 ; 5300]	B3
[12440 ; 14920]	A4	[5300 ; 6200]	B4
[14920 ; 17400]	A5	[6200 ; 7100]	B5
[17400 ; 19880]	A6	[7100 ; 8000]	B6
[19880 ; 22360]	A7	[8000 ; 8900]	B7
[22360 ; 24840]	A8		
[24840 ; 27320]	A9		
[27320 ; 29800]	A10		

$B_1 \rightarrow B_1$
$B_1 \rightarrow B_1$
$B_1 \rightarrow B_1$
$B_1 \rightarrow B_1$
$B_1 \rightarrow B_1$
$B_1 \rightarrow B_2$
$B_2 \rightarrow B_2$

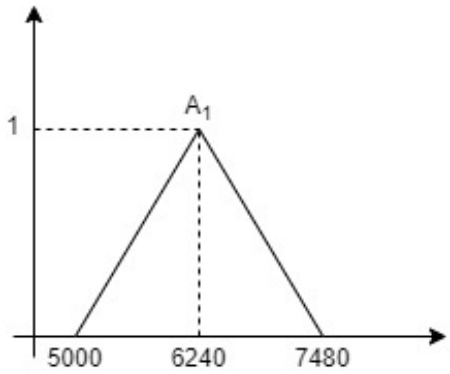
$B_2 \rightarrow B_3$
$B_3 \rightarrow B_3$
$B_3 \rightarrow B_3$
$B_3 \rightarrow B_4$
$B_4 \rightarrow B_4$
$B_4 \rightarrow B_5$
$B_5 \rightarrow B_5$

$B_5 \rightarrow B_5$
$B_5 \rightarrow B_5$
$B_5 \rightarrow B_7$
$B_7 \rightarrow B_7$
$B_5 \rightarrow \#$

Figure 2. Triangular membership function

$$\mu_{\tilde{a}}(x) = \begin{cases} \dfrac{x - 5000}{6240 - 5000} & , \quad 5000 \leq x \leq 6240 \\ \dfrac{7480 - x}{7480 - 6240} & , \quad 6240 \leq x \leq 7480 \\ 0 & , \quad yang\ lainnya \end{cases} \tag{6}$$

Steps 5: Set define a fuzzy set group for each factor, FLR from the main factor:



FLR from the second factor:
Step 6: Forecasting, using the following definition is shown in Table 2.

Table 2. Forecast value

Year	Production (Ton)	Forecast
2000	2991.3	
2001	3152.4	3125
2002	3258.6	3125
2003	3429.2	3125
2004	3496.7	3125
2005	3593.4	3125
2006	3748.5	3425
2007	4101.7	4025
2008	4451.8	4025
2009	4888	5000
2010	5161.6	5000
2011	5349.8	5000
2012	5995.7	5900
2013	6108.9	5900
2014	6332.4	6125
2015	6724.9	6650
2016	6462.1	6875
2017	6685.2	6875
2018	8507.4	6875
2019	8688.9	8450

Step 7: Count the error
Mean Squared Error (MSE)

$$MSE = \frac{\sum_{i=1}^{n}(X_i - F_i)^2}{n} = 197607.2 \quad (7)$$

Then AFER (Average Forecast Error Rate)

$$AFER = \frac{\frac{|X_i - F_i|}{X_i}}{n} \times 100\% = 1.212\% \quad (8)$$

by the following criteria be seen in Table 3.

Table 3. AFER criteria

AFER criteria	
AFER	Criteria
<10%	Very good
10% -20%	Good
20% -50%	Pretty good
> 50%	Not good (bad)

4. CONCLUSION

From the research conducted, In this section, we have fuzzy time series forecasting multi-factor one cross association as a forecasting method to forecast palm oil production influenced by plantation land area then using the frequency density partitioning modification method applied to the database that has been grouped. The results of the estimates show that the proposed method has a higher forecast performance. It is known that the AFER value is 1.212% according to the AFER criteria table 1.212%<10%, it can be concluded that the forecast has very good criteria.

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