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The Implementation of Fuzzy Time Series in Forecasting The Number of Tourist Visits

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ABSTRACT

The development of tourism in West Nusa Tenggara (NTB) Province is supported by its geographical conditions, including scattered small islands (gilis), a tropical climate, and the cultural peculiarities of the Sasak and Mbojo Tribes, thereby becoming an attraction in the development of global tourist destinations. Tourism development in NTB Province would be more attractive with the establishment of the Mandalika National Tourism Development Strategic Area (KSPPN). This research aims to predict the number of tourist visits. A method to forecast the number of tourist visits in NTB Province is needed to assist the government in preparing appropriate facilities and infrastructure in the event of a possible surge in tourist visits. The method used in this study is the Fuzzy Time Series to predict the number of tourist visits in NTB Province. The data used in this study were secondary data sourced from the NTB government tourism office. The result of this research was that the Fuzzy Time Series method was effective in predicting the number of tourist visits in NTB Province, with an accuracy of 90.29%. The forecast result, generated using the Fuzzy Time Series method, was not significantly different from the actual data; in other words, it was almost identical to the actual data. The forecast for tourist visits to the NTB province in the 48th period remains unchanged until the 53rd period, namely 80,739.7 people. The FTS method used in this study cannot be applied to data with long-term seasonal patterns. A suggestion for future researchers is to develop a classical FTS that captures additional long-term seasonal patterns.

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A. INTRODUCTION

The development of tourism in NTB Province is supported by geographical conditions with scattered clusters of small islands (gili), tropical climate, and cultural peculiarities of the Sasak, Samawa, and Mbojo Tribe, so that it becomes an attraction in the development of global tourist destinations (Kurniawan et al., 2023). The development of tourism in NTB Province will be more attractive with the establishment of the Mandalika National Tourism Development Strategic Area (KSPPN) (Soraya et al., 2024). NTB Province can maximize its role along with the momentum of the strategic policy through the development of new growth centers based on the tourism sector in collaboration with other sectors and package the potential of the village to become a thematic tourism village (Rizal et al., 2019).

Forecasting is an activity that aims to predict future events and is a tool. The selection of forecasting methods depends on the data pattern, factors that affect forecasting results, and other factors. Basically, time series forecasting is the prediction of future values as a function of past values, with the model based solely on the time series itself and unaffected by external variables (Syaharuddin et al., 2025). Several studies have been conducted for prediction using various methods such as Autoregressive Integrated Moving Average (ARIMA), Exponential Smoothing and others. Su et al. (2024) with their research entitled "A hybrid model of ARIMA and Multilayer Perceptron (MLP) with a Grasshopper optimization algorithm for time series forecasting of water quality". The result showed that ARIMA failed to capture nonlinear patterns in water quality data (dissolved oxygen, boron, water temperature); the ARIMA model provided significantly lower correlation and accuracy than MLP and hybrid ARIMA–MLP. They showed that the hybrid (ARIMA for the linear component + MLP for the nonlinear residual) achieved significant improvements in accuracy (lower MAPE/RMSE, higher correlation). Previous research that compared several time-series models (ARIMA, Exponential Smoothing, GRNN, and hybrid ARIMA–GRNN) to fit and forecast daily COVID-19 cases in India (data up to May 2021), research by G. Wang et al. (2021). The result showed that ARIMA performed best (with the lowest MAPE value for the selected ARIMA model). Some literature for ARIMA method can be seen in refs (Al-lami & Török, 2025; Kontopoulou et al., 2023; Kozyreff, 2021; Soraya et al., 2024), literature for ARIMA-Long Short Term Memory (ARIMA-LSTM) can be seen in ref Fan et al. (2021), Another method used for forecasting is Exponential Smoothing. Tourism forecasting in the time of COVID-19 by H. Song et al. (2022). They showed that Exponential Smoothing performed well for normal and short-term patterns but required modification/hybridization when significant structural changes occur. Some literature can be seen in refs Saputra et al. (2024); Sinulingga et al. (2025).

Fuzzy Time Series (FTS) is an extension of classical time series methods. Traditional time series uses purely numerical data and statistical/mathematical models (e.g., ARIMA, Exponential Smoothing, etc.). Fuzzy Time Series was developed by Q. Song & Chissom (1993) based on the theory of fuzzy sets and the concept of linguistic variables. Numerical data in the time series is converted into fuzzy sets. The fuzzy logic system is a methodology of "counting" using linguistic variables rather than numbers. The difference between this research and previous studies is that the analysis used Fuzzy Time Series based on fuzzy logic, whereas previous research relied on statistical models or exponential weighting. The method used in this research can be applied to non-stationary data, whereas the previous method cannot. The purpose of this research is to forecast the number of tourist visits in NTB Province using the Fuzzy Time Series method. The contribution of this research is assist the government in preparing proper facilities and infrastructure.

B. RESEARCH METHOD

In this study, the Fuzzy Time Series Method was used to predict the number of tourist visits in NTB Province. The data used are monthly records of tourist visits for the period January 2021 to December 2024. The data in this study is sourced from the website of the West Nusa Tenggara Tourism Office through the https://dinaspariwisata.ntbprov.go.id page. The stages of the research carried out are as follows (P. Wang et al., 2024):

1. Determine the universe of discourse from research data
   The Universe of Discourse of historical data is determined by Equation (1):
$$U = [X_{\min} - D_1,\ X_{\max} + D_2] \tag{1}$$
   where $X_{\min}$ is the minimum value of the observed variable and $X_{\max}$ is the maximum value of the observed variable while D_1 and D_2 are arbitrary positive numbers determined by the researcher.
2. Determine the interval class
   At this stage, the universe of discourse, U is divided into several interval classes with the same interval length for each interval class. The formation of interval classes uses the Sturges rule with the following Equation (2):
$$K = 1 + 3.3\log(n) \tag{2}$$
   where, n is the amount of data observed. Next, determine the length of the interval class with the following Equation (3):
$$I = \frac{R}{K} \tag{3}$$

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where, R is the difference between the minimum and maximum values of the observed data and K is the number of interval classes

3. Determine the fuzzy set
Identify fuzzy sets $A1, A2, ..., A_p$ and perform fuzzification on historical data. The definition of $A1, A2, ..., A_p$ in the universe of discourse U is as Equation (4):

$$\begin{aligned} A_1 &= \frac{1}{u_1} + \frac{0{,}5}{u_2} + \frac{0}{u_3} + ... + \frac{0}{u_p} \\ A_2 &= \frac{0{,}5}{u_1} + \frac{1}{u_2} + \frac{0{,}5}{u_3} + \frac{0}{u_4} + ... + \frac{0}{u_p} \\ A_3 &= \frac{0}{u_1} + \frac{0{,}5}{u_2} + \frac{1}{u_3} + \frac{0}{u_4} + ... + \frac{0}{u_p} \\ &\vdots \\ A_p &= \frac{0}{u_1} + \frac{0}{u_2} + \frac{0}{u_3} + \frac{0}{u_4} + ... + \frac{0{,}5}{u_{p-1}} + \frac{1}{u_p} \end{aligned} \tag{4}$$

4. Fuzzification of research data
The first step in the fuzzy inference process is called fuzzification. After data input, the system determines the membership function values and categorizes the data according to predetermined intervals to convert numeric variables (non-fuzzy) into linguistic variables (fuzzy).
5. Create a Fuzzy Logical Relationship (FLR)
Fuzzy Logical Relationship (FLR) is created based on research data. Fuzzy logic relationship is represented by $A_i \to A_j$, where A_i indicates the fuzzy set in the current state and A_j indicates the fuzzy set in the next state.
6. Classify the FLR obtained into groups so that a Fuzzy Logical Relationship Group (FLRG) is formed
The obtained FLR is grouped to form a Fuzzy Logical Relationship Group (FLRG). FLRG is the result of combining the values of each A_i obtained through the FLR formation process. The Chen and Lee models are among several common approaches for determining the order of FLRG formation. This grouping process is what distinguishes the two models. Because no weighting is used to determine relationships within the group, in the Chen model, the same relationship is assigned a value of 1. In the Lee model, the same relationship is not considered one because, according to Lee, it can affect the predictive value; the value must be calculated.
7. Defuzzification
The forecast value obtained from the middle value of each interval in the FLRG formed in the previous stage is called defuzzification. Prediction is done by considering several rules as follows:
Rule 1: If the fuzzification result on the t-th data is Aj and there is a fuzzy set that does not have a fuzzy logic relation, for example $A_j \to \emptyset$, where the maximum value of the membership function of A_j is in the interval u_j and the middle value of u_j is m_j, then the forecast result of F_{t+1} is m_j.
Rule 2 : If the fuzzification result on the t-th data is A_j and there is only one FLR in the FLRG, for example $A_j = 1 \to A_j = 2$, where the maximum value of the membership function of A_j is in the interval u_j, and the middle value of u_j is m_j, then the forecast result of F_{t+1} is m_j.
Rule 3: If the fuzzification result on the t-th data is A_j and A_j has several FLRs in the FLRG, for example $A_i \to A_{j1},\ A_{j2}, ...,\ A_{jk}$ are fuzzy sets and the maximum value of the membership function of $A_{j1},\ A_{j2}, ...,\ A_{jk}$ is in the interval $u_{j1},\ u_{j2}, ...,\ u_{jk}$ and $m_{j1},\ m_{j2}, ...,\ m_{jk}$, then the forecasting result F_{t+1} is as Equation (5):

$$F_{t+1} = \frac{m_{j1} + m_{j2} + ... + m_{jk}}{k} \tag{5}$$

where k is the number of midpoints and to find the midpoint (m_j) in the fuzzy set interval, the following Equation (6) can be used:

$$m_j = \frac{\text{upper limit } + \text{ lower limit}}{2} \tag{6}$$

8. Accuracy Measurement
In theory, the predicted value is compared with the actual value. Mean Absolute Percentage Error was one of the methods used to assess the model's accuracy. The advantage of MAPE over other methods is that it is easy to understand and intuitive for comparing model performance across datasets with different scales. Researchers or practitioners could immediately know which model is better by looking at the average error percentage. The inaccuracy of the predicted results can be calculated using the MAPE with the following Equation (7):

$$MAPE = \frac{\sum_{t=1}^{n} \left| \frac{X_t - F_t}{X_t} \right|}{n} . 110\% \qquad (7)$$

where, X_t is the historical data at period t and F_t is the predicted data.

9. Forecasting
   The steps for forecasting $t + k$ period, where $k = 1, 2, ...$ using the FTS method are as follows:
   a. Take the last state of the observation data (period 47). Example: A5
   b. From the FLR table, collect all Next States that appear when Current State = A5 (take all occurrences)
   c. For each next-state found, take the midpoint from the Fuzzy_Intervals table
   d. Calculate the average (mean) of these midpoints—this becomes the numerical forecast value for the next period. If there is no next state in the FLR for a Current State, use the midpoint (Current State) as the forecast. Form a list of midpoints according to their occurrence. The midpoints average is obtained using the following formula:

   $$\text{Midpoint average } = \frac{\sum_j m_{j*}}{\sum_j f_{ij}}$$

   Where m_{j*} is the midpoint of the states that have the current state of the latest actual data, and f_{ij} is the number of states that share that same current state.
10. Fuzzify the forecast value (find the fuzzy interval where the forecast value falls) $\rightarrow$ this result becomes the Current State for the next step
11. Repeat steps 2–5 until the desired period is reached.

The steps in this study can be illustrated through the flow chart in Figure 1.

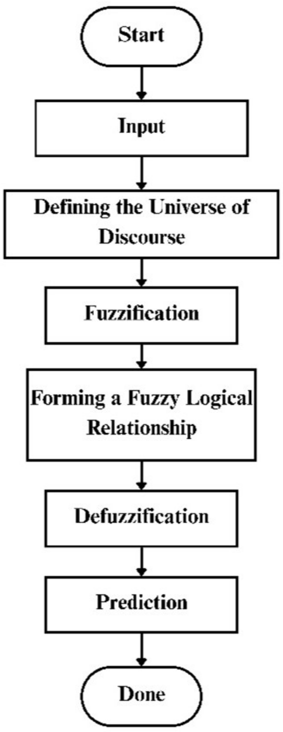

Figure 1. Flowchart for Predicting the Number of Tourist Visits in NTB using the Fuzzy Time Series

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C. RESULT AND DISCUSSION

1. Overview of Tourist Visits in NTB Province for the 2021-2024 Period

Figure 1 shows the distribution of data on the number of tourist visits in NTB Province from January 2021 to December 2024.

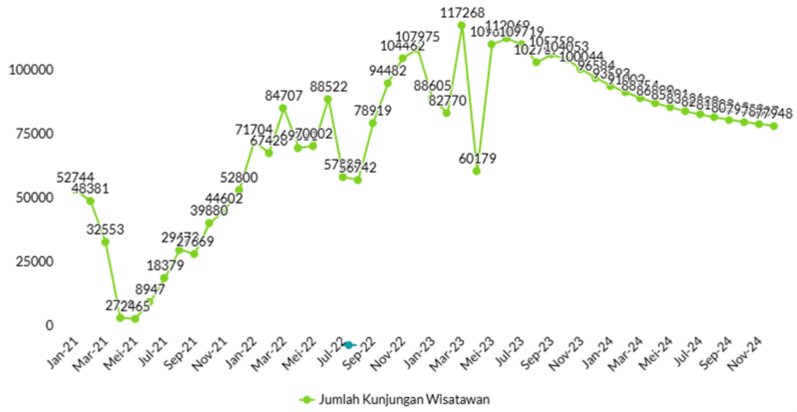

Figure 2. Effects of selecting different switching under dynamic condition

Figure 2 shows that the data on the number of tourist visits in NTB Province are volatile. In the early to mid-2021 period, there was a significant decrease, followed by a significant increase from mid-2021 to mid-2023. This increase in tourist visits can be attributed to several factors, such as the reopening of international borders after the COVID-19 pandemic. From mid-2023 to the end of 2024, the number of tourist visits has declined again. However, the number of visits in that period is still higher than in the 2021 and 2022 periods.

2. Forecasting the Number of Tourist Visits using the Fuzzy Time Series Method

In this study, the Fuzzy Time Series method was used to predict the number of tourist visits in NTB Province. The steps taken to predict the number of tourist visits in NTB Province using the Fuzzy Time Series method are as follows:

a. The Formation of the Universe of Discourse

The first step taken is to sort the data, where the minimum value (the least number of tourist visits) in the data on the number of tourist visits for the period January 2021 to December 2024 is 2,465 people, namely in May 2021 while the maximum value (the highest number of tourist visits) in the data on the number of tourist visits for the period January 2021 to December 2024 is 117,268 people, namely in March 2023, So that the difference between the minimum and maximum values (range) is 114,803 people. Based on Equation (1), where the values D1 and D2 are positive random numbers, then D1 = 0 and D2 = 0, so that the Universe of Discourse formed is:

$$U = [2645 - 0,\ 117268 + 0] = [2645,\ 117268]$$

b. Determination of Class and Interval Length

Before determining the interval length, the number of interval classes must be determined by using the Sturges formula based on the formula in Equation (2), so that the number of interval classes is:

$$k = 1 + 3.3\log(n) = 1 + 3.3\log(48) = 6.54 \approx 7$$

So, many of the interval classes obtained are 7. The next step is to determine the length of the class interval based on the formula in Equation (3), namely:

$$I = R/k = 114,803/7 = 16,400$$

So the length of the class interval is 16,400. Table 1 presents the lower bound, upper bound, and midpoint for each interval class.

Table 1. Lower Bound, Upper Bound, and Midpoint for Each Interval Class

Interval Class	Lower Limit	Upper Limit	Midpoint
A_1	2,465	18,865	10,665.2
A_2	18,865	35,266	27,065.6
A_3	35,266	51,666	43,466.1
A_4	51,666	68,067	59,866.5
A_5	68,067	84,467	76,266.9
A_6	84,467	100,868	92,667.4
A_7	100,868	117,268	109,067.8

The lower and upper bound values are used in the fuzzification process.

c. Fuzzification Process

The fuzzification process is determined based on the upper and lower bound values presented in Table 1 according to the number of interval classes formed, so that the fuzzification results are presented in Table 2:

Table 2. Lower Bound, Upper Bound, and Midpoint for Each Interval Class

Period	Number of Tourist Visits	Fuzzification	Period	Number of Tourist Visits	Fuzzification
Jan-21	52,744	A_4	Jan-23	88,605	A_6
Feb-21	48,381	A_3	Feb-23	82,77	A_5
Mar-21	32,553	A_2	Mar-23	117,268	A_7
Apr-21	2,72	A_1	Apr-23	60,179	A_4
May-21	2,465	A_1	May-23	109,696	A_7
Jun-21	8,947	A_1	Jun-23	112,069	A_7
Jul-21	18,379	A_1	Jul-23	109,719	A_7
Aug-21	29,473	A_2	Aug-23	102,707	A_7
Sep-21	27,669	A_2	Sep-23	105,759	A_7
Oct-21	39,88	A_3	Oct-23	104,053	A_7
Nov-21	44,602	A_3	Nov-23	100,044	A_6
Dec-21	52,8	A_4	Dec-23	96,584	A_6
Jan-22	71,704	A_4	Jan-24	93,593	A_6
Feb-22	67,42	A_4	Feb-24	91,002	A_6
Mar-22	84,707	A_5	Mar-24	88,754	A_6
Apr-22	69,331	A_5	Apr-24	86,8	A_6
May-22	70,002	A_5	May-24	85,101	A_6
Jun-22	88,522	A_6	Jun-24	83,621	A_5
Jul-22	57,88	A_4	Jul-24	82,33	A_5
Aug-22	56,742	A_4	Aug-24	81,203	A_5
Sep-22	78,919	A_5	Sep-24	80,219	A_5
Oct-22	94,482	A_6	Oct-24	79,359	A_5
Nov-22	104,462	A_7	Nov-24	78,607	A_5
Dec-22	107,975	A_7	Dec-24	77,948	A_5

d. Formation of Fuzzy Logical Relationship (FLR)

The formation of FLR is by observing the fuzzy A_i relationship from the current state period to the next state period, where $1 \leq i \leq 7$. The FLR formed is presented in Table 3 as follows:

Table 3. Fuzzy Logical Relationship (FLR) Results

Time Series	Current State	Next State	FLR
January 2021 → February 2021	NA	A_4	NA → A_4
February 2021 → March 2021	A_4	A_3	$A_4 \rightarrow A_3$
March 2021 → April 2021	A_3	A_2	$A_3 \rightarrow A_2$
April 2021 → May 2021	A_2	A_1	$A_2 \rightarrow A_1$
May 2021 → June 2021	A_1	A_1	$A_1 \rightarrow A_1$

Time Series	Current State	Next State	FLR
⋮	⋮	⋮	⋮
August 2024 → September 2024	A_5	A_5	$A_5 \rightarrow A_5$
September 2024 → October 2024	A_5	A_5	$A_5 \rightarrow A_5$
October 2024 → November 2024	A_5	A_5	$A_5 \rightarrow A_5$
November 2024 → December 2024	A_5	A_5	$A_5 \rightarrow A_5$

e. Formation of Fuzzy Logical Relationship Group (FLRG)

The formation of FLRG is carried out by grouping fuzzy sets that have the same current state and then grouping them into one group. The FLRG formed is presented in Table 4 as follows:

Table 4. Results of the Fuzzy Logical Relationship Group (FLRG)

Grup	FLRG
1	$A_1 \rightarrow A_1,\ A_2$
2	$A_2 \rightarrow A_1,\ A_2,\ A_3$
3	$A_3 \rightarrow A_2,\ A_3,\ A_4$
4	$A_4 \rightarrow A_3,\ A_4,\ A_5,\ A_7$
5	$A_5 \rightarrow A_5,\ A_6,\ A_7$
6	$A_6 \rightarrow A_4,\ A_5,\ A_6,\ A7$
7	$A_7 \rightarrow A_4,\ A_6,\ A_7$

f. Defuzzification and Prediction Process

The defuzzification process is carried out using the midpoint of each interval class as shown in Table 1. The defuzzification calculation is carried out using the formula in the equation, so that the defuzzification is generated from the FLRG in Table 5 as follows:

Table 5. FLRG Defuzzification Results

Fuzzy Set	Defuzzification
A_1	10,665
A_2	27,066
A_3	43,466
A_4	59,867
A_5	76,267
A_6	92,667
A_7	109,068

The results of the prediction of the number of tourist visits in NTB Province for the period February 2021 to December 2024 based on fuzzification in Table 2 and defuzzification from FLRG in Table 5 can be seen in Table 6 as follows:

Table 6. Results of Prediction of the Number of Tourist Visits in NTB Province

Period	Prediction of the Number of Tourist Visits
Feb-21	59,867
Mar-21	43,466
Apr-21	27,066
May-21	10,665
Jun-21	10,665
Jul-21	10,665
Aug-21	10,665
Sep-21	27,066
Oct-21	27,066
Nov-21	43,466
Dec-21	43,466
⋮	⋮

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Period	Prediction of the Number of Tourist Visits
Dec-24	76,267

Furthermore, a comparison of the actual data with the predicted data was carried out using the Fuzzy Time Series method to find out the similarity between the prediction results and the actual data. The comparison is illustrated through the data plot in Figure 3 as follows:

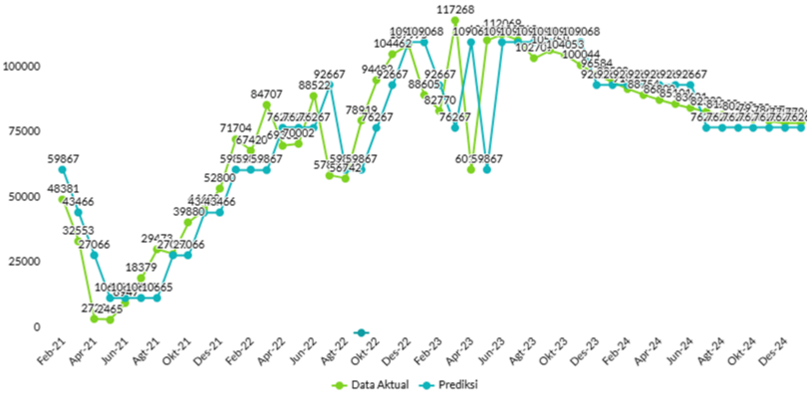

Figure 3. Comparison of Actual Value and Prediction of the Number of Tourist Visits in NTB for the Period February 2021 to December 2024

Based on Figure 3, the actual value and prediction results of the number of tourist visits in NTB Province can be compared using the Fuzzy Time Series method. The green data plot is the actual data plot of the number of tourist visits in NTB Province while the blue data plot is the data predicted using the Fuzzy Time Series method. The findings of this research is the actual and the predicted data did not have much different values. This can be seen through the predicted data pattern following the actual data pattern.

g. Measurement of Accuracy of Prediction Results

The error value is calculated using the Mean Absolute Percentage Error (MAPE) based on Equation (6). The MAPE value produced is 9.71%, which means that the accuracy of prediction using the Fuzzy Time Series method is 90.29%, in other words, the Fuzzy Time Series method is effectively used for forecasting.

h. Forecasting

Forecasting for the 49th (January 2025) period based the last state of the actual data (period 48 or December 2024). Based on FLRG Defuzzification in Table 5, the mean is calculated. The midpoint value becomes the forecast value (numeric forecast) for the next period. Based on the FLR in Table 3, it is known that there are 11 states that have a current state of A5, namely A_4, A_5, A_6, A_6, A_7, A_5, A_5, A_5, A_5, A_5, A_5. Based on table 1, the midpoint for each of these states is as follows:

Midpoint(A4) : 59,866.5
Midpoint(A5) : 76,266.9
Midpoint(A6) : 92,667.3
Midpoint(A7) : 109,068.7

Form a list of midpoints according to their occurrence such as follows:

$[\text{mid}(A4),\ \text{mid}(A5), \text{mid}(A6),\ \text{mid}(A6),\ \text{mid}(A7),\ \text{mid}(A5),\ ...] \rightarrow$ there are 11 states in total

Furthermore, calculate the midpoints average. The midpoints average is obtained as follows:

$$\text{Midpoint average } = \frac{sum\ of\ 11\ midpoints}{11} = \frac{59,866.5 + 76,266.9 + ... + 76,299.9}{11} = 80,739.7$$

Fuzzification 80,739,773 and that value is in interval A_5. It can concluded that the current state for the next period (49th periode or January 2025) is A_5. Since this step produced A5 again, steps will repeat with the same list of matched Next States, so the forecast remains 80,739.7 until 53rd period (May 2025).

The results of the analysis show that forecasting tourist visits using the Fuzzy Time Series method is able to produce a high level of accuracy. This is different from the research by Ainy (2017) and Soraya et al. (2021), where both studies stated that ARIMA had MAPE above 10% in forecasting the number of tourist visits in NTB Province. Our research shows that the Fuzzy Time Series model is a better method in forecasting tourist visits, this is in line with research that has been conducted by Xu et al. (2024), where FTS has a better accuracy (including smaller MAPE) than ARIMA in the case of tourist visits. The weakness of our study are the result are greatly influenced by the way the universe of discourse is divided and the number of fuzzy intervals and can affect the level of accuracy, classical FTS tends to perform better on volatile, nonlinear data, but difficult in capturing long-term seasonal patterns or strong trends without additional modifications.

D. CONCLUSION AND SUGGESTION

Based on the results of the research that has been carried out, it can be concluded that the prediction of the number of tourist visits in NTB Province using the Fuzzy Time Series method produces a value that is close to the actual data value with an accuracy level of 90.29% and the forecast remains 80,739.7 in 49th until 53rd period. Suggestion that can be given to future researchers is develop the classical FTS that can capture additional long-term seasonal patterns.

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AUTHOR CONTIBUTION

All authors contributed to the writing of this article.

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The author declares that there is no conflict of interest in publishing this article.

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