



Forecasting the Number of Tourist Visits in Semarang City Using the *Holt-Winters Multiplicative* and *Fourier Series Analysis (FSA)* Methods

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Abstract

Tourism planning in Semarang City needs accurate monthly forecasts because visits are strongly seasonal and were disrupted by COVID-19: visits rose from 4.29 million in 2017 to 7.23 million in 2024, fell sharply in 2020 and 2021, and recovered from 2022. This study compares two methods for data with trend and seasonality. Holt-Winters Multiplicative was chosen because the seasonal amplitude grows with the level and because the method updates its level, trend, and seasonal components as new data arrive; Fourier Series Analysis (FSA) was chosen because it represents the seasonal pattern by a few sine and cosine harmonics in a regression with a linear trend. Using 96 monthly visits from 2017 to 2024 from the Semarang City Office of Culture and Tourism, the Holt-Winters parameters were searched in Python by minimizing SMAPE, and FSA used five harmonics of which the two dominant were retained; accuracy was measured by MAE and SMAPE. Holt-Winters Multiplicative gave an MAE of 44,498.31 and a SMAPE of 6.76%, against 195,865.1 and 35.32% for FSA, and forecasts about 8.12 million visits in 2025 with a peak in May, whereas FSA forecasts about 6.38 million. Holt-Winters is recommended for short-term tourism planning, with its forecast to be validated against the 2025 actual data.

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1. Introduction

Forecasting is a process that uses historical data to predict future events or occurrences, with broad applications in planning, business management, and industrial processes (Box et al., 2016). Forecasting does not rely solely on technical approaches but also integrates both art and science, as it involves mathematical analysis, intuition, and contextual understanding. Although forecasting results are not always perfectly accurate, the process helps reduce uncertainty and provides insights into future trends. Forecasting methods are generally classified into two main categories: qualitative, which is based on expert judgment, and quantitative, which uses mathematical models derived from historical data (Chenio et al., 2024).

In the tourism sector, forecasting plays a strategic role in supporting planning efforts, particularly because this sector is highly vulnerable to external changes such as global economic fluctuations, natural disasters, and pandemics (Saadah et al., 2023). Variations in the number of tourist visits affect related sectors such as transportation, trade, and regional economic growth (Asmari & Sutrisna, 2021). Therefore, selecting an appropriate forecasting method is crucial to assist local governments and industry stakeholders in formulating effective strategies for tourism development and management.

The concrete problem addressed here is the planning of tourism services under strong seasonality and a structural break. According to the Semarang City Office of Culture and Tourism, visits increased from 4.29 million in 2017 to 7.23 million in 2024, but they fell sharply in 2020 and 2021 and recovered from 2022. The monthly series for 2017 to 2024 ranges from 116,049 visitors (June 2020) to 972,546 visitors (July 2019), an eight-fold difference, with a standard deviation of 176,924 around a mean of 448,231. Planning of transport, accommodation, security, and promotion for 2025 needs month-by-month forecasts, and a method that cannot follow both the seasonal pattern and the pandemic shock will under- or over-estimate demand. The urgency of this research is therefore to find which method gives reliable monthly forecasts for Semarang City.

The two methods were chosen for different reasons. Holt-Winters Multiplicative (Winters, 1960; Holt, 2004) suits data whose seasonal amplitude changes in proportion to the level, as in the multiplicative decomposition of the Semarang series in Section 3.2, and it updates its level, trend, and seasonal components with every new observation, so that it can adapt to a change in level (Hyndman & Athanasopoulos, 2018). Fourier Series Analysis represents the seasonal pattern by sine and cosine terms in a regression with a trend, which needs few parameters and allows the number and strength of harmonics to be inspected through their amplitudes (Bloomfield, 2004; Mardianto et al., 2019; De Livera et al., 2011). The two methods are also contrasting in kind, an adaptive recursive smoother and a global regression, so their comparison shows how each copes with the pandemic break.

Research on forecasting the number of tourist visits has been conducted by Aryati et al. (2020), who applied the *Holt-Winters Exponential Smoothing* method to predict international tourist arrivals to Indonesia. The model produced a Mean Absolute Percentage Error (MAPE) of 0.938%. Similarly, Raihanah et al. (2023) applied the same method to forecast international tourist arrivals at Ngurah Rai and Soekarno-Hatta Airports, with the results indicating significant seasonal fluctuations. On the other hand, a study by Christienova et al. (2018) demonstrated that the *Fourier Series Analysis* (FSA) method was more accurate than *Singular Spectrum Analysis* (SSA) in forecasting air temperature in Surabaya, with a MAPE of 1.8897%.

International studies show that Holt-Winters is a competitive method for tourism data. Lwesya (2017) found that Holt-Winters multiplicative smoothing outperformed seasonal ARIMA for short-run forecasts of tourist arrivals in Tanzania, and Klabi (2014) compared seasonal naïve, Holt-Winters multiplicative, SARIMA, and SARIMAX for visitors to Tunisia, where Holt-Winters performed satisfactorily although SARIMAX, which modeled political shocks, was the most accurate. Song et al. (2019) reviewed research on tourism demand forecasting and showed the wide range of methods used.

Semarang City, as the capital of Central Java Province, holds a strategic role in the development of national tourism thanks to its various supporting facilities and diverse tourist attractions. Accessibility, supported by integrated transportation, further strengthens the city's potential as a rapidly growing tourist destination (Fidyastina et al., 2024). However, the tourism sector faces challenges in the form of fluctuations in the number of tourist visits influenced by various internal and external factors.

To the authors' knowledge, Holt-Winters Multiplicative and Fourier Series Analysis have not been compared for tourist visits to Semarang City. Previous Indonesian studies applied Holt-Winters to international arrivals (Aryati et al., 2020; Raihanah et al., 2023), and FSA was compared with SSA for air temperature (Christienova et al., 2018), a series without a pandemic-type break. The novelty of this study is the head-to-head comparison of an adaptive and a regression-based seasonal method on a tourism series that contains the 2020–2021 shock, together with forecasts of monthly visits for 2025 and their implications for planning.

This study aims to compare the Holt-Winters Multiplicative method and Fourier Series Analysis in forecasting the number of tourist visits to Semarang City. The research questions are: (1) how accurate is each method according to MAE and SMAPE; (2) which method is more accurate; and (3) what monthly visits do the methods forecast for 2025 and what do they imply for tourism planning?

2. Method

This study employs a quantitative approach using time series data. The secondary data utilized consists of the number of tourist visits to Semarang City from January 2017 to December 2024, obtained from the Semarang City Office of Culture and Tourism. The analysis is conducted using two forecasting methods, namely the *Holt-Winters Multiplicative* method and *Fourier Series Analysis* (FSA), to compare the prediction accuracy of each method. All analyses, including forecasting and model evaluation, are performed using the Python programming language. The research procedure is illustrated in the flowchart presented in Figure 1.

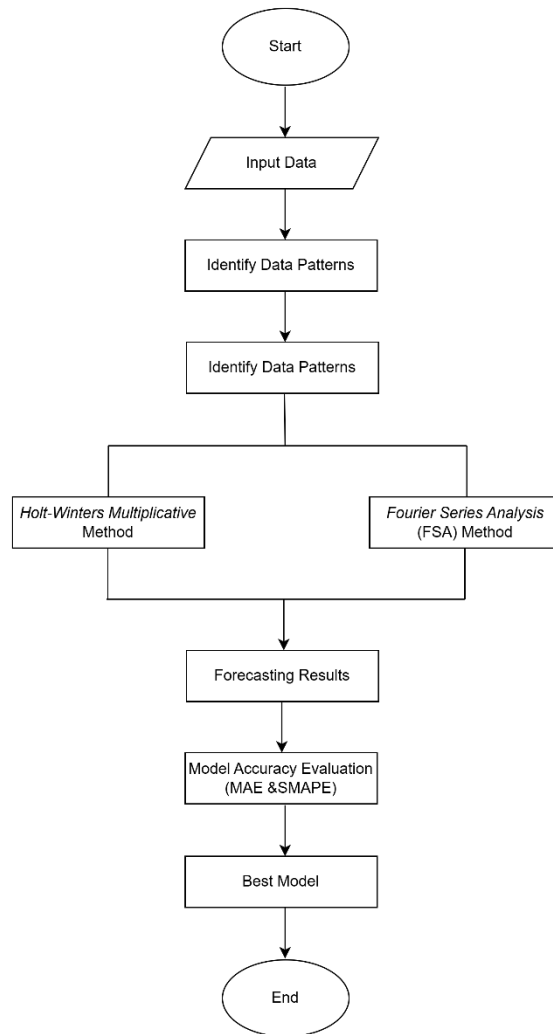


Figure 1 Research Flowchart

- 1) Input the dataset of domestic and international tourist visits to Semarang City.
- 2) Perform descriptive statistical analysis such as mean, median, minimum, maximum, and standard deviation to understand the data distribution.
- 3) Visualize the data using time series plots to identify patterns, including trends and seasonality.
- 4) Conduct modeling using the *Holt-Winters Multiplicative* method:
 - a. Initialize smoothing values for level, trend, and seasonality.
 - b. Determine smoothing parameters for level (α), trend (β), and seasonality (γ).
 - c. Calculate smoothed values for overall level (L_t), trend (b_t), and seasonal component (S_t).
 - d. Forecast the number of tourist visits to Semarang City for the year 2025.
 - e. Calculate forecast errors using MAE and SMAPE to evaluate model performance.
- 5) Conduct modeling using Fourier Series Analysis (FSA):
 - a. Identify seasonal patterns by plotting the data.
 - b. Compute Fourier components ($\cos(\omega t), \sin(\omega t), \cos(2\omega t), \sin(2\omega t), \dots$) based on the fundamental frequency $\omega = \frac{2\pi}{n}$.
 - c. Perform multiple regression to obtain coefficients $a_1, b_1, a_2, b_2, \dots$
 - d. Calculate harmonic amplitudes to determine frequency significance.
 - e. Construct the Fourier Series equation.

- f. Forecast the number of tourist visits to Semarang City for the year 2025
 - g. Calculate forecast errors using MAE and SMAPE to evaluate model performance.
- 6) Compare MAE and SMAPE values between *Holt-Winters Multiplicative* and *Fourier Series Analysis* methods.
 - 7) Determine the best accuracy based on the lowest MAE and SMAPE values.
 - 8) Obtain the forecast of tourist visits to Semarang City for 2025 using the best-performing method.

Forecast accuracy was measured with the Mean Absolute Error and the Symmetric Mean Absolute Percentage Error (Hyndman & Koehler, 2006):

$$\text{MAE} = (1/n) \sum |X_t - F_t|, \quad \text{SMAPE} = (100\%/n) \sum |F_t - X_t| / ((|X_t| + |F_t|)/2)$$

where X_t is the actual and F_t the forecast value in month t . SMAPE is relative and therefore comparable across months of very different volume.

2.1 Forecasting

Forecasting is a technique used to estimate future conditions based on historical data and current information. The goal is to identify patterns, trends, and fluctuations in the data to support more informed decision making (Sarumaha, 2021). According to Ahmad (2020), forecasting is divided into three categories based on timeframe: short-term, medium-term, and long-term. Short-term forecasting covers a period of less than three months and is used for daily operational decisions such as scheduling and purchasing materials. Medium-term forecasting covers a range of one to two years, generally used for sales or production planning. Meanwhile, long-term forecasting covers a period of more than two years and is used for planning major investments such as expansion or opening of new facilities.

Besides being classified based on the time horizon, forecasting is also categorized based on its nature into qualitative and quantitative forecasting (Darmawan et al., 2019). Qualitative forecasting is a method based on opinions, intuition, and expert judgment, and is used in situations with limited historical data, such as forecasting new trends. In contrast, quantitative forecasting uses historical data and statistical techniques to produce more objective and measurable predictions, with the main approaches being time series analysis and causal models.

2.2 Holt-Winters Multiplicative

Holt-Winters Multiplicative is a forecasting method used when the seasonal pattern changes proportionally with the level of the data, where seasonal fluctuations increase or decrease following the data trend. This method is suitable for data with significant growth or decline. The equations used in this method are:

Level Smoothing (α)

$$L_t = \alpha \frac{X_t}{S_{t-s}} + (1 - \alpha)(L_{t-1} + b_{t-1})(1)$$

Trend Smoothing

(β)

$$b_t = \beta(L_t - L_{t-1}) + (1 - \beta)b_{t-1}(2)$$

Seasonal Smoothing (γ)

$$S_t = \gamma \frac{X_t}{L_t} + (1 - \gamma)S_{t-s}(3)$$

Forecasting

$$F_{t+m} = (L_t + mb_t)S_{t+m-s}(4)$$

where:

L_t : level smoothing at period t

b_t : trend smoothing at period t

S_t : seasonal smoothing at period t

X_t : actual value at time t

s : length of the seasonal cycle

L_{t-1} : level smoothing at period $t - 1$

b_{t-1} : trend smoothing at period $t - 1$

α : level smoothing constant ($0 < \alpha < 1$)

β : trend smoothing constant ($0 < \beta < 1$)

γ : seasonal smoothing constant ($0 < \gamma < 1$)

m : number of future periods to be forecasted

F_t : forecast for the desired period

In the *Holt-Winters Multiplicative* method, the level, trend, and seasonal components require initial values, which are calculated using the following equations.

Determination of the initial value for level smoothing (α)

$$L_s = \frac{1}{s}(X_1 + X_2 + \dots + X_k)(5)$$

Determination of the initial value for trend smoothing (β)

$$b_s = \frac{1}{s} \left(\frac{X_{s+1} - X_1}{s} + \frac{X_{s+2} - X_2}{s} + \dots + \frac{X_{s+s} - X_s}{s} \right)(6)$$

Determination of the initial value for seasonal smoothing (γ)

$$S_k = \frac{X_k}{L_s}(7)$$

where:

s : seasonal length

L_s : initial level smoothing value

b_s : initial trend smoothing value

S_k : initial seasonal smoothing values for $k = 1, 2, \dots, s$

X_k : data points $1, 2, 3, \dots, s$

2.3 Fourier Series Analysis

Fourier Series Analysis (FSA) is a mathematical technique that decomposes seasonal patterns in *time series* data by breaking the data into sinusoidal and cosinusoidal functions with specific frequencies and amplitudes (Bloomfield, 2004). This method does not require complex parametric assumptions and is suitable for data exhibiting clear seasonal trends (Christienova et al., 2018). FSA is based on the principle that a periodic function can be represented as an infinite sum of sine and cosine functions, which is formulated in the general Fourier model (Christienova et al., 2018).

$$\hat{Y}_t = a_0 + b_0 t + \sum_{k=1}^K (a_k \cos(k\omega t) + b_k \sin(k\omega t)) \quad (8)$$

where:

$\hat{Y}_t$: forecast value at time t

a_0 : constant term (level data)

b_0 : trend coefficient

a_k and b_k : coefficients of sinusoidal and cosinusoidal amplitudes

ω : $\frac{2\pi}{n}$; fundamental frequency, n = the length of the seasonal period

k : harmonic order of ω

In theory, the Fourier equation can be expanded to the k orde, but in practice it is usually only up to the 5th order due to the complexity that increases at higher orders. To select the significant frequency, the harmonic amplitude is calculated using the following formula:

$$A_k = \sqrt{a_k^2 + b_k^2} \quad (9)$$

The amplitude value A_k indicates the contribution of each frequency component to the overall signal. A frequency is considered significant if $A_k > 0.5$. A high amplitude indicates a seasonal component that has a large effect and contributes to the accuracy of the forecasting model (Zega & Mardiningsih, 2025).

3. Results and Discussion

3.1. Descriptive Analysis

Data exploration was conducted to understand the baseline characteristics of the number of tourist arrivals, using 96 monthly data points from January 2017 to December 2024. Descriptive statistical analysis included mean, median, standard deviation, maximum, and minimum values, with the results presented in Table 1.

Table 1 Descriptive Statistic

N	Mean	Minimum	Maximum	Standard Deviation
96	448231	116049	972546	176924

Based on Table 1 above, it can be seen that the highest number of tourist visits in Semarang City, namely 972,546 people, occurred in July 2019 while the lowest number of visits occurred in June 2020 with only 116,049 visitors. This happens due to seasonal factors, events, and external conditions such as pandemics and government policies.

3.2. Time Series Data Visualization

Time series visualization was conducted to identify trends, seasonal patterns, and fluctuations in the number of tourist arrivals. Figure 2 shows a graph of the movement of tourist arrivals in Semarang City from 2017 to 2024.

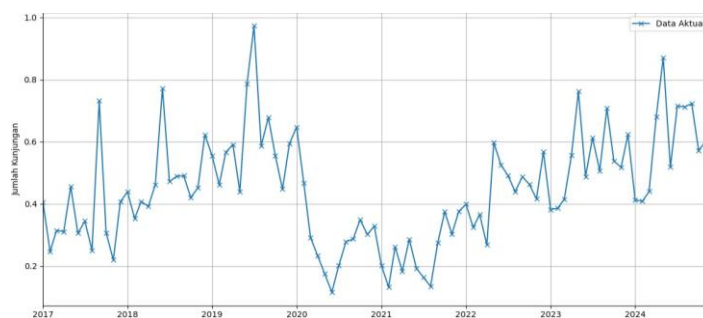


Figure 2 Time Series Plot

The graph shows the actual data of monthly tourist arrivals, which fluctuates significantly. There is a consistent seasonal pattern every year, characterized by recurring spikes and declines in visits during the same period. The number of tourist arrivals increased from 2017 to mid-2019, then declined sharply in 2020 due to the pandemic. A recovery was observed in 2022 and continued until 2024, with a consistent seasonal pattern. For further analysis, a *multiplicative* type seasonal decomposition was used to separate the trend, seasonality, and residual, as shown in Figure 3.

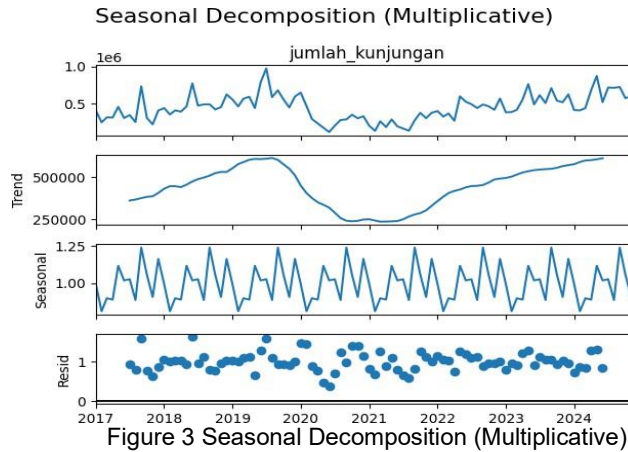


Figure 3 Seasonal Decomposition (Multiplicative)

The seasonal decomposition results show that the trend of tourist arrivals increased significantly until 2019, declined sharply in 2020-2021 due to the pandemic, and then recovered since 2022. The seasonal pattern is stable and repeats every year, indicating a regular cycle of visitation. The residual component is relatively stable, indicating that the model successfully captures the main patterns of the data. These findings confirm the importance of considering trends and seasonality in forecasting modeling for more accurate prediction results.

3.3. Forecasting Using the Holt-Winters Multiplicative Method

The initial stage in applying the multiplicative Holt-Winters method starts with determining the initial values for the level, trend, and seasonal components. These components are initialized using historical data from the initial period to represent the basic pattern and seasonal fluctuations contained in the time series. The seasonal value used in this study is $s = 12$, which covers the seasonal period from the first data to the twelfth data.

- Initial value of smoothing level

$$L_{12} = \frac{1}{12} (X_1 + X_2 + \dots + X_{12}) = \frac{1}{12} (405.732 + 246.870 + \dots + 406.264) = 358.155,50$$

- Initial value of trend pattern smoothing

$$b_{12} = \frac{1}{s} \left(\frac{X_{13} - X_1}{s} + \dots + \frac{X_{24} - X_{12}}{s} \right) = \frac{1}{12} \left(\frac{439.063 - 405.732}{12} + \dots + \frac{622.573 - 406.264}{12} \right) = 10.218,91$$

- Initial value of seasonal pattern smoothing

$$s_1 = \frac{X_1}{L_{12}} = \frac{405,732}{358,155.50} = 1.13$$

The same formula is used to calculate up to $s_{12} = 1.13$.

Next, the optimum smoothing parameters for the level (α), trend (β), and seasonal (γ) components were determined. This process is done by trial and error using Python with the aim of minimizing the forecasting error rate, which is measured using the *Symmetric Mean Absolute Percentage Error* (SMAPE). As a result, optimal parameters were obtained with $\alpha = 0.1$, $\beta = 0.3$, and $\gamma = 0.9$, and a SMAPE value of 6.79%.

After the optimum parameters are set, the historical data is then processed using the *Holt-Winters Multiplicative smoothing* formula for each time period. This process produces a smoothing value that is used in the next stage, which is forecasting. The results of this modeling are used to forecast the number of tourist visits to Semarang City for the period January to December 2025. The results of forecasting tourist arrivals in Semarang City in 2025 using the *Holt-Winters Multiplicative* method are presented in Table 2.

Table 2 Forecasting Tourist Visit of Semarang City 2025 with *Holt- Winters Multiplicative*

Period	Forecasting
Jan-25	459847
Feb-25	456361
Mar-25	497284
Apr-25	740881
May-25	958233
Jun-25	585711
Jul-25	797486
Aug-25	765233
Sep-25	802486
Oct-25	636062
Nov-25	656871
Dec-25	765658

Forecasting tourist arrivals in Semarang City in 2025 using the *Holt-Winters Multiplicative* method shows a strong seasonal pattern with significant fluctuations each month. Peak visitation is predicted to occur in May (958,233) while February (456,361) is the month with the lowest visitation. This information can be used for marketing strategy planning, tourism capacity management, and resource optimization during peak and off-peak periods.

The model evaluation showed excellent performance, with an MAE value of 44,498 and SMAPE of 6.76%, reflecting a relatively low level of prediction error. These results confirm that the model is able to accurately capture seasonal patterns and trends, making it feasible to use as a basis for analysis and decision-making in the tourism sector.

The smoothing parameters are informative: a small α (0.1) means that the level reacts slowly to a single new observation, $\beta = 0.3$ lets the trend adjust moderately, and a large γ (0.9) means that the seasonal indices follow the most recent year closely. The method therefore keeps a stable level while renewing the seasonal pattern quickly, which suits a series whose seasonal shape was disturbed in 2020–2021 and then recovered. The forecasts for 2025 add up to 8,122,113 visits, about 12% above the 7.23 million of 2024, with a monthly average of 676,843. The predicted peak in May (958,233) is close to the historical maximum of 972,546, and the low months are February (456,361) and January (459,847). A forecast this close to the historical maximum should be treated with caution until the 2025 data are available.

3.4. Forecasting Using the Fourier Series Analysis Method

The Fourier transform is used to identify seasonal patterns in tourist arrivals data by breaking the time series into sine and cosine functions. The fundamental frequency is calculated by the formula:

$$\omega = \frac{2\pi}{n}$$

with $n = 12$ months, so $\omega = 0,5236$. The first five harmonics were calculated using the functions $\cos(k\omega t)$ and $\sin(k\omega t)$, $k = 1, 2, \dots, 5$. Data processing was done using Python software. The regression results show that the values of $a_0 = 376.151,26$, $b_0 = 1.519,36$, $a_1 = -33.487,63$, $b_1 = -23.170,58$, $a_2 = 7.656,74$, $b_2 = -26.300,63$, $a_3 = 34.312,89$, $b_3 = -14.281,43$, $a_4 = -2.822,82$, $b_4 = -32.935,64$, $a_5 = -29.477,03$, $b_5 = -9.420,69$.

The Fourier coefficients a_k and b_k obtained from linear regression represent the contribution of the cosine and sine functions in the seasonal pattern. To determine the relative strength of each harmonic component, the amplitude of each harmonic was calculated using the formula:

$$A_k = \sqrt{a_k^2 + b_k^2}$$

Based on the amplitude calculation results, the 1st and 3rd harmonics show the largest values, so the modeling is focused on these two harmonics to simplify the model without reducing the ability to capture the main seasonal pattern. After obtaining the Fourier coefficients from the linear regression, a Fourier series equation was constructed to represent the seasonal pattern in the data. This equation combines the linear trend and the two dominant harmonics as follows:

$$\begin{aligned}\hat{Y}_t = & 376.151,26 + 1.519,36t - 33.487,63 \cos(\omega t) - 23.170,58 \sin(\omega t) + \\ & + 34.312,89 \cos(3\omega t) - 14.281,43 \sin(3\omega t)\end{aligned}$$

Based on the equation above, the forecast for tourist visits to Semarang City in 2025 was generated using the Fourier Series Analysis method, as presented in Table 3.

Table 3 Forecast of Tourist Visits to Semarang City in 2025 Using *Fourier Series Analysis*

Period	Forecasting
Jan-25	468649
Feb-25	453933
Mar-25	517695
Apr-25	559077
May-25	532733
Jun-25	530309
Jul-25	587527
Aug-25	605280
Sep-25	544556
Oct-25	506213
Nov-25	535597
Dec-25	541059

The forecast of tourist visits to Semarang City in 2025 using the *Fourier Series Analysis* method shows a clear seasonal pattern. The highest number of visits is expected in August (605,280), while the lowest is projected in February (453,933). This pattern reflects the influence of holiday seasons and other seasonal factors, which are important for planning more effective tourism management and promotional strategies.

The evaluation of the Fourier Series Analysis model indicates a moderate forecasting accuracy, with a *Mean Absolute Error* (MAE) of 195,865.1 and a *Symmetric Mean Absolute Percentage Error* (SMAPE) of 35.32%. The MAE value suggests that the average difference between the forecast and actual data is approximately 195 thousand visitors per month. However, the SMAPE value of 35.32% indicates that the relative error of the model is still relatively high when compared to the *Holt-Winters Multiplicative* method.

The amplitudes of the five harmonics, computed from the reported coefficients, are 40,722 ($k = 1$), 27,393 ($k = 2$), 37,166 ($k = 3$), 33,056 ($k = 4$), and 30,946 ($k = 5$). The first and third harmonics are the largest, which is why they were retained, but the amplitudes of the five harmonics are of similar size and all are far above the threshold of 0.5 stated in the Method, so that threshold does not discriminate between harmonics and the retained pair is simply the two largest. The trend coefficient is 1,519.36 visits per month, a single straight line fitted to a series that rises, collapses in 2020, and recovers; it cannot represent that break. As a result, the forecasts for 2025 add up to 6,382,628 visits, about 12% below the 7.23 million of 2024, and the monthly average (531,886) is below the 2024 average (602,500), although visits were recovering.

3.5. Discussion

Table 4 Comparison of the Holt-Winters Multiplicative and Fourier Series Analysis methods

Measure	Holt-Winters Multiplicative	Fourier Series Analysis
MAE	44,498.31	195,865.1
SMAPE	6.76%	35.32%
Forecast total, 2025	8,122,113	6,382,628
Change relative to 2024 (7.23 million)	+12.3%	-11.7%
Peak month (visits)	May (958,233)	August (605,280)
Lowest month (visits)	February (456,361)	February (453,933)

Table 4 summarizes the comparison. Holt-Winters Multiplicative has an MAE about 4.4 times and a SMAPE about 5.2 times smaller than FSA, and the two methods differ in the forecast level and in the timing of the peak. The difference in error is explained mainly by how each method treats the pandemic. Holt-Winters recomputes its level, trend, and seasonal components at every month, so after the fall in 2020 and the recovery from 2022 it follows the series. FSA fits one set of coefficients to all 96 months, so the 2020–2021 observations pull the level and the trend of the whole fitted curve, and its forecasts for 2025 are lower than the recent data. The comparison is therefore as much a test of adaptivity to a structural break as of seasonal modeling, and the poor result of FSA should not be generalized to series without such a break.

The finding that Holt-Winters Multiplicative performs well agrees with Lwesya (2017), who found it more effective than seasonal ARIMA for tourist arrivals in Tanzania, with Klabi (2014), who found its performance satisfactory for visitors to Tunisia, and with the Indonesian studies of Aryati et al. (2020) and Raihanah et al. (2023). Klabi (2014) also found that a model with intervention terms for shocks (SARIMAX) was the most accurate, which suggests that adding a pandemic dummy to FSA or to the smoothing models could improve both. In contrast to Christienova et al. (2018), who found FSA more accurate than SSA for air temperature in Surabaya with a MAPE of 1.89%, FSA here has a SMAPE of 35.32%; the difference is consistent with a smooth, stationary-seasonal temperature series on the one hand and a tourism series with a structural break on the other.

The novelty of the findings is that, for Semarang City, an adaptive multiplicative method is clearly preferable to a global harmonic regression on post-pandemic tourism data, and that the two methods lead to opposite conclusions about 2025 (growth of about 12% against a decline of about 12%), so the choice of method changes the planning decision. For the tourism office and operators, the Holt-Winters forecast suggests preparing capacity and promotion for the peak months (May and July to September) and using the low months (January and February) for maintenance and promotion; the forecast should be updated every month and compared with actual visits, and the method should be used for short-term planning of about one year ahead.

Several limitations should be noted. The errors reported for the two methods appear to have been calculated on different bases: the MAE of FSA (195,865.1) is larger than the standard deviation of the series (176,924), which cannot happen for a least-squares fit with an intercept evaluated on the same data, whereas the MAE of Holt-Winters (44,498.31) is of the size of a one-step in-sample error. A fair comparison requires the same evaluation sample for both methods, preferably a holdout or rolling-origin forecast, and parameters selected without using the test months. No benchmark such as a seasonal naïve forecast or SARIMA was included, the 2025 forecasts have not been checked against actual data, and only two methods and one city were studied. Future research should use the same out-of-sample evaluation, add benchmark models and an intervention term for 2020–2021, test additive Holt-Winters and more harmonics, and validate the forecasts when the 2025 data are available.

4. Conclusion

The three research questions are answered as follows. First, the Holt-Winters Multiplicative method ($\alpha = 0.1$, $\beta = 0.3$, $\gamma = 0.9$) has an MAE of 44,498.31 and a SMAPE of 6.76%, and the Fourier Series Analysis method with a linear trend and the first and third harmonics has an MAE of 195,865.1 and a SMAPE of 35.32%. Second, Holt-Winters Multiplicative is the more accurate method for forecasting tourist visits to Semarang City, mainly because it adapts to the level change caused by the pandemic, which a single fitted curve cannot do; this conclusion holds for the evaluation reported here and should be confirmed with a common out-of-sample evaluation.

Third, Holt-Winters Multiplicative forecasts about 8.12 million visits in 2025, with the peak in May (958,233) and the lowest month in February (456,361), whereas FSA forecasts about 6.38 million, with the peak in August (605,280) and the lowest month also in February (453,933). It is recommended that the tourism office use the Holt-Winters forecast for short-term capacity and promotion planning, update it monthly, and compare it with the actual 2025 visits; further research should add benchmark models, an intervention term for the pandemic, and a holdout evaluation.

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