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Comparison of Moving Average and Double Exponential Smoothing Methods in Rice Production Forecasting Based on NTB Satu Data

Asri Mustika Arbyati[1], Andika Ellena Saufika Hakim Maharani[2*]

[1,2]Department of Mathematics, Faculty of Mathematics and Natural Sciences, University of Mataram

[*]**Correspondance author:** a.ellena.saufika@staff.unram.ac.id

ABSTRACT

The rapid development of technology in the industry 4.0 era has led to the emergence of the data literacy era, where data is no longer merely supporting information but has become a strategic asset in decision-making. Recognizing the importance of data utilization, the West Nusa Tenggara/Nusa Tenggara Barat (NTB) Provincial Government launched the NTB Satu Data program through Governor Regulation No. 45 of 2021. This program provides an open, standardized, and integrated sectoral data platform managed by the NTB Communication, Information, and Statistics Agency. Through this platform, data is collected, validated, analyzed, and visualized so that it can be utilized for evidence-based policy planning. This study utilizes annual rice production data from 2001 to 2024 from the NTB Satu Data portal to forecast rice production in 2025. Two commonly used time series forecasting methods, Moving Average (MA) and Double Exponential Smoothing (DES), are applied and compared in terms of accuracy. Evaluation was conducted using the Mean Absolute Percentage Error (MAPE) and Mean Absolute Deviation (MAD) metrics. The analysis results show that the DES (Holt) method produced a MAPE of 9.455% and a MAD of 158.533, outperforming the MA order 2 method with a MAPE of 9.746% and a MAD of 161.700. These findings indicate that DES is more adaptive in capturing historical trend patterns and more effective in modeling production changes over time. The results of this study are expected to provide input for local governments in designing food security policies that are responsive to production dynamics. Utilizing these forecasts will enable more appropriate allocation of resources, increased preparedness for potential food supply disruptions, and strengthening of sustainable food security in NTB Province.

Keywords: Forecasting, Moving Average, Double Exponential Smoothing, Rice Production, NTB Satu Data

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INTRODUCTION

Indonesia, located on the equator, has a tropical climate with two seasons, namely the rainy season and the dry season, and is dominated by volcanic mountainous areas. These conditions make Indonesia one of the countries with the most fertile soil in the world, allowing various food crops such as rice, corn, sago, cassava, sweet potato, and sorghum to grow well. Among these commodities, rice is the main staple food of the Indonesian people. Therefore, rice production plays a strategic role in the agricultural sector and as a pillar of the national economy (4).

The province of West Nusa Tenggara (NTB) is one of the regions that contributes

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significantly to national rice production. According to official data from the Central Statistics Agency (BPS) of NTB, rice production in NTB reached 1.54 million tons of dried milled rice (GKG) in 2023, an increase of 5.89% compared to the previous year. (1). This increase aligns with the expansion of harvested areas and improved productivity in key production regions such as Central Lombok, East Lombok, and Sumbawa districts (2). This situation necessitates efforts in forecasting or prediction to support better agricultural planning and policy-making (3).

In the context of data-driven development, the NTB Provincial Government has initiated the NTB Satu Data program as a form of commitment to supporting the Satu Data Indonesia policy. This program is regulated by NTB Governor Regulation No. 45 of 2021 and managed by the NTB Provincial Communication, Informatics, and Statistics Agency (Diskominfotik). Through the NTB Satu Data portal, various sectoral data, including rice production data, are provided openly, standardized, and integrated, enabling their use for analyses such as time series analysis and evidence-based policy formulation. This data infrastructure aligns with the spirit of the Satu Data Indonesia policy, which emphasizes transparency and integration of sectoral data (6).

One form of data utilization is through time series forecasting to predict future rice production. Forecasting methods are very important in supporting the planning, decision-making, and risk control processes in agriculture. This technique encompasses various methods such as moving average, exponential smoothing, trend projection, and decomposition (8). In this study, the researchers used the moving average method and the double exponential smoothing method.

The Moving Average (MA) method is one of the simplest forecasting techniques and is frequently applied in time series data analysis (5). Meanwhile, the Double Exponential Smoothing (DES) method is a time series forecasting technique developed to address the limitations of the Single Exponential Smoothing method. One of the most common forms of the DES method is the Holt method, which is specifically designed for data with linear trends. In this method, there are two main equations used to simultaneously update the level and trend estimates. The level estimate is updated by combining the latest actual data and the previously predicted trend, while the trend estimate is adjusted based on the level change from the previous period (7).

In this study, a comparison was made between the two methods in predicting rice production in NTB in 2025 based on data from the NTB Satu Data portal for the period 2001–2024. The aim was to determine which method was more accurate and relevant for use in the context of regional development planning, particularly in the agricultural sector. The results of this study are expected to provide input for local governments, particularly the Agriculture Department, in formulating data-driven food security policies and accurate forecasts. Additionally, this research supports the strengthening of open data utilization as a foundation for more efficient, responsive, and targeted agricultural sector development planning.

METHODS

This study uses a quantitative approach with time series analysis to forecast rice production in NTB Province, using the Moving Average and Double Exponential Smoothing methods. The analysis steps are as follows:

a. Identifying Patterns in Data

The first step in the analysis is to identify patterns in historical data on rice production

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in West Nusa Tenggara Province (NTB) during the period 2001 to 2024.

b. Forecasting using the Moving Average (MA) method
The calculation formula used is as follows:

$$\mathrm{MA} = \mathrm{F_{t+1}} = \frac{\mathrm{X_t} + \mathrm{X_{t-1}} + \cdots + \mathrm{X_{t-n+1}}}{n} \quad (1)$$

Description:
MA: Moving Average
$\mathrm{F_{t+1}}$: Forecast for period $t+1$
$\mathrm{X_t}$: Actual data in period t
n: Number of forecasting periods involved
Before forecasting, the best order is sought. For each order value, forecasting is performed and the MAPE error value is calculated.

$$MAPE = \frac{\sum_{t=1}^{n} \left| \left(\frac{X_t - F_t}{X_t} \right) \times 100\% \right|}{n} \quad (2)$$

Description:
F_t: Data from the t^{th} forecast
The order that produces the smallest MAPE value is selected as the best order and used in the final forecasting process.

c. Forecasting using the Double Exponential Smoothing (DES) method
This method considers two components, namely the smoothing value in the current period (S_t) calculated using the following formula:

$$S_t = \alpha X_t + (1-\alpha)(S_{t-1} + b_{t-1}) \quad (3)$$

and the second component is the trend smoothing value over time (b_t):

$$b_t = \beta\,(S_t - S_{t-1}) + (1-\beta\,)b_{t-1} \quad (4)$$

Thus, the forecast value obtained is:

$$F_{t+m} = S_t + b_t m \quad (5)$$

Description
S_t: Single Exponential Smoothing value for period t
α: Exponential Smoothing parameter value $(0 < \alpha < 1)$
b_t: Trend smoothing for period t
β: Trend smoothing parameter value $(0 < \beta < 1)$
m: Future period to be forecasted
F_{t+m}: Forecast value for the $(t + m)^{\text{th}}$ future period
To obtain optimal forecast results, a combination of α and β values is sought using trial and error approach. Then, the MAPE value is calculated for each combination. The combination of α and β that gives the smallest MAPE value is selected as the optimal parameter and used in the final forecasting process.

d. Evaluation and comparison of forecasting accuracy
The final step in this analysis is to compare the forecasting results of the two methods used. This comparison is based on three accuracy measures, namely:
1) Mean Absolute Deviation (MAD)

$$MAD = \frac{1}{n}\sum_{t=1}^{n} |X_t - F_t| \quad (6)$$

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The smaller the MAD value, the more accurate it is, because it has a smaller average difference from the actual data.

2) Mean Absolute Percentage Error (MAPE)
The formula for calculating MAPE is presented in equation (2). A smaller MAPE value indicates a higher level of forecasting accuracy. Ideally, if MAPE is below 10%, the method is considered highly accurate.

RESULTS AND DISCUSSION

The results of the analysis of rice production forecasts in West Nusa Tenggara Province using the Moving Average and Double Exponential Smoothing methods are presented. The data used in this analysis is secondary data obtained from the NTB Satu Data portal, namely annual rice production data from 2001 to 2024. The following is the data used:

Table 1. Data on Rice Production in NTB.

Year	Rice Production (in Tons)
2001	1.458.616
2002	1.370.171
2003	1.422.441
2004	1.466.757
2005	1.367.869
2006	1.552.628
2007	1.526.347
2008	1.750.678
2009	1.870.775
2010	1.774.499
2011	2.067.137
2012	2.114.232
2013	2.193.699
2014	2.116.638
2015	2.417.393
2016	2.095.119
2017	2.323.700
2018	1.460.338
2019	1.402.181
2020	1.317.190
2021	1.419.561
2022	1.452.945
2023	1.538.536
2024	1.453.408

Identification of Historical Data Patterns

The analysis began with identifying trend patterns in rice production data. The process of predicting future data requires an understanding of historical data patterns. Therefore, an initial analysis was conducted to identify patterns in rice production data in West Nusa Tenggara Province from 2001 to 2024.

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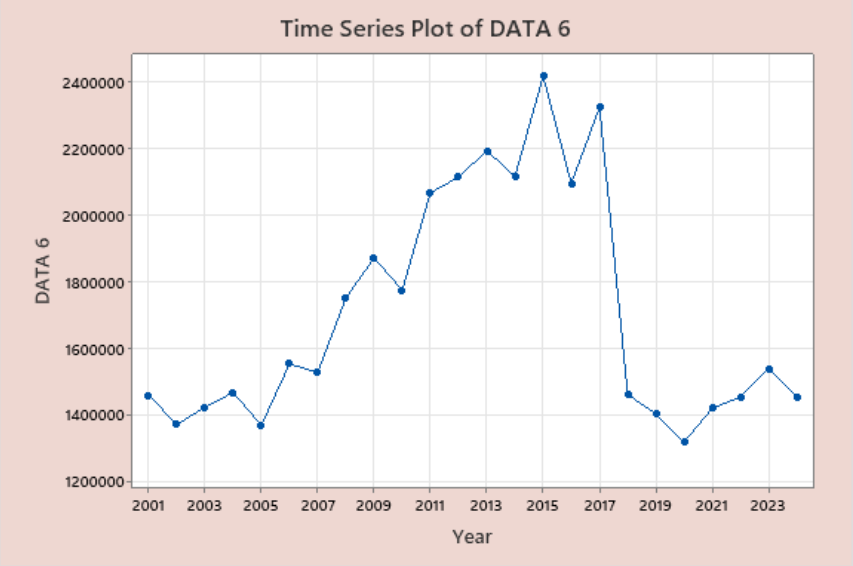

Figure 1. Plot Data on Rice Production in NTB.

Based on Figure 1, it can be seen that there was a general upward trend in production from 2001 until it peaked in 2015. During the period from 2006 to 2015, the graph shows a fairly consistent increase, with the highest value occurring in 2015. However, after 2016, there was a sharp decline to its lowest point in 2020. Although there was a slight increase in the following years, the overall data movement tended to decline after 2016. This shows that the data has a strong upward trend pattern at the beginning of the period, followed by a significant downward trend, with moderate fluctuations in the final years.

Moving Average Method

Before applying the Moving Average method, it is necessary to select the best order value to obtain optimal accuracy. Therefore, trial and error process was conducted on various order values, and the evaluation results are shown in Table 2 as follows.

Table 2. Comparison of Order and MAPE.

Orde	MAPE
2	**9.746**
3	12.051
4	14.530
5	16.993
6	18.596
7	21.536
8	23.578
9	25.264
10	27.065

Table 2 shows that the smallest MAPE value was obtained at order 2 with a value of 9.746. Based on the MAPE interpretation, this value falls into the category of highly accurate forecasting. Therefore, order 2 was selected as the basis for predicting the number of poor people.

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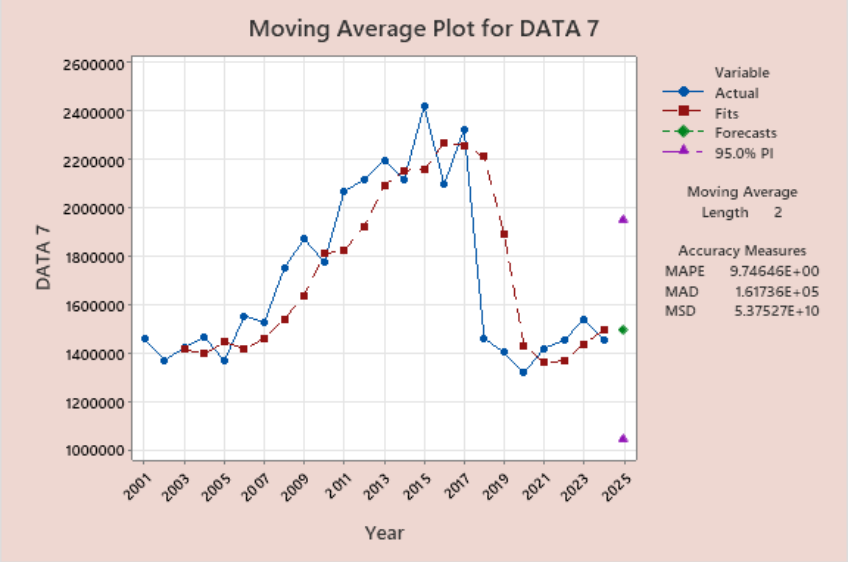

Figure 2. Moving Average Order 2 Forecasting.

Based on the results processed using Minitab 22 software, a MAPE value of 9.746 and a MAD value of 161.700 were obtained. The following are the forecasting results using the second-order MA method.

Table 3. Forecasting Results Using MA Order 2.

Year	*Forecast*	*Lower*	*Upper*
2025	1.495.972	1.041.562	1.950.382

Based on Table 3, the forecast result for 2025 is 1.495.972 (tons), with a confidence interval between 1.041.562 and 1.950.382.

Double Exponential Smoothing (DES)/Holt Method

Before implementing the Double Exponential Smoothing method, the smoothing level (α) and smoothing trend (β) parameters were determined through a trial and error approach to obtain the combination with the lowest MAPE value. Table 4 presents the results of testing several combinations of these parameters.

Table 4. Comparison of α, β, and MAPE.

α	β	MAPE	α	β	MAPE	α	β	MAPE
0.1	0.1	19.787	0.3	0.1	14.544	0.7	0.1	10.269
0.1	0.2	21.581	0.3	0.01	14.066	0.7	0.01	9.860
0.1	0.01	18.267	0.4	0.1	12.444	0.8	0.1	9.917
0.1	0.02	18.424	0.4	0.01	12.250	0.8	0.01	9.623
0.2	0.1	17.715	0.5	0.1	11.230	0.9	0.1	9.629
0.2	0.2	18.254	0.5	0.01	10.881	0.9	0.2	9.796
0.2	0.01	16.336	0.6	0.1	10.638	**0.9**	**0.01**	**9.455**
0.2	0.02	16.509	0.6	0.01	10.168	0.9	0.02	9.486

Two combinations of parameters that give the smallest MAPE value of 9.455 are when is $\alpha = 0.9$ with $\beta = 0.01$. This MAPE value falls into the category of highly accurate forecasting.

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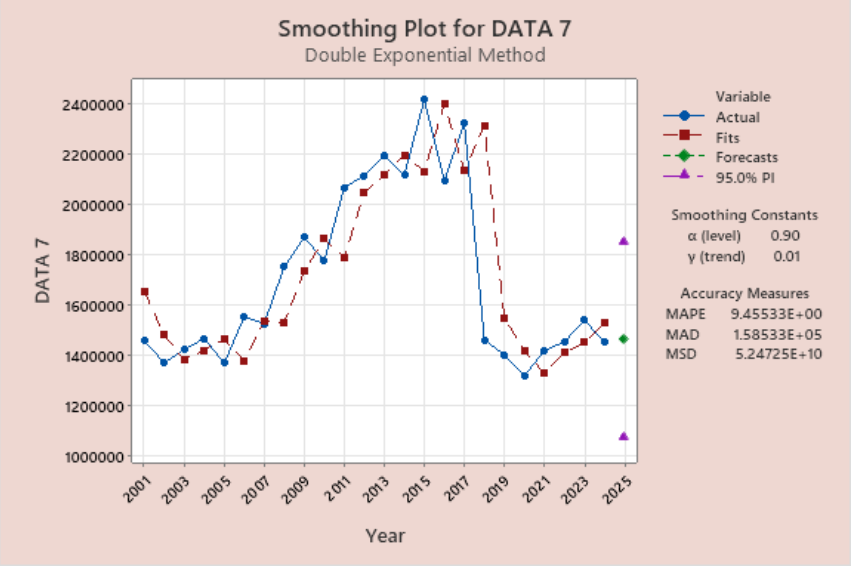

Figure 2. Double Exponential Smoothing (DES)/Holt Forecasting.

Further analysis with a combination of parameters $\alpha = 0.9$ and $\beta = 0.01$ showed a MAPE value of 9.455 and a MAD value of 158.533.

Table 5. Results of Rice Production Forecasts DES.

Year	*Forecast*	*Lower*	*Upper*
2025	1.462.583	1.074.184	1.850.982

Based on Table 5, the forecast result for 2025 is 1.462.583 (tons), with a confidence interval between 1.074.184 and 1.850.982.

Comparison of Forecast Results

Table 6. Comparison of Forecast Results and Model Accuracy.

	Moving Average Order 2	**Double Exponential Smoothing (DES)/Holt** $\alpha = 0.9$ **and** $\beta = 0.01$
MAPE	9.746	9.455
MAD	161.700	158.533
Forecast (2025)	1.495.972 (tons)	1.462.583 (tons)

Table 6 shows a comparison of the prediction results and accuracy levels of the two methods. In terms of MAPE values, the Double Exponential Smoothing (Holt) method shows a lower error rate of 9.455%, compared to the Moving Average method at 9.746%. Based on general MAPE criteria, values below 10% indicate excellent prediction performance. Additionally, the MAD value also indicates that the Double Exponential Smoothing method is superior in terms of prediction accuracy and consistency. The MAD value of 158.533 is lower than that of the Moving Average method, which is 161.700. This suggests that the DES method is more sensitive to historical data trends and more adaptive in modeling annual production changes.

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CONCLUSION

Based on the above topic, which is forecasting rice production using two time series methods, namely Moving Average (MA) and Double Exponential Smoothing (DES). Through this approach, a comparison was made to determine which method provides the most accurate prediction results for rice production data from 2001 to 2024. The analysis results indicate that the Double Exponential Smoothing method yields a MAPE value of 9.455% and a MAD value of 158.533, outperforming the Moving Average (order 2) method, which produces a MAPE value of 9.746% and a MAD value of 161.700. These results indicate that the DES (Holt) method is more accurate for forecasting rice production in NTB for the 2025 period, as it has proven to be superior in capturing historical data trends and producing more consistent and accurate predictions. Therefore, the DES method is recommended as the optimal forecasting approach for projecting rice production in NTB Province.

These forecasting results not only support the implementation of the NTB Satu Data policy as a platform for sectoral data integration but also provide strategic input for local governments, particularly the Agriculture Department, in developing data-driven, measurable, and responsive food security policies. Overall, these forecasting results demonstrate the importance of utilizing open data to support data-driven and measurable food security policies.

ACKNOWLEDGMENTS

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CONFLICT OF INTEREST

The authors declare no conflicts of interest.

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