

Comparison of Simple Moving Average and Least Squares Methods in Forecasting Rice Production in Padang City

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Abstract: Rice production is an important agricultural indicator for supporting regional food availability and agricultural planning. Fluctuations and long-term changes in production require appropriate quantitative forecasting methods to provide information about future production levels. This study aims to compare the performance of the Simple Moving Average (SMA) and Least Squares Method (LSM) in forecasting rice production in Padang City and to determine the method that better represents the historical data. A quantitative descriptive approach was employed using annual rice production data for 2016–2025 obtained from the Kota Padang Dalam Angka publications issued by Badan Pusat Statistik. SMA generated forecasts from the average of the two preceding observations, while LSM estimated production through a linear time-trend equation. Forecasting performance was evaluated using Mean Absolute Deviation (MAD), Mean Squared Error (MSE), and Mean Absolute Percentage Error (MAPE), with all calculations performed using Microsoft Excel. The results showed that rice production generally exhibited a declining trend during the observation period. SMA produced MAD of 10.784,53 tons, MSE of 162.101.692,43, and MAPE of 17,39%, whereas LSM produced lower error measures, with MAD of 5.927,95 tons, MSE of 46.858.619,17, and MAPE of 8,14%. The 2026 forecasts generated by SMA and LSM were 46.685,00 tons and 38.451,59 tons, respectively. Based on the historical error measures, LSM provided a better representation of the declining production pattern. The findings indicate that model selection should consider the characteristics of the observed time series rather than computational simplicity alone.

Keywords: Forecasting; Least Square Method; MAPE; Rice Production; Simple Moving Average

1. Introduction

Rice production is closely related to food availability and agricultural planning in Indonesia. Changes in production from one period to another create uncertainty regarding future production levels, making quantitative forecasting important for supporting planning and decision-making. Previous studies have therefore applied various time-series techniques to rice-production data, ranging from relatively simple methods such as Moving Average and Least Squares to Exponential Smoothing, ARIMA, time-series regression, and machine-learning approaches. Aisya et al. (2025), for example, compared Moving Average and Triple Exponential Smoothing for national rice production and found that Moving Average tended to respond more slowly to changes in actual

production, whereas Triple Exponential Smoothing was more responsive to seasonal patterns and trends. Fitriani et al. (2024) applied Single Exponential Smoothing to rice production in West Java, motivated by the decline in rice production and the need for forecasting to reduce future uncertainty. Meanwhile, Khofi and Farhan (2025) employed ARIMA for rice production in West Nusa Tenggara, illustrating the applicability of time-series models to fluctuating agricultural production. Yanata and Helma (2025) applied Long Short-Term Memory to monthly rice-production data in West Sumatra and obtained a MAPE of approximately 10%, further demonstrating that forecasting accuracy depends on the method and characteristics of the observed data.

Among simpler forecasting approaches, Moving Average remains attractive because it is straightforward to calculate and interpret. Lumentut et al. (2025) applied Simple Moving Average and Weighted Moving Average to forecasting electricity-customer growth and evaluated their performance using MAD, MSE, and MAPE. In agricultural applications, Safitri et al. (2025) compared Naïve, Moving Average, Exponential Smoothing, and Linear Regression/Least Squares for rice production in Lamongan, indicating the importance of comparing alternative forecasting models rather than relying on a single technique. Juniarto et al. (2025) similarly compared Moving Average, Weighted Moving Average, and Exponential Smoothing for production forecasting and evaluated model performance using MAD, MSE, and MAPE. These studies suggest that the simplicity of Moving Average does not automatically guarantee the smallest forecasting error; its performance must be empirically evaluated against the structure of the observed series.

Least Squares provides a different mathematical approach because it represents the overall direction of historical observations through a linear trend. Several recent Indonesian studies have demonstrated its application to agricultural forecasting. Nasution et al. (2024) used Least Squares to forecast rice production in Padang Lawas and obtained a MAPE of approximately 4,23%. Hamdiah et al. (2025) applied the same method to rice production in Mataram and reported a MAPE of 0,28%, indicating a close fit between the trend model and the historical observations used in their study. Fitrawati et al. (2025) also applied Least Squares to rice-production forecasting in West Lombok using historical harvested-area and production data. Furthermore, Andriani et al. (2025) employed LSM to forecast Indonesian wholesale rice prices and reported a MAPE of 2%, demonstrating its potential for modelling time-indexed agricultural data. The usefulness of modelling systematic temporal relationships is also demonstrated by Asyari et al. (2025), whose simple linear regression model for electricity-customer growth produced an R^2 of 98,73%.

More advanced forecasting research further emphasizes that model suitability depends on the pattern contained in the data. Kusuma (2024) compared Holt-Winters and Seasonal ARIMA for Indonesian rice production and identified indications of declining production during particular periods. Fahmuddin et al. (2025) compared Time Series Regression and ARIMA using monthly Indonesian rice-production data and evaluated their performance using MAPE. Rusman et al. (2023) likewise applied forecasting analysis to Indonesian rice production to support assessment of future rice availability. Collectively, these studies indicate that agricultural forecasting is not merely a matter of producing future values; an important mathematical problem is determining which model provides errors sufficiently small for the particular pattern being analyzed.

Despite the growing number of studies on rice-production forecasting, direct comparison between a short-period Simple Moving Average and a Least Squares linear trend using annual rice-production data specifically for Padang City remains limited. This constitutes the main research gap addressed in the present study. Padang City's production data are particularly relevant because the 2016–2025 series exhibits short-term fluctuations accompanied by a substantial overall decline. A method based on recent observations may respond differently to this pattern than a model based on the overall time trend. The use of SMA provides greater emphasis on the two most recent observations, while LSM represents the general direction of the complete historical series. Consequently, comparing both methods on the same dataset provides an opportunity to examine how their different mathematical mechanisms respond to a declining regional agricultural series.

The present study is significant because an inappropriate forecasting method may produce estimates that inadequately represent historical production dynamics. Model comparison using objective error measures is therefore necessary before selecting a forecast for subsequent periods. Accordingly, this study aims to (1) apply SMA and LSM to annual rice production data for Padang City, (2) evaluate their performance using MAD, MSE, and MAPE, (3) identify the method that better represents the historical production pattern, and (4) generate a forecast of rice production for 2026. Rather than proposing a new forecasting algorithm, the contribution of this study lies in providing a transparent and reproducible comparison of two computationally simple mathematical methods using official regional agricultural data.

2. Methods

2.1 Research Design and Data Source

This study employed a quantitative descriptive approach with a forecasting framework to compare the performance of the Simple Moving Average (SMA) and Least Squares Method (LSM) in forecasting rice production in Padang City. The research used annual wetland rice production as the observed variable, expressed in tons.

Secondary data were obtained from the annual Kota Padang dalam Angka publications issued by Badan Pusat Statistik Kota Padang. The observation period covered ten years, from 2016 to 2025. The data were collected using a documentation technique by identifying annual rice production values from the corresponding publications and arranging them chronologically. The dataset used in the analysis is presented in Table 1.

Table 1. Rice Production in Padang City, 2016–2025

No	Year	Rice Production (tons)
1	2016	90.645
2	2017	99.018
3	2018	100.111,80
4	2019	86.540
5	2020	80.735

6	2021	60.730,33
7	2022	71.434
8	2023	54.206
9	2024	46.685
10	2025	46.685

Data analysis was performed using Microsoft Excel. The analysis consisted of calculating forecasts using SMA and LSM, calculating forecasting errors using Mean Absolute Deviation (MAD), Mean Squared Error (MSE), and Mean Absolute Percentage Error (MAPE), comparing the performance of both methods, and generating forecasts for 2026.

2.2 Simple Moving Average (SMA)

The first forecasting method used in this study was the Simple Moving Average (SMA). SMA is a forecasting technique that estimates the value of the subsequent period by calculating the arithmetic mean of a specified number of preceding observations. Lumentut et al. (2025) applied the Moving Average approach to forecasting problems and evaluated its performance using several error measurements.

In this study, two preceding annual observations were used to generate each forecast. The SMA equation is

$$F_t = \frac{Y_{t-1} + Y_{t-2}}{2}, \quad (1)$$

where F_t represents the forecast for period t , Y_{t-1} represents actual rice production one period before t , and Y_{t-2} represents actual rice production two periods before t .

Since SMA requires two preceding observations, the first forecast was generated for 2018 using actual rice production in 2016 and 2017. The same calculation was subsequently performed sequentially until 2025. The 2026 forecast was generated using the two most recent actual observations, namely production in 2024 and 2025.

In Microsoft Excel, the SMA forecasts were calculated using the average function for two consecutive preceding observations. The resulting formula was then copied sequentially to the subsequent periods.

2.3 Least Square Method

The second forecasting method used in this study was the Least Squares Method (LSM). The method constructs a mathematical trend between time and the observed variable by minimizing the squared deviations between actual observations and their fitted values. The general linear trend model is

$$\hat{Y} = a + bX, \quad (2)$$

where $\hat{Y}$ represents estimated rice production, a is the constant, b represents the trend coefficient, and X is the coded time variable.

The use of Least Squares for forecasting time-indexed data follows the approach of Andriani et al. (2025), who applied LSM to forecast wholesale rice prices. The application of historical time-indexed observations for forecasting is also consistent with Asyari et al. (2025).

Because the number of observations was even ($n = 10$), the time variable was coded symmetrically as

$$X = -9, -7, -5, -3, -1, 1, 3, 5, 7, 9,$$

so that $\sum X = 0$.

The model parameters were calculated as

$$a = \frac{\sum Y}{n}, \quad (3)$$

and

$$b = \frac{\sum XY}{\sum X^2}. \quad (4)$$

The fitted value for each observation was obtained by substituting the corresponding X value into the Least Squares equation. The subsequent time code was then used to generate the forecast for 2026. All calculations were performed using Microsoft Excel.

2.4 Forecast Accuracy Measurement

Forecasting accuracy was evaluated using Mean Absolute Deviation (MAD), Mean Squared Error (MSE), and Mean Absolute Percentage Error (MAPE). These measures were selected because they quantify forecasting errors from different perspectives and have also been applied by Lumentut et al. (2025) in evaluating Moving Average forecasting performance.

MAD was calculated as

$$MAD = \frac{\sum |Y_t - F_t|}{n}. \quad (5)$$

MSE was calculated as

$$MSE = \frac{\sum (Y_t - F_t)^2}{n}. \quad (6)$$

Meanwhile, MAPE was calculated as

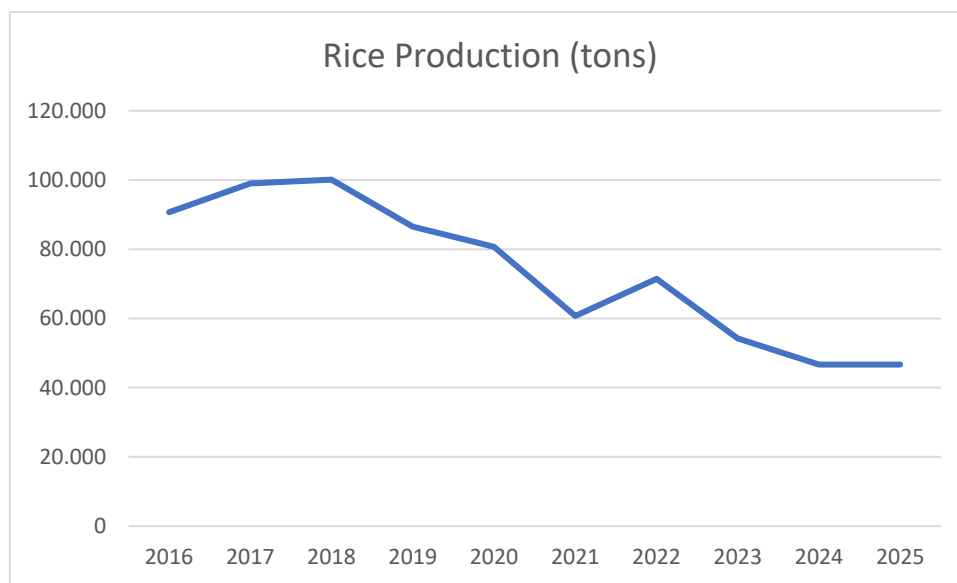
$$MAPE = \frac{1}{n} \sum \left| \frac{Y_t - F_t}{Y_t} \right| \times 100\%. \quad (7)$$

MAPE has also been employed by Andriani et al. (2025) to evaluate forecasting accuracy using LSM.

Smaller MAD, MSE, and MAPE values indicate smaller differences between the model estimates and actual observations. The accuracy measures were calculated in Microsoft Excel and subsequently used to compare the two forecasting methods.

3. Results and Discussion

Rice production in Padang City during 2016–2025 exhibited considerable fluctuations but showed a clear overall downward tendency. Production increased from 90.645 tons in 2016 to 99.018 tons in 2017 and reached the highest value of 100.111,80 tons in 2018. Production subsequently declined to 86.540 tons in 2019 and 80.735 tons in 2020.



Graph 1. Rice Production, 2016-2025

A more substantial decline occurred in 2021, when production reached 60.730,33 tons. Production temporarily increased to 71.434 tons in 2022 before decreasing again to 54.206 tons in 2023 and 46.685 tons in 2024. Production remained at 46.685 tons in 2025.

Comparing the beginning and end of the observation period, rice production decreased (see Graph 1) by 43.960 tons or approximately 48.50%. Therefore, although the series contains several fluctuations, particularly the increases in 2017, 2018, and 2022, its dominant long-term pattern is a decline. This characteristic becomes important in explaining differences in the performance of SMA and LSM.

3.1 Forecasting Using Simple Moving Average

The SMA forecast was calculated from the mean of the two preceding annual production observations. For example, the first forecast, corresponding to 2018, was

$$F_{2018} = \frac{90.645+99.018}{2} = 94.831,50 \text{ tons.}$$

The calculation was then performed sequentially through 2025. The complete results are presented in Table 2.

Table 2. Forecasting Results Using Simple Moving Average

Year	Actual Production (tons)	SMA Forecast (tons)	$ Y - F $ (tons)	APE (%)
2018	100.111,80	94.831,50	5.280,30	5.27
2019	86.540	99.564,90	13.024,90	15.05
2020	80.735	93.325,90	12.590,90	15.60
2021	60.730,33	83.637,50	22.907,17	37.72
2022	71.434	70.732,67	701,34	0.98
2023	54.206	66.082,17	11.876,17	21.91
2024	46.685	62.820	16.135	34.56
2025	46.685	50.445,50	3.760,50	8.06

The results demonstrate considerable variation in the forecasting error across years. The smallest APE was obtained in 2022 at only 0.98%, when SMA predicted 70.732,67 tons compared with actual production of 71.434 tons. Conversely, the largest percentage error occurred in 2021, with an APE of 37.72%. During that year, actual production decreased sharply to 60.730,33 tons, whereas SMA still produced a forecast of 83.637,50 tons.

The overall SMA accuracy measures were:

Table 3. Forecasting Accuracy of Simple Moving Average

Accuracy Measure	Simple Moving Average
MAD	10.784,53 tons
MSE	162.101.692,43
MAPE	17.39%

This result can be related to Lumentut et al. (2025), who demonstrated that the performance of Moving Average forecasting should be assessed through error measures such as MAD, MSE, and MAPE rather than relying only on the simplicity of the method. The present findings similarly show that the selection of the Moving Average period influences forecasting performance.

For 2026, SMA uses the two most recent actual observations :

$$F_{2026} = \frac{46.685 + 46.685}{2} = 46.685 \text{ tons.}$$

Therefore, SMA forecasts rice production of 46.685 tons in 2026. The forecast remains unchanged from 2025 because the actual production values in 2024 and 2025 are identical.

3.2 Forecasting Using the Least Squares Method

The Least Squares calculation using rice production data from 2016–2025 produced $a = 73.679,013$ and $b = -3.202,493$. Accordingly, the estimated trend equation was

$$\hat{Y} = 73.679,013 - 3.202,493X.$$

The negative trend coefficient indicates that the estimated rice-production trend decreases as time progresses. Since the coded X values increase by two units for each additional year, the estimated annual decline is approximately $2(3.202,493) = 6.404,99$ tons/year. The forecasting results using LSM are presented in Table 4.

Table 4. Forecasting Using The Least Squares Method

No	X	Year	Rice Production (tons)	Production LSM	Forecast Error	Error APE
1	-9	2016	90.645	102501,45	11856,45	13,08009
2	-7	2017	99.018	96096,464	2921,536	2,95051
3	-5	2018	100.111,80	89691,478	10420,32	10,40869
4	-3	2019	86.540	83286,492	3253,508	3,759542
5	-1	2020	80.735	76881,506	3853,494	4,773015
6	1	2021	60.730,33	70476,52	9746,19	16,04831
7	3	2022	71.434	64071,534	7362,466	10,30667
8	5	2023	54.206	57666,548	3460,548	6,384068
9	7	2024	46.685	51261,562	4576,562	9,803067
10	9	2025	46.685	44856,576	1828,424	3,916513

This result is consistent with the descriptive analysis showing that production decreased substantially between 2016 and 2025. The accuracy measures obtained from the Least Squares model were as follows.

Table 5. Forecasting Accuracy of the Least Squares Method

Accuracy Measure	Least Squares
MAD	5,927.95 tons
MSE	46,858,619.17
MAPE	8.14%

The relatively small MAPE indicates that the fitted Least Squares values differed from actual production by an average absolute percentage of approximately 8.14%.

The performance of LSM can be explained by the dominant structure of the dataset. Although annual production fluctuated, the overall direction during the ten-year period was downward. Unlike SMA, which only uses recent observations, LSM explicitly represents this direction through its negative trend coefficient.

This finding is consistent with Andriani et al. (2025), who applied the Least Squares Method to wholesale rice-price forecasting and demonstrated that a linear trend equation can provide relatively small forecasting errors when the historical data contain an identifiable trend. It is also conceptually consistent with Asyari et al. (2025), who demonstrated the usefulness of modelling the relationship between time and historical observations for forecasting purposes.

Using $X = 11$ for 2026 gives

$$\widehat{Y}_{2026} = 73.679,013 - 3.202,493(11) = 38.451,59 \text{ tons.}$$

Thus, LSM forecasts rice production in Padang City at approximately 38,451.59 tons in 2026.

4. Conclusion

This study shows that the Simple Moving Average (SMA) and Least Squares Method (LSM) can both be applied to forecast rice production in Padang City using historical data from 2016–2025. However, their performance differs in representing the observed production pattern. The SMA method produced a MAD of 10.784,53 tons, MSE of 162.101.692,43, and MAPE of 17,39%, while the Least Squares Method resulted in lower error values, with a MAD of 5.927,95 tons, MSE of 46.858.619,17, and MAPE of 8,14%. Therefore, based on the error measures used in this study, the Least Squares Method provides a better representation of the historical rice production pattern than Simple Moving Average. This result is associated with the overall declining trend in rice production during the observation period, which can be explicitly represented by the linear trend component of the Least Squares model. The two methods generated different forecasts for 2026, namely 46.685 tons using SMA and 38.451,59 tons using Least Squares. Considering its lower historical errors, the Least Squares estimate is considered the more appropriate model-based forecast. Nevertheless, these forecasts are based solely on historical production data and do not incorporate factors such as harvested area, productivity, rainfall, irrigation, land-use changes, or agricultural policies. In addition, the historical evaluation periods of the two methods are not completely identical because Simple Moving Average requires two preceding observations. Future studies are therefore recommended to evaluate competing methods over the same testing period and incorporate relevant explanatory variables to obtain a more comprehensive forecast of rice production in Padang City.

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