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Implementation of the Double Exponential Smoothing Method in Predicting Palm Oil Harvest Yields

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Abstract
Double Exponential Smoothing (DES) is a forecasting method that combines two main components: level and trend. This method is used for data that shows a trend pattern, meaning data that tends to increase or decrease over time. This study aims to implement the Double Exponential Smoothing method to predict oil palm yields at PT. Amal Tani. The data used in this study consists of historical oil palm yield data from 2019 to 2023. The prediction system designed is web-based, utilizing PHP programming language and MySQL database. The performance evaluation of the prediction model is conducted using the Mean Absolute Percentage Error (MAPE) and Mean Absolute Error (MAE) metrics. The study demonstrates that the Double Exponential Smoothing method can produce accurate and effective predictions. The implementation of this system facilitates data processing and the dissemination of information related to oil palm yields. The results indicate that this prediction model can assist the management of PT. Amal Tani in making more accurate yield forecasts, thereby increasing productivity and operational efficiency. The implementation of this method is also expected to ease the company's decision-making process regarding production planning and seed planting. This study concludes that the Double Exponential Smoothing method is an effective and accurate tool for predicting oil palm yields and provides positive contributions to data management and decision-making processes at PT. Amal Tani. This study offers insights into the application of the Double Exponential Smoothing method in forecasting oil palm yields.
Keywords: Double Exponential Smoothing, Harvest Prediction, Palm Oil, MAE, MAPE

Introduction
Forecasting is an estimation of potential future events, crucial for planning and anticipation across various life aspects. PT. Amal Tani, a palm oil plantation company in Indonesia, faces challenges with its semi-computerized harvest prediction system. Harvest reporting and determination are time-consuming and often inaccurate due to manual data collection and Excel-based calculations, leading to frequent discrepancies with actual seeding data. This study, using harvest data from 2019-2023, aims to identify a more effective method for predicting palm oil yields.

Implementing the Double Exponential Smoothing method enables PT. Amal Tani to improve palm oil harvest predictions by reducing forecast errors and addressing trend and seasonal data. Developing a predictive information system based on this method will streamline harvest estimates and speed up report generation, while also enhancing the accuracy and efficiency of palm seedling forecasts [1].

Some research discussions on palm oil harvest include a study by Fadma and Darma [2], who used Artificial Neural Networks with the Backpropagation method to forecast palm oil production. The study considered factors such as plant age, land area, number of palm trees, and monthly yield. The results yielded a MAPE of 10.0047%.

Literature Review
1. Data Mining
Data mining is a series of processes aimed at discovering added value in the form of information that could not previously be identified manually from a database. Since the 1990s, data mining has developed as an effective method for extracting patterns and useful information to uncover relationships between data. This process enables the grouping of data into one or more clusters, where objects within a cluster have a high degree of similarity. Data mining is also part

of the knowledge discovery process from databases, known as Knowledge Discovery in Databases (KDD) [3].

2. Forecasting

Forecasting is a key component in operational management decision-making, as it provides information on future demand. It assists in determining the necessary capacity or inventory, making decisions related to staff recruitment, budgeting, and ordering goods from suppliers and partners within the supply chain. With accurate forecasting, planning becomes more effective and focused [4].

3. Oil palm

Oil palm is one of Indonesia's plantation crops, known for producing oil alongside coconuts. Originating from the tropical rainforests of West Africa, it is particularly found in Cameroon, Ivory Coast, and Liberia. Oil palm was first discovered by Nicholaas Jacquin in 1763, hence its Latin name *Elaeis Guineensis Jacq.*

Oil palm plants can be harvested when they reach three to four years of age. Production increases as the plant matures, reaching maximum yield at the age of 9 to 14 years, after which production begins to decline. The economic lifespan of oil palm plants ranges from 25 to 26 years. The age of the oil palm plant not only affects yield but also impacts plant productivity.

4. Double Exponential Smoothing

The Double Exponential Smoothing method predicts future period values by assigning weights to several previous periods or observations. Holt's Double Exponential Smoothing is a linear model that uses two parameters (α and β) to smooth trend values with parameters distinct from the original series. The following equations can be used to determine the formula for Holt's Double Exponential Smoothing method[5]:

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

$$T_t = \beta(S_t - S_t - 1) + (1 - \beta)\,T_t - 1 \quad (2)$$

$$F_{t+m} = S_t + Tt_m \quad (3)$$

dimana:

S_t = Smoothed value at period-t

X_t = Actual data for period-t

α, β, γ = Exponential parameter* with a value between 0 and 1

$F_{(t+m)}$ = Forecast result

m = Future periods

T_t = Trend value at period -t

l_t = Seasonal factor

5. Advantages and Disadvantages of the Double Exponential Smoothing (DES) Method

Double Exponential Smoothing (DES) is a time series forecasting method that is well-suited for data with trends, as it applies exponential smoothing twice to account for this characteristic. One of the key advantages of DES is its ability to handle trends effectively, making it useful for data that exhibits consistent increases or decreases over time. Additionally, the method is less complex and computationally demanding compared to more advanced forecasting models, making it relatively quick to implement. By performing smoothing twice, DES also helps reduce the impact of random fluctuations, resulting in a more stable and accurate forecast. The method is responsive to new data, adapting quickly to dynamic environments where forecasts need to be updated frequently.

However, DES also has limitations. It assumes that trends are linear, which can lead to inaccuracies if the data has non-linear trends or seasonal patterns. DES is less effective for time series with strong seasonal variations, as it is primarily designed for trend data without seasonality. Choosing appropriate smoothing parameters, α\alphaα and β\betaβ, is crucial, as incorrect values can lead to unreliable forecasts. Furthermore, the results of DES are sensitive to initial values, which can require additional tuning through trial and error to optimize. Despite these limitations, DES remains a valuable tool for straightforward trend-based forecasting, although Triple Exponential Smoothing (or Holt-Winters) may be more appropriate for data with complex seasonal patterns.

Materials & Methods

1. Data Colections

In this research uses data sourced from P.T Amal Tani, the author will examine the effectiveness of the Double Exponential Smoothing algorithm for predicting palm oil harvest yields, using monthly historical data for each AFD from 2019 to 2023. This study will produce forecasting results and identify the best outcomes based on the evaluation of the smallest error values.

Tabel 1. Actual Data

No	Tanggal	Luas (Ha)	Jumlah Pokok	Hasil Panen (kg)
1	2019-01	351.72	45721	855667
2	2020-01	350.66	45584	722007
3	2021-01	350.66	45584	1050494

⋮	⋮	⋮	⋮	⋮
299	2022-01	530.92	69019	788729
300	2023-01	529.86	68884	893286

2. Methods

Below is the system scheme from the research conduted.

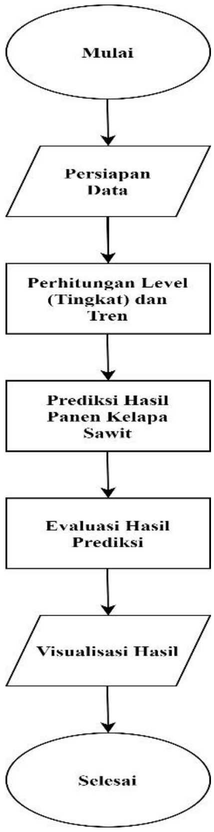

Figure 1. System Scheme

The system process flow will be explained through the following points:

1. Start: The initial step in the process, where the execution of the Double Exponential Smoothing algorithm begins.
2. Data Preparation: This step involves collecting and preparing historical data to be used in forecasting analysis. This data is typically a time series covering a specific period.
3. Calculation of Level and Trend: Here, the level and trend values are calculated based on historical data. This involves applying calculation formulas that consider the values of α and β (smoothing parameters for level and trend).
4. Oil Palm Harvest Prediction: After calculating the level and trend values, the next step is to use these values to forecast the oil palm harvest for the upcoming period. This prediction relies on the Double Exponential Smoothing model that has been built.
5. Prediction Evaluation: After making the prediction, the next critical step is to evaluate its accuracy. This can involve comparing the prediction to the actual historical data values and using evaluation metrics such as Mean Absolute Percentage Error (MAPE) and Mean Absolute Error (MAE).
6. Visualization: Graphs or plots can be created to show how well the prediction fits the historical data.
7. Finish : The final step in the process, where the Double Exponential Smoothing analysis is completed. At this point, the oil palm harvest forecast has been made using the method, and the results have been evaluated.

3. Evaluation

Mean Absolute Percentage Error (MAPE) is a calculation used to determine the average percentage of absolute error. MAPE is useful for measuring the accuracy of the forecasting methods used. By calculating MAPE, one can see the extent of the estimation error as a percentage of the actual values. Below is the formula for calculating the MAPE value [6]:

$$\text{MAPE} = \frac{1}{n}\sum_{i-1}^{n} \left| \frac{\hat{y}i - yi}{yi} \right| x\ 100 \quad (4)$$

Description:

n = Number of data points

$\tilde{y}i$ = Predicted value at index i
yi = Actual value at index i

Table 1. MAPE Range Value

MAPE Value	Criteria
<10%	Very Good Forecasting
10-20%	Good Forecasting
20-50%	Fair Forecasting
>50%	Poor Forecasting

Results and Discussion

In this study, the author will discuss the results of implementing predictions using the Double Exponential Smoothing method. The data used in this discussion involves predictions conducted for the period from January to June 2024.

1. Prediction Results Using the DES Method

At this stage, the author will present the results of the palm oil harvest predictions using the Double Exponential Smoothing method.

A. AFD I Prediction Results

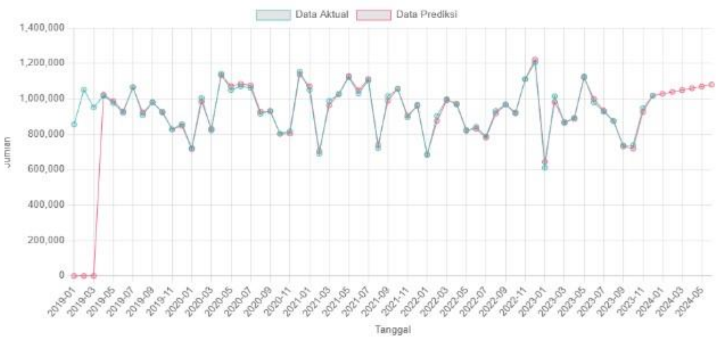

Figure 2. AFD I Prediction Chart

The graph above shows the comparison between actual data and predicted data for palm oil harvests in AFD I from January 2019 to May 2024. The light blue line represents actual data, while the pink line represents the model's predictions. Overall, the predictions closely follow the trend of the actual data, indicating adequate model accuracy. A trend stabilization is observed toward the end of the period.

B. AFD II Prediction Results

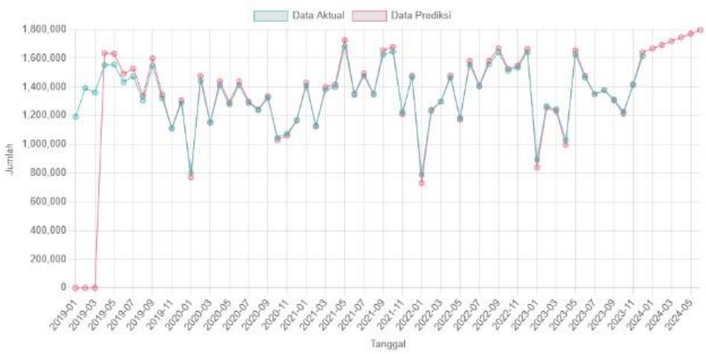

Figure 3. AFD II Prediction Chart

The graph above shows the comparison between actual and predicted data for palm oil harvests in AFD II from January 2019 to May 2024. The light blue line represents the actual data, while the pink line represents the predicted data. The palm oil harvests in AFD II are generally consistent with the predictions, indicating that the prediction model successfully captures historical data patterns with reasonable accuracy, although there is slight variation in some periods.

C. AFD III Prediction Results

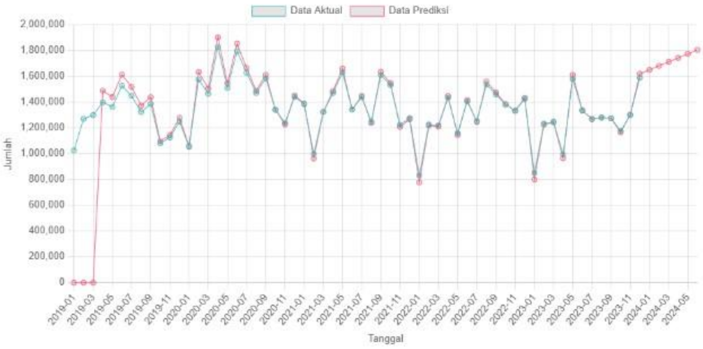

Figure 4. AFD III Prediction Chart

This graph displays the comparison between actual and predicted data for palm oil harvests in AFD III from 2019 to 2024. The light blue line represents the actual data, while the pink line shows the predicted data. Overall, palm oil harvests in AFD III demonstrate a pattern that is fairly consistent with the predictions, indicating that the model used is capable of accurately capturing trends and patterns.

D. AFD IV Prediction Results

Figure 5. AFD IV Prediction Chart

The graph above shows the comparison between actual and predicted data for palm oil harvests in AFD IV from 2019 to 2024. The actual data is represented by the light blue line, while the predictions are shown by the pink line. In general, palm oil harvests in AFD IV follow the predicted pattern fairly well, although there are some periods where the actual results differ slightly from the predictions. These fluctuations indicate variability that may be influenced by external factors.

E. AFD V Prediction Results

Figure 6. AFD V Prediction Chart

The graph above displays the actual and predicted data for palm oil harvests in AFD V from 2019 to 2024. The blue line represents the actual data, while the red line shows the predicted data. Overall, the predictions closely follow the pattern of actual harvests with reasonable accuracy, though there are slight variations in certain periods. The predictions show a stable trend heading into 2024, reflecting consistent management efforts in AFD V.

Conclusions

Based on the discussion above, the conclusions drawn from this research are as follows:

1. The Double Exponential Smoothing (DES) method has been successfully implemented to predict palm oil

production results at P.T Amal Tani, following the established calculation process using the DES method.

2. The prediction results for each AFD using the Double Exponential Smoothing method demonstrate very good accuracy. for AFD I, the accuracy is 2.89% with alpha 0.9 and beta 0.1. AFD II shows an accuracy of 3.36% with alpha 1 and beta 0.1. AFD III has an accuracy of 3.49% with alpha 1 and beta 0.1. AFD IV achieves an accuracy of 3.4% with alpha 1 and beta 0.1, while AFD V shows an accuracy of 3.19% with alpha 1 and beta 0.1.

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