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Information System of Warehouse Management Web-Based with Forecasting Features Using Single Exponential Smoothing Method at Pilar Mas Building Supply Store

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Abstract

This study aims to develops a web-based warehouse management system with forecasting features using the Single Exponential Smoothing (SES) method at Pilar Mas Building Supply Store. The store often experiences overstocking or stockouts due to the lack of accurate demand forecasting. SES was chosen for its simplicity, responsiveness to recent data, and suitability for non-seasonal demand patterns. The system provides functions for inventory management, recording incoming and outgoing goods, and automated sales forecasting. Forecast accuracy was evaluated using the Mean Absolute Percentage Error (MAPE), with an average value of 19.28% across 10 main products, indicating good accuracy. The results demonstrate that the system can generate reliable demand forecasts, support inventory planning, reduce stock imbalances, and enhance operational efficiency.

Keywords: *Warehouse Management System; Forecasting; Inventory Control; Single Exponential Smoothing; MAPE*

1. Introduction

Pilar Mas Building Store is a building materials supplier located in Lamongan. The store provides a wide range of construction materials, including cement, iron, paint, nails, and other essential products. With its high transaction volume and rapid inventory turnover, the store faces difficulties in managing stock effectively. These challenges often result in overstocking or shortages, which can cause project delays, unnecessary costs, and customer dissatisfaction. Therefore, the store requires an efficient and accurate warehouse management system capable of supporting decision-making in inventory control[1].

Warehousing is a key component in supply chain operations. It functions not only as a storage facility but also as an operational support unit that significantly influences company performance. Proper warehouse management ensures product availability, reduces human error in stock recording, and improves customer service[2]. Moreover, efficient inventory management is considered critical to ensure smooth business processes, since it enables easier monitoring of stock levels, supports procurement activities, reduces losses, and optimizes operational efficiency[3].

The rapid development of information and communication technology (ICT) provides opportunities to overcome these challenges by integrating warehouse management with forecasting features. Web-based platforms are particularly advantageous as they allow access from multiple devices, enable real-time monitoring, and provide centralized data management[4]. Compared to desktop-based systems, web technologies offer higher scalability and flexibility, which are crucial for enterprises that need to respond to dynamic market demands. Previous research has also demonstrated that web-based applications can significantly reduce paper usage, improve efficiency, and simplify administrative control compared to conventional approaches[5].

Forecasting plays a crucial role in inventory management by predicting future demand based on historical sales data. This function helps minimize the risks of stockouts and overstocking. Several forecasting methods have been widely applied, including Moving Average (MA), Double Exponential Smoothing (DES), and Linear Regression. Other studies have also applied the Decomposition method to building material sales, showing that this approach is effective in combining trend and seasonal components to generate reliable predictions, particularly when demand patterns exhibit seasonality[6]. MA is simple to use but does not respond quickly to sudden changes[7]. DES can handle trends more effectively but requires additional parameters[8]. Regression analysis is useful for long-term trend prediction but less suitable for short-term demand fluctuations[9]. Furthermore, forecasting itself is an essential element in decision-making, as it relies on analyzing historical data to anticipate future conditions[10].

Single Exponential Smoothing (SES) has been recognized as a suitable method for forecasting when data shows relatively stable patterns without strong seasonality. SES assigns higher weights to recent observations, making it more responsive while maintaining simplicity[11]. Its flexibility in adjusting the smoothing parameter (α) allows researchers to fine-tune predictions according to the characteristics of sales data. In contexts where demand fluctuates moderately, such as in building material supplies, SES offers an effective balance between accuracy and practicality. Using SES in operational systems allows organizations to anticipate short-term demand more accurately, optimize inventory levels, and reduce the risk of overstocking or stockouts, thereby supporting more effective decision-making in warehouse management[12], [13].

This study aims to design and implement a web-based warehouse management information system integrated with SES forecasting. The proposed system is expected to improve inventory accuracy, minimize stock imbalances, and enhance operational efficiency at Pilar Mas Building Store.

2. Methodology

This research is an applied study focused on designing and implementing a web-based warehouse management system integrated with forecasting features. The methodology consists of three main stages: system development, data collection, and system evaluation.

2.1. System Development

The system was developed as a web-based application using PHP and MySQL. Core functionalities include product data management, stock monitoring, transaction recording, and automated sales forecasting using the Single Exponential Smoothing (SES) method. The system architecture was designed to ensure data consistency and ease of use, including user authentication, dashboard visualization, and forecast history. Historical sales data from Pilar Mas Building Store guided the system design to ensure practical alignment with real warehouse operations.

2.2. Data Collection

The dataset comprises monthly sales records of five key building materials—cement, iron, sand, paint, and wire—collected from June 2024 to May 2025. These data serve as the basis for calculating SES forecasts and assessing prediction accuracy. Additional metadata such as product categories, stock levels, and transaction dates were also collected to support inventory monitoring and ensure accurate forecasting.

2.3. System Evaluation

Forecasting accuracy was evaluated using the Mean Absolute Percentage Error (MAPE). The evaluation allows the researchers to verify the reliability of the SES method for predicting short-term demand and to identify potential areas for improvement in inventory management.

3. Results and Discussion

The analysis in this study includes several important components related to the development of the warehouse management system and the application of forecasting methods. The main focus consists of observation data, the application of forecasting formulas, and the evaluation of forecasting accuracy. These stages are essential to ensure that the designed system is both functional and reliable in supporting inventory management at Pilar Mas Building Store.

3.1. Observation Data

The observation data in this study were collected from Pilar Mas Building Store in the period June 2024 to May 2025. The data consist of monthly sales transactions for five types of building materials, namely cement, iron, sand, paint, and wire. These five products were selected because they represent the main items with high turnover in the store.

Table 1 : Sales Data of Pilar Mas Selling in May 2025

No	Produk	Sales Amount
1	Gresik Cement	1500
2	Tiga Roda Cement	1500
3	Iron 6 A x 12	374
4	Iron 8 A x 13	225
5	Iron10 A x 14	315
6	Ploso Sand	46
7	Avian Wall Paint 1kg	378
8	No Drop Wall Paint 2kg	240
9	Wire "1/4" Kg	80
10	Wire "1/2" Kg	78

3.2. Application of Single Exponential Smoothing (SES)

In this study, the forecasting process was carried out using the Single Exponential Smoothing (SES) method to calculate demand prediction based on past sales data. The SES method is suitable for short-term forecasting and gives greater weight to more recent data[11].
The formula for SES is as follows:

$$Ft_{+1} = \alpha \cdot Dt + (1 - \alpha) \cdot Ft_{-1}$$

Where:

Ft_{+1} : forecast for the next period,
Dt : actual demand at time t,
Ft : forecast of the previous period,
α : smoothing constant ($0 < \alpha < 1$)

When applying the Single Exponential Smoothing (SES) method, the choice of smoothing constant (α) significantly impacts forecast results. An α value close to 1 makes the model more sensitive to recent data changes but results in high fluctuations. Conversely, an α value close to 0 provides more stable forecast results but is less responsive to changes in sales trends.

In this study, trial and error tests were conducted with several values of α, including 0.2, 0.5, and 0.8. The comparison results show that the value of α = 0.5 produces the lowest average Mean Absolute Percentage Error (MAPE) value compared to other values. Thus, α = 0.5 was chosen because it is able to provide a balance between the stability of forecast results and sensitivity to fluctuations in sales data, so it is considered most appropriate for the characteristics of building material sales at Pilar Mas Building Supply Store.

To illustrate the process, SES was applied to Ploso Sand using data from June 2024 to May 2025. Three smoothing constants were tested (α=0.5) to evaluate which parameter gives the most accurate result.

Table 2 : Sales Data of Pilar Mas Ploso Sand Selling

No	Period	Actual (Dt)	Forecast (F)
1	June 2024	30	Initial period, no forecast
2	July 2024	32	Dt1 = 30
3	August 2024	41	0.5∗32+0.5∗30=16+15=31
4	September 2024	58	0.5∗41+0.5∗31=20.5+15.5=36
5	October 2024	52	0.5∗58+0.5∗36=29+18=47
6	November 2024	45	0.5∗52+0.5∗47=26+23.5=49.5
7	December 2024	38	0.5∗45+0.5∗49.5=22.5+24.75=47.25
8	January 2025	35	0.5∗38+0.5∗47.25=19+23.625=42.62
9	February 2025	42	0.5∗35+0.5∗42.62=17.5+21.3125=38.81
10	March 2025	48	0.5∗42+0.5∗38.81=21+19.40625=40.40
11	April 2025	44	0.5∗48+0.5∗40.40=24+20.203125=44.20
12	May 2025	46	0.5∗44+0.5∗44.20=22+22.1015625=44.10
13	June 2025	-	0.5∗46+0.5∗44.10=23+22.05078125=45.05

After calculating the SES forecast for Ploso Sand, the same method was applied to all key products sold at Pilar Mas Building Supply Store. Using a smoothing constant of α = 0.5, forecasts were generated for each product based on their historical sales data. This approach allows the system to predict future demand efficiently, taking into account recent sales trends while smoothing out fluctuations. The following table presents the actual sales and corresponding SES forecasts for all products for the latest period:

Table 3 :SES Forecast for All Products

No	Product	Actual (Dt)	Forecast(F)
1	Gresik Cement	1500	1463.17
2	Tiga Roda Cement	1500	1463.17
3	Iron 6 A x 12	374	353.82
4	Iron 8 A x 13	225	211.95
5	Iron10 A x 14	315	363.89
6	Ploso Sand	46	45.05
7	Avian Wall Paint 1kg	378	412.15
8	No Drop Wall Paint 2kg	240	234.21
9	Wire "1/4" Kg	80	69.68
10	Wire "1/2" Kg	78	81.69

3.3. Forecast Accuracy

After generating forecasts using the Single Exponential Smoothing (SES) method, the accuracy of predictions was evaluated using the Mean Absolute Percentage Error (MAPE). Mean Absolute Percentage Error (MAPE) is one of the methods used to evaluate the accuracy of forecasting results. MAPE is calculated by taking the absolute error for each period divided by the actual observed value for that period, and then averaging the absolute percentage errors[14]. A lower MAPE value indicates a better and more accurate forecast.
The formula for MAPE can be expressed as follows[15]:

$$APE = \left(\frac{Xt - Yt}{Xt}\right).100$$

$$MAPE = \left(\frac{\sum APE}{n}\right)$$

Where:

Xt = Actual observed value at period t
Yt = Forecasted value at period t using the model
n = Number of periods

The accuracy level of a forecasting model can be assessed based on the MAPE value. The general classification is shown in below:

Table 4 : MAPE Accuracy Ranges

MAPE Range	Accuracy Description
<10%	Very High
10%-20%	High
20%-50%	Moderate
>50%	Low

This classification demonstrates that MAPE < 10% indicates very high accuracy, 10%–20% indicates high accuracy, 20%–50% indicates moderate accuracy, and values > 50% indicate low accuracy. This range provides researchers with an easy-to-understand evaluation of how well the forecasting model reflects historical data accurately.

Using the SES forecast for Ploso Sand (α = 0.5) from June 2024 to May 2025, the absolute percentage errors for each month were calculated as follows:

Table 5 : MAPE Calculation for Ploso Sand

No	Period	Actual (Dt)	Forecast (F)	APE
1	June 2024	30	-	-
2	July 2024	32	30.00	6.25
3	August 2024	41	31.00	24.39
4	September 2024	58	36.00	37.93
5	October 2024	52	47.00	9.62
6	November 2024	45	49.50	10.00
7	December 2024	38	47.25	24.34
8	January 2025	35	42.63	21.79
9	February 2025	42	38.81	7.59
10	March 2025	48	40.41	15.82
11	April 2025	44	44.20	0.46
12	May 2025	46	44.10	4.13
13	June 2025	-	45.05	-

The average MAPE for Ploso Sand is:

$$MAPE = \frac{162.31}{12} = 14.76$$

According to the classification in Table 5, the SES forecast for Ploso Sand achieves high accuracy, as the MAPE value falls between 10%–20%. This indicates that the forecasting model is reliable and suitable for short-term inventory planning.

Following the evaluation for Ploso Sand, the same SES approach was applied to all key products sold at Pilar Mas Building Supply Store. The resulting MAPE values for each product are summarized in Table 6.

Table 6 : SES Forecasts and MAPE for All Products

No	Product	Actual Sales (Dt)	Forecast (F)	MAPE(%)
1	Gresik Cement	1500	1463.17	16.57
2	Tiga Roda Cement	1500	1463.17	16.57
3	Iron 6 A x 12	374	353.82	25.21
4	Iron 8 A x 13	225	211.95	18.76
5	Iron10 A x 14	315	363.89	25.75
6	Ploso Sand	46	45.05	14.76
7	Avian Wall Paint 1kg	378	412.15	21.62
8	No Drop Wall Paint 2kg	240	234.21	17.36
9	Wire "1/4" Kg	80	69.68	17.03
10	Wire "1/2" Kg	78	81.69	19.20

As shown in Table 6, the SES forecasts for all key products demonstrate generally good accuracy, with MAPE values ranging from 14.76% to 25.75%. Products such as Ploso Sand, Gresik Cement, and Tiga Roda Cement exhibit relatively lower MAPE values, indicating more accurate forecasts. Meanwhile, Iron 10 A x 14, Iron 6 A x 12, and Avian Wall Paint 1kg show the highest MAPE values, though most products still fall within the "moderate to high accuracy" category according to Table 4. These results confirm that the SES method with α = 0.5 provides reasonably reliable short-term demand predictions for the main products at Pilar Mas Building Supply Store, supporting better inventory management and planning.

3.4. System Design

The system design refers to the workflow required to implement the functionalities described previously, integrating inventory management with forecasting features using the Single Exponential Smoothing (SES) method. The design process covers stages from data collection to generating inventory forecasts, ensuring efficient operation and reliable outputs. Flowcharts and Data Flow Diagrams (DFD) were used to illustrate how data is processed within the system.

a. Flowchart

The Flowcharts are graphical representations used to illustrate the steps and sequence of procedures in a system, employing standard symbols for start/end points, input-output, processes, and decisions[16]. Sales data is collected as input, then processed using SES to produce accurate forecasts. Each step is designed to ensure system efficiency and output reliability.

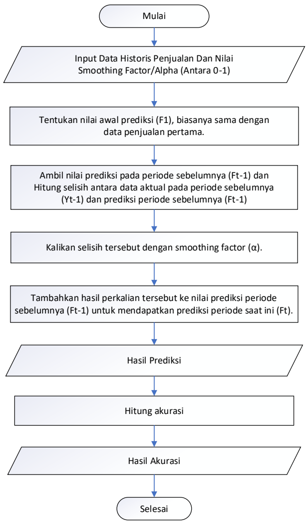

Fig. 1: Flowchart Single Exponential Smoothing

The flowchart illustrates the SES workflow: input historical sales data and a smoothing factor (α) between 0 and 1. The initial forecast (F1) is equal to the first-period sales data. Subsequent forecasts (Ft) are calculated by taking the previous forecast (Ft−1), computing the difference with the previous actual value (Yt−1), multiplying by α, and adding it to Ft−1.

b. Data Flow Diagram (DFD)

A Data Flow Diagram (DFD) is applied to model the flow of data in the system hierarchically, starting from the context diagram to more detailed levels. Its advantage lies in simplifying complex systems so they are easier to understand for both developers and stakeholders. In this study, DFD Level 0 illustrates the interaction of the system with the Admin and Employee, while DFD Level 1 decomposes the internal processes such as sales data processing, incoming goods, and inventory forecasting. This approach is consistent with [17]who emphasized the importance of DFD in describing external and internal interactions in a database system. The DFD demonstrates how data flows in the system, modeling sales data management, incoming goods, and inventory forecasting.

1. DFD Level 0

   The Data Flow Diagram (DFD) Level 0 represents the system as a single high-level entity interacting with two main external actors: the Admin and the Employee. The Admin manages user and product data and accesses the forecast results generated by the system, while Employees are responsible for inputting sales transactions and incoming goods data. The system processes this information using the Single Exponential Smoothing (SES) method to produce inventory forecasts. These forecasts are then returned to the Admin for analysis and can be utilized by Employees for effective stock management. Level 0 provides a broad overview of the system's interactions with external entities without detailing internal processes, offering a clear picture of the overall workflow.

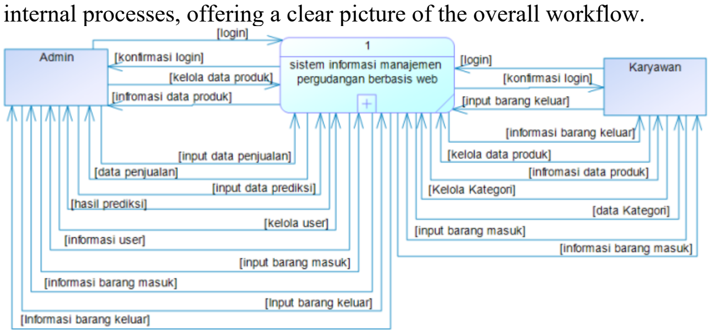

Fig. 2: Data Flow Diagram Level 0

2. DFD Level 1

   The DFD Level 1 decomposes the system into more detailed processes to illustrate the internal operations. The processes include sales data collection, where historical sales information is received and stored; incoming goods data collection, which updates inventory based on new inputs; and inventory forecasting, which calculates stock predictions using SES based on the combined sales and incoming goods data. Each process generates internal data and produces forecast outputs accessible to users.

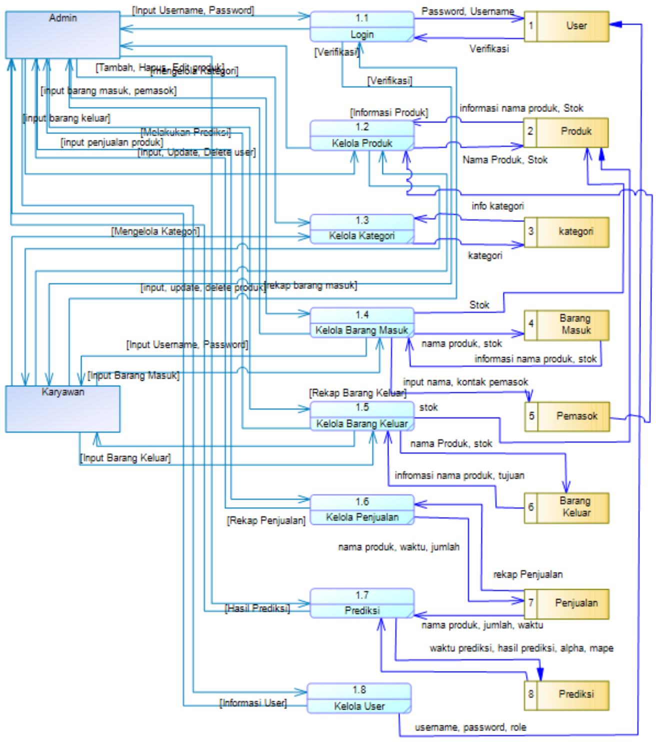

Fig. 3: Data Flow Diagram Level 1

c. Conceptual Data Model (CDM)

CDM represents the logical structure of the database, focusing on entities and relationships without technical implementation details. It includes entities, attributes, and relationships, facilitating stakeholder communication, early problem detection, and standardized documentation for development.

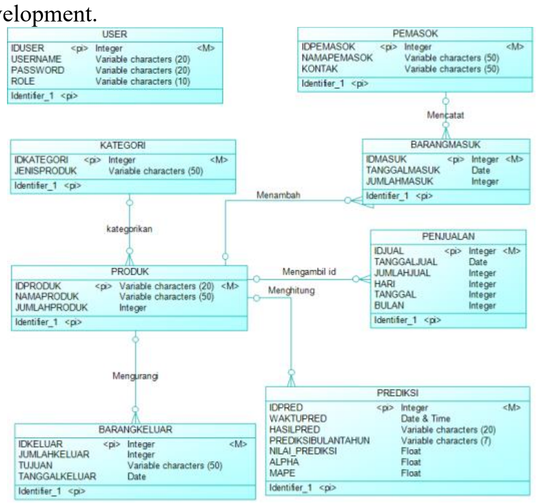

Fig. 4 : Conceptual Data Model

Figure 4 illustrates relationships between tables in the Pilar Mas Building Supply Store sales forecasting system. The CDM includes eight main entities and uses normalization principles to maintain data consistency and support historical sales-based predictions.

d. Physical Data Model (PDM)

PDM shows how data is physically stored, detailing tables, columns, and data types, reflecting the DBMS platform used for implementation.

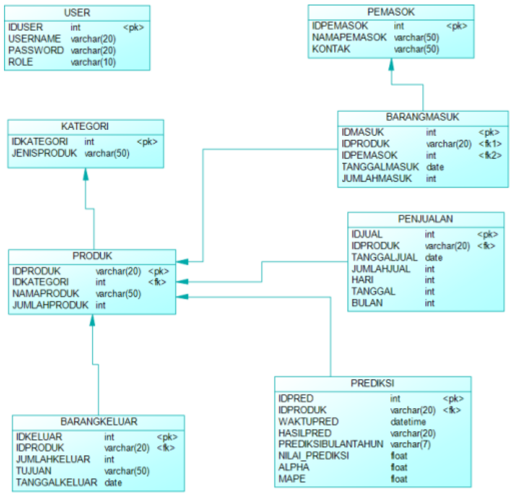

Fig. 5: Physical Data Model

Figure 5 depicts the PDM for the Pilar Mas sales forecasting system, specifying data types (e.g., int for primary keys, varchar for text fields, date for dates, float for forecast calculations) and table constraints (primary key and foreign key) to ensure referential integrity. This design supports CRUD operations and accurate forecasting analysis.

3.5. System Implementation

This implementation provides a clear explanation of the workflow and processes of the warehouse management and sales forecasting system at Pilar Mas Building Supply Store. This section describes how each feature in the application operates, specifically in managing inventory and predicting sales using the Single Exponential Smoothing (SES) method. The main features implemented include login, dashboard, product management, user management, sales data management, forecasting, and forecast history.

a. Login Page

Fig. 6: Login Page

The login page serves as the entry point for all users of the Pilar Mas Building Supply Store system. Users are required to enter a valid username and password to access the system. The login process includes authentication checks against the stored user data in the database. Only users with authorized credentials can access the dashboard and other features. This ensures data security and restricts access to sensitive inventory and sales information.

b. Dashboard

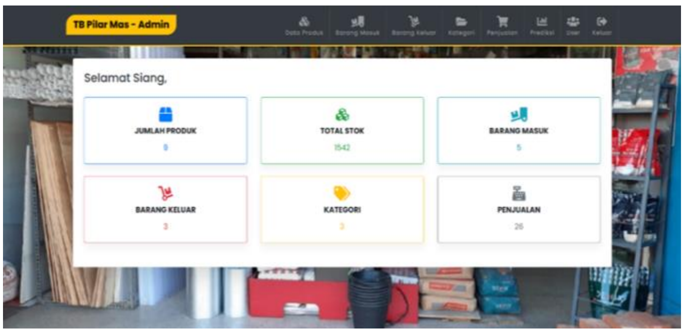

Fig. 7: Dashboard

The dashboard provides an overview of the system's current status, including total products, stock levels, recent sales transactions, and recent forecasts. It offers visualizations such as charts and tables to help users quickly understand key metrics and trends. This page acts as the main hub for navigation to other features in the system.

c. Product Management

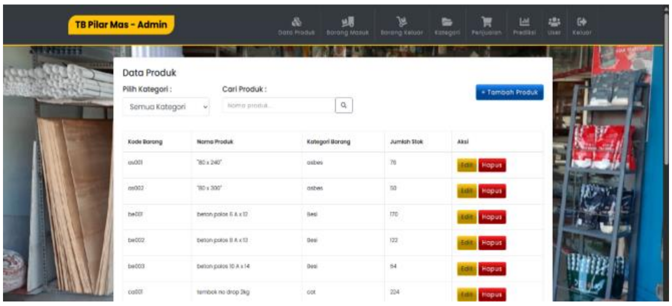

Fig. 8: Product Management

This feature allows users to add, edit, and delete product information. Each product record contains details such as product name, category, stock quantity, and price. Users can also monitor stock levels in real-time, helping to avoid stockouts or overstock situations.

d. User Management

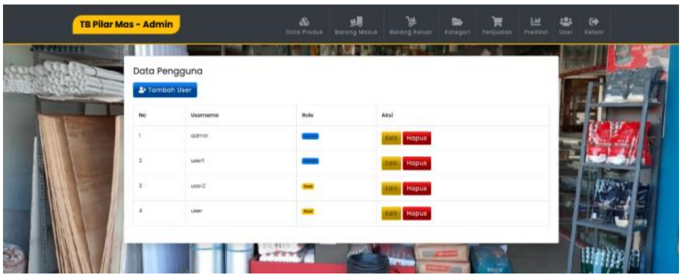

Fig. 9: User Management

The user management feature enables administrators to create, update, and remove user accounts. Different user roles can be assigned, such as admin, staff, or manager, each with specific access permissions. This ensures proper control over who can modify critical data within the system.

e. Sales Data Management

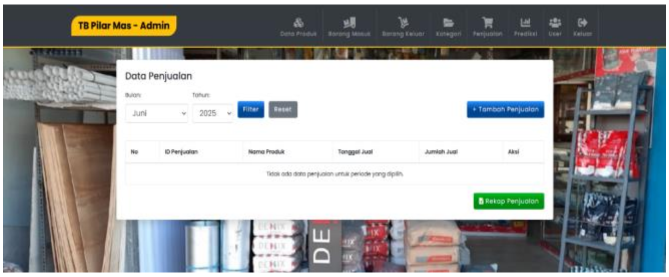

Fig. 10: Sales Data Management

This module manages all sales transactions. Users can input, update, and delete sales records. The system also validates sales entries to maintain data accuracy. These records serve as the foundation for generating forecasts and analyzing sales trends.

f. Forecasting

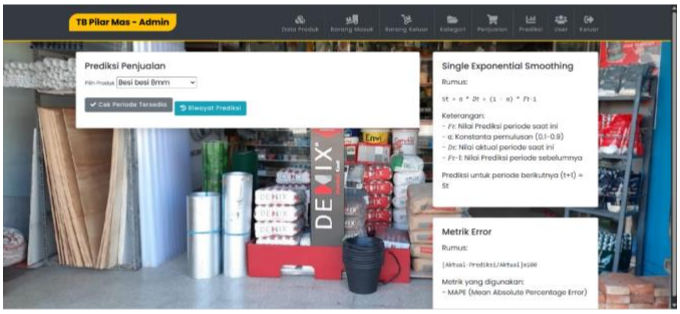

Fig. 11: Forecasting

The forecasting feature uses the Single Exponential Smoothing (SES) method to predict future sales based on historical data. Users can select the product and specify the period for forecasting. The system then calculates the predicted sales value and displays it along with trend graphs. This helps in planning inventory and procurement efficiently.

g. Forecast History

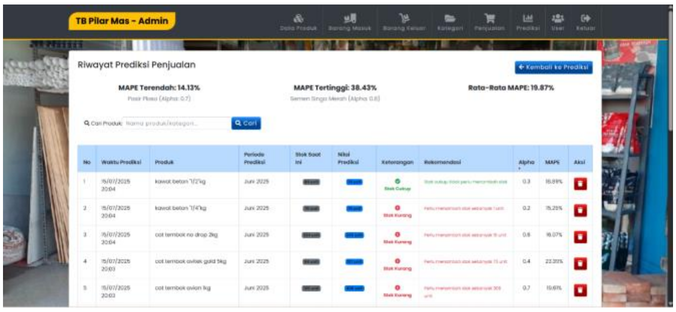

Fig. 12: Forecast History

This module stores all past forecasts along with actual sales data. Users can review and compare historical forecasts with actual results to evaluate forecasting accuracy. This feature helps in adjusting parameters, such as the smoothing constant (α), to improve future predictions.

4. Conclusion

Based of development a web-based warehouse management system integrated with the Single Exponential Smoothing (SES) forecasting method at Pilar Mas Building Supply Store has shown that the system is effective in improving stock control and supporting sales planning. By combining inventory management with automated forecasting, the system reduces manual errors, facilitates real-time monitoring, and provides a more accurate basis for decision-making. The forecasting evaluation using the Mean Absolute Percentage Error (MAPE) produced an overall average of 19.28% across ten key products, placing the accuracy in the high to moderate category. Among these, Ploso Sand achieved the best result with a MAPE of 14.76%, while Iron 10 A x 14 showed the lowest accuracy at 25.75%, demonstrating that SES performance is influenced by the level of demand variability for each product. Despite these differences, the forecasts were sufficiently reliable to anticipate short-term demand, minimize the risks of stockouts and overstocking, and improve operational efficiency. The results also highlight the practical value of SES as a simple yet effective forecasting method for non-seasonal demand patterns, particularly in small to medium-scale enterprises. In conclusion, the integration of SES into a web-based warehouse system provides a data-driven solution that enhances efficiency, accuracy, and decision-making, while offering a foundation for further development with more advanced forecasting methods and larger datasets.

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