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Development of a customs-integrated warehouse management system for inbound and outbound goods monitoring

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ABSTRACT

The growth of international trade and customs-related logistics activities has increased the complexity of warehouse operations, particularly in managing inventory, inbound and outbound transactions, and customs document administration. This study aimed to develop a Customs-Integrated Warehouse Management System (CI-WMS) for monitoring inbound and outbound goods in customs-regulated warehouse environments in Dumai. The system was developed using the System Development Life Cycle (SDLC) based on the Waterfall model, which consists of requirements analysis, system design, implementation, and testing stages. The proposed system integrates product management, importer management, customer management, warehouse management, inbound and outbound transaction processing, customs document administration, and reporting functions within a centralized web-based platform. Functional testing was conducted to evaluate the performance of each system module based on predefined requirements. The testing results demonstrated that all modules operated successfully and produced valid outputs. The developed CI-WMS improves inventory visibility, supports inbound and outbound monitoring, enhances goods traceability, and facilitates customs document management within a single integrated system. The proposed system contributes to improving operational efficiency and supporting customs compliance in warehouse operations.

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1. INTRODUCTION

The growth of international trade and logistics activities has significantly increased the complexity of warehouse operations. Modern warehouses are no longer merely storage facilities; they have evolved into strategic components of supply chain management that support inventory control, traceability, order fulfillment, and operational decision-making. To maintain operational effectiveness and customer satisfaction, organizations require accurate inventory visibility, efficient inbound and outbound processes, and real-time information availability. Consequently, Warehouse Management Systems (WMS) have become essential technologies for improving warehouse performance and operational efficiency (Madamidola et al., 2024; Shanmugamani & Mohamad, 2023; Syahroyyan, 2025).

Warehouse Management Systems play a critical role in managing inventory, warehouse resources, order processing, and shipment activities. The implementation of WMS enables organizations to improve inventory accuracy, optimize warehouse utilization, reduce operational errors, and enhance logistics visibility. (Madamidola et al., 2024) reported that the integration of

barcode technology, Radio Frequency Identification (RFID), and Internet of Things (IoT) significantly improves inventory tracking and operational performance. Similarly, (Samsudin et al., 2023) emphasized that WMS contributes to organizational sustainability by improving warehouse integration, inventory accuracy, and supply chain efficiency.

The advancement of Industry 4.0 technologies has accelerated the digitalization of warehouses ((Pekarčíková et al., 2020; Tikwayo & Mathaba, 2023). Technologies such as RFID, IoT, cloud computing, blockchain, and decision support systems enable organizations to improve warehouse automation, operational flexibility, and the availability of real-time information (Tikwayo & Mathaba, 2023). Furthermore, (Andiyappillai, 2020) demonstrated that digital transformation through WMS improves warehouse productivity, inventory visibility, shipment processing, and monitoring capabilities. The integration of Enterprise Resource Planning (ERP), Warehouse Management Systems (WMS), and Manufacturing Execution Systems (MES) has also been shown to improve inventory traceability, operational transparency, and warehouse efficiency (Tong et al., 2023).

Several studies have demonstrated the effectiveness of WMS implementation in various industrial sectors. (Basuki & Hutahaean, 2025) reported that WMS implementation improved receiving, put-away, storage, picking, and delivery activities while reducing human errors and increasing inventory accuracy. (Syahroyyan, 2025) found that warehouse-integrated systems improved inbound and outbound management, warehouse transparency, and stock monitoring. Likewise, (Rezeki et al., 2025) and (Rachmawati & Handayani, 2024) reported that WMS implementation improved inventory control, warehouse visibility, operational efficiency, and logistics monitoring. These findings confirm that WMS plays an important role in supporting efficient warehouse operations and inventory management.

Despite these developments, customs-regulated warehouse operations continue to face significant challenges. Organizations involved in import-export activities are required to manage not only inventory and physical movement of goods but also customs-related documents, such as import declarations (PIB), export declarations (PEB), invoices, packing lists, and compliance records. In many cases, warehouse transactions and customs administration are managed through separate systems or manual procedures, resulting in fragmented information, duplicate data entry, reporting delays, limited traceability, and increased compliance risks. Such conditions may negatively affect operational efficiency and regulatory compliance, particularly in customs-controlled warehouse environments (Priyambodo et al., 2026; Somadi & Karwan, 2020).

Dumai is one of the strategic industrial and logistics hubs in Indonesia, supported by port facilities, export-import activities, bonded warehouses, and customs-regulated logistics operations. The Port of Dumai plays an important role in supporting international trade activities, freight forwarding services, and export-import operations in the region (Satria & Aprizawati, 2024). In addition, Dumai has considerable potential as a logistics and transshipment hub due to its strategic location and its role in supporting the export of major commodities such as Crude Palm Oil (CPO) (Ananda & Arsy Ash Shiddiqy, 2025). As the volume of goods entering and leaving customs-controlled areas continues to increase, effective warehouse management and customs administration become essential to ensure inventory accuracy, document consistency, operational visibility, and regulatory compliance

Efforts to improve customs-related warehouse management have been reported by (Priyambodo et al., 2026), who developed a web-based inventory system integrated with CEISA for bonded warehouse environments. Their study demonstrated improvements in inventory traceability, customs verification, and compliance monitoring. However, the proposed system primarily focused on bonded warehouse reporting and customs compliance and did not comprehensively integrate inventory management, warehouse transactions, inbound and outbound monitoring, customer management, and customs document administration into a single operational platform.

Based on the existing literature, most previous studies focus on warehouse management, inventory control, warehouse automation, logistics performance, and customs compliance separately (Andiyappillai, 2020; Priyambodo et al., 2026; Tikwayo & Mathaba, 2023). While these studies have contributed significantly to improving inventory visibility, warehouse efficiency, logistics monitoring, and customs compliance, most existing WMS implementations still focus on specific operational functions and do not integrate inventory management, inbound and outbound transaction processing, importer and customer management, customs document administration,

and reporting within a single platform, particularly in customs-regulated warehouse environments. Consequently, a research gap remains in developing a comprehensive Customs-Integrated Warehouse Management System that supports inventory management, inbound and outbound monitoring, goods traceability, and customs document administration within a centralized environment.

To address this gap, this study proposes developing a Customs-Integrated Warehouse Management System (CI-WMS) to monitor inbound and outbound goods in customs-related warehouse operations in Dumai. The proposed system integrates inventory management, warehouse transactions, inbound and outbound processing, customer and supplier information management, and customs document administration into a centralized web-based platform. Through this integration, the system is expected to improve inventory visibility, operational efficiency, traceability of goods, document management, and compliance with customs regulations.

The objective of this study is to design and develop a Customs-Integrated Warehouse Management System that supports efficient monitoring of inbound and outbound goods while improving inventory accuracy, operational visibility, customs document traceability, and compliance management in customs-regulated warehouse environments.

2. RESEARCH METHOD

His study adopts the System Development Life Cycle (SDLC) based on the Waterfall model to develop a Customs-Integrated Warehouse Management System (CI-WMS) for monitoring inbound and outbound goods. The SDLC methodology was selected because it provides a systematic and sequential framework consisting of requirements analysis, system design, implementation, testing, and maintenance stages, enabling the development process to be carried out in a structured and controlled manner (Herawati et al., 2021; Saravanos & Curinga, 2023; Wijaya et al., 2024). Previous studies have demonstrated the effectiveness of SDLC in developing information systems and Warehouse Management Systems (WMS) to support inventory control, warehouse operations, reporting, and workflow integration (Maukar et al., 2023; Ropianto et al., 2020). Furthermore, comprehensive requirements analysis and rigorous testing are essential to ensure that the system meets user requirements, maintains high reliability, and effectively supports warehouse operations (Rana, 2023).

The research was conducted in a customs-related warehouse environment in Dumai, Indonesia. The proposed system was designed to support warehouse operations and customs administration processes, including inventory management, inbound transactions, outbound transactions, customs document management, and reporting.

Data Collection

These techniques are commonly used to understand business workflows and gather user requirements in warehouse management studies (Simatupang et al., 2023). Data was collected through observation, document analysis, and system requirement identification.

1. Observation, an observation was conducted to understand the workflow of warehouse operations, including goods receiving, storage, release, and reporting.
2. Document Analysis, was conducted by examining the WMS-Pabean manual book and related customs document requirements.
3. Requirement Identification, functional requirements were identified from the available system modules, including product category, product, importer, customer, warehouse, inbound, outbound, customs document, and report.

Requirement Analysis

The requirements analysis stage identified the system requirements through observation, interviews, and document analysis. The identified functionalities include login, master data management, inbound and outbound transactions, customs document management, and reporting.

The proposed system is intended for warehouse administrators (system operators) who are responsible for managing daily warehouse operations and customs administration. Their responsibilities include managing product, importer, customer, warehouse, inbound and outbound transaction data, customs documents, and reporting. These user roles and operational responsibilities served as the basis for identifying the functional requirements of the proposed system.

Design

A Use Case Diagram illustrates user interactions and the functional requirements of a system (Didi Rahman, 2024; Fadillah et al., 2026; Janah et al., 2024). The Use Case Diagram illustrates the interactions between users and the proposed system. This diagram describes the main functionalities accessible to users and the relationships between users and the available system features. In this study, the WMS-Pabean system has a single primary actor, namely the Administrator/System Operator, who is responsible for managing all warehouse operations and customs administration processes. The functions available to the user include product category management, product management, importer management, customer management, warehouse management, inbound transaction management, outbound transaction management, customs document management, reporting, and login and logout**.**

Figure 1. Use case diagram of the proposed warehouse management system (WMS-Pabean)

Figure 1 presents the Use Case Diagram of the proposed Customs-Integrated Warehouse Management System (CI-WMS). The system involves a single actor, namely the Administrator, who manages all system functionalities, including product category management, importer management, customer management, warehouse management, inbound and outbound transaction management, customs document management, reporting, and user authentication. The inbound process includes product, importer, and warehouse data, while the outbound process includes product, customer, and warehouse data. Furthermore, customs document management extends the inbound process by supporting customs-related document management. This design enables the integration of warehouse operations and customs administration within a centralized web-based platform.

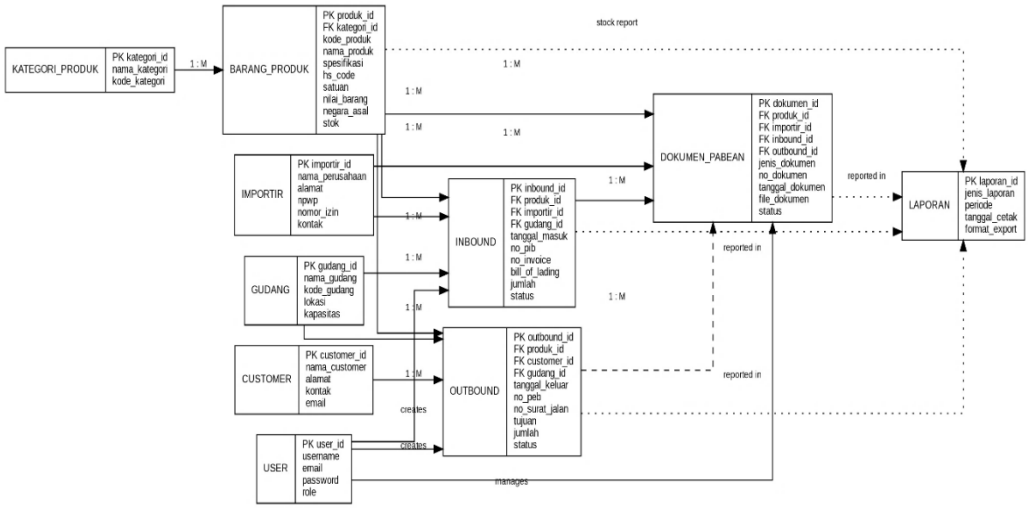

Figure 2. Entity relationship diagram (ERD) of the proposed customs-integrated warehouse management system (CI-WMS)

3. RESULTS AND DISCUSSIONS

This section describes the implementation of the proposed Customs-Integrated Warehouse Management System (CI-WMS) based on the system design developed in the previous stage. The implementation process focuses on transforming the system requirements, use case design, database structure, and user interface design into a functional web-based application. The developed system integrates warehouse management activities, including product management, importer management, customer management, warehouse management, inbound and outbound transaction processing, customs document management, and reporting functions within a centralized platform.

The implementation was carried out using web-based technologies, enabling users to access the system efficiently via a browser interface. Each module was developed in accordance with the functional requirements identified during the analysis stage to ensure the system supports warehouse operations and customs administration processes.

a. Dashboard Interface

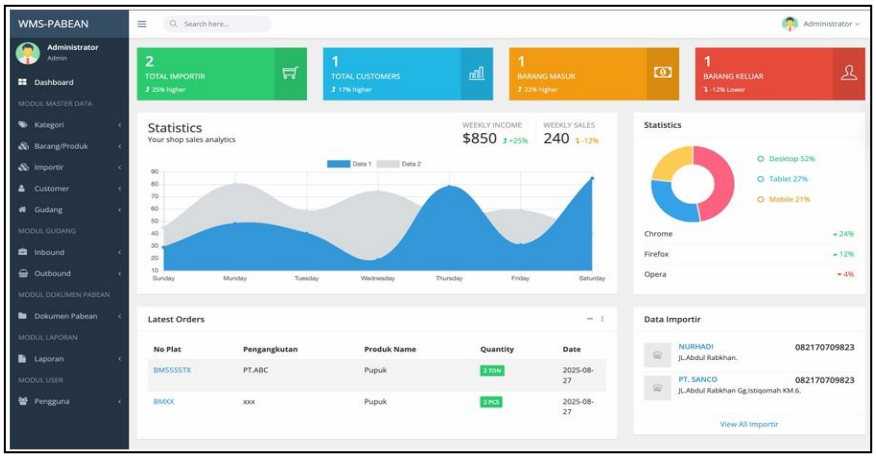

Figure 3. Dashboard interface of the proposed customs-integrated warehouse management system (CI-WMS)

The WMS-Pabean application is a warehouse management system (WMS) integrated with a customs module. This system helps companies manage data on goods, importers, customers, and the flow of incoming and outgoing goods (inbound and outbound) linked to customs documents.

b. Login Interface

Figure 4. Login Interface

Figure 4 presents the login interface, this page serves as the initial access point to the system and authenticates users before they access the application modules. Users are required to enter a valid email address and password, after which the system verifies the credentials and grants access to the dashboard. The login mechanism is implemented to ensure that only authorized users can access warehouse management and customs administration functions, thereby improving data security and system reliability.

c. Product Categories

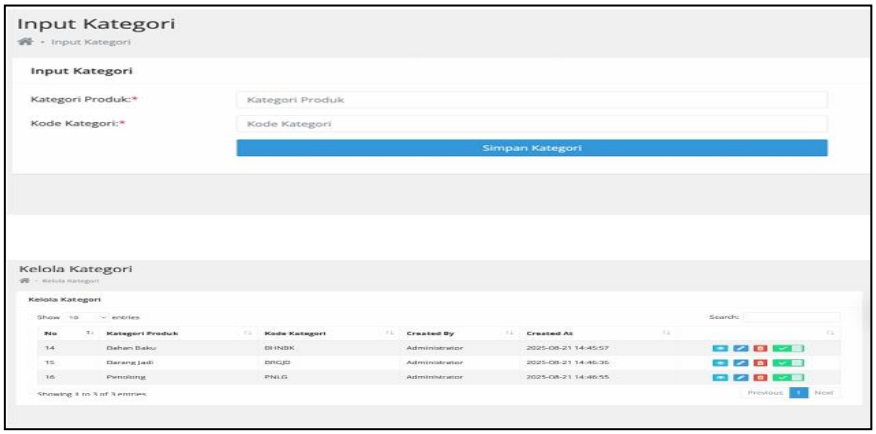

Figure 5. Product Category Management Interface

Figure 5 presents the Product Category Management, this module is used to manage product category information that serves as a reference for organizing products within the warehouse. Users can add new product categories by entering the category name and category code through the input form. In addition, the system provides functionality to view, edit, delete, and search category records through the category management table. The implementation of this module facilitates product classification and supports efficient inventory organization and warehouse data management.

d. Inbound Interface

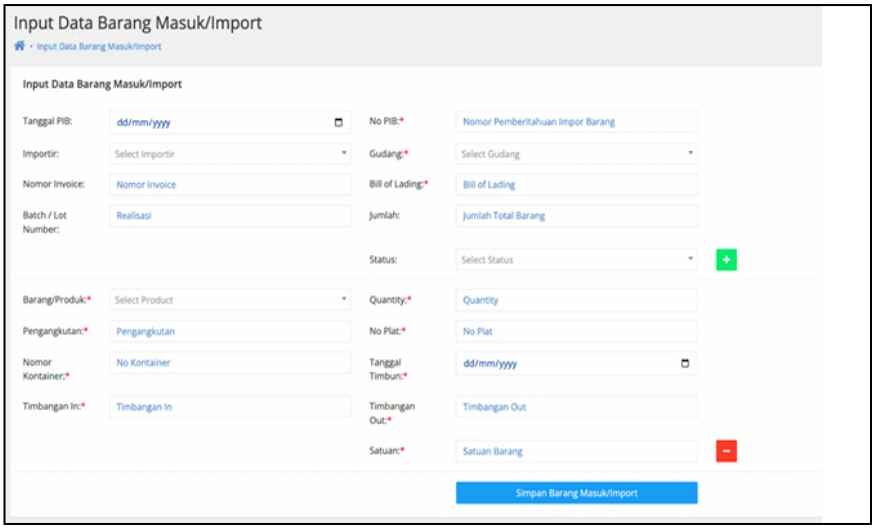

Figure 6. Inbound Transaction Interface

Figure 6 illustrates the Inbound Transaction, this module is designed to record incoming goods transactions from import activities into the warehouse. Users are required to input relevant information, including PIB date, PIB number, importer data, warehouse destination, invoice number, Bill of Lading number, product information, quantity, transportation details, container number, vehicle plate number, weighing information, and transaction status. The module enables the system to monitor incoming goods, maintain inventory accuracy, and ensure that inbound warehouse activities are properly documented and traceable. By integrating warehouse transaction data with customs-related information, the module supports efficient warehouse operations and customs compliance management.

e. Outbound Interface

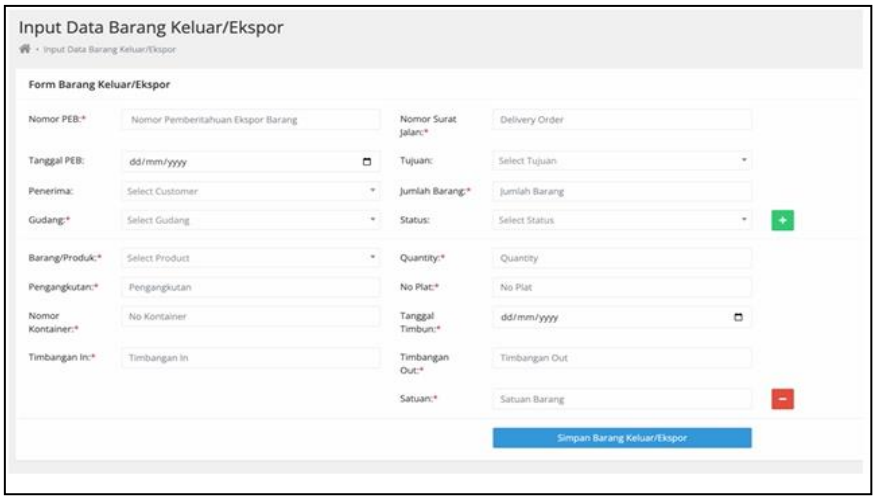

Figure 7. Outbound transaction interface

Figure 7. Outbound Transaction Interface, this module is designed to record outgoing goods transactions from the warehouse associated with export activities or goods distribution processes. Users are required to enter relevant information, including PEB number, PEB date, customer data, destination warehouse, delivery order number, destination information, product details, quantity, transportation information, container number, vehicle plate number, weighing data, and transaction status. The module enables the system to monitor goods movement, update inventory records, and ensure that outbound transactions are properly documented and traceable. Through the integration of warehouse operations and customs-related information, the outbound module supports efficient goods distribution, inventory control, and compliance with customs administration procedures.

Functional Testing

Functional Testing was performed to verify that all system modules functioned according to the specified requirements. The evaluation covered login, product category, product, importer, customer, warehouse, inbound, outbound, customs document, and reporting modules. The results are presented in Table 1.

Table1. Functional testing results

No	Module	Input	Expected Output	Result
1	Login	Valid email and Password	System successfully redirects to the dashboard	Valid
2	Product Category	Category name and category code	Product category data is successfully stored	Valid
3	Product Management	Product code, product name, category, HS Code, and unit	Product data is successfully stored	Valid
4	Importer Management	Company name, tax identification number (NPWP), address, and contact information	Importer data is successfully stored	Valid
5	Customer	Customer name, address, and contact	Customer data is successfully stored	Valid

No	Module	Input	Expected Output	Result
	Management	information		
6	Warehouse Management	Warehouse name, warehouse code and location	Warehouse data is successfully stored	Valid
7	Inbound Transaction	Entry data, product, quality, and warehouse	Inbound transactions are successfully stored, and inventory stock is increased	Valid
8	Outbound Transaction	Exit date, product, quantity and customer	Outbound transactions are successfully stored, and inventory stock is reduced	Valid
9	Custom Document Management	PIB, PEB, Invoice or packing list	Customs documents are successfully stored and can be tracked	Valid
10	Stock Report	Select stock report menu	Stock report is displayed successfully	Valid
11	Inbound Report	Select inbound report menu	Inbound report is displayed successfully	Valid
12	Outboud Report	Select outbound report menu	Outbound report is displayed successfully	Valid
13	Report Export	Click export report	Report file is successfully generated	Valid
14	Logout	Click logout	System redirects	Valid

Based on the functional testing results presented in table 1, all modules of the proposed Customs-Integrated Warehouse Management System (CI-WMS) operated successfully according to the specified functional requirements. The login module authenticated users correctly, granting access to authorized users and rejecting invalid login attempts. The master data management modules, including product categories, products, importers, customers, and warehouses, successfully performed data creation and storage functions without errors.

The inbound and outbound transaction modules also accurately record goods movements. The inbound module successfully stored incoming goods transactions and updated inventory stock levels, while the outbound module correctly processed outgoing goods transactions and reduced inventory quantities accordingly. Furthermore, the customs document management module successfully handled the upload and storage of customs-related documents, including PIB, PEB, invoices, and packing lists, while maintaining document traceability.

The reporting module successfully generated stock, inbound, and outbound reports and exported them to PDF and Excel formats. In addition, the logout functionality correctly terminated user sessions and redirected users to the login page. Overall, all tested functions yielded valid results, indicating that the developed system meets the defined functional requirements and effectively supports warehouse management and customs administration processes.

Although the functional testing results demonstrated that several factors may influence the proposed CI-WMS operated successfully, its implementation in different operational environments. These include the availability of accurate warehouse data, standardized operational procedures, user readiness, and compliance with customs regulations. In addition, differences in warehouse size, organizational workflows, and the level of adoption of digital technology may affect the effectiveness of system implementation. Therefore, successful implementation of the proposed CI-WMS requires both technical readiness and operational support to ensure optimal warehouse management and customs administration.

4. CONCLUSION

This study successfully developed a Customs-Integrated Warehouse Management System (CI-WMS) for monitoring inbound and outbound goods in customs-related warehouse operations in Dumai. The system was developed using the System Development Life Cycle (SDLC) based on the Waterfall model, which includes requirements analysis, system design, implementation, and testing stages. The developed system integrates product management, importer management, customer management, warehouse management, inbound and outbound transaction processing, customs document administration, and reporting functions within a centralized web-based platform. The functional testing results demonstrated that all system modules operated according to the specified requirements and achieved valid results. The proposed CI-WMS enables more effective inventory management, improves visibility of inbound and outbound transactions, enhances goods traceability, and facilitates customs document administration. The integration of warehouse operations and customs administration within a single platform represents the main contribution of

this study. Future research may focus on integrating the system with customs information systems such as CEISA, implementing real-time tracking technologies, and evaluating system performance in large-scale warehouse environments.

The main contribution of this study is the development of a Customs-Integrated Warehouse Management System that integrates warehouse operations and customs document administration within a single web-based platform. The implementation of the proposed CI-WMS has practical implications for improving inventory visibility, goods traceability, operational efficiency, and customs compliance in customs-regulated warehouse environments.

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