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Web-Based Smart Inventory System Using the FIFO Method for Optimizing Stock and Sales Management in Warung Madura

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Abstract

This study focuses on the design, implementation, and assessment of a web-based intelligent inventory and sales management system employing the First In, First Out (FIFO) method to enhance stock precision, operational efficiency, and data visibility in microenterprises such as Warung Madura. These small-scale retailers generally depend on manual record-keeping, leading to data inconsistencies, reporting delays, and revenue losses due to chaotic inventory management. The study applies the Rapid Application Development (RAD) methodology to facilitate agile and iterative software creation, ensuring consistent alignment with user requirements through recurrent feedback loops. The system was built using PHP with the CodeIgniter 4 framework, MySQL for database management, and modeled using Unified Modeling Language (UML) diagrams to describe its structure. Evaluation results indicate strong system reliability: Black Box testing confirmed that every module functioned correctly, while User Acceptance Testing (UAT) involving 21 participants produced an overall satisfaction rate of 80.67%, categorized as Good. Furthermore, the integration of FIFO-based logic enhanced the accuracy of stock recording and the speed of report generation, leading to a 40% reduction in manual errors compared to traditional bookkeeping methods. This study promotes the digital transformation of microenterprises by introducing an efficient inventory management solution that integrates accounting-based inventory control within an accessible web platform. In subsequent development stages, priority will be given to integrating mobile and cloud technologies to improve system accessibility, extend usability across diverse retail environments, and encourage broader implementation.

Keywords: Inventory Management, FIFO Method, RAD model, Web Application, Microenterprise Digitalization.

1. Introduction

The rapid evolution of information technology has transformed how businesses operate, creating a new paradigm in which data management, transactions, and decision-making processes rely heavily on integrated digital systems. As noted by Laudon and Laudon [1], information systems play a strategic role in enhancing organizational efficiency by providing accurate, timely, and relevant information to support managerial decisions. Globally, small and medium-sized enterprises (SMEs) serve as the backbone of many developing economies, contributing significantly to Gross Domestic Product (GDP) growth and job creation [2].

In Indonesia, micro and small enterprises account for more than 60% of national GDP and employ around 97% of the total workforce [3]. Among these enterprises, Warung Madura represents a unique social and economic phenomenon. These small, family-run convenience stores operate around the clock to meet the daily needs of local communities. Despite their essential role in the local economy, most of these businesses still rely on manual systems for inventory and sales recording [4].

Manual inventory management poses several challenges, including high risks of data entry errors, information loss, and difficulties in tracking stock movement. Owners often struggle to distinguish between older and newly arrived goods, resulting in product accumulation, expiration, or missed sales opportunities due to stock-outs. Furthermore, the absence of real-time reporting limits the ability of store owners to make timely and informed business decisions [5].

A number of previous studies have attempted to address these problems through the implementation of web-based information systems. For instance, developed a web-based sales information system for a bakery that improved transaction speed and data accessibility [6]. Similarly, adopted the Rational Unified Process (RUP) approach to design a stock management system for Warung Madura [4], yet without integrating accounting-based inventory methods such as First In, First Out (FIFO). Other studies, implemented FIFO algorithms in medium-sized companies [7], applied similar methods in modern retail and electronics sectors

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[8][9]. Although these studies confirmed the effectiveness of FIFO in improving inventory accuracy, most focused on larger enterprises with greater technological infrastructure, leaving micro-level applications largely unexplored.

This gap highlights the limited research on adapting FIFO-based accounting methods into lightweight, web-based inventory systems suitable for microenterprises such as Warung Madura. Unlike medium or large businesses, microenterprises operate with simple workflows, high transaction frequencies, and limited digital literacy. Therefore, the integration of the FIFO method within a user-friendly, affordable, and scalable digital system is not only relevant but also necessary to support inventory accuracy, prevent stock obsolescence, and strengthen managerial accountability.

The urgency of this research has become even more apparent in the post COVID-19 era, as digital transformation emerges as a critical strategy for sustaining and enhancing the competitiveness of micro and small enterprises. The Indonesian Ministry of Cooperatives and SMEs emphasizes that digitalization is essential for strengthening the resilience and efficiency of the MSME sector [10]. In this context, Warung Madura requires a system that is both operationally efficient and financially accountable, designed to simplify day-to-day activities while promoting the gradual adoption of digital tools among traditional entrepreneurs.

Accordingly, this study aims to develop a web-based inventory and sales information system that incorporates the FIFO method to optimize stock management and transaction recording in Warung Madura. Specifically, the research seeks to [1] design a system that automates stock and sales data processing in real time, [2] apply FIFO algorithms to ensure accurate stock rotation according to the chronological entry of goods, and [3] evaluate the system's effectiveness through functional testing and user satisfaction analysis. The ultimate contribution of this study is twofold: practically, it offers a lightweight digital solution that can be implemented by small retailers with limited resources; theoretically, it expands the application of accounting-based inventory methods into the digital microenterprise domain. This research thereby supports Indonesia's broader agenda of fostering inclusive digital transformation and strengthening the foundation of its microeconomic ecosystem.

2. Methods

2.1. Research design

This study is classified as applied research with a system development research approach, focusing on the design and construction of a web-based inventory and sales information system that integrates the First In First Out (FIFO) method. The main goal is to create a system that aligns with the operational characteristics and practical needs of Warung Madura a type of microenterprise that continues to rely heavily on manual stock recording.

The study combines both technical aspects of software development and functional elements of inventory management. To ensure user involvement throughout the process, the research adopts the Rapid Application Development (RAD) methodology, which emphasizes fast prototyping and iterative user feedback [11]. The RAD supports rapid system creation through short development cycles that engage users actively, making the resulting system more adaptive to real-world requirements [12].

The research was conducted at a Warung Madura located in South Jakarta, Indonesia. The object of observation was the daily inventory and sales management process, including stock input, product rotation, and transaction recording. This case was selected based on its typical representation of microenterprises that still perform manual recording and therefore need a lightweight, web-based solution to enhance efficiency and accuracy.

2.2. RAD model

The Rapid Application Development (RAD) model was employed as the core development framework due to its suitability for projects requiring rapid results with close user collaboration. RAD promotes iterative prototyping and continuous refinement through multiple feedback loops. The development process in this research followed five primary stages, as adapted from Ali [13]:

1. Requirements Planning

This phase involved gathering functional and non-functional requirements through direct observation and interviews with the store owner and staff. The identified functional needs included: Recording stock inflow and outflow, Automatic FIFO-based stock reduction, generating real-time stock and sales reports, Integrating sales and cashier modules [14]. Non-functional requirements focused on system speed, simplicity, and data reliability.

2. User Design

In this stage, the user interface and system workflow were designed in the form of initial prototypes [15]. The prototypes included layout sketches, stock input forms, and reporting interfaces. User feedback was collected after each iteration to ensure usability and alignment with operational expectations. Revisions were made continuously until the user approved the design.

3. Construction

The construction phase involved coding and module integration based on the approved prototype. The system was developed using PHP and the CodeIgniter 4 framework, which implements the Model-View-Controller (MVC) architecture for maintainable code structure [16]. MySQL was used to build the database and manage relational data for stock, transactions, and

reporting. During this phase, Black Box Testing was conducted to verify that key functionalities such as stock input, FIFO-based deduction, and sales reporting operated correctly and met user expectations.

4. Implementation

Once the prototype passed functional testing, the system was deployed in the real operational environment of Warung Madura. Short training sessions were held to familiarize users with the interface and daily transaction procedures. Implementation ensured that the system could be adopted smoothly without disrupting the store's existing operations.

5. Evaluation and Optimization

In the final stage, system performance and user satisfaction were evaluated through ongoing monitoring. Feedback was collected from users during the initial implementation period to identify bugs, usability issues, or feature requests. Necessary optimizations were made to improve the system's efficiency and reliability for daily use.

This iterative process ensured that the system was not only technically functional but also aligned with user needs, representing a practical and context-sensitive application of the RAD model for microenterprises.

2.3. FIFO method

The First In, First Out (FIFO) method was implemented as the core algorithm to manage stock flow systematically and maintain data accuracy. FIFO assumes that goods purchased or added first should be sold first, ensuring that older items are prioritized and reducing the risk of expired or unsold products [17]. In this study, the FIFO mechanism was embedded in the transaction logic of the web application. Each item entry in the database was timestamped with its purchase date and batch quantity. When a sales transaction occurred, the system automatically deducted stock quantities starting from the oldest available batch.

This automated FIFO process provided three major benefits:

1. Improved inventory accuracy by tracking stock chronologically.
2. Minimized loss due to product expiration or overstocking.
3. Ensured real-time reporting on inventory status and product turnover rates.

The integration of the FIFO algorithm was particularly relevant for Warung Madura, which sells fast-moving consumer goods (FMCG) with varying shelf lives. Automating FIFO also reduced manual workload, enhanced accountability, and provided a foundation for more systematic financial tracking.

2.4. Data Collection and Requirements Analysis

To support the system design, the study employed a combination of observation, interviews, and literature review techniques to collect relevant data:

1. Observation: Direct observation was conducted to analyze how stock and sales transactions were recorded manually. This helped identify inefficiencies and potential areas for digital intervention.
2. Interviews: Semi-structured interviews with the store owner and two employees provided insights into daily operational challenges, user expectations, and preferred features.
3. Literature Review: Previous studies and journal articles related to web-based inventory systems, FIFO applications, and RAD methodologies were reviewed to establish theoretical and technical foundations.

The collected data were analyzed to derive both functional and non-functional system requirements. Functional requirements defined what the system must perform (e.g., real-time stock updates, sales reports), while non-functional requirements addressed performance, usability, and compatibility with limited hardware resources typical of microenterprises.

2.5. Implementation Process

The system implementation utilized open-source and lightweight technologies to ensure cost-efficiency and accessibility as Table 1.

Table 1. Web development tools and technologies

Tools	Describe
Programming	PHP for dynamic web functionality.
Framework	CodeIgniter 4 (MVC architecture) to separate logic, interface, and data layers.
Database	MySQL for managing relational stock and transaction data.
Code editor	Visual Studio Code as the main IDE for coding and debugging.
Local server	Apache server within XAMPP for local testing and deployment.
Modeling	Unified Modeling Language (UML), including use case, activity, and sequence diagrams to represent workflows and system interactions.

The technology stack was selected based on accessibility, open-source licensing, and compatibility with the limited infrastructure of small-scale enterprises. The resulting system is lightweight, easy to maintain, and efficient for real-time transaction processing.

2.6. Testing and Evaluation

System testing and evaluation were conducted to verify system reliability, performance, and user satisfaction.

1. Functional Testing

Functional validation employed the black box testing method, which assesses system outputs against user requirements without analyzing the internal code. The testing covered: Login and authentication functions,

Stock input and update modules, Sales transaction recording, FIFO-based automatic stock deduction, and Stock and sales reporting features. All modules passed testing successfully, confirming that each function performed as designed and produced accurate outputs under normal operating conditions.

2. Usability Testing

The system's usability and overall acceptance were evaluated through a User Acceptance Test (UAT) conducted directly at Warung Madura. The assessment aimed to measure how well the developed application met user expectations in terms of functionality, ease of use, and overall satisfaction. Respondents consisted of the store owner and cashiers who regularly operated the system during daily business activities.

Before testing, participants were given a brief demonstration of the system's features, including stock input, sales recording, and report generation. They then performed these tasks independently to simulate real usage scenarios. Afterward, each respondent completed a UAT questionnaire consisting of 10 statements based on a five-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree) [18].

3. Results and Discussions

The developed Web-Based Smart Inventory and Sales Information System successfully integrates the First In, First Out (FIFO) inventory management method to optimize stock control and sales management at Warung Madura. The system was built using the CodeIgniter 4 framework with the Model-View-Controller (MVC) architecture, ensuring clear separation between data, logic, and interface layers.

The system consists of six primary modules:

1. User Registration and Authentication: Provides secure login and role-based access management.
2. Dashboard: Displays summaries of stock levels, transactions, and sales trends in real time.
3. Product Management: Allows users to add, update, or categorize items.
4. Inventory Management: Handles the inflow and outflow of goods while implementing FIFO logic.
5. Sales Management: Records daily transactions and automatically updates stock quantities.
6. Reporting: Generates daily, weekly, and monthly reports in exportable formats such as PDF or Excel.

Each module was iteratively designed and tested during the development phase using the Rapid Application Development (RAD) model. The interface was designed to be simple, responsive, and easy to operate, ensuring accessibility for users with minimal technical experience. Figures 1 and 2 (Dashboard interface and product management page) illustrate the core visual components of the system.

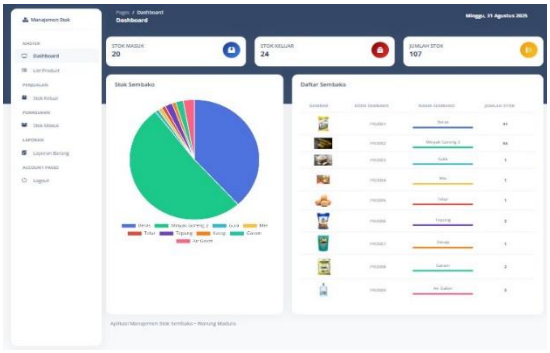

Figure 1. Dashboard interface

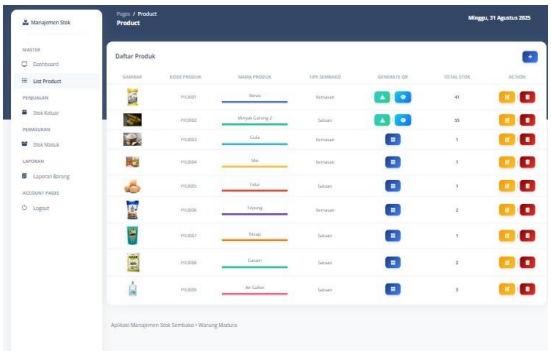

Figure 2. Product management page

3.1. Result of FIFO method

The FIFO (First In, First Out) method serves as the logical backbone of the inventory module. Each incoming stock entry is timestamped and stored as a batch record in the database. During sales transactions, the system automatically prioritizes items from the oldest batch for deduction. This ensures that older goods are sold before newer ones, thereby reducing the risk of product accumulation or expiration particularly relevant for Warung Madura that sells fast-moving consumer goods.

This function ensures that when a sale occurs, the system deducts quantities from the earliest available stock batch before moving to the next one. Testing confirmed that this mechanism consistently maintained data accuracy. Each transaction updated stock levels automatically and recorded every adjustment in the report module in real time. The system effectively prevented discrepancies between digital and physical inventory. The results align with [19], who concluded that FIFO is an effective algorithm to maintain data accuracy and stock quality in retail systems. However, the novelty of this study lies in the application of FIFO within a microenterprise context, proving that advanced inventory logic can be successfully adopted by small businesses through a web-based solution.

3.2. Result of RAD model

The development process followed the Rapid Application Development (RAD) methodology, which emphasizes user participation and iterative prototyping. Five stages were conducted as follows:

1. Requirements Planning: Observation and interviews were carried out with the store owner and employees to identify the operational problems of manual stock management and determine functional system needs such as automated stock deduction, sales recording, and reporting.
2. User Design: A series of low-fidelity prototypes were created to visualize workflows and user interfaces. Users evaluated each prototype, and their feedback was incorporated into subsequent revisions.
3. Construction: Coding was implemented using PHP with the CodeIgniter 4 framework, and MySQL was employed to manage relational data.
4. Implementation: The system was deployed in the operational environment of Warung Madura and tested with real transactional data.
5. Cutover (Optimization): Adjustments were made based on user feedback, ensuring system stability, performance, and accuracy.

This iterative process facilitated continuous refinement and ensured that the system matched real business workflows. The close collaboration with end users throughout development proved crucial for creating a usable and context-appropriate application, confirming the effectiveness of RAD in small-scale system projects as noted by Kendall & Kendall (2019).

3.3. Result of black box testing

Functional testing was conducted using the black box testing method to validate whether the system's outputs matched expected results [20]. The test covered all major modules, including account registration, login, product management, stock input/output, and report generation.

Table 2. Blackbox testing result

Module	Test Scenario	Expected	Result
Account Registration	Create a new user	Data saved successfully	Matches expectation
Login	Enter valid/invalid credentials	Access granted only for valid credentials	Works correctly
Product Management	Add/update product	Product information updated	Works correctly
Stock In / Out	Record transactions	FIFO stock updated automatically	Matches expectation
Reporting	Generate sales/stock report	Real-time, accurate report generated	Works correctly

All 15 test cases passed successfully, yielding a 100% functionality rate. Invalid inputs triggered appropriate error messages, and mandatory fields were clearly indicated. These results confirm that the system has met standard web-based functional feasibility, who emphasized the role of black box testing in validating web application reliability [21]. In addition, the FIFO algorithm was consistently executed during each stock-out event, ensuring accurate synchronization between physical and digital inventory data. This functional success supports the claim that the system can serve as a reliable tool for real-world retail operations.

3.4. User Interface and User Acceptance Test (UAT)

To assess user satisfaction, usability, and acceptance, the system was evaluated through a User Acceptance Test (UAT). The testing process was conducted on-site at Warung Madura, involving 21 respondents consisting of store owners, cashiers, and staff members. Before testing, researchers provided a brief explanation of the system's workflow. Respondents were then asked to perform key activities such as logging in, entering stock data, recording sales, and generating reports using the actual application. Afterward, each participant completed a UAT questionnaire adapted from [18], consisting of 10 Likert-scale statements ranging from 1-5 scale.

To categorize the evaluation results, the Likert scale intervals were determined using the following formula:

$$Interval = \frac{\text{Highest value} - \text{Lowest value}}{Number\ of\ categories} \times 100 \quad (1)$$

Given a maximum score of 50 (10 × 5) and a minimum of 10 (10 × 1), the range is 40. Dividing by 5 categories yields an interval of 8. Therefore, the acceptance criteria were as follows:

Table 3. UAT evaluation indicators

Criteria	Interval	Value	Frequency	(%)
Very Not Good	10–18	1	0	0.00
Not Good	19–26	2	0	0.00
Fair	27–34	3	0	0.00
Good	35–42	4	19	90.47
Very Good	43–50	5	2	9.53
Total			**21**	**100**

$$Percentage = \frac{Total\ score\ obtained}{Maximum\ possible\ score} \times 100 \quad (2)$$

The average UAT result was 80.67%, classified as "Good". A total of 90.47% of respondents rated the system as "Good," while 9.53% rated it as "Very Good." No respondents rated it below these categories.

The results indicate that users found the system easy to understand, functionally complete, and visually clear. Respondents emphasized three major benefits:

1. Simplified transaction and stock entry processes.
2. Faster and more accurate report generation (reducing manual input time by ≈ 40%).

3. Improved accuracy of stock tracking due to automated FIFO logic.

These findings affirm that the developed system meets both functional and usability expectations for microenterprise users. Furthermore, they validate the effectiveness of RAD-based iterative development, which integrates user feedback throughout the process to achieve high user satisfaction.

3.5. Discussion

The integration of the FIFO method, RAD model, and UAT-based evaluation collectively demonstrates that the developed web-based inventory system is both functionally effective and user-accepted. From a technical standpoint, the FIFO algorithm proved efficient in maintaining real-time stock accuracy and preventing the accumulation of unsold or expired goods one of the major operational challenges in micro-scale retail. The system's automatic updates and real-time reporting enhance transparency and accountability.

From a development perspective, applying the RAD methodology shortened development time while maintaining alignment with user needs. Continuous user feedback during iterative prototyping stages ensured that the system remained contextually relevant, easy to use, and technically feasible given the limited digital infrastructure of Warung Madura. From a user experience standpoint, the UAT score of 80.67% confirms that users perceive the system as effective, practical, and beneficial for their daily operations. This finding supports, who highlight that rapid, user-driven development models enhance adoption rates and usability satisfaction in small-scale system projects [18].

Furthermore, these results demonstrate that the system not only meets functional objectives but also contributes to the digital transformation of Indonesia's microenterprises. Through this model, Warung Madura owners gain access to an affordable, open-source solution that modernizes their inventory and sales processes. Nevertheless, this study has limitations. Testing was confined to a single store location, and the system currently operates in a local environment without cloud synchronization or online payment integration. Future research should expand implementation across multiple sites and explore integration with mobile applications, digital payment systems, and cloud databases to enhance accessibility and scalability.

Overall, the findings validate that the Web-Based Smart Inventory System developed using the RAD approach and powered by the FIFO method provides a reliable, efficient, and user-approved solution for managing inventory in micro-scale retail enterprises.

4. Conclusions

This study successfully developed and evaluated a web-based smart inventory and sales management system that integrates the FIFO (First In, First Out) method, specifically designed for Warung Madura as a representative model of Indonesian microenterprises. The system was built using the Rapid Application Development (RAD) approach, which facilitated iterative prototyping and continuous user involvement, resulting in a lightweight and context-appropriate solution. Functional testing using the Black box method confirmed that all system modules operated according to specifications, while the User Acceptance Test (UAT) achieved an overall score of 80.67%, categorized as "Good." The integration of the FIFO algorithm ensured accurate and chronological stock management, reducing the risks of product expiration and data discrepancies, while automated reporting significantly improved operational efficiency and decision-making speed. These outcomes demonstrate that the system effectively addresses common challenges in manual inventory management, such as data inaccuracies, slow reporting, and limited transparency, thereby enhancing both productivity and reliability in daily retail operations.

The findings of this research contribute to the growing body of knowledge on information system applications for microenterprises by bridging the gap between accounting-based inventory methods and accessible web technologies. The study's originality lies in adapting the FIFO method within a web-based system optimized for non-technical users in small-scale retail environments. Practically, the developed system supports micro-entrepreneurs in achieving better stock control, faster reporting, and more accurate sales monitoring—advancing the broader agenda of digital transformation for micro and small enterprises (MSMEs) in Indonesia. Theoretically, it validates the effectiveness of combining the RAD model with the FIFO inventory principle in user-centered software design. Future research should explore the system's scalability through cloud integration, mobile accessibility, and multi-store implementation, ensuring that similar microenterprises can adopt this model as a foundation for efficient, transparent, and sustainable digital inventory management.

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