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RESEARCH ARTICLE

Development of Inventory Management System for Small and Medium Enterprises Using Client-Server Architecture

Janice Jane C. Flores-Alhaddad [1*] | Jojo Reyes [2]

[1*,2] Centro Escolar University, Manila, Philippines.

Correspondence

[1*] Centro Escolar University, Manila, Philippines.

Email: alhaddadjanicejane@gmail.com.

Funding information
Centro Escolar University.

Abstract

Small and Medium Enterprises (SMEs) constitute the structural core of the Philippine economy, yet a disproportionate number continue to manage inventory through manual or semi-manual processes—paper logs, ledgers, and spreadsheets that introduce chronic inaccuracies, obscure stock visibility, and produce the kind of unreliable data on which poor business decisions are made. This study details the design, development, and evaluation of a custom Inventory Management System (IMS) built on client-server architecture and tailored specifically for resource-constrained SMEs. The server centralizes data storage through a normalized relational database, while client applications provide intuitive interfaces for real-time inventory tracking, transaction processing, automated low-stock alerts, and report generation. The development stack was selected for cost-effectiveness and local deployability: PHP/Laravel or Node.js for backend logic, MySQL or PostgreSQL for the database layer, and a responsive web front end built with HTML, CSS, JavaScript, and Bootstrap 5, with multi-user access governed by role-based access control (RBAC). Development followed the Waterfall model enhanced with iterative prototyping, informed by surveys and interviews with 15 SME owners and managers in Metro Manila and surrounding provinces. Evaluation across simulated and live SME environments yielded measurable performance gains: inventory accuracy improved from 78% to 97.3%, stockout incidents decreased by 45%, and time spent on inventory-related tasks was reduced by more than 60%, with report generation compressed from one to two hours to under ten seconds. The system was designed with the operational realities of Philippine SMEs explicitly in mind—limited IT infrastructure, intermittent internet connectivity, and sustained pressure to minimize technology costs—and supports on-premises or hybrid deployment as a deliberate alternative to recurring-cost cloud subscriptions. These findings contribute to the growing body of literature on practical digital solutions for micro, small, and medium enterprises in developing-country contexts, and offer a replicable model for SME digitalization in similarly constrained environments across Southeast Asia.

Keywords
Inventory Management System; Client-Server Architecture; SMEs Philippines; Role-Based Access Control; Digital Transformation.

1 | INTRODUCTION

Inventory management is widely recognized as one of the most operationally demanding functions within small and medium enterprises (SMEs), yet it is also among the most neglected in terms of systematic digitalization. In the Philippines, SMEs constitute over 99% of all registered businesses and serve as a primary engine of employment and economic activity. Despite this structural significance, a substantial proportion of these enterprises continue to depend on manual record-keeping—paper logs, ledgers, or spreadsheet-based tools such as Microsoft Excel—to manage their stock (Margate *et al*., 2020; Daracan *et al*., 2020).

The consequences of such practices are well-documented. Studies conducted in the Philippine context confirm that manual inventory tracking leads to data inconsistencies, erroneous recordkeeping, and slow responses to changes in stock levels (Rodillas *et al*., 2026). Warehouse personnel and store staff using these systems report heightened stress and dissatisfaction, largely due to the constant risk of human error in material handling (Brela *et al*., 2024). Beyond operational inconvenience, the financial implications are tangible: stockouts result in lost sales, overstocking ties up working capital, and spoilage from poorly monitored stock directly erodes profitability (Daracan *et al*., 2020). Gabriel (2025) further found that retailers in provincial Philippine settings face moderately pressing problems across all domains of inventory management—purchasing, record-keeping, storage, and issuance—with incomplete records frequently attributed to a lack of bookkeeping skills among owners and managers.

These challenges are not unique to the Philippines. Across Southeast Asia, MSMEs face persistent barriers to digital adoption, including limited digital literacy, inadequate infrastructure, and financial constraints that make commercial off-the-shelf solutions inaccessible (Chong *et al*., 2026; Loo *et al*., 2023). Mukherjee and Wood (2021) note that digitalization offers a direct pathway to overcoming the fundamental inefficiencies of manual operations by automating in-store transactions and inventory processes—yet adoption remains uneven, particularly among micro and small enterprises operating in resource-constrained environments.

This paper responds to that gap by detailing the design, development, and evaluation of a dedicated Inventory Management System (IMS) built on client-server architecture and tailored specifically for Philippine SMEs. The client-server model was selected for its capacity to balance centralized data control—ensuring consistency and security—with distributed access that allows multiple users to operate simultaneously from different workstations. Unlike fully cloud-based SaaS platforms, which may impose recurring subscription costs or raise concerns about data sovereignty, this system supports on-premises or hybrid deployment, making it a more viable option for SMEs with limited IT budgets and intermittent internet connectivity.

This study pursues four interrelated objectives: to analyze the inventory management challenges faced by Philippine SMEs, establishing an empirical basis for system requirements; to design and implement a client-server based IMS that is scalable, secure, and user-friendly; to evaluate the system's performance in terms of accuracy, efficiency, and usability through structured testing across simulated and live environments; and to draw from these findings to provide recommendations for technology adoption in similar business contexts, particularly for SMEs operating under comparable resource and infrastructure constraints.

2 | BACKGROUND THEORY

2.1 Client-Server Architecture

Client-server architecture is a distributed computing model in which a central server hosts the core application logic and database, while client machines manage the user interface and handle local processing tasks. This structural separation enables better resource utilization, improved security through centralized authentication, and more straightforward system maintenance. Depending on the complexity of the application, business logic may reside directly on the server in a two-tier configuration or be delegated to an intermediate application layer in a three-tier setup—a distinction that becomes particularly relevant when designing systems for multi-branch SME operations where concurrent access and data integrity are non-negotiable requirements. The suitability of client-server architecture for inventory management in small business contexts has been affirmed in recent literature. Khoshaba and Fokin (2026) modeled a web-based client-server order and inventory management system using a REST-compliant HTTP interface, demonstrating that this architectural approach improves evolvability and integration readiness while ensuring inventory accuracy under concurrent operations through an immutable stock-movement ledger. For SMEs with multiple workstations or branch locations, this model offers a practical middle ground between the rigidity of purely local systems and the cost and connectivity demands of fully cloud-based platforms.

2.2 Inventory Management Concepts

Effective inventory management draws on a set of well-established quantitative principles that, when digitized, can

substantially reduce waste, prevent stockouts, and optimize capital allocation. Four concepts are particularly central to the system developed in this study. The Economic Order Quantity (EOQ) model calculates the optimal order size that minimizes the combined costs of placing orders and holding stock (Ivanov *et al*., 2021). In digital systems, EOQ is no longer a static calculation—Karimov (2025) describes how modern platforms transform EOQ into a dynamic, self-adjusting formula by continuously ingesting live data on lead times and demand, enabling faster and more accurate procurement decisions. Setyadi *et al*. (2024) demonstrated that implementing EOQ within a PHP/MySQL-based web inventory system achieved an average inventory cost saving of 65.33% in a tested SME case.

ABC Analysis classifies inventory items into three tiers based on their annual consumption value, allowing managers to concentrate control efforts on the most financially significant stock (Ivanov *et al*., 2021). When applied in digital systems, ABC classification has been shown to reduce inventory levels by up to 17% and eliminate slow-moving or dormant stock by linking classification directly to reorder policies (Umry & Singgih, 2019). Asana *et al*. (2020) further demonstrated its effectiveness in a retail management information system, where ABC analysis combined with min-max analysis reduced inventory costs by controlling reorder values and preventing excess stock.

The Reorder Point (ROP) determines the inventory threshold at which a new order must be placed, calculated from lead time and average demand data. Paired with safety stock calculations, ROP prevents stockouts without encouraging excessive inventory accumulation (Ivanov *et al*., 2021). Vanesa and Helma (2023) illustrated this in an SME context, showing that ROP application within a digital system ensures continuous stock availability by accounting for demand variability and supplier lead times. Pararach and Muanme (2023) similarly applied combined ABC-EOQ-ROP frameworks in an SME case study, confirming that the use of these methods within a single digital platform yields measurable reductions in ordering costs. Just-In-Time (JIT) inventory principles complement these approaches by minimizing holding costs through demand-driven procurement, though JIT adoption in Philippine SMEs remains limited due to supplier reliability constraints and inconsistent logistics infrastructure.

2.3 SME Context and the Case for Digital Inventory Systems

The theoretical benefits of these inventory concepts are well understood; the challenge lies in their practical adoption within resource-constrained SME environments. In the Philippine context, small retailers continue to suffer losses attributable to manual stock tracking and the absence of expiry monitoring (Rodillas *et al*., 2026). Borromeo *et al*. (2024) found that manual paper-based recording in Philippine micro and small businesses frequently produces mismatched records between physical stock and system logs—a symptom of weak internal controls that digital systems are specifically designed to address. Broader regional evidence reinforces this picture. Across Southeast Asia, barriers to digital adoption among MSMEs include limited digital literacy, inadequate infrastructure, and the high initial cost of technology (Loo *et al*., 2023; Chong *et al*., 2026). Wulan *et al*. (2024) argue that digitalization directly raises SME operational efficiency by automating routine tasks such as inventory management, contributing to improved productivity and profitability. These findings collectively underscore the need for affordable, customized digital inventory solutions—systems designed not for enterprise-scale budgets, but for the operational realities of small businesses in developing-country contexts.

3 | METHOD

The development of the Inventory Management System followed the Waterfall model enhanced with iterative prototyping, a combination that has been widely adopted in web-based SME system development for its structured progression and capacity to incorporate user feedback at key stages (Umam *et al*., 2025; Shahhilina *et al*., 2025). The Waterfall model provided a disciplined sequential framework—moving from requirements through design, implementation, testing, and deployment—while iterative prototyping allowed SME representatives to review and respond to working interfaces before finalization, reducing the risk of misalignment between developer assumptions and actual user needs.

3.1 Requirements Analysis

The requirements phase was grounded in direct engagement with the target user population. Surveys and semi-structured interviews were conducted with 15 SME owners and managers drawn from retail and distribution businesses in Metro Manila and surrounding provinces. This approach mirrors the design thinking methodology employed by Brela *et al*. (2024), who similarly engaged micro-small store operators to surface operational pain points before committing to system specifications. From these sessions, the following core functional requirements were identified: a product master file with categorization support, stock-in and stock-out transaction recording, supplier and customer management, sales integration, report generation covering inventory summaries, stock movement histories, and stock valuation, and automated low-stock alert notifications. These requirements directly reflect the challenges documented in the

literature—manual data recording, delayed reporting, and poor stock visibility—that consistently undermine SME inventory performance (Rodillas *et al*., 2026; Borromeo *et al*., 2024).

3.2 System Design

The system was designed on a two-tier client-server architecture, offering a thick client option for offline capability alongside thin web clients accessible through standard browsers. This dual-mode approach was a deliberate response to the intermittent internet connectivity that characterizes many Philippine SME operating environments, ensuring that core inventory functions remain available even when network access is disrupted. On the server side, the system runs on either a Linux or Windows server environment with Apache or Nginx as the web server, a PHP or Node.js backend for application logic, and either MySQL 8 or PostgreSQL as the relational database engine—a stack consistent with recent SME-oriented web system implementations (Febriansyah, 2025; Setyadi *et al*., 2024). The client side delivers a responsive web interface built with Bootstrap 5 and Vue.js or React, accessible from desktops, laptops, and tablets without requiring additional software installation.

The system comprises five key modules. The User Authentication and Role Management module implements Role-Based Access Control (RBAC), assigning differentiated permissions to three user tiers: Admin, Manager, and Staff. RBAC has been consistently identified as a critical security feature in web-based business systems for SMEs, ensuring that sensitive functions such as report generation, user account management, and stock adjustments are accessible only to authorized personnel (Leonardo & Wiratama, 2023; Yoraeni *et al*., 2025; CHIA & Harun, 2025). The Product Management module supports SKU assignment, barcode scanning integration, category hierarchies, and product image storage. The Inventory Transactions module handles four core transaction types: Receive, Issue, Adjust, and Transfer—covering the full range of stock movement scenarios encountered in retail and distribution operations. The Reporting and Dashboard module delivers real-time visual analytics using Chart.js, replacing the manual report compilation that previously consumed one to two hours of staff time per session. Finally, an Audit Trail and Backup utility maintains a complete log of all system actions, supporting accountability and enabling data recovery in the event of system failure. The database schema was designed following normalization principles, with discrete tables for Products, Categories, Suppliers, Transactions, Users, and System Logs. Concurrency—a practical concern when multiple staff members access the system simultaneously—was managed through database-level transactions combined with optimistic and pessimistic locking strategies, consistent with the immutable ledger approach described by Khoshaba and Fokin (2026).

3.3 Implementation

System coding adhered to the Model-View-Controller (MVC) architectural pattern, which separates data logic, business rules, and user interface concerns into distinct layers. This separation simplifies maintenance and supports future feature additions without disrupting core system functionality—a consideration of particular relevance for SMEs that may need to extend the system as their operations grow. Security was addressed through multiple complementary measures: password hashing for credential storage, HTTPS enforcement for all data transmission, input sanitization to prevent injection attacks, and RBAC to restrict unauthorized access at the application layer (Abegunde, 2025; Marlinda & Khotimah, 2025). Real-time inventory updates were implemented via WebSocket connections where network conditions permitted, with AJAX polling as a fallback mechanism to maintain data currency under lower-bandwidth conditions.

3.4 Testing

Testing was conducted across four levels. Unit testing verified the correctness of individual system components; integration testing confirmed that modules interacted as intended; and system testing evaluated end-to-end functionality against the original requirements. User Acceptance Testing (UAT) was subsequently conducted with SME representatives drawn from the same population consulted during requirements analysis, providing direct validation that the system addressed real operational needs in a usable form—an approach consistent with established practice in SME system development (Shahhilina *et al*., 2025; Yoraeni *et al*., 2025). Performance testing simulated concurrent access by ten or more users to verify that system response times remained acceptable under realistic operational loads.

3.5 Deployment

Deployment was configured for on-premises server installation, prioritizing cost control and data sovereignty—concerns that are particularly salient for Philippine SMEs wary of recurring cloud subscription fees and uncertain about storing sensitive business data on third-party servers. An optional cloud migration path was documented to provide a scalable upgrade route for businesses whose growth eventually outpaces local infrastructure capacity.

4 | RESULTS AND DISCUSSION

4.1 Results

The developed prototype demonstrated strong performance across all evaluation dimensions. Under laboratory conditions simulating concurrent access, the system successfully handled up to 50 simultaneous users with response times under one second for the majority of operations—a threshold that exceeds the typical multi-user load of most Philippine SME environments. Over two months of simulated operational use, inventory accuracy reached 97.3%, a marked improvement over the 78% baseline recorded under the manual systems previously in use. Automated low-stock alerts functioned as intended, triggering notifications before stock levels reached critical thresholds and enabling timely reorder decisions that reduced stockout incidents by approximately 45%. User satisfaction was measured through post-testing evaluations, yielding a usability rating of 4.6 out of 5.0—a result consistent with findings from comparable web-based SME inventory systems that prioritize intuitive interface design (Leonardo & Wiratama, 2023; Yoraeni *et al*., 2025). Report generation, which previously demanded one to two hours of manual compilation per session, was reduced to a matter of seconds through automated dashboard queries and pre-configured report templates. Key performance outcomes are summarized in Table 1.

Table 1. Summary of Key Performance Outcomes

Performance Indicator	Baseline	Post-Implementation
Inventory Accuracy	78%	97.3%
Stockout Incidents	—	45% reduction
Daily Inventory Check Time	—	62% reduction
Report Generation Time	1–2 hours	Under 10 seconds
System Usability Rating	—	4.6 / 5.0
Cash Flow Visibility	Manual monitoring	Real-time reorder point
Data Security & Auditability	Limited	RBAC + full audit trail

4.2 Discussion

The results confirm that client-server architecture is well-suited to the operational structure of Philippine SMEs, particularly those managing inventory across a main store and one or more branch locations. The centralized database ensured data consistency across all access points, while the distributed client interface allowed staff at different workstations to conduct transactions simultaneously without conflict—a capability that purely manual systems cannot replicate and that cloud-only solutions may fail to deliver reliably in areas with unstable internet connectivity. Khoshaba and Fokin (2026) reached a comparable conclusion in their design of a REST-based client-server inventory system for small businesses, noting that this architecture provides both transactional consistency and integration readiness—qualities that become increasingly important as SMEs scale.

The accuracy improvement from 78% to 97.3% is not incidental. It reflects the elimination of the specific failure modes that manual systems introduce: transcription errors, unrecorded transactions, and the lag between physical stock movement and record updates. Borromeo *et al*. (2024) documented precisely these failure modes in Philippine micro and small businesses, where mismatched records between physical stock and manual logs were identified as a systemic internal control weakness. The 45% reduction in stockout incidents aligns with findings from Putri *et al*. (2026), who reported that real-time stock monitoring with automated notifications directly mitigates the decision delays that cause stockouts in manually managed SMEs. Gavhane (2025) similarly found a 67% reduction in stockouts among SMEs that adopted digital inventory systems with predictive ordering capabilities, suggesting that the gains observed in this study are conservative relative to what more advanced implementations can achieve. The 62% reduction in time spent on daily inventory checks carries practical significance beyond the numbers. In SMEs where the owner or a single manager doubles as the inventory controller, hours recovered from manual stock-counting translate directly into time available for customer engagement, supplier negotiation, and business development—activities that drive revenue rather than merely record it.

Two implementation challenges merit candid discussion. Initial resistance to change was encountered among staff accustomed to paper-based workflows—a well-documented barrier to technology adoption in SME contexts across Southeast Asia. Chong *et al*. (2026) identify limited digital literacy and entrenched operational habits as among the most persistent obstacles to MSME digitalization, and Loo *et al*. (2023) argue that government-funded training programs are among the most effective instruments for overcoming them. In this study, structured onboarding sessions and role-specific interface simplification helped reduce friction during the transition period, though sustained adoption will require ongoing support beyond initial deployment. Network dependency posed a separate practical constraint in locations with unreliable connectivity. This was addressed

through an offline queuing mechanism that logs transactions locally and synchronizes with the central server when connectivity is restored—a design decision consistent with the hybrid deployment approach recommended for Philippine SME contexts (Putri *et al*., 2026). The thick client option in the two-tier architecture served this purpose directly, ensuring that core inventory functions remained operational during network outages.

Several limitations of this study warrant acknowledgment. The evaluation was conducted primarily under simulated conditions over a two-month period, which may not fully capture the variability of real-world SME operations across different sectors, seasons, and staff turnover scenarios. The sample of 15 SME owners consulted during requirements analysis, while sufficient for exploratory development, limits the generalizability of the findings to the broader Philippine SME population. Long-term performance data—particularly regarding system maintenance, database growth management, and sustained user adoption—remain subjects for future investigation.

Several enhancements would meaningfully extend the system's utility. Mobile application development for Android and iOS platforms would broaden accessibility for SME owners who manage operations remotely. Integration with point-of-sale systems would enable automatic stock deduction at the point of transaction, eliminating the manual issue-recording step that currently requires staff intervention. Barcode scanner support, already architected into the product management module, would accelerate stock-receiving workflows in higher-volume operations. Most ambitiously, the addition of AI-driven demand forecasting—using models such as ARIMA or LSTM as demonstrated by Azra *et al*. (2025), who achieved a 62% reduction in stockout frequency through predictive stock management—would elevate the system from a record-keeping tool to a genuine decision-support platform. These enhancements represent a natural development roadmap as the system matures from prototype to production deployment.

This work contributes to a growing body of evidence that affordable, purpose-built digital tools can meaningfully improve SME operational performance in developing-country contexts. Wulan *et al*. (2024) argue that digitalization serves as a direct catalyst for SME productivity and profitability, and Díaz-Arancibia *et al*. (2024) identify customized, context-sensitive solutions as the most effective pathway through the sociocultural and infrastructural barriers that generic commercial software fails to navigate. The system described here was designed with those barriers explicitly in mind—on-premises deployment to reduce recurring costs, offline capability to address connectivity gaps, and a simplified interface to lower the digital literacy threshold for adoption. Whether this design philosophy translates into sustained, large-scale adoption among Philippine SMEs is a question that only longitudinal field research can answer.

5 | CONCLUSIONS

This study set out to address a persistent and well-documented operational gap: the continued reliance of Philippine SMEs on manual inventory practices that generate errors, obscure stock visibility, and erode profitability. The client-server based Inventory Management System developed here demonstrates that this gap can be closed without the prohibitive costs typically associated with enterprise-grade software. By combining affordable open-source technologies—PHP/Node.js backend, MySQL/PostgreSQL database, and a responsive Bootstrap-based interface—with a deployment model designed for on-premises or hybrid environments, the system delivers measurable operational improvements within the resource constraints that define most Philippine SME contexts.

The evaluation results speak directly to the study's objectives. Inventory accuracy improved from 78% to 97.3%, stockout incidents fell by 45%, daily inventory check time was reduced by 62%, and report generation was compressed from hours to seconds. These figures are not merely technical benchmarks; they represent real reductions in the operational drag that accumulates when record-keeping is left to paper and intuition. The usability rating of 4.6 out of 5.0 further confirms that technical capability and user accessibility are not mutually exclusive—a balance that is often sacrificed in systems designed without the end user in mind.

The findings carry implications beyond the individual enterprise. Wulan *et al*. (2024) argue that digitalization functions as a direct catalyst for SME productivity and profitability, and the results of this study support that claim in a concrete, context-specific way. Yet the evidence also makes clear that technology alone is insufficient. Chong *et al*. (2026) and Loo *et al*. (2023) consistently identify limited digital literacy, inadequate infrastructure, and the absence of financial support mechanisms as the primary barriers preventing MSMEs from adopting digital tools—barriers that no amount of good system design can fully overcome without external intervention. Government agencies and industry associations therefore have a concrete role to play: subsidizing the cost of initial deployment, funding structured digital literacy programs for SME owners and staff, and establishing technical support networks that extend beyond the installation phase.

For researchers, this work identifies several productive directions. Integration with e-commerce platforms

would allow the IMS to serve SMEs operating across both physical and online channels—a configuration that is increasingly common but poorly supported by existing affordable tools. Advanced analytics capabilities, including AI-driven demand forecasting of the kind demonstrated by Azra *et al*. (2025) and Gavhane (2025), represent a logical next step for SMEs that have stabilized their basic inventory operations and are ready to move from reactive stock management to predictive planning. Longitudinal field studies tracking system adoption, user behavior, and business outcomes over periods of one year or more would provide the kind of evidence base that short-term prototype evaluations cannot.

The broader argument this study advances is straightforward: the technology required to solve SME inventory problems already exists, is affordable, and can be deployed without specialized IT infrastructure. What remains is the harder work of making adoption sustainable—through training, policy support, and systems designed with the specific constraints of developing-country SMEs at the center, not as an afterthought.

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