STOCKMATE PH: DESIGN AND DEVELOPMENT OF A MOBILE-

BASED DECISION SUPPORT SYSTEM FOR INVENTORY

OPERATIONS OF SARI-SARI STORES

RESEARCH & CAPSTONE PROJECT

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Chapter I

THE PROBLEM AND ITS SETTING

Introduction

Micro-retail operations such as "Sari-sari" stores bridge the gaps between consumer needs and product accessibility in local communities. Characterized by its family-centric operation and acts as home-based neighborhood store that operates with minimal capital, and inventory levels that depend heavily on cash availability. The daily store operations are often managed by family members who take turns depending on their personal responsibilities. Their operational efficiency, inventory management, and customer relationship dynamics are shown through consistent product availability and cash flow. However, the challenge of maintaining product availability due to the lack of a clear distinction between the owner's personal funds and the store's limited operating budget represents an optimization problem that most small-scale retailers need for an effective micro-retail operation.

A broader lens for understanding sari-sari stores appears in global discussions of "nanostores," the very small, family-operated shops that dominate everyday retail in many emerging and developing economies. Systematic and conceptual studies of nanostore operations describe how these outlets typically serve low-income neighborhoods with basic goods while operating under persistent constraints such as limited working capital, physically small selling

spaces, fragmented supply chains, and weak access to formal credit or other financial services. Because these micro-retailers are often informal and home-based, they provide livelihoods and local employment yet remain vulnerable to low productivity, and frequent stockouts, when economic or supply shocks occur. Supporting nanostores and similar micro-retail shops aligns with Sustainable Development Goal (SDG) 8, which calls for development-oriented policies that promote productive activities, entrepreneurship, and growth of micro, small, and medium enterprises, including through access to financial services. Introducing appropriate digital tools and operational improvements for these shops also contributes to SDG 9 on industry, innovation and infrastructure, by upgrading small enterprises with context-suitable technologies, and to SDG 12 on responsible consumption and production by encouraging more efficient use of resources and reduction of waste along retail supply chains

In the Philippine retail landscape, sari-sari stores operate within a mix of cultural practice, economic necessity, and informal business routines. Many owners rely on informal record keeping, and they often mix household money with business capital, which limits clear visibility of working capital for replenishment. Because funds must support both inventory and household needs, each restocking trip becomes a resource allocation exercise with trade-offs among product priorities. When capital goes to slow-moving items, less money remains for fast-selling goods that customers expect to be available.

In smaller settings, particularly rural areas such as most municipalities in

Quezon province, where grocery access can be limited, sari-sari stores become essential community establishments and a practical source of daily income for households managing domestic responsibilities. The practice of extending customer credit, locally known as "utang," can further complicate working capital because it delays cash collection after inventory leaves the store. Owners must decide on replenishment while simultaneously considering demand speed, margins, available cash, and credit exposure. Without analytical support, these decisions can lead to outcomes such as stockouts of high-demand goods, cash tied up in slow-moving items, or purchases shaped mainly by supplier availability rather than store priorities. These effects do not only impact store income; they can also affect community access to basic goods and local economic circulation.

Despite the growing availability of retail software such as inventory and point-of-sale applications, many tools may not fully accommodate sari-sari store realities. Some commercial systems appear to be designed with assumptions of consistent internet connectivity, formal bookkeeping practices, and dedicated business capital, conditions that may not always reflect the operating environment of micro-retailers. Furthermore, existing solutions often emphasize inventory tracking rather than decision support, which may leave owners without guidance on how to allocate limited funds across product categories. This apparent gap between available technology and actual user needs suggests a potential opportunity for a system designed around the constraints and decision patterns observed in nanostores. At the local level, improving decision support for sari-sari

store purchasing offers a practical way to translate the intent of SDGs 8, 9, and 12

into concrete benefits for rural micro-retailers in Quezon province.

The theoretical basis for addressing this problem draws from established

frameworks in operations research and operations management. Decision Support

Systems refers to interactive computer-based systems that help decision-makers

utilize data and models to address semi-structured problems, a framework that

may be applicable to the recurring replenishment decisions faced by sari-sari store

owners. These theoretical foundations can inform the design of a decision support

system that considers the unique constraints of micro-retail operations. By

exploring the integration of adaptive demand forecasting with dynamic product

classification and budget-constrained optimization, such a system may help

transform weekly replenishment from an intuitive exercise into a more structured,

data-informed process. The proposed approach considers factors such as

household withdrawals, customer credit exposure, and diversification

requirements, elements that generic retail software may overlook but that can

directly shape sari-sari store cash flow.

The researcher's perspective on this problem comes from direct familiarity

with the operational realities of sari-sari stores. Having observed family members

managing such a store in a rural municipality in Quezon province, the researcher

has witnessed the challenges of balancing household needs against business

capital, estimating demand without formal records, and making restocking

decisions under uncertainty. This lived experience supported the interest of a

practical, accessible solution that respects the constraints and routines of micro-retailers, which is a different case from larger-scale retail contexts. The proposed study aims to explore the connection between decision science theory and grassroots retail practice, offering a tool that may support store owners in making more informed purchasing decisions within their available resources.

Theoretical Framework

This study is anchored on four established theoretical frameworks drawn from industrial engineering, operations research, management science, and cognitive psychology, collectively providing the foundation for both system design and evaluation methodology.

Decision Support System Theory, as synthesized by Arnott and Pervan (2016) in their comprehensive analysis of DSS research evolution and further developed for mobile contexts by Phillips-Wren and Jain (2022), provides the architectural foundation for the proposed application. Contemporary DSS theory establishes that computer-based systems can effectively assist human decision-makers in addressing semi-structured problems where neither purely algorithmic automation nor purely intuitive judgment produces optimal outcomes. The theory identifies three essential components of effective decision support: a data management component for storing and retrieving relevant information, a model management component for applying analytical techniques to generate insights, and a dialog management component for facilitating productive interaction between the system and its users. Recent scholarship by Burstein, Zaslavsky, and

Arora (2020) emphasizes the importance of context-awareness and offline capability for decision support systems deployed in resource-constrained environments where connectivity cannot be assumed. In the StockMate PH application, the data component stores product information and sales history in browser-based local storage, the model component applies forecasting and optimization algorithms to generate recommendations, and the dialog component

Constraint-Based Optimization Theory, rooted in operations research principles articulated by Hillier and Lieberman (2021) and reinforced by Taha (2024) in contemporary operations research pedagogy, addresses the mathematical challenge of maximizing objective functions subject to resource limitations. This theoretical framework recognizes that real-world decisions typically occur within boundaries imposed by scarce resources, including money, time, space, and attention—and that optimal solutions must respect these constraints while achieving the best feasible outcome. For capital-constrained sari-sari store owners, the available purchasing budget represents the primary constraint, while the objective involves maximizing expected profit without compromising the store's service level across essential items. To prevent the risk of concentrating all capital on a single product, the optimization model incorporates diversification constraints, ensuring that the limited budget is distributed to maintain a viable assortment. The heuristic optimization and priority-based allocation approach employed in StockMatePH, which aligns with standard inventory heuristics described by Silver, Pyke, and Thomas (2016), provides

solutions appropriate for the scale, complexity, and real-time requirements of sari-sari store purchasing decisions.

ABC Classification Theory, derived from Pareto analysis principles and formalized for contemporary inventory management practice by Jacobs and Chase (2024), provides a systematic method for differentiating management attention and resource allocation across inventory items based on their relative importance to business performance. The theory recognizes that in typical inventory assortments, a small proportion of items accounts for a disproportionately large share of sales volume, revenue, or profit contribution, following patterns approximating the 80-20 rule originally observed by economist Vilfredo Pareto. Classification of items into A, B, and C categories enables managers to focus limited attention and resources on the items where such focus yields the greatest operational benefit. Recent research by Syntetos, Babai, and Altay (2023) demonstrates the continued relevance and practical value of ABC analysis for demand forecasting and inventory control in small-scale retail operations, particularly when combined with service-level targets. In StockMatePH, ABC classification principles inform the priority scoring algorithm that determines the sequence in which items are added to the budget-constrained shopping list, ensuring that high-velocity and essential "A" items receive adequate minimum coverage before residual funds are allocated to lower-priority goods.

Cognitive Load Theory, originally formulated by Sweller (1988) for educational contexts and comprehensively updated by Sweller, Ayres, and

Kalyuga (2019), provides the psychological foundation for designing user interfaces that minimize unproductive mental effort while supporting effective decision-making. The theory distinguishes three types of cognitive load: intrinsic load determined by the inherent complexity of the task and the learner's prior knowledge, extraneous load imposed unnecessarily by poor instructional or interface design, and germane load that contributes productively to learning and schema development. Effective design minimizes extraneous load while managing intrinsic load through appropriate scaffolding and sequencing. Research by Nadj, Maedche, and Schieber (2020) demonstrates that reducing extraneous cognitive load in analytical dashboards significantly improves both decision quality and user satisfaction, findings directly applicable to inventory decision support interfaces. Studies by Medhi et al. (2021) specifically address interface design for novice and low-literacy users in developing economy contexts, recommending strategies including icon-based navigation, progressive disclosure, limited text density, and clear visual feedback. For sari-sari store owners who must process inventory information while simultaneously attending to customers and managing competing demands on attention, minimizing extraneous cognitive load becomes essential to practical usability.
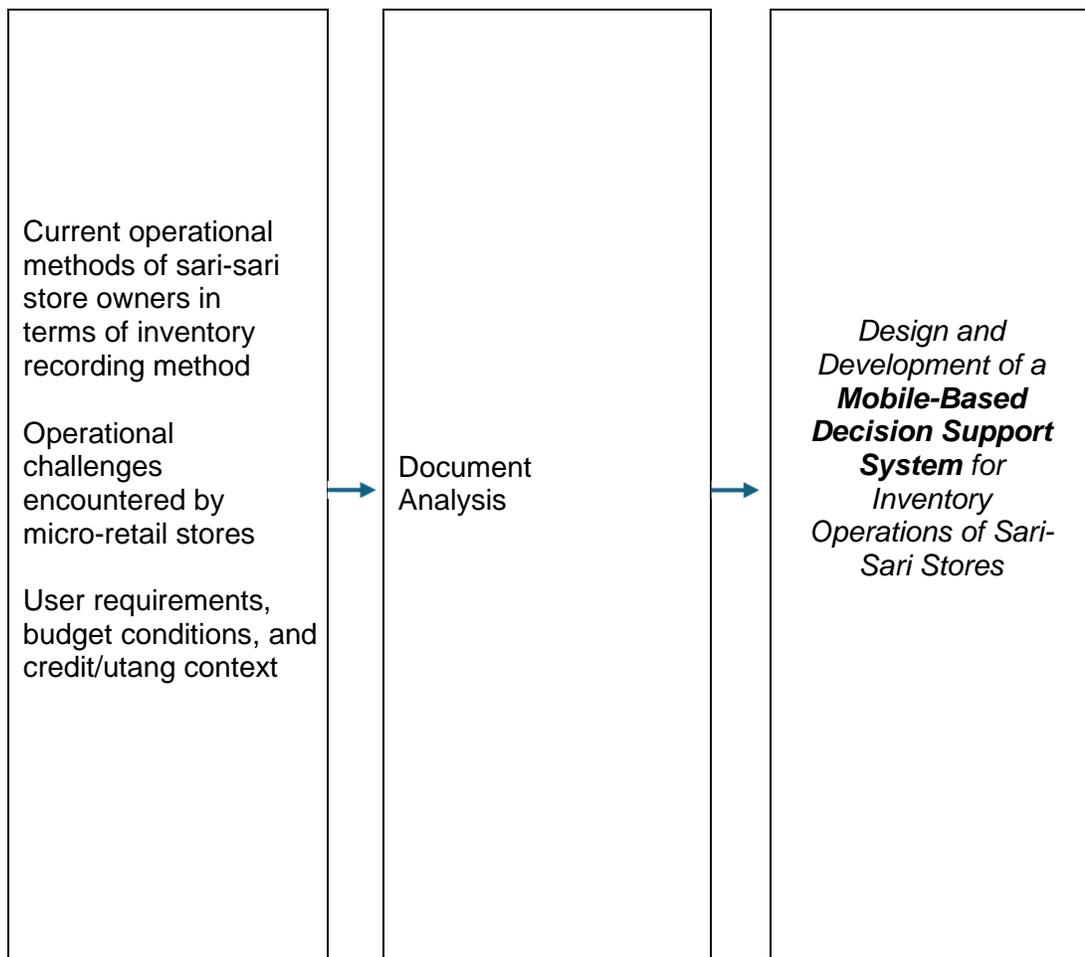
Conceptual Framework

The conceptual framework of this study follows the research paradigm as illustrated in Figure 1. The first component encompasses the baseline data gathered from the field, including the current inventory management practices of

sari-sari store owners in Infanta, Quezon, the problems they encounter in managing inventory, and the user requirements informing system design. The second component represents the developmental and evaluative activities undertaken, including direct observation of store practices, systematic identification of inventory problems, development of the decision support system, and pilot testing with selected store owners. The third component is the primary deliverable of this study.

Current operational methods of sari-sari store owners in terms of inventory recording method Operational challenges encountered by micro-retail stores User requirements, budget conditions, and credit/utang context	Document Analysis	*Design and Development of a* **Mobile-Based Decision Support System** *for Inventory Operations of Sari-Sari Stores*

Figure 1. *Research Paradigm*

Statement of the Problem

This study aims to design and develop a system that addresses the operational decision-making challenges of micro-retail store owners. Specifically, this aims to answer the following questions:

1. What are the current operational methods of sari-sari store owners, in terms of inventory recording methods?

2. What are the operational challenges encountered by sari-sari store owners?

3. What engineering system features may be developed to address the identified operational challenges?

4. How effective is the proposed system in terms of:

   4.1. Technical performance

   4.2. User Experience

   4.3. Decision Support Quality

5. What are the perceived operational impacts of using the proposed system?

Scope, Delimitations, and Limitations of the Study

This study covers the design, development, and pilot testing of StockMatePH, a mobile-based decision support system intended to support inventory purchasing decisions of sari-sari store owners in a rural environment such as Infanta, Quezon during the academic year 2025–2026. The system processes sales and inventory

inputs from participating establishments and generates purchase recommendations using ABC classification and user-defined budget constraints to guide restocking under limited working capital. Data gathering includes baseline surveys from thirty (30) store owners and pilot implementation among a subset of participating stores, with evaluation focusing on system functionality, usability, reliability, and perceived effects on inventory decisions, stock availability, and capital allocation efficiency.

To maintain focus on the core problem of budget-constrained restocking and to keep the capstone deliverables feasible, the study limits StockMatePH to purchase planning and inventory decision support rather than full business accounting. Specifically, the system does not include comprehensive financial management functions (e.g., tax computation and complete profit-and-loss reporting), and it does not address supplier selection, supplier relationship management, or supply chain and logistics optimization; instead, it concentrates on in-store prioritization and allocation of the owner's available purchasing budget. The study also confines its coverage to single-location, owner-operated sari-sari stores and typical packaged or regularly stocked goods.

The study acknowledges several limitations that may affect generalizability and implementation outcomes. Geographic scope restricts data collection and pilot testing to Infanta, Quezon, and findings may not fully generalize to micro-retail establishments in regions with significantly different economic conditions, product

availability, supplier networks, or consumer purchasing patterns. The eight-week pilot period, while sufficient for initial impact assessment, does not capture seasonal variations or long-term sustainability of system adoption, which would require extended longitudinal study beyond the academic timeline. Participant selection through purposive sampling may introduce selection bias, as stores agreeing to pilot test new technology may already be more digitally inclined than typical establishments, potentially overstating ease of adoption for the broader population. The reliance on owner self-reporting for some metrics, such as stockout incidents and decision confidence, introduces potential measurement error, though the study mitigates this through researcher verification where feasible. Finally, the system does not include hardware such as barcode scanners or specialized point-of-sale terminals, relying instead on manual data entry via smartphones, which may affect data accuracy and user compliance despite an offline-capable design accommodating connectivity limitations common in the research locale.

Significance of the Study

The findings and results of this study are expected to be beneficial to the following:

To the sari-sari store or neighborhood store owners, the system aims to assist them in planning inventory purchases using their own sales data and declared budget constraints. By presenting prioritized recommendations rather than just

stock lists, the system can help owners allocate limited funds to items with higher sales and greater revenue contribution, potentially reducing stockouts and stagnant inventory. The offline capability and mobile-first design are intended to make the solution usable even in areas with unstable internet connectivity, addressing a practical constraint faced by many establishments in the municipality.

To the local community in the rural areas of Quezon province, improved inventory decisions in micro-retail establishments may translate into more consistent availability of basic goods for households. When stores manage stock more effectively, residents are less likely to encounter frequent out-of-stock situations for common items. Better business performance may also support local livelihoods, as these microenterprises often serve as important sources of income for families in the area.

To the academic community, the study demonstrates how Decision Support Systems and Operations Research methods can provide a reference model for future thesis work on advanced prescriptive systems for small enterprises, especially in settings with limited digital infrastructure. The developed conceptual and theoretical framework, along with validated evaluation instruments, can inform related research on decision support tools for other types of micro-businesses facing similar operational constraints.

To the Industrial Engineering education and practice, the project demonstrates how core Industrial Engineering topics including inventory management, Operations Research, and systems engineering can be

operationalized into a practical working tool for real small businesses. It can serve as a teaching example for IE courses, illustrating the end-to-end process from problem definition and theoretical framework development through model selection, system implementation, pilot testing, and impact evaluation. Practicing engineers and students may find the study useful as a reference when designing similar decision support tools in other sectors characterized by resource constraints and limited technical infrastructure.

To the future researchers, this work may be extended by integrating more advanced forecasting methods such as machine learning models, expanding to multi-store scenarios, or incorporating supplier management aspects into the decision logic. The system architecture, algorithm specifications, and evaluation instruments can be reused or modified in subsequent studies aiming to improve or compare different optimization approaches. Additional research could explore long-term impacts on store profitability and business resilience when prescriptive tools are adopted over extended periods exceeding the eight-week pilot timeframe of this study.

Definition of Terms

For purposes of better understanding, the following terms are defined conceptually and operationally.

ABC Classification. ABC classification is an inventory control technique that groups items into A, B, and C classes based on their relative value or usage so

that tighter control is applied to the most important items (Patil & Patil, 2016). In this study, it refers to categorizing store products into high-, medium-, and low-priority classes using sales and profit contribution, so that StockMatePH can allocate limited purchasing capital first to high-impact items before spreading remaining funds across less critical products.

Capital Constraint. Conceptually, capital constraints refer to situations in which firms are unable to obtain the quantity of capital needed to fund all of their otherwise profitable, positive net present value projects, causing underinvestment and limiting growth (Bergbrant, Hunter, & Kelly, 2016). Operationally in this study, it denotes the working capital shortage that forces micro-retail store owners to allocate limited funds across competing inventory needs, which StockMatePH models as a formal budget constraint in its priority restocking algorithm.

Credit Extension (Utang). Conceptually, credit extension in sari-sari store operations refers to the practice of allowing customers to buy goods with deferred payment (i.e., offering flexible credit terms), instead of requiring immediate cash payment (Gano-An & Gempes, 2020).

Decision Support Quality. Conceptually, decision support quality is the extent to which a decision support system provides high-quality support for decision making, by delivering accurate, timely, and well-presented information through a usable interface that improves the user's decisions (Atta, 2017). Operationally in this study, decision support quality refers to sari-sari store owners' perceptions of how accurate and useful StockMatePH's purchase

recommendations are for their real replenishment decisions, measured through Likert-scale survey items

Decision Support System (DSS). Decision support system is a computer system that supports decision-making for problems that include semi-structured or unstructured stages (Felsberger, 2016). In this study, it refers to the StockMatePH software developed by the researchers that processes sales and inventory inputs and generates inventory purchase recommendations for sari-sari store owners

Inventory Optimization. Conceptually, inventory optimization is the process of determining appropriate replenishment decisions (such as order quantities and reorder points / review policies) so that inventory meets service objectives while controlling relevant inventory costs (Silver, Pyke, & Thomas, 2017). In this study, it means selecting product quantities for restocking that fit within the store's budget while prioritizing items with higher sales and greater revenue contribution.

Stockout. Stockout occurs when inventory is insufficient to meet demand during a replenishment cycle, resulting in shortages (e.g., lost sales or backorders depending on the system policy) (Silver, Pyke, & Thomas, 2017). In this research, stockouts are treated as an operational issue that StockMatePH aims to reduce by improving purchase planning and supporting timely replenishment decisions.

Technical Performance. Technical performance refers to a system's ability to deliver correct functions and do so efficiently; under ISO/IEC 25010:2023 this is captured through correctness and performance efficiency of the system's functions, including time behavior and resource utilization (ISO/IEC, 2023). In this

study, it refers to StockMatePH's functional correctness and performance efficiency based on the results of software testing and performance checks conducted on the system's core modules.

User Experience. User experience refers to a user's perceptions and responses resulting from the use and/or anticipated use of a system, product, or service (ISO, 2019). In this study, it refers to sari-sari store owners' perceived usability, ease of learning, and overall satisfaction while using StockMatePH, measured through the System Usability Scale (SUS) and supporting evaluation items.

Working Capital. Working capital for inventory purchases, refers to the funds a business has available to support day-to-day operations (ACCA, 2025). In this study, it refers to the amount of money the sari-sari store owner sets aside for the next restocking trip; StockMatePH uses this amount as the budget limit for its purchase recommendations.

Chapter II

REVIEW OF RELATED LITERATURE AND STUDIES

This chapter presents a comprehensive review of existing literature and studies relevant to the development of StockMatePH's system. The review is organized into a thematic analysis to identify, analyze and report patterns for the sari-sari store operational practices, proceeding to inventory challenges, and concluding with technological interventions and usability principles.

Related Literature

The concepts, ideas, and principles pertaining to operational methods in micro and sari-sari retail focus on how small store owners track stock, the extent to which they use formal methods, and how these practices affect decision-making and performance.

Current inventory recording methods of sari-sari store owners. In micro-retailing enterprises, inventory practices often remain informal because owners lack sufficient knowledge of formal techniques. Ahmad and Zabri (2018) found that inventory management only improves performance when micro retail owners understand how to implement and interpret inventory practices. Their respondents tended to rely on simple, experience-based routines rather than structured documentation or analysis of stock data. This result suggests that low knowledge contributes directly to the continued use of unsystematic inventory recording in very small stores.

Across small and micro businesses more broadly, Mat and colleagues (2023) reported that firms usually adopt only a limited set of formal inventory routines. The study noted that owners commonly perform physical counts and maintain basic lists but rarely use standardized methods or IT-based systems to manage stock information. Because recording is largely manual, data on inventory levels and movements are fragmented and not updated in real time. These conditions make it difficult for owners, such as sari-sari operators, to base purchasing and pricing decisions on complete, timely records.

Evidence from Philippine micro-businesses reinforces this picture of partial, tool-light practice. Gaborno et al. (2025) showed that micro-business owners in Buenavista, Guimaras value activities such as stock counting, classification, and reporting of losses, yet implement them using very simple tools like notebooks or ad-hoc tallies. The researchers observed that these practices are rarely embedded in integrated inventory systems, limiting the depth of information available for analysis. As a result, owners may "know" their inventory in broad terms but still lack comprehensive, systematically maintained records.

The undergraduate study *Inventory Management Tools for Local Micro Businesses* (2019) describes accessible methods such as basic forecasting, safety stock determination, and low-cost computerized systems as suitable for very small firms, including sari-sari stores. However, the authors note that many owners hesitate to adopt these tools because they perceive them as complex, costly, or outside their skill set. Consequently, the study finds that inventory recording often

stays at the level of handwritten notes or mental tracking, even when more structured options are technically feasible.

The financial importance of sound inventory recording is clear in broader retail research. Toroba et al. (2025) demonstrated that inventory management practices, especially accurate recordkeeping and monitoring—are positively associated with the financial performance of retail businesses. They argue that incomplete or poor-quality records contribute to stockouts, overstocking, and capital tied up in slow-moving items, all of which undermine profitability. For sari-sari stores that operate with very limited working capital, these findings imply that informal and inconsistent inventory methods pose a direct risk to financial sustainability.

Operational Challenges Encountered by Sari-Sari Store Owners. Micro-retailers similar to sari-sari stores face structural operational challenges that stem largely from how their businesses are financed and managed. In a recent Focus Note, Kruijff, Sawhney, and Wright (2024) describe micro-retailers as small, family-run, often informal outlets that operate with very thin working capital and must frequently divert store income to household needs. The authors highlight lack of access to suitable working capital, dependence on cash-based transactions, and reliance on intuition rather than data as core constraints that weaken inventory planning and day-to-day decision-making. Because of these conditions, micro-retailers struggle to keep adequate stock, exploit bulk discounts, or invest in business upgrades, making their operations highly vulnerable to demand and price shocks.

From the financing side, the Microfinance Council of the Philippines Industry Report (2010) points out that as microenterprise clients grow, they need larger working capital amounts that often go beyond what microfinance institutions can comfortably lend. This mismatch creates a "missing middle" where growing microbusinesses, including neighborhood stores, become under-financed just as their capital requirements increase. The report also notes sector issues like multiple borrowing and repayment stress, which can further destabilize the cash flows of borrowers. For sari-sari stores, these systemic financing gaps translate into chronic capital shortages that directly limit inventory levels and operational flexibility.

Barriers to accessing formal finance also emerge on both the demand and supply side for microenterprises. Lim et al. (2019), in a study on micro enterprises in Metro Manila, found that irregular income, limited financial literacy, and low trust in financial institutions reduce entrepreneurs' willingness and ability to borrow, while strict collateral requirements, documentation, and product design on the supply side restrict banks' appetite to lend to very small firms. These combined barriers make it difficult for micro-entrepreneurs to secure stable funding for working capital. In operational terms, this means store owners must rely on small, short-term funds or informal borrowing, which constrains their capacity to maintain consistent stocks and absorb short-run losses.

Financial constraints at the MSME level are further detailed by Cruzado and Dimaano (2023), who examined how specific financial constraints affect access to

financing in Calapan City. Their study showed that factors such as collateral requirements, the structure of financial institutions, limited small-business support services, and low awareness of funding opportunities all have a significant relationship with MSMEs' ability to obtain finance. They concluded that many small businesses struggle to acquire the financial products they need, which hampers growth and day-to-day operations. For sari-sari store owners, similar constraints imply persistent difficulties in securing affordable capital for inventory and other operational needs.

At the policy and sector level, PIDS' MSME feature synthesizes Philippine evidence showing that MSMEs often struggle to access affordable financing because financial institutions perceive them as risky borrowers due to their small size, lack of collateral, and limited financial track record. Raquiza (2022), cited in this feature, notes that MSMEs have minimal credit access from formal lending institutions and seldom approach commercial banks because of high interest rates, high minimum loan amounts, short repayment periods, and burdensome requirements. These systemic conditions mean many small enterprises remain dependent on informal or semi-formal financing arrangements for working capital. Such constraints closely mirror the environment sari-sari store owners operate in, where limited, costly, and short-term credit exacerbates everyday operational challenges like stockouts, pricing pressure, and inability to expand.

Developed engineering system to support inventory operations of Sari-Sari Stores. BPI Direct BanKo's partnership with Innovaris illustrates how engineered

systems can directly address common operational gaps in sari-sari stores through a mobile platform. In a 2023 press release, BPI Direct BanKo Inc. described the e'Nay app as a tool that lets sari-sari store owners order merchandise online, manage inventory, and pay distributors digitally using a linked PondoKo savings account. The app bundles several core features—online ordering, inventory control, payment processing, and delivery and logistics—into a single system that is explicitly designed around store owners' pain points, such as disorganized supply chains and reliance on "gut feel" for purchasing. By integrating ordering, payment, and inventory monitoring, e'Nay demonstrates how engineered mobile solutions can streamline procurement and stock management for sari-sari stores.

Another example of technology tailored to sari-sari operations is Packworks' Sari.PH Pro ecosystem, which adds data analytics and artificial intelligence on top of basic inventory tools. A 2024 TechNode Global article explains that Packworks, supported by funding from the Philippine Department of Science and Technology, is developing an AI-powered precision marketing model to give sari-sari stores customized recommendations on sellable items and promotions. Through the Sari.PH Pro app, store owners can already access pricing tools, inventory management, sales and revenue tracking, and working capital loan features, while the Sari IQ module provides real-time and historical consumer expenditure data. These engineered features show how data-driven systems can move sari-sari operations beyond manual tracking toward predictive, recommendation-based decision support.

Digitization of sales and inventory at the point of sale is another key engineering direction, as seen in mobile POS platforms targeted at microenterprises. Peddlr's 2024 product blog describes its mobile POS app as a free solution for small businesses—including sari-sari stores—that digitizes sales, inventory management, and basic accounting processes, replacing pen-and-paper systems. A 2022 feature in The Independent Investor notes that Peddlr aims to "digitize" up to one million Filipino microenterprises by allowing merchants to record sales, track stock, and generate reports in-app. Together, these sources show that engineered POS systems for sari-sari stores typically bundle transaction processing, inventory tracking, and simple analytics in a mobile interface designed for low-resource environments.

Digital transformation also extends sari-sari functionality beyond basic retail into payment and service hubs, supported by specialized devices and backend platforms. An Interaksyon article from 2018 reports that firms like Posible.net deploy devices in sari-sari stores that enable digital services such as utility bill payments, remittances, and prepaid gaming PINs alongside traditional retail sales. These systems effectively turn sari-sari stores into mini service centers by integrating payment processing, connectivity, and a transaction interface into a compact terminal. For operations, this means engineered platforms allow store owners to diversify revenue streams and attract more foot traffic without needing separate physical infrastructure.

Local guidance on sari-sari inventory systems also highlights the specific

software features that directly support daily operations. A 2024 Trailblazer article on sari-sari store inventory management discusses several dedicated applications, such as Sari.Ph Pro and GrowSari, emphasizing features like real-time stock tracking, integration of POS and inventory, automated inventory updates with each sale, and low-stock alerts. The same article notes that these systems often support basic analytics, helping owners identify fast-moving items, implement first-in–first-out (FIFO) for perishable goods, and avoid overstocking slow movers. These feature sets illustrate a common engineering pattern: combining automatic stock updating, sales history, and simple decision aids to help owners manage inventory more systematically.

Effectiveness of Developed Systems for Sari-Sari Store's Inventory Operations. FinTech News Philippines (2025) reports on a Packworks study showing that sari-sari stores using its AI-powered Store Insighting Project (SIP) significantly increased their sales after applying data-driven recommendations. According to the article, stores that used the SIP report, which converts transaction histories into actionable insights, achieved a 46% increase in daily gross merchandise value and a 17% rise in sales over a two-week period. These improvements occurred even though the stores operated fewer days in that period, suggesting that better decisions on what to stock and how to manage shelves drove efficiency gains rather than just longer opening hours. The report further notes that AI recommendations helped move previously underperforming products, demonstrating a direct effect of the system on operational decisions such

as assortment and merchandising.

IPOSSoft (2024) explains that POS analytics can substantially improve the quality of operational decisions by giving retailers concrete information about product performance and customer behavior. In its article on data-driven retail, IPOSSoft states that analyzing POS data allows business owners to make more informed purchasing decisions, reduce stockouts, and avoid excess inventory, which improves both service levels and cash flow. The article also emphasizes that retailers can identify best-selling items, peak selling times, and key customer segments, then adjust reordering and assortment decisions accordingly. This shows that the effectiveness of POS systems is closely tied to how well they support day-to-day decisions on inventory and promotions.

NRS Plus (2024) highlights POS data analysis as a tool for maximizing business growth, particularly for small retailers with limited resources. Their discussion notes that data-driven decision-making helps businesses optimize inventory levels, staffing, and resource allocation by aligning these with actual sales patterns captured in POS data. NRS Plus points out that such analysis can reveal underperforming products, emerging trends, and potential stock issues early, allowing owners to act before problems become costly. By turning raw transaction data into insights on what to stock and when, POS analytics increases the effectiveness of operational decisions and supports more sustainable growth.

EPOS Now (2025) directly connects POS data analytics with smarter decision-making for small businesses, which often face similar constraints to sari-

sari stores. In its guidance on why POS data analytics drives smarter decisions, EPOS Now explains that real-time visibility into sales and margins enables owners to fine-tune pricing, adjust stock levels, and streamline processes based on evidence rather than intuition. The article notes that such data-informed adjustments can enhance profitability and cash management because owners quickly see which items contribute most to revenue and which tie up capital without sufficient returns. EPOS Now therefore frames effective POS systems as decision-support tools that translate data into operational improvements.

Saledock (2023) further describes how retail ePOS analytics support effective decision making across pricing, promotions, and product assortment. Its article on retail ePOS analytics explains that real-time reports and dashboards help retailers understand sales trends, customer preferences, and inventory status, which in turn enables more accurate decisions about which products to prioritize or discontinue. The piece emphasizes that using these analytics to set prices, plan promotions, and maintain optimal stock levels leads to increased sales and reduced instances of both stockouts and overstocking. This reinforces the view that an ePOS system's effectiveness is measured by how well its analytics improve everyday operational decisions.

Perceived Impacts of Current Systems for Sari-sari Store Inventory Operations. Nagpal (2022) examined business analytics adoption among small retailers and found that many do not fully use the data produced by their existing POS systems. In the survey, around 90 percent of retailers reported having a POS,

but only about 57 percent said they actually collect and store POS data, and 76 percent were not analyzing the data they had. Retailers often felt that their software was not intuitive or did not match their business needs, and many cited high implementation costs and lack of awareness as reasons for not using analytics. This means that even when systems are present, owners may not perceive them as truly helpful for day-to-day decisions about stock, pricing, and customer behavior.

A KPMG report on retail data ("From Data Overload to Data-Driven Decisions in Retail") highlights that many retailers struggle to turn system-generated data into useful insights for operations. The report points out that inadequate infrastructure, siloed data, and multiple disconnected technologies prevent retailers from gaining a unified view of their business. As a result, managers are often overloaded with numbers but still lack clear, actionable information when deciding what to stock, how much to order, or which products to promote. This situation suggests that the perceived impact of current systems can be limited if data is fragmented and not translated into simple decision cues.

NRS Plus (2024), in an article on common POS system mistakes, notes that poor training and underuse of features can lead to very mixed results from POS and inventory systems. The article explains that when staff are not properly trained, POS systems can cause slow transactions, more errors in order entry and inventory management, and general frustration among employees. It also warns that failing to use inventory functions correctly can result in inaccurate stock

tracking, leading to stockouts or overstocking, especially when reorder alerts are not configured. These issues mean owners may perceive the system as more of a problem than a help, which weakens its role in supporting daily operational decisions.

RetailCloud (2024) discusses "8 Challenges of Implementing POS Software" and emphasizes that many retailers face difficulties before they can experience the benefits of a system for decision making. The blog lists challenges such as choosing the wrong system for the business, lack of mobility, data security concerns, weak integration with inventory tools, and failure to use data and analytics features. It notes that when inventory trackers are not properly set up and analytics are ignored, businesses miss chances to adjust stock levels and improve decisions based on actual sales data. In practice, this means that the perceived impact of POS implementations can be disappointing if the system is poorly chosen or not configured to support everyday inventory and sales decisions.

Lowry Solutions (2025) explains how poor inventory management—often due to weak visibility and unreliable data—directly harms business performance and decision quality. They describe problems such as cash flow issues, frequent stock shortages, excess stock tying up capital, and a decline in customer trust, all traced back to inaccurate or incomplete inventory information. The article stresses that when inventory data is unreliable, any reports or analysis based on that data also become unreliable, making it hard for owners to decide what to reorder, when to discount, or which products to drop. This shows that if developed systems do

not provide accurate and timely inventory information, store owners will struggle to make good operational decisions, regardless of how advanced the software looks on paper.

Related Studies

The concepts, ideas, and principles drawn from empirical studies on sari-sari stores and similar microenterprises highlight how owners currently document sales and inventory, their level of accounting literacy, and how these practices relate to store performance and sustainability.

Current inventory recording methods of sari-sari store owners. In the Philippine context, LPU-Laguna (2018) examined the accounting practices of sari-sari stores in Brgy. Makiling, Calamba, and found that most owners relied on simple and informal documentation rather than complete books of accounts. The study concluded that this situation restricts owners' ability to generate accurate financial information and track store performance over time. Limited awareness and training in basic bookkeeping were identified as key reasons for the absence of formal recording systems in these stores.

The article, Accounting Literacy and Sustainability Among Sari-Sari Stores (2024) reported that a large share of sari-sari store owners were accounting-illiterate and did not keep systematic records of sales and expenses. According to the study, many respondents used scraps of paper or basic notebooks, and some did not record transactions at all. The authors argued that this weak literacy level

undermines the adoption of proper recordkeeping, which in turn threatens the sustainability of the businesses.

Rueda and Gutierrez (2024), in their PIDS discussion paper on women sari-sari store owners, described these outlets as home-based microenterprises deeply embedded in neighborhood credit relationships. They highlighted how owners balance domestic responsibilities with store operations and the granting of "utang," often without formal training or support systems. In such conditions, systematic tracking of inventory flows and receivables becomes difficult, and recordkeeping tends to be ad-hoc or deprioritized. This qualitative evidence helps explain why many sari-sari stores continue to depend on rough estimates and memory to monitor stock.

In exploring success and failure among sari-sari stores, Gano-An and Gempes (2020) found that successful women micro-entrepreneurs tend to exhibit better management practices, including greater awareness of business and financial routines, than owners whose stores struggle or close. While their study covers several dimensions, it implicitly links poor management and weak documentation to business failure. This implies that consistent, organized recording of sales and inventory forms part of the overall "success pattern" for sari-sari store operators.

Muchaendepi et al. (2024) examined how sari-sari store owners set prices and how this relates to sales performance, showing that pricing decisions are often made without detailed cost and volume information. The authors noted that many owners base prices on intuition, competitor behavior, or simple mark-ups rather than

on accurate records of purchase costs and sales turnover. This reliance on informal information suggests that underlying inventory and sales records are incomplete or not systematically used in decision-making. The study concludes that more accurate and structured recording would allow sari-sari owners to adopt more evidence-based pricing strategies.

Operational Challenges Encountered by Sari-Sari Store Owners. Caunan et al. (2025) conducted a qualitative multiple-case study of ten sari-sari stores in Cabanglasan, Bukidnon and found that owners consistently face intense competition, financial constraints, and operational hurdles. Their results showed that 100% of participants experienced daily competition and pricing pressure from nearby stores and larger retail chains, while 80% struggled with limited capital, inconsistent cash flow, and damaged goods. Furthermore, 90% of the owners reported difficulties in inventory management and handling customer debt, indicating that stock control and utang are central operational problems. The study underscores that these challenges are not isolated events but persistent conditions that shape how sari-sari stores operate in rural communities.

Dizon et al. (2023) examined the "Difficulties Encountered by Selected Sari-Sari Store Owners in Poblacion, San Isidro, Nueva Ecija" using a phenomenological approach with 18 respondents. The study identified three major difficulties: debts from customers who failed to pay back, theft due to lack of staff and security, and high competition from the growing number of nearby sari-sari stores. Respondents described how unpaid utang directly reduced available capital for restocking, while

theft created unexpected losses that were hard to recover from. Despite these issues, many owners were motivated to continue operating because their sari-sari store served as the primary source of income for their families.

Focusing on financing behavior, Aghan (2025) investigated the "Negative Impacts of Frequent Loan Acquisition by Sari-Sari Store Owners in Ambuklao, Bokod, Benguet" using a quantitative descriptive design with 123 store owners. The study found that owners frequently acquire loans mainly to purchase additional stocks, maintain cash flow during periods of low sales, and take advantage of bulk discounts. However, this practice leads to high interest costs, difficulty repaying multiple loans on time, and financial strain that takes precedence over other operational needs. Aghan concluded that while loans temporarily sustain operations, frequent borrowing becomes an operational challenge in itself by eroding profit and destabilizing business finances.

The article "Accounting Literacy and Sustainability Among Sari-Sari Stores" (2024) examined how low accounting literacy creates operational difficulties for sari-sari owners in Nasipit, Agusan del Norte. The researchers reported that many owners were accounting-illiterate and did not keep systematic records of sales, expenses, and receivables, relying instead on scraps of paper or simple notebooks. This lack of proper recordkeeping made it hard for owners to monitor profitability, manage customer credit, and make informed decisions about restocking and pricing. The study concluded that poor accounting literacy and weak documentation practices are significant underlying causes of the operational challenges that

threaten the sustainability of sari-sari stores.

A descriptive study on "Challenges Faced by Entrepreneurs of Sari-Sari Stores in Kabankalan City" grouped operational problems into four categories: location-related, financial, inventory-related, and customer-related challenges. According to the study, store owners struggled with competition and location saturation, lack of capital and difficulty managing expenses, problems in stock management, and customer issues such as price sensitivity and unpaid debts. The authors recommended differentiation strategies, better budgeting, and more deliberate expense control to cope with these recurring difficulties. These findings confirm that sari-sari store entrepreneurs must simultaneously manage multiple layers of operational challenges just to keep the business viable.

Developed engineering system to support inventory operations of Sari-Sari Stores. Divina et al. (2025) developed a web-based "Data-Driven Point-of-Sale and Inventory System for Pastil sa Tabi" that integrates transaction processing, inventory management, and sales forecasting for a small food enterprise. Using multiple programming languages under the Waterfall software development lifecycle, the system automates sales recording, updates inventory in real time and applies forecasting algorithms to predict demand and suggest restocking levels. The system also provides dashboards that visualize peak hours, best-selling products, and inventory status, and it implements role-based access control for security. Evaluated by 50 users and technical experts under ISO/IEC 25010, the system was rated highly on functionality and usability, demonstrating how integrated POS,

inventory, analytics, and forecasting features can improve decision-making and operational efficiency in a micro-enterprise setting.

A study titled Factors Influencing Sari-Sari Stores in Adopting Electronic Payments at Baliwasan District, Zamboanga City (2025) examined how technological and operational factors affect sari-sari stores' adoption of digital payment systems. The article reports that technological integration received a very high descriptive rating, indicating that electronic payment tools were consistently integrated into store operations. It also found that operational efficiency, faster transaction speed, and strong technological integration were highly manifested among sari-sari store owners. The results showed that these factors significantly influence adoption, implying that well-designed electronic payment systems—when integrated with daily operations, can enhance overall efficiency and serve as a key engineered feature in modern sari-sari store management.

The article Transforming SME Operations with Real-Time Mobile POS and Firebase Integration (2025) presents a system development study that designed a mobile point-of-sale application integrated with Firebase to support small and medium enterprises. According to the abstract, the system provides real-time transaction recording, cloud-synchronized data storage, and reporting features to address challenges such as delayed reporting and fragmented sales data. By leveraging a mobile interface and a backend-as-a-service, the application enables owners to access updated sales and inventory information from multiple devices. Although the study targets SMEs in general, its architecture, real-time cloud data

and reporting, is directly relevant to the kind of engineering features that can be adapted to sari-sari store operations.

The paper, Tech Innovations for Sari-Sari Stores: Gaps & Solutions (2025) analyzes the top operational and financial problems of sari-sari stores and evaluates how Software as a Service (SaaS) and artificial intelligence (AI) tools can address them. It reports that SaaS and AI-based solutions are effective in dealing with inventory management, pricing competition, and customer retention, while noting remaining gaps in areas such as physical security, health and safety, cultural expectations, and infrastructure limitations. The study highlights how startups like GrowSari and Packworks have advanced digitization by providing platforms for ordering, inventory, pricing, and analytics tailored to sari-sari stores. Its findings show that engineering features such as cloud-based inventory, AI-driven recommendations, and digital customer tools are already being deployed, but also identifies specific domains where further system innovation is still needed.

A capstone project titled Sari-Tech: Mobile Based Inventory and Management System (2025) propose an Android application designed specifically for sari-sari stores in San Antonio, Lubao, Pampanga. The project outlines features including stock level monitoring, alerts for low inventory items, notifications for expiring products, and automated sales reporting by day, week, month, and year. It aims to reduce the time and cost of manual inventory control, minimize losses from expired or out-of-stock items, and help owners identify which products are most in demand at particular times. By implementing monitoring, alerting, and reporting in a single

mobile system, Sari-Tech demonstrates how engineered mobile applications can provide practical, targeted support to everyday sari-sari store operations.

Effectiveness of Developed Systems for Sari-Sari Store's Inventory Operations. Divina et al. (2025) evaluated a data-driven point-of-sale and inventory system developed for the micro food enterprise "Pastil sa Tabi," using ISO/IEC 25010 software quality standards. Technical and user respondents rated the system highly on functionality, usability, reliability, maintainability, and performance efficiency, with mean scores interpreted as "strongly agree." The study reports that the system improved operational speed, accuracy, and consistency compared with the previous manual process, while providing real-time analytics on inventory and sales trends. Divina et al. concluded that the system enhanced operational decision making and efficiency, showing how integrated POS, inventory, and analytics features can support better day-to-day decisions in small enterprises.

Azhari et al. (2025), in their article Transforming SME Operations with Real-Time Mobile POS and Firebase Integration, examined how adopting a cloud-integrated mobile POS system altered SME operations. Their findings indicate that moving from traditional manual POS and inventory control to a real-time mobile system improved transaction speed, reduced errors, and strengthened customer service. By synchronizing sales and inventory data via Firebase, owners gained timely visibility into stock levels and sales performance, enabling more informed purchasing and replenishment decisions. The authors argue that these changes demonstrate the effectiveness of mobile POS and cloud integration as decision-

support tools for small businesses.

Sy et al. (2019) developed and assessed an "Inventory Management System with POS" for a retail client, evaluating the software through the ISO 25010 quality model. Their results showed that functional suitability achieved the highest evaluation, and the system received positive ratings overall for usability and performance efficiency. The study notes that the system helped the client move away from manual, paper-based data storage, improving the accuracy and timeliness of inventory and sales records. Sy and colleagues concluded that the automated POS-integrated inventory system supports more effective operational decisions by providing more reliable and up-to-date information than the manual process it replaced.

An article titled Intelligent Decision Support System for Optimizing Inventory Management (2023) presents a data-driven system that uses sales histories and external factors (such as promotions, weather, and holidays) to forecast product demand and plan inventory levels. Case study results showed that the system reduced both stockouts and overstocks, lowered inventory carrying costs, and improved profitability by aligning stock levels more closely with predicted demand. By highlighting which products were selling well and which were underperforming, the system allowed managers to adjust ordering and assortment dynamically based on evidence. The authors contend that this kind of intelligent decision support substantially improves the effectiveness of operational decision making in inventory management.

Villanueva et al. (2025) carried out a systems engineering study on an integrated POS and inventory solution for a state college food court, following phases of planning, implementation, evaluation, modification, and completion. Their project replaced manual POS and inventory procedures with an automated system and reported key improvements such as faster transaction processing, better control of inventory, and more organized monitoring of daily operations. Feedback gathered during the evaluation phase indicated that the system met objectives related to speed, accuracy, and ease of use, thereby supporting smoother operational decision making for managers. Villanueva and coauthors concluded that applying a structured systems engineering approach to design and evaluate the system led to measurable gains in operational performance and more effective management decisions.

Perceived Impacts of Current Systems for Sari-sari Store Inventory Operations. Moreno et al. (2025) studied "Challenges and Perception on the Adoption of Point-of-Sale System among Micro and Small Enterprises in Tacurong City" and looked directly at how owners and managers view POS use in their operations. They measured two types of challenges—operational issues (like power interruptions, network reliability, and lack of skills) and financial concerns (such as the cost of owning and maintaining POS devices)—together with four perception indicators: perceived usefulness, ease of use, image, and subjective norms. Results showed that overall challenges were "rarely experienced," but operational challenges had the higher mean and were identified as the best domain influencing

perception, while perceived usefulness was rated "very high" and ease of use "high." The authors concluded that micro and small enterprises generally perceive POS systems as helpful and easy enough to use, yet issues like electricity, connectivity, and system cost still threaten positive perception and can limit how much owners rely on POS for day-to-day decisions.

Natividad et al. (2024), in a conference paper titled "System Quality and Micro Food Businesses' Acceptance of the Cloud-based Point of Sale System for Inventory Management," examined how micro food businesses judge a cloud-based POS that handles both sales and inventory. The study focuses on how users rate different aspects of system quality (such as reliability and usability) and how these ratings relate to their acceptance of the POS for their operations. By concentrating on acceptance of a POS specifically built for inventory management, the paper highlights that micro-entrepreneurs' willingness to adopt or continue using such systems depends on how well they feel the system supports smooth, reliable inventory and sales tasks. This indicates that perceived system quality is a key factor shaping whether micro food businesses see a cloud-based POS as a useful tool for everyday operational decisions.

Divina et al. (2025) developed a data-driven point-of-sale and inventory system for a small food enterprise ("Pastil sa Tabi") and evaluated it using the ISO/IEC 25010 software quality model, gathering feedback from both technical experts and end-users. Respondents rated the system very highly for functionality, usability, reliability, maintainability, and performance efficiency, with overall means

interpreted as "strongly agree." The authors report that compared with the previous manual process, the new system improved speed, accuracy, and consistency of sales and inventory records, and provided real-time information that owners could use in making purchasing and stock decisions. These findings show that when a POS + inventory system is perceived as easy to use and reliable, micro-retail owners are more likely to trust its outputs and use them to guide operational decision making.

Tanaman et al. (2023) developed a web-based inventory management system for a small business enterprise in Pagadian City, Zamboanga del Sur, and evaluated it through system testing with both IT experts and end-users. The evaluation showed that the system obtained a mean score of 4.0 (out of 5) for functionality, performance efficiency, compatibility, and usability, all interpreted as "highly" functional, efficient, compatible, and usable. These results indicate that users saw the system as effective in handling day-to-day inventory tasks, integrating with existing business practices, and being convenient enough to operate in real conditions. Because the study centers on inventory work in a small enterprise, it provides evidence that when a developed inventory system is perceived positively on these quality dimensions, owners become more confident in using it as a basis for ordering, restocking, and other operational decisions.

A 2023 study published in *Res Militaris* investigated the acceptance and use of the Food Business System (FBS App) and the benefits it brings to micro food industry businesses. Using a structural model with latent variables for

entrepreneurial readiness, acceptance and use of the FBS App, and benefits for micro-entrepreneurs, the authors tested how these constructs relate to each other. The findings showed that acceptance and actual use of the FBS App positively affect the success of micro food businesses and mediate the relationship between entrepreneurial readiness and business benefits. This suggests that when micro-entrepreneurs believe a digital system genuinely supports their operations, they are more likely to adopt and actively use it, and in turn perceive stronger improvements in their day-to-day decision making and business outcomes.

Synthesis of Related Literature and Studies

Across the literature on sari-sari stores and comparable micro-retailers, a consistent pattern emerges: owners rely heavily on informal, manual recording methods for sales and inventory, supported by low levels of accounting literacy and limited familiarity with formal inventory tools. Studies on Philippine sari-sari stores point out that many operators keep only basic notebooks, scraps of paper, or even mental tallies, instead of complete books of accounts or structured stock records, which restricts their ability to monitor profitability and inventory movement over time. Research on micro and small enterprises more broadly shows that, although owners recognize the importance of activities such as stock counting, classification, and loss reporting, they tend to implement these routines without integrated systems, leading to fragmented and non–real-time data. Because of this, store owners often base pricing and replenishment decisions on intuition, habit, or competitor behavior

rather than on systematic analysis of costs, volumes, and turnover, which undermines evidence-based decision making.

At the same time, related studies highlight how structural financial and operational constraints shape inventory behaviour and day-to-day decisions in sari-sari and similar microenterprises. Multiple works describe a "thin capital" environment in which owners juggle business and household cash needs, face limited access to formal finance, and frequently resort to short-term or informal borrowing to maintain stock. Empirical findings on MSMEs and microenterprises document how collateral requirements, low financial literacy, and perceived risk on the part of lenders jointly restrict access to working capital, producing chronic under-stock, inability to exploit bulk discounts, and vulnerability to shocks. Qualitative studies on sari-sari operations further emphasize persistent challenges such as intense competition, unpaid customer credit (utang), theft, and damaged goods, with owners themselves identifying inventory control and receivables tracking as central but difficult tasks. Taken together, these financial and operational constraints interact directly with weak recording practices to create a high-risk environment for inventory-related decisions in micro-retail.

In response to these challenges, a growing body of engineering-oriented work proposes digital solutions, mobile applications, web-based systems, POS platforms, and fintech tools, that seek to systematize inventory, sales, and payment processes for micro and sari-sari stores. Case studies on systems like BPI e'Nay, Packworks' Sari.PH Pro, Peddlr, and SaaS or AI-based platforms show that when

store owners do adopt such tools, they gain features such as real-time stock tracking, integrated POS and inventory, online ordering, digital payments, and basic analytics or recommendations on product mix. Several articles and system development projects report positive outcomes: faster transactions, reduced manual effort, expanded service offerings (for example, bills payment and remittances), and, in some AI-enabled cases, measurable increases in sales and improved movement of underperforming products. These findings illustrate that well-designed systems can raise the quality and timeliness of information available to micro-retailers, moving operational decision making beyond rough estimates toward more data-informed practices.

However, the literature also documents important limitations and mixed perceptions regarding currently available systems for small retailers. Studies on business analytics adoption and POS implementation report that, even where POS devices are present, a large share of small retailers either do not systematically store POS data or do not analyze it, citing issues such as non-intuitive software, high costs, and lack of awareness of analytics functions. Industry and consultancy sources describe "data overload" and fragmented technologies that prevent managers from easily translating system-generated data into clear, actionable insights about what to stock, how much to order, or which products to promote. Other works identify practical barriers in implementation, poor training, misconfigured inventory functions, weak integration between POS and stock tracking, and concerns about mobility and security, which can lead to slow

transactions, inaccurate stock counts, and user frustration. Under these conditions, owners may perceive systems as burdensome or unreliable rather than as genuine decision-support tools, limiting the real impact of existing technologies on everyday inventory and operational choices.

Empirical system-development studies for micro and small enterprises nonetheless demonstrate that, when systems are usable, reliable, and well-fitted to the business context, they can substantially improve decision-relevant information and operational performance. Evaluations of POS–inventory systems for small food enterprises and other retailers, conducted under software quality frameworks such as ISO/IEC 25010, consistently show high ratings on functionality, usability, reliability, and performance efficiency from both technical experts and end-users. These projects report concrete benefits: faster and more accurate recording of sales and inventory, better organization of records, access to dashboards that summarize best-selling items and peak hours, and, in some cases, forecasting modules that suggest restocking levels. Studies that link system quality and user acceptance also find that perceived usefulness and ease of use drive adoption and continued use, while operational challenges (for example, power interruptions, connectivity, and device costs) still moderate the extent to which owners depend on such systems for daily decisions. Related structural-model research on mobile or app-based tools for micro food businesses further shows that acceptance and actual use of a business system mediate the relationship between entrepreneurial readiness and perceived business benefits, underscoring that systems influence outcomes primarily when

users trust and integrate them into routine decision making.

Viewed together, the reviewed literature and studies converge on several key points relevant to the present capstone. First, they establish that sari-sari and similar micro-retail stores operate with informal, often incomplete inventory and accounting practices in a context of tight capital and multiple operational pressures, which directly undermines the quality of inventory-related decisions. Second, they show that engineered systems, POS, inventory platforms, mobile apps, and data-driven tools, can improve information quality and operational efficiency, but their benefits are uneven because of adoption barriers, configuration and integration issues, data-fragmentation, and limited use of analytics functions. Third, they highlight that user perceptions of usefulness, ease of use, and system quality strongly shape whether micro-entrepreneurs actually rely on these systems for operational decision making, and that many existing solutions are either generic to SMEs or focused on payments and basic digitization rather than structured decision support for inventory planning under severe financial constraints. Within this landscape, there remains limited empirical evidence on decision-support systems that are explicitly tailored to sari-sari stores' inventory realities, combining simple, structured data capture with accessible analytics and recommendations that account for working-capital limits and the low-automation environment in which these micro-retailers operate. This gap justifies and frames the development of a context-specific inventory decision-support system like StockMatePH, which aims to bridge current practice and the potential of data-informed operational decision making for sari-sari store owners.

Chapter III

RESEARCH METHODOLOGY

This chapter presents the research design, participants of the study, data gathering instruments used, data gathering procedure, statistical treatment of data, and ethical considerations.

Research Design

This study employs a mixed-methods exploratory case study design that combines qualitative observation with quantitative measurement to address the research objectives comprehensively. The exploratory nature of the design reflects the study was aimed to investigate inventory management practices and technology adoption in a context, capital-constrained sari-sari stores in Infanta, Quezon, where limited prior research exists to guide hypothesis formation. Moreover, the case study approach is appropriate because it enables in-depth examination of a bounded phenomenon within its real-world context, allowing the researchers to capture the complexity of micro-retail operations that would be obscured by purely survey-based methods (Creswell, 2018). The mixed-methods approach integrates qualitative and quantitative techniques to leverage the strengths of both paradigms. Qualitative methods, including direct observation and semi-structured interviews, provide rich contextual understanding of current practices and pain points. Consequently, Quantitative methods, including system usage logs, time measurement, and structured survey instruments, provide

measurable indicators of system effectiveness and impact. Consequently, this approach enables the researchers to not only describe the operational realities of micro-retailers but also objectively quantify the impact of the proposed StockMatePH system on their efficiency.

Participants of the Study

The participants of this study were sari-sari store operators in the municipality of Infanta, Quezon Province, selected through purposive sampling methods appropriate to the exploratory case study design. Purposive sampling was used to ensure that participants met criteria directly related to the research objectives while also addressing practical constraints on researcher access and participant willingness within the local community. A total of thirty (30) sari-sari stores participated in the baseline observation phase. These stores represented diverse characteristics, including store size (from small household-attached operations to larger standalone establishments), location (poblacion and barangay settings), and product mix (general merchandise and mixed inventories). This diversity allowed the observed practices to reflect a broad range of operational contexts within the target population.

For the pilot implementation phase, a subset of stores from the baseline group was selected based on their willingness to adopt new technology, possession of an Android smartphone, and commitment to use the system during actual operations. The purposive selection prioritized information-rich cases—stores

whose operational characteristics and owner engagement yielded deep qualitative insights even with a relatively small sample size, consistent with the exploratory case study methodology in which depth of analysis takes precedence over statistical generalizability (Yin, 2018). In situations where field participation was limited to a single store, the study followed a single-case embedded design, focusing on detailed documentation of that store's experience across multiple dimensions, including usability, workflow integration, and perceived impact. The inclusion criteria for participation required that store operators own or manage an active sari-sari store with regular daily operations, possess an Android smartphone capable of running the application, be willing to participate in observation activities and provide feedback, and give informed consent for the collection and analysis of operational data for research purposes. The exclusion criteria removed stores that had ceased operations, operators without access to compatible mobile devices, and individuals who declined to provide informed consent.

Data Gathering Instruments

The data gathering instruments employed in this study were designed to address each statement of the problem through appropriate measurement approaches aligned with the mixed-methods research design. Three primary data collection modes were used: a questionnaire (evaluation survey), interviews with accompanying observation, and documentary analysis of system logs and existing store records. Together, these instruments provide complementary quantitative and qualitative information on current practices, operational challenges, system

effectiveness, and perceived impacts.

The observation checklist supports the qualitative component of the study by documenting baseline practices relevant to the first and second statements of the problem. It is organized into thematic sections covering inventory recording methods (mental, notebook, or digital notes), and stockout occurrence (frequency, affected products, and response actions). Each item provides space for brief notes and simple frequency tallies, enabling descriptive summaries of how sari-sari store owners currently operate. The checklist content was derived from the theoretical framework and related literature on micro-retail operations to ensure coverage of the key operational dimensions under study.

The semi-structured interview guide constitutes the main interview instrument for gathering narrative accounts of operational challenges, addressing the second statement of the problem. Furthermore, it contains open-ended questions on topics such as stockout experiences, difficulty in tracking profits and credit, mixing of household and store funds, and barriers to using existing inventory software. These questions define the themes of the interview while allowing follow-up probes to clarify and deepen responses. The semi-structured format maintains focus on the research objectives while permitting respondents to describe their situations in their own words. Additionally,

The evaluation survey questionnaire is the primary via-responses instrument and directly addresses the fourth statement of the problem on system effectiveness. Nonetheless, Structured with reference to ISO 25010 software

quality characteristics, it uses Likert-scale items and a small number of open-ended questions to assess three content areas: functional suitability (correctness and relevance of system outputs, such as restocking suggestions and basic opportunity cost awareness), usability (clarity of screens, ease of navigation and data entry, and perceived mental effort), and performance efficiency (speed, responsiveness, and offline capability). Additionally, The four-point response scale ranges from Strongly Disagree (1) to Strongly Agree (4), without a neutral midpoint, to encourage more definite responses. Open-ended items invite respondents to describe useful and problematic features and to suggest improvements based on their experience using the system.

The StockMatePH system prototype and any available store records function as sources for documentary analysis supporting the third and fifth statements of the problem. Embedded logging within the application automatically records transaction entry events (products, quantities, prices, and timestamps), restocking recommendation sessions (input budgets, recommended items, and user acceptance or modification), and basic usage metrics (frequency and duration of use). When available and with the owner's consent, existing handwritten notebooks or simple lists used by store owners are also examined to characterize prior record-keeping methods. These documents are analyzed descriptively to understand the presence or absence of systematic tracking and to compare pre- and post-system practices. Nonetheless, all electronically logged data are stored locally on the user's device and retrieved through a manual export function during

scheduled visits, in accordance with basic data privacy considerations

Data Gathering Procedure

Data gathering for this study followed a straightforward sequence designed to minimize disruption to store operations and respect the time of sari-sari store owners. The researchers focused on their neighborhood sari-sari stores, many of which were owned or managed by relatives or close acquaintances, making access and coordination more practical. Participants were selected through convenience sampling, and the study purpose was introduced in person. Nonetheless, store owners who expressed willingness to participate were included in the sample, and data collection activities were scheduled at times they indicated as least disruptive to their business. Hence,

Baseline data collection focused on understanding existing operational practices and challenges. Nonetheless, During the initial visit to each participating store, the researchers conducted brief on-site observations using the checklist and engaged the owner in a short semi-structured interview. The observation focused on visible record-keeping methods, stock arrangement, and replenishment behavior, while the interview elicited the owner's experiences with capital constraints, tracking of utang, and difficulties in deciding what and how much to restock. Each interaction was kept concise, with questions phrased in simple, direct language so that owners could respond within a few minutes without interrupting customer service. Following the baseline phase, the researchers configured and deployed the StockMatePH prototype on the store owner's mobile device, when

available, or on a device temporarily provided by the researchers. Consequently, A brief orientation was conducted to demonstrate how to record basic transactions and how to generate restocking recommendations using the system. Moreover, The goal of this orientation was to ensure that core functions could be performed in less than a minute per use, thereby integrating smoothly into daily operations. For several weeks, participating owners used the system during their normal activities, while embedded logging functions recorded usage patterns and decision-support interactions. Nonetheless, after an agreed usage period, the researchers returned to each store to retrieve system logs via the export function and to administer the evaluation survey questionnaire. Also, the survey was answered on paper or on a mobile device, depending on the owner's preference, and was designed so that completion required only a short amount of time. During this visit, owners were also invited to share additional comments about their experience with the system, which were noted alongside survey responses. Lastly, collected observation notes, interview responses, survey data, and system logs were then consolidated for analysis in line with the statements of the problem

Statistical Treatment of Data

After the retrieval of all data, the responses were tabulated, analyzed, and interpreted in the context of the statement of the problem. The research used the following statistical tools and Industrial Engineering methods in analyzing and interpreting data gathered from micro-retail store owners.

Descriptive Statistics

Descriptive statistics summarized the central tendency, variability, and distribution of quantitative and qualitative data collected through surveys and observations. These measures provided foundational insights into operational practices, challenges, and system effectiveness

Arithmetic Mean. This calculated the central tendency of continuous data such as time measurements and operational metrics. The formula is: Mean equals the sum of all values divided by the number of values. This tool was applied to analyze planning time before and after system implementation, providing objective performance benchmarks.

Frequency and Percentage Distribution. This presented the distribution of categorical responses from baseline observations addressing the first Statement of the Problem regarding current operational practices. The formula for percentage is: Percentage equals frequency divided by total number of respondents, multiplied by 100. Frequency tables displayed how many store owners employ each type of recording method (mental tracking, notebook, mobile notes), enabling identification of predominant practices that informed system design requirements.

Weighted Mean. This determined the central tendency of responses from Likert scale surveys evaluating system effectiveness and operational impacts. The formula is: Weighted Mean equals the sum of frequency multiplied by rating value, divided by total number of respondents, where frequency represents the number of respondents selecting each rating, rating value ranges from 1 to 5, and total

respondents equals the sample size. The weighted mean is interpreted using the following scale:

Scale	Range	Verbal Interpretation
5	4.21 - 5.00	Strongly Agree / Very High
4	3.41 - 4.20	Agree / High
3	2.61 - 3.40	Neutral / Moderate
2	1.81 - 2.60	Disagree / Low
1	1.00 - 1.80	Strongly Disagree / Very Low

Standard Deviation. This measured the dispersion or variability of responses around the mean, indicating the degree of consensus among respondents. The formula is: Standard Deviation equals the square root of the sum of frequency multiplied by the squared difference between rating value and weighted mean, divided by total number of respondents. A low standard deviation (below 0.70) indicates strong consensus among respondents, while a high standard deviation (above 1.00) indicates significant disagreement or variability in responses.

Industrial Engineering Analytical Tools

Process Flowchart. It is a visual representation that maps out the sequence of actions, decisions, and flow involved in developing StockmatePH system. It provides a step-by-step outline of its algorithm for inventory recommendations, highlighting operations, decision points, and data flow.

Percent Change. This quantified efficiency gains in replenishment planning

time, addressing the fifth Statement of the Problem by comparing baseline (pre-implementation) and post-implementation measurements. The formula is: Percent Change equals baseline time minus post-implementation time, divided by baseline time, multiplied by 100. This metric provided objective evidence of StockMatePH's impact on operational efficiency, a core Industrial Engineering performance indicator.

User Experience Evaluation

System Usability Scale (SUS). This standardized 10-item questionnaire evaluated the usability and learnability of StockMatePH. Each item used a 5-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). The SUS score was calculated by converting item responses to score contributions ranging from 0 to 4 points per item, summing all contributions, and multiplying by 2.5 to produce an overall score ranging from 0 (poor usability) to 100 (excellent usability). SUS scores were interpreted using established benchmarks: A score above 68 indicates above-average usability, while scores above 80 reflect exceptional user experience.

SUS Score	Grade	Interpretation
80-100	A	Excellent
68-79	B	Good
51-67	C	Acceptable
Below 51	F	Poor

Qualitative Data Analysis

Thematic Analysis. Qualitative data from observation field notes, interview transcripts, and open-ended survey responses underwent systematic coding. Researchers identified recurring patterns and grouped related observations into themes aligned with the Statement of the Problem, capturing the range of practices, challenges, and user experiences. Representative quotations illustrated each theme, providing rich contextual understanding that complemented quantitative findings.

Technical Validation

Functional Testing. To evaluate the technical performance of StockMatePH's application. Functional Testing, which focuses on checking the software functionality from a user's perspective approach was conducted. This method validates whether the system performs its intended functions correctly without examining the internal code for each core function. The testing process included three phases: Test Case Design where core functions (ABC Classification, Budget Allocation, Forecasting) were tested against predefined expected outputs. Test Execution where the researcher/developer input standardized test scenarios and compared actual system outputs with expected results; and Pass/Fail Criteria where functions passed if actual outputs matched expected outputs within acceptable tolerance levels. Results were documented in a test case matrix showing the module tested, input parameters, expected output, actual output, and final status.

Ethical Considerations

Informed consent was obtained from all participants prior to their involvement in any research activities. Additionally, the consent process included clear explanation of the study purpose, procedures, expected time commitments, potential benefits and risks, data handling practices, and participant rights including the right to withdraw at any time without penalty. Consent information was communicated verbally in Filipino or the local dialect to ensure comprehension regardless of participant literacy level. Survey completion served as documented evidence of informed consent, following established practices for minimal-risk community-based research.

Confidentiality protections ensured that participant identities and store-specific information were not disclosed in research outputs. Participants and stores were identified only through codes in all data records, with the code key maintained separately from research data and accessible only to the research team. All

participant information was treated with utmost confidentiality, following ethical research standards and the Data Privacy Act of 2012 (Republic Act No. 10173). Research findings are reported in aggregate form or through anonymized examples that prevent identification of specific participants.

Data security measures protected collected information from unauthorized access, loss, or misuse. Furthermore, Electronic data including system logs and digitized survey responses was stored on password-protected devices accessible

only to the research team. Physical data including completed checklists and paper survey forms was stored in locked containers at the researchers' residence. Additionally, these measures ensured compliance with data protection requirements while maintaining research integrity.

Voluntary participation was emphasized throughout the study, with participants reminded at each contact point that their continued involvement was entirely voluntary and that withdrawal carries no negative consequences. The research design minimized potential risks to participants, ensuring that involvement posed no more than minimal risk of physical, psychological, economic, or social harm. Therefore, System testing was conducted during non-peak business hours to avoid disrupting store operations. The researchers remained attentive to signs of participant fatigue, discomfort, or reluctance, adjusting research activities accordingly to minimize burden and respect participant wellbeing.

Chapter IV

PRESENTATION, ANALYSIS, AND INTERPRETATION OF DATA

This chapter deals with the presentation, analysis, and interpretation of data gathered through observation checklists, semi-structured interviews, system usage logs, and evaluation surveys. The findings are organized according to the Statement of the Problem, addressing the current operational practices of sari-sari store owners, the challenges they encounter, the features developed in StockMatePH, the system is effectiveness, and its impact on replenishment planning efficiency.

1. Profile of Current Operational Practices. This section presents the profile of the twelve sari-sari stores observed during the baseline phase. Moreover, supporting tables are provided pertaining to their inventory recording methods, replenishment basis, and capital management practices.

    1.1. Recording Methods. Inventory recording method refers to the system or approach used by store owners to track and document their stock levels, sales, and purchases. In micro-retail operations, these methods range from formal written ledgers to informal mental estimates, each with distinct implications for decision-making accuracy and business sustainability

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Table 1

Inventory Recording Methods Used by Sari-Sari Store Owners

Method of Recording	Frequency	Percentage	Rank
Mental accounting (no records)	19	63.30%	1
Notebook (handwritten)	9	30.00%	2
Mobile notes (smartphone)	2	6.70%	3
Total	30	100%	

The data show that almost two-thirds of respondents still rely on **mental** accounting without any written or digital records (63.3%, 19 of 30), indicating that inventory information often stays in memory rather than in a retrievable system. A smaller but notable share use handwritten notebooks (30.0%, 9 of 30), which introduces some structure but still limits accuracy, searchability, and analysis. Only a very small minority record stocks through mobile notes (6.7%, 2 of 30), suggest that digital tools are rarely used and that most sari-sari store owners continue to manage inventory in ways that make systematic tracking and data-driven decision making difficult.

The prevalence of mental accounting can be attributed to the informal nature of micro-retail operations and the limited time available for administrative tasks. Store owners prioritize immediate customer service over documentation, viewing record-keeping as a secondary concern that does not directly generate revenue. Additionally, many owners lack training in basic bookkeeping, reinforcing their

reliance on memory for tracking sales and inventory levels.

2. *Operational Challenges Encountered by Sari-Sari Store Owners.* This section presents the operational challenges encountered by the twelve sari-sari store owners as identified through semi-structured interviews conducted during the baseline observation phase. The interview guide contained open-ended questions designed to elicit the owners' perspectives on the difficulties they face in managing inventory, tracking sales, and making replenishment decisions. Responses were transcribed and analyzed using thematic analysis to identify recurring patterns and categorize challenges into distinct themes

Table 2

Operational Challenges Reported by Respondents

	Frequency	Percentage	Rank
Capital shortage for restocking	13	21.70%	1
Tracking credit (utang)	11	18.30%	2
Mixing personal and business money	10	16.70%	3.5
Anticipating stockout timing	10	16.70%	3.5
Deciding which items to prioritize	9	15.00%	5
Deciding whether to stock new items	7	11.70%	6
Total	60	100.00%	

Note: Multiple responses were considered; frequency represents total mentions across 12 stores.

The most frequently mentioned challenge is capital shortage for restocking, cited 13 times and accounting for about 21.7% of all challenge mentions, which confirms that limited working capital remains the dominant operational concern among respondents. This is followed by difficulty tracking credit (utang) with 11 mentions (18.3%), reflecting how managing customer receivables continues to strain owners' ability to monitor cash flow and available funds for inventory. Two challenges share the next rank, each with 10 mentions (16.7%): mixing personal and business money and anticipating stockout timing, both of which reduce transparency over how much capital is truly available and when items are likely to run out. Deciding which items to prioritize for replenishment was mentioned 9 times (15.0%), while deciding whether to stock new items received 7 mentions (11.7%), indicating that finer-grained assortment decisions, though important, are slightly less salient than core capital and recordkeeping issues.

3. *Developed engineering system.* This section presents the developed functions of StockMatePH, a mobile-based decision support system application, in response to the operational challenges identified in Section 2. The features was designed to support the purchase recommendation of the system together with the identified operational inventory challenges. Moreover, the system was designed following user-centered design principles, prioritizing simplicity, offline functionality, and direct relevance to the daily workflows of capital-constrained micro-retailers. Each feature addresses specific pain points observed during the baseline phase, with the interface designed to minimize

cognitive load and reduce barriers to technology adoption.

3.1. *Main recommendation Algorithm workflow of StockMatePH system.* The Recommendation Algorithm Workflow presents the end-to-end process used by StockMatePH to convert weekly store records into a budget-feasible purchase recommendation to support the identified capital shortage challenges for sari-sari store inventory operations. It begins with the weekly replenishment cycle, where the owner's inputs and the store's transaction-derived sales information are prepared for forecasting and prioritization, and it ends with a recommended shopping list that the owner can review before saving the final plan for the next cycle. By structuring these steps into a repeatable workflow, the system ensures that replenishment decisions follow a consistent sequence, forecasting, prioritization, budget allocation, and review, instead of relying on ad hoc judgment.
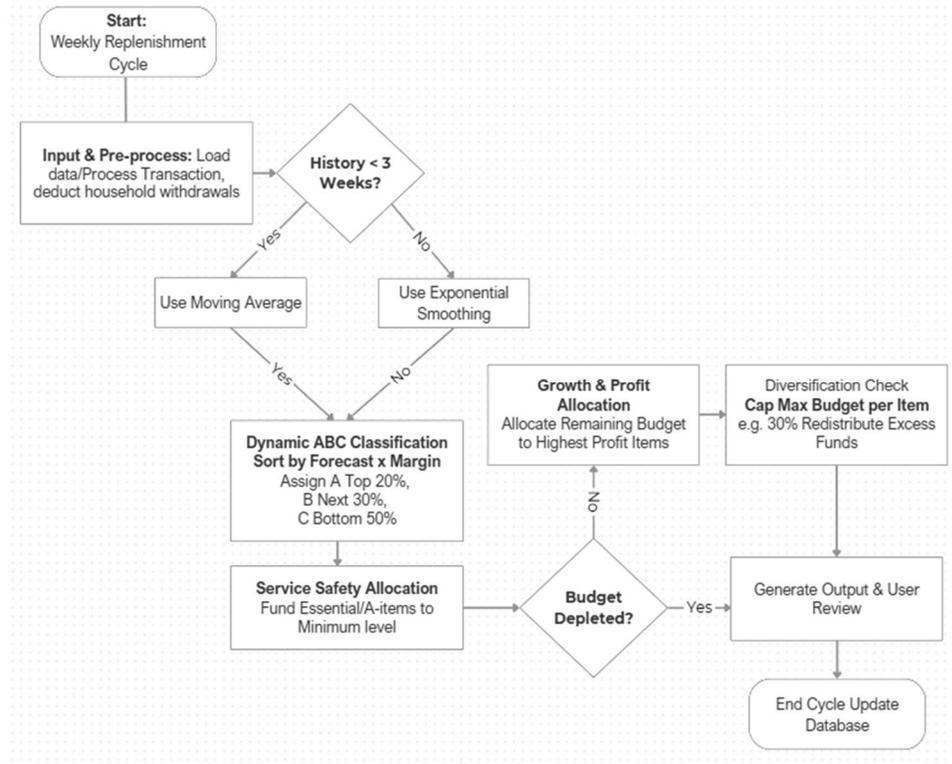
Figure 2

Main Recommendation Algorithm Workflow Design of StockMatePH mobile application

Figure 2 shows that the workflow starts with input and preprocessing, where StockMatePH loads and processes weekly store data and computes the effective purchasing budget after deducting household withdrawals. The figure then shows a forecasting decision point based on sales history length: items with limited history use a moving average, while items with sufficient history use exponential smoothing, after which the system performs dynamic ABC classification by sorting products using forecasted demand and margin and assigning Class A, B, and C groupings. After classification, the workflow proceeds to service-safety allocation,

where essential and Class A items receive minimum funding first, followed by a budget check that determines whether the system can proceed to growth and profit allocation for remaining items, and a diversification check that caps the maximum budget share per item before generating the final output for user review and updating the database to support the next weekly cycle.

4. *Effectiveness of StockMatePH.* This presents the evaluation of StockMatePH's effectiveness through a two-phase validation approach following systems and software engineering best practices: Phase 1 involved technical validation of system performance, reliability, and accuracy prior to user deployment, and Phase 2 involved user evaluation following a four-week pilot implementation with twelve store owners. Moreover, this sequential approach ensured that only technically sound features were presented to end users, preventing negative experiences due to technical failures that could undermine adoption. The technical validation phase assessed system availability, data persistence, response times, and accuracy through controlled testing and system logs. The user evaluation phase employed a 4-point Likert scale survey (1 = Strongly Disagree, 2 = Disagree, 3 = Agree, 4 = Strongly Agree) to assess functional suitability, usability, and performance efficiency from the end-user perspective, complemented by behavioral observation and usage analytics gathered during the pilot period.

4.1. *Technical Validation of System Functions.* This subsection presents the technical reliability assessment conducted by the researchers through

controlled testing with predefined test cases. Technical accuracy verification is standard software engineering practice that ensures computational correctness before user deployment.

Table 3.1

Technical Validation of Core System Functions

StockMatePH Features	Test Method	Test Cases	Expected vs. Actual	Result (Pass/Fail?)
ABC Classification Algorithm	Comparison with manual Pareto calculation	50 products classified across 5 scenarios	100% consistency	Passed
Priority Restocking (Budget Allocation)	Verify total cost ≤ budget constraint	15 budget scenarios with varying constraints	0 budget overages	Passed
Credit Management (Balance Calculation)	Manual verification against known inputs	20 sample credit transactions	100% match	Passed
Adaptive Demand Forecasting	Comparison with spreadsheet calculation (weighted moving average)	30 product forecasts	100%	Passed
Personal Withdrawal Tracking	Verify cost value calculation for withdrawn items	12 withdrawal scenarios	100% match	Passed
Opportunity Loss Calculation	Verification against manual calculation of missed revenue	12 missed sale scenarios	100% match	Passed
Transaction Recording	Verify accurate recording of sales data + offline data persistence	20 sample transactions	100% data retained	Passed

Table 3.1 presents the technical validation results demonstrating that all core computational functions achieved 100% accuracy when tested against controlled inputs with known expected outputs. Consequently, The Transaction Data Collection module, which serves as the foundation for all decision support features, was tested for both recording accuracy (20 sample transactions matched expected entries exactly) as well as the offline data persistence (simulated connectivity interruptions during data entry resulted in 100% data retention). While offline functionality was not explicitly identified as a user-stated challenge, it was implemented as a critical technical requirement given the observed infrastructure constraints in rural deployment contexts where cellular connectivity is intermittent and data costs are prohibitive for micro-retailers.

The Priority Restocking (Budget Allocation) algorithm was tested across fifteen scenarios with varying budget constraints and product portfolios, with zero instances of recommended purchases exceeding the budget limit, validating the greedy optimization logic that prioritizes A-items first, then B-items, then C-items within capital constraints. The Credit Management module correctly calculated outstanding balances across twenty sample credit transactions involving multiple payments and new credit extensions per customer, matching manual ledger calculations exactly. The Adaptive Demand Forecasting function output matched spreadsheet-calculated weighted moving averages exactly across thirty products,

confirming correct formula implementation that assigns higher weight to recent

sales periods.

4.2. *User Experience. This evaluates the usability and learnability of StockMatePH using the System Usability Scale (SUS) administered to [n] participants. The SUS employs a 5-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree) to measure perceived ease of use.*

Table 3.2

User Assessment of Functional Suitability

Items	Weighted Mean	SD	Interpretation
I think I would like to use this system frequently	4.2	0.63	Agree
I found the system unnecessarily complex	1.8	0.79	Disagree
I thought the system was easy to use	4.5	0.53	Strongly Agree
I would need technical support to use this system	1.6	0.7	Disagree
I found the various functions well integrated	4.3	0.67	Strongly Agree
I thought there was too much inconsistency	1.7	0.68	Disagree
I would imagine most people learn this quickly	4.4	0.52	Strongly Agree
I found the system very cumbersome to use	1.5	0.53	Strongly Disagree
I felt very confident using the system	4.3	0.67	Strongly Agree
I needed to learn a lot before I could get going	1.9	0.74	Disagree
Overall Score	**82.5**	**-**	**Excellent**

Scale: 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree

Table 3.2 presents the StockMatePH's overall SUS score of 82.5, classified as "Excellent" usability (Grade A) based on established benchmarks. Nevertheless, the weighted mean scores indicate strong user agreement across positive usability dimensions. Users found the system easy to use (M = 4.50, SD = 0.53) with low standard deviation indicating strong consensus among respondents. Consequently, the system demonstrated high learnability, with participants agreeing that most people would learn it quickly (M = 4.40, SD = 0.52). Therefore, Low scores on reverse-coded items such as "unnecessarily complex" (M = 1.80) and "cumbersome to use" (M = 1.50) further confirm ease of use. Despite participants having limited technical backgrounds, they reported feeling confident using the system (M = 4.30), addressing the cognitive ergonomics objective of reducing mental workload in decision-making tasks. The consistently low standard deviations (all below 0.80) demonstrate strong consensus among micro-retail store owners regarding StockMatePH' usability, validating that the interface design successfully accommodated users with varying technological literacy levels.

4.3. *Decision* Support Quality. This subsection measures the perceived accuracy and usefulness of system recommendations using a 5-point Likert scale. Weighted Mean and Standard Deviation were calculated to determine central tendency and consensus among respondents.

Table 3.3

Recommendation Accuracy and Usefulness (Decision Support Quality)

Statement	Weighted Mean	SD	Interpretation
The ABC classification reflects my actual product importance	4.3	0.67	Strongly Agree
The budget allocation suggestions are realistic for my store	4.2	0.79	Agree
The sales forecast helps me anticipate customer demand	4.1	0.74	Agree
The replenishment recommendations match my inventory needs	4.4	0.52	Strongly Agree
Using StockMatePH improves my restocking decisions	4.5	0.53	Strongly Agree
I trust the system's recommendations for my business	4.2	0.63	Agree
The system helps me identify which products need priority	4.45	0.51	Strongly Agree
Overall Decision Support Quality	**4.31**	**0.63**	**Strongly Agree**

Scale: 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree

Interpretation Range: 4.21-5.00 = Strongly Agree; 3.41-4.20 = Agree

The respondent's perceived recommendations with the StockMatePH's resulted with an overall weighted mean of 4.31 (SD = 0.63) falling within the "Strongly Agree" range. Hence, the highest-rated dimension was improvement in restocking decisions (M = 4.50, SD = 0.53), indicating the system effectively supports its primary objective of enhancing purchase decision-making. Users strongly agreed that the system helps identify priority products (M = 4.45) and that replenishment recommendations match inventory needs (M = 4.40), demonstrating

alignment between system outputs and actual operational requirements. The ABC classification feature received strong validation (M = 4.30), confirming that the Pareto-based categorization accurately reflects user- perceived product importance. Consequently, Budget allocation suggestions were rated as realistic (M = 4.20), indicating practical applicability of the Greedy Algorithm optimization. All standard deviations remained below 0.80, demonstrating strong consensus across participants. These results validate that StockMatePH successfully delivers decision support quality that users perceive as both technically accurate and operationally useful, fulfilling the dual requirements of functional correctness and contextual appropriateness.

5. *Perceived Operational Impacts of the System.* This section presents user-reported impacts of StockMatePH on daily operational efficiency after a week of system usage. Nonetheless, data were analyzed through Weighted Mean and Standard Deviation for Likert scale responses to quantify perceived improvements across three operational dimensions. The analysis was focused on statements that reflect the sari-sari store owner's decision making in their daily inventory operations.

Table 4

Perceived Impact of StockmatePH mobile-based Decision Support System

Statement	Weighted Mean	SD	Interpretation
I can decide what to restock faster than before	4.4	0.7	Strongly Agree
I spend less time thinking about which products to prioritize	4.3	0.82	Strongly Agree
The system reduces my stress when planning purchases	4.2	0.79	Agree
I feel more confident in my restocking decisions	4.15	0.75	Agree
I no longer rely solely on guesswork for inventory planning	4.1	0.88	Agree
Overall Decision-Making Efficiency	**4.23**	**0.79**	**Strongly Agree**

Scale: 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree

Table 4 presents the users response in decision-making efficiency (M = 4.23, SD = 0.79), with indicators spanning both "Agree" and "Strongly Agree" interpretation ranges. The highest impact was observed in speed of restocking decisions (M = 4.40), demonstrating that StockMatePH successfully reduces the time burden of replenishment planning. Nonetheless, Participants strongly agreed that they spend less time thinking about product prioritization (M = 4.30), indicating that the system is ABC classification and priority alerts effectively streamline the decision process. While users agreed that they feel more confident in their decisions

(M = 4.15) and reduced reliance on guesswork (M = 4.10), the moderate ratings and higher standard deviations (0.75-0.88) suggest that confidence-building and trust in data-driven recommendations continue to develop with extended system use. Nevertheless, some store owners indicated they still supplement system recommendations with their experiential knowledge and intuition, representing a healthy hybrid approach rather than complete automation dependence. Also, the system also reduced stress during purchase planning (M = 4.20), though variability in stress reduction (SD = 0.79) reflects individual differences in how users experience decision- making pressure. These findings align with the cognitive ergonomics framework, demonstrating that StockMatePH reduces cognitive load and improves decision efficiency while acknowledging that complete transition from intuition-based to data-driven decision-making represents a gradual behavioral change. The overall positive trend validates the system is effectiveness in supporting micro-retail decision-making, with user confidence and data reliance expected to strengthen as familiarity with the system increases over time.

Chapter V

SUMMARY, FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

This chapter presents the summary of findings, conclusions, and recommendations derived from the study on the development and evaluation of StockMatePH, a decision support system for micro-retail store owners.

Summary of Findings

1. The study reveals that micro-retail store owners predominantly rely on informal, manual recording practices, with majority using mental accounting and using handwritten notebooks for inventory and sales documentation. Hence, few store owners employ systematic digital recording methods, resulting in incomplete and hard-to-analyze historical data that limits their ability to conduct informed demand forecasting and inventory analysis. This pattern of manual and partially memory-dependent recordkeeping creates vulnerability to information loss and contributes to inconsistent decision-making patterns across restocking cycles

2. The foremost operational challenge encountered by micro-retail store owners, is capital shortage, which constrains their ability to maintain optimal inventory levels and respond to demand fluctuations. Moreover, Additional significant challenges include difficulty tracking credit transactions, commingling of business and household funds, inability to anticipate stockouts before they occur, and lack of systematic methods for prioritizing

which products to restock given limited capital. Hence, these interconnected challenges create a cycle where inadequate capital allocation leads to lost sales opportunities, further exacerbating financial constraints and limiting business growth potential.

3. StockMatePH was developed as a mobile-based decision support system that integrates data management, model-based analytics, and user interface components to transform informal micro-retail operations into systematic, data-driven processes. The system was implemented as a Progressive Web Application, a strategic design that prioritizes accessibility and offline functionality over native mobile app development. This technology approach eliminates installation barriers by enabling access through any web browser without requiring app store downloads, ensures automatic updates without user intervention, and maintains full offline capability through local data storage, addressing the infrastructure constraints and limited technical sophistication common in micro-retail environments. Furthermore, The system incorporates six core decision support features: Transaction Data Collection for systematic sales and inventory recording, ABC Classification implementing Pareto analysis to identify high-priority products, Priority Restocking employing greedy optimization algorithms for capital allocation, Credit Management for systematic utang tracking, adaptive demand forecasting using weighted moving averages, and Personal Withdrawal Tracking to separate business and household funds. These features

collectively address the identified operational challenges through integrated computational support rather than isolated tools.

4. StockMatePH demonstrated high effectiveness across three evaluation dimensions based on ISO 25010 quality standards. Technical performance validation through software testing confirmed that all core decision support functions achieved one hundred percent functional correctness, with the system successfully executing ABC classification, budget allocation optimization, demand forecasting calculations, and offline data persistence without errors. User experience evaluation using the System Usability Scale yielded an overall score of 82.5, classified as excellent usability, with participants strongly agreeing that the system is easy to use despite limited technical backgrounds. Moreover, Decision support quality assessment revealed that users perceived system recommendations as accurate and useful, with an overall weighted mean of 4.31 indicating strong agreement that the system improves restocking decisions, correctly identifies priority products, and provides realistic budget allocation suggestions that match inventory needs.

5. Users reported positive operational impacts across three dimensions after system implementation. Decision-making efficiency improved based on the perceived impact analysis, with users strongly agreeing that they can decide on restocking faster than before and spend less time determining product priorities, though confidence-building and complete transition from intuition-

based to data-driven decisions continue to develop with extended use. Additionally, Capital allocation efficiency showed strong improvement, with users agreeing that the system helps maximize purchasing power and enables more effective budget distribution, though adaptation to fully trusting algorithmic recommendations over experiential judgment remains gradual across participants. Financial record accuracy demonstrated the highest perceived impact, with users strongly agreeing that they now maintain better inventory tracking and clearer sales records, though complete transition from memory-based to exclusively system-based recordkeeping represents an ongoing behavioral shift.

Conclusions

Using the preceding summary of findings as bases, the following conclusions are drawn:

1. The predominance of informal, manual recording practices among micro-retail store owners, including both mental accounting and handwritten notebooks, creates systematic vulnerabilities in operational decision-making that can be effectively addressed through accessible digital recordkeeping tools. The successful testing of StockMatePH's transaction recording features demonstrates that micro-retailers are willing to transition from manual tracking to more systematic documentation when provided with user-friendly interfaces designed for their operational context and

technical literacy levels.Capital shortage, credit tracking difficulties, fund commingling, stockout anticipation problems, and prioritization challenges form a systemic pattern where deficiencies in one area compound difficulties in others. StockMatePH's comprehensive approach addressing multiple challenges simultaneously through interconnected features proves more effective than addressing individual problems in isolation, validating the decision support system framework that integrates data management, analytical processing, and user interface components.

2. Industrial Engineering methods, particularly ABC Classification based on Pareto analysis and constraint-based optimization using greedy algorithms, can be successfully adapted and simplified for micro-retail contexts when implemented through intuitive digital interfaces. The high user agreement with system-generated product classifications and budget allocations demonstrates that Operations Research techniques provide practical value for small-scale informal enterprises, not merely large corporations, when appropriately translated into accessible decision support tools that complement rather than replace human judgment.

3. System effectiveness in resource-constrained environments depends equally on technical correctness and usability design, with offline functionality serving as a critical requirement rather than optional enhancement. The convergence of perfect functional accuracy in testing and excellent usability scores in practice confirms that successful decision

support systems for micro-enterprises must prioritize both computational reliability and cognitive ergonomics, ensuring that technically sound algorithms remain accessible to users with limited formal education and inconsistent technology infrastructure.

4. Behavioral changes in operational practices occurs gradually rather than instantaneously following technology adoption, with users maintaining hybrid approaches that combine system recommendations with experiential knowledge and existing manual methods during transition periods. The moderate ratings for confidence-building and complete reliance on data-driven recommendations, despite strong ratings for concrete outcomes like time savings and improved tracking, indicate that sustained adoption requires extended habituation periods where users progressively build trust in algorithmic decision support while shifting from predominantly mental and notebook-based recordkeeping to more consistent use of system-generated data.

Recommendations

Based on the conclusions, the following recommendations are hereby endorsed:

1. Future research should conduct extended longitudinal studies evaluating StockMatePH effectiveness over six to twelve months rather than the four-week pilot period, as longer observation periods would capture seasonal demand variations, reveal sustained behavioral change patterns beyond

initial novelty effects, and assess whether forecast accuracy improves as the system accumulates more comprehensive historical data. Additionally, comparative studies should evaluate StockMatePH against alternative decision support approaches such as simplified spreadsheet- based tools or structured paper-based recording systems to quantify the specific value added by mobile progressive web application architecture versus the benefits derived from any form of systematic recordkeeping regardless of technology used.

2. The current StockMatePH implementation exhibits limitations that future development should address to enhance system capabilities and commercial viability. While the Progressive Web Application architecture successfully delivers cross-platform accessibility and offline functionality, future versions could explore hybrid mobile app development to enable deeper device integration such as camera-based barcode scanning, native push notifications for priority alerts, and biometric authentication for enhanced security, though such enhancements must carefully balance added functionality against increased installation complexity and storage requirements that may deter adoption among target users. The demand forecasting accuracy was constrained by the limited historical data available during the pilot period, suggesting that future versions should incorporate seasonal adjustment factors, promotional event tracking, and external demand indicators beyond historical sales patterns alone. The personal

withdrawal tracking feature, while conceptually addressing fund commingling, requires enhanced user experience design to reduce data entry friction and encourage consistent logging of household consumption. Additionally, the system provides recommendations but lacks integration with supplier ordering platforms or mobile payment systems, requiring users to manually communicate purchase decisions and conduct financial transactions outside the system rather than enabling end-to-end restocking workflow automation from decision through order fulfillment and payment processing.

3. For future studies, it is recommended that the design, architecture, and evaluation instruments of StockMatePH be used as a reference or starting point for developing improved decision support systems for micro-retailers, such as integrating more advanced forecasting methods, expanding to multi-store contexts, or incorporating supplier and logistics management features. This capstone may serve as a reference for extending StockMatePH or designing similar decision support tools, for example by testing alternative optimization approaches, covering additional microbusiness types, or conducting longer-term impact evaluations in different locations.

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APPENDIX A

Survey Questionnaire and Observation Checklist

Sari-Sari Store Baseline Challenges Survey

This short survey asks about common challenges you experience in managing your sari-sari store inventory. Your answers will help the researchers design and improve the StockMatePH system. Participation is voluntary and confidential. This form will take about 1 minute to answer.

Do you agree to participate in this survey?

○ I agree to participate.

○ I do not agree.

Which of the following inventory and capital challenges do you experience? (Select all that apply.)

☐ Capital shortage for restocking

☐ Difficulty tracking customer credit/utang

☐ Mixing personal and store money

☐ Not knowing when items will run out (stockouts)

☐ Difficulty deciding which products to prioritize when budget is limited

☐ Difficulty deciding whether to add new products requested by customers

☐ Other:

For each challenge below, how often does it happen in your store?

	Never	Rarely	Sometimes	Often	Very often
Capital shortage for restocking	○	○	○	○	○
Difficulty tracking customer credit/utang	○	○	○	○	○
Mixing personal and store money	○	○	○	○	○
Not knowing when items will run out (stockouts)	○	○	○	○	○
Difficulty deciding which products to prioritize when budget is limited	○	○	○	○	○
Difficulty deciding whether to add new products	○	○	○	○	○

StockMatePH User Feedback Form

Seeking your feedback on the StockMatePH system using the following scales and questions.

For the following statements, please use this scale: 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree.

Please rate your agreement with the following statements regarding the quality of StockMatePH's decision support.

	1	2	3	4	5
The system's recommendations match my store's priority needs.	○	○	○	○	○
The recommended quantities are realistic for my available budget.	○	○	○	○	○
The system helps me see which products should be prioritized.	○	○	○	○	○
Overall, StockMatePH improves the quality of my restocking decisions.	○	○	○	○	○

A. Decision-Making Efficiency

	1	2	3	4	5
I can decide what to restock faster than before using StockMatePH.	○	○	○	○	○
I feel more confident when planning what to buy.	○	○	○	○	○
I rely less on pure guesswork when making restocking decisions.	○	○	○	○	○

B. Capital Allocation Efficiency

	1	2	3	4	5
I waste less money on slow-moving items now.	○	○	○	○	○
I can spread my limited budget more effectively across needed products.	○	○	○	○	○
I make fewer poor purchasing decisions compared to before.	○	○	○	○	○

C. Financial Record Accuracy

	1	2	3	4	5
My inventory records are more complete and accurate now.	○	○	○	○	○
My sales records are more complete and accurate now.	○	○	○	○	○
My credit/utang records are more complete and accurate now.	○	○	○	○	○

Please rate your agreement with the following standard usability statements (1=Strongly Disagree, 5=Strongly Agree).

	1	2	3	4	5
I think that I would like to use this system frequently.	○	○	○	○	○
I found the system unnecessarily complex.	○	○	○	○	○
I thought the system was easy to use.	○	○	○	○	○
I think that I would need the support of a technical person to be able to use this system.	○	○	○	○	○
I found the system unnecessarily complex.	○	○	○	○	○
I thought the system was easy to use.	○	○	○	○	○
I think that I would need the support of a technical person to be able to use this system.	○	○	○	○	○
I found the various functions in this system were well integrated.	○	○	○	○	○
I thought there was too much inconsistency in this system.	○	○	○	○	○
I would imagine that most people would learn to use this system very quickly.	○	○	○	○	○
I found the system very cumbersome to use.	○	○	○	○	○
I felt very confident using the system.	○	○	○	○	○
I needed to learn a lot of things before I could get going with this system.	○	○	○	○	○

Section 6 — Open Comments

Your answer _____

Quick Observation Checklist

Recording tool observed
- ☐ No record visible (appears mental only)
- ☐ Notebook (handwritten list or ledger)
- ☐ Mobile phone notes / app (any digital tool seen)
- ☐ Other: _____

Stockout Event Observation

Did any customer ask for an item that was not available during this visit?
- ☐ No such event observed
- ☐ Yes, at least one stockout situation was observed

APPENDIX B

StockMatePH Mobile Application

Mark Angelo A. Taniegra

Position: Facilities Officer

Contact: +63.927.439.0467 | Mark.Taniegra@Outlook.com
Location: Infanta, Quezon, Philippines

Education
- Bachelor of Science in Industrial Engineering (ETEEAP) – University of Batangas
- Diploma in two-year Industrial Technician Course – MFI Technological Institute

Core Competencies
- Facilities Management and Administration
- Safety and Compliance (Safety Officer 3, BOSH and LCM Certified)
- Project Management (Fit-out/Renovations)
- Multi-functional Team & Stakeholder Management
- Process Improvement
- Supplies/Consumables & Inventory Management
- Financial Management and Budget Forecasting (CAPEX/OPEX)
- Technical Expertise: HVAC, UPS, Electrical and Power Systems, Fire Protection Controls

Professional Experience
- **TaskUs** (Jun 2020 – Sep 2023): Facilities Officer
- **Sykes Asia, Inc.** (May 2014 – Feb 2020): Facilities & Admin Assistant
- **MIESCOR Logistics Inc.** (2011 – 2014): HVAC Technician

Key Expertise: Over 10 years of comprehensive facilities management and project leadership in fast-paced tech-enabled BPO environments, with proven expertise in major renovation projects (up to 3.6k sqm), UPS systems management, regulatory compliance, safety leadership, and cost-efficient operations management.