



Development of TrackPOS-IN: A Digital Solution for Managing Operations of Small Stalls and Mobile Food Businesses

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RESEARCH ARTICLE INFORMATION	ABSTRACT
Received: March 6, 2026 Reviewed: May 15, 2026 Accepted: June 18, 2026 Published: June 30, 2026	Micro food enterprises often operate in places with intermittent or unreliable internet access, and some combine a fixed stall with mobile selling units. In these settings, sales and inventory are commonly recorded through handwritten logs and informal messaging, which can lead to fragmented records, delayed reconciliation, and weak traceability. Aligned with Sustainable Development Goals 8 and 9, this study developed TrackPOS-IN (Tracking and Point-of-Sale with Inventory), an integrated web-and-mobile platform for stall-plus-mobile operations. Using a design-and-development approach with iterative prototyping, the system was built and piloted with Kuya Siomai in Isabela, Philippines. The prototype includes an Android POS with local data storage and synchronization when connectivity returns, centralized inventory with adjustment logging and low-stock alerts, consolidated dashboards, GPS monitoring for mobile sellers, and embedded CCTV viewing for restricted monitoring. Feasibility was examined through functional testing and task-based user acceptance with the owner, co-owner, stall seller, and mobile seller, using ISO/IEC 25010 quality dimensions. Results showed reliable offline transaction capture, support for more timely reconciliation in the pilot setting, and high user acceptance. TrackPOS-IN presents an offline-resilient operational design for microenterprise settings and points to future work on stronger privacy-by-design controls, cashless payment support, and multi-site evaluation. In this single-enterprise pilot test, all seven representative functional test cases passed,

and the task-based user acceptance result reached a grand mean of 4.68. The highest-rated areas were security, performance efficiency, usability, privacy, and portability ($M = 4.75$).

Keywords: *point-of-sale, offline-first system, inventory management, GPS monitoring, micro food enterprise*

Introduction

Micro food enterprises are important to local economies because they create income, provide affordable meals, and support community trade. In the Philippines, many of these businesses use a hybrid setup with a fixed stall and mobile selling units. This setup helps owners reach more customers, but it also spreads sales, inventory, and accountability across different people and locations (Department of Trade and Industry, 2022; Menes et al., 2019; Baltazar et al., 2025). As a result, coordination becomes difficult when operations are managed manually.

In the Kuya Siomai setting, the difficulty was not only the internet signal. The owner also needed to check if the products being sold were the approved items, if the money reported by the seller matched the actual selling activity, and if the mobile seller was staying too long in one place where few sales were made. These situations affected sales control, inventory trust, and the owner's decision on where the seller should be assigned next.

In many small food businesses, daily transactions are still recorded in notebooks, tally sheets, or chat messages. These methods are familiar and low-cost, but they often lead to scattered records, delayed reconciliation, and weak stock traceability. The problem becomes worse when internet access is unstable because cloud-only tools may not be available when sellers need to record a sale. This can force staff to return to handwritten notes and increase the risk of incomplete or inconsistent records (Mia et al., 2024; Burka et al., 2023; Android Developers, 2025). Tanaman et al. (2023) also described a small business with branches and a mobile store where manual inventory and sales records caused data inaccuracy and slow report preparation. This is close to the problem observed in Kuya Siomai, where stock movement, sales records, and mobile selling activities still need manual checking.

Previous studies show that point-of-sale and inventory systems can improve transaction accuracy, reporting, and operational visibility in small businesses (Mangmang, 2018; Canlas, 2019; Sison et al., 2019). However, many commercial systems assume stable internet access, integrated digital payments, or marketplace-based order processing. These assumptions do not always fit cash-based ambulant selling, especially when one business must combine stall and mobile operations in a single view. GPS tracking can improve visibility over moving assets (Andutan & Ucat, 2022), but it is often separate from transaction and inventory records. CCTV can also support security and anomaly review, but its use brings privacy obligations under Republic Act No. 10173 and NPC CCTV guidance (National Privacy Commission, 2024).

For this reason, the GPS, CCTV, and inventory modules were included as support tools for the owner's present operation, not as general surveillance features. GPS gives location context for mobile selling, CCTV helps the owner review the stall area when a sales or stock concern has to be checked, and the inventory logs show when products are added, deducted, or adjusted. These records make it easier to review daily activity instead of depending only on verbal reports. Moreno et al. (2025) also showed that the

problems faced by micro and small enterprises can affect how owners accept and use POS systems. In the case of Kuya Siomai, this means that the system had to follow the actual work of the business, including cash selling, mobile selling, inventory checking, and owner monitoring.

In response, this study developed TrackPOS-IN (Tracking and Point-of-Sale with Inventory), an integrated digital platform for stall-and-mobile operations. Unlike many commercial systems that assume stable connectivity or fixed-location selling, the platform was designed for cash-based and distributed microenterprise workflows. It combines seller-side transaction capture, centralized inventory control, consolidated reporting, GPS monitoring, and embedded CCTV viewing for stall security in one web-and-mobile environment. The study also aligns with Sustainable Development Goal (SDG) 8 by supporting efficiency, accountability, and resilience in microenterprise work, and with SDG 9 by presenting an offline-resilient digital solution for small-business infrastructure constraints.

The paper contributes a system design that combines five needs in one workflow: offline-first mobile POS, stall-plus-mobile inventory control, GPS-linked field monitoring, role-restricted CCTV viewing, and pilot-level evaluation using selected ISO/IEC 25010 quality dimensions. This combination is important because the owner needs sales records, stock movement, seller location, and security review to be checked together, rather than through separate tools.

The study aimed to design, develop, and assess TrackPOS-IN as a digital solution for small stalls and mobile food businesses. Specifically, it sought to: (1) identify problems in manual sales and inventory recording; (2) implement an Android-based offline-first POS that syncs when connectivity returns; (3) centralize inventory control, adjustment logging, and reporting; (4) integrate GPS monitoring for mobile sellers and CCTV viewing for stall security; and (5) evaluate the feasibility and user acceptability of the prototype using selected ISO/IEC 25010 quality dimensions.

Methods

Research Design

This study used a design-and-development approach with iterative prototyping. This method suited the study because the main output was a working digital platform that needed refinement based on actual business workflows, not only on written requirements. Iterative prototyping allowed the study to move from problem analysis to successive working versions, with each cycle used to clarify requirements, improve usability, and correct workflow issues before the next revision.

Early testing showed that the seller workflow still needed support when the device had no stable connection to the server. This led to the use of local SQLite storage, a sync queue, and unique offline identifiers. Later revisions focused on the owner dashboard, stock adjustment logs, GPS display, CCTV permission rules, and report views after the owner and sellers tried the actual selling tasks.

Locale and Participants

The pilot implementation was conducted with Kuya Siomai, a micro food enterprise in Alicia, Isabela, Philippines. This setting was appropriate because the business combined stall-based selling with mobile vending and still relied largely on manual recording. Four key participants took part in the prototype evaluation: the owner, the co-owner, the stall seller, and the mobile seller. Their involvement allowed the study to cover both owner-side and seller-side workflows.

The four (4) participants were selected through purposive sampling because they were the people directly involved in owner-side and seller-side operations during the pilot. The selection criteria were direct use of the system, responsibility for sales or monitoring, familiarity with the previous manual process, and willingness to join the task-based evaluation. This made the group suitable for pilot feasibility testing, but it does not represent all small food businesses.

Table 1. Evaluation Participants

Role	Participation in Evaluation	Contribution to the Study
Owner	Requirements validation, report review, and pilot feedback	Confirmed operational relevance and decision-support needs
Co-Owner	Dashboard, inventory, GPS, CCTV, and reporting tasks	Validated owner-side workflows and monitoring controls
Stall Seller	POS, stock count, and reconciliation tasks	Tested seller-side usability in the fixed-stall context
Mobile Seller	Offline POS, synchronization, and GPS tasks	Validated field use under intermittent connectivity

Research Instruments and Prototype

The main research instrument was the TrackPOS-IN prototype, which consisted of a seller mobile application and an owner-facing web dashboard. The mobile app was built with Expo and React Native and used SQLite for local data storage, while the web dashboard used React (Vite) for centralized monitoring and reporting. The backend API was developed with Node.js and Express, PostgreSQL 15, and Prisma ORM. Supporting technologies included Leaflet and React-Leaflet with OpenStreetMap for map display, Cloudflare Tunnel for secure remote access, and MediaMTX with HLS playback for embedded CCTV viewing (Cloudflare, n.d.; Bluenviron, n.d.). The study also used interview guides, observation notes, issue logs, functional test checklists, and a task-based user acceptance questionnaire. The questionnaire was developed by the researcher and was based on the current ISO/IEC 25010 product quality model, with items matched to the implemented modules and pilot scenarios. Selected product-quality characteristics, namely functional suitability, security, reliability, performance efficiency, usability, maintainability, and portability, were translated into task-based statements. Privacy safeguards required by the deployment context were also included (International Organization for Standardization, 2023; Mission, 2020; National Privacy Commission, 2024; Republic Act No. 10173, 2012).

Software Development Model and Technical Architecture

The system followed an iterative prototyping model. Requirements from the owner were translated into small working builds, and each build was checked against practical tasks such as product setup, selling, syncing, stock review, GPS checking, and CCTV viewing. On the technical side, React and Vite served the owner dashboard, while Node.js and Express provided the API used by both the web dashboard and the React Native mobile app. PostgreSQL stored the central records, Prisma handled database access, and SQLite kept temporary local records on the seller's device when internet service was not available.

For CCTV viewing, the camera stream was routed through MediaMTX and displayed in the owner's dashboard through HLS playback. The dashboard did not make the camera feed public. Seller accounts were blocked from the CCTV module, while owner access was controlled through login, role restriction, and event logging. During remote testing, Cloudflare Tunnel provided a controlled route to the backend service; when HTTPS access was enabled, data transmission was protected by TLS. These controls were added because the system handled location and camera information that should only be viewed for legitimate business review.

Data Collection Procedure

Data collection started with interviews and direct observation of daily operations to identify problems in sales recording, inventory monitoring, supervision, and reporting. The findings were translated into functional requirements and used to build early prototypes. After each iteration, the updated build was reviewed against actual workflows and revised using issue logs and user feedback. The completed prototype then underwent representative functional tests covering authentication, online and offline sales capture, synchronization, GPS visibility, inventory handling, and CCTV access control. Task-based user acceptance testing was then conducted with the four participants using work scenarios and the ISO/IEC 25010-based questionnaire. The evaluation focused on pilot feasibility and acceptability within the target enterprise. It was not designed to establish effectiveness across other business settings.

The task walkthrough covered the main procedures expected from the system: login, product selection, cash checkout, offline sale saving, synchronization after reconnection, stock count review, inventory adjustment review, low-stock checking, report access, GPS viewing, route review, and CCTV permission testing. The pilot was exploratory and limited to one enterprise, so the task results were used to judge feasibility and acceptability rather than to make broad claims for all micro food businesses.

Data Analysis

The analysis used both descriptive and interpretive methods. Functional testing results were summarized using a pass-or-fail criterion based on whether the observed behavior matched the expected workflow outcome. Role-based task completion during the pilot was summarized as task success rate, calculated by dividing the total number of completed task instances by the total number of attempted task instances across all participants, then multiplying by 100. User acceptance responses were collected using a five-point Likert scale (1 = strongly disagree to 5 = strongly agree) and summarized through mean scores and standard deviations for the main evaluation areas. Qualitative observations from pilot use, review sessions, and issue logs were synthesized to explain how the system supported reconciliation, visibility, and operational accountability. The evaluation framework was based on product-quality characteristics of ISO/IEC 25010:2023, especially functional suitability, security, reliability, performance efficiency, usability, maintainability, and portability, while privacy was assessed through context-specific items aligned with Philippine data-privacy requirements (International Organization for Standardization, 2023; National Privacy Commission, 2024; Republic Act No. 10173, 2012).

The study did not treat the comparison between manual work and system use as a formal before-and-after timing experiment because the pilot period was short and involved only one business. Instead, the analysis reported functional pass-or-fail

outcomes, user-acceptance scores, observed workflow changes, and issues noted during testing. This limitation was considered when interpreting the results.

Ethical Considerations

The study involved low-risk operational participants, and ethical safeguards were applied throughout the pilot. Participation in interviews, observations, and task-based evaluation was voluntary, and participants were informed about the purpose of the study and the reporting of results in an aggregated form. Personal identifiers were excluded from the findings, and the monitoring features were treated as restricted operational tools, not public-facing content. Informed consent was obtained from the owner, co-owner, stall seller, and mobile seller. Access to live GPS and CCTV feeds was limited to authorized owner accounts, and any retained logs or recordings were kept only as needed for pilot testing, operational review, and anomaly checking during the evaluation period. Access to the GPS and CCTV modules was controlled through role-based access, and the study followed the policy, data-privacy principles, and security requirements stated in Republic Act No. 10173, particularly Sections 2, 11, and 20, together with NPC Circular No. 2024-02 on CCTV systems.

Before testing the monitoring modules, the participants were informed that GPS and CCTV were included for operational security, route verification, and anomaly review. CCTV was used for restricted viewing of the stall area and was not treated as public research material. GPS logs and system activity logs were retained only for pilot checking and operational review, and access was limited to authorized owner accounts. Password-protected accounts, role-based permissions, restricted routes, and audit/event logs were used to limit access to sensitive system functions.

Results and Discussion

Problems Identified in the Manual Workflow

The first objective was addressed through interviews and observation of Kuya Siomai operations. The manual setup made it difficult for the owner to check sales and inventory on time because records were kept through notebooks, messages, and verbal updates. The owner also described a previous concern in which unauthorized products could be added to the mobile selling activity, with the proceeds not reflected in the official sales record. Another concern was that the mobile seller could remain in one place even when the area produced few sales. These issues showed why the system needed POS records, stock logs, GPS context, and restricted camera review in one workflow.

Implemented Architecture and Core Functions

TrackPOS-IN was implemented as a client-server platform that linked seller-side data capture with centralized owner oversight. Figure 1 shows the deployed architecture. The seller's mobile application records transactions and GPS activity in the field, the backend API handles synchronization and business rules, and the web dashboard consolidates reporting, inventory, GPS, and CCTV functions. The design aimed to maintain operations even when the seller device temporarily lost internet connectivity.

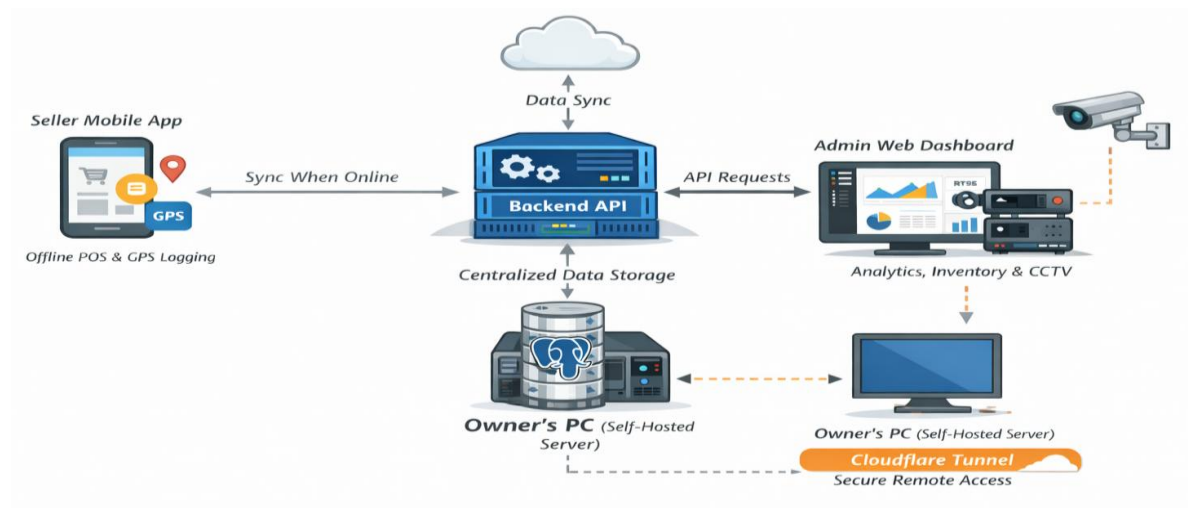


Figure 1. System Architecture of TrackPOS-IN

At the technical level, the platform combines offline-first transaction capture, centralized inventory storage, and role-restricted monitoring within a single environment. This directly addresses the fragmented records that often arise when stall and mobile operations are documented separately. Unlike standalone POS or tracking tools, the system makes transaction history, inventory adjustments, GPS context, and CCTV access available through one console for authorized owners.

Table 2. Core Functions Implemented in TrackPOS-IN

Module	Key Capability	Operational Contribution
Seller Mobile POS	Cash sale capture with local persistence and queued synchronization	Maintains transaction recording during connectivity interruptions
Centralized Inventory	Stock balances, adjustment logging, low-stock alerts, and reconciliation support	Supports visibility of movement, shortages, and end-of-day review
Web Dashboard and Reports	Consolidated summaries, activity metrics, and downloadable reports	Supports management review and faster reporting
GPS Monitoring	Last-seen status, route history, and location context for mobile sellers	Supports field visibility and route verification
Embedded CCTV Viewing	Role-restricted viewing of the stall camera feed within the dashboard	Supports stall security monitoring and anomaly review

Offline-First Transaction Continuity and Centralized Oversight

The most important design requirement was continuity during connectivity interruptions. As shown in Figure 2, the mobile application saves pending sales and GPS records to a local SQLite store and sync queue before uploading them to the backend when connectivity returns. Duplicate prevention is enforced through unique offline identifiers, which allow repeated uploads to be deduplicated on the server. This

design follows current offline-first guidance that treats the local store as the primary source of truth during intermittent connectivity (Android Developers, 2025).

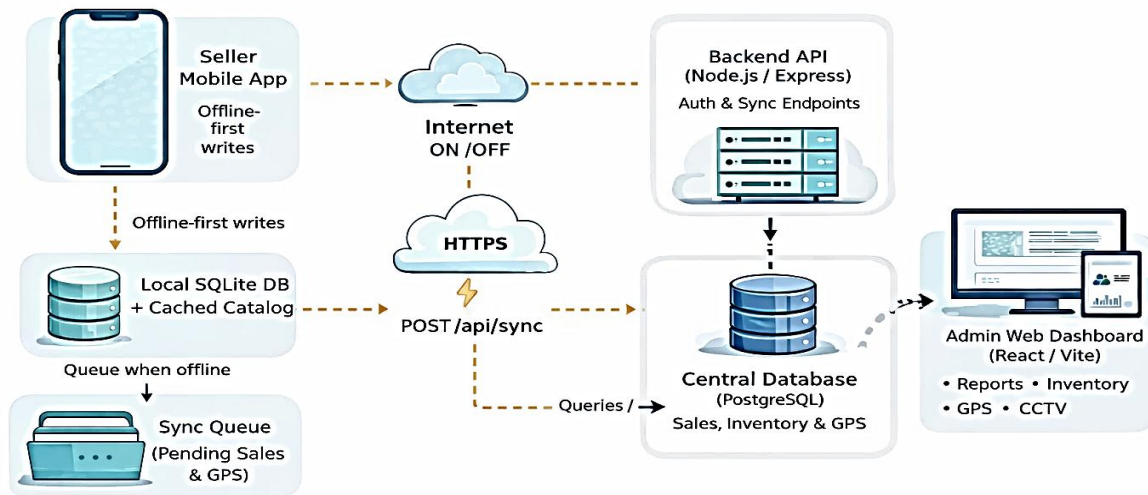


Figure 2. High-level Offline-First Synchronization Flow

In the pilot setting, this architecture allowed sales recording to continue even when signal quality varied along mobile routes. Once the seller device was reconnected, queued records were synchronized to the central database and became available in the dashboard. In practical terms, the design reduced the need to re-encode transactions from notebooks and supported more timely reconciliation across stall and mobile operations during the pilot. This pattern is consistent with earlier studies that link digital transaction systems to improved operational control and reporting (Mangmang, 2018; Sison et al., 2019).

Prototype Evaluation and User Acceptance

Representative functional testing showed that the prototype successfully carried out the core workflows expected from the design. As shown in Table 3, all selected tests passed, including online sale recording, offline persistence after restart, deduplicated synchronization after reconnection, GPS visibility, and role-based restriction of the CCTV module. Taken together, these findings show that the platform was feasible in the pilot setting for the intended use case. All seven (7) representative functional test cases included in the pilot test passed.

Table 3. Representative Functional Test Results

Test Case	Scenario	Expected Result	Result
TC-01	Log in as admin	Admin modules are accessible	Passed
TC-02	Record sale online	Sale saved; totals and deduction are correct	Passed
TC-03	Record sale offline	Stored locally; persists after restart	Passed
TC-04	Sync after reconnect	Queued records sync once; no duplicates	Passed
TC-05	View GPS map	Last-seen and route history are shown	Passed
TC-06	Seller attempts CCTV	403 Access Denied	Passed
TC-07	Admin opens CCTV	Stream loads; event logged	Passed

During testing, the main issues observed were operational rather than critical system failures. The seller needed to understand when a sale was still queued and when it had already synced. GPS accuracy also depended on the mobile device signal, and CCTV viewing depended on the camera gateway and HLS service being online. These points were noted as deployment concerns because they affect how the owner interprets the dashboard during daily use.

User acceptance results supported the pilot-level functional findings. During field evaluation, participants completed role-based tasks involving login, checkout, stock counting, reconciliation, GPS review, report access, and controlled monitoring. Observations from the pilot indicated that participants were generally able to complete the assigned tasks as intended. Mean scores in Table 4 also showed generally favorable views across functional suitability, usability, performance efficiency, reliability, security, maintainability, and portability, indicating that users found the prototype acceptable for the pilot context.

Table 4. Summary of User Acceptance Results

Evaluation Area	Mean	SD	Interpretation
Functional Suitability	4.63	0.49	Agree to Strongly Agree
Security	4.75	0.46	Strongly Agree
Reliability	4.50	0.58	Agree
Performance Efficiency	4.75	0.46	Strongly Agree
Usability	4.75	0.46	Strongly Agree
Maintainability	4.50	0.58	Agree
Privacy	4.75	0.46	Strongly Agree
Portability	4.75	0.46	Strongly Agree
Grand mean	4.68	—	Very High Acceptance

The participants found the checkout screen, product selection, sales totals, dashboard summaries, and low-stock indicators easy to follow because these matched the way the business already worked. The more difficult parts were the initial understanding of offline syncing, GPS route review, and CCTV access restrictions. These were addressed through clearer labels, role-based menus, and owner-side reminders that monitoring features were for verification and security review only.

Operational Visibility, Privacy, and Practical Implications

Figures 3, 4, 5, and 6 present selected interfaces and the actual prototype setup of the system. The owner-facing web dashboard brought together revenue, activity summaries, and operational modules in one web interface. The seller's mobile POS supported item selection and cash checkout on the field device. GPS monitoring displayed the last known location and route history, while the CCTV module embedded viewing controls within the same web environment. Combining these components is important because microenterprise owners often need a single view of operations rather than separate tools for sales, inventory, and monitoring.

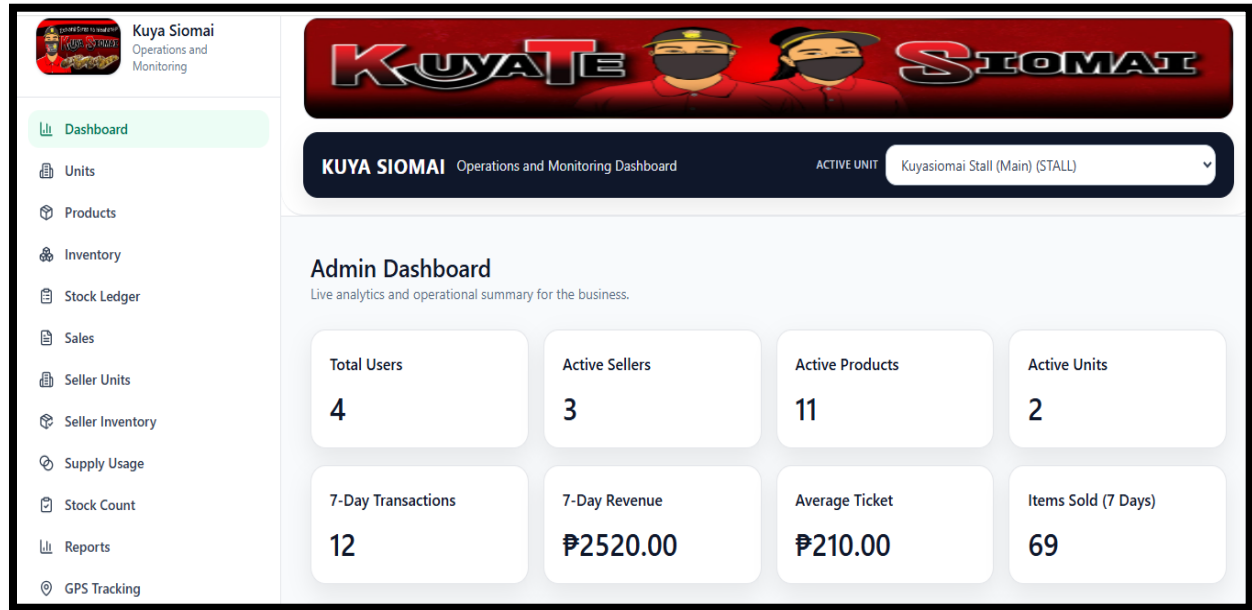


Figure 3. Web Dashboard

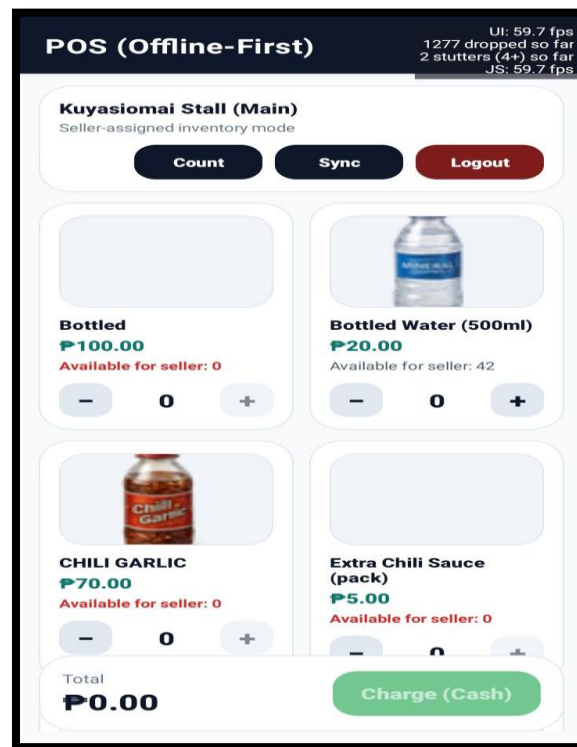


Figure 4. Seller Mobile POS

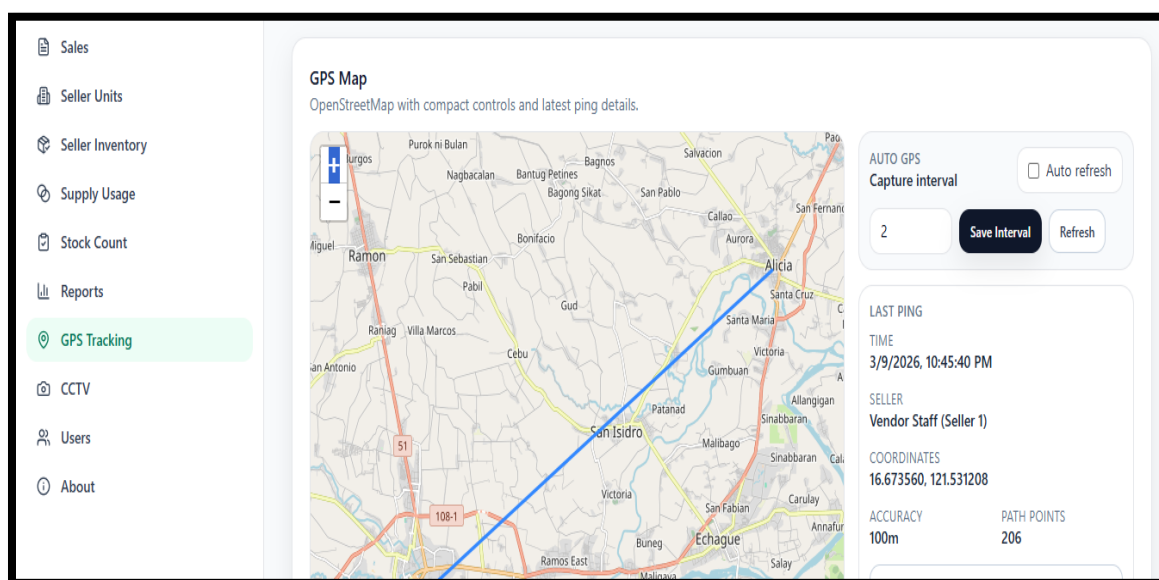


Figure 5. GPS Monitoring

Figure 6 shows the actual prototype used during pilot operation. The setup combined the owner-facing web dashboard, seller mobile application, and camera hardware in one self-hosted environment. This arrangement illustrates how transaction monitoring, GPS visibility, and operational oversight were integrated during field use.

In the business case, the monitoring modules answered specific owner concerns. GPS helped check whether the mobile seller was moving through productive areas or remaining too long in one low-sales area. CCTV supported review of the stall area when there were questions about stock movement, unauthorized selling, or activity that could not be explained by the POS record alone. Inventory logs then connected these observations with product counts and sales reports.

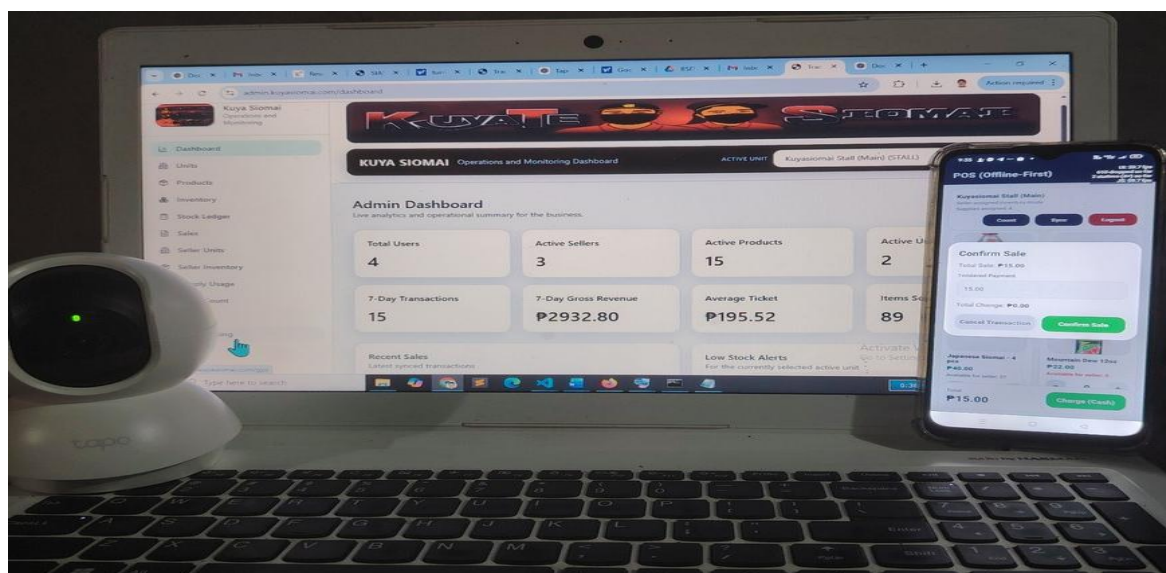


Figure 6. Actual Prototype of TrackPOS-IN: Web Dashboard, Camera, and Mobile POS

The integration of monitoring features required a balanced view of operational value and privacy obligations. In the prototype, GPS and CCTV were restricted owner functions and were not available to public users. Access was limited to authorized owner accounts, and monitoring was framed around operational security, route verification, and anomaly review. This approach is consistent with Philippine privacy guidance, which emphasizes transparency, legitimate purpose, proportionality, and security for monitoring systems (National Privacy Commission, 2024; Republic Act No. 10173, 2012).

From a practical standpoint, the prototype suggests that integrated digital operations can be introduced at relatively low cost in microenterprise settings. Because the design relied on owner and seller devices that were already available, the system could be deployed without specialized enterprise hardware. Project cost estimates suggested that a functional setup could be achieved through a modest one-time investment, with recurring expenses mainly limited to mobile data and electricity. This point matters for small Philippine businesses that want digital tools but operate with limited resources (DTI, 2022; Mia et al., 2024).

The findings support the broader view that small-business digitalization is not only about automating one task but about linking operational data in ways that improve decision-making and accountability (DTI, 2022; Mia et al., 2024). In TrackPOS-IN, this linkage was achieved by combining transaction records, inventory adjustments, GPS context, and CCTV access within one owner-side workflow. The system, therefore, extends earlier POS and inventory studies by emphasizing offline resilience and operational integration for a stall-plus-mobile business model (Mangmang, 2018; Canlas, 2019).

Compared with the POS adoption work of Moreno et al. (2025) and the inventory system of Tanaman et al. (2023), TrackPOS-IN also focuses on sales and stock control. Its added value is that it brings these functions into a stall-and-mobile setup with offline selling, GPS monitoring, and restricted CCTV viewing. The findings may also be connected to related local studies on digital records, tracking, and process monitoring. Conlu and Tarun (2025) discussed how manual reporting can leave records fragmented and difficult to track, which is similar to the paper-based and message-based records observed in Kuya Siomai. Ignacio et al. (2025) showed the value of GPS-based real-time tracking for moving operations, while Bacalso et al. (2024) emphasized process monitoring and visibility in a management system. TrackPOS-IN relates to these studies by applying tracking, monitoring, and digital records to a small food business with both stall and mobile selling.

The results also show that the value of an offline-first design is not only technical. In settings with intermittent connectivity, the ability to continue selling without service interruption affects customer service, record completeness, and the credibility of end-of-day reconciliation. In the same way, GPS and CCTV were not included simply as surveillance tools; their value lies in giving context to transactions and exceptions so that the owner's review is based on evidence and clear records. Within the limits of a small pilot, the study therefore supports the view that integrated systems can help microenterprises improve accountability and operational visibility while still requiring careful privacy safeguards.

Conclusions and Future Works

This study developed and evaluated TrackPOS-IN as an integrated digital platform for managing small stalls and mobile food businesses. The prototype combined

offline-first seller-side transaction capture, centralized inventory control, consolidated dashboard reporting, GPS monitoring, and embedded CCTV viewing for stall security in one web-and-mobile environment. Functional testing showed feasibility in the pilot setting, and task-based user acceptance indicated high pilot-level acceptability.

TrackPOS-IN presents how a small food business with both a stall and mobile selling can bring sales, inventory, location, and monitoring records into one workflow. For the pilot enterprise, the platform addressed daily problems that were difficult to manage through notebooks, messages, and verbal updates alone. Its value is seen not only in the POS function but also in the way the system links transaction records with inventory movement, seller location, and restricted security review.

The study adds to current work on small-business digitalization by showing that offline resilience and consolidated oversight can be designed together for a stall-plus-mobile operating model. The findings suggest that integrated transaction, inventory, GPS, and monitoring data can support reconciliation, traceability, and owner visibility without requiring enterprise-scale infrastructure. These implications also align with SDG 8, which highlights decent work and economic resilience, and SDG 9, which emphasizes innovation that fits local infrastructure conditions.

Future work may include multi-site evaluation, longer deployment under routine operating conditions, stronger privacy-by-design safeguards for monitoring data, and added features such as cashless payments, barcode-based stock handling, an accounting module, and more advanced analytics. These steps would help validate the platform beyond the initial pilot and extend its usefulness to a wider range of microenterprise settings. Moreover, the main limitation is that TrackPOS-IN was tested in only one microenterprise with four direct users. The findings should therefore be read as pilot evidence, not as proof that the same results will occur in all small food businesses. For wider use, the system would need a simple deployment package, owner and seller orientation, a written privacy notice, a camera-placement guide, a backup-and-recovery procedure, and technical support for internet, device, and CCTV gateway setup. The offline-first design may also be adapted for other small retail stalls, mobile vendors, and similar businesses that need local selling records, location context, and controlled monitoring.

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Conflict of Interest

The author declares no conflict of interest related to the publication of this paper.

Artificial Intelligence (AI) Declaration Statement

ChatGPT was used only to assist with language refinement, wording options, and document organization. It was not used to fabricate data, generate results, or replace the author's analysis and implementation work. All AI-assisted suggestions were reviewed, edited, and verified by the author before inclusion in the manuscript.