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Web-Based Household Waste Management Information System at Rumah Pilah Sawitri

William David Ravelino [1*], **Mesra Betty Yel** [2], **Veri Arinal** [3]

[1*,2,3] Department of Informatics Engineering, Faculty of Computer Technology, Sekolah Tinggi Ilmu Komputer Cipta Karya Informatika, East Jakarta City, Special Capital Region of Jakarta, Indonesia.

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***Corresponding Author:**
Williamdavid1291@gmail.com

Abstract: Household inorganic waste management at the community-based unit Rumah Pilah Sawitri currently relies on conventional paper-based ledgers for daily transactions. This manual mechanism presents four major operational constraints: lengthy transaction handling times reaching 10 minutes per member, vulnerability to mathematical calculation errors (*human error*), risks of physical record deterioration or loss, and recurring delays in preparing monthly financial and operational reports. To resolve these issues, this study designs and implements a web-based household waste management information system. The software engineering methodology adopts the System Development Life Cycle (SDLC) Waterfall approach, encompassing requirements analysis, system architecture and database design using Unified Modeling Language (UML) and Entity Relationship Diagrams, program implementation using PHP and MySQL, and system verification. Functional validity was evaluated through black-box testing, while usability and acceptance were measured via User Acceptance Testing (UAT) using a 5-point Likert scale across administrators and members. Empirical implementation results confirm that the system reduces average transaction duration by 80%, decreasing from 10 minutes to 2 minutes per member by automating weight-to-price balance conversions. Furthermore, the web platform eliminates calculation discrepancies, enables instant administrative report compilation, and provides members with real-time balance tracking dashboards. UAT evaluation yielded high acceptance scores ranging from 4.7 to 4.9 across ease of use, interface clarity, and functional relevance, validating the system as viable for full operational deployment.

Keywords: Information System; Waste Management; Web-Based; SDLC Waterfall; Black-Box Testing; User Acceptance Testing.

1. Introduction

Rapid population growth and accelerated regional urban development across Indonesia have substantially increased the volume of municipal solid waste generated daily. In practice, unmanaged domestic waste accumulation poses severe ecological and social threats, including extensive terrestrial pollution, recurrent drainage obstructions causing urban flash floods, offensive odor emissions, and the proliferation of disease vectors that undermine public health (Saputri *et al.*, 2023; Yulianto & Febrianto, 2025; Zuliani & Nunsina, 2022). For decades, municipal waste management across most Indonesian administrative regions has adhered to a linear "collect-transport-dispose" framework, directing raw domestic refuse straight to final disposal sites (*Tempat Pembuangan Akhir* / TPA). However, this conventional approach is no longer viable because existing waste treatment infrastructures cannot keep pace with exponential daily generation rates. Land availability constraints and critical capacity overruns across major landfills provide indisputable evidence of the limitations inherent in this centralized paradigm. In response to this ecological crisis, the Government of Indonesia established Law Number 18 of 2008 on Waste Management, legally mandating a comprehensive paradigm transition centered on substantial volume reduction and decentralized waste segregation directly at the source, particularly at the household level (Arthalia Wulandari & Widodo, 2022; Yulianto & Febrianto, 2025). Implementing this regulatory mandate requires community-based initiatives, such as waste banks and sorting facilities, designed to foster civic participation and circular resource management. Through this decentralized model, residents segregate recyclable inorganic fractions—such as plastics, paper, glassware, and metals—which are subsequently deposited, weighed, and converted into monetary savings. Within this institutional landscape, Rumah Pilah Sawitri functions as an essential grassroots unit coordinating the systematic sorting, collection, and economic valorization of community inorganic waste, thereby generating tangible financial incentives for participants while strengthening local environmental stewardship (Kaki *et al.*, 2024; Yulianto & Febrianto, 2025; Zuliani & Nunsina, 2022).

Despite its socio-economic potential, daily administrative operations at Rumah Pilah Sawitri remain constrained by conventional paper-based record-keeping using manual ledgers and unstructured spreadsheets. As transaction frequencies and active memberships rise, this manual workflow exhibits severe operational bottlenecks. Physical ledger entries result in prolonged transaction handling times reaching up to 10 minutes per participant, high vulnerability to numerical calculation discrepancies (*human error*), permanent risks of ledger loss or physical deterioration, and significant impediments to compiling timely monthly performance summaries for administrative audits (Arthalia Wulandari & Widodo, 2022; Yulianto & Febrianto, 2025; Zuliani & Nunsina, 2022). To resolve these operational bottlenecks, adopting dedicated web-based information technology has become imperative. Centralized web applications integrate member databases, material inventories, and transactional ledgers into a secure, transparent repository. Prior empirical studies indicate that digitizing community waste management workflows significantly accelerates field transactions, eliminates arithmetic discrepancies, automates dynamic pricing conversions, and streamlines periodic reporting mechanisms (Atin *et al.*, 2022; Lestari & Nada, 2025; Muryani *et al.*, 2025; Saputri *et al.*, 2023). Furthermore, providing real-time savings dashboards enhances administrative accountability and fosters sustained community trust. Addressing the operational bottlenecks and technological opportunities identified above, this study designs and implements a web-based household waste management information system tailored to the administrative workflow of Rumah Pilah Sawitri, delivering an automated pricing engine and transparent transaction records to support sustainable waste governance.

2. Related Work

Research on information technology applications for municipal and domestic waste governance has expanded substantially in recent years. To position this study within the existing literature, previous investigations can be grouped into three major technological and operational domains: macro-level institutional reporting systems, alternative software development paradigms, and functional process automation. In the first domain, several studies have focused on macro-level, centralized monitoring frameworks designed for municipal authorities. For example, Kaki *et al.* (2024), Febrianto and Yulianto (2025), and Arthalia Wulandari and Widodo (2022) developed web platforms to aggregate district-wide waste records and streamline data transfers to municipal environmental agencies (*Dinas Lingkungan Hidup*). Similarly, Widaningsih and Suheri (2019) engineered a centralized administrative platform across regional collection units. While these studies address administrative coordination between community units and governmental oversight bodies, they do not resolve micro-level transaction delays and manual bookkeeping burdens that occur at physical weighing points. This study specifically targets field-level operational efficiency within an autonomous community facility, Rumah Pilah Sawitri. In the second domain, existing literature demonstrates diverse software development approaches. While Siswanto *et al.* (2023) utilized User-Centered Design (UCD) and Susilawati *et*

al. (2022) as well as Maharani and Kurniawan (2023) implemented prototyping methodologies, other works by Lestari and Nada (2025) and Silvia and Nada (2025) applied the traditional Waterfall model to stabilize functional scope. In keeping with this structured discipline, the present study adopts the linear SDLC Waterfall methodology, which provides sequential predictability for transitioning physical ledgers into secure database tables without scope deviations. In the third domain, functional emphasis varies across specialized features. Prior platforms have prioritized route dispatching for waste pick-up services (Kusrini *et al*., 2019), simple member balance records (Atin *et al*., 2022; Mahendra *et al*., 2023; Muryani *et al*., 2025; Rosadi, 2025; Suleman *et al*., 2022; Zuliani & Nunsina, 2022), or basic data synchronization (Al Amin *et al*., 2023; Dava Nabila *et al*., 2023; Saputri *et al*., 2023). However, many of these systems do not integrate automated mathematical calculation engines directly linked to fluctuating commodity rates during in-person weigh-ins. Furthermore, operations must align with national administrative standards stipulated in the Regulation of the Minister of Environment and Forestry Number 14 of 2021 (Kementerian Lingkungan Hidup dan Kehutanan, 2021). The systematic comparison between these prior studies and the system developed for Rumah Pilah Sawitri is summarized in Table 1.

Table 1. Comparative Summary of Related Studies

No.	Author(s) and year	Research focus	Relation to this study
1	Kaki *et al*. (2024)	Developed an integrated web-based waste bank system for the Ende Regency Environmental Agency to overcome manual records.	Focused on macro-level governmental oversight, whereas this study addresses daily operational workflows in a community unit.
2	Zuliani & Nunsina (2022)	Constructed a web-based Waste Bank Information System (SIBS) for the Bireuen community.	Shared the use of a web repository; this study incorporates an integrated automated calculation engine to eliminate arithmetic human error.
3	Siswanto *et al*. (2023)	Designed the Guyub Rukun Waste Bank system using the User-Centered Design (UCD) method.	Prior work applied UCD; this research utilizes the SDLC Waterfall model to guarantee sequential verification and service acceleration.
4	Mahendra *et al*. (2023)	Developed a web-based waste bank management application for the STMIK Kuwera campus environment.	Implemented for academic campus personnel, whereas this study is customized for residential household waste sorting and administration.
5	Susilawati *et al*. (2022)	Built a web-based waste bank system using a prototyping approach in Padasuka Village.	Shared the focus on report optimization; this study implements a personalized, secure member dashboard for transaction and balance transparency.
6	Muryani *et al*. (2025)	Implemented a web-based transaction application to digitize the Gestari Waste Bank.	Both streamline real-time recording; this study retains an offline balance withdrawal process to avoid premature third-party payment gateway dependencies.
7	Rosadi (2025)	Developed a website to optimize workflow management at Ddorocare Waste Bank in Central Lombok.	Provided reference for digital recording; this study explicitly targets physical transaction time reduction from 10 to 2 minutes per member.
8	Silvia & Nada (2025)	Implemented a web-based system focused on balance withdrawal transactions using the Waterfall method.	Both apply the Waterfall model; this research encompasses the end-to-end weight-to-currency balance conversion process.
9	Kusrini *et al*. (2019)	Built the "Di Asmara" web system to facilitate waste pick-up scheduling services.	Prior work prioritized transport dispatching, whereas this study optimizes on-site weighing and counter transaction recording.
10	Atin *et al*. (2022)	Designed a web-based system to digitize administrative functions and member reporting.	Both replace physical books with database storage; this research customizes transactional workflows specifically for Rumah Pilah Sawitri.

11	Lestari & Nada (2025)	Developed a web system via the Waterfall model focusing on waste deposit transactions.	Shared architectural approach; this study introduces an integrated member dashboard alongside automated reporting for managers.
12	Saputri *et al.* (2023)	Engineered the "e-Resik" platform in Kentong Village for member and financial synchronization.	Both resolve administrative errors; this study introduces an automated calculation engine responsive to fluctuating commodity unit prices.
13	Febrianto & Yulianto (2025)	Developed a regency-level waste information platform in Bantul using Modified Waterfall.	Focused on multi-unit municipal aggregation, whereas this study addresses granular operational transactions at a single community facility.
14	Arthalia Wulandari & Widodo (2022)	Built a web reporting system for the Metro City Environmental Agency.	Geared toward administrative reporting to government agencies, whereas this study reduces clerical burdens at field collection sites.
15	Kementerian Lingkungan Hidup dan Kehutanan (2021)	Established regulatory guidelines under Permen LHK No. 14 of 2021 for standardized waste bank operations.	Serves as the legal and operational baseline; this research implements digital tools to enforce standard operating compliance.
16	Maharani & Kurniawan (2023)	Developed an Adiwiyata school waste management system using a prototyping model.	Targeted academic environmental programs, whereas this study addresses community household management via the SDLC Waterfall model.
17	Widaningsih & Suheri (2019)	Engineered a centralized web-based waste bank system in Cianjur Regency.	Addressed inter-district data loss; this study focuses on local operational efficiency while providing transparent digital balance access to members.
18	Suleman *et al.* (2022)	Developed a web-based management system for the Sampurna Berkah Waste Bank.	Both overcome manual reporting; this study emphasizes rapid field transaction speeds using an integrated valuation engine.
19	Al Amin *et al.* (2023)	Engineered the "E-Trash" web platform to digitize waste bank services.	Provided digital community interfaces; this study structures transparent, role-based dashboards for administrators and members.
20	Dava Nabila *et al.* (2023)	Designed a web-based waste bank system for Bank Sampah Mandiri in Lakarsantri.	Addressed physical archive deterioration; this study adds empirical time-efficiency validation and calculation engine automation.

Based on the comparative synthesis presented in Table 1, existing literature predominantly bifurcates into macro-level monitoring platforms managed by municipal agencies and localized campus or administrative prototypes. While these systems demonstrate the feasibility of digital records, several critical research gaps remain unaddressed. First, most regency-level systems (such as those by Arthalia Wulandari & Widodo, 2022; Febrianto & Yulianto, 2025; Kaki *et al.*, 2024) prioritize inter-agency data flow but overlook field-level transaction delays experienced by grassroots operators during physical weigh-ins. Second, existing localized applications (such as Atin *et al.*, 2022; Siswanto *et al.*, 2023; Susilawati *et al.*, 2022) frequently separate transaction logs from instant, dynamic arithmetic calculation engines, thereby leaving operators susceptible to computational discrepancies when commodity prices fluctuate. Finally, several recent works incorporate complex architectures or theoretical frameworks that do not account for the digital readiness of community operators, resulting in underutilized features or fragile deployment pipelines. This research addresses these empirical and technical gaps by engineering an operational web platform tailored specifically to the procedural realities of Rumah Pilah Sawitri. Rather than simply digitizing static ledger entries, the system bridges the gap between field-level counter operations and backend financial reporting. By coupling a deterministic pricing engine with strict role-based access control, the proposed platform guarantees arithmetic consistency, streamlines counter servicing times to a targeted two-minute threshold, and complies with national operational standards set forth in Permen LHK No. 14 of 2021. Furthermore, the linear predictability of the SDLC Waterfall

approach ensures that each functional requirement identified in this comparative review is methodically analyzed, modeled, implemented, and empirically verified against user operational criteria.

3. Methodology

3.1 Software Development Life Cycle

This study implements the System Development Life Cycle (SDLC) using the classic Waterfall model. The Waterfall methodology was selected due to its sequential and structured workflow, which enforces rigorous completion and verification of each technical milestone prior to subsequent implementation. The research methodology encompasses five core phases:

1) Requirements Analysis: Systematically identifying operational bottlenecks in physical ledger record-keeping and formulating functional specifications (including user authentication, automated calculation engines, and report compilation) as well as non-functional requirements (security protocols and deployment infrastructure).
2) System Design: Translating operational specifications into technical architectural blueprints using Unified Modeling Language (UML) notations (specifically Use Case diagrams), Entity Relationship Diagrams (ERD) for relational data persistence, and ergonomic User Interface/User Experience (UI/UX) prototypes.
3) Implementation (Coding): Translating architectural blueprints into executable source code using native PHP, HTML5, CSS (Bootstrap framework), and JavaScript, backed by a relational MySQL database management system.
4) Testing: Conducting structured functionality verification via Black Box Testing to validate input-output mappings, boundary conditions, and the calculation engine without examining internal logic routines, complemented by field-based User Acceptance Testing (UAT).
5) Maintenance: Administering post-deployment system stability, including relational schema integrity audits, scheduled database backups, and hosting server optimization.

3.2 Requirements Analysis and Project Timeline

Based on operational observations at Rumah Pilah Sawitri, a centralized, responsive web platform was conceptualized. The system leverages native PHP and a MySQL database to ensure deterministic transaction processing, secure role separation, and real-time ledger synchronization. The phased development schedule executed under the Waterfall framework is summarized in Table 2.

Table 2. System Development Lifecycle Timeline

No.	Project parameters	Analysis	Design	Implementation	Testing	Maintenance
1	Field observation and data collection	✓				
2	Analysis of existing operational workflows	✓				
3	System architecture and relational modeling (UML & ERD)		✓			
4	User interface and experience prototyping (UI/UX)		✓			
5	Frontend interface coding			✓		
6	Relational MySQL database schema implementation			✓		
7	Automated pricing and balance calculation engine integration			✓		
8	Functional Black Box testing				✓	
9	Field deployment and production hosting configuration				✓	
10	Administrative user training and system maintenance					✓

3.3 System Design

The structural architecture of the web-based household waste management platform encompasses role-based functional specifications, relational database modeling, and physical hosting infrastructure.

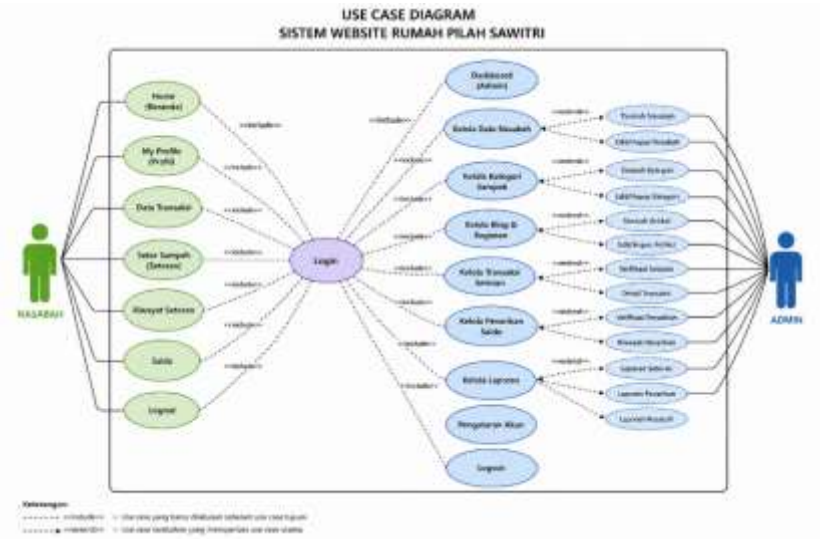

Figure 1. Use Case Diagram of the Proposed Waste Management System

As illustrated in Figure 1, the platform enforces strict role-based access control. All registered members (*nasabah*) must authenticate using verified credentials to access system features. Once logged in, members can navigate the landing page, update personal profile credentials, inspect historical deposit logs, monitor real-time financial balances, submit waste deposit intents, and terminate sessions securely. Conversely, administrators manage back-office operations through a dedicated administrative dashboard. Administrator privileges include full member record lifecycle management (CRUD), material category and pricing configuration, informational article publishing, counter deposit verification, balance cash-out administration, automated periodic audit report generation, and global system parameter configuration.

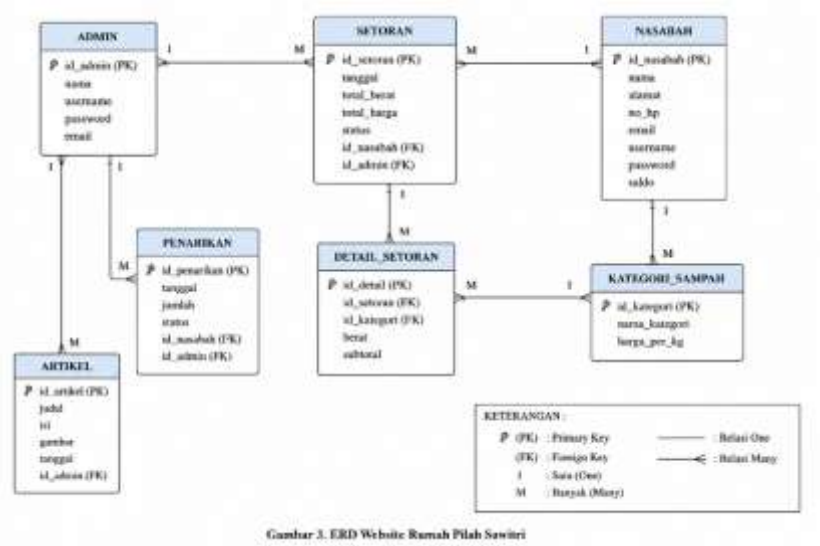

Figure 2. Entity Relationship Diagram (ERD) of Relational Schema

The logical database structure depicted in Figure 2 establishes normalized relational data entities. Referential integrity is maintained through foreign key constraints binding member identifiers across transactional ledgers and withdrawal records. Waste category lookup entities provide dynamic unit prices per kilogram (IDR/kgIDR/kg), allowing the core calculation engine to compute monetary valuations deterministically during counter transactions.

Figure 3.System Architecture of the Web-Based Waste Management Platform

Figure 3 outlines the three-tier web deployment architecture. End users interact with the system via standard mobile and desktop web browsers. Client requests are transmitted over secure Hypertext Transfer Protocol Secure (HTTPS) connections, encrypted via TLS certificates, to mitigate data interception risks. The hosting server at Rumahweb parses requests through an Apache web server daemon, routing transaction parameters to the PHP backend processing engine. Business logic routines execute identity verification, balance updates, dynamic valuation calculations, and administrative reporting queries against the normalized MySQL relational schema. Outbound transaction alerts and system analytics can be piped outward to third-party integrations, including the WhatsApp Messaging API and Google Analytics, ensuring an auditable and secure processing pipeline.

3.4 Hardware and Software Environment Specifications

System development, testing, and deployment environments were standardized across specific hardware baselines and software libraries, as summarized in Table 3.

Table 3. Hardware and Software Specifications

No.	Architectural component	Technology and technical specifications
1	Operating system	Microsoft Windows 10 / Windows 11 (64-bit)
2	Development IDE	Visual Studio Code v1.85+
3	Production web server	Apache Web Server (Cloud Hosting by Rumahweb)
4	Database engine	MySQL Relational Database Server
5	Web client browsers	Google Chrome, Mozilla Firefox, Safari
6	External API integrations	WhatsApp Business API Gateway, Google Analytics API
7	Presentation framework	HTML5, CSS3, Twitter Bootstrap v5.x, JavaScript
8	Development workstations	Intel Core i3 / Core i5 processor, 8 GB DDR4 RAM
9	Client test endpoints	Android Mobile Devices, Intel-based Laptop Computers
10	Network connectivity	Local Area Network (Wi-Fi 802.11ac) and 4G/5G Cellular Data

3.5 System Validation and Evaluation Protocol

Validation of the engineered platform was executed through a three-stage empirical protocol encompassing functional verification, field service duration measurement, and user acceptance evaluation:

1) Black Box Functional Testing: Each implemented functional module was audited using Black Box boundary-value analysis and equivalence partitioning without inspecting internal code syntax. Test vectors targeted authentication security, member master record mutations, waste pricing classification changes, deposit entry calculations, balance ledger updates, and dynamic PDF summary generation.
2) Empirical Service Duration Measurement: Field counter servicing duration was recorded empirically by measuring transaction processing times across a cohort of N=10 active members during the collection cycle spanning August 1–10, 2026. A calibrated digital stopwatch captured the precise temporal interval elapsed from the initial physical waste weigh-in to the finalized database ledger commit. These empirical durations were benchmarked against historical baseline transaction logs extracted from manual physical ledgers recorded during the preceding month.

3) User Acceptance Testing (UAT): System usability and user satisfaction were evaluated by administering a standardized User Acceptance Testing survey to administrative officers and member respondents at Rumah Pilah Sawitri. The survey instrument utilized a five-point Likert scale (ranging from 1 = Strongly Disagree to 5 = Strongly Agree), structured across four analytical dimensions: operational ease of use, interface visual ergonomics, functional task alignment, and balance reporting transparency. The survey instrument demonstrated high internal consistency, yielding an overall Cronbach's Alpha reliability coefficient of $\alpha=0.82$, confirming that the evaluation construct satisfies psychometric reliability thresholds ($\alpha>0.70$).

4. Results and Discussion

4.1 Results

Following the architectural designs detailed in the previous section, the web-based household waste management information system for Rumah Pilah Sawitri was successfully deployed and made publicly accessible via the production domain https://www.rumahpilahsawitri.com/. The deployed platform operates simultaneously as a public informational portal and a centralized transactional processing engine. The interface incorporates responsive CSS frameworks, ensuring rendering stability and accessibility across desktop monitors, portable laptops, and mobile browser viewports.

Figure 4. Landing page interface of the Rumah Pilah Sawitri web platform

The landing page shown in Figure 4 serves as the unauthenticated public entry point. Visitors can examine organizational profiles, mission statements, recyclable material classifications, unit pricing schedules, and community environmental activities without credential authentication.

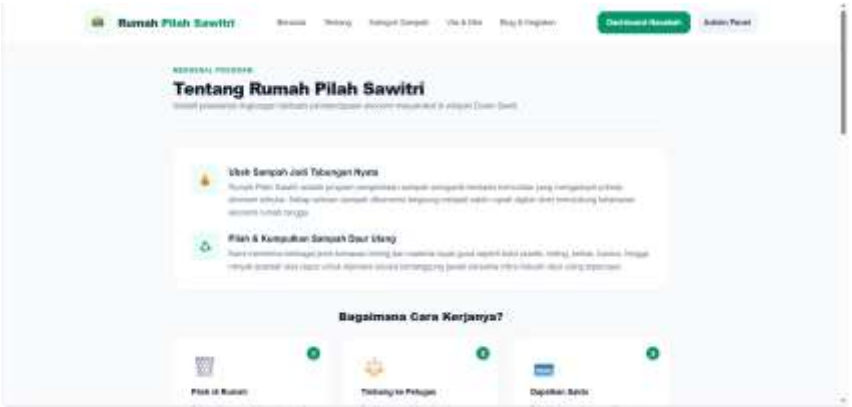

Figure 5.Organizational profile and informational interface ("About Us")

Figure 5 illustrates the public organizational disclosure interface. This module outlines institutional background, operational objectives, and community sorting guidelines, thereby fostering public transparency and civic engagement in municipal waste diversion. Authenticated users (administrators and registered members) bypass these static views by logging into dedicated dashboard environments governed by their assigned authorization privileges. System operational readiness was evaluated through functional Black Box testing, User Acceptance Testing (UAT), and empirical service duration benchmarking.

Black Box testing was conducted across all operational endpoints to verify functional compliance without inspecting internal logic scripts. Eight core transactional scenarios were executed, spanning role authentication, master data maintenance, dynamic pricing rules, weigh-in transaction commits, balance increment integrity, and reporting engines. The evaluation results are compiled in Table 4.

Table 4.Functional Black Box Testing Results

No.	System feature	Test scenario	Expected outcome	Result
1	User authentication	User enters valid username and password credentials.	System grants session access and directs the user to the role-specific dashboard.	Pass
2	Member management	Administrator inputs and submits a new member registration record.	Record is committed to the relational schema and populated in the active member directory.	Pass
3	Material category configuration	Administrator adds or updates recyclable categories and unit prices (IDR/kgIDR/kg).	Category updates persist in the database and immediately refresh rate lookup tables.	Pass
4	Waste deposit recording	Administrator enters member ID, material category, and net weight (kgkg).	Transaction record commits, calculation engine computes value, and member balance increments instantly.	Pass
5	Member balance dashboard	Authenticated member accesses account ledger and transaction logs.	Interface displays historical weigh-in logs and real-time cumulative balance accurately.	Pass
6	Audit report compilation	Administrator triggers periodic transaction report generation.	System queries relational tables and exports structured periodic audit logs.	Pass
7	Session termination	User activates the logout action link.	Application invalidates session tokens and redirects client to the login interface.	Pass

As summarized in Table 4, all seven core functional suites achieved a 100% execution pass rate without encountering computational discrepancies, schema constraint failures, or unauthorized route traversals.
Following technical verification, User Acceptance Testing (UAT) was conducted to evaluate user satisfaction and operational alignment. Standardized Likert-scale questionnaires (ranging from 1 = Strongly Disagree to 5 = Strongly Agree) were completed by organizational managers (N=2) and active member participants (N=10). The itemized mean evaluation scores are presented in Table 5.

Table 5. User Acceptance Testing (UAT) Evaluation Scores

No.	Evaluation statement	Mean score (scale 1.0–5.0)
1	System operational ease and navigation usability	4.80
2	Visual layout clarity and interface ergonomics	4.70
3	Feature alignment with practical waste management requirements	4.90
4	Accessibility and transparency of transaction logs and financial balances	4.80
5	Overall operational efficiency enhancement in administrative workflows	4.90

The aggregate UAT ratings ranged from 4.70 to 4.90 out of a maximum of 5.00, demonstrating high user satisfaction and operational acceptance. Participants highlighted the clarity of visual summaries and the convenience of instant balance verification as substantial improvements over manual bookkeeping. Empirical time benchmarking conducted during the August 1–10, 2026 collection period confirmed dramatic operational speed gains. Physical counter transaction processing times decreased from a pre-implementation baseline of 10.0 minutes per member (recorded in physical ledger books) to an average of 2.0 minutes per member using the web-based calculation engine. This represents an 80.0% reduction in counter queuing duration (Δt=8.0 minutes).

4.2 Discussion

The deployment of the web-based waste management platform at Rumah Pilah Sawitri addresses the structural inefficiencies inherent in conventional ledger-based administration. By centralizing transactional records, member directories, and commodity valuations within a relational database, the system eliminates administrative bottlenecks that previously hindered community participation. The empirical reduction in

counter servicing duration from 10 minutes to 2 minutes per member directly resolves transaction delays, while the integrated pricing engine prevents arithmetic discrepancies (*human error*) caused by fluctuating commodity rates. These operational gains corroborate findings by Rosadi (2025), Lestari and Nada (2025), and Atin *et al*. (2022), who reported that digitizing counter workflows accelerates transaction throughput and reinforces civic trust in community waste initiatives. Furthermore, adopting the SDLC Waterfall methodology provided a structured framework for this engineering initiative; given that the primary project objective was translating established physical bookkeeping practices into stable digital architectures, the linear progression of the Waterfall model ensured that requirements remained well-defined throughout design and deployment. Progressing systematically through requirements analysis, UML/ERD modeling, source coding, and Black Box verification prevented feature creep and minimized software defects prior to deployment, which was instrumental in achieving high functional reliability as evidenced by the 100% pass rate in Black Box test vectors and the 4.82 composite UAT score. Despite these positive operational outcomes, several technical and institutional limitations warrant consideration in future research iterations: first, while member deposit records and balance increments are fully automated, balance withdrawals currently require manual cash handovers by collection officers, suggesting that future iterations could integrate verified Indonesian payment gateways or automated e-wallet disbursements to support cashless operations; second, because the current database schema is optimized for a single operational facility, adapting the platform into a multi-tenant software-as-a-service (SaaS) architecture would enable neighboring community units to utilize shared infrastructure while preserving partitioned data boundaries; and finally, whereas the current system manages marketable inorganic waste streams, subsequent modules could be expanded to track organic compost production batches and municipal hazardous household waste (*Limbah B3*), thereby establishing comprehensive operational compliance with Permen LHK No. 14 of 2021.

5. Conclusion and Recommendations

This study successfully engineered and deployed a web-based household waste management information system for Rumah Pilah Sawitri, resolving administrative bottlenecks caused by conventional physical ledger recording. Developed through the structured System Development Life Cycle (SDLC) Waterfall model, the platform systematically translates field requirements into operational modules, including automated pricing engines, real-time balance ledgers, and centralized reporting interfaces. Empirical evaluation demonstrates that the web-based system reduces physical counter servicing duration from 10 minutes to an average of 2 minutes per member, representing an 80% gain in transaction throughput while eliminating arithmetic discrepancies in commodity balance calculations. Furthermore, functional Black Box testing confirmed a 100% test execution pass rate across all administrative and member features, while User Acceptance Testing yielded an aggregate satisfaction score of 4.82 out of 5.00, demonstrating that the system is functionally robust, ergonomically intuitive, and operationally viable for modernizing community-based circular waste governance. Building upon these findings, future research should expand the technological and operational scope of the platform. Immediate software enhancements could incorporate dedicated native Android mobile applications to improve accessibility for members in low-bandwidth environments. In addition, integrating licensed third-party payment gateways would facilitate direct cashless balance disbursements, eliminating manual cash handovers during withdrawals. From an analytical perspective, implementing an executive business intelligence dashboard equipped with predictive time-series forecasting could assist facility managers in anticipating recyclable waste volume trends, optimizing inventory turnarounds, and supporting data-driven municipal waste management policies.

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