Journal of Social Research

P-ISSN:2827-9832
E-ISSN: 2828-335x
Vol. 5, No. 7, June 2026
http://ijsr.internationaljournallabs.com/index.php/ijsr

Design and Implementation of a Web-Based Waste Management Information System to Improve Operational Efficiency at the Environmental Agency of Minahasa Utara Regency

Rolando Ariesky Gansalangi*, Juan Mark Jevlands Carlos, Zefanya Mandagi, Ottopianus Mellolo, Sintya Paula Junaedy
Politeknik Negeri Manado, Indonesia
Email: rolandogansalangi25@gmail.com*, jelands@gmail.com, zefanyamandagiti@gmail.com

Keywords:
Web-based Information System, Waste Management, Laravel, MySQL, System Usability Scale, Dinas Lingkungan Hidup, Minahasa Utara

ABSTRACT

Waste management in Minahasa Utara Regency faces operational challenges including the lack of an integrated digital information system, manual record-keeping processes, and limited real-time monitoring capabilities for waste collection activities. This study presents the design and implementation of a web-based waste management information system for the Environmental Agency (Dinas Lingkungan Hidup) of Minahasa Utara Regency. The system was developed using the PHP Laravel framework with a MySQL relational database and deployed on a local server within the agency's network infrastructure. Key modules implemented include waste collection scheduling, route management, vehicle and personnel tracking, report generation, and a public-facing waste complaint submission portal. The system was evaluated through functional testing using the black-box method and usability testing using the System Usability Scale (SUS) questionnaire administered to 15 agency staff members. Functional testing results show a 100% pass rate across all 42 test cases. The SUS score of 81.3 out of 100 places the system in the "Excellent" usability category. The implementation demonstrates significant improvements in operational documentation efficiency, reducing daily report preparation time by an estimated 65% compared to the previous manual process. The system provides a scalable and maintainable digital platform for modernizing waste management operations in the regency.

INTRODUCTION

Waste management is one of the most pressing environmental and public health challenges facing local governments in Indonesia (Al Fariz et al., 2024; Kusumanigrum & Pujiyanto, 2023; Wikurendra et al., 2023). Rapid urbanization, population growth, and changing consumption patterns have resulted in increasing volumes of solid waste that must be collected, transported, and processed in a timely and organized manner. For regional government agencies such as the Dinas Lingkungan Hidup (Environmental Agency), managing these operations efficiently requires accurate, up-to-date, and accessible information about waste collection schedules, vehicle deployments, personnel assignments, and complaint handling.

The Dinas Lingkungan Hidup Kabupaten Minahasa Utara currently relies on manual record-keeping processes, including paper-based logbooks, physical attendance records, and spreadsheet files maintained separately by each operational unit. This fragmented approach leads to difficulties in data consolidation, delays in report generation, and limited visibility into real-time operational status (Adepoju et al., 2022; Olayinka, 2021). The absence of a centralized digital system also hinders the agency's ability to respond promptly to public complaints regarding waste collection gaps (Bugge et al., 2019; Lakhouit, 2025; Prata et al., 2025).

Web-based information systems have been widely adopted in Indonesian local government agencies to address similar administrative and operational challenges (Hertati, 2023; Ibrahim et al., 2026; Ramadani et al., 2025; Sihotang et al., 2023, 2025; Suhendra & Santiko, 2022). Prasetyo and Santoso (2021) demonstrated that a web-based waste management system implemented for a district government in East Java reduced administrative processing time by 58% and improved data accuracy. Fauzi and Kuswardani (2020) presented a PHP-based solid waste tracking system with GPS integration for municipal governments, showing improved route compliance rates. Gunawan and Fitriyani (2020) reviewed the application of the Laravel framework in government information systems, citing its MVC architecture and built-in security features as key advantages for rapid and maintainable development. Building upon these findings, this study designs and implements a comprehensive web-based system tailored to the specific operational requirements of the Dinas Lingkungan Hidup Kabupaten Minahasa Utara.

This paper is organized as follows: Section 2 provides theoretical background on waste management information systems, web development frameworks, and usability evaluation methods. Section 3 describes the research methodology. Section 4 describes the system design and requirements analysis. Section 5 covers the implementation details. Section 6 presents and analyzes the testing and evaluation results. Section 7 discusses the findings, and Section 8 concludes the paper with recommendations for future development.

METHOD

Research Approach

This study employs a Research and Development (R&D) approach, in which the primary research output is a working software product whose effectiveness is subsequently evaluated empirically. The objective is not only to design and build a web-based waste management information system for the Dinas Lingkungan Hidup Kabupaten Minahasa Utara, but also to validate that the resulting system meets its functional requirements and is usable by the intended agency staff. System development within this R&D approach follows the Waterfall System Development Life Cycle (SDLC) model. The Waterfall model was selected because the operational requirements of the agency could be defined comprehensively at the outset through interviews and document analysis, the project scope was well bounded, and the development was carried out as a single sequential pass from requirements to deployment without the need for iterative reformulation of requirements. Each phase produces a defined deliverable that becomes the input to the next phase, which provides clear traceability between the agency's stated needs and the implemented and tested system.

Research Stages

The research was conducted in five sequential stages aligned with the Waterfall SDLC model. (1) Requirements analysis: identifying operational problems and functional needs at the agency through interviews and document analysis. (2) System design: translating the requirements into a three-tier architecture, a use case model, and an entity relationship diagram of the database. (3) Implementation (coding): developing the system modules using the Laravel framework and a MySQL database according to the design. (4) Testing: verifying that all functional requirements were correctly implemented using black-box testing. (5) Evaluation and deployment: assessing system usability with end users, observing operational efficiency, and deploying the system on the agency's local server. The detailed design, implementation, and evaluation outcomes produced by these stages are reported in Sections 4, 5, and 6, respectively.

Data Collection Methods

Three data collection techniques were used. First, structured interviews were conducted with five staff members of the Dinas Lingkungan Hidup Kabupaten Minahasa Utara — the Head of Operations, two field supervisors, the administrative officer, and the IT coordinator — to elicit operational workflows, pain points, and functional expectations for the system. Second, document analysis was performed on existing paper-based forms, spreadsheet templates, and operational standard operating procedures (SOPs) to understand the current record-keeping practices and the data items that the system must accommodate. Third, direct observation was used during the evaluation stage to measure and compare the time required to prepare standard operational reports under the previous manual process versus the proposed system. Data obtained from interviews and document analysis became the basis for the functional requirements specification, while the observation data supported the operational efficiency assessment.

System Development Method

The system was developed following the four core phases of the Waterfall SDLC model. In the requirements phase, the functional and non-functional needs gathered from interviews and document analysis were specified and validated with agency stakeholders. In the design phase, the system architecture, use case model, and entity relationship diagram were produced as the blueprint for development. In the implementation phase, the design was realized as program code using the Laravel 10 framework (PHP 8.1) with a MySQL 8.0 relational database, Laravel Eloquent ORM for data access, the Blade templating engine and Bootstrap 5 for the user interface, and role-based access control for authorization. In the testing phase, the completed system was verified against the functional requirement specification. The system was then deployed on an Apache web server running on Ubuntu Server within the agency's internal local area network, in accordance with the agency's existing infrastructure and data sovereignty preferences. The detailed design artifacts and implementation are presented in Section 4 and Section 5.

Testing and Evaluation Methods

The system was evaluated using three complementary methods. (1) Black-box functional testing was used to verify that every functional requirement was correctly implemented. A set of test cases was prepared for each module, each specifying an input action, the expected output, and a pass or fail judgment based on the observed output, without reference to the

internal code structure. (2) Usability evaluation was conducted using the System Usability Scale (SUS), a validated ten-item questionnaire administered to agency staff after a guided session and independent task completion with the system; individual responses were converted to a 0–100 score and interpreted using the established SUS adjective rating benchmarks. (3) Operational efficiency observation was used to estimate the practical benefit of the system by comparing the average time required to prepare a standard daily operational report under the previous manual process against the time required to generate the equivalent report using the new system. The instruments, sample sizes, and detailed results for each of these methods are reported in Section 6.

RESULTS AND DISCUSSION

System Design and Requirements Analysis

Requirements Analysis

Requirements were gathered through structured interviews with five staff members of the Dinas Lingkungan Hidup Kabupaten Minahasa Utara, including the Head of Operations, two field supervisors, the administrative officer, and the IT coordinator. Document analysis was also conducted on existing paper forms, Excel templates, and operational standard operating procedures (SOPs). The requirements elicitation identified the following primary functional needs: (1) digital management of waste collection schedules by zone and route; (2) vehicle and driver assignment tracking; (3) daily waste volume input and reporting; (4) public complaint submission and status tracking; and (5) dashboard-level operational summary for management reporting.

System Architecture

The system is built on a three-tier web application architecture. The presentation tier consists of HTML5/CSS3 web pages rendered by the Laravel Blade engine and styled with the Bootstrap 5 framework, accessed via standard web browsers. The application tier is implemented in PHP 8.1 using the Laravel 10 framework, handling business logic, authentication, authorization, and API responses. The data tier uses MySQL 8.0 as the relational database management system, managed through Laravel's Eloquent ORM and database migrations.

The system is deployed on a local server (Apache 2.4 on Ubuntu Server 22.04 LTS) within the agency's internal network, accessible to all agency staff via the local area network without requiring an internet connection. This architecture was chosen in accordance with the agency's existing network infrastructure and data sovereignty preferences.

Figure 1. Three-tier web application architecture diagram of the waste management information system.

Use Case and Entity Relationship Diagram

The use case model identifies three primary actors: Administrator, Operator (field supervisor), and Public User. The Administrator actor has access to all system modules including user management, master data configuration, and report export. The Operator actor can input daily waste collection data, update route completion status, and manage complaint responses. The Public User actor can submit waste collection complaints through a dedicated public portal without requiring authentication.

The Entity Relationship Diagram (ERD) defines 12 primary entities: User, Role, Zone, Route, Vehicle, Driver, CollectionSchedule, CollectionRecord, WasteVolume, Complaint, ComplaintResponse, and Report. Key relationships include: each CollectionSchedule belongs to one Zone and one Route; each CollectionRecord references one Schedule, one Vehicle, and one Driver; each WasteVolume record is linked to one CollectionRecord.

Figure 2. Entity Relationship Diagram (ERD) of the waste management information system database.

Development Environment and Technology Stack

Table 1. Technology stack and development tools used in system implementation.

Component	Technology / Version
Backend Framework	Laravel 10 (PHP 8.1)
Frontend Framework	Bootstrap 5.3, HTML5, CSS3, JavaScript (jQuery 3.7)
Database	MySQL 8.0
ORM	Laravel Eloquent ORM
Web Server	Apache 2.4 on Ubuntu Server 22.04 LTS
Authentication	Laravel Breeze with session-based auth
Authorization	Spatie Laravel-Permission (role-based)
Report Export	DomPDF (PDF), Laravel Excel (XLSX)
Chart Library	Chart.js 4.4
Development IDE	Visual Studio Code 1.87
Version Control	Git / GitHub

Key Module Implementation

The Collection Schedule module allows administrators to create, edit, and deactivate waste collection schedules by assigning a zone, route, vehicle, and driver to each scheduled collection day. The schedule list view displays weekly schedules in a calendar-style grid with color-coded status indicators (scheduled, in-progress, completed, missed). Laravel's Policy classes enforce that only Administrators can modify schedule configurations, while Operators can update completion status.

The Daily Collection Record module provides Operators with a form to log the outcome of each day's collection activity, including actual start and end times, GPS-verified completion checkpoints (entered manually from field reports), waste volume collected (in kg), and remarks. This data populates the management dashboard and serves as the primary data source for monthly operational reports.

The Public Complaint Portal is a separate, unauthenticated route (/complaint) that renders a simple form where citizens can submit waste collection complaints by selecting their sub-district, entering a description, and optionally uploading a photo. Submitted complaints are assigned a unique tracking code returned to the submitter for status inquiry. Agency

operators can view, triage, and respond to complaints through the internal complaint management module.

The Report module generates monthly operational summaries exportable as PDF or XLSX files. Reports include total waste volume collected per zone, collection success rate per route, complaint resolution rate, and vehicle utilization statistics. Charts generated with Chart.js on the dashboard provide real-time visual summaries of the same metrics.

Figure 3. Screenshot of the system management dashboard showing operational summary charts and recent activity log.

Black-Box Functional Testing

Functional testing was conducted by the researcher across 42 test cases covering all system modules: User Management (6 cases), Zone and Route Management (8 cases), Collection Schedule (8 cases), Daily Collection Record (7 cases), Complaint Portal (6 cases), and Report Generation (7 cases). Each test case specified an input action, expected output, and actual output, with a pass/fail judgment. All 42 test cases returned results matching the expected output, yielding a 100% functional test pass rate.

Table 2. Black-box functional testing summary by module.

Module	Test Cases	Passed	Pass Rate
User Management	6	6	100%
Zone & Route Management	8	8	100%
Collection Schedule	8	8	100%
Daily Collection Record	7	7	100%
Complaint Portal	6	6	100%
Report Generation	7	7	100%
Total	**42**	**42**	**100%**

System Usability Scale (SUS) Evaluation

SUS testing was conducted with 15 participants — agency staff members comprising 4 administrators, 7 operational staff, and 4 field supervisors — who were given a 30-minute guided session with the system followed by independent task completion, and then asked to complete the 10-item SUS questionnaire. Individual SUS scores ranged from 72.5 to 92.5. The mean SUS score was 81.3, placing the system in the "Excellent" usability category according to Bangor et al. (2008) adjective rating scale.

Table 3. System Usability Scale (SUS) evaluation results summary

Parameter	Value
Number of Respondents	15 (agency staff)
Minimum SUS Score	72.5
Maximum SUS Score	92.5

Parameter	Value
Mean SUS Score	81.3
Standard Deviation	5.8
Usability Category	Excellent (> 80.3)
Functional Test Pass Rate	100% (42/42 test cases)
Estimated Report Prep. Time Reduction	~65% compared to manual process

Operational Efficiency Observation

To estimate the improvement in operational documentation efficiency, the researcher timed the process of preparing a standard daily operational report under the previous manual process (referring to the agency's existing SOP and interviewing the administrative officer) and compared it with the time required to generate the equivalent report using the new system. The manual process — involving data collection from field supervisors, entry into Excel, formatting, and printing — required an average of 47 minutes per daily report. The equivalent report generated by the system required an average of 16.5 minutes (primarily for data entry by the operator), representing a reduction of approximately 65%.

The results confirm that the implemented system fulfills its primary design objectives. The 100% functional test pass rate validates that all specified requirements were correctly implemented and that the system behaves as expected under normal operating conditions. The test coverage of 42 cases across six modules provides confidence that all critical user-facing features have been verified, though future regression testing should be automated using tools such as PHPUnit and Laravel Dusk to maintain coverage as the system evolves.

The SUS score of 81.3 is particularly significant given that the agency staff participants have varying levels of digital literacy and no prior experience with similar systems. This score exceeds the "Good" threshold (68) by a wide margin and approaches the "Excellent" benchmark (80.3), suggesting that the Laravel/Bootstrap-based interface design — with its familiar tabular layouts, color-coded status badges, and form validation feedback — was well-suited to this user group. Qualitative comments collected after the SUS session highlighted the complaint portal and schedule calendar view as the most positively received features, while several participants noted a desire for mobile application access for field staff.

The estimated 65% reduction in daily report preparation time aligns with findings from comparable implementations in Indonesian local government contexts (Prasetyo & Santoso, 2021; Sudaryono et al., 2019). This efficiency gain translates directly to reduced administrative burden on agency staff, freeing time for higher-value operational coordination activities. It should be noted that this estimate is based on direct observation and interview data rather than a controlled before-after experiment, and may be subject to learning curve effects as staff become more proficient with the system over time.

A limitation of this study is that the system was evaluated in a controlled deployment environment prior to full production rollout. Long-term performance under sustained multi-user load, network reliability variations in field conditions, and data growth over extended operational periods were not fully addressed. Future work should include a load testing phase using tools such as Apache JMeter to characterize system behavior under concurrent user

access, and a longitudinal evaluation of efficiency metrics after 6–12 months of production use.

CONCLUSION

The study successfully designed and implemented a web-based waste management information system tailored to the operational needs of the Dinas Lingkungan Hidup of Minahasa Utara Regency. Functional testing across 42 test cases confirmed a 100% pass rate, while usability assessment using the System Usability Scale (SUS) yielded a score of 81.3, categorizing the system as "Excellent." The system improved operational efficiency significantly, reducing the average daily report preparation time by approximately 65% compared to the previous manual process. Key features such as digital collection scheduling, vehicle and personnel tracking, and a public complaint portal enhanced both internal workflow management and citizen engagement. Overall, the research demonstrates that integrating modern web-based technologies with user-centered design principles can effectively modernize municipal waste management operations, ensuring better service delivery and data-driven decision-making.

For future research, longitudinal studies should assess the system's performance and usability under sustained multi-user and real-world operational conditions over extended periods. Additionally, exploring mobile application integration for field staff, incorporating real-time IoT-enabled waste sensors, and implementing automated regression testing can further enhance system scalability and reliability. Comparative studies across other regional environmental agencies could validate the generalizability of the findings and identify best practices for the broader adoption of digital waste management systems in Indonesia and similar contexts.

REFERENCE

Adepoju, A. H., Austin-Gabriel, B., Eweje, A., & Collins, A. (2022). Framework for automating multi-team workflows to maximize operational efficiency and minimize redundant data handling. *IRE Journals*, *5*(9), 663–664.

Al Fariz, R. D., Muis, R., Anggraini, N., Rachman, I., & Matsumoto, T. (2024). Good environmental governance roles in sustainable solid waste management in Indonesia: A review. *Journal of Community Based Environmental Engineering and Management*, *8*(1), 45–56.

Bangor, A., Kortum, P. T., & Miller, J. T. (2008). An empirical evaluation of the System Usability Scale. *International Journal of Human-Computer Interaction*, *24*(6), 574–594.

Bugge, M. M., Fevolden, A. M., & Klitkou, A. (2019). Governance for system optimization and system change: The case of urban waste. *Research Policy*, *48*(4), 1076–1090.

Fauzi, M. R., & Kuswardani, D. (2020). Sistem informasi pengelolaan sampah berbasis web dengan integrasi GPS untuk pemerintah kota. *Jurnal Informatika*, *14*(1), 45–54.

Gunawan, I. K., & Fitriyani, N. (2020). Penerapan framework Laravel dalam pengembangan sistem informasi pemerintahan: Studi literatur. *Jurnal Ilmiah Teknologi dan Rekayasa*, *25*(3), 172–183.

Hertati, D. (2023). Evaluation of the Quality of Web-Based Integrated Administration Services (PATEN) in Sidoarjo District, Indonesia. *Lex Localis: Journal of Local Self-Government*, *21*(1).

Ibrahim, A. I., Tabingke, S. J., Ntopu, K., Barael, N. G., Andriani, N., & Utami, A. P. (2026). The Role and Challenges of Website-Based Management Information Systems in Organizations: A Literature Review. *International Journal of Health, Economics, and Social Sciences (IJHESS)*, *8*(1), 312–317.

Kusumanigrum, A. E., & Pujiyanto, R. (2023). Environmental Health-Based Medical Waste Management: Implementation of Local Government Responsibilities in Central Java. *Journal of Law and Sustainable Development*, *11*(11), 143.

Lakhouit, A. (2025). Revolutionizing urban solid waste management with AI and IoT: A review of smart solutions for waste collection, sorting, and recycling. *Results in Engineering*, *25*, 104018.

Laudon, K. C., & Laudon, J. P. (2020). *Management information systems: Managing the digital firm* (16th ed.). Pearson.

Olayinka, O. H. (2021). Big data integration and real-time analytics for enhancing operational efficiency and market responsiveness. *Int J Sci Res Arch*, *4*(1), 280–296.

Prasetyo, A., & Santoso, B. (2021). Rancang bangun sistem informasi pengelolaan sampah berbasis web pada Dinas Kebersihan Kabupaten Jember. *Jurnal Teknologi Informasi dan Ilmu Komputer*, *8*(2), 301–310.

Prata, J., Simões, C. L., & Simoes, R. (2025). Improvements to municipal solid waste collection systems using real-time monitoring. *Sustainability*, *17*(4), 1405.

Ramadani, A., Lestari, A., & Ilman, N. (2025). A digital-based information system to enhance public service delivery in samsat services across two indonesian provinces. *Buletin Poltanesa*, *26*(1), 620327.

Sihotang, D. M., Hidayanto, A. N., & Kurnia, S. (2025). The e-government adoption ecosystem from the perspective of stakeholder theory: A case study on the village information systems in Indonesia. *Information Development*, *41*(4), 1342–1355.

Sihotang, D. M., Purwandari, B., Eitiveni, I., Putri, M. F., & Hidayanto, A. N. (2023). Factors influencing village information systems adoption in Indonesia: A qualitative study. *The Electronic Journal of Information Systems in Developing Countries*, *89*(5), e12271.

Sudaryono, Rachman, A., & Rahardja, G. (2019). Efektivitas implementasi sistem informasi pada Dinas Lingkungan Hidup: Studi kasus di Kabupaten Tangerang. *Jurnal Riset dan Aplikasi Akuntansi Manajemen*, *4*(2), 118–127.

Suhendra, A., & Santiko, A. (2022). Governance through electronic-based information system by Papua Provincial Government. *International Journal of Regional Innovation*, *2*(4), 43–50.

Wikurendra, E. A., Abdeljawad, N. S., & Nagy, I. (2023). A review of municipal waste management with zero waste concept: strategies, potential and challenge in Indonesia. *International Journal of Environmental Science and Development*, *14*(2), 147–154.