Journal of Information System and Technology Research

journal homepage: https://journal.aira.or.id/index.php/jistr/

Centralized Report Verification and Monitoring in Waste Bank Management: A Web-Based Information System Case Study at the Environmental Agency of Tegal City

Rachma Fadilah Kurnianto[1,*], Mohammad Humam[2], Bayu Aji Santoso [3]

[1,2,3]Department of Information Systems, Faculty of Science and Technology, Universitas Harkat Negeri, Tegal, Indonesia

ARTICLE INFO

Article history:

Received 10 April 2026
Accepted 31 May 2026
Available online 31 May 2026

Keywords:

Waste Bank Management
Information System
Waterfall Model
User Acceptance Testing
Role-Based Access Control
Centralized Data Governance

How To cite :
R. F. Kurnianto, M. Humam, and B. A. Santoso, "Centralized Report Verification and Monitoring in Waste Bank Management: A Web-Based Information System Case Study at the Environmental Agency of Tegal City," *Journal of Information System and Technology Research*, vol. 5, no. 2,pp 318-330 May 2026

ABSTRACT

Waste bank data management at the Environmental Agency of Tegal City relied on Google Forms, spreadsheet recapitulation, and manual report compilation, causing data duplication, incomplete reports, inconsistent records, and delayed monitoring; of 187 registered waste bank units, only about 30% submitted monthly reports consistently, and recapitulation took one to two weeks. Previous waste bank information systems mainly supported single-unit operations such as transaction recording and internal reporting, leaving a gap in how a public authority could centrally verify and monitor data from many decentralized units. This study addressed that gap by developing BASMAN, a web-based Waste Bank Management Information System built using the Waterfall approach, integrating master data, operational data, monthly reports, report verification, monitoring, notifications, and data export in one centralized platform with role-based access for administrators and waste bank managers. Unlike prior systems that treated data submission and acceptance as a single step, BASMAN introduced a dedicated agency-level verification stage before report approval. Blackbox Testing confirmed all 35 scenarios passed successfully, and User Acceptance Testing yielded an average score of 4.21 (84.29% acceptance), categorized as highly feasible, demonstrating that BASMAN was both functionally sound and well accepted by its intended users.

Corresponding Author:

Rachma Fadilah Kurnianto,
Department of Information Systems, Faculty of Science and Technology, Universitas Harkat Negeri, Tegal, Indonesia
Email: rachmafadilahkr@gmail.com

1. INTRODUCTION

Waste management remains a complex environmental challenge requiring active involvement from multiple stakeholders [1], [2]. Internationally, the shift toward smart and technology-enabled waste management, encompassing IoT-based monitoring, artificial intelligence, and data-driven decision support, has been widely documented as a strategy to improve collection efficiency and environmental sustainability in both developed and developing countries [3], [4]. Population growth and shifting consumption patterns have driven a steady increase in daily waste volumes, and without proper management, accumulated waste poses risks ranging from environmental pollution to public health problems [1]. In the Indonesian context, the waste bank (*bank sampah*) program has emerged as a relevant community-based approach, encouraging public participation while delivering economic, social, and environmental benefits [1]. Digital platforms and

interactive technologies have also been identified as key enablers for increasing community interest and engagement in waste bank initiatives, including through real-time information dissemination and educational content [5].

However, deploying such digital platforms is not merely a matter of technical development; it also depends on whether intended users will actually accept and use the resulting system. This acceptance dimension is commonly examined through the Technology Acceptance Model (TAM), which identifies perceived usefulness and perceived ease of use as the primary determinants of technology adoption, including within public sector institutions where digital governance initiatives depend heavily on user acceptance to succeed [6]. Empirical evidence from Indonesian public administration has shown that these two constructs, together with the resulting attitude toward use, significantly shape citizens' and officials' behavioral intention and actual use of electronic government services [6]. This acceptance-oriented perspective forms part of the theoretical framework underlying the present study, since a system's feasibility depends not only on its functional correctness but also on the extent to which its intended users, in this case DLH Admins and Waste Bank Managers, find it usable and beneficial.

International studies have advanced technology-driven waste management largely around sensor and AI-based operational efficiency, but comparatively fewer studies address the administrative and governance layer, particularly how waste-related data is verified, consolidated, and monitored across many decentralized units by a public authority. For example, recent IoT-based smart waste management architectures pair centralized cloud data management with role-based mobile and desktop applications to coordinate administrative and field-level users [7], yet such systems remain oriented toward operational bin- and route-level monitoring rather than the agency-level report verification and multi-unit compliance tracking that the present study addresses. Prior studies on waste bank information systems have generally focused on single-unit management or specific operational aspects such as transactions, member management, and internal reporting [8], [9], while studies exploring broader waste management or mobile-based waste bank applications did not specifically address centralized report verification and monitoring at the agency level [10], [11].

In practice, however, many waste banks still rely on manual recording and unstructured digital tools for transactions, operational data, and report preparation [8]. This dependence introduces risks of data duplication, recording errors, and declining information quality that can undermine decision-making [8], [12]. When data from different sources are collected without adequate integration, consistency suffers and monitoring becomes less effective [13]. This pattern mirrors challenges reported in the broader digital-government literature. Digital transformation in public-sector organizations involves not only technology adoption but also institutional restructuring of how data is validated, shared, and used for decision-making, and local or regional public authorities often lag behind national-level agencies in system integration due to limited infrastructure and weak institutional coordination [2]. This pattern has been documented across diverse governance contexts, from pilot studies of IT service management in national public-sector agencies to systematic reviews of the strategies local governments use to adopt digital technologies despite persistent capacity constraints [14], [15]. A unified digital system is therefore important to support timely and accurate waste management information [2], [3]. Embedding digital technologies within waste management practices, including IoT, cloud computing, artificial intelligence, and data analytics, has been shown to significantly improve the efficiency of waste-related processes and support the long-term sustainability of waste management programs [4].

These problems were observed at the Environmental Agency (*Dinas Lingkungan Hidup*/DLH) of Tegal City. Data collection relied on Google Forms and manual recapitulation into separate spreadsheets covering master data, operational data, and monthly reports. Not all waste banks submitted reports consistently, leaving data incomplete at each reporting period. Shared spreadsheets carried risks of duplicate entries and inconsistent records because no validation mechanism existed to ensure completeness or standardization across units.

Interviews with DLH staff revealed that of 187 registered waste bank units, only approximately 30% submitted reports consistently each month. Recapitulation from photo documentation and Google Forms to spreadsheets took one to two weeks depending on agency workload, delaying evaluation and making comprehensive monitoring difficult. This gap highlights the need for a system designed not only for individual units but for agency-level centralized management, one that supports coordination across many units, multi-area data collection, report verification, performance monitoring, and centralized compilation to strengthen the effectiveness and accuracy of waste bank data management. These conditions pointed to the need for a system with centralized data storage, input validation, role-based access control, report verification, and data export capabilities.

To address the access-control requirement, this study adopts Role-Based Access Control (RBAC), which assigns system permissions based on predefined organizational roles rather than individual identities, allowing administrators to enforce differentiated access without managing permissions for each user separately [16]. This foundational framework, in which permissions are organized around job functions rather than individual user identities, was formally defined by Sandhu et al. and has since been widely applied in web-based and enterprise information systems to reduce unauthorized data modification and strengthen accountability in multi-user environments [17], [18]. In BASMAN, RBAC separates the roles of waste bank operators who handle data input, agency verifiers who validate reports, and administrators who monitor the system as a whole, a structure aligned with the centralized-authority model proposed in this study.

In terms of development approach, system methodologies are commonly compared along a spectrum from structured, sequential approaches such as Waterfall to iterative, adaptive approaches such as Agile. Comparative analyses of these approaches indicate that Waterfall remains suited to projects with fixed, well-documented requirements, since its

sequential structure provides predictability and minimizes miscommunication when project scope is stable, whereas Agile is more effective when requirements are expected to change frequently during development [19]. Simulation-based studies of the Waterfall lifecycle further show that the model's phase-by-phase structure allows completion times and resource needs to be estimated with reasonable accuracy when requirements are clearly defined in advance [20]. Given that BASMAN's functional requirements were derived from a fixed regulatory and reporting structure at DLH Tegal City, rather than requirements expected to evolve iteratively, the Waterfall approach was selected to ensure systematic documentation and verification at each development phase.

This study addressed that gap by developing BASMAN (Bank Sampah Management System), a web-based Waste Bank Management Information System for DLH Tegal City using the Waterfall approach. Three research problems guided this study. The first concerned how BASMAN should be designed and implemented to integrate waste bank data management at the agency level. The second examined the extent to which the developed system, based on system testing results, is able to reduce data duplication, improve data consistency, and accelerate the waste bank report compilation process compared to the previous method. A third problem addressed the feasibility level of the developed information system based on functional testing and user acceptance testing results in supporting the effectiveness and accuracy of waste bank data management. Accordingly, the research aimed to produce a web-based Waste Bank Management Information System integrated at the Environmental Agency of Tegal City, to produce a system proven capable of reducing data duplication, improving data consistency, and accelerating the waste bank report recapitulation process compared to the previous method based on system testing results, and to determine the system's feasibility level based on functional testing and user acceptance testing results.

This research contributes a centralized government-level waste bank information architecture integrating reporting verification, RBAC, and multi-unit monitoring, a combination not addressed by prior single-unit waste bank systems. This positions the Environmental Agency as the central authority for data validation and monitoring, rather than treating each waste bank unit in isolation.

2. RESEARCH METHOD

2.1. Research Design

The present work was undertaken as a form of applied investigation, as its main objective was to produce a web-based information system that could be used to address waste bank data management problems at the Environmental Agency of Tegal City. The descriptive nature of the study was reflected in its effort to explain the existing data management process, including data collection, recapitulation, reporting, verification, and monitoring. A mixed-method approach was also applied to combine qualitative and quantitative data. The qualitative approach was used to identify problems and system requirements through observation and interviews, while the quantitative approach was used to evaluate system functionality and user acceptance through Blackbox Testing, pilot testing, and User Acceptance Testing.

The object of this study was BASMAN, a Waste Bank Management Information System delivered as a web-based platform developed for the Environmental Agency of Tegal City. The system involved two user groups, namely DLH Admins and Waste Bank Managers. DLH Admins were responsible for managing master data, monitoring operational data, verifying monthly reports, managing users, and exporting data. Waste Bank Managers were responsible for entering operational data, submitting monthly reports, viewing report status, receiving notifications, managing profiles, and exporting data according to their access rights.

The evaluation procedure in this study focused on two aspects of the developed system, namely functional correctness and user acceptance. Functional correctness was evaluated through Blackbox Testing to verify whether each system feature, including account registration validation, reporting period validation, and mandatory field validation, operated according to its intended specification. User acceptance and usability were evaluated through pilot testing and User Acceptance Testing (UAT), which measured users' perceived ease of use and satisfaction after interacting with the system according to their respective roles, in accordance with the *Sangat Layak* (Highly Feasible) classification obtained.

Improvements in data consistency were addressed structurally rather than through direct time measurement. Duplication was prevented by restricting each Waste Bank Manager account to a single registered waste bank unit and by disallowing more than one monthly report submission for the same reporting period, while mandatory field validation ensured that incomplete entries could not be submitted. These mechanisms were verified through the corresponding Blackbox Testing scenarios rather than through a separate error-count comparison against the previous manual process.

Regarding reporting efficiency, the previous manual workflow required DLH staff to consolidate data from Google Forms, photo documentation, and spreadsheets, a process that typically took one to two weeks depending on agency workload. Under BASMAN, once a monthly report is verified by a DLH Admin, the corresponding recapitulation is available for immediate export in PDF or Excel format without further manual consolidation. This comparison is presented primarily as a structural change in the reporting workflow, since the system had not yet been deployed in daily operational use at the time of this study, so a statistically controlled, repeated-measurement comparison across the full reporting cycle was not conducted. An informal single-trial timing illustration limited to the export stage was instead carried out during the revision process, as reported in the Discussion section.

Scalability testing across a larger number of concurrent users or waste bank units was not conducted within the scope of this study, as testing was limited to functional verification and role-based user acceptance under the pilot testing and UAT respondent groups.

2.2. Data Collection

Four instruments underpinned data gathering, namely observation, interviews, literature study, along with questionnaires. Observation was conducted by examining the ongoing waste bank data management process at the Environmental Agency of Tegal City, especially the use of Google Forms, photo documentation, and spreadsheets. Interviews were conducted with the Environmental Agency to obtain information about current problems, system needs, reporting obstacles, and expected functions. Literature study was used to support the theoretical foundation and compare related studies. Questionnaires were used during pilot testing and User Acceptance Testing after respondents had tried the system according to their respective roles.

The User Acceptance Testing questionnaire was divided into three parts. Part A consisted of nine general statements and was completed by all respondents. Part B consisted of five statements directed for DLH Admins. Part C consisted of five statements specifically for Waste Bank Managers. The assessment used a five-level Likert scale ranging from 1 to 5. Each result was derived based on total score, maximum score, average score, percentage, and feasibility category.

2.3. System Development Procedure

Construction of the system followed a Waterfall approach, where the sequential phases consisted of problem identification, requirement gathering, system blueprinting, construction, verification, and post-deployment refinement. This Waterfall approach was used because the system requirements could be identified from the beginning through observation and interviews, and the development process required structured documentation at each stage [9], [19], [20].

In the problem identification stage, the existing data management process was analyzed to identify the main problems, including scattered data, manual recapitulation, duplicate entries, inconsistent records, delayed reporting, and limited monitoring. These findings were then translated into functional and nonfunctional requirements. The functional requirements were grouped into several core modules, including user authentication, waste bank data management, operational data management, monthly report management, report verification, notifications, master data management, role-based user management, and data export.

During the system blueprinting stage, the system was represented through database schematics, interface mockups, class diagrams, activity diagrams, sequence diagrams, and use case diagrams. Applying Unified Modeling Language helped represent system actors, processes, interactions, and structures before implementation. During the construction stage, the blueprint was converted into a web-based system. During the testing phase, the system was examined through Blackbox Testing, pilot testing, and User Acceptance Testing. In the concluding maintenance stage, improvements were made to keep the system aligned with operational needs after testing.

2.4. Testing and Data Analysis

Blackbox Testing was used to evaluate whether each system function produced output according to the expected result. This method focused on input and output without examining the internal program structure [21], [22]. Recent work continues to advance blackbox and model-based testing through automated test-path generation tools that reduce manual test-case design effort while preserving functional coverage [23]. The test scenarios covered authentication, registration, master data management, operational data, monthly reports, CSV import, report verification, notifications, data export, permission-based access restrictions, and mobile display. Each test case was categorized as suitable or unsuitable. The pass rate was derived by dividing the tally of successful test cases against the overall test case count and multiplying the result by 100%.

Pilot testing was conducted before the main UAT to gauge the readability, clarity, along with the initial viability of the questionnaire. Internal consistency analysis was conducted using Cronbach's Alpha for Part A because it was completed by all pilot testing respondents. Cronbach's Alpha is commonly employed to estimate the coherence among questionnaire items, although interpretation should consider the number of respondents and the purpose of the test [24]. In this study, the pilot testing reliability result was used only as an indicative result because the number of pilot respondents was limited.

User Acceptance Testing was used to measure user acceptance of BASMAN after users tried the system according to their roles. UAT is commonly used to determine whether a system can be accepted by users based on their experience in using the system [25], and has long been distinguished from earlier testing phases such as unit, integration, and system testing owing to its focus on operation-based acceptance criteria drawn from real usage scenarios [26]. The UAT within this study involved six respondents consisting of three DLH Admins and three Waste Bank Managers. The feasibility percentage was computed by comparing the accumulated score against a maximum possible score and multiplying by 100%. The system was considered successful when the average score reached at least 4.0 and the feasibility percentage was categorized as feasible or highly feasible.

3. RESULTS AND DISCUSSION

3.1. Existing System Problems and System Requirements

Waste bank data management at DLH Tegal City was carried out through several disconnected media. Reports arrived via photo documentation, Google Forms, and spreadsheets, each requiring manual transfer and checking before the data could be used. Of 187 registered waste bank units, only approximately 30% submitted monthly reports consistently, and the recapitulation process took one to two weeks depending on agency workload. These conditions made comprehensive monitoring difficult and delayed the evaluation process.

The main problems identified were incomplete monthly reports, duplicate entries in shared spreadsheets, inconsistent records across waste bank units due to the absence of input standards, lack of validation mechanisms, and delayed report availability. Table 1 summarizes the identified problems and the corresponding system requirements derived from observation and interview findings, showing how each operational problem was translated into a specific system feature.

Table 1. Summary of Identified Problems and System Requirements

Identified Problem	System Requirement
Waste bank data were stored in separate media	Centralized database and integrated data management
Reports were manually recapitulated from Google Forms, photos, and spreadsheets	Monthly report input, monitoring, filtering, and export features
Duplicate entries could occur in shared spreadsheets	Validation of account registration and report periods
Records were inconsistent between waste banks	Standardized input forms and validation rules
Reports required verification before being used	Report verification feature for DLH Admins
Users had different responsibilities	Role-based access between DLH Admins and Waste Bank Managers
Report status was not easily monitored	Notification and report status features

(Source: Developed by the Author)

Based on these findings, the system was directed toward supporting two main roles: DLH Admins and Waste Bank Managers. DLH Admins required features for master data management, operational data monitoring, monthly report verification, user management, and data export. Waste Bank Managers required features for registration, operational data input, monthly report submission, report status monitoring, notifications, and unit-level data export. Figure 1 illustrates the proposed workflow of BASMAN, showing how data flows between DLH Admins and Waste Bank Managers across the stages of input, verification, monitoring, and export.

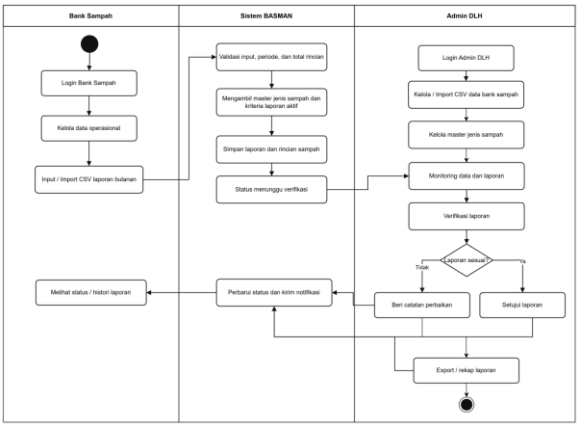

Figure 1. Proposed Workflow of BASMAN
(Source: Developed by the Author)

The identified system requirements demonstrate that waste bank management at the Environmental Agency level extends beyond the operational functions commonly implemented in previous waste bank information systems. Earlier studies primarily focused on supporting transaction recording, member management, and reporting within individual waste

bank units whereas the findings of this study indicate the need for additional capabilities, including centralized report verification, standardized data validation, role-based access control, and integrated monitoring across multiple waste bank units [8], [9]. These findings justify the development of BASMAN as an agency-level information system that strengthens administrative governance by enabling the Environmental Agency to coordinate, validate, and monitor waste bank data through a centralized platform.

3.2. System Design and Implementation

BASMAN was implemented as a web-based multi-user system with role-based access control separating DLH Admin and Waste Bank Manager functions [16], [17]. This separation ensured that each user could only access features within their authority, maintaining data integrity across the workflow.

The role separation was reflected in the feature structure of the system. DLH Admins were given access to features related to centralized control, including waste bank data management, operational data monitoring, monthly report verification, user management, area and waste type master data, report criteria and operational option management, notifications, and data export. Meanwhile, Waste Bank Managers used the system mainly for unit-level activities, such as account registration, email verification, operational data input, monthly report submission, report history, report status monitoring, notifications, profile management, and data export according to their access rights. Table 2 presents the main features available to each user role, reflecting the role-based access control structure implemented in the system.

Table 2. Main Features of BASMAN

User Role	Main Features
DLH Admin	Manage waste bank data, monitor operational data, verify monthly reports, manage users, manage area data, manage waste types, manage report criteria, manage operational options, view notifications, export data
Waste Bank Manager	Register account, verify email, login, manage operational data, submit monthly reports, view report history, view report status, receive notifications, manage profile, export data

(Source: Developed by the Author)

The database was designed with a centralized structure connecting waste bank master data, operational data, monthly reports, verification results, and user accounts in one integrated schema. This approach supports data consistency and reduces the risk of information gaps that commonly arise when data are stored across multiple disconnected files [27].

Two key implementation aspects are highlighted in this study. First, the monthly report form was designed to be flexible by displaying active waste type columns and active report criteria columns based on the configuration set by DLH Admins. This mechanism allows the reporting format to adapt to agency needs without requiring structural changes to the system. Second, the report verification workflow was implemented so that reports submitted by Waste Bank Managers had to be reviewed by DLH Admins before being used in recapitulation. Once approved, the reports were locked to prevent post-verification modification.

The implementation of BASMAN is represented through two main DLH Admin features, operational data monitoring and monthly report monitoring with verification. These two features were selected because they directly represent the main purpose of the system, namely supporting centralized monitoring, report control, and data recapitulation at the Environmental Agency level.

Figure 2 presents the operational data monitoring interface accessible to DLH Admins, displaying workforce data, member count, monthly income, selling location, and recording system for each waste bank unit, along with filtering and export functions.

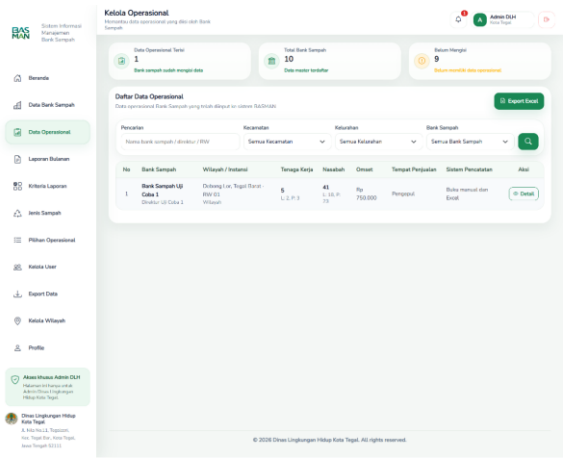

Figure 2. Operational Data Monitoring Interface in BASMAN
(Source: Developed by the Author)

Figure 3 presents the monthly report monitoring and verification interface, where DLH Admins can view report submission counts categorized by status, apply filters by month, year, report status, and waste bank name, and proceed to verification and recapitulation.

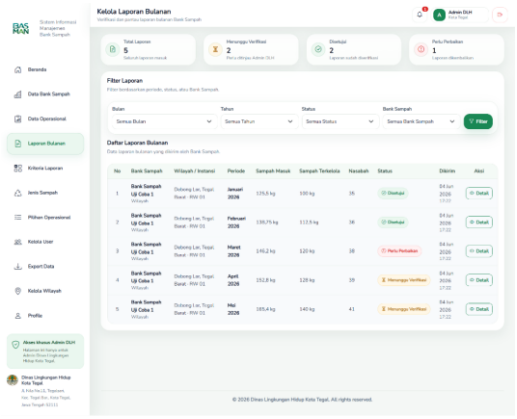

Figure 3. Monthly Report Monitoring and Verification Interface in BASMAN
(Source: Developed by the Author)

The implementation of these interfaces shows that BASMAN was not only developed as a data entry system, but also as a centralized monitoring and verification platform. Operational data and monthly reports could be accessed through structured tables, filtered according to administrative needs, and exported to support administrative recapitulation. These features were then evaluated through Blackbox Testing to verify operational correctness and through User Acceptance Testing to measure user acceptance.

3.3. Blackbox Testing Results

Blackbox Testing was conducted across 35 scenarios covering authentication, registration, master data management, operational data, monthly reports, CSV import, report verification, notifications, data export, access restrictions, and mobile display. Table 3 presents the Blackbox Testing results grouped by actor, showing the number of test cases, successful executions, failures, and pass rate for each group.

Table 3. Summary of Blackbox Testing Results by Actor

Actor	Number of Test Cases	Successful	Failed	Percentage
General or Cross-Role	7	7	0	100%
DLH Admin	11	11	0	100%
Waste Bank Manager	17	17	0	100%
Total	35	35	0	100%

(Source: Developed by the Author)

All 35 scenarios passed, yielding a 100% pass rate. This confirmed that the system's core functions produced outputs consistent with expected results across all tested scenarios. Several mechanisms relevant to the study's objectives were also verified: duplicate account registration was prevented through unit-based account restrictions, duplicate monthly reports for the same period were rejected through period validation, and approved reports were locked against further modification by Waste Bank Managers. The 100% pass rate reflects functional suitability within the tested scenarios and does not represent user acceptance, which was measured separately through UAT.

3.4. Pilot Testing Results

Pilot testing was conducted before the main UAT to evaluate the readability, clarity, and initial feasibility of the questionnaire. The pilot testing involved three respondents consisting of two DLH Admins and one Waste Bank Manager. Part A was completed by all respondents, Part B was completed only by DLH Admins, and Part C was completed only by the Waste Bank Manager.

Part A obtained a total score of 113 out of 135, with an average score of 4.19 and a percentage of 83.70%. This result was categorized as highly feasible. The Cronbach's Alpha value for Part A was 0.173, which did not meet the reliability threshold of 0.70. However, this result was interpreted as indicative because the number of pilot respondents was limited and the main purpose of the pilot testing was to evaluate questionnaire readability and initial feasibility.

Part B obtained a total score of 41 out of 50, with an average score of 4.10 and a percentage of 82.00%. Part C obtained a total score of 23 out of 25, with an average score of 4.60 and a percentage of 92.00%. Overall, pilot testing obtained a total score of 177 out of 210, with an average score of 4.21 and a percentage of 84.29%. This result showed that the questionnaire items were generally considered clear and feasible to be used in the main UAT, although reliability results should be interpreted cautiously due to the limited number of pilot respondents. Table 4 summarizes the pilot testing results for each questionnaire part, including total score, maximum score, average, percentage, and feasibility category.

Table 4. Summary of Pilot Testing Results

Component	Total Score	Maximum Score	Average	Percentage	Category
Part A	113	135	4.19	83.70%	Highly Feasible
Part B	41	50	4.10	82.00%	Highly Feasible
Part C	23	25	4.60	92.00%	Highly Feasible
Overall Pilot Testing	177	210	4.21	84.29%	Highly Feasible

(Source: Developed by the Author)

3.5. User Acceptance Testing Results

A User Acceptance Testing phase was carried out to gauge how well BASMAN was received by users after they tried the system according to their roles. The UAT involved six respondents consisting of three DLH Admins and three Waste Bank Managers. The UAT questionnaire was divided into three parts. Part A was completed by all respondents, Part B was completed only by DLH Admins, and Part C was completed only by Waste Bank Managers.

Part A represented the general user assessment of the system. The result showed that Part A obtained a total score of 225 out of 270, with an average score of 4.17 and an acceptance percentage of 83.33%. This result was categorized as highly feasible. The result indicates that, in general, both user groups considered the system clear, usable, and suitable for supporting waste bank data management. Table 5 presents the UAT result for Part A completed by all respondents.

Table 5. UAT Result for Part A

Component	Total Score	Maximum Score	Average	Percentage	Category
Part A for all respondents	225	270	4.17	83.33%	Highly Feasible

(Source: Developed by the Author)

The UAT result for DLH Admins was calculated from Part A and Part B. Part A for DLH Admins obtained a total score of 115 out of 135, with an average score of 4.26 and a percentage of 85.19%. Part B for DLH Admins obtained a total score of 65 out of 75, with an average score of 4.33 and a percentage of 86.67%. Overall, the DLH Admin group obtained a total score of 180 out of 210, with an average score of 4.29 and an acceptance percentage of 85.71%. Table 6 presents the UAT results specifically for DLH Admins calculated from Part A and Part B.

Table 6. UAT Results for DLH Admins

Component	Total Score	Maximum Score	Average	Percentage	Category
Part A for DLH Admins	115	135	4.26	85.19%	Highly Feasible
Part B for DLH Admins	65	75	4.33	86.67%	Highly Feasible
Total for DLH Admins	180	210	4.29	85.71%	Highly Feasible

(Source: Developed by the Author)

These findings indicate that BASMAN was well received by DLH Admins. The system was considered suitable for supporting centralized data management, operational monitoring, report verification, and data export according to the authority of the Environmental Agency. This result is important because DLH Admins are the main users responsible for controlling and validating data before the reports are used for monitoring and recapitulation.

The UAT result for Waste Bank Managers was calculated from Part A and Part C. Part A for Waste Bank Managers obtained a total score of 110 out of 135, with an average score of 4.07 and a percentage of 81.48%. Part C for Waste Bank Managers obtained a total score of 64 out of 75, with an average score of 4.27 and a percentage of 85.33%. Overall, the Waste Bank Manager group obtained a total score of 174 out of 210, with an average score of 4.14 and an acceptance percentage of 82.86%. Table 7 presents the UAT results for Waste Bank Managers calculated from Part A and Part C.

Table 7. UAT Results for Waste Bank Managers

Component	Total Score	Maximum Score	Average	Percentage	Category
Part A for Waste Bank Managers	110	135	4.07	81.48%	Highly Feasible
Part C for Waste Bank Managers	64	75	4.27	85.33%	Highly Feasible
Total for Waste Bank Managers	174	210	4.14	82.86%	Highly Feasible

(Source: Developed by the Author)

From the Waste Bank Manager perspective, BASMAN was also considered highly feasible. The system supported operational data input, monthly report submission, report status monitoring, notifications, and data export within the scope of each waste bank unit. Although the percentage from Waste Bank Managers was slightly lower than that of DLH Admins, both groups still provided results in the highly feasible category. Table 8 summarizes the overall UAT results across both user groups.

Table 8. Overall UAT Results

Respondent Group	Total Score	Maximum Score	Average	Percentage	Category
DLH Admins	180	210	4.29	85.71%	Highly Feasible
Waste Bank Managers	174	210	4.14	82.86%	Highly Feasible
Overall UAT	354	420	4.21	84.29%	Highly Feasible

(Source: Developed by the Author)

The overall UAT result showed that BASMAN obtained a total score of 354 out of 420, with an average score of 4.21 and an acceptance percentage of 84.29%. This result exceeded the minimum success criterion of an average score of 4.0 and was categorized as highly feasible. The UAT result indicates that BASMAN was accepted by both user groups and considered suitable for supporting centralized waste bank data management at the Environmental Agency of Tegal City.

3.6. Discussion

BASMAN addressed the data management challenges at DLH Tegal City by replacing a fragmented, media-dependent workflow with a centralized platform. The shift from manual recapitulation across photo documentation, Google Forms, and spreadsheets to a system where data are submitted directly, stored in a single database, and immediately available for verification, monitoring, and export represents a structural improvement in the reporting process. Centralized database implementation, input validation, duplicate account prevention, reporting period validation, report verification, and post-verification report locking collectively supported the reduction of data duplication and improved data consistency

across waste bank units. As part of the revision process, an informal timing trial was conducted to illustrate the practical impact of this structural change on the export stage of the reporting workflow. Generating the full monthly recapitulation report took 17.31 seconds in PDF format and 14.23 seconds in Excel format when no filter was applied, while generating a report filtered by sub-district (*kecamatan*) took 7.84 seconds in PDF format and 4.47 seconds in Excel format, reflecting the smaller data volume processed for a filtered request. This trial was conducted on a single device and network connection and was not a controlled or repeated statistical measurement; processing time may vary depending on hardware specifications, network conditions, and server load, and is expected to increase as the volume of stored data grows. These figures are therefore presented only as an indicative illustration of the export stage, rather than as a formal efficiency benchmark for the full reporting process. While the overall magnitude of time savings across the entire reporting cycle was not measured statistically, the elimination of manual transfer and cross-checking steps directly addresses the one-to-two-week recapitulation delay identified in the existing process, since exported data becomes available immediately once a report has been verified rather than requiring separate manual compilation.

The UAT results, with an overall acceptance of 84.29% across both user groups, indicate that this structural change was recognized and positively received by users involved in the actual workflow. DLH Admins obtained 85.71% and Waste Bank Managers obtained 82.86%, both categorized as highly feasible. The slightly higher score from DLH Admins may reflect the greater familiarity of administrative staff with structured digital systems, while Waste Bank Managers represent a user group with more varied digital literacy levels. Both scores nonetheless fall in the highly feasible category, suggesting that the system design was accessible enough for both roles. The use of UAT also supports the evaluation of whether a system is acceptable from the user's perspective after direct use [25], consistent with earlier work that positioned UAT as an operation-based strategy for validating software against real-world acceptance criteria rather than internal code structure [26].

The Blackbox Testing result of 100% across all 35 scenarios confirms that functional suitability was achieved. Each tested function produced outputs consistent with expected results, supporting the view that Blackbox Testing is effective in verifying system output without examining internal program logic [21], [22]. In particular, the mechanisms designed to prevent data duplication, namely restricting each Waste Bank Manager account to its own registered unit, enforcing mandatory field validation, and rejecting duplicate submissions for a reporting period that had already been submitted, were confirmed to function as intended through their corresponding test scenarios rather than through a separate before-after error count comparison. The UAT result further confirms that this functionality translated into a system that users found appropriate for their actual work contexts.

This result becomes more meaningful when placed against previous waste bank information system studies rather than treated as an isolated feasibility score. Prior manual recording processes in comparable systems have been reported to cause data inaccuracy and delayed recapitulation, a condition similar to what was found at DLH Tegal City before BASMAN was implemented [8]. Other comparable web-based systems focused on customer and transaction data management have shown that digitalization reduces data loss and recording errors, but such systems generally treat data entry and data acceptance as a single step, without a separate verification stage [28]. BASMAN differs from these prior systems in that it introduces a report verification feature specifically assigned to DLH Admins, separating data submission from data validation. This addition directly targets one of the governance weaknesses identified in the existing condition, namely reports being used before they were properly checked.

Beyond single-organization systems, digital platforms have also been shown to support value co-creation in municipal solid waste management by acting as a knowledge-sharing broker that connects citizens, municipalities, and waste management companies [29]. BASMAN differs from this citizen-facing brokerage model in that it directs its centralizing and verifying function inward, toward the relationship between waste bank operators and the supervising agency, reflecting its distinct institutional focus on agency-level governance rather than outward citizen engagement.

Centralized data storage has similarly been emphasized as a core improvement in action research on a waste bank system developed for another regional environmental agency, supporting the observation that centralization has become a common baseline feature across waste bank systems [30]. However, unlike that system, BASMAN extends centralization with role-based monitoring and structured export features, allowing DLH Admins to track reporting compliance across many registered units rather than a single service area. Compared with these previous waste bank systems, BASMAN therefore provides an additional centralized verification mechanism that improves administrative governance, rather than only replicating the basic digitalization of record-keeping that earlier studies had already achieved. This distinction is particularly relevant for local government contexts such as DLH Tegal City, where oversight of 187 registered waste bank units through a single platform requires more than centralized storage; it requires a mechanism to ensure that only checked and standardized data reaches the evaluation stage.

The adoption of digital technologies in waste management has been broadly associated with improvements in operational efficiency and data handling and the results of this study reflect that pattern within the specific context of agency-level waste bank administration [2], [4].

It should be noted that the UAT sample was limited to six respondents within the coordination scope of this study and was not intended to generalize to all 187 waste bank units. The Cronbach's Alpha value from pilot testing (0.173) did not reach the standard reliability threshold due to the small pilot sample, and the export timing figures reported above reflect a single informal trial under one specific hardware and network condition rather than a controlled performance

benchmark. These limitations suggest directions for future research, including larger and more representative respondent samples, statistically measured efficiency comparisons conducted under varied hardware, network, and data-volume conditions, and long-term system stability evaluation under real operational conditions.

4. CONCLUSION

The present research produced BASMAN, a web-based Waste Bank Management System for Tegal City's Environmental Agency using the Waterfall approach. The system was designed to integrate waste bank master data, operational data, monthly reports, report verification, monitoring, notifications, and data export in one centralized platform, supporting two main user roles, DLH Admins and Waste Bank Managers, with different access rights and responsibilities.

The Blackbox Testing outcomes confirmed that all 35 scenarios ran successfully with a perfect pass rate, indicating that core system functions, including authentication, data management, input validation, report submission, report verification, notifications, data export, access restrictions, and mobile display, worked according to expected outputs. The system also supported mechanisms to reduce duplicate data and improve consistency through account restrictions, reporting period validation, role-based access control, verification, and locking of approved reports. The User Acceptance Testing results further showed that BASMAN was highly feasible based on user assessment, with DLH Admins obtaining an acceptance percentage of 85.71%, Waste Bank Managers obtaining 82.86%, and an overall UAT result of 84.29% with an average score of 4.21, indicating that the system was accepted by both user groups and considered suitable for supporting centralized waste bank data management.

Beyond these technical outcomes, this study contributes a centralized government-level waste bank information architecture that integrates report verification, role-based access control, and multi-unit monitoring, a combination not addressed by prior single-unit waste bank systems, positioning the Environmental Agency rather than individual waste bank units as the central authority for data validation and monitoring. Practically, the system directly replaces a fragmented, media-dependent reporting process with a single verified data source, allowing DLH staff to move from manual multi-week recapitulation toward a workflow where verified reports are immediately available for export and monitoring. However, this study has several limitations, including the restriction of UAT evaluation to six respondents rather than across all 187 registered waste bank units, the absence of a statistically controlled, repeated-measurement comparison of processing time between the manual and system-based workflows across the full reporting cycle (an informal single-trial illustration of the export stage was reported instead), and a pilot testing reliability value that did not meet the standard Cronbach's Alpha threshold due to the limited number of pilot respondents. Future research is therefore recommended to evaluate BASMAN under actual multi-unit operational use to obtain statistically measured efficiency and scalability data, to expand respondent coverage across a larger and more representative sample of waste bank units, and to explore integration with complementary technologies such as mobile-based reporting or API-based data verification to support broader adoption across other regional environmental agencies with similar waste bank coordination needs.

5. ACKNOWLEDGEMENTS

Gratitude is extended to the Information Systems Study Program, Faculty of Science and Technology, Universitas Harkat Negeri, for academic support during the research process. The author also thanks the supervisors for their guidance, suggestions, and corrections throughout the preparation of this study. Appreciation is also addressed to the Environmental Agency of Tegal City for providing permission, information, and support during data collection and system testing.

6. REFERENCES

[1] A. Budiyarto, B. Clarke, and K. Ross, "Overview of Waste Bank Application in Indonesian Regencies," *Waste Management & Research: The Journal for a Sustainable Circular Economy*, vol. 43, no. 3, pp. 306–321, Mar. 2025, doi: 10.1177/0734242X241242697.

[2] L. G. F. Rittl, A. Zaman, and F. H. de Oliveira, "Digital Transformation in Waste Management: Disruptive Innovation and Digital Governance for Zero-Waste Cities in the Global South as Keys to Future Sustainable Development," *Sustainability*, vol. 17, no. 4, p. 1608, Feb. 2025, doi: 10.3390/su17041608.

[3] J. Prata, C. L. Simões, and R. Simoes, "Improvements to Municipal Solid Waste Collection Systems Using Real-Time Monitoring," *Sustainability*, vol. 17, no. 4, p. 1405, Feb. 2025, doi: 10.3390/su17041405.

[4] N. Onur, H. Alan, H. Demirel, and A. R. Köker, "Digitalization and Digital Applications in Waste Recycling: An Integrative Review," *Sustainability*, vol. 16, no. 17, p. 7379, Aug. 2024, doi: 10.3390/su16177379.

[5] N. Ulhasanah, S. Suhardono, C.-H. Lee, A. S. Faza, A. Zahir, and I. W. K. Suryawan, "Modelling Participation in Waste Bank Initiatives at Public Transport Hubs to Advance Circular Economy Development," *Discover Sustainability*, vol. 6, no. 1, p. 153, Mar. 2025, doi: 10.1007/s43621-025-00940-4.

[6] H. Warsono, T. Yuwono, and I. R. Putranti, "Analyzing technology acceptance model for collaborative governance in public administration: Empirical evidence of digital governance and perceived ease of use," *International Journal of Data and Network Science*, vol. 7, no. 1, pp. 41–48, 2023, doi: 10.5267/j.ijdns.2022.12.008.

[7] R. Alnanih, L. Elrefaei, and A. Al-Ahwal, "Advancing Sustainability Through an IoT-Driven Smart Waste Management System with Software Engineering Integration," *Sustainability*, vol. 17, no. 21, p. 9803, Nov. 2025, doi: 10.3390/su17219803.
[8] A. Muhardono, D. Susilo, N. R. S. Fitri, and M. Khasanah, "Sistem Informasi Bank Sampah Berbasis Web untuk Manajemen Pengelolaan Sampah di Desa Sumurjomblangbogo Kabupaten Pekalongan," *G-Tech : Jurnal Teknologi Terapan*, vol. 7, no. 4, pp. 1540–1549, Oct. 2023, doi: doi.org/10.33379/gtech.v7i4.3248.
[9] M. Khairullah, M. Syamsu, and E. Sestri, "Rancang Bangun Sistem Informasi Bank Sampah Berbasis Web Menggunakan Metode Waterfall (Studi Kasus: Bank Sampah Desa Pamegarsari)," *Jurnal Sistem Informasi (JUSIN)*, vol. 5, no. 1, pp. 9–20, May 2024, doi: 10.32546/jusin.v5i1.2452.
[10] A. Febrianto and D. Yulianto, "Sistem Informasi Pengelolaan Sampah Kabupaten Bantul Berbasis Website Menggunakan Model Modified Waterfall," *Technomedia Journal (TMJ)*, vol. 9, no. 3, pp. 309–320, Feb. 2025, doi: doi.org/10.33050/tmj.v9i3.2168.
[11] M. R. Pratama and S. D. Sancoko, "Pengembangan Aplikasi Pengelolaan Bank Sampah Srikandi Mobile di Gunungkidul," *Jutisi : Jurnal Ilmiah Teknik Informatika dan Sistem Informasi*, vol. 14, no. 3, pp. 2094–2105, Dec. 2025, doi: 10.35889/jutisi.v14i3.3334.
[12] P.-L. Poon, M. F. Lau, Y. T. Yu, and S.-F. Tang, "Spreadsheet Quality Assurance: A Literature Review," *Front. Comput. Sci.*, vol. 18, no. 2, p. 182203, Apr. 2024, doi: 10.1007/s11704-023-2384-6.
[13] I. M. Putrama and P. Martinek, "Heterogeneous data integration: Challenges and opportunities," *Data Brief*, vol. 56, p. 110853, Oct. 2024, doi: 10.1016/j.dib.2024.110853.
[14] M. I. Sarwar, Q. Abbas, T. Alyas, A. Alzahrani, T. Alghamdi, and Y. Alsaawy, "Digital Transformation of Public Sector Governance With IT Service Management–A Pilot Study," *IEEE Access*, vol. 11, pp. 6490–6512, 2023, doi: 10.1109/ACCESS.2023.3237550.
[15] A. David *et al.*, "Understanding Local Government Digital Technology Adoption Strategies: A PRISMA Review," *Sustainability*, vol. 15, no. 12, p. 9645, Jun. 2023, doi: 10.3390/su15129645.
[16] M. Margam, "Understanding Authentication and Authorization: A Comparative Analysis of Role-Based Access Control (RBAC), Attribute-Based Access Control (ABAC), and Relationship-Based Access Control (ReBAC) Authorization Models," *International Journal of Advanced Computer Science and Applications*, vol. 17, no. 2, pp. 95–99, 2026, doi: 10.14569/IJACSA.2026.0170211.
[17] L. Logrippo, "Data Flow Security in Role-Based Access Control," *Journal of Information Security and Applications*, vol. 90, p. 103997, May 2025, doi: 10.1016/j.jisa.2025.103997.
[18] R. S. Sandhu, E. J. Coyne, H. L. Feinstein, and C. E. Youman, "Role-based access control models," *Computer (Long. Beach. Calif).*, vol. 29, no. 2, pp. 38–47, 1996, doi: 10.1109/2.485845.
[19] A. Mishra and Y. I. Alzoubi, "Structured software development versus agile software development: a comparative analysis," *International Journal of System Assurance Engineering and Management*, vol. 14, no. 4, pp. 1504–1522, Aug. 2023, doi: 10.1007/s13198-023-01958-5.
[20] A. Saravanos and M. X. Curinga, "Simulating the Software Development Lifecycle: The Waterfall Model," *Applied System Innovation*, vol. 6, no. 6, p. 108, Nov. 2023, doi: 10.3390/asi6060108.
[21] E. Krupalija, E. Cogo, S. Becirovic, I. Prazina, K. Hodzic, and I. Besic, "Forward-Propagation Approach for Generating Feasible and Minimum Test Case Suites From Cause-Effect Graph Specifications," *IEEE Access*, vol. 10, pp. 124545–124562, 2022, doi: 10.1109/ACCESS.2022.3225097.
[22] E. Krupalija *et al.*, "ETF-RI-CEG-Advanced: A graphical desktop tool for black-box testing by using cause–effect graphs," *SoftwareX*, vol. 25, p. 101625, Feb. 2024, doi: 10.1016/j.softx.2023.101625.
[23] R. Gh. Alsarraj, A. M. Altaie, and E. Zuhair Majeed, "Developing an Automated Model-Based Software Testing Tool From the Design Phase," *IEEE Access*, vol. 13, pp. 58548–58558, 2025, doi: 10.1109/ACCESS.2025.3553967.
[24] Y. F. Zakariya, "Cronbach's Alpha in Mathematics Education Research: Its Appropriateness, Overuse, and Alternatives in Estimating Scale Reliability," *Front. Psychol.*, vol. 13, Dec. 2022, doi: 10.3389/fpsyg.2022.1074430.
[25] Aliyah Aliyah, N. Hartono, and A. A. Muin, "Penggunaan User Acceptance Testing (UAT) Pada Pengujian Sistem Informasi Pengelolaan Keuangan Dan Inventaris Barang," *Switch : Jurnal Sains dan Teknologi Informasi*, vol. 3, no. 1, pp. 84–100, Dec. 2024, doi: 10.62951/switch.v3i1.330.
[26] H. K. N. Leung and P. W. L. Wong, "A study of user acceptance tests," *Software Quality Journal*, vol. 6, no. 2, pp. 137–149, Jun. 1997, doi: 10.1023/A:1018503800709.
[27] D. Trihapningsari and M. A. Putri, "Perancangan Basis Data Sistem Reservasi Wisma Universitas Terbuka dengan Metode Database Life Cycle," *Jurnal Teknologi Sistem Informasi dan Aplikasi*, vol. 7, no. 4, pp. 1638–1646, Oct. 2024, doi: 10.32493/jtsi.v7i4.45421.
[28] F. Nuraini and J. Sutopo, "Pengembangan Sistem Informasi Bank Sampah untuk Optimalisasi Pengelolaan Data," *JTIM : Jurnal Teknologi Informasi dan Multimedia*, vol. 5, no. 3, pp. 249–261, Nov. 2023, doi: 10.35746/jtim.v5i3.409.

[29] L. Mersico, S. Aureli, and E. Foschi, "Exploring the role of digital platforms in promoting value co-creation: evidence from the Italian municipal solid waste management system," *Sustainability Accounting, Management and Policy Journal*, vol. 17, no. 1, pp. 233–266, Feb. 2026, doi: 10.1108/SAMPJ-03-2024-0317.

[30] A. D. Mulawarman, N. Q. Lutfillah, F. N. Ramadhani, and M. Ananda, "Aplikasi Sistem Informasi Bank Sampah: Sebuah Studi Kasus," *Jurnal Riset dan Aplikasi: Akuntansi dan Manajemen*, vol. 5, no. 3, Mar. 2022, doi: 10.33795/jraam.v5i3.002.