SAGA: Journal of Technology and Information Systems
Vol 4, Issue 3, August 2026, Page 690-699
ISSN: 2985-8933 (Media Online)
DOI: 10.58905/SAGA.v4i3.830

Closing the Loop in Citizen Waste Reporting: An Android E-Government Application with Status Tracking and Service Rating for North Minahasa Regency, Indonesia

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Abstract. Citizens of North Minahasa Regency report illegal waste dumping to the Environmental Agency through a public Facebook page, and operators relay the posts to field officers through a WhatsApp group. Interviews with the head of the agency's waste management division revealed three shortcomings: responses were immediate or absent, operators could not confirm that reported piles existed, and citizens never learned the outcome of their reports. We developed an Android application that brings the process into one workflow for three roles. The citizen submits a report with a description, an address, and a photograph and tracks its progress. The field officer accepts or rejects the report, marks it as on the way, and closes it by uploading a photograph of the cleaned site. The citizen then rates the service on a five-point scale, and the ratings are made available to the head of the agency. It was built with Rapid Application Development, UML, React Native, Expo, and Firebase Realtime Database. A walkthrough with test accounts for all three roles showed a report passing through every status from submission to rating. None of the reviewed systems asks citizens to rate the service or routes their ratings to agency leadership, which this study adds. Because the walkthrough shows functional feasibility only, the study also specifies the verification, access control, data protection, exception handling, rating design, and field evaluation that deployment requires.

Keywords: E-Government, Waste Reporting, Mobile Application, React Native, Firebase

1 Introduction

Indonesian local governments struggle to keep pace with the waste that households produce. Studies in Jakarta report limited landfill capacity, widespread illegal dumping, and concerns about the capacity and sustainability of municipal services [1], [2]. Plastic is the second-largest component of Indonesian solid waste, and 58% of it goes uncollected [3]. In Banten, residents still mix waste that should go to recyclers with general waste [4]. Law No. 18 of 2008 obliges local governments to collect and process household waste [5], so a pile of waste beside a road represents a failure of public service.

The quality of this service depends on two parties. In a survey of 400 residents of Bukittinggi, Fajriatul Rahmi et al. found that both the performance of sanitation workers and community participation influence the effectiveness of waste management, yet citizens play only a marginal role in evaluating programs [6]. A reporting system can serve both functions: it lets residents point to specific piles of waste, and it gives them a way to judge how responsive officers are.

Indonesian studies show that digital channels make complaint handling faster and more transparent [7]. Even so, users of LAPOR, the national complaint platform, remain dissatisfied with the responses they receive [8], and perceived ease of use is positively associated with user satisfaction [9]. A complaint platform therefore serves citizens well when it lets them follow how the agency processes their complaints.

This problem is evident in the Environmental Agency (Dinas Lingkungan Hidup, DLH) of North Minahasa Regency. New housing estates have no temporary waste collection points, so residents dump waste along the roads. Complaints are posted on the DLH Facebook page, and operators forward them to a WhatsApp group that includes the field officers. The head of the waste management division explained that some complaints receive an immediate response while others receive none. Operators find it hard to tell genuine complaints from hoaxes, and the only channel they fully trust is the one that runs through the Regent's office.

To address this problem, we developed an Android waste reporting application that connects citizens, field officers, and the head of the agency. The study explores the design requirements for a reporting application that (a) supports the verification of reports, (b) makes report handling visible to the citizen, and (c) gives agency leadership a measure of field service. The contributions are (i) a set of requirements elicited from the agency; (ii) a three-role design with an explicit report lifecycle that ends with a citizen rating; (iii) a working implementation in React Native and Firebase; and (iv) a specification of the verification, security, exception handling, and evaluation measures that deployment requires.

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2 Related Work

Table 1 compares our application with Indonesian waste applications developed before and after our project began. Dewi and Yahdin [10] built an Android application with which citizens of Banda Aceh report the location of waste to the sanitation authority. Sauda and Agustini [11] used the prototype model to develop Smart Cleaning, in which an administrator approves citizen reports through a web interface and officers record task completion. Oktarino et al. [12] mapped public waste disposal sites in Jambi City, and Afuan et al. [13] developed a web-based information system for a village waste bank.

Recent studies have begun to build a feedback loop between citizens and field officers. Umar et al. [14] designed E-Trash for Makassar, with location-based reporting, two-way notifications between reporter and officer, and a dashboard for policymakers; the system was validated by black-box testing of 24 features and a two-week field trial in two subdistricts. Affan and Handayani [15] worked with a DLH to design citizen and officer applications and a dashboard using Rapid Application Development, required photographic evidence of task completion, and reported a 62.5% improvement in reporting efficiency in limited testing. Outside Indonesia, volunteers in Tamaulipas, Mexico, reported 120 unofficial dumpsites with a mobile prototype, and an administrator verified 80 of these reports [16]. EcoCheck in the Philippines uses geotagged photographs for local government units and was evaluated against ISO/IEC 25010 [17]. In the United States, a camera-based system detects dumping events with 97% accuracy [18].

Table 1. Comparison with related waste applications (– = not reported in the cited study).

Study	Platform	Actors	Status tracking	Cleanup proof	Citizen rating
Dewi and Yahdin [10]	Android	Citizens, agency	–	–	–
Sauda and Agustini [11]	Android, web admin	Citizens, admin, officers	Yes	–	–
Oktarino et al. [12]	Android	General public	–	–	–
Afuan et al. [13]	Web	Customers, admin, manager	–	–	–
Umar et al. [14]	Mobile, dashboard	Citizens, officers, policymakers	Yes	–	–
Affan and Handayani [15]	Mobile, web admin	Citizens, officers, DLH admin	Yes	Yes	–
This study	Android	Citizens, officers, head of agency	Yes	Yes	Yes

Among the systems in Table 1, three track report status and one requires proof of cleanup. None asks citizens to rate the service or passes such feedback to agency leadership. These observations apply only to the systems reviewed here and cannot be generalized to all Indonesian systems.

The studies in Table 1 were identified in the literature review for the first author's undergraduate thesis. Sources were retrieved from Google Scholar and supplemented with the Consensus database for publications from 2023 onward. We included publications that describe an implemented application for reporting or collecting waste. General complaint services that accept any type of complaint without modeling a waste collection process, such as LAPOR [9] and LAKSA [19], were excluded.

3 Methodology

3.1 Development Model

We used Rapid Application Development (RAD), whose structure is shown in Figure 1. The model suits small teams because it delivers working systems quickly and allows them to be adjusted in response to user feedback. In the communication phase, we interviewed the head of the waste management division and the field operators of DLH North Minahasa to understand the existing reporting chain. In the planning phase, the interview results were translated into system requirements and a project scope. Modeling involved drawing UML use case, activity, and class diagrams and designing the screens in Figma. In the construction phase, the modules for each user role were developed in parallel. Deployment covered database integration, building and releasing test builds, and collecting user feedback for further corrections.

We also reviewed books, journal articles, and official sources on waste services, e-government, and mobile development. The interviews produced the conceptual workflow shown in Figure 2, which positions the application between the citizen, the field officer, and the head of the agency.

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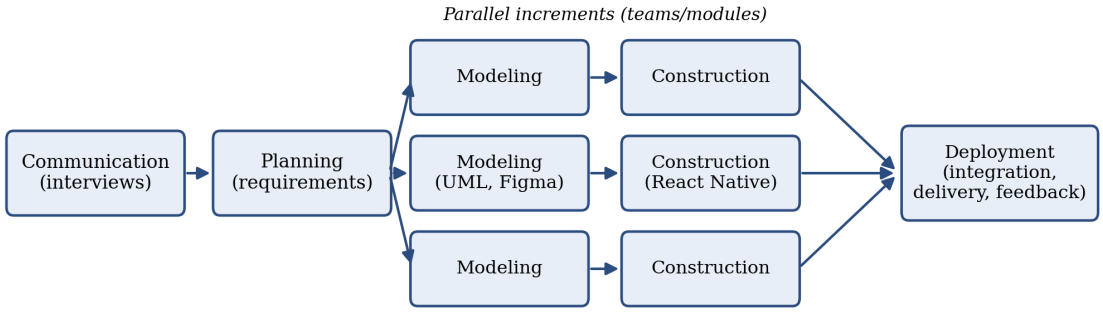


Figure 1. Rapid Application Development model as applied in this study, adapted from [20].

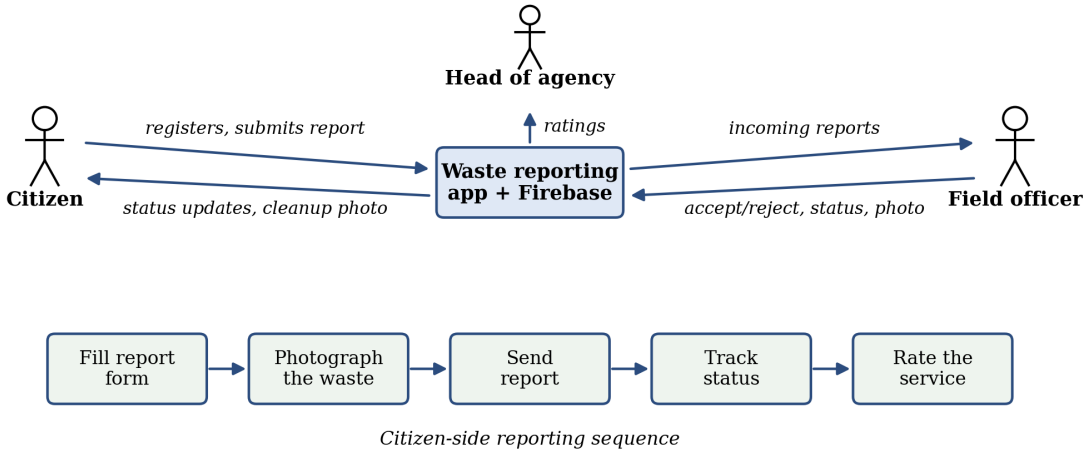


Figure 2. Conceptual workflow of the waste reporting application.

3.2 Development Environment

The application was written in JavaScript with React Native, which renders native Android components from a single code base [21]. Users and reports are stored in Firebase Realtime Database, which propagates changes to all connected clients, so a status change made by an officer appears on the citizen's screen without a refresh. Development used the Expo CLI and the Expo Go client, which run the application on a physical device without building an APK or using an emulator. React Native combined with Firebase has been used in Indonesian projects to build service-oriented applications that require real-time synchronization [22].

Development was carried out on a laptop with an AMD Athlon Silver 3050U 2.30 GHz processor, 4 GB of RAM, a 1366 × 768 display, and a 1 TB HDD, running Windows 10 Pro with Visual Studio Code, Node.js, and Yarn. This configuration does not meet the 8 GB RAM requirement for Android emulation; running the application in Expo Go on a smartphone avoided the problem.

4 Results and Discussion

4.1 Requirements

The interviews identified four requirements. First, a report must contain evidence, namely a photograph of the waste, its location, and the identity of a registered reporter, so that its authenticity can be checked. Second, the officer must be able to accept or reject each report. Third, citizens must be able to follow the progress of a report through its stages until a photograph of the cleaned site is uploaded. Fourth, the head of the agency needs a summary of citizens' ratings of field service. The scope is limited to waste reporting in North Minahasa Regency on Android.

These requirements reflect the agency's perspective. We interviewed the division head and the field operators but no citizens. Citizens' needs regarding usability, reliability, availability, visibility, and feedback were therefore inferred from the agency's account and from previous research on LAPOR users that links user

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satisfaction with usability and responsiveness [8], [9]. These citizen needs are assumptions of this study, and Section 4.9 describes how they will be assessed.

4.2 System Design

Figure 3 shows the use case diagram. Citizens, officers, and the head of the agency share common functions such as registration, login, and viewing the agency profile. Citizens submit reports, track report status, view their report history, and rate the officers' service. Officers view incoming reports and their details, accept or reject them, and update the status by adding a photograph of the cleaned site. The head of the agency views the aggregated ratings. During registration, each user enters a full name, phone number, address, national identity number (NIK), e-mail address, and password and then selects a role. In the prototype, users choose their own role at registration; Section 4.6 treats this as a security gap that deployment must close.

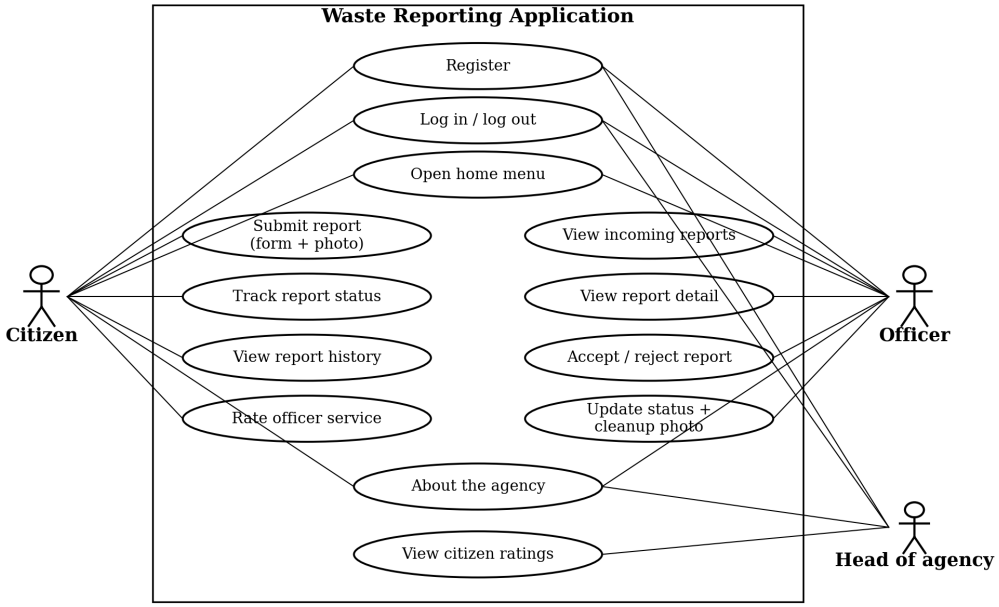


Figure 3. Use case diagram for the three roles.

Figure 4 shows the report lifecycle derived from the activity diagrams. The officer either rejects or accepts a newly submitted report, sets an accepted report to *On the way* on departure, and completes it by photographing the cleaned site. The citizen then rates the service from 1 to 5, and the head of the agency can view the rating. The class diagram reflects these permissions: citizens create, read, and submit reports; officers update and reject them; and the head of the agency has read access. This lifecycle covers the main path only; Section 4.7 adds the exception states that field operations need.

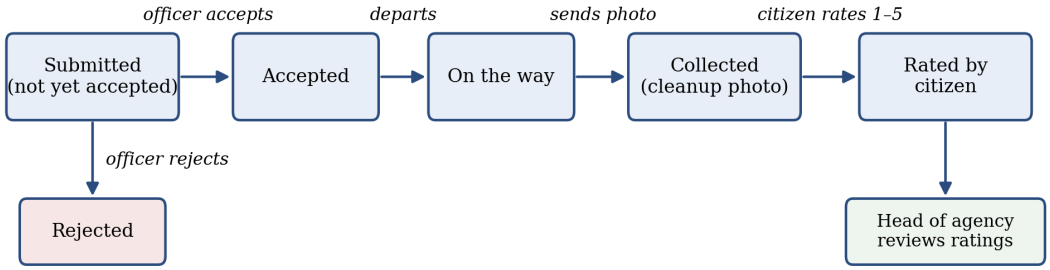


Figure 4. Report lifecycle from submission to rating.

Table 2 describes the database structure. Firebase Realtime Database holds two main nodes: one for the users of all three roles and one for reports.

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Table 2. Firebase Realtime Database nodes.

Node	Contents
data_user	Name, address, NIK, phone number, e-mail, password, and role for citizens, officers, and the head of the agency
data_laporan	For each report: description, address, photograph, status, and timestamp, with the reporter's e-mail, the cleanup photograph, and the citizen's rating, as displayed in the application screens

4.3 Implementation

Figure 5 shows the citizen screens. The home menu offers four options: *Report form*, *Track report*, *Report history*, and *About DLH*. The report form contains a description, an address, and a photograph taken with the phone's camera, and the application does not accept an incomplete form. After submission, the citizen sees the report with the status *Not yet accepted*. Once the officer completes the report, the tracking screen shows both photographs, and the citizen rates the service on a five-point scale.

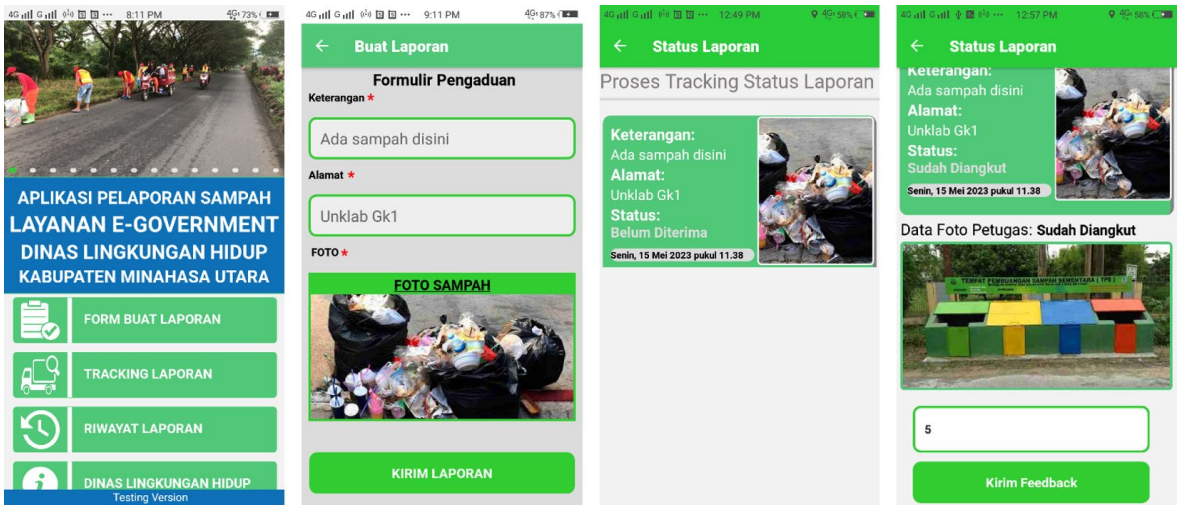


Figure 5. Citizen screens: (a) home menu, (b) report form, (c) report status, and (d) cleanup photograph and rating.

Figure 6 shows the officer screens. The incoming list shows every report with its photograph, description, location, and timestamp, together with *Reject* and *Accept* buttons. The detail view places the reporter's profile above the report, so the officer can contact the reporter and judge the credibility of the report. After accepting a report, the officer selects *On the way*; on arrival, the officer photographs the cleaned site and taps *Send*, which changes the status to *Collected*.

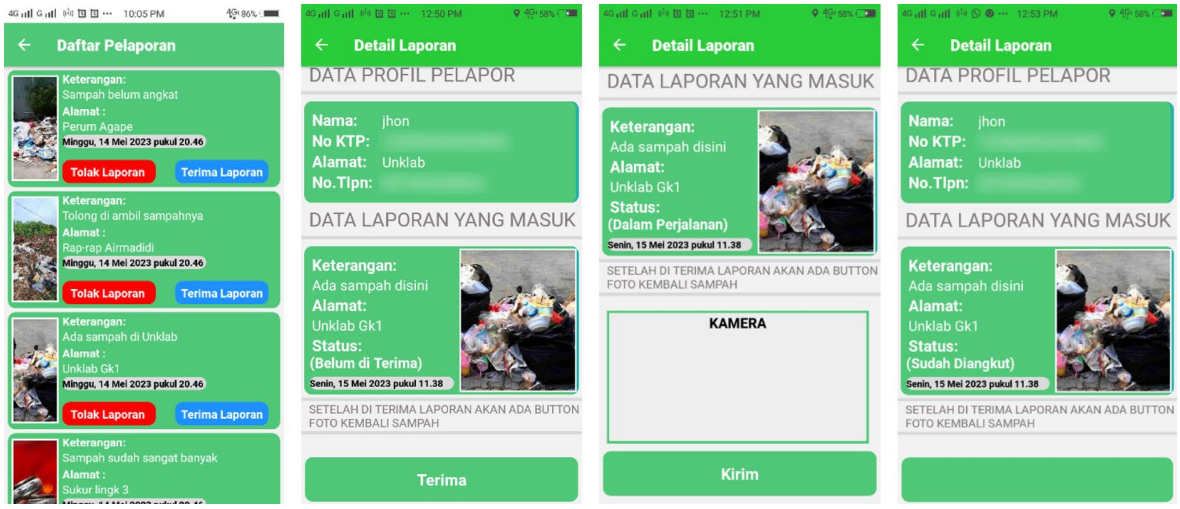


Figure 6. Officer screens: (a) incoming reports, (b) report detail before acceptance, (c) *On the way* status with camera, and (d) report collected. Identity and phone numbers are blurred.

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4.4 End-to-End Walkthrough

We did not run a formal test suite. Instead, we followed one report through its entire lifecycle over two days, using test accounts for all three roles and recording every screen visited. Table 3 outlines the walkthrough. Every step produced the expected screen and status, and each change made by the officer appeared on the citizen's tracking screen.

Table 3. End-to-end walkthrough of one report.

No.	Role	Action	Observed result
1	All roles	Register with name, phone, address, NIK, e-mail, password, and role	Accounts created; login opens the role's home menu
2	Citizen	Submit a report with description, address, and photograph	Report saved with status *Not yet accepted*
3	Officer	Open the incoming list and the report detail; tap *Accept*	Status changes to *Accepted*
4	Officer	Tap *On the way*	Status changes to *On the way*
5	Officer	Photograph the cleaned site and tap *Send*	Status changes to *Collected*; cleanup photograph attached
6	Citizen	Open tracking, view the cleanup photograph, and rate 5	Rating saved with the report
7	Head of agency	Open the ratings menu	Rated report listed with a score of 5/5

The walkthrough shows that the main path works for one report on one device. It did not cover the rejection path, invalid input, two officers updating the same report, poor connectivity, other Android versions, or access attempts by an unauthorized role, and no real users took part. We therefore read the result as evidence of functional feasibility, not of improved service. Section 4.9 sets out the tests and the field pilot for the next stage.

4.5 Report Verification

In the prototype, three elements support confidence in a report: the reporter's registered identity, a required photograph, and the officer's discretion to reject a report after reviewing the reporter's profile and calling the reporter. Together, these elements make a prank more costly than an anonymous Facebook post. They do not, however, guarantee that a report is authentic, current, or tied to the stated address. A user could photograph waste at another location, upload an old photograph, or report the same pile several times. Khan et al. describe the verification of user-generated images as an assessment of provenance, source, date, location, and motivation supported by multimedia forensics [23], and Kaźmierczak et al. show how binding satellite-derived location and time to a report increases the credibility of citizen reporting [24].

For deployment, we specify five measures, none of which the prototype implements. First, the application should accept only photographs taken with the in-app camera at submission and store the capture time and GPS coordinates with each one. Second, the server should flag a new report that falls within a set radius and time window of an open report, so that the officer can merge duplicates. Third, the officer should confirm the pile on arrival and close a false report with the reason *not found*. Fourth, the system should count false reports per account and suspend accounts that exceed a threshold set by DLH. Fifth, the cleanup photograph should carry the same capture data, which lets the citizen and the head of the agency check that the officer reached the reported site.

4.6 Access Control and Data Protection

The prototype was built to demonstrate the process flow and contains the security weaknesses listed in Table 4. Users choose their own role at registration, so a citizen can register as an officer or as the head of the agency. The *data_user* node stores the NIK and the password together with other profile data. The prototype defines no role-specific Firebase Security Rules, so any authenticated client can read or write any node. Status changes are written directly to the report, without validating the transition or checking that the officer is assigned to the report. These shortcuts were accepted to produce a working prototype for this study.

Table 4. Security gaps in the prototype and controls required before deployment.

Gap	Risk	Required control
Self-selected role	A citizen gains officer or head-of-agency functions	Remove role selection. Citizens self-register; a DLH administrator creates officer and head-of-agency accounts and assigns roles as Firebase Authentication custom claims, which the security rules check.
Password stored in	Credentials exposed if the	Delegate authentication to Firebase Authentication, which stores

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Gap	Risk	Required control
data_user	node leaks	salted password hashes, and delete the password field.
NIK and contact data in *data_user*	Identity misuse; obligations under Law No. 27 of 2022	Collect the NIK only if DLH needs it for verification and only with consent for that purpose; store it in a node readable only by the owner and the DLH administrator; show officers a masked NIK; set a retention period and allow deletion on request.
No role-based security rules	A citizen reads other citizens' data; an officer edits another officer's report	Deny by default. Citizens create and rate only their own reports; officers read reports in their area and write only to reports assigned to them; the head of the agency reads aggregated ratings.
Unchecked status writes	Skipped or conflicting statuses when users act at the same time or sync after working offline	Validate each status change against the stored state, the assigned officer, and the permitted next state; record each change in a history log with a timestamp and user ID.
No breach procedure	Late or missing notification	Log access, review anomalies, and notify the data subjects and the competent authority in writing within 72 hours (3 × 24 hours) of a breach.

Law No. 27 of 2022 requires a lawful basis, consent, safeguards, and breach notification for personal data such as the NIK [25]. Firebase Realtime Database evaluates security rules on the server for every read and write, and its rules can compare the stored value with the incoming one, which makes the transition check in Table 4 possible [26]. The same rules can declare indexes on the status and assigned-officer fields that the officer's report list queries. Because the client queues writes made offline and sends them on reconnection, the server-side check must reject a queued status change that no longer matches the current state.

4.7 Exception Handling in the Report Lifecycle

The lifecycle in Figure 4 assumes that an officer can clear every valid report in one visit. Field work often breaks this assumption: a pile may lie outside the regency, contain hazardous material, require a truck the unit does not have, or reappear after cleanup. Table 5 extends the lifecycle with states and reason codes for these cases. The prototype implements none of them; we derived them from the failure scenarios in our use case descriptions and from the agency's account of field operations.

Table 5. Exception states proposed for deployment.

State or event	Trigger	System behavior
Rejected with reason	Officer rejects a report	Officer selects a reason (duplicate, not found, outside jurisdiction, or insufficient evidence), which the citizen can see
Merged	New report close to an open report in place and time	The report links to the original, and the citizen follows the original's status
Deferred	Valid report that needs equipment, scheduling, or another visit	Officer records the reason and an expected date, both visible to the citizen
Referred	Hazardous waste or a matter outside the DLH mandate	Report goes to the responsible unit with the status *Referred*
Reassigned	Officer unavailable or in the wrong area	A supervisor assigns another officer; the history keeps both
Escalated	No acceptance or completion within a service time set by DLH	The head of the agency receives an alert, and the report is flagged
Reopened	Citizen disputes completion within a set number of days	Report returns to *Accepted*; the rating waits until the officer closes it again

4.8 Design of the Service Rating

A single score from 1 to 5 is a coarse signal. It mixes the officer's conduct with conditions the officer does not control, such as truck availability, distance, and the size of the pile, and a handful of reports yields too few scores to judge an individual. We therefore treat the current score as citizen feedback on the service, not as a measure of an individual officer's performance.

For deployment, we propose three changes. First, the rating form should ask about separate dimensions adapted from service quality research [27], namely timeliness, cleanliness of the site, communication, and courtesy, each rated from 1 to 5, with an optional comment. Second, the dashboard should show the ratings alongside the acceptance and completion timestamps and the deferral reasons in Table 5, so that the head of the agency can distinguish a service failure from a resource constraint. Third, the dashboard should aggregate

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ratings by team and area over a period, show the number of ratings behind each average, and hide averages based on fewer ratings than a minimum set by DLH.

4.9 Evaluation Plan

Table 6 sets out the evaluation that must precede deployment. Functional, compatibility, security, and concurrency tests come first. Residents and officers then test usability, and a field pilot compares the current Facebook–WhatsApp channel with the application. Residents in the pilot will also be interviewed about trust, accessibility, and the value of status updates, and their answers will be used to revise the requirements in Section 4.1.

Table 6. Evaluation plan for the next stage.

Stage	Method	Measures
Functional	Black-box test cases for every use case, including rejection, invalid input, and failure scenarios	Pass rate per test case
Compatibility	Devices with at least three Android versions and screen sizes	Crashes and layout defects
Security	Cross-role access, edits to another officer's report, and reads of another citizen's data, tested against the deployed rules	Share of attempts blocked
Concurrency and connectivity	Two officers update one report at the same time; updates made offline and synchronized later	Invalid or lost status changes
Usability	Task-based sessions with residents and officers, rated against the ISO/IEC 25010 quality characteristics [28] and the System Usability Scale [29]	Task success, errors, SUS score
Field pilot	A baseline period on the Facebook–WhatsApp channel, followed by a pilot period with the application in selected districts	Validation rate, time to response, time to completion, unresolved and duplicate reports, citizen satisfaction, officer workload

4.10 Discussion

The application is designed to address each weakness of the old channel, and the walkthrough shows that the designed workflow runs. A registered identity, a required photograph, and the officer's right to reject a report give operators more grounds for judging a report than an anonymous Facebook post, although Section 4.5 shows that these elements alone cannot prove a report genuine. Defined statuses make report handling visible to the citizen, a feature that users of Surabaya's WargaKu application associated with faster processing and higher satisfaction [30]. The rating step extends E-Trash [14] and the RAD-based system of Affan and Handayani [15] by giving residents the evaluative role that Fajriatul Rahmi et al. found to be missing [6], subject to the changes proposed in Section 4.8. Whether these features improve response time, validation rate, or accountability will remain untested until the pilot in Table 6.

Data protection is a precondition for deployment. Registration currently collects the NIK and the password, and Law No. 27 of 2022 requires a lawful basis, consent, and safeguards for such data [25]. Table 4 lists the controls that the production version must implement.

The study has six limitations. First, the requirements came from DLH staff only, and no citizens took part in elicitation. Second, Table 1 covers a limited set of studies, so the novelty claim applies only to that set. Third, the current build records a typed address without GPS coordinates, so officers must interpret addresses manually, a step that E-Trash and the system of Affan and Handayani automate [14], [15]. Fourth, the prototype lets users choose their own roles, stores passwords and NIK in the database, and defines no role-based security rules. Fifth, the evidence of correctness is a single walkthrough with test accounts on one device. Sixth, the application sends no notifications, so officers learn about new reports only by opening the list. Sections 4.5 to 4.8 and Table 6 address these limitations for the next phase.

5 Conclusion

This study developed an Android waste reporting application for North Minahasa Regency that brings citizens, field officers, and the head of the Environmental Agency into one process. Built with Rapid Application Development, React Native, Expo, and Firebase Realtime Database, the application lets citizens submit a report with a photograph, track its status through acceptance, dispatch, and collection, and rate the service. Officers close each report with a photograph of the cleaned site. A walkthrough with test accounts took a report through every status from submission to rating. Routing citizen ratings to agency leadership distinguishes the application

from the systems reviewed. Deployment requires the verification, access control, data protection, exception handling, and rating measures specified in this paper, and any claim of improved service or accountability must wait for a field trial that compares the application with the current Facebook–WhatsApp channel.

Disclosure Statements

Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

Conflict of Interest

The authors declare that there are no conflicts of interest regarding the research, authorship, and publication of this article.

Author Contributions

P.P.H.L.T.: Conceptualization, Investigation, Software, Writing – Original Draft. J.H.M.: Methodology, Supervision, Writing – Review & Editing. All authors have read and approved the final version of the manuscript.

Acknowledgements

The authors would like to acknowledge the head of the Waste, Waste Materials, and Hazardous and Toxic Materials Division and the field operators of the Environmental Agency of North Minahasa Regency for their time and information.

Artificial Intelligence (AI) Use Statement

During the preparation of this manuscript, the authors used Claude (Anthropic) to translate the text from Indonesian into English, to condense it into journal format, and for language editing, formatting to the journal template, and conversion of references to IEEE style. All AI-assisted output and the cited sources were reviewed and verified by the authors. The authors take full responsibility for the accuracy, integrity, originality, and final content of the manuscript.

Data Availability Statement

The interview notes, design documents, and source code supporting the findings of this study are available from the corresponding author upon reasonable request.

Ethics Statement

Ethical approval was not required for this study because it involved only interviews with government officials about their work processes, and the walkthrough used test accounts with fictitious data. Informed consent was obtained from the interviewed officials.

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