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TRASH2CASH: An AI-Assisted Mobile Application for Incentivized Waste Management and Sustainable Resource Recovery

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Abstract

Improper waste segregation and inefficient household waste collection remain major challenges in rapidly urbanizing cities, placing considerable pressure on existing municipal infrastructure, contributing to environmental pollution, and leading to the loss of valuable recyclable resources. In many households, dry, wet, and electronic waste are still mixed together, making recycling less effective and increasing landfill processing costs. Although source-level segregation is essential for sustainable waste management, many citizens lack the motivation to participate due to a lack of direct incentives. To address these challenges, this paper presents TRASH2CASH, a cross-platform mobile application developed using the Flutter framework that encourages responsible waste disposal through financial rewards. The application allows registered users to submit waste collection requests by uploading photographic evidence paired with geotagged location data. An AI-powered image analysis module automatically processes the uploaded images to classify the waste type and identify constituent objects, thereby reducing manual data entry and improving classification accuracy. Based on administrator-defined per-kilogram rates, the system estimates the monetary value of the submitted waste. Following verification by a municipal administrator through a dedicated dashboard, approved payments are credited to the user's in-app wallet in real time. Beyond waste collection, the platform integrates a community-driven reuse marketplace for item donations, a grievance management module for reporting unresolved collection issues, and an environmental impact tracker that visualizes landfill diversion metrics and estimated 〖"CO" 〗_2 emission reductions via interactive charts. To simplify deployment and minimize infrastructure overhead, application data is stored locally using a JSON-based file storage system managed through a centralized state management layer, providing complete create, read, update, and delete (CRUD) functionality without requiring a continuously available backend server. Preliminary evaluation of the prototype indicates that integrating AI-assisted waste classification with a gamified reward system significantly increases citizen participation in source-level waste segregation, promotes recycling, and effectively supports sustainable resource recovery.

Keywords: *Waste Management, Flutter, Mobile Application, Artificial Intelligence, Image Classification, Recycling Incentives, E-Waste, Sustainability, Gamification, Local Data Persistence.*

1. Introduction

Rapid urbanization in Indian metropolitan areas, such as Bengaluru, has led to a significant increase in household waste, underscoring the urgent need for systems that encourage responsible citizen behavior through meaningful incentives. To address these challenges, this paper presents TRASH2CASH, a cross-platform mobile application developed using Flutter that promotes sustainable waste disposal through a reward-based approach. The application enables users to submit waste collection requests by uploading photographs of their waste along with location details. An AI-assisted image classification

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module helps identify the type of waste, reducing manual errors and improving the accuracy of waste categorization. Following administrator verification, users receive monetary rewards through an in-app wallet based on the quantity and category of recyclable waste submitted. In addition to waste collection, the application features a community donation marketplace for reusable items, a grievance management module for reporting collection issues, and an environmental impact tracker that helps users visualize their contributions toward waste reduction and sustainability. The main contributions of this work include: (1) the development of a cross-platform mobile application for incentivized waste management; (2) the integration of an AI-assisted waste classification pipeline to improve submission accuracy; (3) the implementation of a digital reward system to encourage citizen participation; and (4) the inclusion of community engagement and environmental impact tracking features to support sustainable resource recovery [1-5].

2. Methodology

2.1. System Architecture

The overall architecture of the TRASH2CASH application. The system is organized into five functional layers that work together to provide an efficient and user-friendly waste management solution Shown in Figure 1.

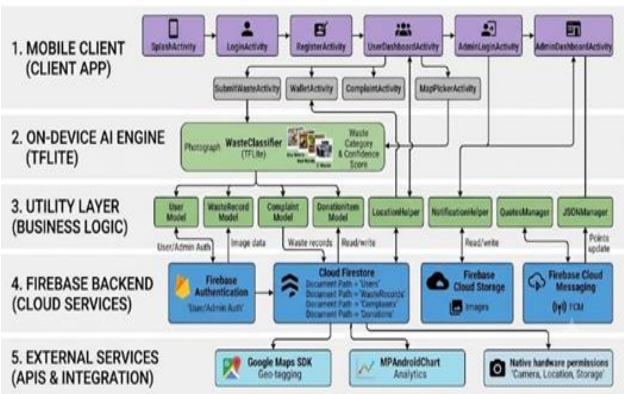

Figure 1 System Architecture of TRASH2CASH

The Mobile Client Layer: The Mobile Client Layer represents the user interface of the application and consists of all screens accessed by citizens and administrators. It includes modules such as Splash Screen, Login, Registration, User Dashboard, Waste Submission, Wallet, Complaint Management, Map Picker, Admin Dashboard, and Administrator Login. Users interact with these screens to submit waste, view rewards, donate reusable items, register complaints, and monitor their environmental impact, while administrators verify waste submissions, process payments, and manage system activities.

2.2. AI-Based Waste Classification Layer

The AI layer assists users during waste submission by analysing uploaded waste images. After a photograph is captured, the AI model classifies the waste into categories such as Dry Waste, Wet Waste, or E-Waste and identifies the objects present in the image. This reduces manual classification errors, improves the accuracy of waste categorization, and simplifies the submission process [6-10].

2.3. Application Logic Layer:

The Application Logic Layer manages the core functionality of the system. It contains modules responsible for user management, waste records, complaints, reusable item donations, location handling, notifications, pricing, and JSON data management. This layer processes user requests, applies business rules, and coordinates communication between the user interface and the data storage layer Shown in Figure 2.

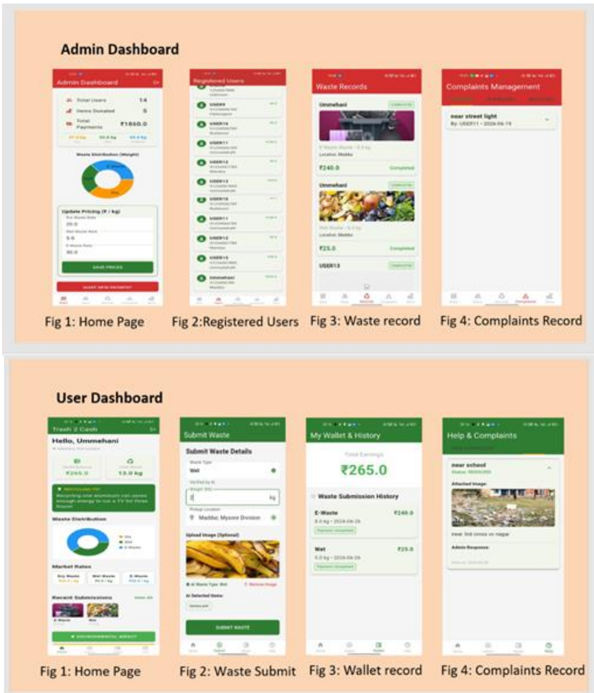

Figure 2 Interface Screens

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2.4.Data Storage and Cloud Services Layer

This layer is responsible for storing and managing application data. It handles user authentication, application records, uploaded images, and notifications. In the implemented prototype, structured application data is maintained locally using JSON files, allowing the application to function even in areas with limited internet connectivity while reducing dependence on a continuously available backend server [11-15].

2.5.External Services Layer

The External Services Layer integrates third-party services required by the application. Google Maps is used for location selection and geotagging of waste submissions, Google Generative AI assists in waste image classification, chart libraries are used to visualize environmental statistics and user contributions, and native device features such as the camera, storage, and GPS are used to capture images and location information. Overall, the layered architecture separates the user interface, business logic, data management, AI processing, and external service integration into independent components. This modular design improves maintainability, scalability, and ease of future enhancements while ensuring efficient communication between different parts of the application.

3. Workflow Diagram

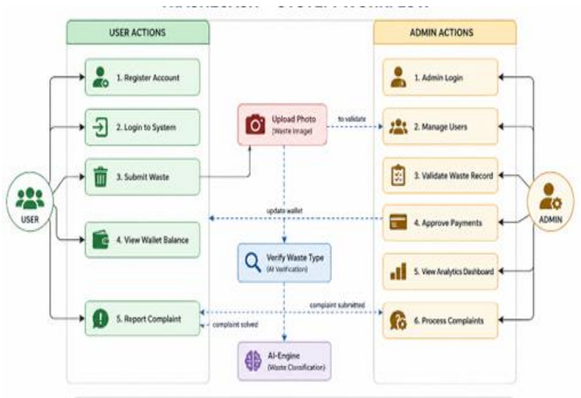

Figure 3 Workflow Diagram

The following diagram illustrates the complete workflow of the TRASH2CASH application, showing the interaction between citizens and administrators from waste submission to reward payment. The process begins when a registered citizen logs into the application and captures or uploads a photograph of the waste. The AI-assisted classification module analyzes the image and predicts the appropriate waste category. Users can either accept the suggested category or modify it before submitting the waste details, including the waste type, weight, photograph, and location information. The submitted data is stored locally and made available for administrator review. The administrator accesses the submitted requests through the dashboard, verifies the waste details and collection information, and approves or rejects the submission based on the verification results. Once a submission is approved, the system calculates the corresponding reward based on the predefined payment rates and credits the amount to the user's in-app wallet. The updated wallet balance is immediately reflected on the citizen's dashboard, providing a transparent and efficient reward process that encourages responsible waste segregation and recycling Shown in Figure 3.

4. Results and Discussion

4.1.Search and Discovery Performance

The usability of the TRASH2CASH application was evaluated through prototype testing to assess the effectiveness of the waste submission and reusable item discovery processes. Users were able to complete the waste submission workflow with minimal guidance by logging into the application, capturing a waste image, reviewing the AI-generated waste category, and submitting the request for administrator verification. The reward amount displayed during submission encouraged users to participate actively and helped reinforce responsible waste segregation practices. The reusable item marketplace also provided an efficient way for users to discover donated items available nearby. By utilizing location information, the application displayed items based on proximity, making it easier for users to find reusable products within their local area. This location-based search improved accessibility while encouraging the reuse of household items instead of disposal [16-19].

4.2.Response Performance

The AI-assisted waste classification module successfully analysed uploaded waste images and provided category predictions for Dry Waste, Wet Waste, and E-Waste. Users were given the flexibility to accept or modify the predicted category before submitting the request, reducing the impact of occasional classification errors and improving the reliability of the submission process. The application provided smooth navigation between screens and responded efficiently to common user operations such as waste submission, complaint registration, wallet updates, and donation management. Interactive charts displaying environmental impact and waste collection statistics were generated without noticeable delays, providing users with immediate feedback on their contribution toward sustainable waste management.

4.3. Database and Application Performance Evaluation

The application uses an offline-first data management approach by storing application data locally in JSON files. This approach enabled users to access core features, including waste submission, complaint management, donation listing, and wallet tracking, even without a continuous internet connection. Data was successfully loaded when the application started and updated whenever changes were made, ensuring consistency across different modules. During prototype testing, the application demonstrated stable performance with normal usage and effectively handled user records, waste submissions, complaints, reusable item listings, and payment information. While local JSON storage is sufficient for a prototype and small-scale deployments, larger implementations with a high volume of data would benefit from a dedicated local database or cloud-based storage solution to improve scalability and performance.

5. Limitations and Future Work

5.1. Limitations

The current prototype operates entirely offline, which works well for single-location deployments but prevents sharing waste records, complaints, and reusable item listings across multiple devices or locations. A citizen registering on Device A cannot access waste submission history or wallet balance on Device B without manual data export/import. The AI-assisted classification pipeline depends entirely on Google Generative AI API availability; if the API becomes unavailable or expensive to operate at scale, the application degrades gracefully to manual category selection but loses the efficiency benefit of automated classification. The accuracy of AI predictions has not been systematically evaluated against a test set of waste images; anecdotal observations suggest occasional misclassification (e.g., wet vs. organic waste), but a rigorous evaluation would require a hand-labelled dataset of several hundred images from the target use context. Data security is a significant limitation in the current design. The JSON files are stored in the application-documents directory with only the minimal file-system permissions isolation provided by the Android/iOS operating system. An attacker with physical device access can extract the JSON files and read sensitive data (user contact information, wallet balances, payment history). Administrator credentials are stored as plain-text password hashes in the Admin record, which provides some protection against casual observation but would not withstand determined attack. For production deployment, all data should be encrypted using industry-standard algorithms (AES-256) with keys derived from the user's device passcode.

5.2. Future Work

Several enhancements can be made to improve the functionality and scalability of TRASH2CASH. A cloud-based backend can be integrated to synchronize data across multiple devices, allowing users to access their waste history, wallet balance, and other information from anywhere. Cloud storage would also enable centralized data management and support large-scale deployment. Future versions of the application can include a dedicated AI model trained specifically on waste images to improve classification accuracy and reduce dependence on external AI services. Running the model directly on the device would also reduce response time, improve user privacy, and allow the application to function without an internet connection. The application can also be integrated with municipal waste management systems to automate waste collection verification and improve communication between citizens and local authorities. This integration would help streamline collection activities and provide users with timely updates on the status of their waste submissions. Additional features such as user ratings, feedback for waste collection services, and a reputation system can further encourage community participation and improve service quality. Finally, integrating digital payment platforms such as the Unified Payments Interface (UPI) would allow users to transfer their earned rewards directly to their bank accounts, making the reward system more convenient and practical.

Conclusion

TRASH2CASH demonstrates that mobile application designed to encourage responsible waste segregation through financial incentives and AI-assisted waste classification. The application provides an easy-to-use platform where citizens can submit waste collection requests, receive rewards for recyclable waste, donate reusable items, report waste-related issues, and monitor their environmental impact. By combining artificial intelligence with a reward-based approach, the system aims to increase citizen participation in sustainable waste management and promote responsible recycling practices. The application was developed using the Flutter framework with an offline-first architecture, enabling core functionalities such as waste submission, wallet management, complaint handling, and reusable item donation without requiring a continuously available backend server. The integration of AI-assisted waste classification simplifies the waste submission process by helping users identify the correct waste category, while the administrator dashboard streamlines verification and payment management. Prototype testing demonstrated that the application provides a smooth user experience and supports efficient waste management workflows. Although the current implementation is designed as a prototype, it provides a strong foundation for future development. Integrating cloud-based storage, improving AI classification accuracy through custom-trained models, and supporting secure digital payment systems would further enhance the application's scalability and usability. Future versions can also integrate with municipal waste management systems to automate collection verification and improve coordination between citizens and local authorities. Overall, TRASH2CASH demonstrates how mobile technology, artificial intelligence, and incentive-based rewards can work together to encourage responsible waste disposal and sustainable resource recovery. By promoting active citizen participation and supporting efficient waste management practices, the proposed system has the potential to contribute to cleaner communities and a more sustainable urban environment.

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