ECOBIN

A smart waste management tool

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Abstract

This research paper presents **EcoBin**, a smart waste management platform aimed at solving prevalent issues in urban waste collection systems, particularly in cities like **Kathmandu**. Current waste management processes suffer from numerous inefficiencies, including **unstructured billing**, **lack of accountability**, **poor segregation practices**, and **limited integration with digital tools**. These inefficiencies result in **higher pollution levels**, **inefficient municipal operations**, and **low citizen engagement**.

EcoBin proposes a comprehensive digital solution featuring:

- A **centralized dashboard** for government monitoring
- A **landlord-tenant registry system** for tracking waste violations
- A **GPS-enabled driver portal** for optimized collection routes
- **AI-powered classification** of organic and inorganic waste using Gemini Flash 2.0
- **Automated notifications** for collection schedules and changes
- A **penalty-based billing system** with digital payment support through platforms like eSewa, Khalti, and bank integration

The proposed system enhances transparency, encourages responsible disposal behavior, and simplifies the billing and communication process. By leveraging modern technologies, EcoBin seeks to revolutionize urban waste management and contribute to cleaner, smarter, and more accountable cities.

Contents

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Introduction

In recent years, urban centers like **Kathmandu** have experienced rapid growth, placing immense pressure on public infrastructure and municipal services. One of the most pressing challenges has been the **management of solid waste**, which has become increasingly complex due to population density, limited resources, and lack of technological integration in current systems. Traditional waste collection methods often rely on outdated practices, leading to unorganized billing, poor communication, inefficient waste collection routes, and a lack of waste segregation, all of which contribute to environmental pollution and reduced public hygiene.

EcoBin is a smart waste management system designed to address these critical gaps by leveraging **modern technology** and **automation**. It provides a user-friendly dashboard for residents, real-time vehicle tracking for drivers, and centralized monitoring for government authorities. The platform not only enables the digitalization of billing and payment but also introduces an **AI-powered system** to classify waste into degradable and non-degradable categories.

Through integration with popular digital wallets like **eSewa** and **Khalti**, along with a robust penalty system for non-compliance, EcoBin redefines how communities interact with waste management services. It is a step forward in transforming cities into **smart cities** where technology works hand-in-hand with environmental responsibility.

Problem Statement

Urban areas like Kathmandu face significant challenges in effective waste management. The existing systems suffer from inefficiencies such as:

- Lack of centralized access to waste data for government authorities.
- No structured registry of landlords and their tenants, making accountability difficult.
- Absence of live tracking or optimized routing for waste collection vehicles.
- Poor waste segregation practices, with most users mixing organic and inorganic waste.
- No automated penalty system for non-compliance (e.g., failure to dispose waste or improper segregation).
- Manual billing processes that are prone to errors and delays.
- Lack of communication with residents about waste collection schedules or updates.
- Limited or no integration of digital payment systems for invoice clearance.

These issues lead to increased environmental pollution, inefficient municipal operations, and low user engagement in maintaining waste hygiene.

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Proposed Solution

We propose a **Smart Waste Management Tool**, a comprehensive digital platform that combines database access, GPS technology, AI integration, and automated billing to streamline the entire waste management process. Key features include:

1. **Government Dashboard**
   A centralized database accessible to municipal authorities for real-time monitoring of registered users, disposal patterns, and compliance.
2. **User Registration System**
   Profiles for landlords with tenants registered under them to ensure traceability and responsibility for waste violations.
3. **Driver Portal with GPS Integration**
   A mobile/web portal for waste truck drivers that enables live location tracking, optimal route suggestions, and route history.
4. **AI-Based Waste Classification**
   Integration of Gemini Flash 2.0 to automatically identify and separate organic and inorganic waste using visual recognition.
5. **Real-Time Notifications**
   Residents receive alerts for waste truck arrival, collection delays, or schedule changes via app or SMS.
6. **Automated Billing & Penalty System**
   Invoices generated based on the weight and type of disposed waste, with additional penalties for:
   - Mixed (unsorted) waste
   - No disposal on scheduled days
7. **Digital Payment Integration**
   Residents can pay invoices directly through **eSewa**, **Khalti**, or linked bank accounts.

This solution will digitize waste handling operations, reduce manual errors, improve waste segregation, and enhance accountability among residents, landlords, and service providers alike.

Research and demographics

According to the **Central Bureau of Statistics (CBS) Nepal**, as of the latest report:

- **Kathmandu Valley** has over **600,000 households**
- On average, **1.1 kg of waste per household per day** is generated
- Roughly **70%** of waste is organic, but only **15%** gets properly sorted

This highlights the need for a tech-driven solution like **EcoBin** that promotes segregation, traceability, and efficient processing.

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Business model

EcoBin will operate on a **commission-based revenue model**. Here's how:

- Each household receives a **monthly invoice** for waste disposal (based on volume/weight)
- EcoBin **automatically deducts 10%** of every invoice as a **service fee**
- Example:
    - Household invoice: NPR 300/month
    - EcoBin earns: **NPR 30/month** from that household
- At scale:
    - With 50,000 households, revenue = **NPR 1,500,000/month**

Revenue will support:

- Platform maintenance and updates
- Salaries for developers/support staff
- Expansion to new municipalities

Additional revenue may come from:

- Premium analytics dashboards for government bodies
- Partnership with recycling companies
- EcoBin smart bins or IoT device sales

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Technologies to be used

Frontend: ReactJS, TypeScript

Backend: Nodejs, ExpressJS

Database and storage: MongoDB, cloudinary, firebase

Application: React-Native

Tools: AWS, tailwindcss, shadCN ui, chartjs etc.

Design: Figma

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References

- Central Bureau of Statistics Nepal — Household Survey 2022
- Kathmandu Metropolitan City Waste Profile Report
- Ministry of Urban Development (MoUD) — Waste Management Guidelines
- Gemini Flash 2.0 — AI SDK Documentation (Google Developers)
- Digital Payment Trends in Nepal — Nepal Rastra Bank, 2024

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