B.M.S. COLLEGE OF ENGINEERING BENGALURU

Autonomous Institute, Affiliated to VTU

OOMD Mini Project Report

Smart waste segregation System

Submitted in partial fulfillment for the award of degree of

Bachelor of Engineering
in
Computer Science and Engineering

Submitted by:

Bhoomi Udedh(1BM23CS066)
Chethana C (1BM23CS077)
Darshan Y G (1BM23CS087)
Deepthi M (1BM23CS088)

Department of Computer Science and Engineering
B.M.S. College of Engineering
Bull Temple Road, Basavanagudi, Bangalore 560 019

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B.M.S. COLLEGE OF ENGINEERING

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

DECLARATION

We, Bhoomi Udedh (1BM23CS066), Chethana C (1BM23CS077), Darshan Y G (1BM23CS087), Deepthi M (1BM23CS088) students of 5th Semester, B.E, Department of Computer Science and Engineering, BMS College of Engineering, Bangalore, hereby declare that, this OOMD Mini Project entitled "**Smart waste segregation System**" has been carried out in Department of CSE, B.M.S. College of Engineering, Bangalore during the academic semester August 2025- December 2025. I also declare that to the best of our knowledge and belief, the OOMD mini Project report is not from part of any other report by any other students.

Signature of the Candidate

Bhoomi Udedh(1BM23CS066)
Chethana C (1BM23CS077)
Darshan Y G (1BM23CS087)
Deepthi M (1BM23CS088)

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CERTIFICATE

This is to certify that the OOMD Mini Project titled "**Smart waste segregation System**" has been carried out by Bhoomi Udedh (1BM23CS066) , Chethana C (1BM23CS077) , Darshan Y G (1BM23CS087) , Deepthi M (1BM23CS088) during the academic year 2025-2026.

Signature of the Faculty in Charge
Roopashree C S
Assistant Professor
BMSCE, Bengaluru

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Chapter 1: Problem Statement
Smart waste segregation System

Modern cities generate large quantities of waste every day, and improper segregation of this waste leads to environmental pollution, increased landfill usage, health hazards, and ineffective recycling processes. Manual waste segregation is time-consuming, labor-intensive, and often inaccurate due to human error. To address these challenges, there is a need for an automated system that can identify different types of waste and classify them correctly.

The Smart Waste Segregation System aims to design an object-oriented software solution that simulates or controls an automated waste-sorting mechanism. The system should detect waste items, identify their category (such as biodegradable, recyclable, plastic, metal, or hazardous), and direct them to the appropriate bin using predefined rules or sensor-based logic. The system will allow users (administrators/operators) to monitor waste types, track segregation accuracy, and generate summary reports.

The project must be designed using Object-Oriented Programming principles such as classes, objects, inheritance, polymorphism, interfaces, and encapsulation. Each module—waste detection, classification, bin control, user interaction, and reporting—should be represented as separate interacting objects. The final system should demonstrate how OOP concepts can be applied to build a scalable, modular, and maintainable waste management solution.

Chapter 2: Software Requirement Specification

1. Introduction

1.1 Purpose

The purpose of this SRS is to define the complete requirements for the Smart Waste Segregation System. This system automates waste identification, segregation, bin management, data analytics, and notifications using a structured object-oriented model. The document serves as a reference for developers, testers, and stakeholders to understand system functionality and constraints.

1.2 Scope

The Smart Waste Segregation System is designed to automate waste handling through sensors, segregation mechanisms, and automated bins. It processes waste items, classifies them, directs them to suitable bins, sends alerts when bins are full, manages recycling units, records waste statistics, and allows users to report complaints or schedule pickups. The system also stores data, analyzes trends, and generates reports through the Data Manager and Recycling Unit modules.

1.3 Definitions

- Sensor – Detects waste type and sends signals to the Segregator.
- Waste – Any item processed, categorized by material, weight, and type.
- Segregator – Mechanism that sorts waste into corresponding bins.
- Bin – Container assigned to specific waste categories.
- Recycling Unit – Facility where waste is processed and recycled.
- User – Citizen/operator interacting with the system.
- Notification System – Module for alerts and updates.
- Data Manager – Module that stores, analyzes, and manages system data.

1.4 References

- IEEE Std 830-1998 SRS Guidelines
- Municipal Solid Waste Management Guidelines
- OOP Modeling & UML Standards

2. Overall Description

2.1 Product Perspective

The system is composed of multiple interacting modules as represented in the class diagram. The major components include:

- Sensors detecting waste
- Segregator deciding bin mapping
- Bins collecting waste
- Data Manager storing analytics
- Recycling Unit processing waste
- User interface
- Notification System for alerts. It is a distributed, object-oriented application that may

interface with hardware components.

2.2 Product Functions

The system performs the following major operations:

- Detect waste via sensors
- Analyze waste properties
- Classify and segregate into correct bins
- Monitor bin levels
- Notify users when actions are needed
- Record and store waste statistics
- Generate system analytics and recycling reports
- Allow user complaint submission and pickup scheduling

2.3 User Characteristics

- Citizens using the mobile/web interface
- System operators managing recycling and pickup
- Admin staff viewing data reports

  Users require only basic knowledge to interact with the system interface.

2.4 Constraints

- Sensor accuracy affects waste detection
- Limited bin capacity
- Real-time segregation requires fast processing
- Hardware-software synchronization needed

2.5 Assumptions and Dependencies

- Sensors are functional and calibrated
- Network connectivity is stable
- Bins are correctly installed
- Recycling units have capacity for processing waste

3. Functional Requirements

3.1 Overview

FR1: The system shall detect waste type using the Sensor object.

FR2: The sensor shall send detection signals to the Segregator.

FR3: The sensor shall allow calibration to adjust sensitivity levels.

FR4: The system shall store waste attributes (ID, type, weight, material).

FR5: The system shall classify waste based on material properties.

FR6: The system shall calculate weight using predefined formulas.

FR7: The system shall receive waste data from the Sensor.

FR8: The Segregator shall determine the appropriate bin based on WasteType.

FR9: The Segregator shall direct waste to the correct bin.

FR10: The system shall store bin attributes (ID, type, capacity, currentLevel).

FR11: The system shall update bin level when waste is added.

FR12: The system shall check bin level periodically.

FR13: If the bin exceeds its threshold, the system shall trigger the Notification System.

FR14: The system shall send waste from bins to the Recycling Unit.

FR15: The Recycling Unit shall recycle materials according to category.

FR16: The Recycling Unit shall generate recycling and processing reports.

FR17: Users shall register complaints through the system.

FR18: Users shall view recycling statistics.

FR19: Users shall schedule waste pickup requests.

FR20: The system shall send alerts when bins are full.

FR21: The system shall notify users regarding updates or scheduled pickups.

FR22: The system shall update user status when notifications are delivered.

FR23: The system shall store waste statistics and bin activity data.

FR24: The Data Manager shall generate analytics (daily/weekly/monthly).

FR25: The Data Manager shall upload or store data in cloud/local storage.

5. Non-Functional Requirements

5.1 Performance

- Waste classification shall complete in < 2 seconds
- Notification delivery shall occur in real-time

5.2 Reliability

- 95% operational uptime
- System should handle sensor failure gracefully

5.3 Security

- User account must be authenticated
- Data logs must be protected

5.4 Usability

- Simple and clean UI
- Easy retrieval of reports

5.5 Maintainability

- Modular class-based structure allows easy updates
- New types of waste or bins can be added without system redesign

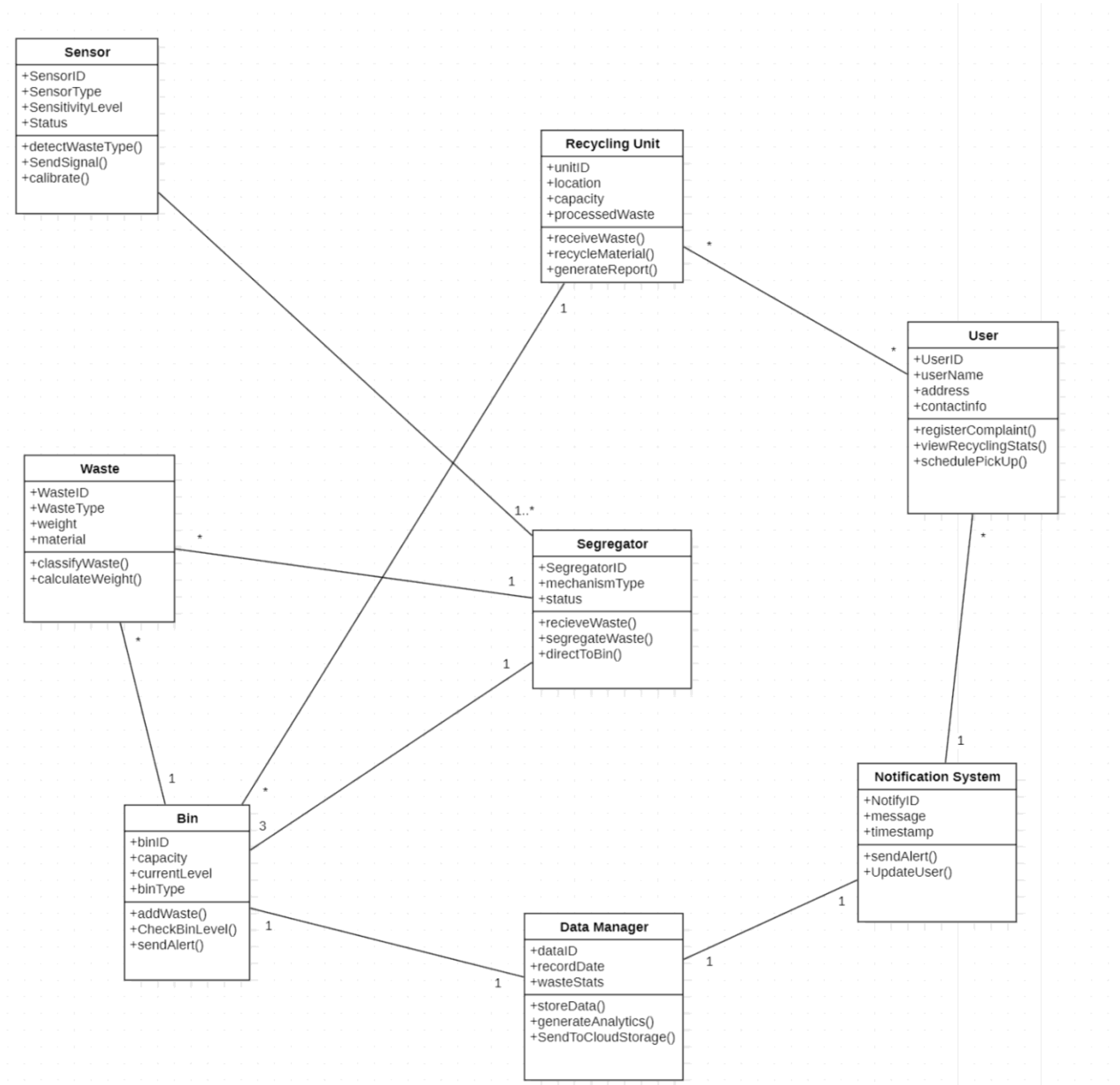
5.6 Portability

- Works across desktop and mobile platforms

6. Conclusion

The Smart Waste Segregation System outlined in this SRS provides a comprehensive, modular, and object-oriented approach to modern waste management challenges. By integrating sensors, automated segregation mechanisms, bin monitoring, user interaction modules, and robust data management, the system ensures efficient, accurate, and scalable waste handling. Each component of the class diagram is translated into detailed functional and non-functional requirements, ensuring clarity for developers and stakeholders. Overall, this SRS establishes a solid foundation for designing and implementing an intelligent waste segregation solution that enhances recycling efficiency, reduces manual intervention, and supports sustainable environmental practices.

Chapter 3: Class Diagram



It consists of the following core components:

1. Sensor Class

Description:

The Sensor class represents the device responsible for detecting waste items. It identifies the type of waste based on sensing mechanism and sends relevant signal to the Segregator for processing.

Attributes:

- SensorID – Unique identifier assigned to each sensor.
- SensorType – Specifies the kind of sensor (e.g., optical, infrared, weight).
- SensitivityLevel – Defines the precision or sensitivity of detection.
- Status – Current operational state (Active/Inactive/Faulty).

Operations:

- detectWasteType() – Detects and determines the waste type.

- sendSignal() – Sends detection signals to the segregator unit.
- calibrate() – Adjusts sensor sensitivity/settings for optimal performance.

2. Waste Class

Description:

The Waste class models the properties of the waste items being processed. It stores essential characteristics and provides behavior for classification.

Attributes:

- WasteID – Unique identifier for each waste item.
- WasteType – Category of waste (e.g., plastic, metal, organic).
- Weight – Weight of the waste item.
- Material – Exact material type (paper, aluminum, PET plastic, etc.).

Operations:

- classifyWaste() – Classifies waste based on material or sensor data.
- calculateWeight() – Computes or measures the waste item's weight.

3. Segregator Class

Description:

The Segregator class represents the mechanism/system responsible for sorting waste into appropriate bins based on classification data received from sensors.

Attributes:

- SegregatorID – Unique ID of the segregator system.
- MechanismType – Type of segregation mechanism (robotic arm, conveyor, rotating funnel).
- Status – Operational status of the segregator.

Operations:

- receiveWaste() – Receives waste information from sensors or the Waste object.
- segregateWaste() – Determines the correct bin category for disposal.
- directToBin() – Sends or directs the waste to its designated bin.

4. Bin Class

Description:

The Bin class represents storage containers for different categories of waste. It keeps track of waste levels and sends alerts when bins approach capacity.

Attributes:

- binID – Unique identifier for each bin.
- capacity – Total storage capacity of the bin.
- currentLevel – Current amount of waste inside the bin.
- binType – The type/category of waste this bin is assigned to (organic, recyclable, metal, etc.).

Operations:

- addWaste() – Adds waste into the bin and updates the current level.
- checkBinLevel() – Checks if the bin is full or nearing capacity.

- sendAlert() – Triggers an alert when the bin level exceeds the threshold.

5. Recycling Unit Class

Description:

The Recycling Unit class models a facility or subsystem responsible for processing and recycling waste collected from bins.

Attributes:

- unitID – Unique identifier for the recycling unit.
- location – Physical or logical location of the unit.
- capacity – Maximum amount of waste the unit can process.
- processedWaste – Quantity of waste already processed.

Operations:

- receiveWaste() – Accepts waste transferred from bins.
- recycleMaterial() – Executes the recycling process for waste items.
- generateReport() – Creates recycling output reports or summaries.

6. User Class

Description:

The User class represents individuals interacting with the system—citizens, operators, or administrators.

Attributes:

- UserID – Unique identifier for each user.
- userName – Name of the user.
- address – User's address for pickup or notifications.
- contactInfo – User's mobile/email contact details.

Operations:

- registerComplaint() – Allows users to lodge complaints about waste issues.
- viewRecyclingStats() – Enables users to view recycling data or system statistics.
- schedulePickUp() – Users can schedule a waste pickup request.

7. Notification System Class

Description:

The Notification System class handles alerts, updates, and user notifications. It ensures timely communication between the system and its users.

Attributes:

- NotifyID – Unique identifier for each notification.
- message – The message content of the notification.
- timestamp – Time at which the notification is generated.

Operations:

- sendAlert() – Sends alerts to users or system modules.
- updateUser() – Updates the user interface or user notification list.

8. Data Manager Class

Description:

The Data Manager class manages the system's data storage, analytics, and cloud synchronization operations.

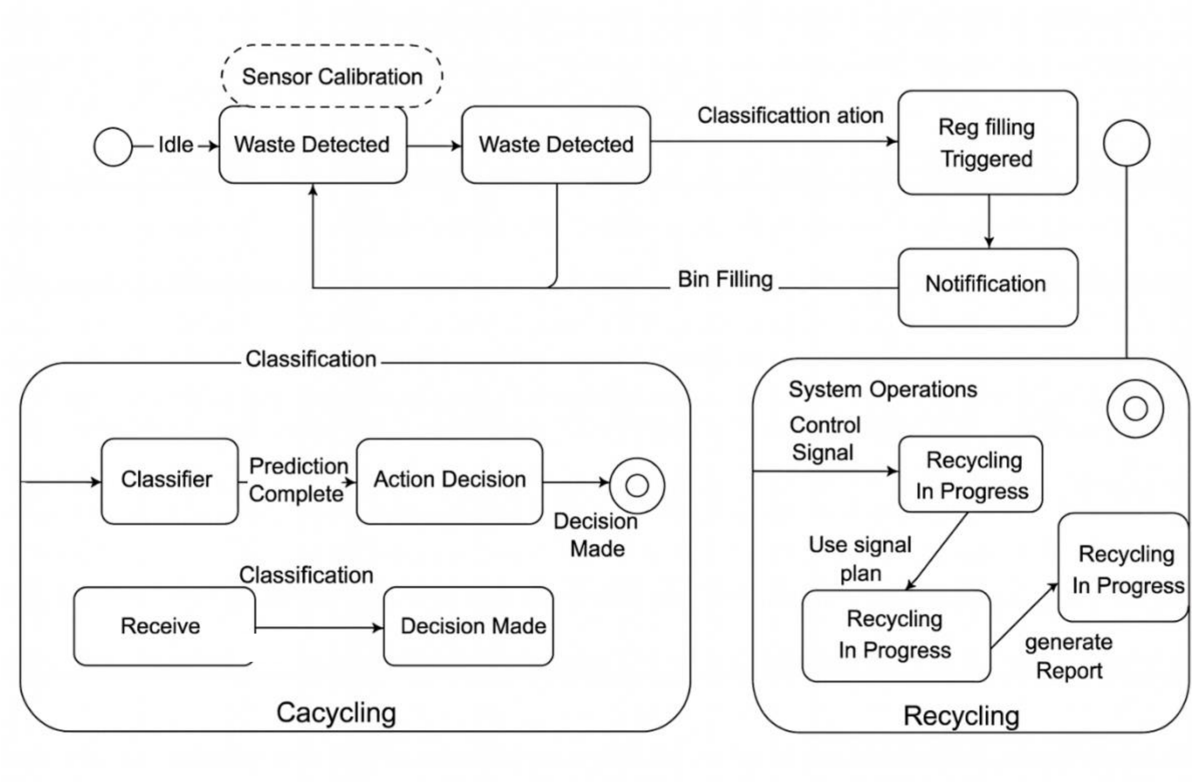
Attributes:

- dataID – Unique identifier for each data record.
- recordDate – Date/time when the data was recorded.
- wasteStats – Statistical information related to waste collected or processed.

Operations:

- storeData() – Stores waste data and system logs.
- generateAnalytics() – Produces data insights and graphical analytics.
- sendToCloudStorage() – Uploads data to cloud backup systems.

Chapter 4: State Diagram



1. Main Waste Flow Region

This region represents the primary workflow from the moment the system is powered on until waste is either sorted or sent for recycling.

Idle State: The system begins in the Idle state, where it continuously waits for sensor input. No processing occurs at this stage, conserving system resources.

Waste Detected:

When the sensor detects the presence of waste:

- The system transitions into the Waste Detected state.
- If sensor precision is questionable, it briefly enters the Sensor Calibration sub-state to adjust sensitivity before retaking the measurement.

This ensures accurate classification in subsequent stages.

Classification Triggered: Once detection is confirmed, the system enters the Classification transition, indicating that waste data is now ready for processing.

Bin Filling Process

- The waste is routed to the appropriate bin.

- The system enters Bin Filling state, where it updates bin levels and records bin usage.

Full Bin Notification: If the bin level exceeds a defined threshold, the system moves to the Notification state. Here, alerts are generated and sent to users or administrators to ensure timely intervention or maintenance. This maintains operational efficiency while preventing overflow.

2. Classification Cycle Region

This region models the internal AI/Logic-driven decision-making process responsible for categorizing waste.

Classifier State: Upon receiving raw sensor data:

- The system enters the Classifier state.
- Analytical models interpret waste features such as weight, material type, or optical signatures.

Prediction Complete: Once classification logic finishes executing, the system transitions to Prediction Complete, indicating the availability of a predicted waste category.

Action Decision: The system then enters the Action Decision state, where:

- It evaluates classification results.
- Determines routing actions (e.g., plastic → bin A, organic → bin B).
- Verifies whether bin capacity allows the new waste entry.

Decision Made: The cycle concludes with the Decision Made state, confirming that the system has finalized an internal decision and triggering either:

- Bin filling, or
- Dispatching to recycling operations.

This cycle ensures that waste is handled using clean, rule-based, and intelligent processing logic.

3. Recycling Cycle Region

This region represents the end-stage processing where categorized waste is transported for recycling or processing.

Receive State: When recycling conditions are triggered (e.g., full bin, scheduled recycling):

- Waste enters the Receive state inside the recycling subsystem.

Recycling in Progress: The system then transitions into Recycling In Progress:

- Waste is broken down, processed, sorted, or compacted according to its type.
- Internal protocols ensure safety, energy efficiency, and environmental compliance.

System Operations Sub-Region: A sub-region inside recycling handles:

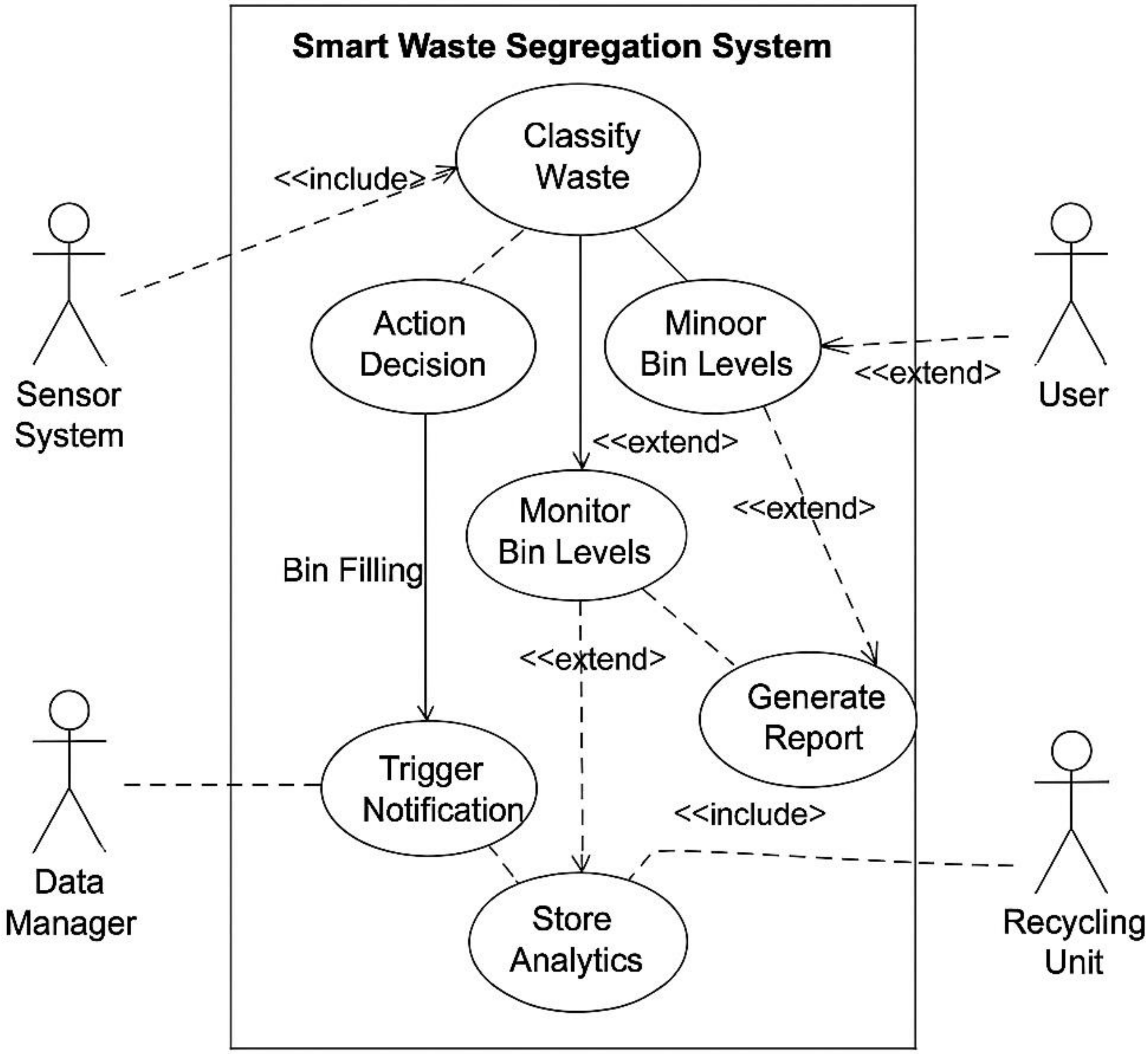
- Control signal execution
- Monitoring of recycling cycles
- Ensuring that premature cycle endings are detected and mitigated
- Re-running incomplete cycles

Generate Report: After successful processing:

- The system generates analytical reports summarizing processed waste quantities, recycling efficiency, and cycle durations.

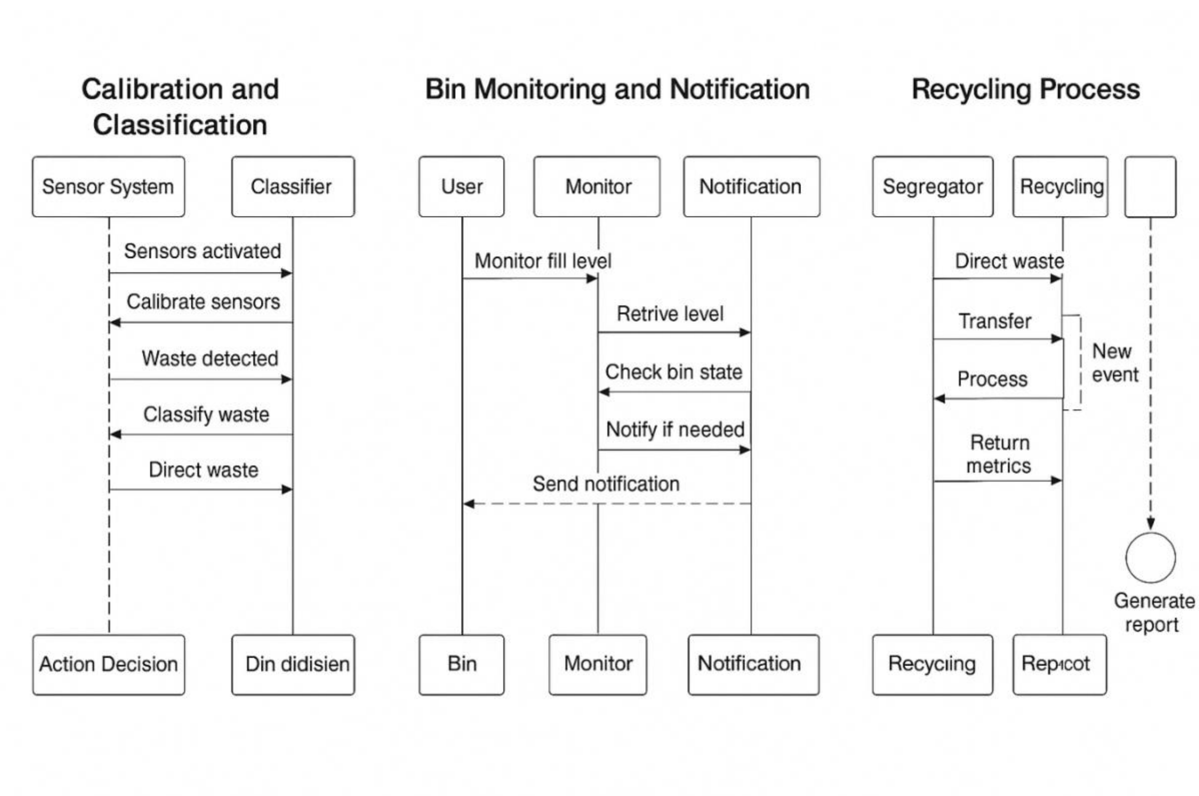
These reports are essential for monitoring system performance, auditing, and optimizing segregation strategies.

Chapter 4.1: Interaction Diagrams : Use case Model


Smart Waste Segregation System
Classify Waste
<<include>>
Sensor System
Action Decision
Minoor Bin Levels
User
<<extend>>
<<extend>>
Monitor Bin Levels
<<extend>>
Bin Filling
<<extend>>
Generate Report
Data Manager
Trigger Notification
<<include>>
Recycling Unit
Store Analytics

Use Case Name	Description	Pre-Condition	Post-Condition	Relationship
Classify Waste	System analyzes sensor data to determine the type of waste (organic, recyclable, hazardous, etc.)	Waste must be detected by the sensor	Waste is successfully categorized	*Included in:* Action Decision
Action Decision	Determines routing: whether waste should go to a bin or to recycling	Waste classification must be complete	Waste is assigned to a bin or marked for recycling	*Includes:* Classify Waste
Monitor Bin Levels	Continuously monitors bin fill levels and updates status	Bin level data must be available	Updated bin level stored, system knows if bin is nearing full	*Extended by:* Trigger Notification, Minor Bin Levels
Trigger Notification	Sends alerts when bins reach warning or full thresholds	Bin level crosses warning/critical limit	User receives alert; event stored in logs	*Extends:* Monitor Bin Levels
Minor Bin Levels	User views early warning bin level status	System functioning and bin monitoring active	User informed about near-full conditions	*Extends:* Monitor Bin Levels
Generate Report	Creates waste processing, bin usage, and recycling analytics reports	Sufficient system data must be available	Report is generated and accessible to user	*Includes:* Store Analytics
Store Analytics	Saves all system processes, logs, and recycling information	Operations generate new data	Data stored in database or cloud	*Included in:* Generate Report
Process Waste	Recycling unit processes waste marked for recycling	Waste must be assigned to recycling by Action Decision	Waste processed, metrics ready for reporting	*Extended by:* Generate Report

Chapter 4.2: Interaction Diagrams : Sequence Model



1.Calibration and Classification Sequence

Involved Lifelines:

- Sensor System
- Classifier
- Action Decision

Description:

Sensors Activated: The system begins by activating the sensors to continuously check for the presence of waste.

Sensor Calibration: When reading accuracy is low, the system sends a calibration request to adjust sensitivity.

Waste Detected: Upon detection, the sensor notifies the classifier with raw material data.

Classify Waste: The classifier analyzes weight, material, and sensor readings to determine the waste category.

Direct Waste: Once classification is complete, the classifier sends the result to the Action Decision module, which decides whether the waste should be sent to a bin or to recycling.

Outcome: The system successfully categorizes waste and prepares it for routing.

2. Bin Monitoring and Notification Sequence

Involved Lifelines:

- User
- Monitor
- Notification Module
- Bin

Description:

Monitor Fill Level: The system periodically sends a request to check the current bin level.

Retrieve Level: The Monitor retrieves updated fill-level data from the Bin lifeline.

Check Bin State: The Monitor evaluates whether the bin has crossed a warning or full threshold.

Notify: If the bin is nearly full or full, the Notification module is triggered.

Send Notification: The user receives an alert that the bin requires attention (replacement, emptying, or maintenance).

Outcome: The user stays informed about bin capacity, preventing overflow or waste accumulation.

3. Recycling Process Sequence

Involved Lifelines:

- Segregator
- Recycling Unit
- Report Generator

Description:

Direct Waste: Once the Action Decision module marks waste for recycling, the Segregator initiates a transfer request.

Transfer to Recycling Unit: The Recycling Unit receives the waste batch.

Process Waste: The recycling subsystem sorts, compacts, and processes the waste based on its type.

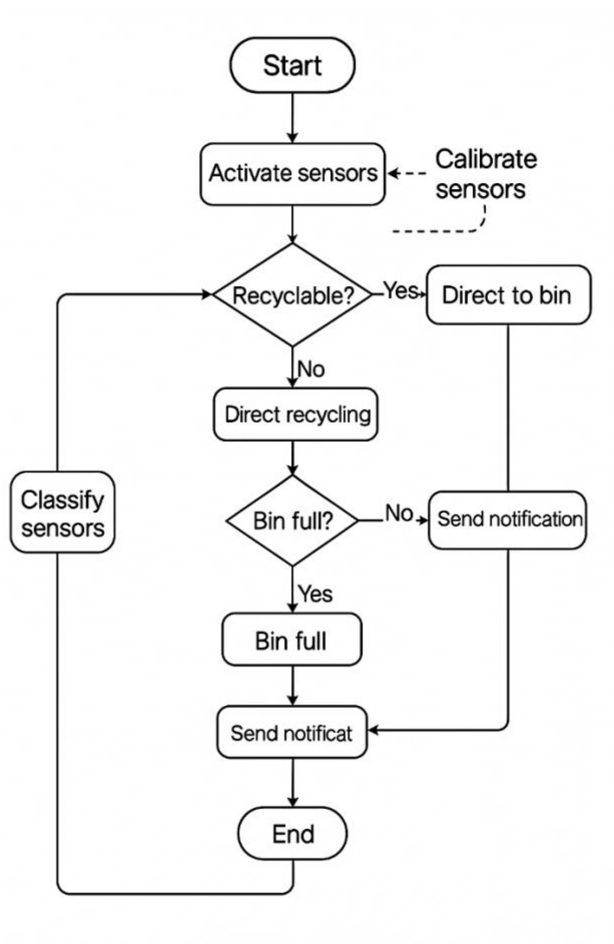
Return Metrics: Processing results (processed volume, materials recovered, timestamps) are returned to the system.

Generate Report: The Report Generator compiles the recycling data into an analytics report for system logs and user viewing.

Outcome:

Recycled waste is processed efficiently, and the system generates performance and recycling statistics.

Chapter 4.3: Interaction Diagrams: Activity Model



1. Start of Process

The activity begins when the system enters the Start state and waits for waste input. Once waste is introduced, the system proceeds to the next step.

2. Waste Detection

The system's sensors identify the presence of waste. This triggers the initial processing workflow.

3. Sensor Calibration Decision

A decision node checks whether sensor calibration is required.

- If calibration is needed, the system performs Calibrate Sensor and returns to waste detection.
- If calibration is not needed, the system directly proceeds to classification.

4. Waste Classification

The waste item is classified according to its type (organic, plastic, metal, recyclable, etc.).
Classification determines which bin the waste should be deposited into.

5. Bin Level Check

After classification, the system checks the current bin level for the assigned waste category.

6. Notification Trigger

If the bin is near or above its threshold:

- The system triggers Send Notification to alert users or operators that the bin is full or nearing capacity.

7. Bin Full Decision

A decision node evaluates whether the bin is full:

- If NO, the process continues in monitoring mode.
- If YES, the system moves to recycling operations.

8. Recycling Process

When the bin reaches full capacity, the waste is moved to the recycling unit.
The system performs the Recycling Process, where waste is sorted, processed, or treated depending on the category.

9. Generate Report

Upon completion of recycling, the system generates a Recycling Report, which logs:

- Amount of waste processed
- Category-wise distribution
- Recycling statistics
- System performance indicators

10. End of Activity

The process terminates at the End state.

The system returns to the idle mode, ready for the next waste detection cycle.

Chapter 5: Simple UI Design with Screenshots

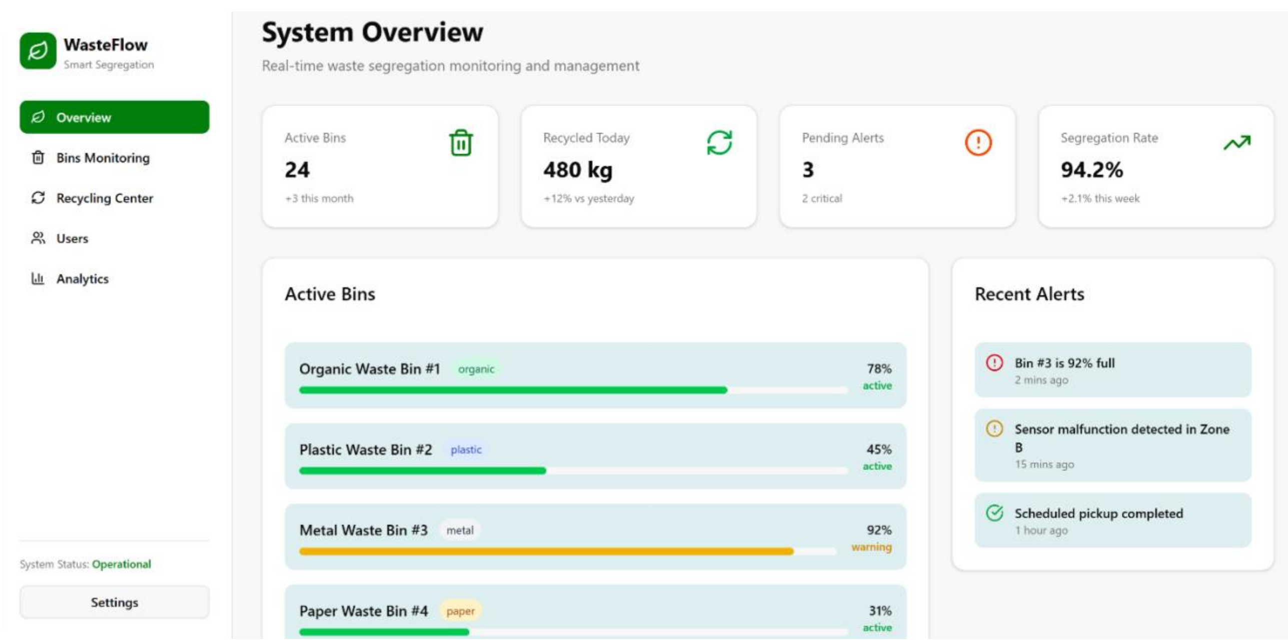


Fig 5.1 System Overview (Home page)

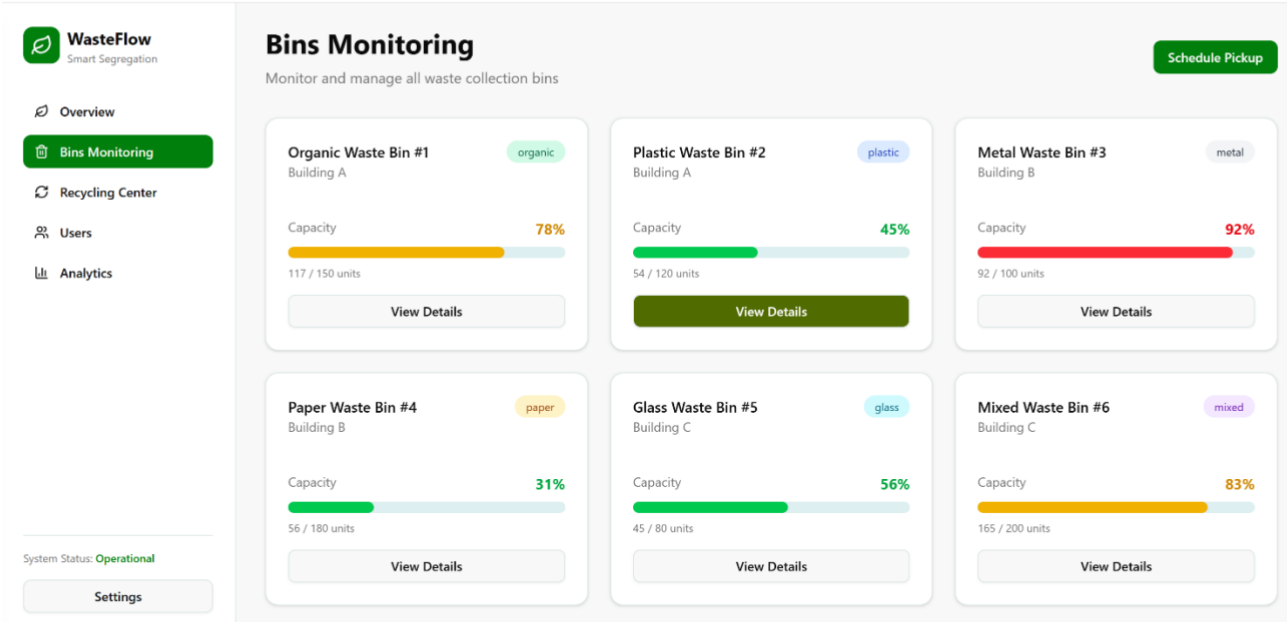


Fig 5.2 Bins Monitoring

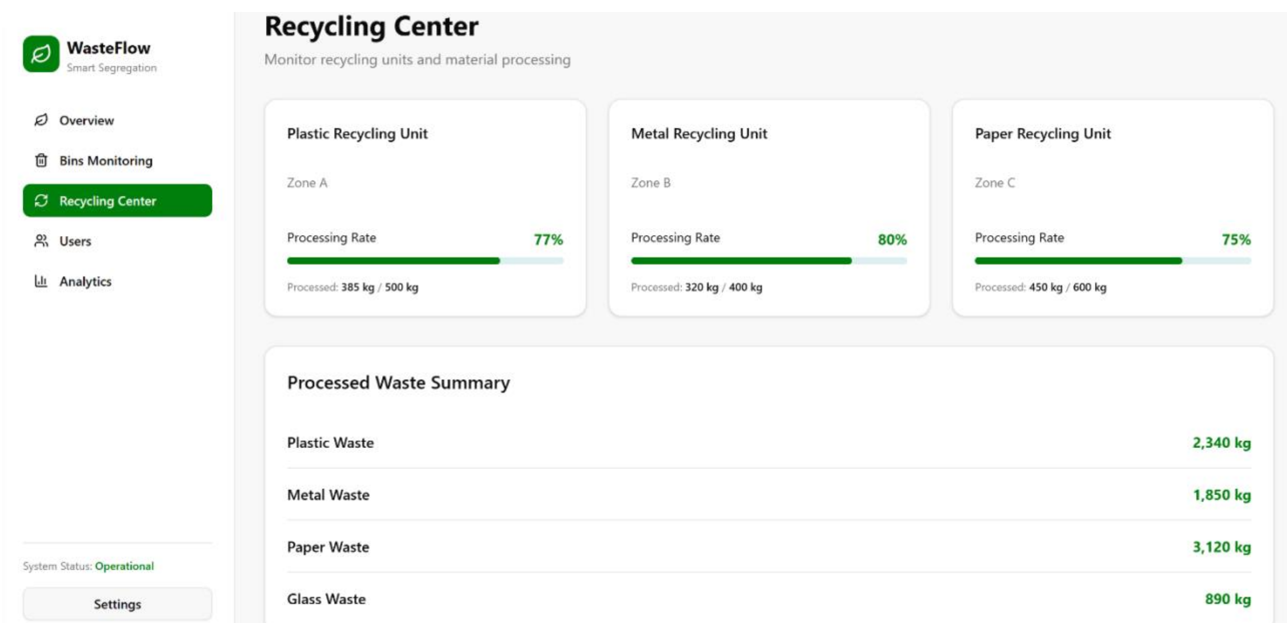


Fig 5.3 Recycling Center

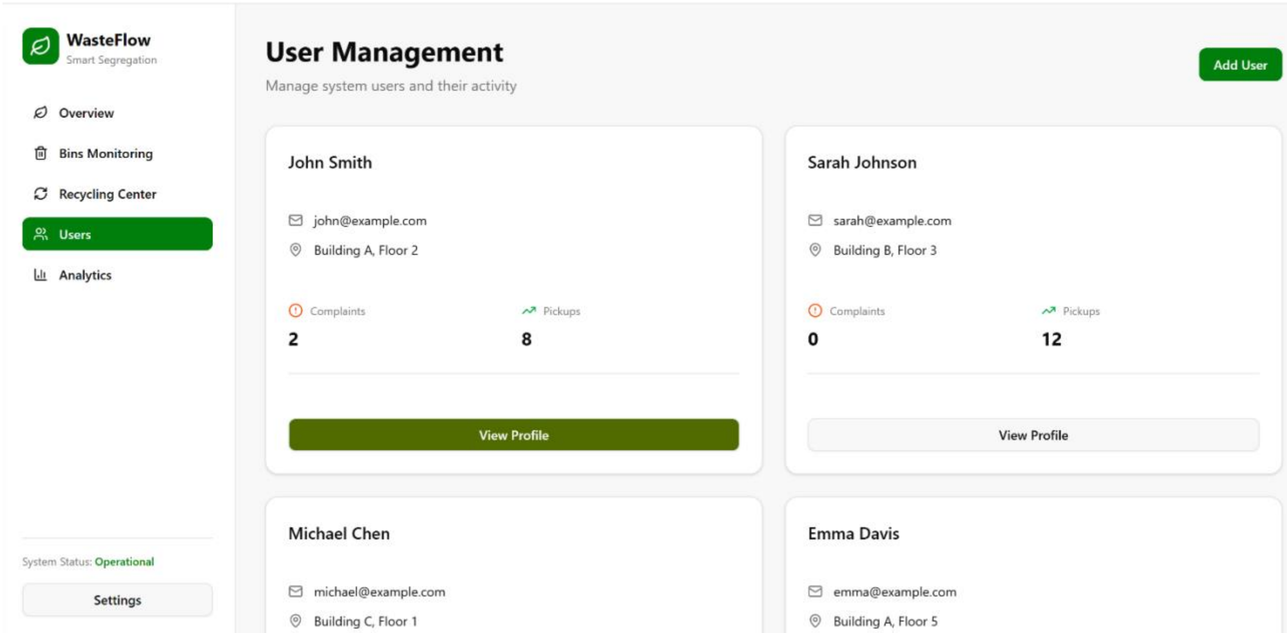


Fig 5.4 User Handling

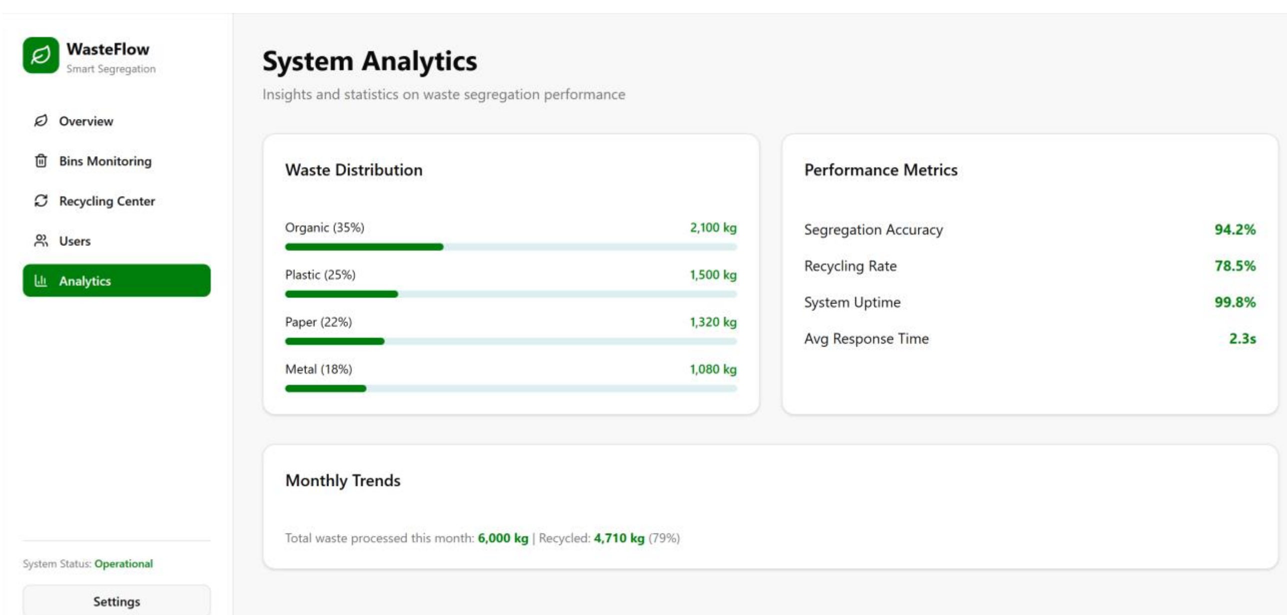


Fig 5.5 System Analytics