Product Description

1. Waste Generation & Smart Bin Usage

- Citizens dispose waste into smart bins categorized for paper, plastic, metal & glass, organic waste, and hazardous materials (for institutions).
- Each bin has a barcode that users can scan when disposing waste, ensuring traceability and adding points to their profiles if the waste is correctly classified.
- If an item is placed in the wrong bin, the system issues a penalty (point deduction) and notifies the manager, so that this bin is checked again in the recycling facility.
- Bin capacity is monitored using sensors, which notify the manager when bins approach their limits. These sensors also make possible the scanning of waste when disposed to check whether they are of the proper type.

2. Waste Collection & Transportation Optimization

- The system provides a service territory map that marks pickup locations, institutions, and recycling facilities.
- Waste collection is optimized using statistics-based scheduling that predicts waste accumulation based on past data and adjusts pickup schedules accordingly.
- Collection routes are optimized using Google Maps, ensuring efficient vehicle dispatching and special routes for institutions that require hazardous waste handling. There is a different vehicle for institutions.
- In extreme weather conditions, the system adjusts collection schedules and notifies operators and citizens.
- Garbage collectors receive real-time notifications about their assigned routes and pickup schedules.
- Real-time vehicle tracking allows managers to monitor collection operations.

3. Recycling & Waste Processing

- The vehicle has 5 containers where the 4 respective bins are divided and the last one is for the bins that alerted wrong disposal (they need to be checked again).
- Waste is transported to the recycling facility, where the contents of the 5^{th} container of each vehicle undergo additional scanning and classification to ensure proper segregation. Also, glass is further divided from metal.
- Institutions have dedicated vehicles for hazardous waste collection.
- Each material undergoes its respective process of recycling after they are all divided into their proper material types, for ex organic waste goes into composting process.
- The system tracks the recycling process in real-time, including waste conversion rates and financial returns from recycled materials.

4. User Interaction & Awareness

- Citizens have personal profiles that store their waste disposal activity, accumulated points, rewards and pickup requests.
- A reward system grants users points based on the amount and type of waste they dispose of correctly. Points can be redeemed for discounts or vouchers at partnered businesses.
- Points are gained from waste disposal (weight/density of material), donations or participation in events.
- The system enables pickup requests for large or special waste disposals.
- Users can upload an image of an item, and the system will determine the appropriate bin for disposal, if the user has doubts where to put that material.
- The system integrates with other applications to show advertisements.
- Users can submit reports and feedback regarding waste management issues.

5. Compliance, Reporting & Analytics

- Citizens are billed automatically based on waste collection services, with various payment methods available.
- The system generates detailed reports and analytics, tracking waste disposal by area, carbon footprint, recycling profits, and government funding contributions.
- Predictive analytics help forecast future waste generation trends for better resource planning.

6. Community & Educational Initiatives

- The system organizes awareness events such as clean-up campaigns on special occasions like Earth Day.
- Users can donate used items at designated centers and receive points when scanned. When a considerate amount is collected, we give them to donation agencies.
- A leaderboard ranks users and communities based on their results on our events, with rewards for top 3 performers (funded by government).

General Purpose of the Product

The purpose of this Waste Management System is to create a smart, efficient, and sustainable solution for waste collection, disposal, and recycling. By leveraging automation, real-time monitoring, AI-driven optimization, and citizen engagement, the system aims to:

- Enhance waste collection efficiency through optimized scheduling, smart routing, and predictive analytics.
- Promote proper waste segregation and recycling using smart bins, traceability features, and real-time waste classification.
- Encourage citizen participation by offering reward-based incentives, personalized waste tracking, and community engagement initiatives.
- Ensure environmental sustainability by reducing landfill waste, tracking carbon footprints, and supporting recycling processes.
- Improve compliance and reporting through automated billing, regulatory tracking, and data-driven analytics.

By integrating technology, community engagement, and sustainability efforts, the system fosters a cleaner environment, reduces waste management costs, and contributes to a more circular economy.

Product Context

The Waste Management System is a smart, interconnected platform that interacts with various external systems and technologies to ensure efficient waste collection, processing, and citizen engagement.

The system interfaces with multiple third-party services to enhance its functionality:

- Navigation & Mapping Services (e.g., Google Maps) – Used for optimizing waste collection routes.
- Weather Forecast APIs – Helps adjust collection schedules based on extreme weather conditions.
- Payment Gateways – Supports online billing and payment processing for waste services.
- Business Integration – Allows users to redeem recycling points at partnered stores
- Government & Regulatory Databases – Ensures compliance with waste management laws and policies.
- Machine Learning & AI Systems – Utilized for predictive analytics, waste classification(sensors), and collection optimization.

While the system can function independently as a self-contained platform, its modular design allows integration with municipal waste management systems,and community-driven recycling programs.

The system includes web and mobile applications for user interaction, smart bins for automated monitoring, and a cloud-based infrastructure for real-time data processing and reporting.

Overall, this product is not standalone but rather an integrated, scalable system that enhances waste management through cross-platform collaboration and technological synergy.

User Levels

1. Citizens :

- Dispose of waste correctly using smart bins categorized by material type.
- Scan bin barcodes to earn reward points for proper waste separation.
- Request waste pickups for large or special disposals.
- Receive notifications about collection schedules, environmental awareness programs, and system updates (if they allow those notifications).
- Participate in community recycling events and donate used items at designated centers.
- Access their personal waste profile to track points, disposal history and rewards. Also, to find in which bin a product belongs by uploading a photo of it.

2. Garbage Collection Employees :

- Follow optimized collection routes based on schedules and real-time updates.
- Receive notifications for daily pickups and special requests.
- Use GPS tracking and route maps to navigate efficiently.
- Collect waste from smart bins and institutions, putting each bin's material in the correct container.
- Transport waste to recycling and processing facilities.

3. Company Managers (System Administrators) :

- Oversee system operations, waste collection schedules, and vehicle tracking.
- Send all the notifications to users or even employees.
- Monitor real-time data and analytics on waste generation, recycling efficiency, and system performance.
- Ensure compliance with environmental regulations and municipal waste management policies.
- Manage citizen reports, feedback, and issue resolution.
- Handle business integrations, allowing users to spend their points there.
- Maintain system security, scalability, and third-party integrations (e.g., payment processing, Google Maps, AI-based waste classification, weather updates).

4. Recycling and Processing Facility Operators :

- Receive and process waste transported from collection vehicles.
- Conduct secondary waste classification using AI, sensors, or manual sorting to ensure proper recycling, just for the container that has the waste taken from the bins that alerted wrong disposal.
- Track recycling efficiency, waste diversion rates, and facility operations.
- Handle hazardous waste disposal in compliance with safety regulations.
- Report waste processing data to system administrators for analytics and sustainability tracking.

Actors and Goals

Actors	Goals
Citizens	To make requests for waste collection and enter feedback of the whole process
Waste collectors	To collect waste effectively and report necessary information for better management.
Management (Process Manager)	To manage the waste collection process, assign tasks, and manage reports efficiently.
Recycling Facility Operators	To handle the recycling of different materials that come within the vehicle.
Sensors	To check capacity and assist in proper waste segregation
GSI	To provide accurate geographical map provided with all possible destinations and info per each. Also, must be able to provide the route optimization.
Institutions staff	To make requests for collection of specified (medical/electronic) waste collection
Database	To store and manage data related to citizens and waste collection.
Internet Site	Enable stakeholders get access to all features
Phone	Enable stakeholders use the app
App	Enable stakeholders get access to all features
Servers	Allow internet to run
Donation Agencies	Responsible for donating all collected stuff that we give them
Government authorities	Responsible for waste management policies and regulations and giving funds

System Requirements

Functional Requirements

IDENTIFIER	PRIORITY	REQUIREMENT
****1. WASTE COLLECTION & TRANSPORTATION OPTIMIZATION****		
REQ-1: Working Zone Map	2	The system shall provide a service territory map with pickup destinations, institutions location, recycling facility location and adding new location if bins are added.
REQ-2: Statistics-Based Collection Prediction	3	The system shall use the statistics generated to predict waste collection demands and optimize schedules.
REQ-3: Schedule and Plan	2	The system shall provide all the scheduled pick-ups that are programmed in normal conditions and also the special pick-ups (requested by users)
REQ-4: Road Optimization	3	The system shall find the best route (using google maps) for rubbish collection and recycling facility delivery. There will be a special vehicle with a different optimized route that collects the waste materials of institutions.
REQ-5: Notification for Collection	3	The system shall notify garbage collectors for daily pickups based on their work schedules and job position.
REQ-6: Vehicle Tracing	3	The system will provide a real-time map of all pickup vehicle locations for the manager to trace them.
REQ-7: Weather-Based Collection Adjustment	3	The system shall integrate with real-time weather forecast services to monitor extreme weather conditions and adjust waste collection schedules and routes. It shall notify operators and citizens about schedule changes due to hazardous conditions such as storms, heavy snowfall, or extreme heat, ensuring safety, operational efficiency, and service continuity.
****2. SMART WASTE BINS & CITIZEN ENGAGEMENT****		
REQ-8: Barcode for Traceability	2	Each bin will have a distinct code that is scanned to track pickup destinations and so that users can scan it and automatically all their waste disposal activity and points are recorded in their own profile
REQ-9: Bin Capacity Control	3	The system shall detect bin capacity using sensors and notify the manager.
REQ-10: Citizen Profile	2	The system shall maintain a personal profile for each citizen to keep track of their points, allow them to make pickup requests, get notifications for events, donations...

REQ-11: Smart Bin Categorization	2	The system shall deploy 4 smart bins per area: paper, plastic, metal & glass and organic waste bins. As for institutions, they will have their own bins including the one for hazardous waste, and their own vehicle for collecting them.
REQ-12: Reward Points System	3	The system shall track users' waste thrown each time in our smart bins and grant reward points that can be redeemed. Of course, all people can throw waste in our bins but only those logged in (that scan the barcode) will gain points (if all waste is in accordance with the bin material), otherwise they lose points. Points will be calculated weight of all the waste over product density. Points can be also gained from donations or from being part of our events.
REQ-13: Dynamic Pricing for Waste	2	The system shall calculate dynamic pricing based on the weight and type of waste (in case of requested pickups).
REQ-14: Smart Bin Error Handling	2	If waste is incorrectly placed in a bin, the system will notify the user, issue a small penalty (reduction in points), and alert the manager for this bin. When the collection vehicle comes this bin will be put in a special division of the vehicle. It will not be mixed with paper division if it was a paper bin for example.
****3. RECYCLING & WASTE PROCESSING****		
REQ-15: Waste Further Processing and Verification	2	Upon arrival at recycling facility, the system shall conduct further scanning and classification using sensors, AI, or manual inspection to ensure proper segregation. Especially for the waste collected from bins that alerted wrong waste disposal.
REQ-16: Recycling Management	2	The system shall take care of different waste properly for proper disposal. For this reason, each of our vehicles has 5 containers: 4 for each bin and the 5^{th} is for the bins that alerted wrong waste disposal (this one is further scanned and divided properly). Also, institutions have their own vehicle to collect their waste including hazardous materials. Each waste undergoes a different process of recycling.
REQ-17: Recycling Process Tracking	3	The system shall track the recycling process and provide real-time data on waste conversion rates and profits.
****4. USER INTERACTION & AWARENESS****		
REQ-18: Report & Feedback	3	The system shall allow users (citizens and employees) to report any issues or give feedback.
REQ-19: Informative Notifications	3	The system shall send notifications to all users, but each user has the option to select which notifications he wants to receive.
REQ-20: Waste Classification Assistance	3	The system shall allow users to upload an image of a product and automatically determine the appropriate waste bin for disposal based on image recognition technology.

REQ-21: Pickup request	3	The system shall enable citizens to request and schedule pickups for their own waste.
REQ-22: Integration with Businesses	3	The system shall integrate with different businesses, like supermarkets, and give their customers the ability to use their points there. This is done by giving them vouchers.
REQ-23: Integration with Other Apps	3	The system shall integrate with different applications for advertisements.
REQ-24: Collaboration with Donation Agency	3	The system shall provide 2 main centers for users to enter their used stuff there (and if they scan the barcode their points increase). When a reasoning amount is collected, they are sent to the donation agency.
REQ-25: Recycling Leaderboard and Reward System	3	The system shall rank users or communities based on their results of each event organized by us. And the 3 first places will get rewards. (All this process is in collaboration with the government)
****5. COMPLIANCE, REPORTING & ANALYTICS****		
REQ-26: Automated Billing	2	The system shall automatically calculate bills for citizens based on waste pickup and services.
REQ-27: Pay Bill	1	The system shall let citizens pay their waste bills using different methods.
REQ-28: Report Analytics	2	The system shall generate overall statistics, like : amount of waste disposal for each area and their carbon footprint, profits from recycling, funds from government…
REQ-29: Predictive Waste Generation of Different Areas	3	The system shall analyze past waste trends (using reports) to predict future generation and optimize resource allocation.
****6. COMMUNITY & EDUCATIONAL INITIATIVES****		
REQ-30: Organization of Events	**3**	The system shall organize events, especially on given dates like Earth Day, which may include garbage collection or raising awareness programs.

Non-Functional Requirements

IDENTIFIER	PRIORITY	REQUIREMENT
REQ-1: Sensors	5	Sensors will be applied near landfills which will help the process of sorting bins and segregation. Also, sensors will be used inside bins in order to identify capacity of them.
REQ-2: Database	5	The system shall have a database of all homes and bin accounts in order to save important information for waste management process.
REQ-3: User-friendly Interface	4	The system interface will have a simple and intuitive design to enhance user experience. Each screen will follow a consistent layout to minimize user confusion.
REQ-4: Real-time Updates	4	The system will provide real-time updates to users on collection schedules, bin statuses, and service requests.
REQ-5: Environmental Impact	3	The waste management system will prioritize environmentally friendly practices, such as optimizing collection routes to minimize fuel consumption and emissions
REQ-6: Meet legislative requirements of waste management	5	The system will comply with relevant waste management regulations and standards, ensuring that all operations meet legal requirements.
REQ-7: Data Security	5	The system will implement robust security measures to protect sensitive data, including encryption of data transmission and secure storage practices.
REQ-8: System Availability	5	The system shall ensure a high level of **availability**, with at least 99.9% uptime to ensure continuous operation, especially during critical hours when waste collection is taking place.
REQ-9: Performance	5	The system shall provide fast response times for user interactions and backend processing. **Response times** for key functionalities (such as bin pickup requests or vehicle tracking) should not exceed 3 seconds.
REQ-10: Scalability	4	The system shall comply with **accessibility standards** to ensure that it is usable by individuals with disabilities, including those with visual and motor impairments.
REQ-11: Backup & Recovery	5	The system shall include a comprehensive **backup and disaster recovery** plan, with daily backups and the ability to restore data in the event of a system failure or outage.
REQ-12: Internationalization & Localization	4	The system shall support **multiple languages** and regional customizations, allowing the system to be used in different geographical locations with language, currency, and legal adaptations.
REQ-13: Integration with Third-Party Systems	4	The system shall be designed to easily integrate with **third-party systems** such as payment gateways, government databases, or other waste management software via APIs.
REQ-14: System Monitoring & Alerts	4	The system shall include **real-time monitoring** tools to track system performance and **alert administrators** to any issues such as system malfunctions, service disruptions, or security breaches.

REQ-15: Auditing & Traceability	5	The system shall provide full **audit trails** for all critical actions, such as waste collection, payments, and data access, to ensure accountability and traceability.
REQ-16: Load Balancing	4	The system shall utilize **load balancing** techniques to distribute system traffic efficiently across servers, ensuring optimal performance even during peak usage times.
REQ-17: User Authentication & Authorization	5	The system shall support **strong user authentication**, including two-factor authentication (2FA), to ensure secure access. **Role-based access control (RBAC)** will be implemented to ensure users only have access to the features they are authorized for.
REQ-18: Customizability	3	The system shall allow **customizable settings** for waste management companies, enabling them to tailor schedules, billing rates, and notification preferences based on local regulations and needs.
REQ-19: Energy Efficiency	3	The system shall be designed to be **energy-efficient**, minimizing the environmental impact of the hardware used to run the system and optimizing power consumption.
REQ-20: Data Retention & Disposal	4	The system shall follow strict **data retention policies**, ensuring that personal and sensitive data is kept only as long as necessary, and properly disposed of in compliance with legal and regulatory standards.

FURPS+ Table

FURPS (Priority Five)	
Functionality	• Features sensors that detect bin capacity and help segregation of waste materials. • Make use of GSI subsystem for maps and routes and GPS for tracing vehicles. • Allow citizens to make pickup requests for waste disposal. • Must be able to generate accurate reports on waste collection, processing, and recycling. • Allow users to enter reviews about services and functionality.
Usability	• The user interface should follow accessibility guidelines to ensure usability for all users, including those with disabilities. • The system should provide clear and intuitive error messages to assist users in troubleshooting. • Include guidelines for users to easily understand the waste management process and system features. • The system should maintain simplicity in both user interface and interactions.
Reliability	• The system should decrease rates of system failure by using reliable hardware and software components. • The system shall not lead to data loss, ensuring proper data management practices. • The system must be able to recover from failures within 5 minutes without data loss.

Performance	• The system must respond to user requests within 2 seconds under normal load conditions. • Should be able to afford high workload, such as thousands of user requests without decreasing performance. • Sensors shall perfectly work in order to give 100% detection accuracy. • Location of homes shall be 100 % accurate and system shall have access and information about all possible routes.
Supportability	• The system will be supported with regular maintenance and updates to address bugs, security vulnerabilities, and improve functionality as needed. • The system will include diagnostic tools to facilitate troubleshooting and diagnosis of issues, allowing support personnel to quickly identify the root cause of problems. • A feedback mechanism will be provided to gather input from users, allowing for continuous improvement of the system and support processes. • Code should be well-documented to facilitate maintenance and future enhancements.
Availability	• The system must be available 24/7 to handle pickup requests, user interactions, and waste management services. • The system should ensure redundancy in critical components (servers, databases) to minimize downtime. • The system should be scalable, allowing for future expansion in terms of user base, geographical areas, and services offered.
Security	• The system must ensure data privacy and secure handling of user information in compliance with relevant regulations (e.g., GDPR, local data laws). • The system must implement secure authentication for users, especially for administrative access and waste management interactions. • Data encryption must be used for communication between users, devices, and servers. • The system must implement regular security audits and have measures in place to prevent unauthorized access or data breaches.