IC-201P

PROJECT REPORT- GROUP 07

WASTE COLLECTION MANAGEMENT SYSTEM FOR IIT MANDI

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INTRODUCTION TO THE PROBLEM STATEMENT AND ITS NEED

IIT Mandi, nestled amidst the pristine landscapes of Himachal Pradesh, is committed to fostering a sustainable and environmentally conscious campus. However, the growing population of students, faculty, and staff has led to a significant increase in waste generation, posing a challenge to the campus's ecological balance.

The diverse nature of waste produced on campus, ranging from food scraps to plastics and electronic waste, demands a comprehensive and efficient management system. Currently, the lack of a structured waste collection and disposal process contributes to environmental pollution and negatively impacts the campus's overall well-being.

To address these issues, it is imperative to implement a robust waste management system that includes:

- **Segregation at Source:** Encouraging students, faculty, and staff to segregate waste into biodegradable, non-biodegradable, and recyclable categories at the point of generation.
- **Efficient Collection:** Establishing a regular and efficient waste collection system to ensure timely removal of waste from various campus locations.
- **Proper Disposal and Recycling:** Implementing appropriate disposal methods for different waste types, including composting organic waste and recycling materials like plastics and electronics.
- **Environmental Education:** Promoting awareness and education about waste management practices among the campus community to foster a culture of environmental responsibility.

POSSIBLE SOLUTIONS

1. **Dustbin Modification Approaches**

- **Compressed Air-Powered Trash Collection**: This concept involves designing bins with compressible air bags that compress waste to reduce its volume. By decreasing the space occupied by waste, it helps in addressing storage issues and allows for less frequent waste collection.
- **Solar-powered Trash Compactor Bin**: These bins use solar power to compact the waste inside them, reducing the volume of trash collected. By increasing the bin's capacity, it lowers the frequency of waste collection while being energy-efficient and sustainable.
- **Smart Waste Segregation Bins with Arduino**: Utilizing Arduino microcontrollers and sensors, this system automatically detects the type of waste (organic, recyclable, non-recyclable) and opens the appropriate compartment for segregation, improving efficiency and accuracy in waste management.

2. **App Integration Approaches**

- **App for Waste Collection Management**: This is a versatile app that can manage various waste-related tasks, such as tracking waste collection, monitoring bin status, and even providing users with insights on how to reduce waste generation. It can be integrated with sensors in bins to offer real-time updates.
- **Location-based Garbage Management System**: This idea involves capturing a photo of filled trash cans along with their location and uploading them to an app. The system allows users to notify authorities when bins need to be emptied, making the process more efficient.

- **Smart Bin with Sensors and QR code**: These bins have built-in sensors that detect when they are full and send an alert to waste management personnel, ensuring timely waste collection without manual checks.
- **Up cycling and Reverse Vending App**: This app encourages users to recycle and upcycle waste by offering rewards for recycling containers via reverse vending machines. It also allows users to upload creative ideas for reusing waste.

3. **Recycling and Reusing Approaches**

- **Plastic Waste to 3D Printer Filament**: This approach focuses on recycling plastic waste by converting it into filaments used for 3D printing. It promotes a circular economy by repurposing waste materials for the creation of new objects and prototypes.
- **Waste to Brick**: The idea involves using waste materials to form bricks, which can be used in construction. This promotes sustainable building practices and reduces the environmental impact of traditional brick manufacturing.
- **Integrated Approach for Organic and Plastic Waste**: This involves combining different techniques, such as using plastic bottles to create greenhouses while employing anaerobic digestion to convert organic waste into useful by-products like biogas and compost.

4. **Advanced Waste Processing Approaches**

- **Automated Litter Detection Drone**: This concept utilizes drones equipped with cameras and AI to detect litter across campus grounds. The drone can either notify personnel of the litter's location or autonomously collect and dispose of it.
- **AI-Assisted Recycling**: AI technology is used to sort waste in recycling

centers. Using image processing, the AI system can identify different types of waste and separate them accordingly. This process can be enhanced by using vacuum systems for picking up waste.

5. **Sustainability-Oriented Approaches**

- **Compost Pit System with Automated Aeration**: This system accelerates the composting process by automatically regulating airflow in compost pits. By doing so, it improves the efficiency of organic waste decomposition and supports sustainable waste management.
- **Converting Organic Waste into Biogas**: Organic waste is decomposed in controlled conditions to produce biogas, which can be used as an alternative to LPG. This approach not only reduces waste but also provides a renewable energy source.

Statistical analysis of solutions

A: Cost of the Idea ((30000/Amount) *10)

B: Availability of Parts

C: Ease of Manufacturing/Assembly

D: Fulfilment of Purpose

E: Ergonomics / Aesthetics

F: Integration of Power Source

G: Integration of Electronics

H: Timebound Manufacturing Feasibility

I: Maintenance/Servicing Cost

J: Overall Feel/Confidence in the Solution

K: Overall Score

Sr. no.	A	B	C	D	E	F	G	H	I	J	K
1	15	7	7	11	10	8	8	10	7	10	93
2	12	9	7	10	9	9	9	9	8	7	89
3	7	10	10	8	7	7	7	8	6	8	78
4	12	8	9	7	10	10	9	10	9	9	93
5	7	6	5	8	7	6	6	7	5	5	62
6	13	10	10	10	10	10	10	10	10	10	97
7	10	10	9	8	8	10	10	10	10	9	94
8	15	10	10	9	9	10	10	10	10	10	98
9	10	6	7	9	9	7	8	10	6	8	85
10	10	8	7	9	7	7	7	8	5	6	74
11	6	6	5	10	8	7	7	7	7	7	70
12	11	9	8	10	7	7	7	7	6	7	79
13	13	10	10	10	9	10	10	9	9	8	98
14	11	9	8	10	10	9	9	10	8	8	91

OUR PROPOSED SOLUTION

The proposed solution is a **Smart Waste Segregation Bin** designed to enhance waste collection efficiency at IIT Mandi. The bin is equipped with sensors to automatically detect the type of waste—biodegradable, non-biodegradable, or other— and segregate it accordingly. An accompanying mobile app offers users multiple features for interaction and engagement, supporting the institution's goal of promoting sustainable waste management.

Smart Bin Features:

1.Automatic Waste Segregation:

- The bin features **optical module and sensors** installed centrally to detect the type of waste deposited.
- Based on the detected waste type, the corresponding compartment's **automatic lid** opens to allow correct disposal.
- The waste is segregated into **three categories**: biodegradable, non-biodegradable, and others.

2. Design and Durability:

- Constructed using durable materials such as stainless steel or weather-resistant plastic, the bin is suitable for both indoor and outdoor environments.
- Optional **solar panels** provide a sustainable power source for operating the sensors and motorized lids, reducing energy consumption.

3. App Integration:

- The bin is fitted with **App Integration** to measure its waste capacity in real-time, which is displayed on the app.
- Notifications are automatically triggered to the waste management team when a bin is full, ensuring timely disposal and reducing manual checking

Mobile App Integration:

The smart bin is paired with a mobile application that offers modern features, making waste management at IIT Mandi more efficient and interactive. The app encourages community involvement through:

- **Fullness Indicator**: Users and waste management staff are notified when the bin is nearing full capacity, improving collection efficiency.
- **Real-Time Monitoring**: The app allows for monitoring the fill level of bins across the campus, with alerts for when waste collection is required.
- **Rewards System**: Users can submit waste recycling ideas and earn rewards or points through the app. This feature encourages innovation and active participation in reducing campus waste.
- **Waste Analytics**: The app logs data on the amount of waste generated, providing valuable insights into waste management practices at IIT Mandi. This data will help optimize collection routes and waste reduction strategies.
- **QR Code Access**: Each bin is equipped with a QR code for users to scan. This provides real-time information on the bin's status and motivates users to dispose of waste properly.

Conclusion:

The **Smart Waste Segregation Bin** and its integrated app represent a comprehensive solution of waste management challenges IIT Mandi. With automated segregation, real-time monitoring, and community engagement, the system not only reduces manual labor but also helps minimize the environmental footprint of the camp.

Efficiency Of Our Solution:

The efficiency of our **Waste Collection Management System for IIT Mandi** is driven by its ability to autonomously and accurately identify and segregate waste. The system uses a combination of advanced sensors and algorithms to distinguish between biodegradable and non-biodegradable materials, significantly reducing the manual effort required for waste segregation. By automating the process, the system ensures quicker sorting times, thereby minimizing delays in waste disposal.

Additionally, the system is designed to optimize energy usage, with sensors and actuators that only activate when waste is detected, leading to low power consumption. This contributes to an efficient, low-maintenance solution, promoting sustainability in the waste management process.

Target Area:

The **Waste Collection Management System** is specifically designed for deployment at **IIT Mandi**, with a focus on high-traffic areas such as hostels, academic buildings, and common spaces. These areas generate a diverse range of waste, including food waste, paper, plastic, and metals. The system will be positioned strategically to handle the volume and variety of waste in each location.

By focusing on these high-waste zones, the system aims to ensure efficient waste collection and segregation at the source, reducing contamination and making subsequent recycling and disposal more effective. Expanding this system campus-wide will further enhance the overall sustainability efforts at IIT Mandi.

Benchmarking Of Final Solution

1. Overview of the Proposed System

The Smart Waste Segregation Bin is designed for public spaces like IIT Mandi. It automatically classifies waste into three categories: biodegradable, non-biodegradable, and others. The system uses sensors and a camera to detect the waste type, opening the appropriate bin compartment. A mobile app supports real-time monitoring, user notifications, and engagement, such as alerts for full bins and user feedback options.

2. Market Overview of Smart Waste Management Systems

2.1 Existing Solutions

Several smart bins are currently available, with TrashBot by CleanRobotics being one of the most notable products. TrashBot uses robotics, computer vision, and machine learning (ML) to sort recyclable items like plastic, paper, and aluminium with 95% accuracy. However, TrashBot primarily targets high-traffic areas like airports and stadiums, focusing on separating recyclables from general waste at the point of disposal.

Existing systems like TrashBot emphasize recyclables, often overlooking categories like biodegradable waste. Moreover, TrashBot' s reliance on robotics makes it more suitable for commercial and large-scale environments rather than institutions like universities, where waste management needs to be simple, cost-effective, and durable.

3. Advantages of Our System Over TrashBot and Other Market Solutions

3.1 Waste Segregation at Source

Unlike TrashBot, which focuses on recyclables, our system segregates waste into biodegradable, non-biodegradable, and other categories at the source. This early-stage sorting reduces the burden on later waste management processes, making it more suitable for environments like universities, where quick and efficient disposal is essential.

3.2 Cost Efficiency

Our system utilizes low-cost components like microcontrollers, cameras, and simple motors, making it more affordable compared to TrashBot' s robotics-heavy design. This makes our solution more scalable across an entire institution like IIT Mandi without heavy infrastructure costs.

3.3 Broader Waste Classification

In contrast to TrashBot' s recyclable-centric sorting, our system also includes biodegradable waste segregation, which is crucial for reducing landfill waste and promoting composting initiatives. This broader classification supports better environmental sustainability.

3.4 App Integration and User Engagement

While TrashBot offers real-time monitoring and data collection, our system includes an app that enhances user engagement. It features real-time notifications for bin capacity, a complaint system, and even a rewards program to encourage proper waste disposal. This level of interaction is essential in institutional settings for driving community involvement and efficiency.

4. Comparative Analysis: Technological and Financial Aspects

Feature	Our System	TrashBot (CleanRobotics)
Waste Segregation	Biodegradable, Non-biodegradable, Others	Recyclables Focus
Segregation at Source	Yes (at public places like IIT Mandi)	Yes (primarily recyclables at point of disposal)
AI/ML-based Sorting	Yes (Broader classification)	Yes (Focused on recyclables)
Cost Efficiency	High (Low-cost components)	Medium (High-cost robotics)
Scalability	High (Cost-effective for multiple bins)	High (Costly to scale)
App Integration	Yes (Full integration + user engagement)	Yes (Data collection and monitoring)
Sustainability Focus	Strong (Biodegradable waste included)	Moderate (Focus on recyclables)

5. Long-Term Benefits of Early Waste Segregation

5.1 Reduced Transportation Costs

Segregating waste at the source reduces the need to transport mixed waste to centralized sorting facilities. Only specific types of waste need to be transported, lowering costs and energy usage.

5.2 Energy Savings

Our system's early waste segregation minimizes the need for large, energy-intensive machines for post-disposal sorting, reducing overall energy consumption in the waste management process.

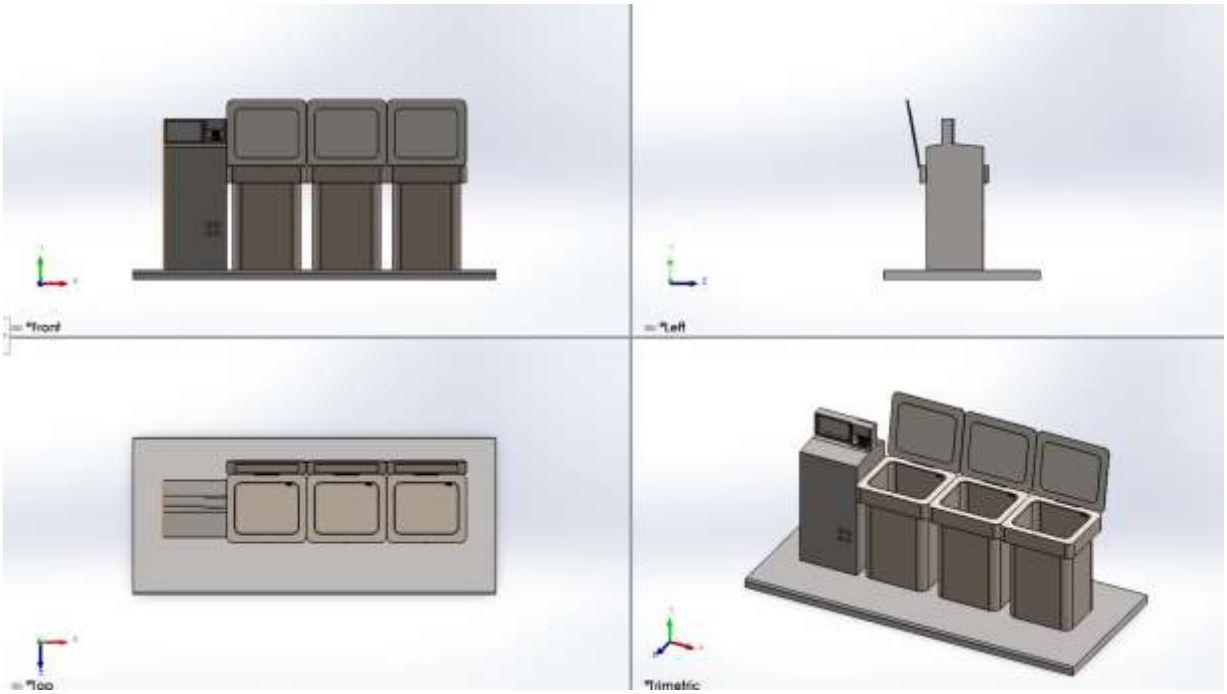
5.3 Sustainability and Environmental Impact

By categorizing biodegradable waste early, our solution supports composting initiatives and reduces the amount of methane-generating organic matter in landfills, further promoting sustainability.

6. Conclusion

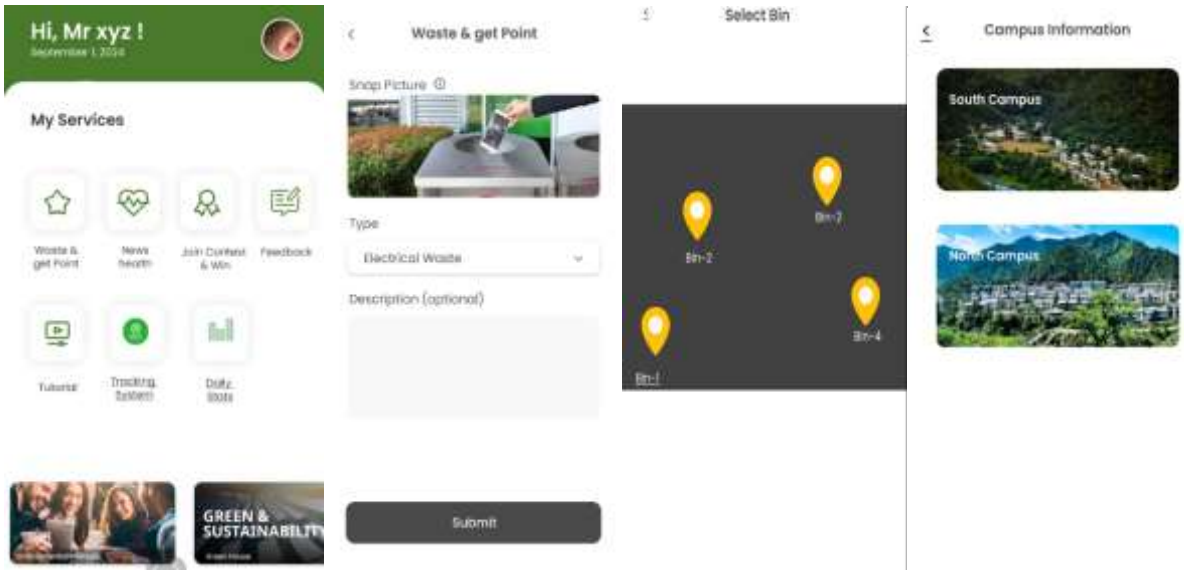
The Smart Waste Segregation Bin for IIT Mandi offers clear advantages over solutions like TrashBot by CleanRobotics. By focusing on waste segregation at the source, broader classification, lower costs, and enhanced user engagement, our system is a more suitable solution for public places and institutions. Its modularity, cost efficiency, and sustainability focus make it an ideal choice for campuses aiming to improve their waste management systems.

Conceptual design (CAD Model):



App Integration

Follow this link to view the detailed app design:



https://www.figma.com/proto/SX6O9vvEQLcScNc1cOV6wi/Waste-Management-Apps-(Community)?node-id=1-60&node-type=FRAME&t=xxxKdC2mPkpmST5X-1&scaling=min-zoom&content-scaling=fixed&page-id=0%3A1&starting-point-node-id=1%3A60

BUDGET

Item Name	Quantity	Approximate Cost	Remarks
Sensor (for waste type detection)	1	₹4,000	Detects whether waste is biodegradable or non-biodegradable
Motorized Lid Mechanism	2	₹3,000	For automatic bin opening based on sensor input
Microcontroller (e.g., Arduino/Raspberry Pi)	1	₹5,000	To control sensors and the motorized lids
Frame and Bin Stand	1	₹2,000	For supporting the two bins and central sensor system
Dustbins (Biodegradable & Non-biodegradable)	2	₹4,500	Separate bins for different types of waste
Welding and Assembly Cost	1	₹1,000	For building and assembling the structure
Power Supply Unit	1	₹1,000	To power the sensors, microcontroller, and motors
Wires and Connectors	-	₹1,500	For connecting components and ensuring stable power
Mobile App Development	1	₹4,000	For a different use case in the project
Testing and Calibration Kit	1	₹2,000	To test and fine-tune the sensor-based system
Miscellaneous (screws, mounts, etc.)	-	₹2,000	Additional small parts needed for assembly
TOTAL		**₹30,000**	

BIBLIOGRAPHY

1) https://robu.in
2) https://www.figma.com/community
3) https://cleanrobotics.com/Trashcon/
4) https://chatgpt.ai