# PROJECT REPORT

## SMART WASTE MANAGEMENT FOR METROPOLITAN CITIES

**TEAM ID:** PNT2022TMID20530

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**TEAM MEMBER:** ANJU JESSICA C

**TEAM MEMBER:** PAUL KEINS B

**TEAM MEMBER:** SELVA MURUGAN P

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# 1. INTRODUCTION

## 1.1 Project Overview

Project Name : **Smart Waste Management System For Metropolitan Cities.**
Category **: Internet Of Things.**

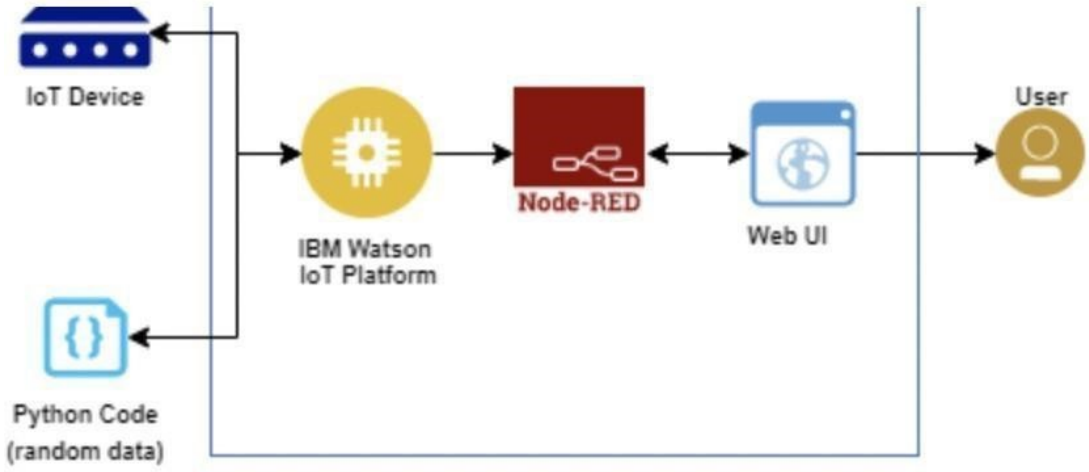
**Project Description:**

1. Garbage level detection in bins.
2. Getting the weight of the garbage in the bin.
3. Alerts the authorized person to empty the bin whenever the bins are full.
4. Garbage level of the bins can be monitored through a web App.
5. We can view the location of every bin in the web application by sending GPS location from the device.

**Skills Required:**

Python, IoT Cloud Platform, IBM Cloud, Node-RED, IBM IoT Platform, IBM Node-red, IBM Cloudant DB

**Technical Architecture :**



## 1.2 Purpose

The main objective of the project is to manage the waste using iot platfrom efficiently. In the proposed system, we intimate the garbage collector about the garbage level before overflowing.

Smart city waste management technology allows workers to empty bins before they become overflowing with trash or recycling, and before infestation becomes an issue. Smart waste sensors can also alert garbage collectors when bins develop unpleasant smells which can then be treated to eliminate odors.Smart waste management control lots of problems which disturbs the society in pollution and diseases.

**Main objectives:**

1. Reduce human intervention
2. Using technology to automate waste management
3. Save time and cost
4. Helps to prevent diseases due to garbage dumps
5. Clean cities and healthy environment

# 2. LITERATURE SURVEY

## 2.1 Existing problem

The traditional way of manually monitoring the wastes in waste bins is a complex and utilizes more human effort, time and cost. Manual waste management causes missed pickups, overflowing bins. This will cause hygiene problems and in order to overcome all these problems, we are proposing the smart waste management system which helps in them anagement of waste without human interaction in order to maintain a clean environment.

## 2.2 References

**Paper 1:**

A Survey on Garbage Collection and Monitoring System for Smart cities using IOT

**Publisher**: Dept of Computer Engineering, Terna Engineering College,Nerul,Navi Mumbai **Reference**: https://www.irjet.net/archives/V5/i2/IRJET-V5I2118.pdf

**Paper 2:**

IOT enabled solid waste management in smart cities

**Publisher:** S. Vishnu 1 , S. R. Jino Ramson 1,2,3,* , Samson Senith 4 , Theodoros Anagnostopoulos 5 , Adnan M. Abu-Mahfouz 6 , Xiaozhe Fan 2 , S. Srinivasan 3 and A. Alfred Kirubaraj 4

**Reference:** https://www.mdpi.com/2624-6511/4/3/53/pdf

**Paper 3:**

IOT enabled intelligent solid waste management system for smart city

**Publisher:**
https://www.semanticscholar.org/paper/IoT-Enabled-Intelligent-Solid-Waste-Management-f or-De wangan/6fbe2679732dbcff5132ed75114137e00dcc53beisher

**Reference:** https://www.irjet.net/archives/V5/i2/IRJET-V5I2118.pdf

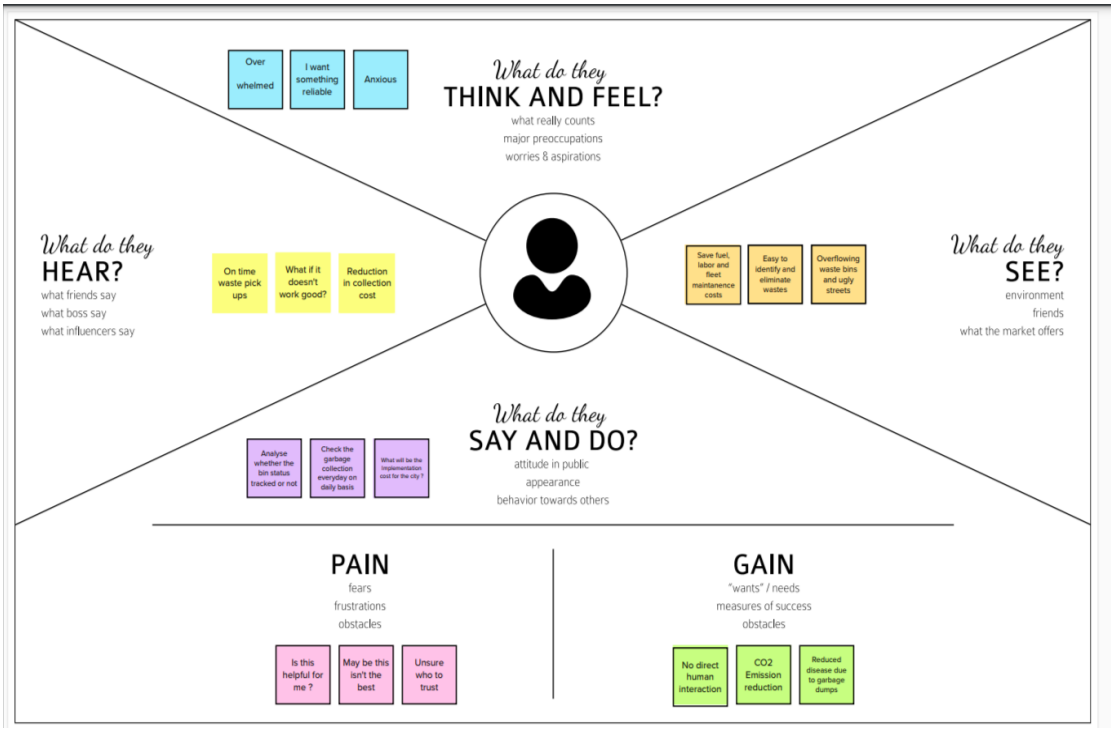
## 2.3 Problem Statement Definition

A reduction in the number of waste collections needed by up to 80%, resulting in less manpower, emissions, fuel use and traffic congestion. A reduction in the number of waste bins needed. Analytics data to manage collection routes and the placement of bins more effectively.

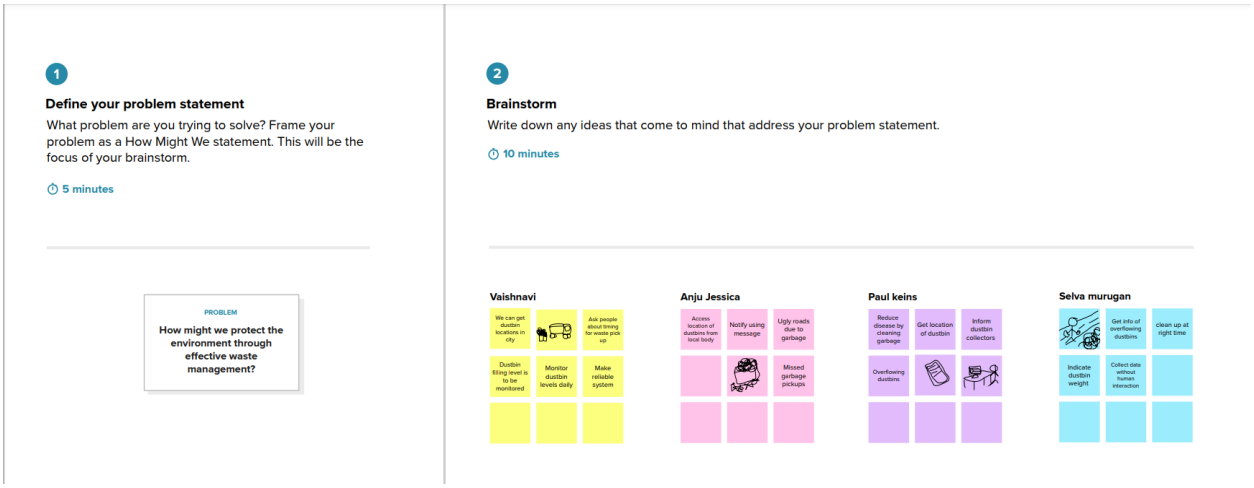
Theme: Internet of Things
Technologies: LoRa, Smart Mesh, RF, WiFi

# 3. IDEATION & PROPOSED SOLUTION

## 3.1 Empathy Map Canvas




## 3.2 Ideation & Brainstorming



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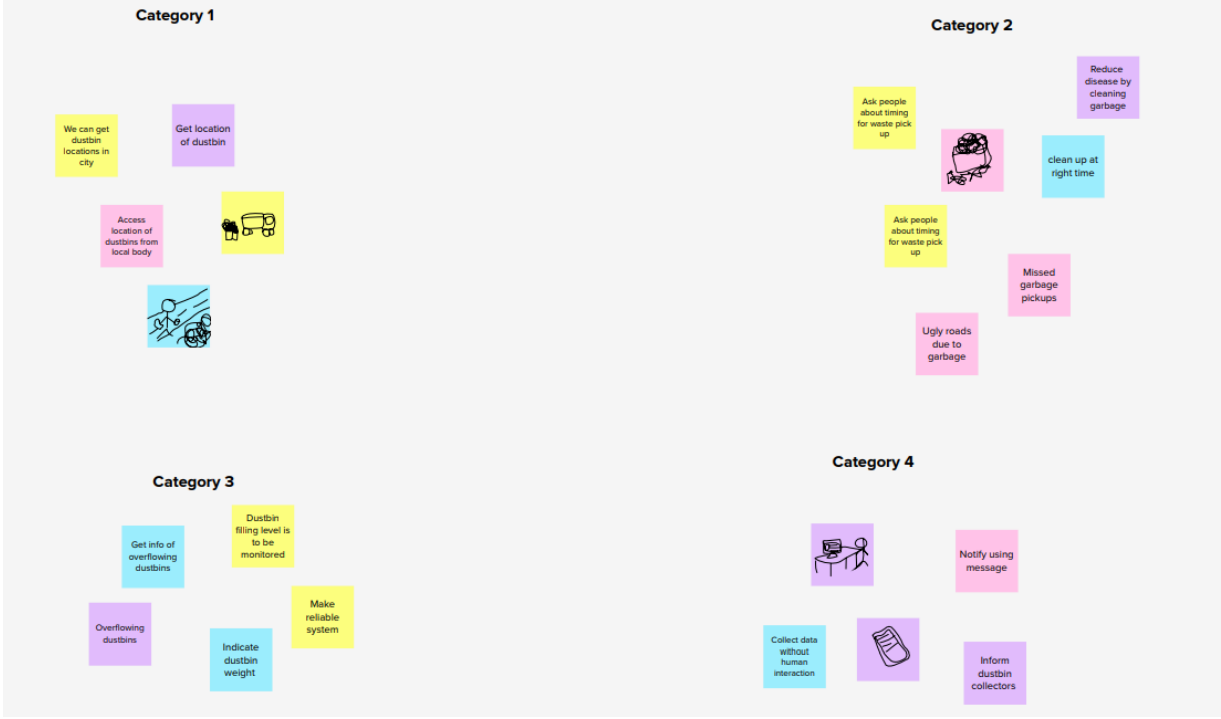
## Group ideas

Take turns sharing your ideas while clustering similar or related notes as you go. In the last 10 minutes, give each cluster a sentence-like label. If a cluster is bigger than six sticky notes, try and see if you and break it up into smaller sub-groups.

20 minutes



Brainstorming session.pdf 1 / 1 26%

4

**Prioritize**

Your team should all be on the same page about what's important moving forward. Place your ideas on this grid to determine which ideas are important and which are feasible.

20 minutes

**Category 2**

Reduce disease by clearing garbage

Ask people about timing for waste pick up

clean up at right time

Ask people about timing for waste pick up

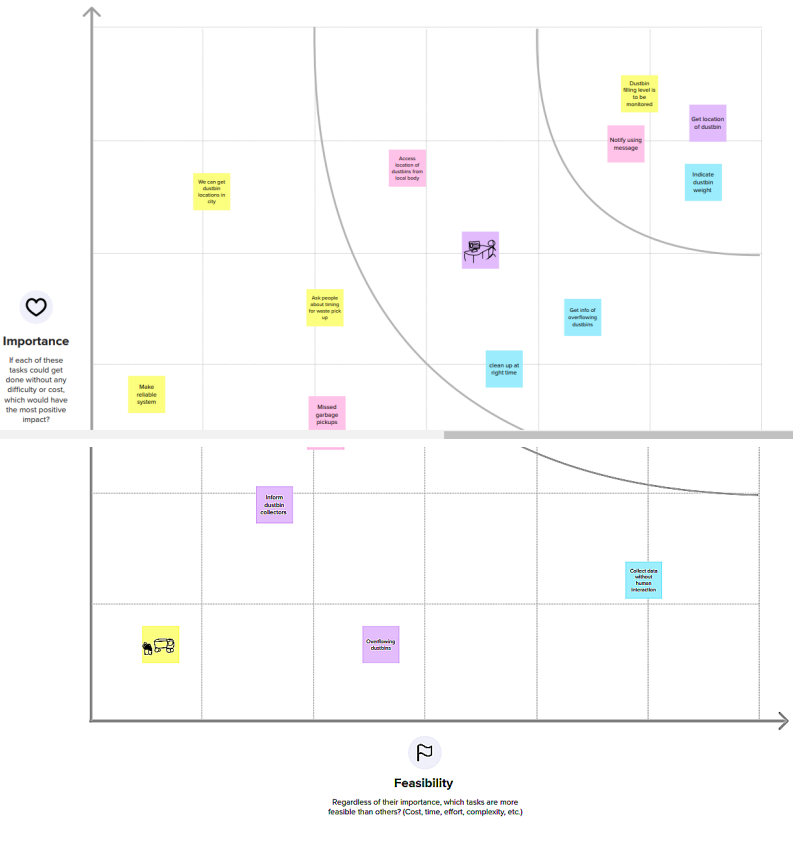
Missed garbage pickups

Ugly roads due to garbage

**Category 4**

Notify using message

Inform dustbin collectors




**Importance**

If each of these tasks could get done without any difficulty or cost, which would have the most positive impact?

**Feasibility**

Regardless of their importance, which tasks are more feasible than others? (Cost, time, effort, complexity, etc.)

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### 3.3 Proposed Solution

| S.No | Parameter | Description |
|---|---|---|
| 1. | Problem Statement | India faces major environmental challenges associated with waste generation and lacking waste collection, transport, treatment, and disposal. conventional systems in India can't manage the volumes of waste generated, and this impacts the surroundings and public health. |
| 2. | Idea/Solution description | A Web application is built where the location of garbage bins, their weight, and the level of the waste collected are monitored. Sensors are fitted in the garbage bins and the required data is collected and acquired from them. The real-time monitoring system indicates when the bin is full and alerts the authorized person to empty the bin. |
| 3. | Novelty/Uniqueness | This project introduces a way to sort out problems like missed pickups and overflowing garbage bins. This prevents the wastage of labor costs, fuel costs, and time. |
| 4. | Social Impact / Customer Satisfaction | Provides healthy Environment<br>Improves hygiene because of timely waste collection<br>Clean cities can be achieved<br>Control the level of pollution and gases |
| 5. | Business Model (Revenue Model) | The software can be offered as a Service model to the Government.<br>The revenue can be generated by charging the customers for the provision of services from waste management to safe disposal and recycling. |
| 6. | Scalability of the Solution | The proposed solution uses sensors where the information about garbage bins can be collected in real-time. Communication technologies enable the authorized person to check data online. |

## 3.4 Problem Solution fit


## 4. REQUIREMENT ANALYSIS

### 4.1 Functional requirement

| FR No. | Functional Requirement (Epic) | Sub Requirement (Story / Sub-Task) |
|---|---|---|
| FR-1 | User Registration | Download the application through online registration |
| FR-2 | User Confirmation | Confirmation via E-mail<br>Confirmation via OTP using the phone number |
| FR-3 | Cloud | Sensor details are updated and stored in the cloud database. |
| FR-4 | Notifier | Notification should send automatically to the registered mail or phone when bins are filled |
| FR-5 | Sensor | Garbage bins are fitted with sensors that will monitor the wastage level. |

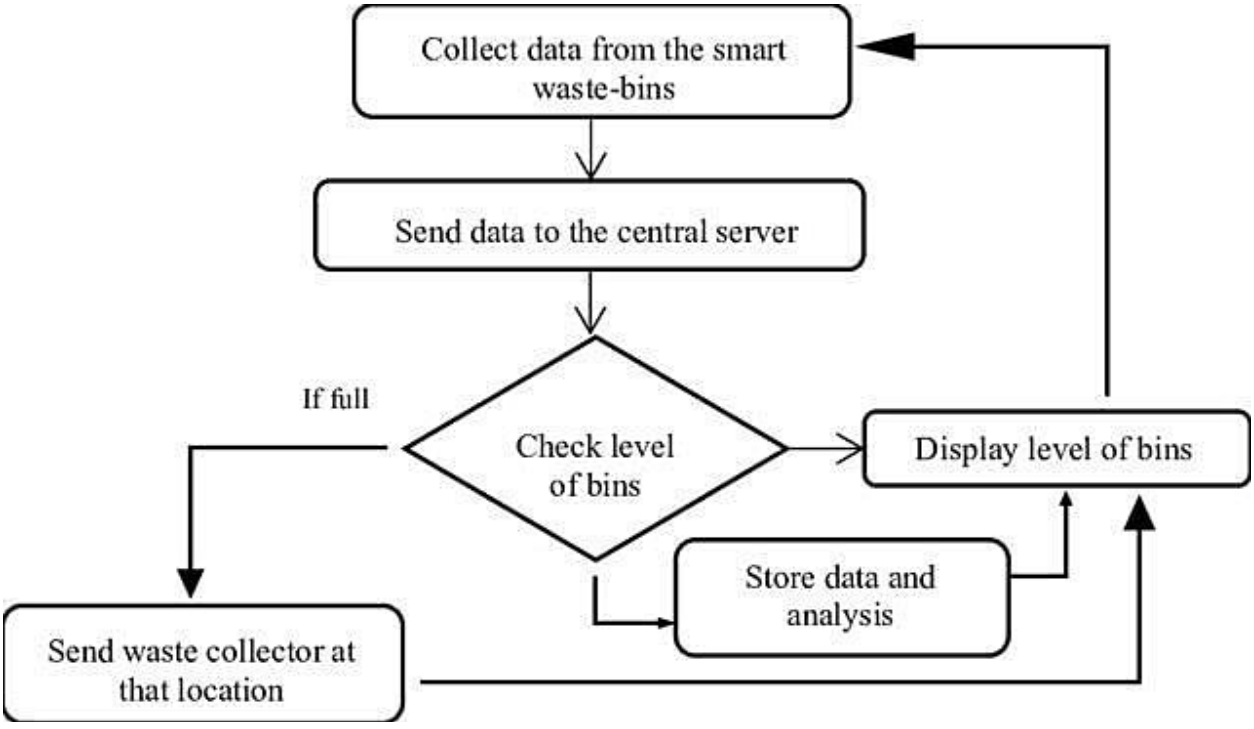
## 4.2 Non-Functional requirements

| FR No. | Non-Functional Requirement | Description |
|---|---|---|
| NFR-1 | **Usability** | It will stop the overflowing of dustbins along roadsides and localities as smart bins are managed in real time. |
| NFR-2 | **Reliability** | Details are maintained in the cloud. |
| NFR-3 | **Performance** | It provides a clean environment |
| NFR-4 | **Availability** | This method is available for all urban people in smart city |
| NFR-5 | **Scalability** | Maintaining garbage bin monitoring and providing guiding service based on the database. |

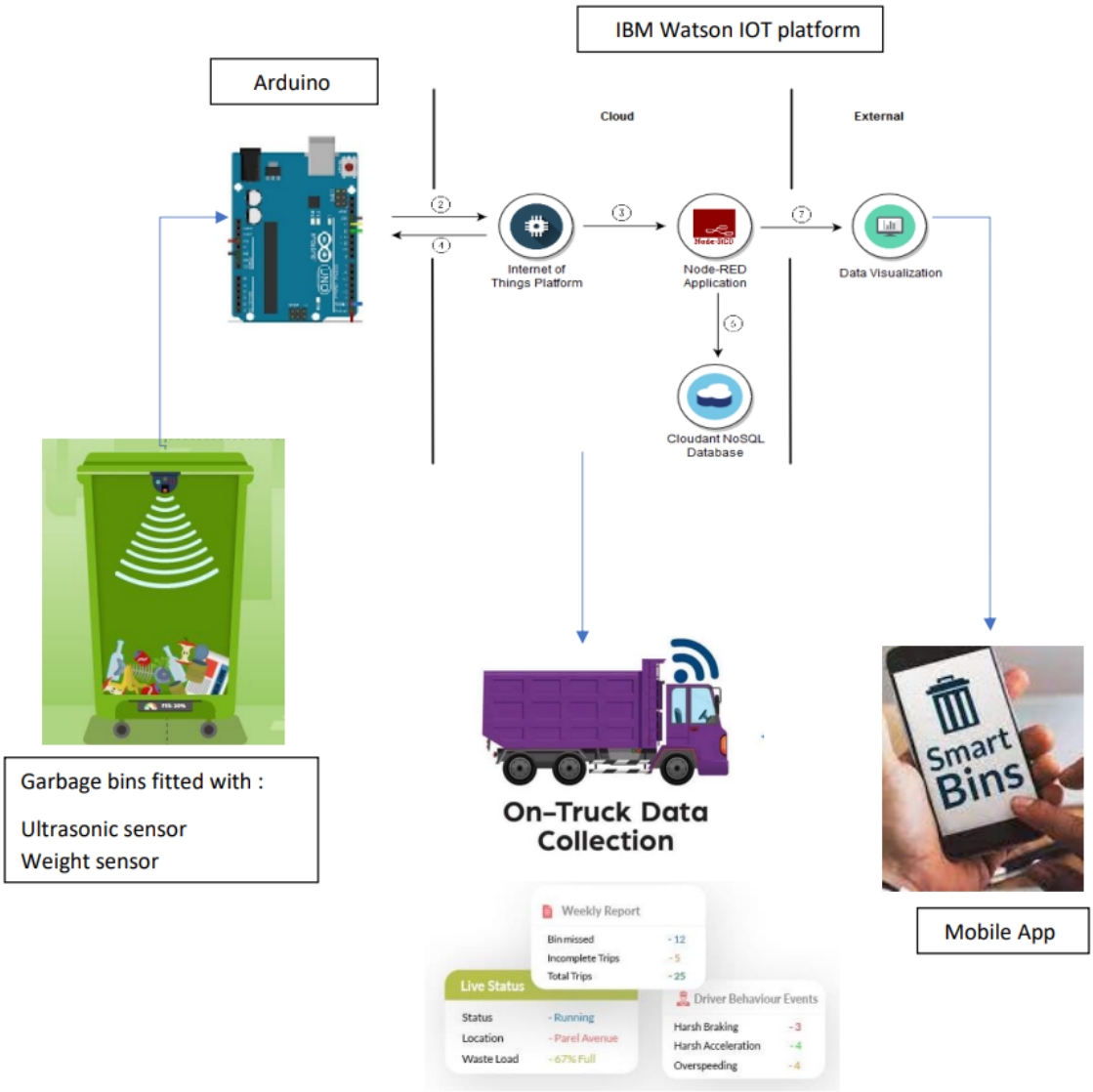
# 5. PROJECT DESIGN

## 5.1 Data Flow Diagrams

A Data Flow Diagram (DFD) is a traditional visual representation of the information flows within a system. A neat and clear DFD can depict the right amount of the system requirement graphically. It shows how data enters and leaves the system, what changes the information, and where data is stored.



## 5.2 Solution & Technical Architecture



### 5.3 User Stories

| User Type | Functional Requirement (Epic) | User Story Number | User Story / Task | Acceptance criteria | Priority | Release |
|---|---|---|---|---|---|---|
| Customer (Mobile user) | Registration | USN-1 | As a user, I can download the application | I can view the data sent by the hardware | High | Sprint-3 |
| Customer (web user) | Registration | USN-1 | As a user, I can view the application web page | I can view the data sent by the hardware | High | Sprint-3 |
| Customer (Data types) | Data viewing | USN-1 | As a user, I can view garbage level monitoring | Data from the hardware | High | Sprint-1 |
| | | USN-2 | As a user, I can view the level of wastage | Data from the hardware | High | Sprint-1 |
| | | USN-3 | As a user, I can view the level of dustbin is detected | Data from the hardware | High | Sprint-1 |
| Customer | Actions | USN-1 | As a user, I can receive notification that appears on the phone | I receive notification | Medium | Sprint-2 |
| | | USN-1 | As a user, I need sensor Access which connected to mobile | Based on the sensor the level of the garbage will monitor | Medium | Sprint-2 |
| Administrator | Storage | USN-1 | As an administrator, I can store the data | All the data are stored in a cloud database | High | Sprint-4 |

## 6. PROJECT PLANNING & SCHEDULING

### 6.1 Sprint Planning & Estimation

| Title | Description | Details |
|---|---|---|
| **Literature Survey & Information Gathering** | Literature survey on the selected project & gathering information by referring the, technical papers,research publication etc . | 28 SEPTEMBER 2022 |
| **Prepare Empathy Map** | Prepare Empathy Map Canvas to capture the user Pains & Gains, Prepare list of problem Statements. | 24 SEPTEMBER 2022 |
| **Ideation** | List the by organizing the brainstorming session and prioritize the top 3 ideas based on the feasibility & importance. | 25 SEPTEMBER 2022 |
| **Proposed Solution** | Prepare the proposed solution document, which includes the novelty, feasibility of idea, business model, social impact, scalability of solution, etc. | 23 SEPTEMBER 2022 |
| **Problem Solution Fit** | Prepare problem - solution fit Document. | 30 SEPTEMBER 2022 |
| **Solution Architecture** | Prepare solution architecture Document. | 28 SEPTEMBER 2022 |
| **Customer Journey** | Prepare the customer journey maps to understand the user interactions & experiences with the application (entry to exit). | 20 OCTOBER 2022 |
| **Functional Requirements** | Prepare the functional requirement document. | 08 OCTOBER 2022 |
| **Data Flow Diagrams** | Draw the data flow diagrams and submit for review. | 09 OCTOBER 2022 |

| | | |
|---|---|---|
| **Technology Architecture** | Prepare the technology architecture diagram. | 10 OCTOBER 2022 |
| **Prepare Milestone & Activity List** | Prepare the milestones & activity list of the project. | 22 OCTOBER 2022 |
| **Project Development - Delivery of Sprint-1, 2, 3 & 4** | Develop & submit the developed code by testing it. | IN PROGRESS |

### 6.2 Sprint Delivery Schedule

| Sprint | Functional Requirement (Epic) | User Story Number | User Story / Task | Story Points | Priority | Team Members |
|---|---|---|---|---|---|---|
| Sprint-1 | Login | USN-1 | As an Administrator, I need to give a user id and passcode to every workers over there in the municipality | 2 | High | Vaishnavi<br>Anju Jessica<br>Paul keins<br>Selva Murugan |
| Sprint-1 | Login | USN-2 | As a Co-Admin, I'll control the waste level by monitoring them via a real-time web portal. Once the filling happens, I'll notify the trash truck with the location of the bin with bin ID | 2 | High | Vaishnavi<br>Anju Jessica<br>Paul keins<br>Selva Murugan |
| Sprint-2 | Dashboard | USN-3 | As a Truck Driver, I'll follow Co-Admin's Instruction to reach the filling bin in short roots and save time | 2 | High | Vaishnavi<br>Anju Jessica<br>Paul keins<br>Selva Murugan |
| Sprint-3 | Dashboard | USN-4 | As a Local Garbage Collector, I'll gather all the waste from the garbage, load it onto a garbage truck, and deliver it to Landfills | 2 | High | Vaishnavi<br>Anju Jessica<br>Paul keins<br>Selva Murugan |
| Sprint-4 | Dashboard | USN-5 | As a Municipality officer, I'll make sure everything is proceeding as planned and without any problems | 2 | High | Vaishnavi<br>Anju Jessica<br>Paul keins<br>Selva Murugan |

**Project Tracker, Velocity & Burndown Chart:**

| Sprint | Total Story Points | Duration | Sprint Start Date | Sprint End Date (Planned) | Story Points Completed (as on Planned End Date) | Sprint Release Date (Actual) |
|---|---|---|---|---|---|---|
| Sprint-1 | 20 | 6 Days | 24 Oct 2022 | 29 Oct 2022 | 20 | 29 Oct 2022 |
| Sprint-2 | 20 | 6 Days | 31 Oct 2022 | 05 Nov 2022 | 20 | 05 Nov 2022 |
| Sprint-3 | 20 | 6 Days | 07 Nov 2022 | 12 Nov 2022 | 20 | 12 Nov 2022 |
| Sprint-4 | 20 | 6 Days | 14 Nov 2022 | 19 Nov 2022 | 20 | 19 Nov 2022 |

## 7. CODING & SOLUTIONING

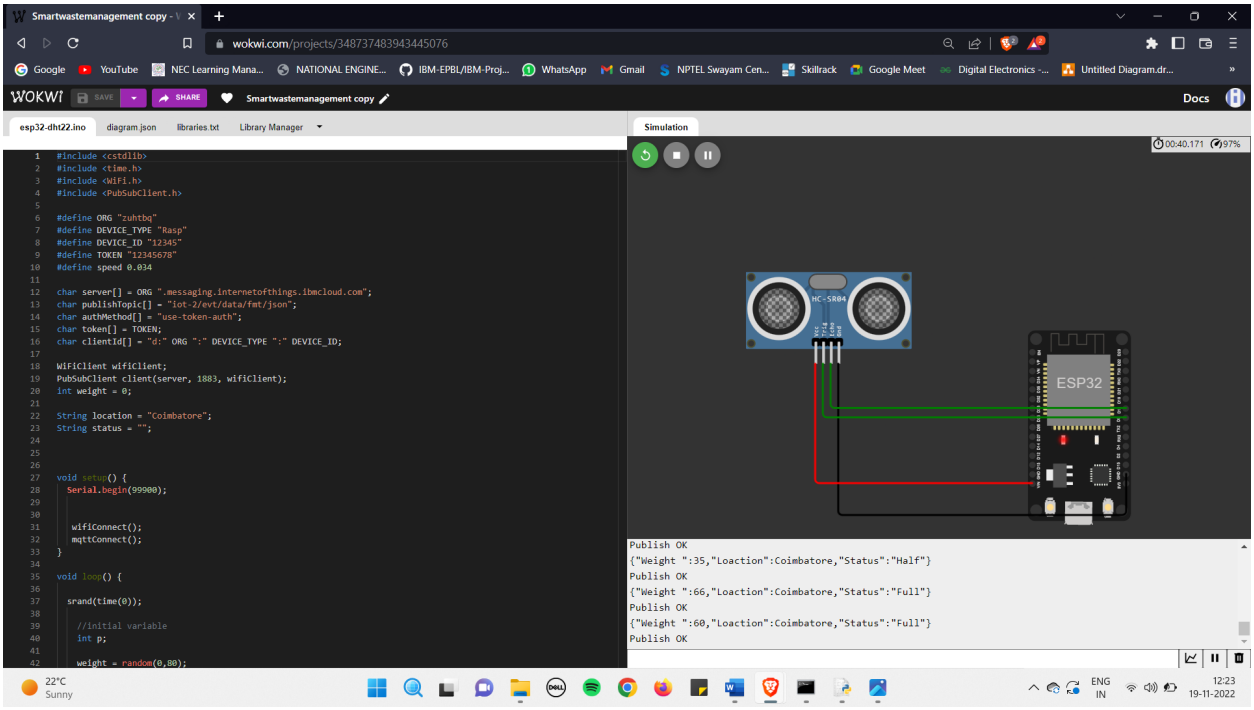
### 7.1 Feature 1

```
#include <cstdlib>
#include <time.h>
#include <WiFi.h>
#include <PubSubClient.h>

#define ORG "evd8ss"
#define DEVICE_TYPE "raspberrypi"
#define DEVICE_ID "1234"
#define TOKEN "12345678"
#define speed 0.034

char server[] = ORG ".messaging.internetofthings.ibmcloud.com";
char publishTopic[] = "iot-
2/evt/data/fmt/json";
char authMethod[] = "use-token-auth";
char token[] = TOKEN;
char clientId[] = "d:" ORG ":" DEVICE_TYPE ":" DEVICE_ID;

WiFiClient wifiClient;
PubSubClient client(server, 1883, wifiClient);
```

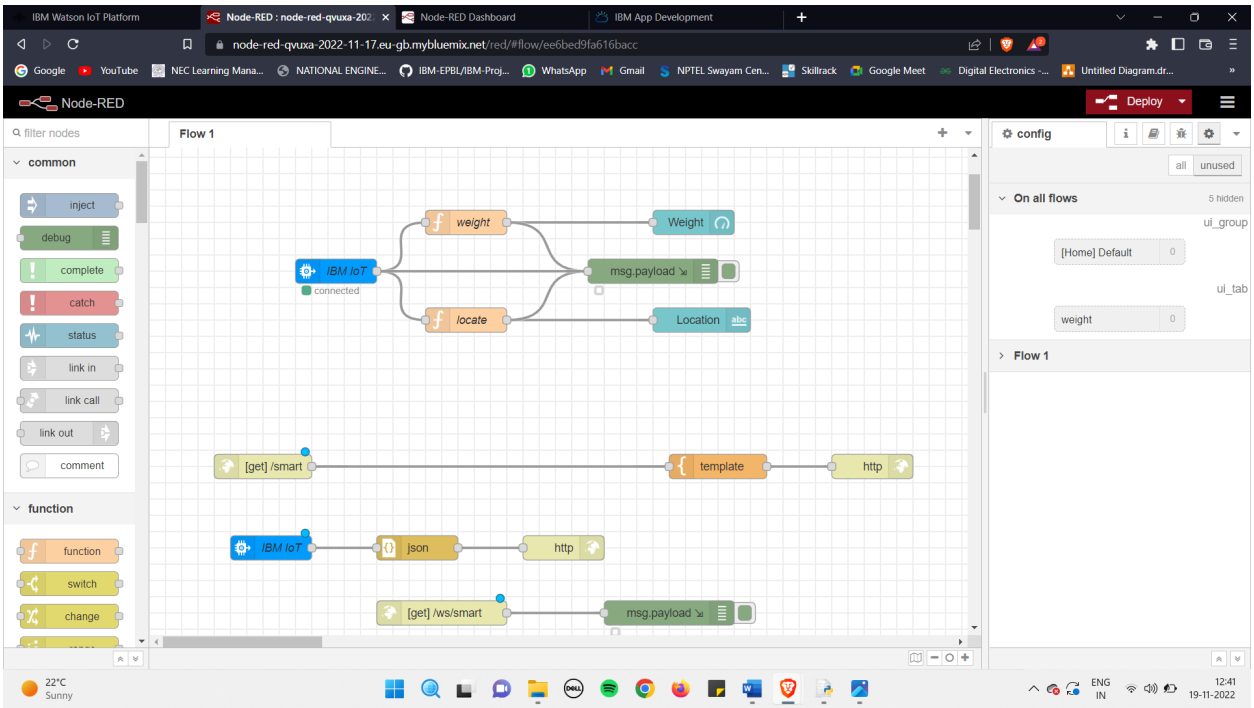
```
int weight = 0;

String location = "Coimbatore";
String status = "";


void setup() {
  Serial.begin(99900);

   wifiConnect();
mqttConnect();
}

void loop() {

  srand(time(0));

   //initial
variable     int p;

   weight = random(0,80);
   if(weight > 0  && weight < 25){
      p = 0;
   }
   else if(weight > 25  && weight < 50){
      p = 1;
   }

else{
p =
2;
   }

   //set a quality status
```

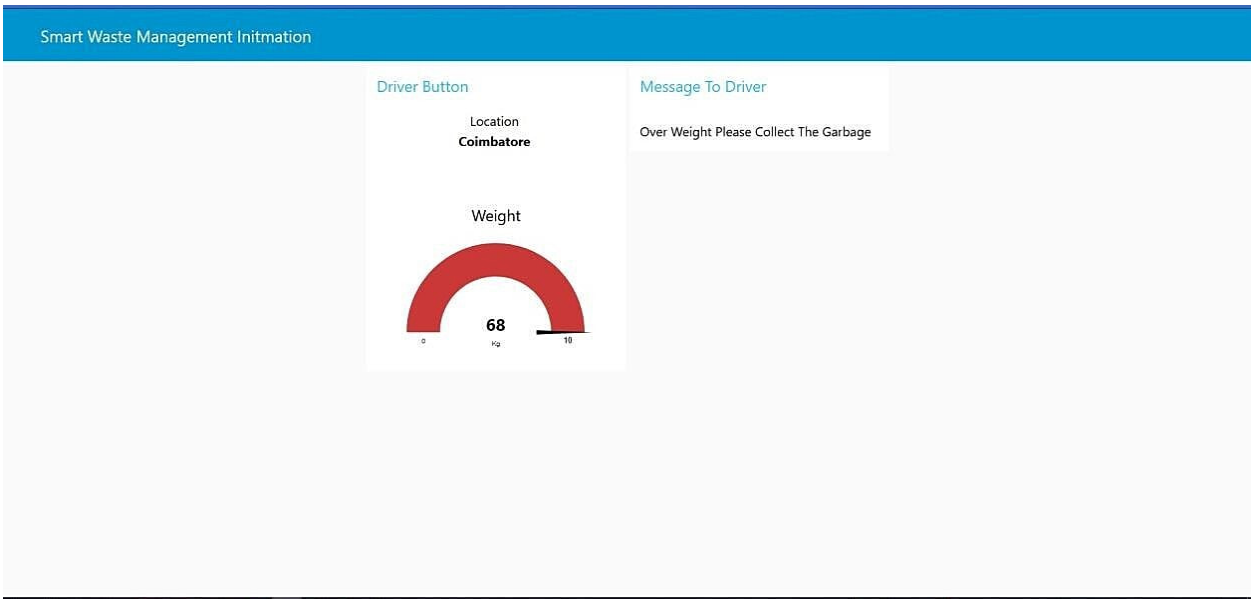
```
   switch (p) {
case 0:
status = "Low";
break;    case 1:
       status =
"Half";
break;     case
2:         status =
"Full";
break;
   }

  //Obivously the output.It is like json format 'cause it will help us
for future sprints     String payload = "{";     payload+="\"Weight
\":";     payload+=weight;     payload+=",";
payload+="\"Loaction\":";     payload+="Coimbatore";
   payload+=",";
   payload+="\"Status\":\""+status+"\"}";
   Serial.println(payload);


  if(client.publish(publishTopic, (char*) payload.c_str()))
  {
   Serial.println("Publish OK");
  }
  else{
   Serial.println("Publish failed");
  }
  delay(1000);


  if (!client.loop())
  {
   mqttConnect();
  }
```

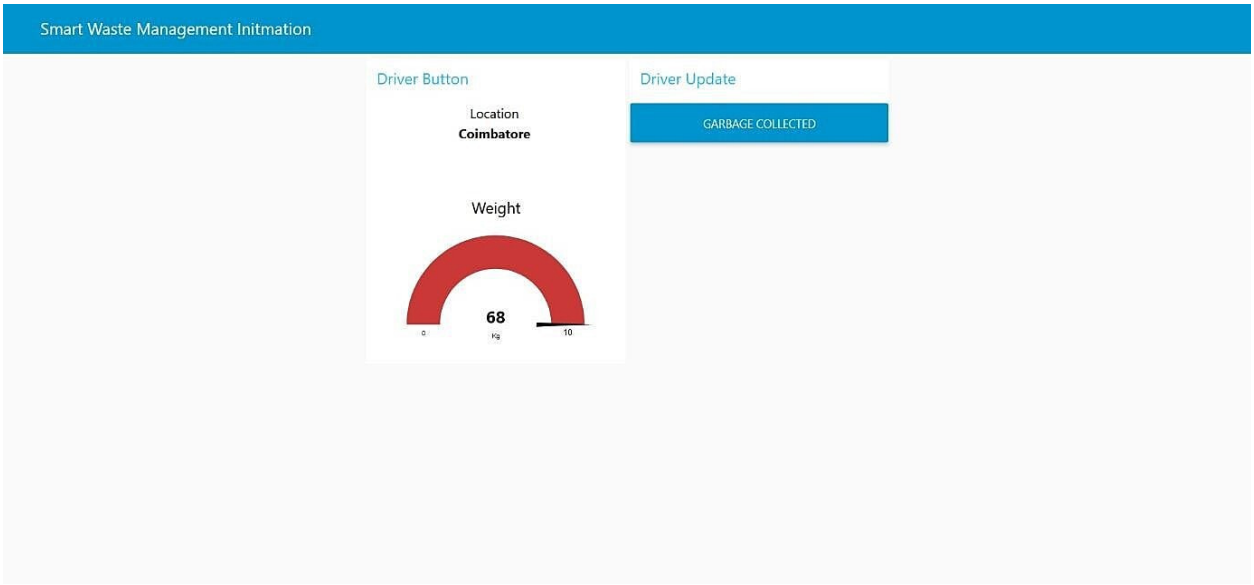
```
}

void wifiConnect()
{
  Serial.print("Connecting to ");
  Serial.print("Wifi");
  WiFi.begin("Wokwi-GUEST", "", 6);
  while (WiFi.status() != WL_CONNECTED)
  {
    delay(500);
    Serial.print(".");
  }
  Serial.print("WiFi connected, IP address: ");
  Serial.println(WiFi.localIP());

}

void mqttConnect()
{
  if (!client.connected())
  {
    Serial.print("Reconnecting MQTT client to ");
Serial.println(server);
    while (!client.connect(clientId, authMethod, token))
    {
      Serial.print(".");
delay(500);
    }

    Serial.println();
  }
}
```


Smartwastemanagement copy
wokwi.com/projects/348737483943445076
WOKWI
Smartwastemanagement copy
Docs
esp32-dht22.ino
diagram.json
libraries.txt
Library Manager
Simulation
ESP32
Publish OK
{"Weight ":35,"Loaction":Coimbatore,"Status":"Half"}
Publish OK
{"Weight ":66,"Loaction":Coimbatore,"Status":"Full"}
Publish OK
{"Weight ":60,"Loaction":Coimbatore,"Status":"Full"}
Publish OK

## 7.2 Node red


IBM Watson IoT Platform
Node-RED Dashboard
IBM App Development
node-red-qvuxa-2022-11-17.eu-gb.mybluemix.net/red/#flow/ee6bed9fa616bacc
Node-RED
Deploy
Flow 1
common
function
inject
debug
complete
catch
status
link in
link call
link out
comment
function
switch
change
weight
Weight
IBM IoT
connected
msg.payload
locate
Location
[get] /smart
template
http
IBM IoT
json
http
[get] /ws/smart
msg.payload
config
On all flows
ui_group
[Home] Default
ui_tab
weight
Flow 1


Smart Waste Management Initmation
Driver Button
Location
Coimbatore
Weight
68
Kg
0
10
Message To Driver
Over Weight Please Collect The Garbage


Smart Waste Management Initmation
Driver Button
Location
Coimbatore
Weight
68
Kg
0
10
Driver Update
GARBAGE COLLECTED

## 8. TESTING

### 8.1 Test Cases

**TEST CASE 1:**
WEIGHT: 0 KG
STATUS: NOT FILLED, DUSTBIN IS EMPTY

**TEST CASE 2:**
WEIGHT: 10KG
STATUS:20% FILLED, NOT READY TO DISPOSE

**TEST CASE 3:**
WEIGHT: 20KG
STATUS: 40% FILLED, NOT READY TO DISPOSE

**TEST CASE 4:**
WEIGHT: 30KG
STATUS: 60% FILLED, NOT READY TO DISPOSE

**TEST CASE 5:**
WEIGHT: 45KG
STATUS: 90% FILLED, READY TO DISPOSE

## 9. RESULTS

### 9.1 Performance Metrics

Total MSW Generated = Total tons Recycled + Total tons Recovered + Total tons Disposed MSW = Municipal Solid Waste (does not include industrial, special and demolition wastes)

## 10. ADVANTAGES & DISADVANTAGES

**ADVANTAGES:**

A reduction in the number of waste collections needed by up to 80%, resulting in less manpower, emissions, fuel use and traffic congestion.
A reduction in the number of waste bins needed. Analytics data to manage collection routes and the placement of bins more effectively.

**DISADVANTAGES:**

Misunderstanding of the operations of smart sensors
Non-optimized truck routes

## 11. CONCLUSION

Monitoring the garbage bins through sensors, it is possible to achieve a more efficient system than the manual method. The project "Smart waste management system", mainly concentrates on providing a smart technology for waste system without human intervention, reducing human time and effort and which results in healthy and waste ridden environment. The proposed idea can be implemented for smart cities where the residents would be busy enough and wouldn't have enough time for managing waste. The bins can be implemented in a city if desired where there would be a large bin that can have the capacity to accumulate the waste of solid type for a single apartment. The cost could be distributed among the residents leading to cheaper service provision.

## 12. FUTURE SCOPE

Waste management in future includes improvement in monitoring systems, data collection, and advancements based on new upcoming technologies.

## 13. APPENDIX

**Source Code :**https://wokwi.com/projects/348737483943445076

**GitHub:**https://github.com/IBM-EPBL/IBM-Project-33561-1660222837

**Project Demo Link: https://github.com/IBM-EPBL/IBM-Project-33561-1660222837/blob/main/Final%20Deliverables/Demo%20link.mp4**