SCHOOL OF COMPUTER SCIENCE & ENGINEERING

B. TECH COMPUTER SCIENCE AND ENGINEERING

SMART WATER SOLUTIONS FOR SMART CITIES

NAME OF INVENTORS:

SACHET ZODE – 16BCE1002

YUKTA GUPTA – 16BCE1101

HARIT KAPOOR – 16BCE1105

JAINIL DIXIT – 16BCE1155

AADARSH MAHESHWARI – 16BCE1292

UNDER THE GUIDANCE OF:

Dr. Geetha S

Prof. Jayanthi R

TABLE OF CONTENTS

ABSTRACT:

Due to increasing population, the government has now started to emphasize on pre-planned development to ensure rationalized use of resources and to reduce overexploitation of resources. These pre planned cities or establishments are known as Smart Cities. The government of India has emphasized on smart cities from past few years and is constantly thriving to make the cities smart by upgrading the basic amenities required in day to day life of the citizens. To improve the living standards of the citizens, the government has proposed automation of various things like electricity supply, water distribution, sewage water management as well as waste management. Water management solutions are needed for the emerging new planned smart cities as water is one of the basic requirements for survival of the human being.

In this project we aim to provide a smart solution for the management of water resources by capitalizing the existing resources in an efficient manner. We aim to provide a technical answer to the problem of water distribution and handling the treated sewage water generated from the sewage water treatment plants. The Project has an intent of providing a robust automated mechanism for water distribution based on the water level of the water tank and the requirement of the sector. The treated water generated from the sewage water plants is also integrated in the mechanism to make sure that there is proper utilization of the available resources without wasting it. Also, to capitalize on the rain water, we have also incorporated rain water harvesting in the proposed model which will harvest the rain water into the reservoir.

WHAT IS SMART CITY [1]?

In the imagination of any city dweller in India, the picture of a smart city contains a wish list of infrastructure and services that describes his or her level of aspiration. To provide for the aspirations and needs of the citizens, urban planners ideally aim at developing the entire urban eco-system, which is represented by the four pillars of comprehensive development-institutional, physical, social and economic infrastructure. This can be a long-term goal and cities can work towards developing such comprehensive infrastructure incrementally, adding on layers of ‘smartness’. In the approach of the Smart Cities Mission, the objective is to promote cities that provide core infrastructure and give a decent quality of life to its citizens, a clean and sustainable environment and application of ‘Smart’ Solutions. The focus is on sustainable and inclusive development and the idea is to look at compact areas, create a replicable model which will act like a light house to other aspiring cities. The Smart Cities Mission of the Government is a bold, new initiative. It is meant to set examples that can be replicated both within and outside the Smart City, catalysing the creation of similar Smart Cities in various regions and parts of the country. The core infrastructure elements in a smart city would include:

1. Adequate water supply,
2. Assured electricity supply,

3. Sanitation, including solid waste management,
4. Efficient urban mobility and public transport,
5. Affordable housing, especially for the poor,
6. Robust IT connectivity and digitalization,
7. Good governance, especially e-Governance and citizen participation,
8. Sustainable environment,
9. Safety and security of citizens, particularly women, children and the elderly,
10. Health and education

New areas (greenfield) will be developed around cities in order to accommodate the expanding population in urban areas. Application of Smart Solutions will enable cities to use technology, information and data to improve infrastructure and services. Comprehensive development in this way will improve quality of life, create employment and enhance incomes for all, especially the poor and the disadvantaged, leading to inclusive Cities.

SMART CITIES, SMART WATER [2]

The World Health Organization reports that for the first time ever, the majority of the world's population lives in a city, and this proportion continues to grow with projections of 70 percent by 2050. Currently, around half of all urban dwellers live in cities with populations between 100,000 and 500,000 people, and almost 10 percent of urban dwellers live in megacities.

As cities around the world experience this exploding growth, the need to ensure they can expand sustainably, operate efficiently and maintain a high quality of life for residents becomes even greater than it is today. This is where smart cities come into the picture. One of a city's most important pieces of critical infrastructure is its water system. With populations in cities growing, it is inevitable that water consumption will grow as well. The term "smart water" points to water and wastewater infrastructure that ensures this precious resource - and the energy used to transport it - is managed effectively. A smart water system is designed to gather meaningful and actionable data about the flow, pressure and distribution of a city's water. Further, it is critical that that the consumption and forecasting of water use is accurate. A city's water distribution and management system must be sound and viable in the long term to maintain its growth and should be equipped with the capacity to be monitored and networked with other critical systems to obtain more sophisticated and granular information on how they are performing and affecting each other. Water systems are often overlooked yet are critical components of energy management in smart cities, typically comprising 50 percent of a city's total energy spend. Energy is the largest controllable cost in water/wastewater operations, yet optimizing treatment plants and distribution networks has often been overlooked as a source of freeing up operating funds by cash-strapped municipalities. Once facilities are optimized and designed to gather meaningful and actionable data, municipal leaders can make better and faster decisions about their operations, which can result in up to 30 percent energy savings and up to 15 percent reduction of water losses.

EFFECTIVE WATER MANAGEMENT – INDISPENSABLE FOR SMART CITIES [3]

Intelligent water management systems are a critical foundation to making Smart Cities successful. Smart Cities will have to plan and implement smart water solutions that can provide clean water on a 24x7 basis. A smart water solution is a fully integrated set of products which collects real-time meaningful and actionable data from the water network. As smart water solutions are implemented, water utilities are generating the same amount of data in one day that they previously generated in a year. The issue that utilities currently face is that this data is stored separately and in different areas of the business for different purposes. Utilities and Governments must implement next-generation smart water solutions in order to achieve 24x7 water supply and smart city development. Additionally, treating wastewater to a high standard would provide an additional and vital source of a city's water supply, and this reuse of water is important to minimise the pressure on traditional sources. It is high time to expedite water conservation measures in every possible way to retain, recycle and reuse water in India too.

HOW THE PRIORITY OF WATER BASED ON LEVEL WAS DECIDED?

The sectors for water distribution were decided after thorough research. The conclusion was derived that the water needs to be distributed as per the below sequence in a decreasing order:

1. Housing
2. Agriculture
3. Industries

The news articles supporting the claim can be found below.

Mr A.G. Kodgi, Chairman of Taskforce on Implementation of Recommendations of the Third Finance Commission of Karnataka, said [4] this while addressing the representatives of urban local bodies "Priority should be given for proper drinking water supply in urban areas". Later when presspersons drew his attention on the recent water supply problem to industries in Mangalore, he said "all sectors – including industries and agriculture – should get water. But that should not be done at the cost of drinking water".

Drinking water supply a priority: Vijay Rupani [5]

As drought prevails, Maharashtra government mulls more water cuts for industries [6]

In view of the serious drought conditions prevalent in the Marathwada, the Maharashtra government is mulling to further cut down water supply for the industries in the area.

SYSTEM DESIGN:

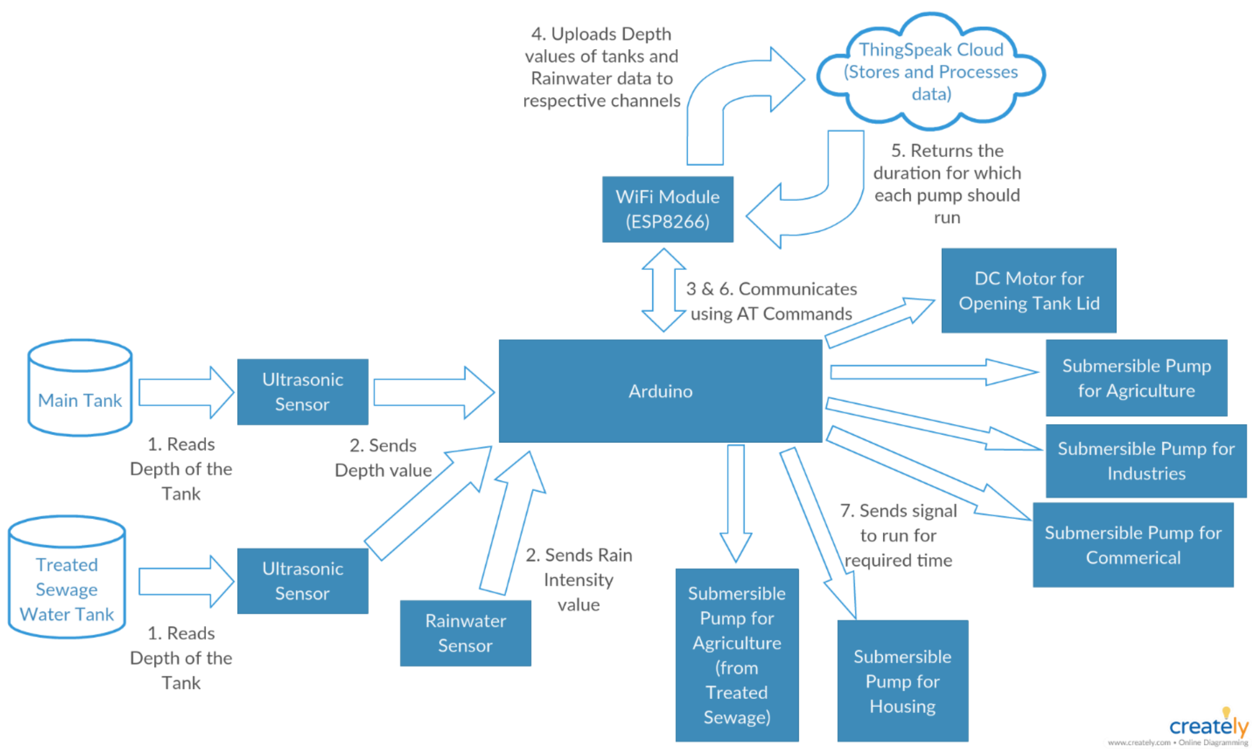
First, the overall system shown in Fig. 1 is discussed, following which details about each part of the system are provided. On the left-hand side of the figure, there are two tanks. The water level in these tanks is measured by the ultrasonic sensors mounted at top of the tanks. These sensors send and receives sound waves in pulses. The time lapse between sending and receiving is measured by the Arduino. Then this value is sent to the cloud using a Wi-Fi module. This time delay is used to calculate the distance of water level from the sensors. Thus, the water level is measured by subtracting the distance between water level and sensor by total height of the tank and the water remaining in the tank at that moment is calculated. The formula for calculating the distance is:

$$\text{Distance} = (t * 0.034) / 2$$

where, t is the time lapse in microseconds.

These calculations are done on the ThingSpeak cloud, where the data is stored and processed. After calculating the distance, the values from the cloud are collected by the Arduino using Wi-Fi module. The returned values are the status of each motor (either 1 or 0).

There is a rainwater sensor too, which is used to detect the rain. And if it's raining and the tank is not full, then the Arduino sends the signal to motor driver for opening the lid of the tank and vice versa.



COMPONENTS:

1. Arduino Uno: Arduino is a microcontroller equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits. It is programmable with the Arduino IDE (Integrated Development Environment) via a type B USB cable, and can be powered by a USB cable or by an external 9-volt battery. In the project, it acts as a controller, which manages the sensors, actuators and the requests to Cloud.

2. ESP8266 Wi-Fi Module: The ESP8266 is a low-cost Wi-Fi microchip with full TCP/IP stack and microcontroller capability. We use the ESP8266 to connect with the Wi-Fi, and to send and receive the data from the Cloud via internet.

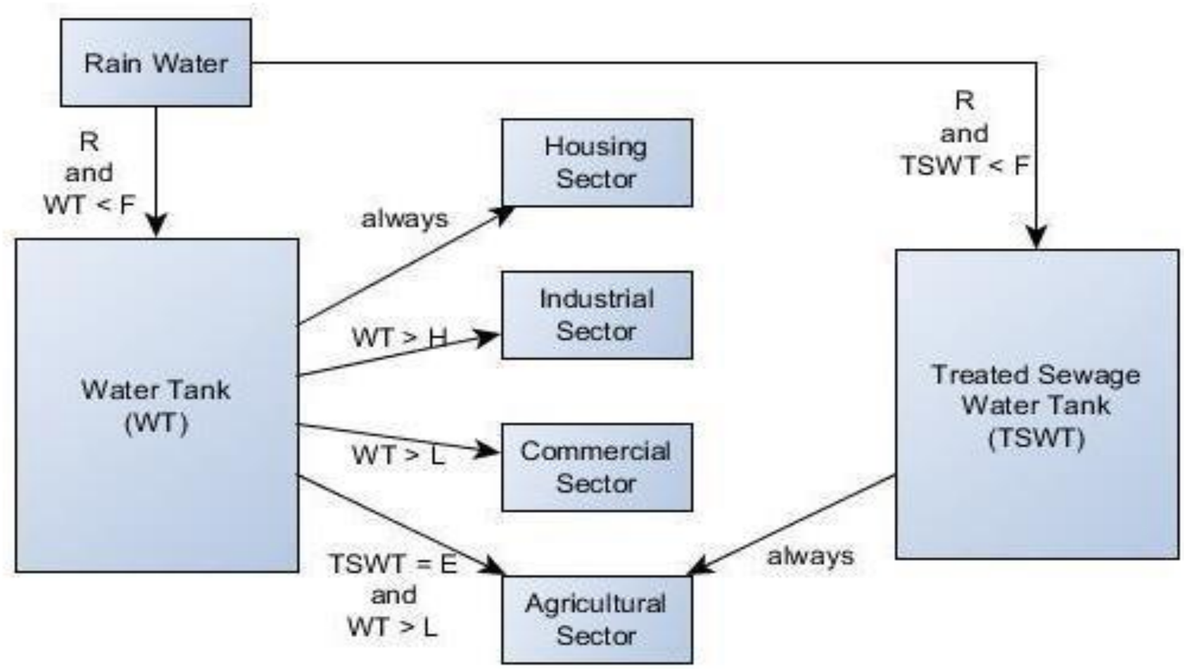
3. Ultrasonic Sensors: Ultrasonic sensors are used to calculate the depth using Ultrasonic waves. They consist of Trig and Echo, which send and receive sound waves at 40000 Hz. The sensor returns the time ‘t’ in microseconds for which the sound travelled, which can be converted into the distance using the formula (t * 0.034) / 2.

4. Submersible Pumps: These are DC motors used to send water to the respective region from various tanks. They are operated on High and Low signals given by the Arduino for the time retrieved from the Cloud.

5. Transistors: We use 2N7000 N-channel transistors, which act as a gate between the Arduino and Submersible pumps. They are needed to regulate the working of the pumps.

6. Rain-water sensor: A water sensor is used to detect weather it’s raining or not. It is compatible with Arduino and sends the signal of the status continuously.

BLOCK DIAGRAM:



PERFORMANCE ANALYSIS

The Existing products for the smart water distribution are mostly focusing on the water purification. This project mainly concentrates on efficient distribution of potable water and also utilizing the purified sewage water which is generated from the sewage water treatment plants. Moreover, it can be implemented at remote locations which cannot be accessed by humans on daily basis. The system also makes sure that a drought like situation is always avoided and water is always sent to the housing colonies. The project can also be used to remotely monitor and give a predictive analysis of the water usage patterns of each and every area.

- Reduces the wastage of water
- Utilizes sewage water and thus saves fresh water
- Sewage water which was polluting the fresh water bodies is now used. Thus, the freshwater resources are not polluted.
- Rainwater is harvested which further reduces the fresh and potable water getting wasted.
- Automated facility will help to remove the laborious jobs that are being done
- Encourage greater investment in water infrastructure to create jobs and contribute significantly to local economic development.
- Provide remote monitoring of the data

CODE:

Arduino:

```
#include<SoftwareSerial.h> //to interface esp8266 with arduino through serial communication

SoftwareSerial esp8266(3,4);//set the software serial pins RX=3,TX=4

#define SID "sachet"

#define PASS "sachetzode"


/*

int trig = 12, echo = 11; // For main tank

int trig2 = 10, echo2 = 9; // For sewage tank

int p1 = 2, p2 = 7, p3 = A0, p4 = A1, p5 = 8; // p1 - home, p2 - commercial, p3 - industrial, p4 -
agricultural, p5 - sewage

int x1 = 5, x2 = 6; // For lid


int depth, depth2;

int analogPin = A5;

long duration, duration2;

String main = "9KPZFWKHBJ8PL8FT";

String sewage = "ZNCD1R7Z36D3R5V9";

*/


int lidStatus = 0;

String response = "";


// For communication between Arduino and ESP using AT Commands

void sendAT(String command,const int timeout){

  response="";

  int copy = 0;

  esp8266.print(command);
```

```
  long int time=millis();
  while((time+timeout)>millis()){
    while(esp8266.available()){
      char c = esp8266.read();
      if(isAlpha(c))
        copy=0;
      if(copy)
        response +=c;
      if(c==':')
        copy=1;
    }
  }
}

// For connecting to WiFi
void connectwifi(){
  Serial.println("Connecting...");
  sendAT("AT\r\n",2000); //Send AT
  sendAT("AT+CWMODE=1\r\n",2000); //call sendAT function to set esp8266 to station mode -
used to connect to WiFi
  sendAT("AT+CWJAP=\""SID"\",\""PASS"\"\r\n",2000);//AT command to connect with wifi
network
  while(!esp8266.find("OK")){
    Serial.println("Looping");
    //wait for connection
  }
  Serial.println("Connection successful");
  sendAT("AT+CIFSR\r\n",2000);//AT command to print IP address on serial monitor
  sendAT("AT+CIPMUX=0\r\n",2000);//AT command to set esp8266 to single connection
```

```
}

void setup() {
  Serial.begin(9600);
  esp8266.begin(115200); //Begin the software serial communication with baud rate 115200
  pinMode(12,OUTPUT);
  pinMode(11,INPUT);
  pinMode(10,OUTPUT);
  pinMode(9,INPUT);
  sendAT("AT+RST\r\n",2000); //Call sendAT function to send Reset AT command
  connectwifi();
}


void loop() {
  // For reading depth of main tank and updating to thingspeak
  Serial.println("Reading from main tank");
  digitalWrite(12,HIGH);
  delayMicroseconds(10);
  digitalWrite(12,LOW);
  long duration=pulseIn(11,HIGH);
  int depth=duration*0.034/2;
  Serial.println("Depth: " + String(depth));
  updateThingspeak(String(depth), "9KPZFWKHBJ8PL8FT");
  delay(1000);

  // For reading depth of sewage tank and updating to thingspeak
  Serial.println("Reading from sewage tank");
```

```
  digitalWrite(10,HIGH);
  delayMicroseconds(10);
  digitalWrite(10,LOW);
  long duration2=pulseIn(9,HIGH);
  int depth2=duration2*0.034/2;
  Serial.println("Sewage Depth: " + String(depth2));
  updateThingspeak(String(depth2), "ZNCD1R7Z36D3R5V9");
  delay(5000);

  // For running all the motors based on main tank
  readThingSpeak(2);
  delay(1000);
  readThingSpeak(7);
  delay(1000);
  readThingSpeak(0);
  delay(1000);
  readThingSpeak(1);
  delay(1000);

  // For operating lid of main tank
  operateLid();

  // For running motor based on sewage tank
  readThingSpeak(8);
  delay(15000);
  Serial.println();
  Serial.println();
}
```

```
void readThingSpeak(int p){
  String xyz = "";
  sendAT("AT+CIPSTART=\"TCP\",\"api.thingspeak.com\",80\r\n",2000);
  String cmd, cmdlen;
  if(p == 2)
  {
    cmd="GET /channels/613117/field/field1/last\r\n";
    xyz = "Home";
  }
  else if(p == 7)
  {
    cmd="GET /channels/712371/field/field1/last\r\n";
    xyz = "Commercial";
  }
  else if(p == 0)
  {
    cmd="GET /channels/712372/field/field1/last\r\n";
    xyz = "Industrial";
  }
  else if(p == 1)
  {
    cmd="GET /channels/712380/field/field1/last\r\n";
    xyz = "Agricultural";
  }
  else if(p == 8)
  {
    cmd="GET /channels/712402/field/field1/last\r\n";
```

```
  xyz = "Sewage";
}
else { return; }
cmdlen=cmd.length();
sendAT("AT+CIPSEND="+cmdlen+"\r\n",2000);
esp8266.print(cmd);
sendAT("AT+CIPCLOSE\r\n",2000);
Serial.print("Response from API: ");
Serial.println(response);
int t = response.toInt();
Serial.println("Pump status: "+String(t));
if(t == 1){
  if(p == 0)
  {
    Serial.println("High " + String(xyz) + " " + String(A0));
    digitalWrite(A0, HIGH);
  }
  else if(p == 1)
  {
    Serial.println("High " + String(xyz) + " " + String(A1));
    digitalWrite(A1, HIGH);
  }
  else
  {
    Serial.println("High " + String(xyz) + " " + String(p));
    digitalWrite(p, HIGH);
  }
}
```

```
  else {


    if(p == 0)
    {
      Serial.println("Low " + String(xyz) + " " + String(A0));
      digitalWrite(A0, LOW);
    }
    else if(p == 1)
    {
      Serial.println("Low " + String(xyz) + " " + String(A1));
      digitalWrite(A1, LOW);
    }
    else
    {
      Serial.println("Low " + String(xyz) + " " + String(p));
      digitalWrite(p, LOW);
    }
  }
}


void updateThingspeak(String value, String key){
  sendAT("AT+CIPSTART=\"TCP\",\"api.thingspeak.com\",80\r\n",2000);//tcp connection with domain name and port no.
  String cmdlen;
  String cmd = "GET /update?api_key=" + key + "&field1=" + value + "\r\n";//update the depth values to thingspeak channel
  cmdlen=cmd.length();
  sendAT("AT+CIPSEND="+cmdlen+"\r\n",2000);
  esp8266.print(cmd);
```

```
  sendAT("AT+CIPCLOSE\r\n",2000);
  Serial.println("Sent "+value);
}

void operateLid()
{
  int val = 0;
  // Read rain value and convert to rain status
  int rain = analogRead(A5);
  Serial.println("Rain: " + String(rain));
  if(rain > 50)
  {
    val = 1;
  }
  Serial.println("Rain status: "+String(val));

  // To operate lid based on lid and rain status
  if(val == 1 and lidStatus == 0){
    Serial.println("Lid Opening");
    digitalWrite(5, LOW);
    digitalWrite(6, HIGH);
    lidStatus = 1;
    delay(1500);
    digitalWrite(5, LOW);
    digitalWrite(6, LOW);
  }
  if(val == 0 and lidStatus == 1) {
    Serial.println("Lid Closing");
```

```
    digitalWrite(5, HIGH);
    digitalWrite(6, LOW);
    lidStatus = 0;
    delay(1500);
    digitalWrite(5, LOW);
    digitalWrite(6, LOW);
  }

  if(lidStatus == 0)
  {
    Serial.println("Lid Status: Closed");
  }
  else
  {
    Serial.println("Lid Status: Open");
  }
}
```

Cloud:

```
depth = 20
depth2 = 15
% Read from main tank
readChannelID = 584128;
[data1, time1] = thingSpeakRead(readChannelID);
% Read from sewage tank
readChannelID = 712401;
[data2, time2] = thingSpeakRead(readChannelID);
% For sewage motor
writeChannelID = 712402;
writeAPIKey = '7RPNOSAI01J8C1Z5';
if data2 < depth2
    y = 1;
```

```
else
    y = 0;
end
thingSpeakWrite(writeChannelID, y, 'WriteKey', writeAPIKey);
% For first motor
writeChannelID = 613117;
writeAPIKey = '33BE0NHO4YKZJL4L';
if data1 < depth
    y = 1;
else
    y = 0;
end
thingSpeakWrite(writeChannelID, y, 'WriteKey', writeAPIKey);
% For second motor
writeChannelID = 712371;
writeAPIKey = 'SEYY9FK7EJ5UYITY';
if data1 < (2 * depth / 3)
    y = 1;
else
    y = 0;
end
thingSpeakWrite(writeChannelID, y, 'WriteKey', writeAPIKey);
% For third motor
writeChannelID = 712372;
writeAPIKey = '3F9TBIBI9U6Z0LA1';
if data1 < (depth / 3)
    y = 1;
else
    y = 0;
end
thingSpeakWrite(writeChannelID, y, 'WriteKey', writeAPIKey);
% For fourth motor
writeChannelID = 712380;
writeAPIKey = '20AA68ZKII3Y1XDZ';
if (data1 < (2 * depth / 3) && data2 >= depth2)
    y = 1;
else
    y = 0;
end
thingSpeakWrite(writeChannelID, y, 'WriteKey', writeAPIKey);
```

SUMMARY OF THE INVENTION:

In this project we aim to provide a smart solution for the management of water resources by capitalizing the existing resources in an efficient manner. We aim to provide a technical answer to the problem of water distribution and handling the treated sewage water generated from the sewage water treatment plants. The Project has an intent of providing a robust automated mechanism for water distribution based on the water level of the water tank and the requirement of the sector. The treated water generated from the sewage water plants is also integrated in the mechanism to make sure that there is proper utilization of the available resources without wasting it. Also, to capitalize on the rain water, we have also incorporated rain water harvesting in the proposed model which will harvest the rain water into the reservoir.

The water demands arising from the cities can be classified roughly into 4 sectors based on the type of usage

1. Housing
2. Farming
3. Commercial
4. Industrial

The water is distributed to the various sectors based on the depth of the water tank.

		Main Tank		
		High	***Medium***	***Low***
Sewage	***High***	Industry, Commercial, Housing, Agriculture from Sewage	Commercial, Housing, Agriculture from Sewage	Housing, Agriculture from Sewage
	Low	Industry, Commercial, Housing, Agriculture from Main Tank	Commercial, Housing, Agriculture from Main Tank	Housing

Rainwater harvesting will help to replenish the water tank. Integration of sewage water distribution will help to use the sewage water which currently is disposed into fresh water sources and contributing as a major pollutant for them.

The project can also be used to remotely monitor the water level of the tank. The remote monitoring of the depth can help get the data remotely of the tanks located at isolated places.

LIMITATIONS (CHALLENGES)

- The main challenge will be to make the device with minimal cost such that it can be employed with minimal cost.
- The system must be portable enough so that it can be carried to the place of installation
- The system should be easy and quick to install and work upon.
- Longevity- The system must be able to work for a long time without breaking down.
- Single point failure- In case of failure, the water has to supplied manually. There exists no backup system to undertake the operation in case of failure of the system
- Providing quick solution in case of failure

FUTURE WORK

The future work for this can be remotely controlling the water distribution from a mobile app. This can help to distribute the water to the various zones without manually going ad then switching the pumps to distribute water. We can also add a app based interactive dashboard which will tell the users the water level of the tank which can be used to warn the zone of water cut. This can help them to secure ample amount of resource before they are devoid of the access of the resource.

REFERENCES

[1] http://smartcities.gov.in/upload/uploadfiles/files/What%20is%20Smart%20City.pdf

[2] https://www.waterworld.com/articles/print/volume-29/issue-12/water-utility-management/smart-water-a-key-building-block-of-the-smart-city-of-the-future.html

[3] http://bwsmartcities.businessworld.in/article/Effective-Water-Management-Indispensable-for-smart-cities-/09-05-2018-148681/

[4] https://www.thehindubusinessline.com/economy/%E2%80%98Give-priority-for-drinking-water-supply-in-urban-areas/article20431446.ece

[5] https://timesofindia.indiatimes.com/city/ahmedabad/drinking-water-supply-a-priority-rupani/articleshow/62761721.cms

[6] https://economictimes.indiatimes.com/news/politics-and-nation/as-drought-prevails-maharashtra-government-mulls-more-water-cuts-for-industries/articleshow/48774979.cms