Real Time Decision Support System In Agriculture

Presented By:-

ALOK ROY(12000320052)
CHHANDA NIYOGI(12000320077)
SURAJIT PATAR(12000320080)

FOR:

PROJECT STAGE –II (EC-881)

Under the Supervision of : Dr. Sarit Pal

OF

ELECTRONICS AND COMMUNICATION ENGINEERING

DR. B. C. ROY ENGINEERING COLLEGE, DURGAPUR

CONTENT

Introduction

- Application of smart irrigation system.
- Adoption of Smart Irrigation Systems for optimized water usage and automated irrigation scheduling.
- Aim:
  - Enhance environmental monitoring
  - Promote smart farming
  - Improve yield
  - Optimize water usage
  - Reducing manual labor

Related works

1. **S. Harishankar et al. (2014)**
    1. Collect field data using soil moisture sensor, converting it into voltage readings.
    2. Decision circuit deployed for determination of water requirements based on the reference voltage.

2. **Datta, Stivers, & Taghvaeian (2017)**
    1. Explored fundamental soil water concepts to improve irrigation scheduling efficiency.
    2. Defined crucial thresholds, such as saturation, field capacity, and management allowable depletion, emphasizing their variability depending on soil type, crop type, and climate conditions.

Related works (Cont..)

3. **R. Nageswara Rao et al. (2018)**
   1. System consists of Raspberry Pi 3, soil moisture sensors, an LM35 temperature sensor, an LM358, and a relay.
   2. Digitized crop data and controlled the motor in response to predetermined soil moisture thresholds.
   3. Adjusted voltage thresholds to accommodate diverse crop types and seasonal fluctuations.

4. **Sultana et al. (2022)**
   1. Activates a pump at a preset water level threshold.
   2. Compared current water levels with preset threshold for decision-making.
   3. Integrated a SIM800L module for real-time field condition notifications to the farmer’s mobile.

Research Gap and Problem Formulation

1. **S. Harishankar et al. (2014)**
   - Method for determining the threshold value was not specified.

2. **R. Nageswara Rao et al. (2018)**
   - Though effective, but not cost-efficient due to the use of Raspberry Pi.
   - Details regarding the determination of the threshold value and its adjustment according to various crop fields and seasons were not addressed.

3. **Sultana et al. (2022)**
   - Used an additional components SIM800L for communication.
   - Integration challenges, network connectivity and compatibility issues, affecting real-time notifications.
   - Additionally, the power consumption of SIM800L, especially in remote areas, poses a concern for sustained operation.

Proposed System

- Establishes a real-time decision-making system considering crop type and soil type of the field.
- Helps to automate the irrigation scheduling process by determining the threshold value of soil moisture content for irrigation.
- Aims to automate the irrigation process using real-time data of the soil moisture, temperature, and humidity sensors.
- By deploying a network of sensors with ESP32 across fields, data is transmitted and stored on the ThingSpeak API for monitoring and analysis.
- Based on crop-specific Management Allowable Depletion (MAD) values, irrigation is scheduled, preventing under or over-irrigation.

Proposed System (Cont…)

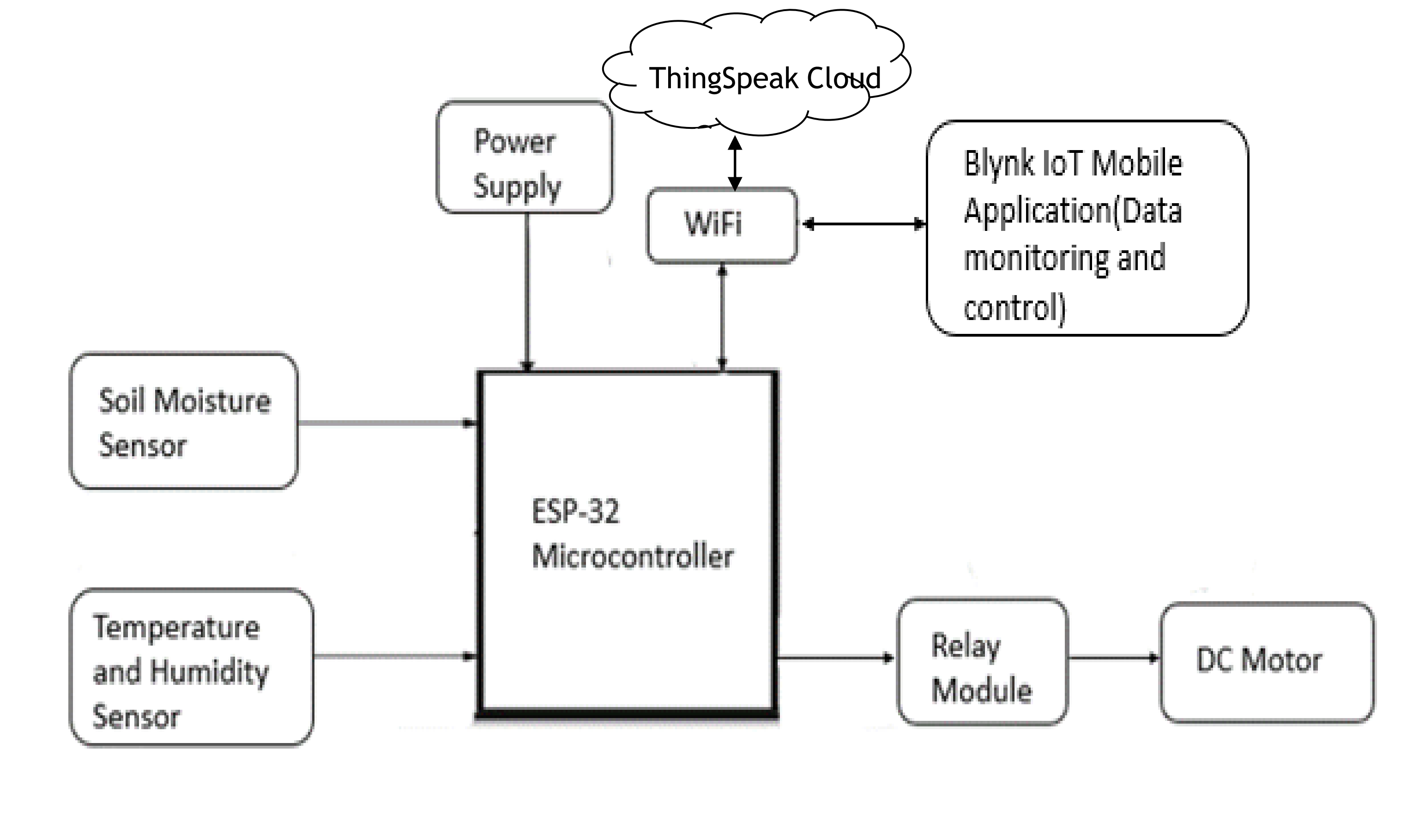


Fig 1. Block Diagram of the Proposed System

Equipment Used:

Here are some of the key equipments used in the project:

a) HARDWARE

- ESP32 Microcontroller
- Soil Moisture Sensor (Resistive and capacitive)
- Temperature and Humidity – DHT11 Sensor
- Relay Module
- 9V mini submersible water pump
- Jumper Wires and Breadboard

b) SOFTWARE

- Thonny IDE
- ThingSpeak
- Arduino IDE
- Blynk IoT

ESP-32 Communication with Thingspeak Cloud

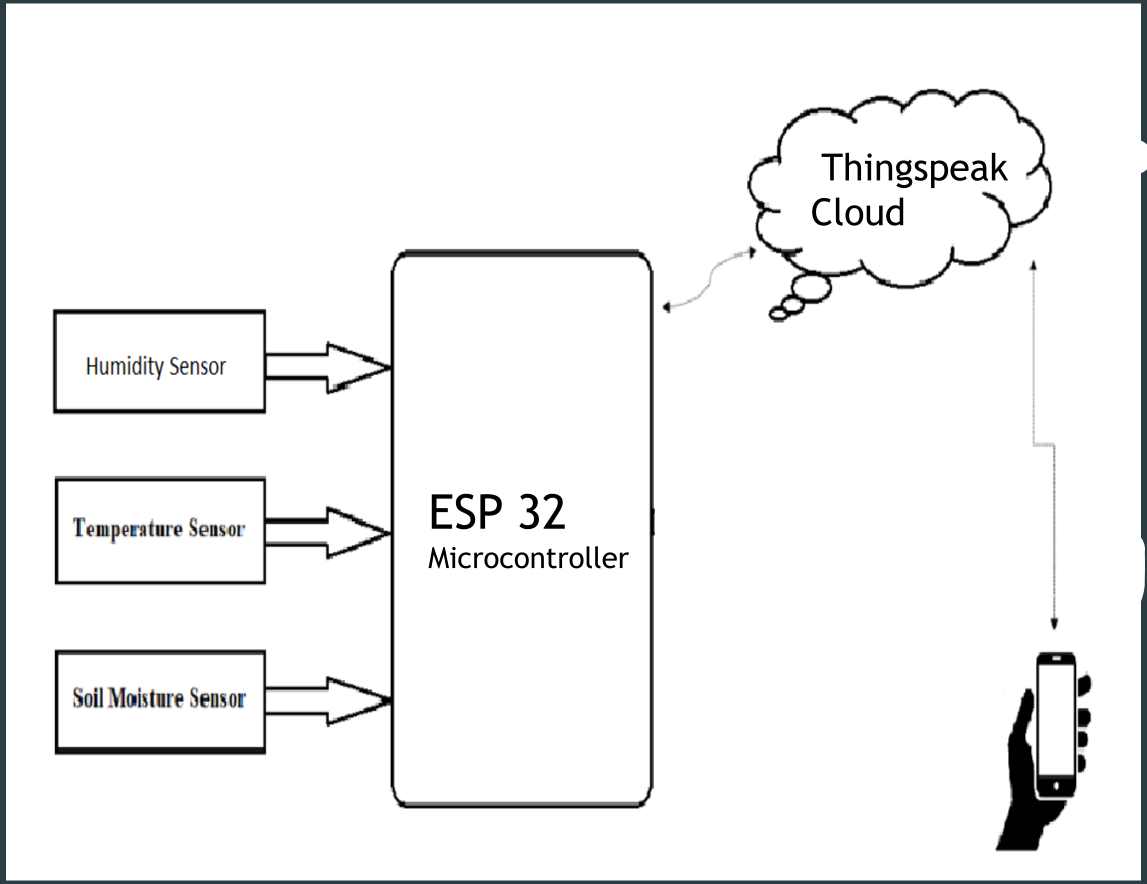
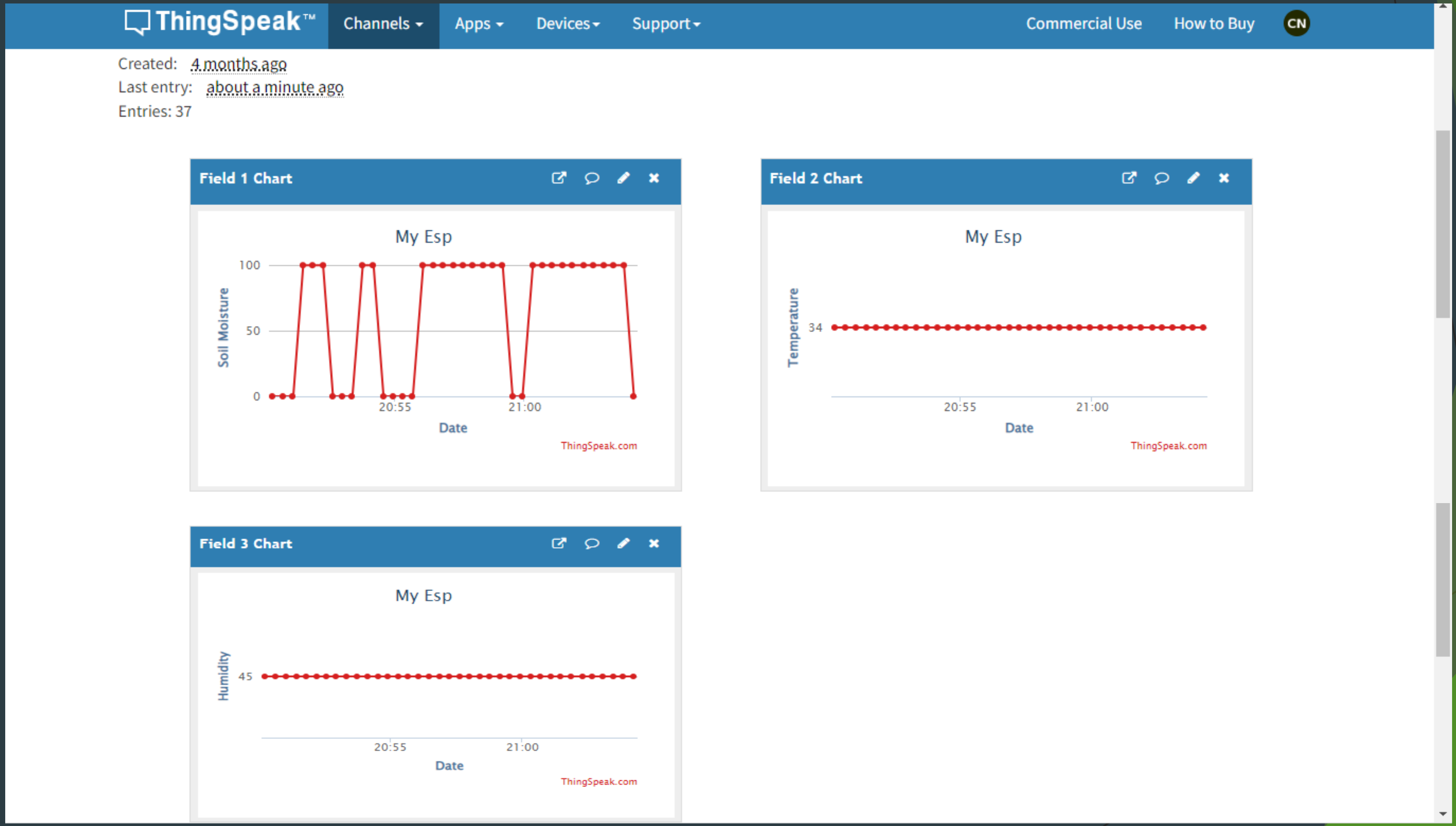


Fig 2. Block diagram of ESP 32 communication with Thingspeak cloud

Data Visualisation In Thingspeak

Thingspeak channel link: Click here



Sensor Data Stored In Excel Sheet

	A	B	C	D	E
1	timestamp	Soil Moisture 1	Temperature	Humidity	Soil Moisture 2
2	2023-11-09T08:50:29+05:30	0.8701172	25	51	0.8958984
3	2023-11-09T08:50:44+05:30	0.928125	25	51	0.9635742
4	2023-11-09T08:50:59+05:30	0.918457	25	51	0.9410156
5	2023-11-09T08:51:15+05:30	1.008691	25	51	1.060254
6	2023-11-09T08:51:33+05:30	1.028027	25	51	1.076367
7	2023-11-09T08:51:49+05:30	0.9861328	25	51	1.034473
8	2023-11-09T08:52:07+05:30	0.9216797	25	51	0.9861328
9	2023-11-09T08:52:23+05:30	1.060254	25	51	1.086035
10	2023-11-09T08:55:32+05:30	1.105371	25	51	1.018359
11	2023-11-09T08:55:47+05:30	0.9990234	25	51	1.034473
12	2023-11-09T08:56:06+05:30	1.028027	25	51	1.060254
13	2023-11-09T08:56:25+05:30	1.005469	25	51	1.076367
14	2023-11-09T08:56:40+05:30	0.9152344	25	51	1.024805
15	2023-11-09T08:56:55+05:30	1.018359	25	51	1.028027
16	2023-11-09T08:57:10+05:30	1.021582	25	51	1.024805
17	2023-11-09T08:57:25+05:30	1.047363	25	51	1.086035
18	2023-11-09T09:17:33+05:30	0.9893555	25	51	1.082812
19	2023-11-09T09:17:48+05:30	0.8314453	25	49	1.053809
20	2023-11-09T09:18:07+05:30	0.8926758	25	49	1.102148
21	2023-11-09T09:18:26+05:30	1.008691	25	50	1.102148
22	2023-11-09T09:18:41+05:30	1.011914	25	50	1.105371
23	2023-11-09T09:18:56+05:30	0.9925781	25	49	1.082812
24	2023-11-09T09:19:11+05:30	1.040918	25	49	1.124707
25	2023-11-09T09:19:26+05:30	1.008691	25	49	1.102148
26	2023-11-09T09:39:35+05:30	0.9861328	25	49	1.057031
27	2023-11-09T09:39:53+05:30	0.9925781	25	50	1.063477
28	2023-11-09T09:40:09+05:30	0.9925781	26	50	1.063477
29	2023-11-09T09:40:25+05:30	0.9861328	26	50	1.060254
30	2023-11-09T09:40:40+05:30	0.9861328	26	50	1.060254

9th Nov

Soil Moisture Sensing and Analysis

- After establishing communication with the cloud, soil moisture sensor is placed in the soil planted with **Impatiens balsamina**

- **Two Sensor Directions:**
  - **Vertical Placement:**
    - Positioned one sensor vertically from the top level of the soil.
    - Monitors moisture content in the upper layers of the soil.
  - **Horizontal Placement near Root Area:**
    - Placed another sensor horizontally, close to the root area.
    - Monitors moisture content in the soil around the roots.

- The temperature, humidity and the soil moisture sensor reading for the two sensors are taken for more than 2 months and a datasheet is prepared.

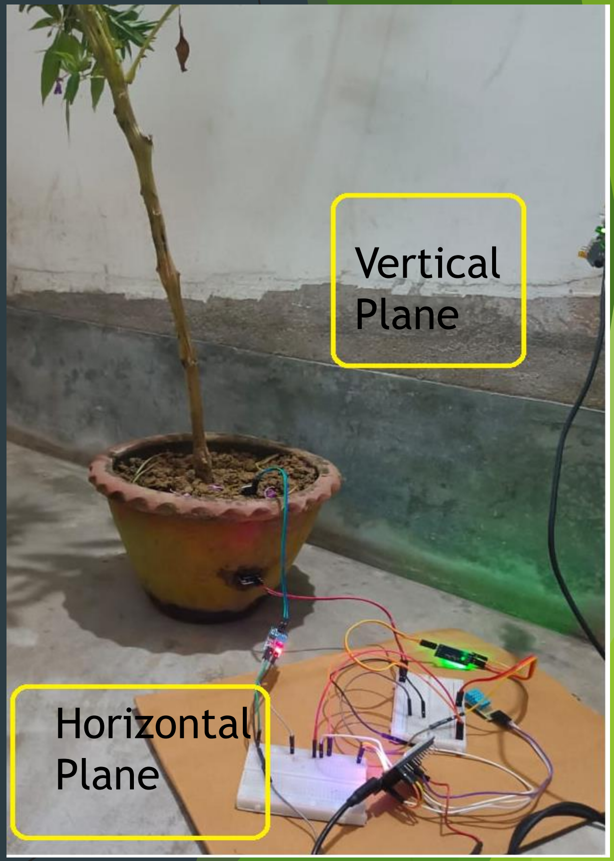


Fig 3: Two Sensor Position

STATISTICAL ANALYSIS OF OBSERVED DATA

- Performed calculations on the observed dataset for each individual day.
- Computed the max value of each parameter.
- Plotted the graph between Temp vs Max Voltage Value (i.e. min moisture)
- Soil Moisture Sensor 1(SMS1)is the top level sensor
- Soil Moisture Sensor 2(SMS2) is the root level sensor

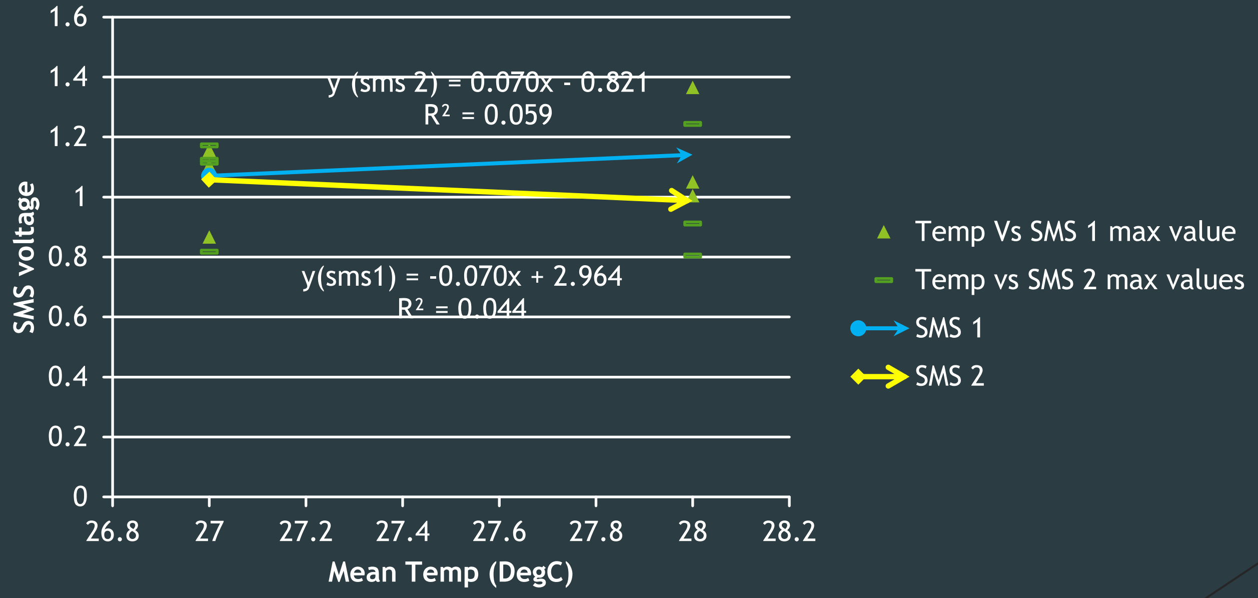


Fig 4: Temp vs Max of SMS1 and MAX SMS2

STATISTICAL ANALYSIS OF OBSERVED DATA(Cont..)

- **SMS1 Decrease:**
  - Due to its location at the topsoil, SMS1 experiences quicker evaporation.
  - Evaporation leads to a decrease in SMS1 levels over time.
- **SMS2 Evaporation Dynamics:**
  - SMS2, being deeper in the soil, experiences less evaporation compared to SMS1.
  - The presence of plant roots at this depth contributes to moisture retention in SMS2.
- **Root Absorption Effect:**
  - The roots in the depth of SMS2 hold a significant amount of moisture, contributing to a balanced moisture level.
  - This absorption effect helps prevent SMS2 from showing a rapid decrease in moisture.

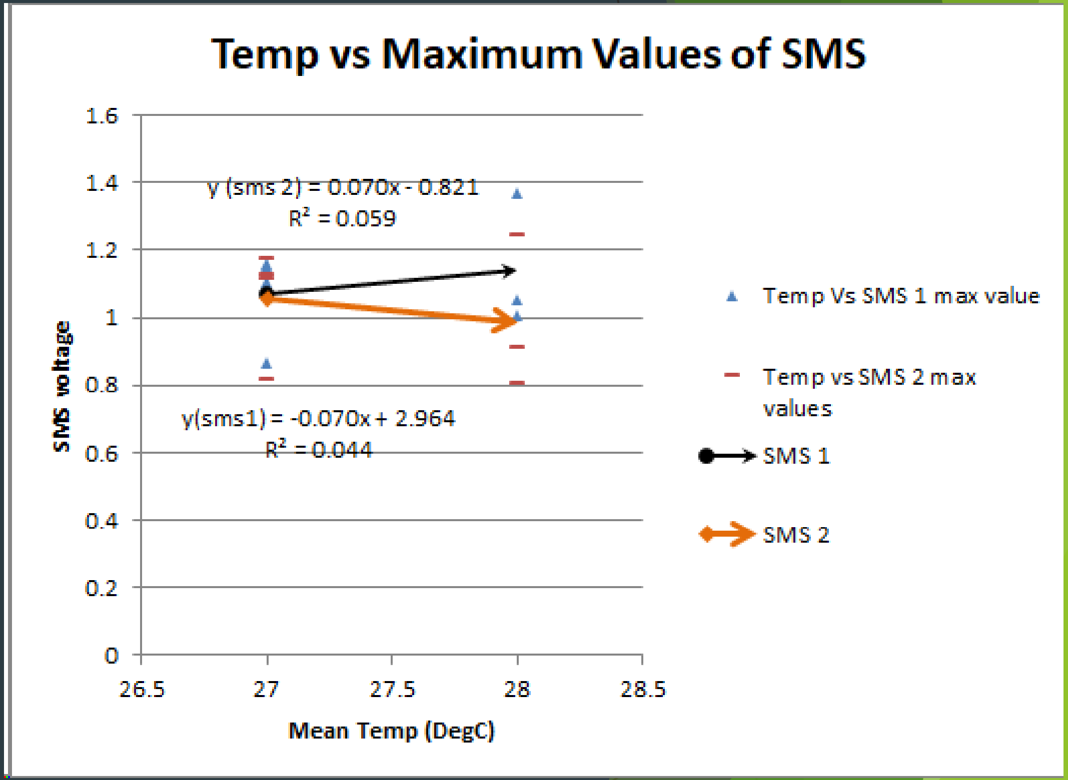


Fig 5:Soil Moisture 1 (SMS1) vs. Soil Moisture 2 (SMS2) Analysis

Road Map of the Proposed System

Real-time Field data sensing and Monitoring using Blynk IoT

Shrinkage Limit Test
(Saturation level of the soil is determined)

Sensor Calibration
(Mapping the sensor output voltage against different proportions of saturation moisture content)

Polynomial Regression
(The relation between the actual soil content and sensor output voltage is determined.)

Soil Type
(By visual Inspection)

TAW
(Total Available water of the soil type is determined.)

MAD
(Management Allowable Depletion percentage of the crop type is determined.)

Threshold value
(Threshold Water content
=(MAD%)*TAW(%)*saturation moisture content of soil)

Automated Irrigation based on Threshold value

Real-time Field Data Monitoring

Components: Soil moisture sensor, DHT11 , Blynk IoT platform

Monitored Parameters: Soil moisture, Temperature, Humidity

Data Communication:

- Real-time data transmission to Blynk cloud.
- User-friendly interface for easy monitoring Soil moisture, Temperature and Humidity.
- Accessible via Blynk IoT mobile application.

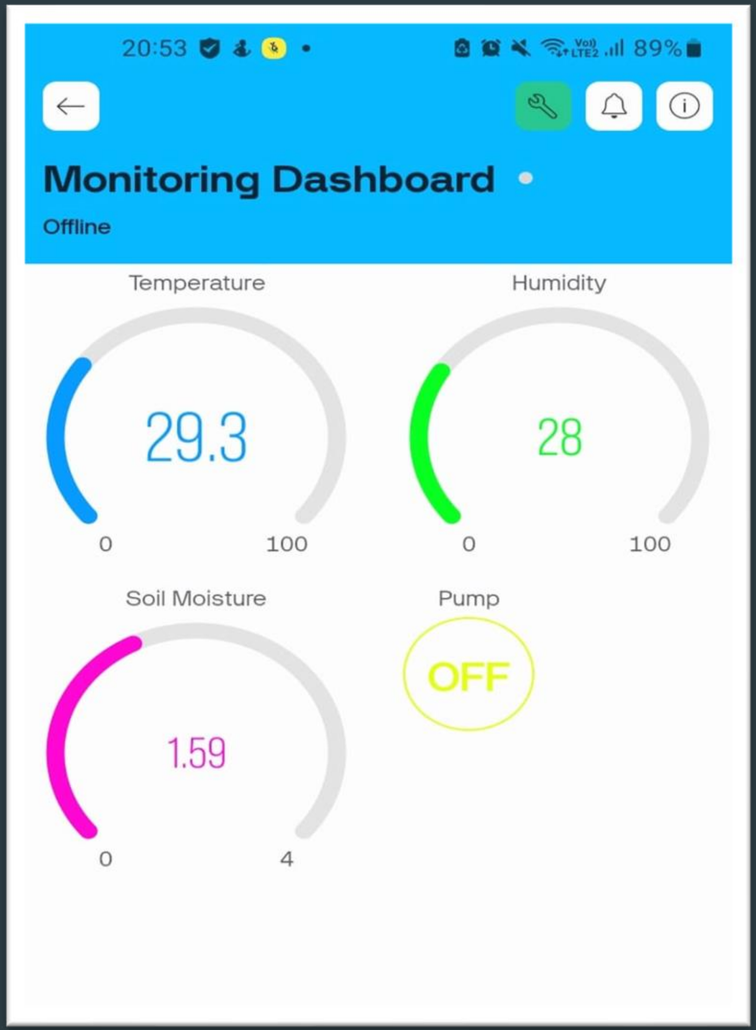


Fig 6: Blynk IoT mobile app

Road Map of the Shrinkage Limit Test

Soil Sample Preparation

(Oven-dry soil, Pulverize and sieve, Coat shrinkage dish, Weigh empty dish (W1))

Fill Dish with Moist Soil

(Add soil in layers, Level top layer, Weigh dish with wet soil (W2))

Oven-dry the Soil

(Dry at 110°C for 24 hrs, Weigh dish with dry soil (W3))

Determine Volume of Wet Soil

(Fill dish with mercury, Press glass plate, Weigh dish with mercury (Wf) , Calculate volume (V))

Determine Volume of Dry Soil

(Immerse dry soil in mercury, Weigh dish with mercury, after displacement (Wp), Calculate volume (V0))

Calculate Shrinkage Limit

(Calculate initial water content (w), Use Shrinkage Limit formula)

Lab Pictures of Shrinkage Limit Test

Fig 7: Calculating the weight of the wet soil content

Fig 8: Calculating the weight of the dry soil content

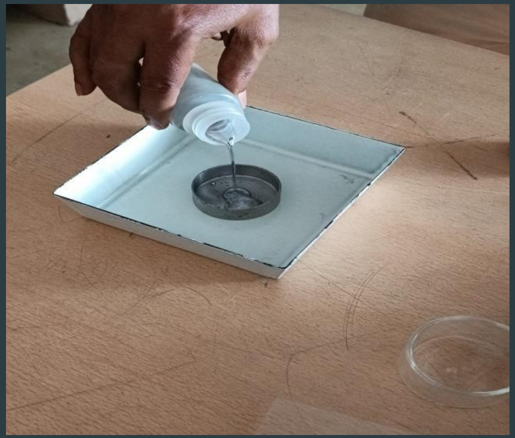


Fig 9: Taking mercury in a dish

Fig 10: Measuring the weight of the dish with mercury

Lab Pictures of Shrinkage Limit Test (Cont..)

Fig 11: Dipping the dry soil pat into the filled mercury container

Fig 12: Measuring the weight of the dish after mercury displacement

Observation Table of Shrinkage Limit Test

Determination	Value
Weight of Container in gm(W1)	31.396 gm
Weight of container + Weight of wet soil pat(in gm)(W2)	73.598 gm
Weight of Container + Weight of dry soil pat(in gm)(W3)	61.774 gm
Weight of oven dry soil pat(in gm)(W0)	29.635 gm
Weight of water (in gm)(Ww= W2-W3)	11.824 gm
Moisture content or water content(w) = (Ww/W0)*100%	39.89 %
Volume of wet soil pat(V)(in cm3)	22.042 cm^3
Volume of dry soil particle(V0)(in cm3)	16.5812 cm^3

Relation between sensor output voltage and actual soil moisture content

- Using the Shrinkage limit test, the saturation water content of the sampled soil is calculated.
- Now, different proportion of the saturation water content is added to identical samples of the soil, and its corresponding soil moisture sensor output is observed.
- For the conversion of sensor output raw data to sensor output voltage, the formula used is:
- $v = u * \frac{3.3}{1024}$

  where, v= Sensor Voltage (in Volts)

  u = Sensor raw data
- Polynomial regression is performed, considering the sensor output voltage as the dependent variable 'y' and soil moisture content as the independent variable 'x'.

Observation Table

Moisture content (in %)	Water content (in gm)	Soil Moisture Sensor raw data	Soil moisture Sensor voltage (in V)
0	00	511	1.6467467
18	1.69	504	1.624
32	3.0	449	1.44
50	4.695	395	1.27
70	6.5732	364	1.17
85	7.982	294	0.947
100	9.3903	232	0.747

Table 1. Observation table of soil moisture sensor output

Relation between sensor output voltage and actual soil moisture content (Cont..)

- The relation between the sensor output voltage (y) and actual soil moisture content (x) is calculated to be:

$$y = -0.005x^2 - 0.0502x + 1.6644$$

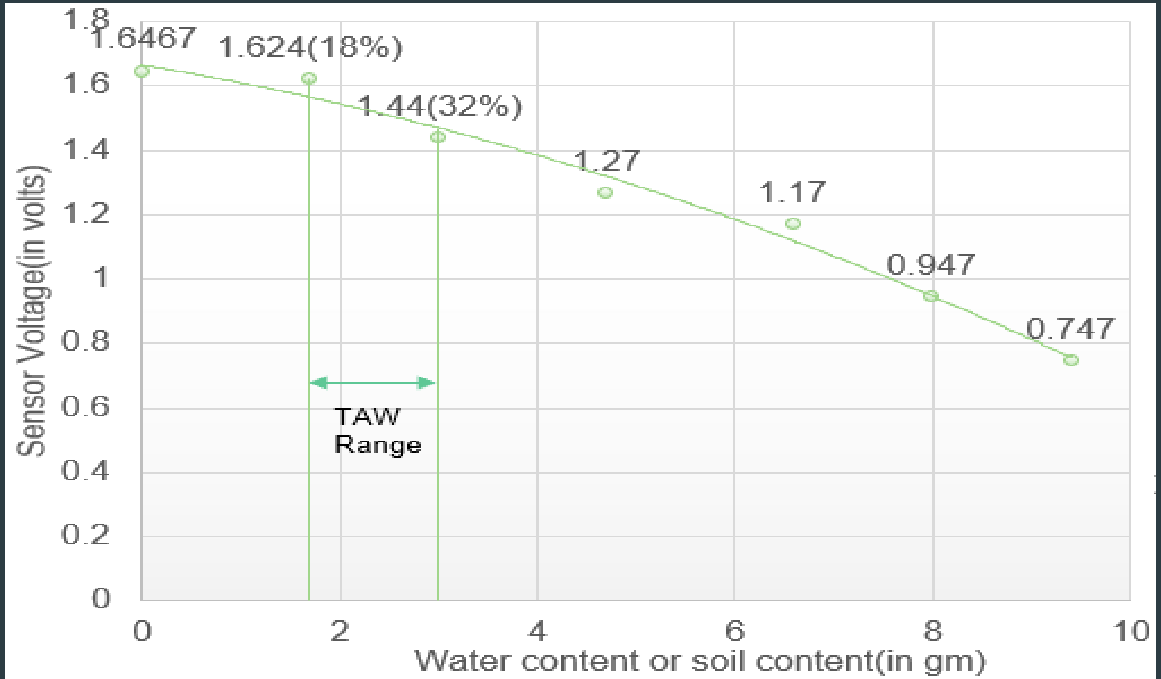


Fig 13. Water content vs sensor voltage graph

Identification of Soil Type

- Type of soil is classified based on visual attributes of the soil in the field.
- Soil seems as a blend of sandy and clay particles due to
  - Variations in soil color.
  - Muted hue influenced by both sandy lightness and clayey richness.
  - Granular texture, resulting from the combination of sand's gritty texture and clay's stickiness.
- After identifying the soil type, the TAW(in %) (Total Available Water) of the soil is assessed.

Soil texture	FC (%)	PWP (%)	TAW (%)
Sand	10	4	6
Loamy sand	16	7	9
Sandy loam	21	9	12
Loam	27	12	15
Slit loam	30	15	15
Sandy clay loam	36	16	20
Sandy clay	**32**	**18**	**14**
Clay loam	29	18	11
Silty clay loam	28	15	13
Silty clay	40	20	20
Clay	40	22	18
Source: Ratliff et al. (1983); Hanson et al. (2000) Referred by Sumon Datta, Saleh Taghvaeian, Jacob Stivers (2017)			

TABLE 2. FC, PWP, and TAW (%) of soil textures

Graphical Representation of TAW

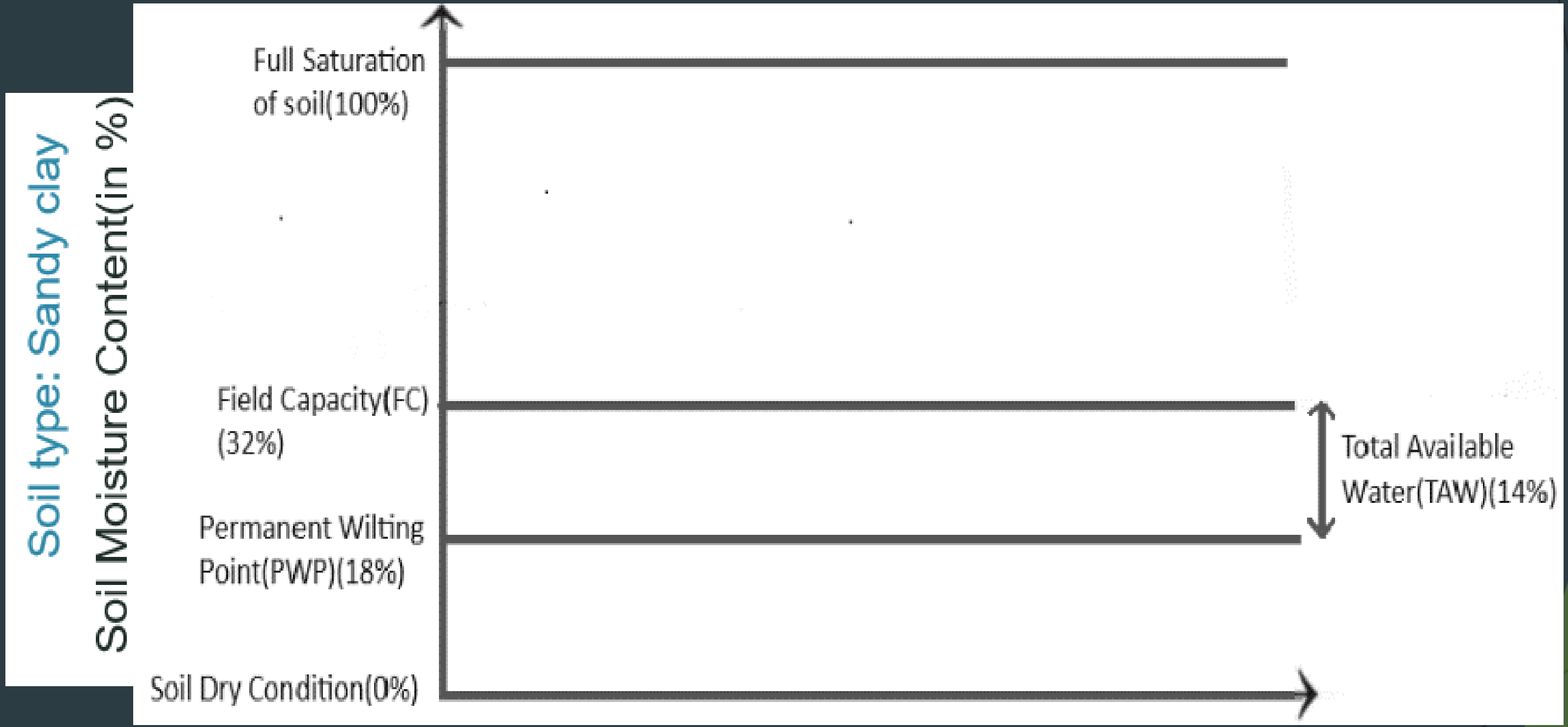


Fig 14. Graphical representation of FC,PWP and TAW of sandy clay soil

Estimation of Threshold soil moisture sensor output voltage

- Now, as per crop type, the MAD percentage of the crop can be determined.
- Threshold Water content=(MAD% of the crop)*(TAW% of the soil)*(saturation water content of the soil).
- Threshold Soil moisture sensor output voltage is determined using the polynomial relation between actual soil moisture content(x) and sensor output voltage(y).

$$y = -0.005x^2 - 0.0502x + 1.6644$$

where, y= Sensor Voltage output of the soil at x amount of moisture content.

x= Water Content or moisture Content of the Soil

Type of Crop	MAD	Maximum Root Depth(ft)
Rice	0.20	1.6-3.3
Beans	0.45	1.6-4.3
Soybeans	0.50	2.0-4.1
Cool Season-Turf grass	0.40	1.6-2.2
Warm season-Turf grass	0.50	1.6-2.2
Carrots	0.35	1.5-3.3
Cantaloupes/Watermelons	0.40-0.45	2.6-5.0
Potatoes	0.65	1.0-2.0
Source: Allen et al. (1998) Referred by Sumon Datta, Saleh Taghvaeian, Jacob Stivers (2017)		

TABLE 3. Mad values for different crops

Irrigation Scheduling using Blynk IoT

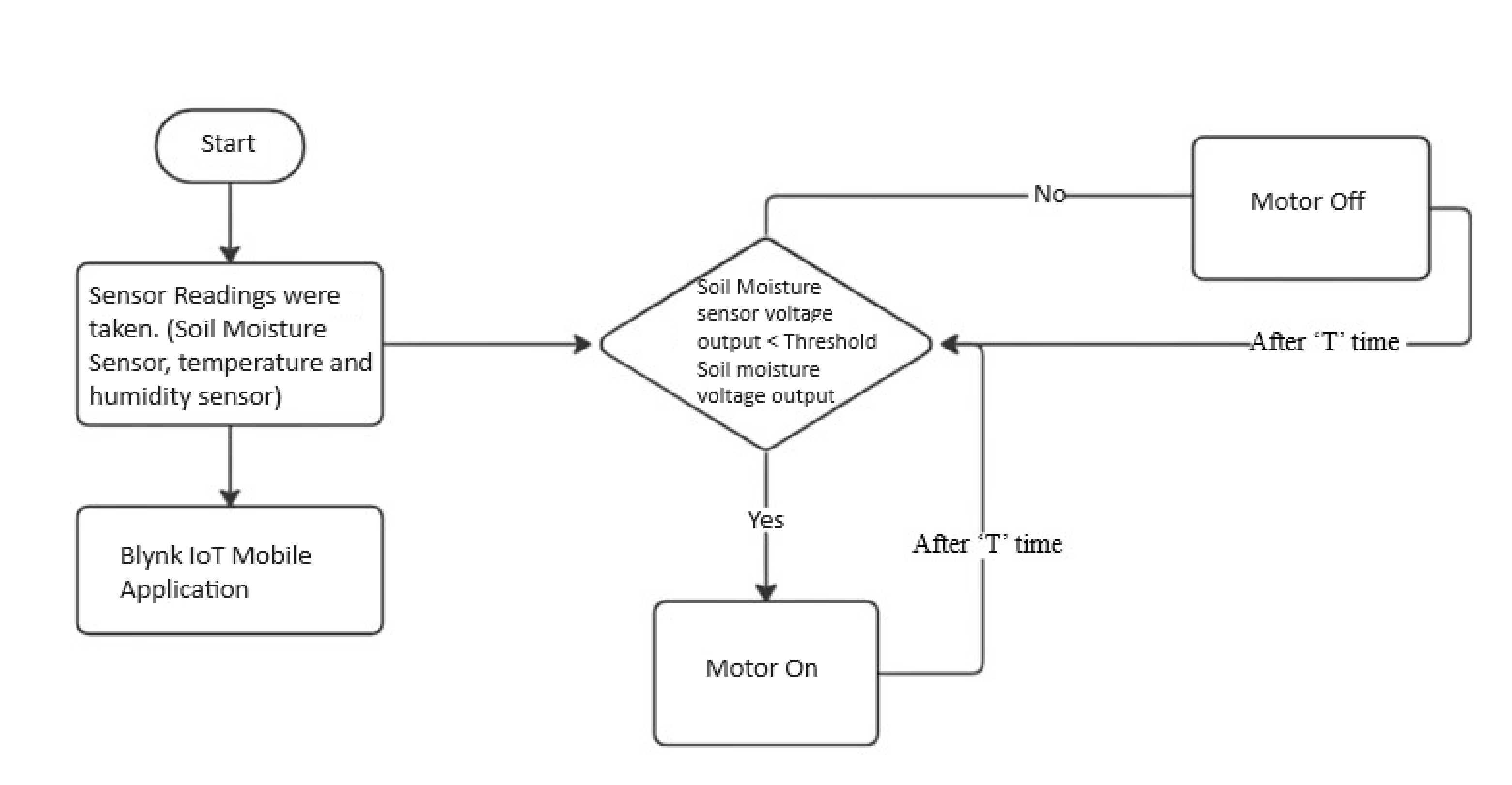


Fig 15. Flow Diagram Of The Automated Irrigation System

Results

- Using the shrinkage limit test, the saturation moisture content of the sample soil of 50 gm is found to be 9.3903gm of water.

- Using polynomial regression, the relation between the sensor output voltage (y) and actual soil moisture content (x) is calculated to be:

$$y = -0.005x^2 - 0.0502x + 1.6644 \quad \text{--------(i)}$$

- Soil sample is identified as Sandy-Clay soil.

- TAW (Total Available Water) percentage of Sandy-clay soil is 14%.

Results (Cont..)

- MAD (Management Allowable Depletion) percentage of the sample plant is 50%.
- Threshold Moisture content for 50gm soil sample is calculated as 2.3475 gm of water.
- The corresponding threshold soil moisture sensor output voltage is calculated using the polynomial relation (i) as 1.5189V.
- As the soil moisture sensor output voltage goes above 1.5189V value, water pump is switched on and irrigation is started.

Pros and Cons of the Proposed System

	ADVANTAGES	DISADVANTAGES	
1	Reduces water wastage, ensuring crops receive precisely what they need.	Time taking calculations.	1
2	Ensures real-time remote monitoring of field conditions.	Climatic changes are not considered.	2
3	Improved water management leads to improve yield and increased productivity.	More environmental factors needs to be considered for improving efficiency.	3
4	Cost efficient system.		
5	Both crop and soil type are considered while determining threshold.		

Conclusions & Future Work

- Research finds soil moisture threshold for irrigation using MAD and TAW values.
- The need for regression analysis to calibrate sensors accurately.
- Establishment of a robust irrigation scheduling framework using MAD values.
- In the future, we aim to increase the precision of the system by analyzing more environmental factors and weather conditions.
- Refining threshold values based on types of crop, soil, and climatic conditions.

References

[1].Sumon Datta, Saleh Taghvaeian, Jacob Stiver, “Understanding soil water content and thresholds for irrigation management”, Oklahoma Cooperative Extension Service, Issue 1537, Oklahoma State University, 2017.

[2]. R. Nageswara Rao, B. Sridhar, "Iot based smart crop-field monitoring and automation irrigation system", IEEE Xplore Compliant, ISBN:978-1-5386-0807-4, 2018.

[3].Yu-Chuan Chang, Ting-Wei Huang, Nen-Fu Huang, "A machine learning based smart irrigation system with lora p2p networks", IEEE, 2576-8565, 10.23919/APNOMS.2019.8893034, 2019.

[4]. Revanth Kondaveti, Akash Reddy and Supreet Palabtla, "Smart irrigation system using machine learning and iot", IEEE, 10.1109/ViTECoN.2019.8899433, 2019.

[5]. Atia Sultana et al., "Iot-based low-cost automated irrigation system for smart farming", ResearchGate, 10.1007/978-981-16-6309-3_9, 83-91, 2022.

Thank You!

Any Question?