Development of IoT-Based Irrigation System for Sustainable Agriculture

Thesis Pre-Defense

Presenter: Charles Mzigo Kajanja
Registration : E222-01-0102-2022

Supervisors: 1. Dr. Sam Macharia
2. Dr. Charles Kagiri

MSc. Advanced Manufacturing and Automation Engineering

Presentation Highlights

1. Introduction
2. Literature Review
3. Material and Methods
4. Results and Discussion
5. Conclusion
6. Recommendation

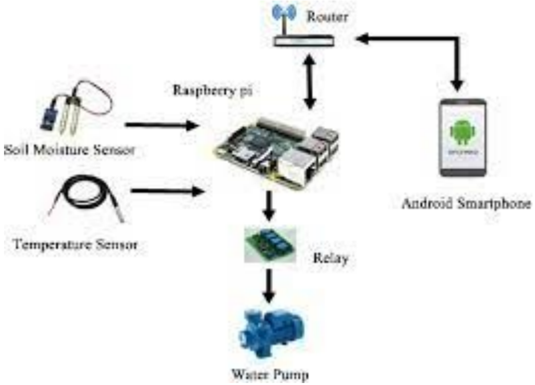
Introduction

Background Information

Agriculture is the Source of Food, Raw material for industry and Domestic, Contributes to the National Economy

Resources for Agriculture

Automation and IoT System



Farming and Irrigation Methods

Challenges in Agriculture

Water and Land scarcity, High Food demand

Causes of the Challenges

Climate changes, Urbanisation, Population growth

Facing Challenges

Efficient use of Available Water, land, Modernising Agriculture

Problem Statement

Limited arable land compels to multiple-crop farming, which challenges farm monitoring and irrigation processes, compromising water scarcity management strategies.

Problem	Causes	Gap	Proposed solution
Challenges in Monitoring and scheduling irrigation process in multiple crop farming	Crop Difference growing parameters and water requirements	There is no adequate information on the concept of IoT and automation in multiple crop farming in (EAC).	IoT Irrigation system to Monitor and schedule irrigation processes on the intercropped farm.

Rationale

Scarce of resources issues

Popularity of Intercropping for Smallholder farmers (SHF).

Engineering aspect on solving problems in Agriculture.

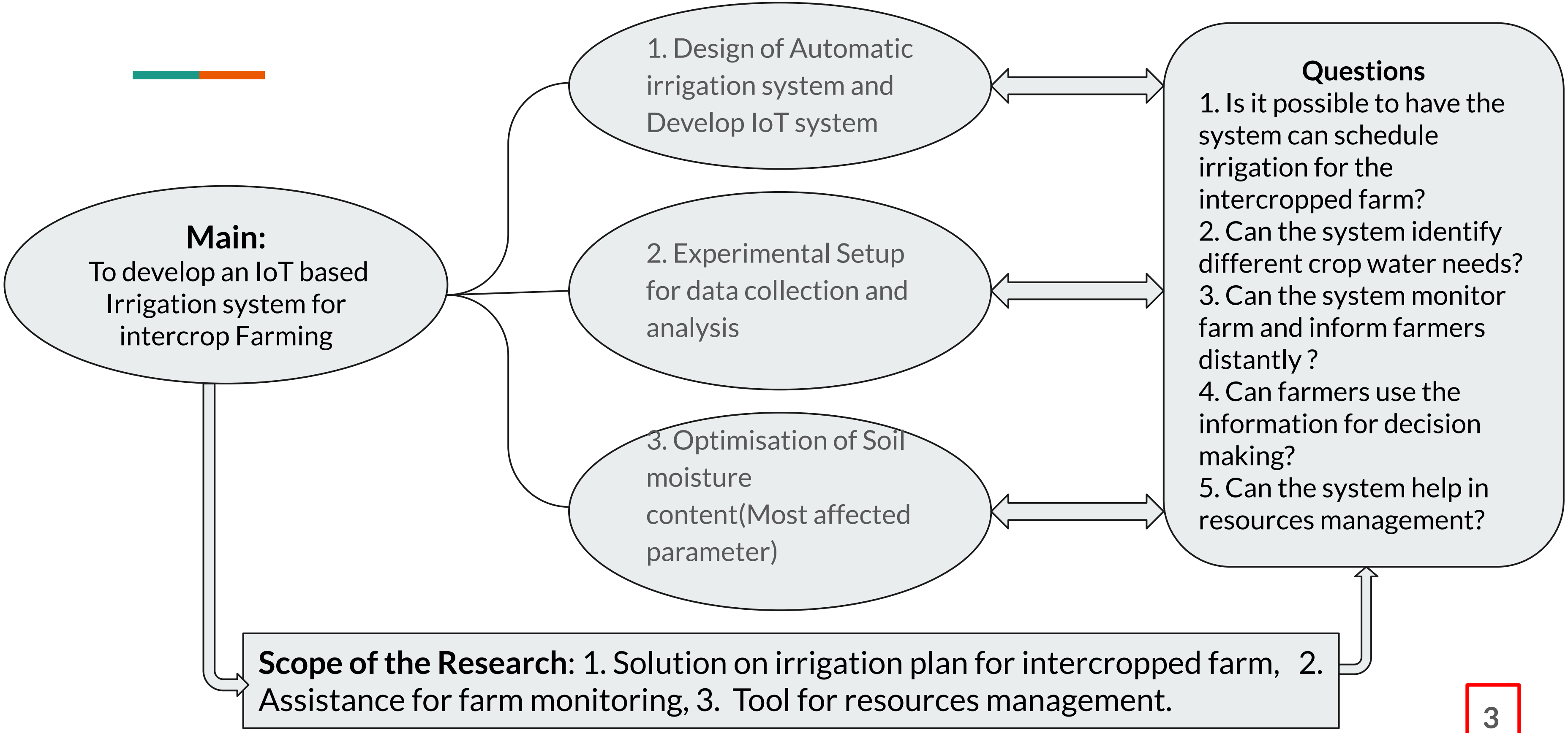
Motivation

Impact on addressing farming challenges in the society.

Automating irrigation system improves farming.

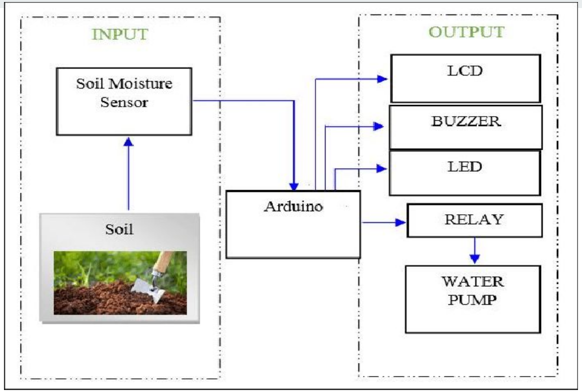
IoT tech can help SHF for farm monitoring.

Research Objectives and Scope



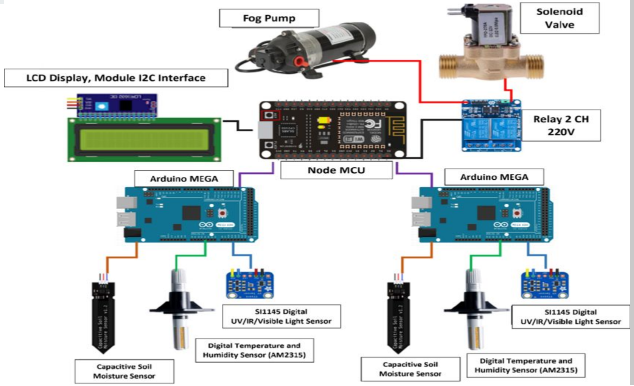
Literature Review

Automatic irrigation



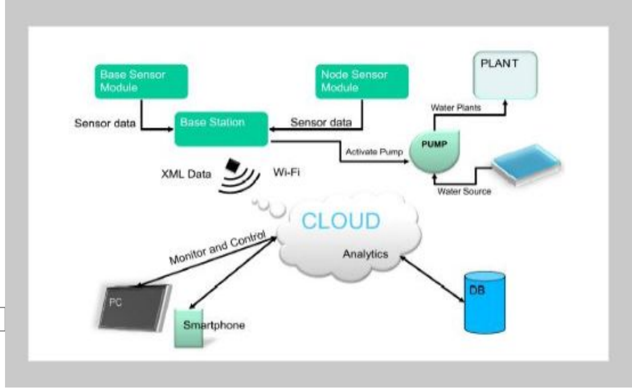
Mon Arjay, et al. (2020)
https://doi.org/10.30534/ijatcse/2020/216922020

IoT controlled irrigation

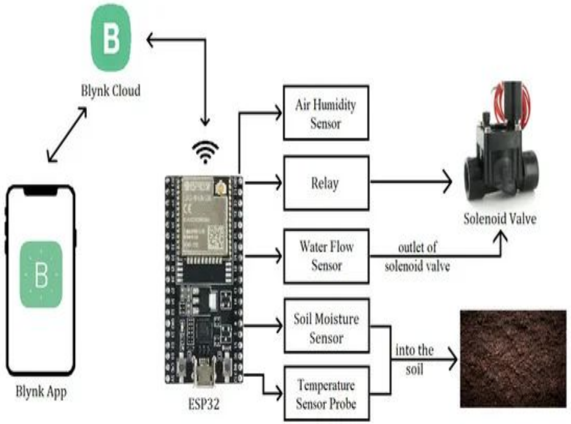


Chanthana Susawaengsup, et al. (2022)
https://doi.org/10.3390/horticulturae8121130

IoT irrigation for smart farming



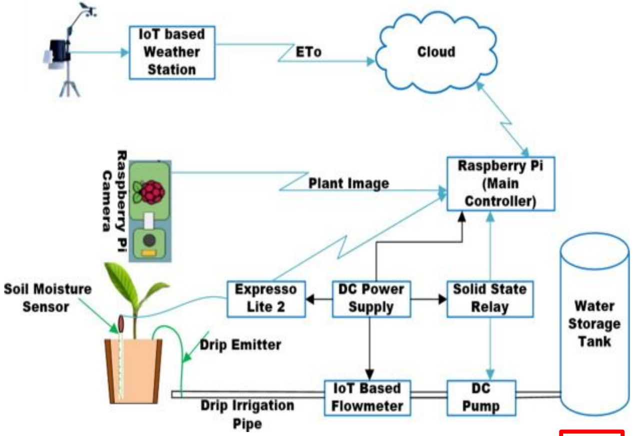
Dhanalakshmi R., et al. (2020)
https://doi.org/10.6180/jase.202208_25(4).0009



Gilroy P., et al.(2022)
https://doi.org/10.3390/iot4030012

Results:
Minimized Water wastage while satisfying crop needs.
Monitoring weather condition
Maximize crop production
Simplified farming

Gap:
IoT and Automation in Multiple crop farming is limited



Emmanuel, et al. (2020)
https://doi.org/10.1016/j.inpa.2020.05.004

Materials and Methods

Study Area Description

The Research was conducted in Mechatronic Labs Department of mechatronic Engineering , School of engineering at the Dedan Kimathi University of Technology

Location : 0^o 23’ 51’’ S, 36^o,57’31’’E

Lab temperature 17-19 oC and Humidity 90 - 93%

Materials

Hardware Components

DS18B20

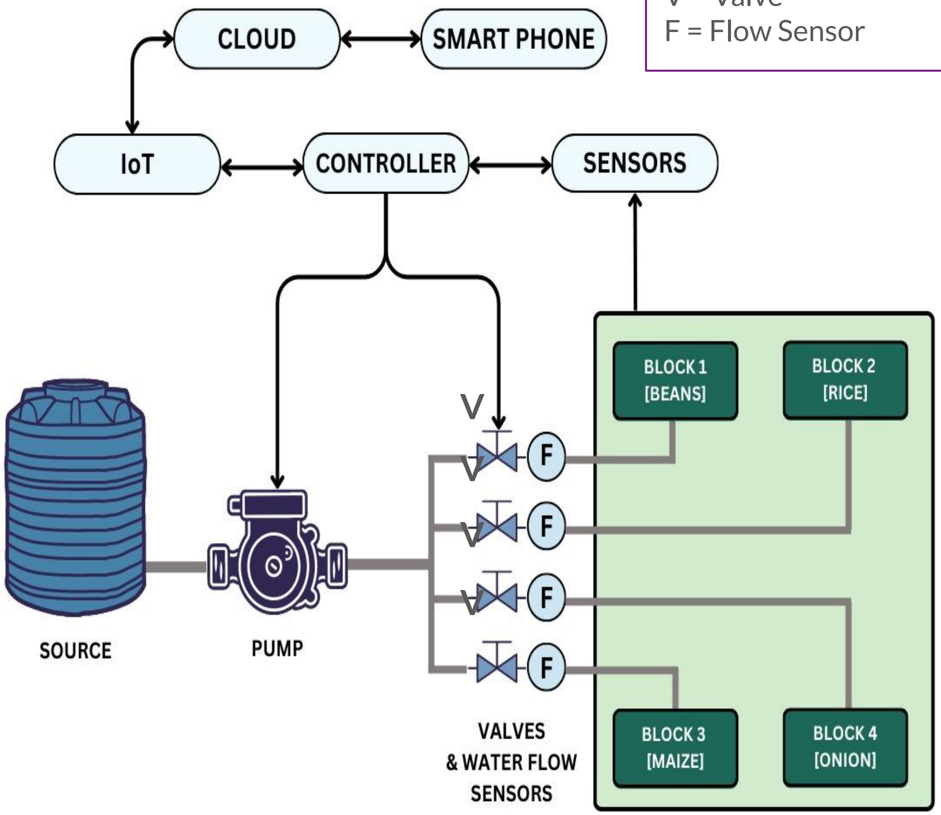
Software Components

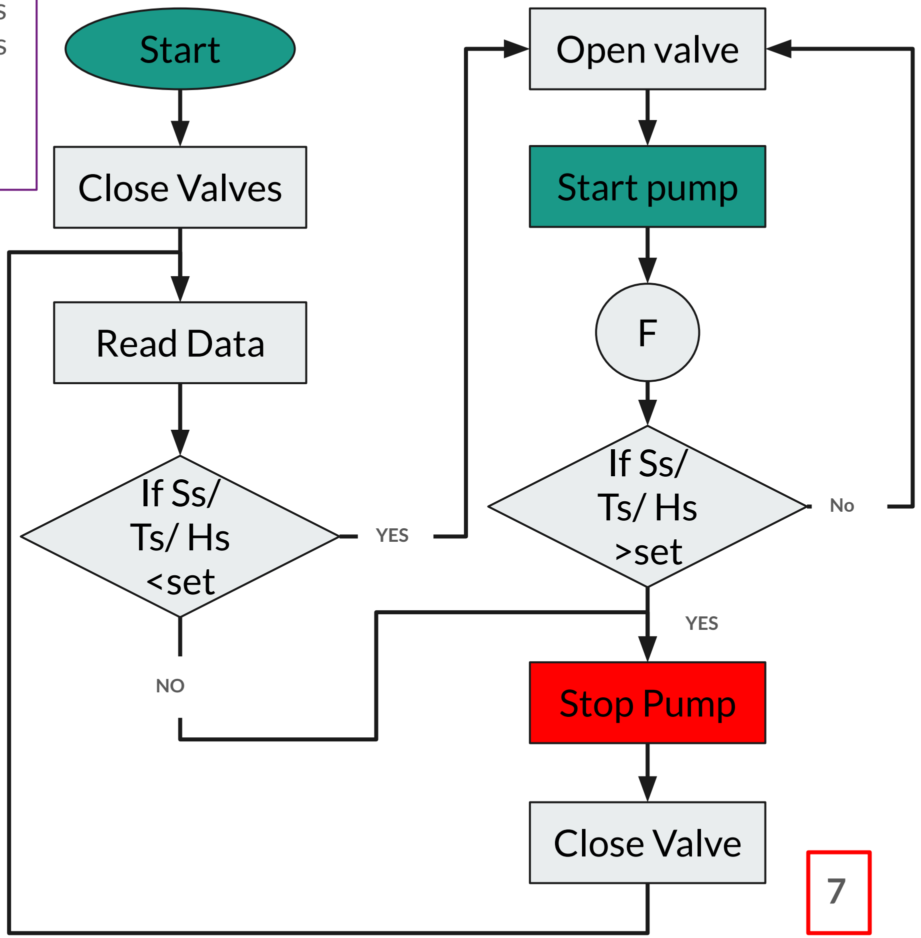
Software	Version	Function
Arduino IDE	2.1.0	Programing the system
Node-Red	v3.0.2	Data processing
Influx BD	v1.8.10	Database to store Data
Grafana	10.0.3	Data Analysis & Visualization
MQTT	2.0.11	Communication Protocol
Proteus	Pro. 8	Electrical Circuit Design
Python	3.9.2	Data analysis
RealVNC	7.1.0	Cloud Connection

Proposed system: System Architecture

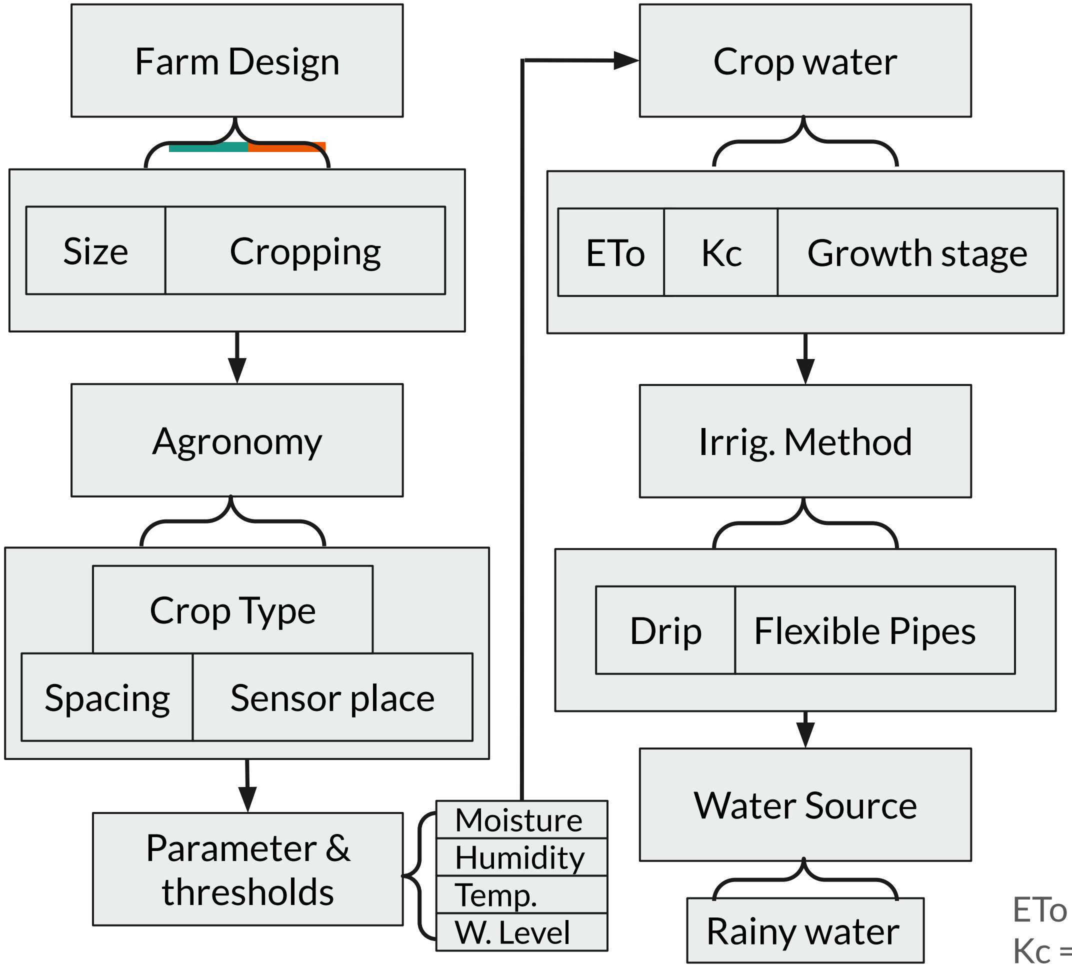
Working Principle

Ss= Soil Moisture Sensors
Ts = Temperature Sensors
Hs = Humidity Sensors
V = Valve
F = Flow Sensor

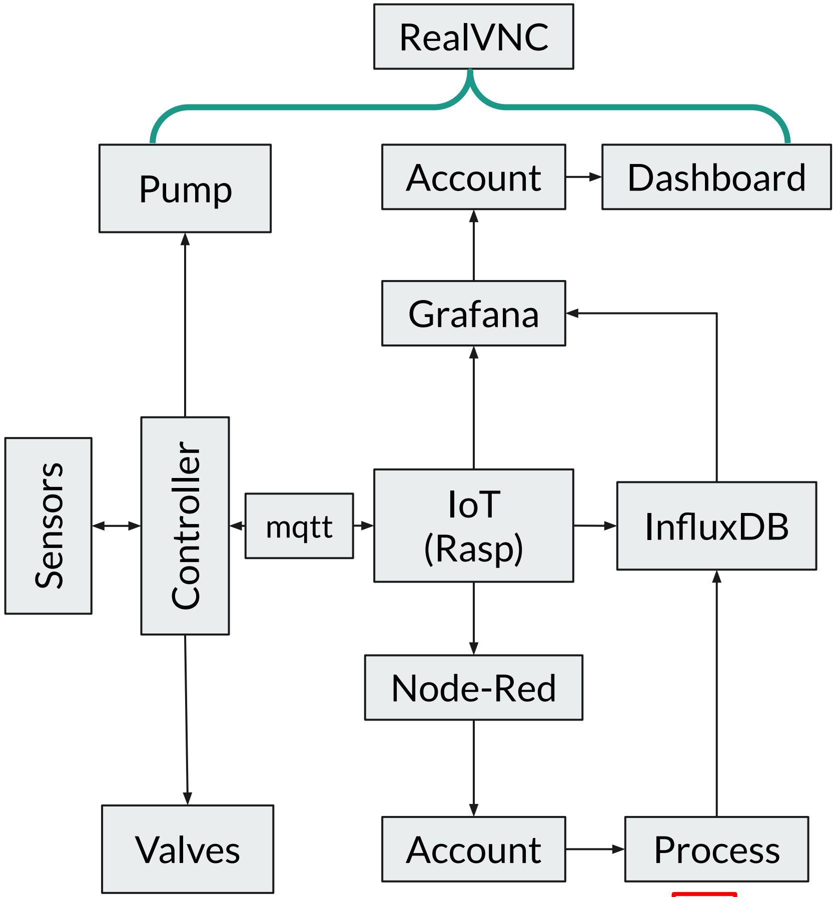




Method 1: Irrigation System Design



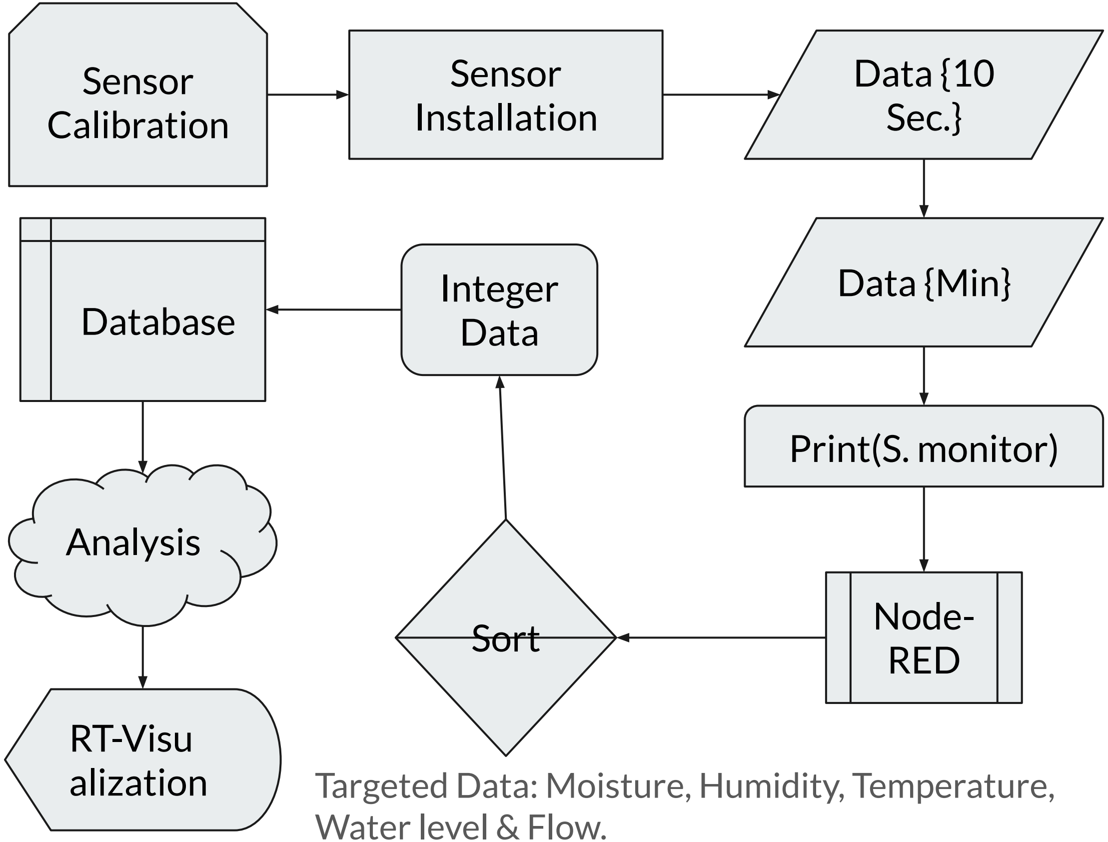
IoT System Development



ETo = Reference crop evapotranspiration
Kc = Crop factor

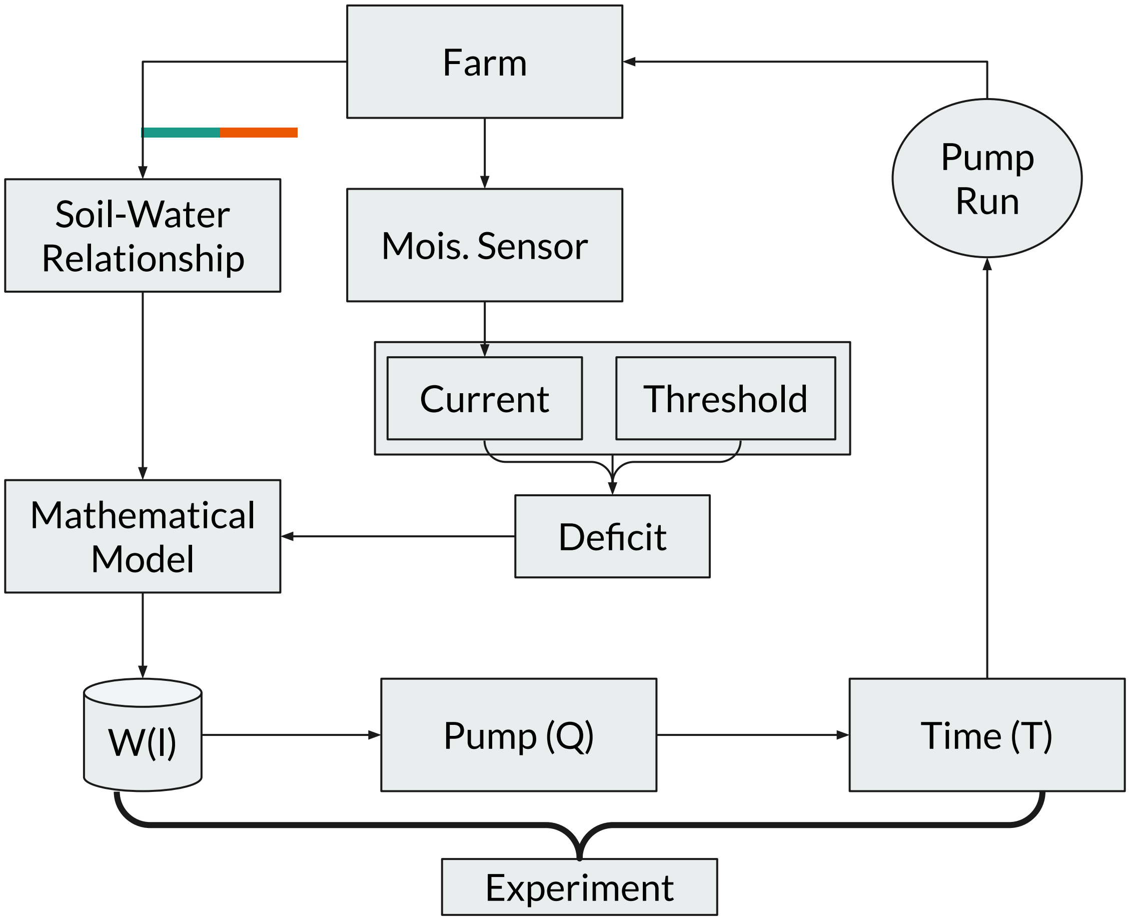
Method 2:Experimental Setup

Data collection Techniques

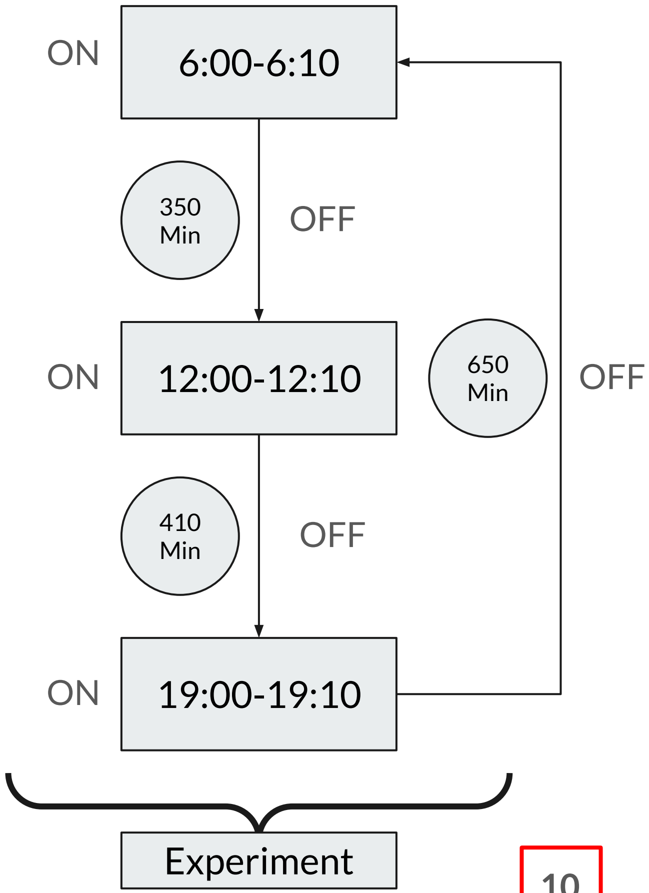


Targeted Data: Moisture, Humidity, Temperature, Water level & Flow.

Method 3: Soil Moisture Optimization

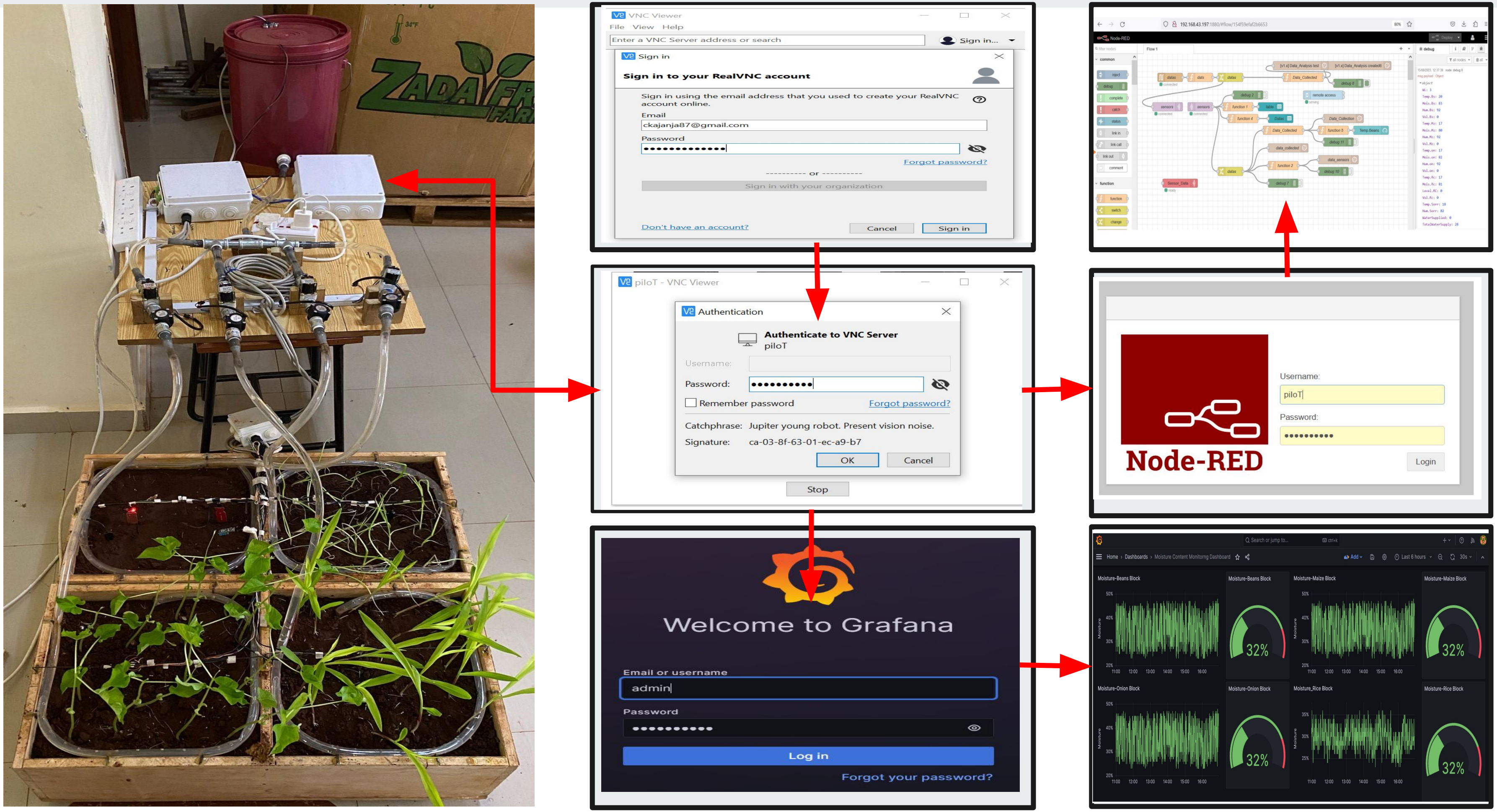


Energy use management

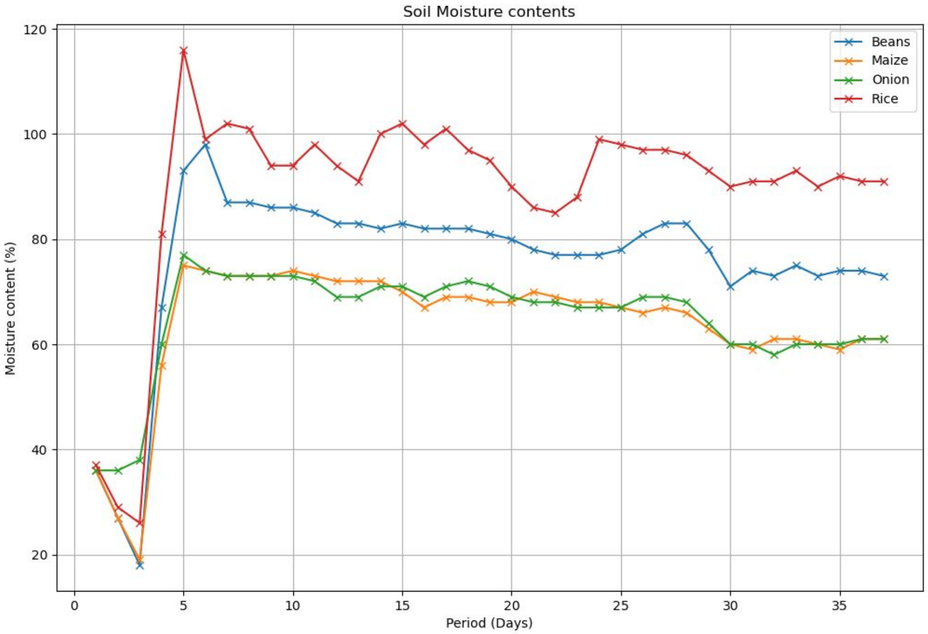


Results and Discussions

Irrigation system : IoT system



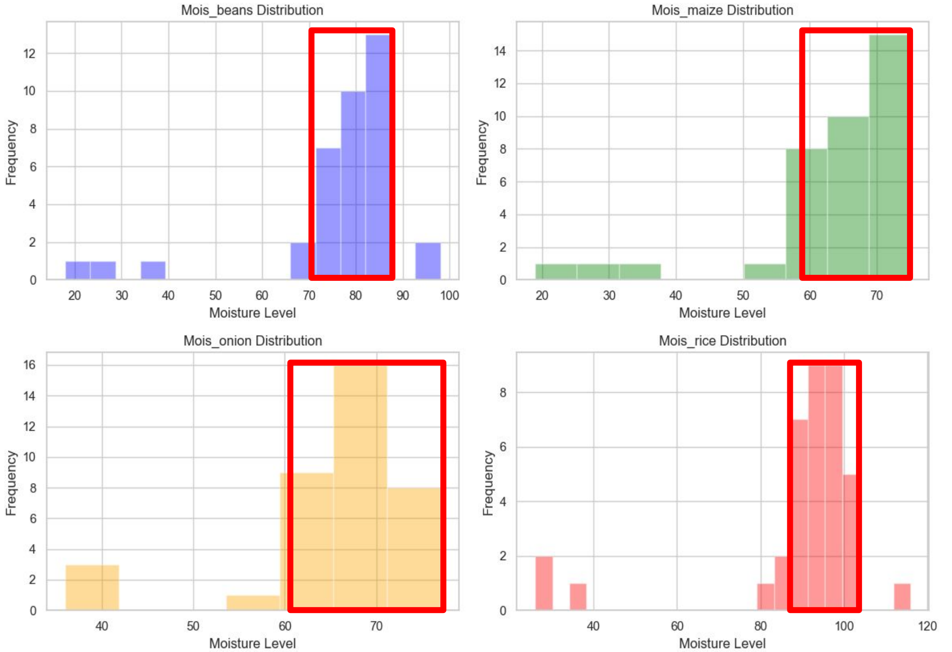
Soil Moisture Content



- The system maintained moisture levels within the range for all crops with an average of 75,65,64 & 95% for beans, maize, onion and rice.

❖ The system can identify the crop needs
❖ It can help farmers to automatically plan irrigations

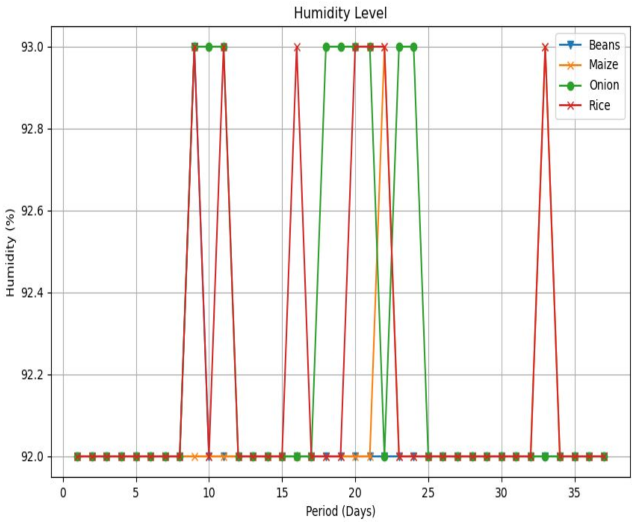
Soil Moisture Patterns

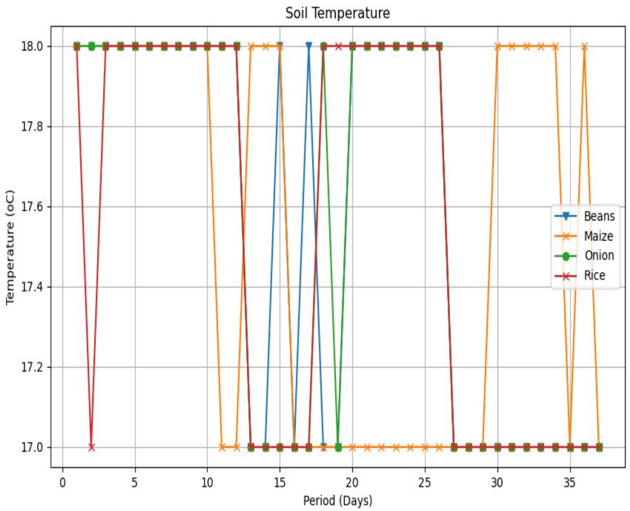


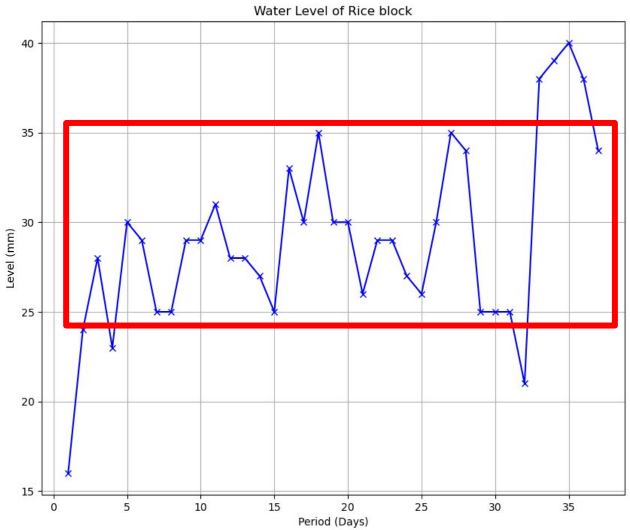
- Beans maintained 70-85% for 32 days, maize 60-75% for 33 days, 0nion 60-75% for 33 days, rice 90-100% for 32 days.

❖ The system achieved the range of moisture contents most of the days.

Humidity Temperature Water Level







- Humid range between 92 & 93%
- Many days humidity was 92%

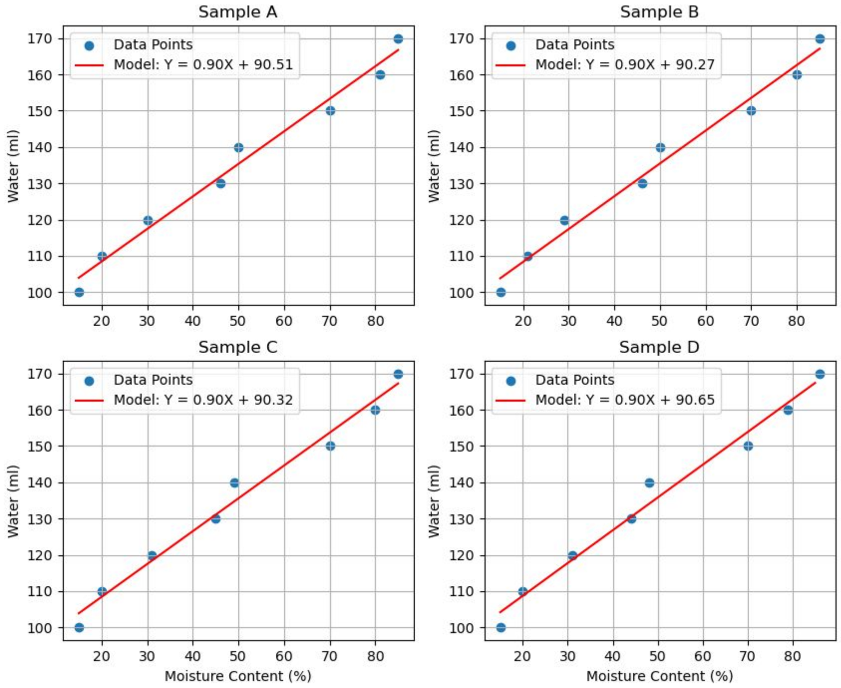
- Temp. reneged between 17 & 18° C
- Many days temp was 18° C

- Water level mostly ranged between 25-35 mm.
- Average of 29 mm allover experiment period.

❖ Humidity and Temp found to have no significant changes
❖ Does not caused any schedule of irrigation processes
❖ However, they are important especially during hottest seasons

❖ It can help on maintaining required water level.
❖ It helps smallholder farmers (SHF) to achieving optimal water levels preventing overflow.

Soil -water volume relationship

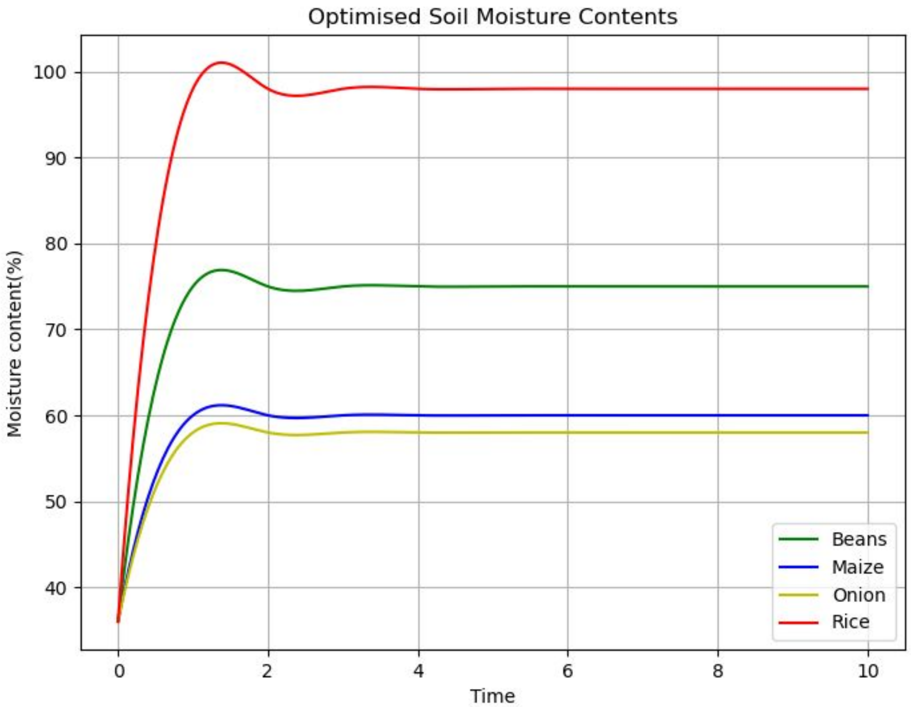


- The models for all samples found to have a correlation of 0.99.

❖ It indicates that as water increases also the moisture content increase.

❖ The model can be used to optimise soil moisture

Soil moisture optimisation

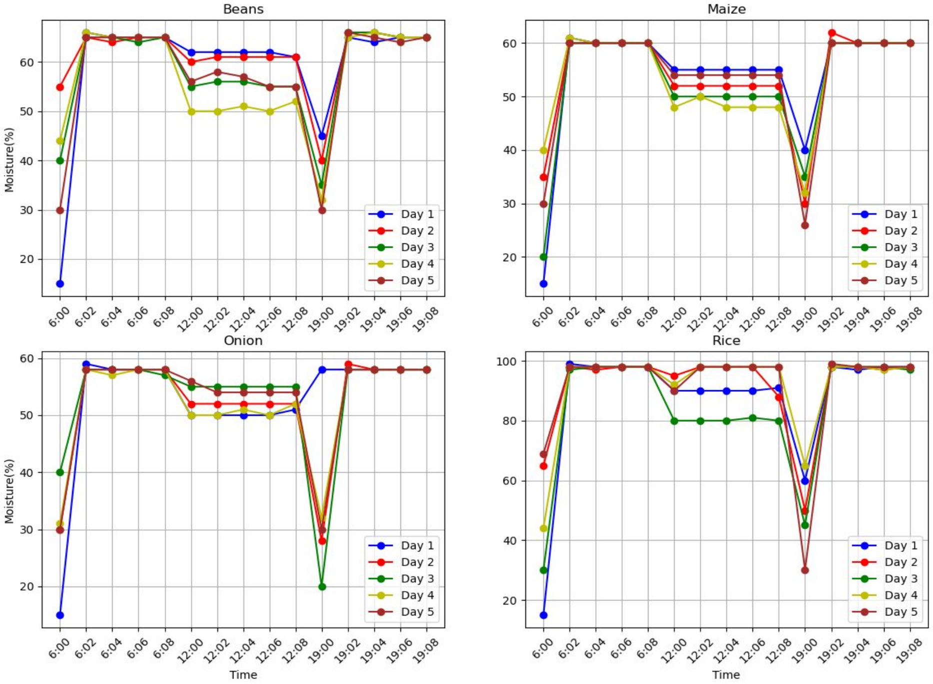


- Soil- water volume relationship achieved optimal soil moisture level for all crops.
- Moisture contents of 75, 60, 58 & 98% for beans , maize, onion and rice was achieved.

❖ It allocates the right amount of water to the crop

❖ It promotes crop health for improved crop production

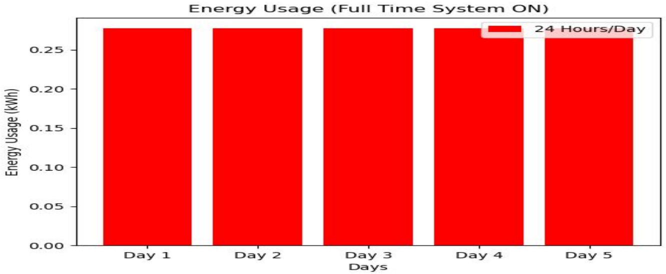
Soil moisture Confirmation

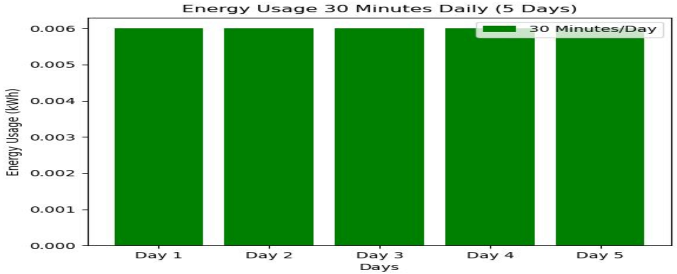


- Sensors confirmed soil moisture and schedule Irrigations during optimal irrigation hours.
- The technique yielded the same results as when the IoT system remained ON for 24 hours.

❖ The technique can be used for energy use Management
❖ It promotes system’s scalability in areas with energy scarce

Energy Saving

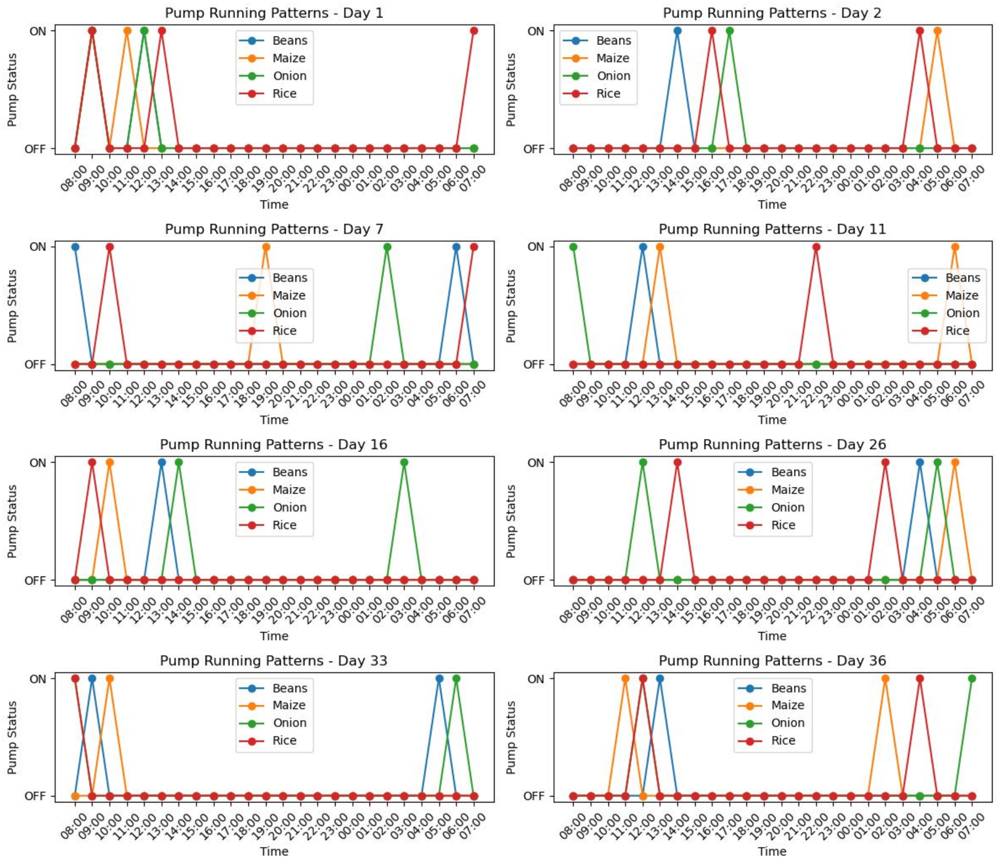




- Optimal irrigation hours scheduling technique can save energy up to 97% .

❖ It can be a tool energy use managements
❖ Can help smallholder farmers in remote areas to adopt the system.

Irrigation Scheduling Plans



Discussion

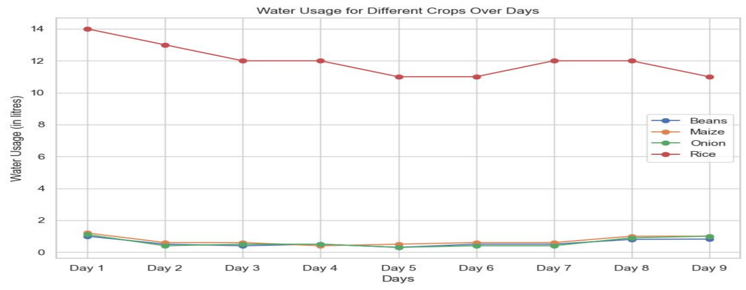
- Day 1 irrigation happened twice for beans, maize and onion, and three times in rice.
- Day 2 happened once for all crops except for the rice happened twice.

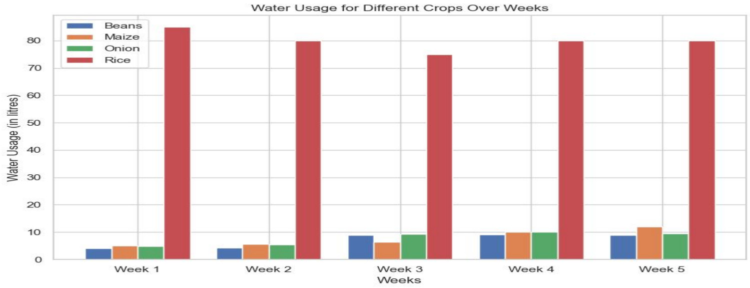
- From Day 7 irrigation became dynamic happening once or twice daily.
- Beans: Day7 & D33. Maize: Day 11 & 36. Onion: Day 16 & 26.
- Rice maintained twice irrigations except on Day 16 & 33 happened once.

❖ It is difficult for SHF to detect water crop needs and take action on time.

❖ The system is important to farmers helping on water resources allocation.

Water Usage



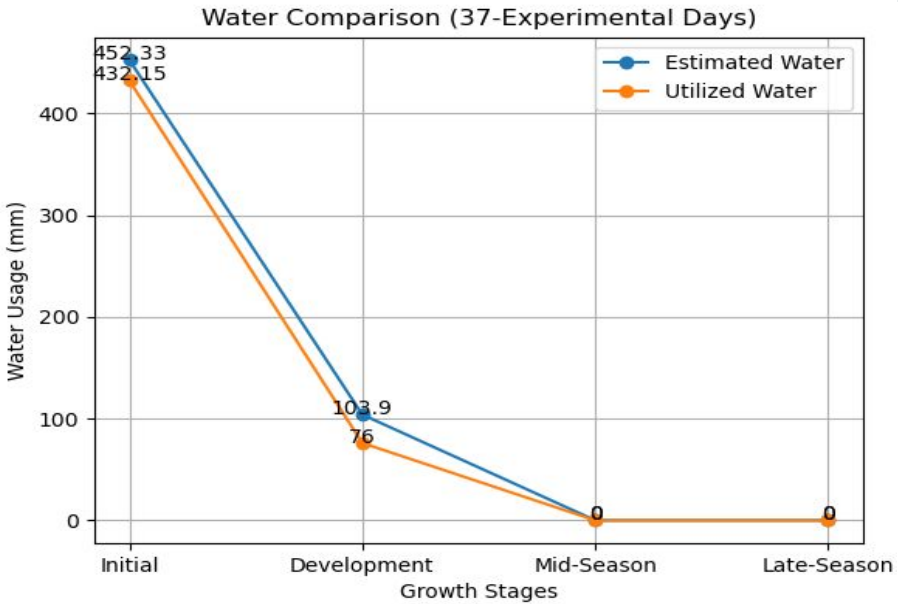


- More water Day 1, normal up to Day 7.
- Started to increased from Week 2

❖ The system can detects water needs in the right time.

❖ Efficient utilisation of water

Water Saving



- IoT Irrigation system utilized less water by 8.6% .

❖ It can be a tool for managing water usage.

❖ Can provide the right water at the right time.

Conclusion

1

The developed system managed to schedule irrigation processes depending on crop water needs on the intercropped farm.

The system respond to the unpredictable, dynamic changes of moisture content

It helps farmers automatically allocate water resources and reduce water waste

2

Using IoT sensors, the system Monitors farm remotely.

It can eliminate physical presence in the field, simplifying farming practices for farmers

It can help farmers identify abnormalities on the farm and make the right decisions

3

Optimal soil moisture content attained by using soil and water volume relationship.

Optimal soil moisture contents can promote crop health.

It maximizes utilization of water resources.

4

Using Optimal irrigation hours scheduling technique saves energy .

Less energy use can promote the system's scalability for farmers in remote areas where energy is scarce.

Enables irrigation to happen during optimal irrigation hours

<u>Contributions</u>

The Research Provides: Insights on the integration of automation and IoT technology in multiple crop farming,
:Soil Moisture and Water volume relationship technique for optimisation of soil moisture contents.
: Optimal irrigation hours scheduling technique for energy use Management.

Recommendations

Future research may prioritise on:

- ★ Design of wireless sensors to streamline the process of removing and replacing of wires during the farming process.
- ★ Integrate the system with a database containing crucial crop growing parameters, allowing the system's adaptability of crop rotations.
- ★ Integrating the system with other sensing technologies such as disease detection and fertigation systems.

Acknowledgement

Thank You !

EAC SCHOLARSHIP PROGRAMME

Dedan Kimathi University of Technology