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NOIDA

Long Range (LoRa) based soil moisture monitoring

Submitted By:
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Abhay Patel 21102087

Submitted To:
Dr. Alok Joshi

project report submitted in partial fulfillment of the requirement for the degree of

Bachelor of Technology in Electronics and Communication Engineering

Certificate

This is to certify that Dhwaj Agarwal (21102071) and Abhay Patel (21102087), students of Electronics and Communication Engineering, Jaypee Institute of Information Technology, Noida, have successfully completed the project on the topic "Long Range (LoRa) based Soil Moisture Monitoring " under the guidance of Mr. Alok Joshi during the year 2023. This work has not been submitted partially or wholly to any other University or Institute for the award of this or any other degree or diploma.

Signature of Supervisor ……………………….

Name of Supervisor: Dr. Alok Joshi Designation ……………………….

Date: 30/11/20

ACKNOWLEDGEMENT

I would like to extend our heartfelt appreciation to our supervisor, Mr. Alok Joshi, for offering invaluable guidance, insightful comments, and constructive suggestions throughout the duration of the project. His consistent motivation and direction played a pivotal role in steering us towards the successful completion of the project. I am sincerely grateful to Mr. Joshi for his unwavering supervision and for providing essential information related to the project.

Nevertheless, the realization of this project would not have been achievable without the generous support and encouragement of our parents and colleagues. Their contributions, coupled with their individual skills, have been instrumental in the development of the project.

Signature ……………………….

Dhwaj Agarwal, 21102071

Abhay Patel, 21102087

Date: 30/11/2023

CANDIDATE’S DECLARATION

This certificate attests that the B. Tech Minor Project Report titled "Long Range (LoRa) based Soil Moisture Monitoring " has been submitted by the students specified in accordance with the requirements for the Bachelor of Technology degree in Electronics & Communication Engineering at Jaypee Institute of Information Technology, Noida. The report, reflecting our independent work, covers the period from August 2023 to December 2023.

Acknowledging the guidance received during this project, we express our gratitude to Dr. Alok Joshi from the Electronics & Communication Engineering Department for his diligent supervision.

(Student Signature)	(Student Signature)
Dhwaj Agarwal	**Abhay Patel**

This is to certify that the above statement made by the candidates is correct to the best of my knowledge.

(Signature of supervisor)

Dr Alok Joshi

Date: 30/11/2023

Table of Content

CHAPTER-1

INTRODUCTION

Long Range (LoRa) technology, known for its prowess in enabling long-distance wireless communication with minimal power consumption, has been a transformative force across various domains. Leveraging the capabilities of LoRa in conjunction with ESP32 microcontrollers—renowned for their versatility, integrating Wi-Fi and Bluetooth functionalities—this project delves into the domain of soil moisture monitoring in agriculture.

Soil moisture, a critical factor in ensuring optimal crop health, has spurred the need for precise and real-time monitoring solutions. Traditional methods often face limitations, prompting the exploration of innovative technologies. The integration of LoRa technology and ESP32 microcontrollers presents a promising avenue for addressing these challenges.

This project specifically focuses on the development of a Long Range (LoRa) based soil moisture monitoring system implemented on an ESP32 WebServer. The amalgamation of these technologies aims to provide a robust and efficient solution for remote soil moisture monitoring in agricultural settings. By transcending geographical constraints through long-range communication capabilities and leveraging the adaptability of ESP32 microcontrollers for field deployment, this project seeks to revolutionize the way soil moisture data is collected and utilized in precision agriculture.

In the following sections, we will delve into the components, technologies, and objectives of this endeavour, emphasizing its potential to enhance agricultural efficiency and sustainability through the utilization of real-time data delivered by the LoRa ESP32 WebServer-based soil moisture monitoring system.

The primary contributions of the "Long Range (LoRa) based soil moisture monitoring on ESP32 WebServer" project can be distilled into two key points:

- **Innovative Integration of Long Range (LoRa) Technology:**
    - Pioneering the use of Long Range (LoRa) technology for soil moisture monitoring, enabling extended communication range and low-power operation, essential for efficient and cost-effective agricultural applications.

- **ESP32 WebServer for Real-time Data Accessibility:**
    - Implementation of an ESP32 WebServer, providing a user-friendly interface for real-time access to soil moisture data. This contributes to precision agriculture by empowering farmers with actionable insights for optimized irrigation practices based on up-to-date information.

Related Work:

In the realm of soil moisture monitoring, numerous endeavours have explored diverse technologies and methodologies to address the challenges posed by agricultural landscapes. Existing studies have employed various communication protocols and microcontroller platforms to achieve real-time data acquisition.

1. **Wireless Sensor Networks (WSN):**
   - Previous research has extensively utilized Wireless Sensor Networks for soil moisture monitoring. While effective, traditional WSNs often encounter limitations in communication range and power efficiency. The Long Range (LoRa) technology employed in this project represents a novel approach to overcome these challenges, providing ***extended coverage with low power consumption*.**

2. **Microcontroller-Based Monitoring Systems:**
   - Numerous studies have implemented soil moisture monitoring systems utilizing microcontrollers. However, the versatility and adaptability of the ESP32 microcontroller, especially when coupled with the built-in Wi-Fi and Bluetooth capabilities, offer a distinctive advantage. This project aims to leverage the ESP32 WebServer for real-time data accessibility, providing a user-friendly interface for farmers and stakeholders.

Motivation:

The motivation behind embarking on the project of "Long Range (LoRa) based soil moisture monitoring " stems from the following key factors:

1. **Enhancing Agricultural Efficiency:**
    - The motivation lies in the pursuit of advancing precision agriculture. By integrating Long Range (LoRa) technology, the project aspires to transcend geographical constraints, offering an extended communication range critical for large-scale agricultural setups. Real-time soil moisture data, accessible through the ESP32 WebServer, empowers farmers to make informed decisions, optimizing irrigation practices and resource utilization.

2. **Addressing Power and Connectivity Challenges:**
    - Traditional soil moisture monitoring systems often grapple with power limitations and connectivity issues. The project seeks to address these challenges by employing LoRa technology for its low-power operation and extended communication range. The ESP32 microcontroller adds an extra layer of adaptability and efficiency, contributing to sustainable, cost-effective, and reliable long-term operation in agricultural environments.

In summary, the motivation behind this project is to contribute to the evolution of soil moisture monitoring technologies, utilizing LoRa and ESP32 to provide a robust, scalable, and user-friendly solution for precision agriculture.

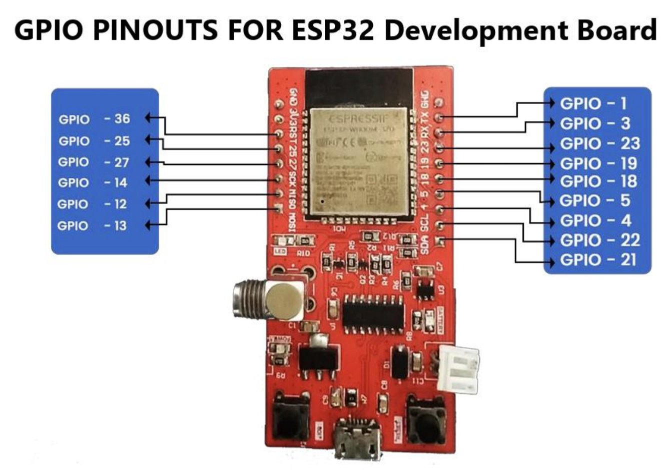
CHAPTER 2

Hardware Walkthrough

1.ESP32

It is a series of low-cost, low-power system on a chip microcontroller with integrated Wi-Fi and dual-mode Bluetooth. It has a number of key features, including:

- Low power consumption
- Dual-core
- Dual-mode Bluetooth
- Wi-Fi capabilities
- Arduino programming language compatibility
- MicroPython compatibility
- High-level integration
- Great peripheral I/O interface
- Strong security feature
- Reliable board, firmware, and peripherals
- Built-in peripherals
- Package and pinout
- Fine-grained clock gating
- Various power modes
- Dynamic power scaling
- Sleep modes
- Power management features
- 34 × programmable GPIOs
- 12-bit SAR ADC up to 18 channels
- 2 x 8-bit DAC



2.Lora

A long-range radio (LoRa) sensor is a method of transmitting data for the Internet of Things (IoT) and machine-to-machine (M2M) devices through the cloud. LoRa sensors have a wide range of compatibilities, allowing you to connect them with various machines, devices and even animals and people. These sensors often connect with Smart devices, like smoke alarms and vending machines, to help monitor devices.

The main features and functions of LoRa sensors make them an excellent choice for any business that needs a quick and easy way to send information and messages. However, there are plenty of other benefits of LoRa sensors provide users:

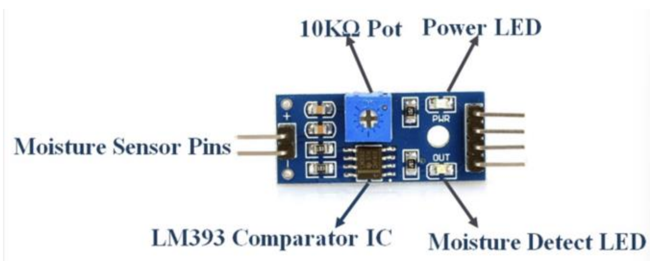
- **Wireless connection:** With LoRa and LPWAN technology, you can centralize your connectivity wirelessly while bypassing the heavy traffic and cell phone dependency of Bluetooth and similar networks.
- **Lower connectivity costs:** Compared to other connection options, LoRa provides a cheaper alternative that still offers high levels of functionality and other benefits. When you switch to LoRa technology, you’ll know you’re making a cost-effective choice.
- **Bi-directional communication:** LoRa sensors can send information to and from multiple devices, allowing you to open up more channels of communication with your sensors. LoRa devices can receive information from their network to help them process data.
- **Better security:** LoRa sensors contain specific and specialized security protocols and encryption codes to protect your information as it travels from the sensors to its destination.

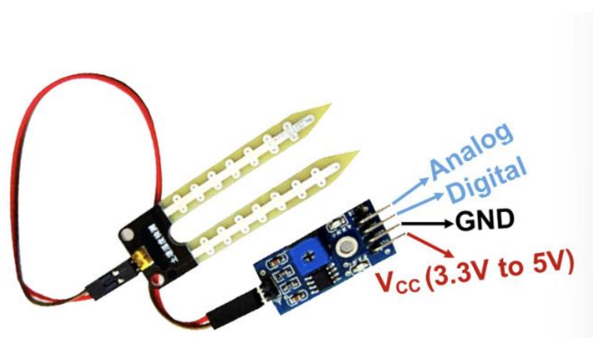
- **Easy to install:** A significant appeal to LoRa sensors is that they require minimal infrastructure to implement, making them simple and easy to install and use.

3)Soil Moisture Senser

Features & Specifications

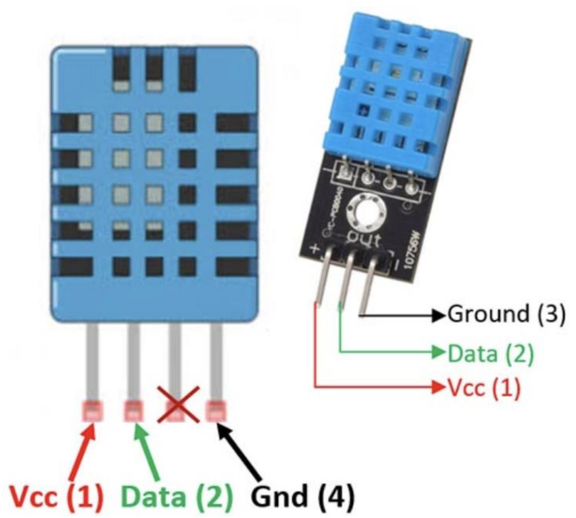
- Operating Voltage: 3.3V to 5V DC
- Operating Current: 15mA
- Output Digital - 0V to 5V, Adjustable trigger level from preset
- Output Analog - 0V to 5V based on infrared radiation from fire flame falling on the sensor
- LEDs indicating output and power
- PCB Size: 3.2cm x 1.4cm
- LM393 based design
- Easy to use with Microcontrollers or even with normal Digital/Analog IC
- Small, cheap and easily available





4)Temperature-humidity Senser (DHT11)

- 3 to 5V power and I/O.
- 2.5mA max current use during conversion (while requesting data)
- Good for 20-80% humidity readings with 5% accuracy.
- Good for 0-50 °C temperature readings +-2 °C accuracy.
- No more than 1 Hz sampling rate (once every second)
- Body size 15.5mm x 12mm x 5.5mm



CHAPTER 3

FUTURE SCOPE

The future scope of Long Range (LoRa) based soil moisture monitoring on ESP32 holds promising opportunities in several areas:

Advancements in IoT Agriculture:

1. Precision Agriculture: LoRa-based soil moisture monitoring on ESP32 can contribute to precision agriculture by providing real-time, accurate soil moisture data. This data can enable optimized irrigation schedules and resource management.
2. Smart Farming Solutions: Integration with other sensors (temperature, humidity, etc.) can create comprehensive smart farming systems. This integration enables farmers to make informed decisions based on various environmental factors.

Environmental Monitoring and Conservation:

1. Water Conservation: Efficient soil moisture monitoring can aid in water conservation by ensuring water is applied to crops only when necessary, reducing water wastage in agricultural practices.
2. Ecosystem Management: Extending soil moisture monitoring beyond agriculture can assist in monitoring natural ecosystems, contributing to conservation efforts and better understanding the impact of climate change.

Technological Enhancements:

1. Sensor Fusion: Integrating soil moisture monitoring with other sensor data, such as weather forecasting or plant health sensors, could lead to more comprehensive agricultural management systems.
2. AI and Data Analytics: Leveraging AI algorithms and advanced data analytics on the collected data can provide predictive insights, optimizing crop yields, and resource utilization.

Expansion of IoT Applications:

1. Scalability: Further advancements in LoRa and ESP32 technology can enhance scalability, enabling larger networks of sensors covering vast agricultural areas or even across multiple farms.
2. Interoperability and Standards: Developing standardized protocols and interoperable systems can foster compatibility between different IoT devices, facilitating seamless integration and data exchange.

Accessibility and Affordability:

1. Cost Reduction: Continued development may reduce the cost of LoRa modules, ESP32 boards, and sensors, making such technology more accessible to small-scale farmers and research organizations.
2. User-Friendly Interfaces: Improvement in user interfaces and remote accessibility can simplify the interaction with monitoring systems, making them more user-friendly for farmers and stakeholders.

Regulatory and Policy Implications:

1. Regulatory Support: Regulatory frameworks supporting IoT applications in agriculture and environmental monitoring can further encourage the adoption of such technologies.
2. Data Privacy and Security: Enhancements in data security measures are crucial to protect sensitive agricultural data and maintain farmer trust in these technologies.

The future scope of LoRa-based soil moisture monitoring on ESP32 lies in its potential to revolutionize agricultural practices, improve resource management, and contribute to environmental sustainability. As technology evolves and becomes more accessible, the integration of IoT solutions in agriculture is poised to play a significant role in ensuring global food security and ecological balance.

CHAPTER 4

REQUIREMENT SPECIFICATION

4.1 HARDWARE SPECIFICATION

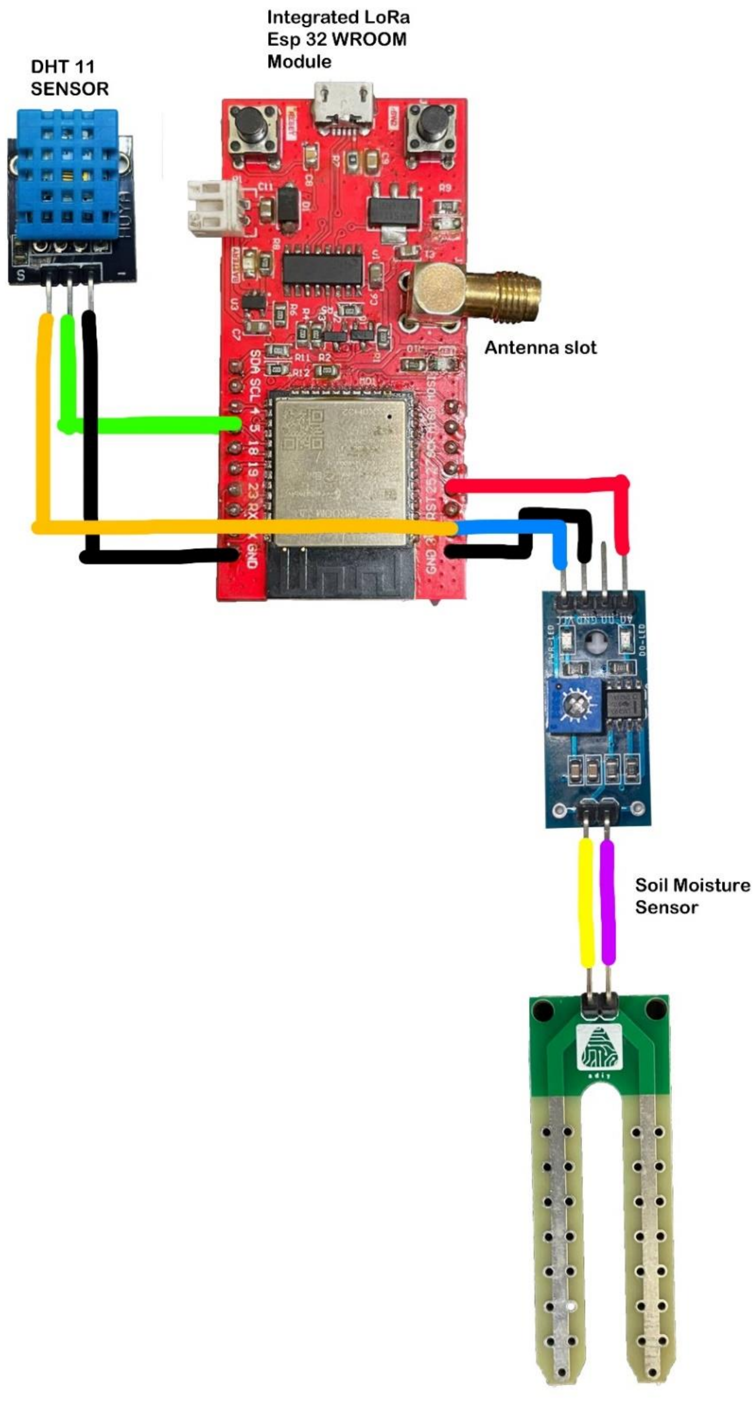
1. ESP32 Development Board
2. LoRa Transceiver Module
3. Soil Moisture Sensor
4. Power Supply
5. Integration and Development
    - Breadboard
    - Jumper Wires
6. Temperature and Humidity Sensor (DHT11)
7. Computer and USB Cable

4.2 SOFTWARE SPECIFICATION

1. Arduino IDE

CHAPTER 5

CIRCUIT DIAGRAM



CHAPTER 6

PROJECT IMPLEMENTATION

Software used for code implementation: Arduino IDE 2.2.1

Libraries to be installed:

1. LoRa by Sandeep Mistry
2. DHT sensor Library by Adafruit

Location Frequency used: 433E6(ASIA)

Board type selection: SparkFun LoRa Gateway 1-Channel

Transmitter module code:

```
#include <SPI.h>
#include <LoRa.h>
#include "DHT.h"


#define DHTPIN 5
#define DHTTYPE DHT11


 DHT dht ( DHTPIN, DHTTYPE );

//define the pins used by the transceiver module
#define ss 16
#define rst 14
#define dio0 26
//  #define ss 10
//  #define rst 9
//  #define dio0 2
int _moisture,sensor_analog;
const int sensor_pin = 25;

int counter = 0;
```

```
void setup() {
  //initialize Serial Monitor

  dht.begin();
  Serial.begin(115200);
  while (!Serial);
  Serial.println("LoRa Sender");
   Serial.println();
    Serial.println();
   Serial.println(" Temperature");
    Serial.println("And Humidity");
  //setup LoRa transceiver module
  LoRa.setPins(ss, rst, dio0);

  //replace the LoRa.begin(---E-) argument with your location's frequency
  //433E6 for Asia
  //866E6 for Europe
  //915E6 for North America
  while (!LoRa.begin(433E6)) {
    Serial.println(".");
    delay(500);
  }
   // Change sync word (0xF3) to match the receiver
  // The sync word assures you don't get LoRa messages from other LoRa transceivers
  // ranges from 0-0xFF
  LoRa.setSyncWord(0xF3);
  Serial.println("LoRa Initializing OK!");
}

void loop() {
  Serial.print("Sending packet: ");
  Serial.println(counter);
float humidity = dht.readHumidity();
 float temprature = dht.readTemperature();

Serial.print("current humidity=");
  Serial.print(humidity);
  Serial.print("%,");
  Serial.print("current temperature=");
  Serial.print(temprature);
  Serial.println("C");

//>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>
  sensor_analog = analogRead(sensor_pin);
  _moisture = ( 100 - ( (sensor_analog/4095.00) * 100 ) );
```

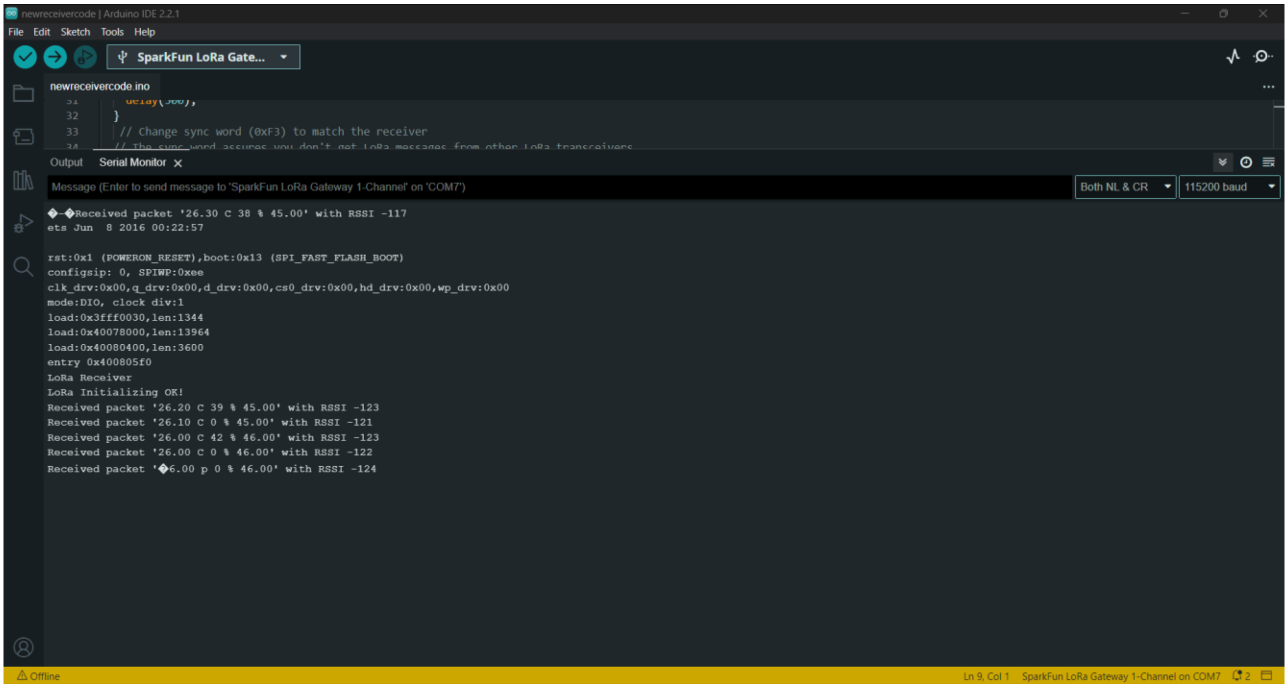
```
  Serial.print("Moisture = ");
  Serial.print(_moisture);  /* Print Temperature on the serial window */
  Serial.println("%");

  //Send LoRa packet to receiver
  LoRa.beginPacket();
  LoRa.print(temprature);
   LoRa.print(" ");
   LoRa.print("C");
   LoRa.print(" ");

   LoRa.print(_moisture);
   LoRa.print(" ");
   LoRa.print("%");
   LoRa.print(" ");

//LoRa.endPacket();
//
//  LoRa.beginPacket();
    LoRa.print(humidity);
  LoRa.endPacket();

  counter++;

  delay(10000);
}
```

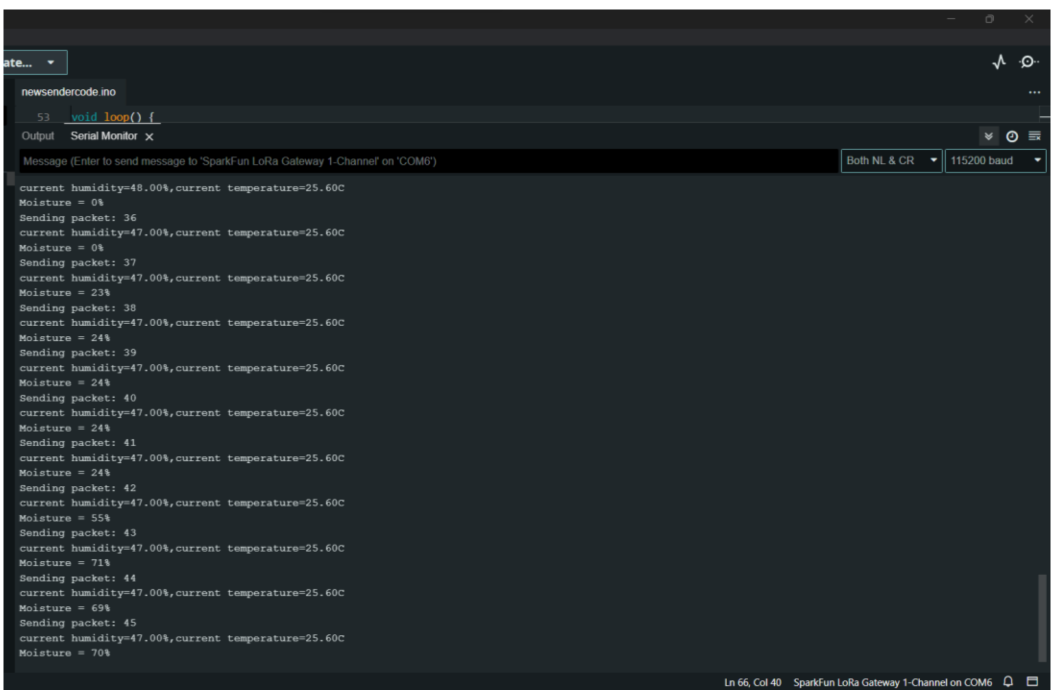
Receiver module code:

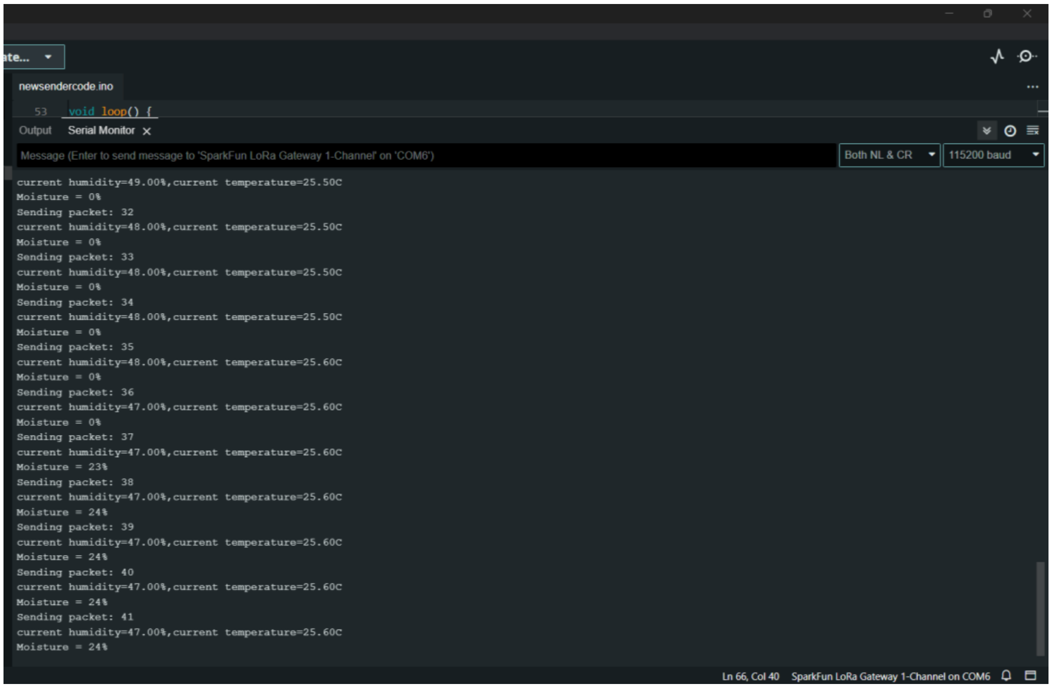
```
#include <Wire.h>
#include <SPI.h>
#include <LoRa.h>

//define the pins used by the transceiver module
#define ss 16
#define rst 14
#define dio0 26

void setup() {
  //initialize Serial Monitor
```

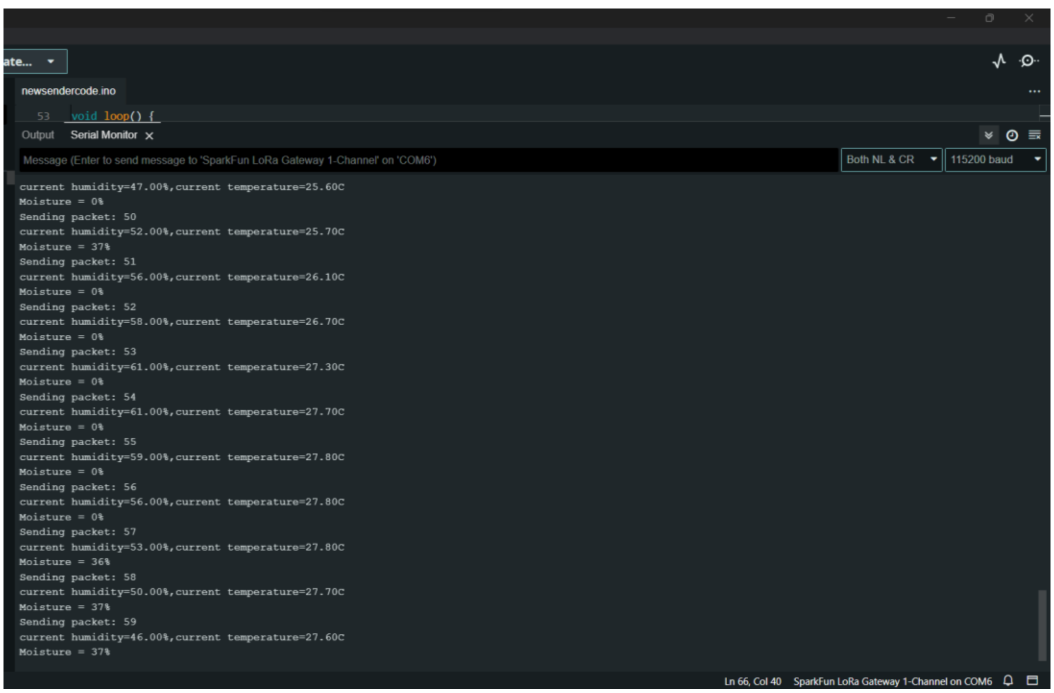
```
  Serial.begin(115200);
  while (!Serial);
  Serial.println("LoRa Receiver");

  delay(2000);


  //setup LoRa transceiver module
  LoRa.setPins(ss, rst, dio0);

  //replace the LoRa.begin(---E-) argument with your location's frequency
  //433E6 for Asia
  //866E6 for Europe
  //915E6 for North America
  while (!LoRa.begin(433E6)) {
    Serial.println(".");
    delay(500);
  }
   // Change sync word (0xF3) to match the receiver
  // The sync word assures you don't get LoRa messages from other LoRa transceivers
  // ranges from 0-0xFF
  LoRa.setSyncWord(0xF3);
  Serial.println("LoRa Initializing OK!");
}

void loop() {
  // try to parse packet
  int packetSize = LoRa.parsePacket();
  if (packetSize) {
    // received a packet
    Serial.print("Received packet '");

    // read packet
    while (LoRa.available()) {
      String LoRaData = LoRa.readString();
      Serial.print(LoRaData);
    // print RSSI of packet
    Serial.print("' with RSSI ");
    Serial.println(LoRa.packetRssi());
  }
}
  }
```

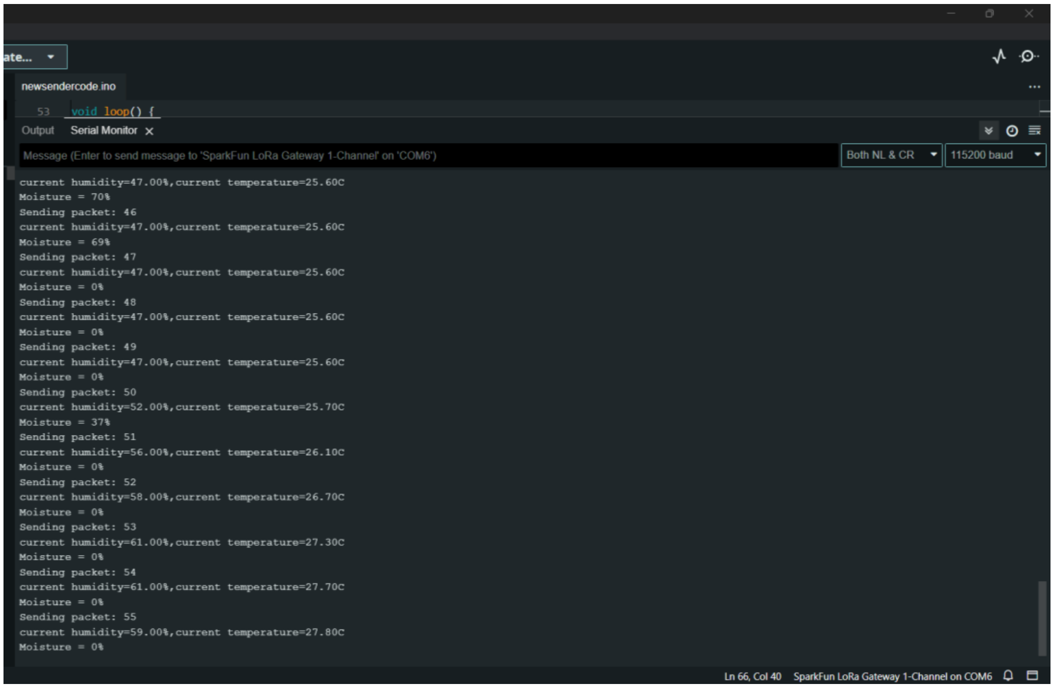
Sample Output:

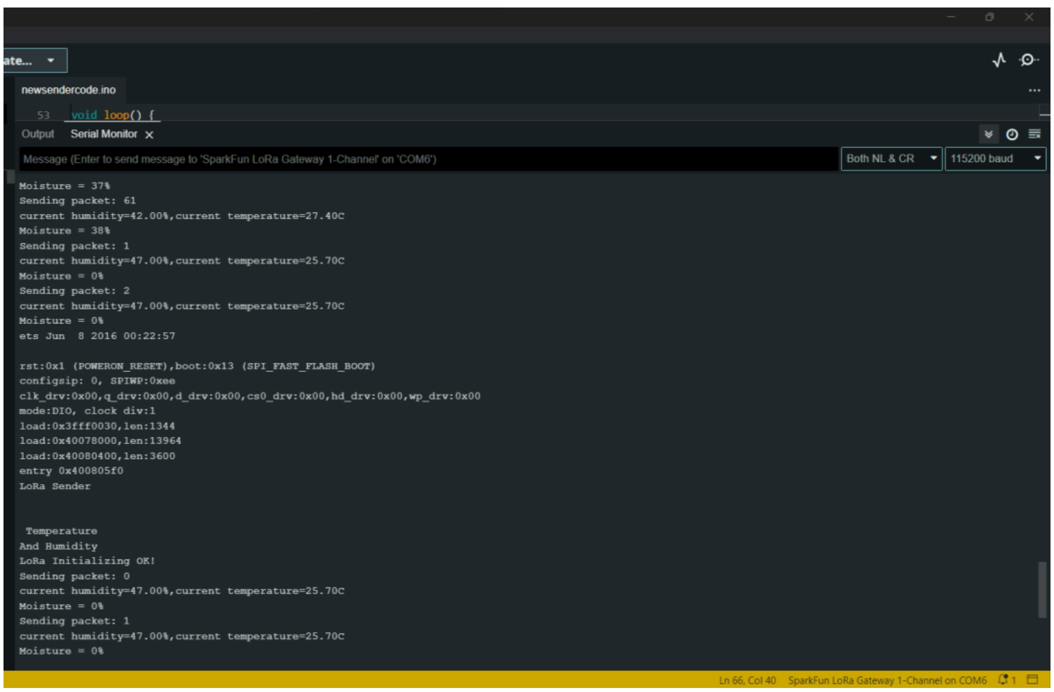


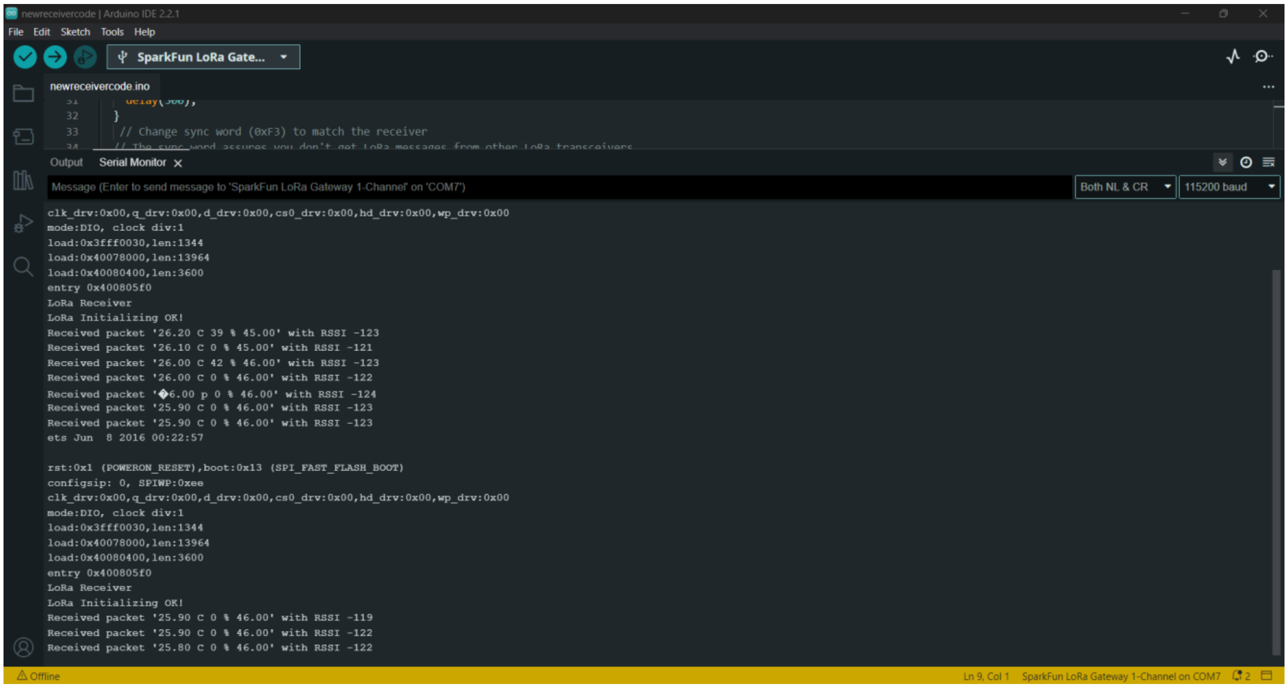



newsendercode.ino
53 void loop() {
Output
Serial Monitor
Message (Enter to send message to 'SparkFun LoRa Gateway 1-Channel' on 'COM6')
Both NL & CR
115200 baud
current humidity=49.00%,current temperature=25.50C
Moisture = 0%
Sending packet: 32
current humidity=48.00%,current temperature=25.50C
Moisture = 0%
Sending packet: 33
current humidity=48.00%,current temperature=25.50C
Moisture = 0%
Sending packet: 34
current humidity=48.00%,current temperature=25.50C
Moisture = 0%
Sending packet: 35
current humidity=48.00%,current temperature=25.60C
Moisture = 0%
Sending packet: 36
current humidity=47.00%,current temperature=25.60C
Moisture = 0%
Sending packet: 37
current humidity=47.00%,current temperature=25.60C
Moisture = 23%
Sending packet: 38
current humidity=47.00%,current temperature=25.60C
Moisture = 24%
Sending packet: 39
current humidity=47.00%,current temperature=25.60C
Moisture = 24%
Sending packet: 40
current humidity=47.00%,current temperature=25.60C
Moisture = 24%
Sending packet: 41
current humidity=47.00%,current temperature=25.60C
Moisture = 24%
Ln 66, Col 40
SparkFun LoRa Gateway 1-Channel on COM6


newsendercode.ino
53 void loop() {
Output
Serial Monitor
Message (Enter to send message to 'SparkFun LoRa Gateway 1-Channel' on 'COM6')
Both NL & CR
115200 baud
current humidity=47.00%,current temperature=25.60C
Moisture = 0%
Sending packet: 50
current humidity=52.00%,current temperature=25.70C
Moisture = 37%
Sending packet: 51
current humidity=56.00%,current temperature=26.10C
Moisture = 0%
Sending packet: 52
current humidity=58.00%,current temperature=26.70C
Moisture = 0%
Sending packet: 53
current humidity=61.00%,current temperature=27.30C
Moisture = 0%
Sending packet: 54
current humidity=61.00%,current temperature=27.70C
Moisture = 0%
Sending packet: 55
current humidity=59.00%,current temperature=27.80C
Moisture = 0%
Sending packet: 56
current humidity=56.00%,current temperature=27.80C
Moisture = 0%
Sending packet: 57
current humidity=53.00%,current temperature=27.80C
Moisture = 36%
Sending packet: 58
current humidity=50.00%,current temperature=27.70C
Moisture = 37%
Sending packet: 59
current humidity=46.00%,current temperature=27.60C
Moisture = 37%
Ln 66, Col 40
SparkFun LoRa Gateway 1-Channel on COM6


ate...
newsendercode.ino
53 void loop() {
Output
Serial Monitor
Message (Enter to send message to 'SparkFun LoRa Gateway 1-Channel' on 'COM6')
Both NL & CR
115200 baud
current humidity=47.00%,current temperature=25.60C
Moisture = 70%
Sending packet: 46
current humidity=47.00%,current temperature=25.60C
Moisture = 69%
Sending packet: 47
current humidity=47.00%,current temperature=25.60C
Moisture = 0%
Sending packet: 48
current humidity=47.00%,current temperature=25.60C
Moisture = 0%
Sending packet: 49
current humidity=47.00%,current temperature=25.60C
Moisture = 0%
Sending packet: 50
current humidity=52.00%,current temperature=25.70C
Moisture = 37%
Sending packet: 51
current humidity=56.00%,current temperature=26.10C
Moisture = 0%
Sending packet: 52
current humidity=58.00%,current temperature=26.70C
Moisture = 0%
Sending packet: 53
current humidity=61.00%,current temperature=27.30C
Moisture = 0%
Sending packet: 54
current humidity=61.00%,current temperature=27.70C
Moisture = 0%
Sending packet: 55
current humidity=59.00%,current temperature=27.80C
Moisture = 0%
Ln 66, Col 40
SparkFun LoRa Gateway 1-Channel on COM6


ate...
newsendercode.ino
53 void loop() {
Output
Serial Monitor
Message (Enter to send message to 'SparkFun LoRa Gateway 1-Channel' on 'COM6')
Both NL & CR
115200 baud
Moisture = 37%
Sending packet: 61
current humidity=42.00%,current temperature=27.40C
Moisture = 38%
Sending packet: 1
current humidity=47.00%,current temperature=25.70C
Moisture = 0%
Sending packet: 2
current humidity=47.00%,current temperature=25.70C
Moisture = 0%
ets Jun 8 2016 00:22:57
rst:0x1 (POWERON_RESET),boot:0x13 (SPI_FAST_FLASH_BOOT)
configsip: 0, SPIWP:0xee
clk_drv:0x00,q_drv:0x00,d_drv:0x00,cs0_drv:0x00,hd_drv:0x00,wp_drv:0x00
mode:DIO, clock div:1
load:0x3fff0030,len:1344
load:0x40078000,len:13964
load:0x40080400,len:3600
entry 0x400805f0
LoRa Sender
Temperature
And Humidity
LoRa Initializing OK!
Sending packet: 0
current humidity=47.00%,current temperature=25.70C
Moisture = 0%
Sending packet: 1
current humidity=47.00%,current temperature=25.70C
Moisture = 0%
Ln 66, Col 40
SparkFun LoRa Gateway 1-Channel on COM6


newreceivercode | Arduino IDE 2.2.1
File Edit Sketch Tools Help
SparkFun LoRa Gate...
newreceivercode.ino
32 }
33 // Change sync word (0xF3) to match the receiver
Output
Serial Monitor
Message (Enter to send message to 'SparkFun LoRa Gateway 1-Channel' on 'COM7')
Both NL & CR
115200 baud
clk_drv:0x00,q_drv:0x00,d_drv:0x00,cs0_drv:0x00,hd_drv:0x00,wp_drv:0x00
mode:DIO, clock div:1
load:0x3fff0030,len:1344
load:0x40078000,len:13964
load:0x40080400,len:3600
entry 0x400805f0
LoRa Receiver
LoRa Initializing OK!
Received packet '26.20 C 39 % 45.00' with RSSI -123
Received packet '26.10 C 0 % 45.00' with RSSI -121
Received packet '26.00 C 42 % 46.00' with RSSI -123
Received packet '26.00 C 0 % 46.00' with RSSI -122
Received packet '�6.00 p 0 % 46.00' with RSSI -124
Received packet '25.90 C 0 % 46.00' with RSSI -123
Received packet '25.90 C 0 % 46.00' with RSSI -123
ets Jun 8 2016 00:22:57
rst:0x1 (POWERON_RESET),boot:0x13 (SPI_FAST_FLASH_BOOT)
configsip: 0, SPIWP:0xee
clk_drv:0x00,q_drv:0x00,d_drv:0x00,cs0_drv:0x00,hd_drv:0x00,wp_drv:0x00
mode:DIO, clock div:1
load:0x3fff0030,len:1344
load:0x40078000,len:13964
load:0x40080400,len:3600
entry 0x400805f0
LoRa Receiver
LoRa Initializing OK!
Received packet '25.90 C 0 % 46.00' with RSSI -119
Received packet '25.90 C 0 % 46.00' with RSSI -122
Received packet '25.80 C 0 % 46.00' with RSSI -122
Offline
Ln 9, Col 1
SparkFun LoRa Gateway 1-Channel on COM7

CHAPTER 6

CONCLUSION

The conclusion of a Long Range (LoRa) based soil moisture monitoring project on the ESP32 platform highlights the significance and impact of this technology-driven solution.

The utilization of LoRa technology coupled with the capabilities of the ESP32 microcontroller showcased a robust and efficient system for remote soil moisture monitoring. Real-time soil moisture data provided actionable insights, empowering stakeholders to make informed decisions for optimized irrigation and resource management. Beyond agriculture, the project's extension to environmental monitoring signifies its potential contribution to ecosystem management and sustainable environmental practices.

The system's efficiency in long-range communication and power management laid the groundwork for reliable and prolonged monitoring in remote areas. The availability of timely and accurate soil moisture data empowers farmers, researchers, and environmentalists to implement precise measures for improved outcomes. The modular design and integration potential of the ESP32 platform offer scalability, adaptable to various applications and evolving technological advancements.

Further optimizations in communication range, data visualization, and sensor integration can elevate the system's efficiency and usability. As IoT and sensor technologies advance, opportunities arise for incorporating additional sensors and improving system capabilities. The success of this project lays a foundation for influencing smart farming practices and environmental monitoring on a larger scale, impacting agricultural productivity and sustainability.

The implementation of LoRa-based soil moisture monitoring on the ESP32 not only demonstrates the viability of IoT in agriculture and environmental monitoring but also underscores its potential to revolutionize these sectors. This technology-driven solution is poised to contribute significantly to informed decision-making, resource optimization, and sustainable practices in the realms of agriculture and environmental conservation.

CHAPTER 7

REFERENCES

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CHAPTER 8

APPENDIX

D. Project Timeline:

Task	Start Date	End Date
Project Initiation	01/08/2023	10/08/2023
Hardware Setup	30/08/2023	25/08/2023
Software Coding	05/10/2023	15/10/2023
Testing and Debugging	05/11/2023	15/11/2023
Final Report Writing	20/11/2023	30/11/2023
Submission	30/10/2023	30/11/2023

E. Budget Estimate:

Item	Quantity	Unit Price (Rs.)	Total Cost (Rs.)
LoRa ESP 32 Transceiver Module	2	15000	30000
Soil Moisture Sensor	1	25	25
DHT11 Temperature Sensor	1	50	50
Jumper Wires	-	10	10
Breadboard	-	100	100
Total Budget Estimate	-	-	30185

F. Risk Analysis:

1. **Technical Risks:**
    - Interference from other wireless devices.
    - Calibration issues with sensors.
2. **Operational Risks:**
    - Power supply failures.
    - Communication signal loss.
3. **Environmental Risks:**
    - Weather conditions affecting outdoor sensors.
    - Soil conditions impacting sensor accuracy.
4. **Project Management Risks:**
    - Delays in component procurement.
    - Unforeseen technical challenges.

G. Ethical Considerations:

1. **Data Privacy:**
    - Ensure that collected data is used only for the intended purpose.
    - Implement encryption for transmitted data.
2. **Informed Consent:**
    - Obtain consent for the use of data from participants or stakeholders.
    - Clearly communicate the purpose and scope of the monitoring system.
3. **Environmental Impact:**
    - Dispose of electronic waste responsibly.

    - Minimize any environmental impact during the installation and operation of the system.

H. User Manual:

Refer to the attached document titled "User Manual" for detailed instructions on setting up, operating, and troubleshooting the Long Range (LoRa) based Soil Moisture Monitoring system implemented on the ESP32 platform.