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IoT based Terrace Gardening System using LoRa Technology

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ABSTRACT
Agriculture is one of the important aspects of Indian economy. Traditional method integrated with the wireless sensor network helps in increasing the productivity of the field and thus raising one's profit. Internet of things (IoT) plays a pivotal role in smart gardening system. Irrigation is key factor of agriculture and thereby achieving the efficient watering system to utilize the water resources adequately. Thus, the paper aims at achieving automation in gardening by controlling and monitoring the system ensuring the safety of the plants. It focuses on increasing the quality and quantity of agricultural production using sensing technology making the system efficient and cost effective. The system uses various sensors such as Moisture sensor, DHT11, PIR and LDR which helps in monitoring and controlling several parameters. These sensor data are transferred via LoRa transmitter and received via LoRa receiver which connects to the server using MQTT protocol. The features of this application include displaying the sensor output using an Android application which uses MQTT protocol to receive the data, controlling the watering system and providing feedback to the user.

KEYWORDS:*Agriculture, CSS,IoT, LoRa technology, MQTT protocol,Sensor nodes, Smart farming,*

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I. INTRODUCTION

The largest sector of Indian economy is agriculture where India being the second largest farm producer in the world contributes to 17-18% of GDP and is responsible for 50% of employment in the country. Almost 43% of geographical area is occupied by the agricultural sector and over 70% of the households depend on agriculture[1].The main source of income and the commitment of agribusiness in India is the basis for agriculture being the backbone of nation's economy. According to the survey of FAO, 1/3rd of food production has become a challenge in Indian agricultural sector due to the ever-growing population. Green-house farming in terrace helps in energy conservation and thereby energy sources can be easily controlled. Green-house helps in creating and controlling the optimum growing environmental parameters to enhance the growth of plants and gives healthier better-producing plants.
IoT helps in eliminating the traditional methods of farming and provides the real time information about the agricultural fields[2]. Here the system is built for monitoring the plants with the help of sensors and automates the irrigation system. LoRa (Long Range) technology is a low power wireless platform for building IoT networks worldwide[3]. It offers a combination of long range, low power consumption and secured data transmission. This technology provides better solution for connecting sensors and gateway at longer distances with low-battery consumption. This paper focuses on deployment of automated and controlled irrigation system by interpreting moisture, temperature and humidity values. In this system, we use sensors like PIR sensor,

DHT11 sensor, Moisture sensor, LDR and each sensor has its own different functionalities. The sensor nodes are connected to the Arduino Uno with LoRa transmitter and these sensor data are sent to LoRa receiver which is connected with ESP8266 NODE MCU. Then the received sensor data is sent using MQTT protocol to the server. Android application is developed using the Android Studio which monitors the system.

II. RELATED WORKS

In IoT based Smart Irrigation System [4]focuses on how to monitor the plants as well as maintains desired moisture contents required for the soil. The control unit is implemented using ATMEGA328P microcontroller. This system is used to measure the water content in the soil by making use of the soil moisture sensors. There are two sections in this paper that is the hardware and the software section. Hardware section consistsof embedded systems and the software section about webpage design. It consists of three section that is moisture sensing section, control section and IoT section. The sensors values are transmitted to GSM-GPRS SIM900A modem that supports features like integrated TCP/IP stack, Voice, GPRS and SMS. The last is the IoT section that comprise of webpage that connects to the thing speaks that depicts sensor values and displays the water sprinkler status using on-off button.

In IoT based Agriculture System using Node MCU [5],says current agricultural practices have a great impact on the development of the economy of a nation. Hence, this paper brings in an innovative project to help the farmers and also the farms. Smart Agriculture is a real time monitoring system. This developing model monitors the soil properties like temperature, humidity, soil moisture, PH, etc. Arduino Nano boards microcontrollers are being included with the Node MCU which acts as a microcontroller as well as a server. This paper focuses on supplying water when the farm is dry and to prevent water being wasted during the irrigation process. Finally an App is created which displays the Temperature and humidity values and water pump can also be controlled using the app based on the farmer’s needs.

In Precision Agriculture Using LoRa[6], here it is explained in brief about the precision agriculture in farming, its uses and how LoRa technology is used in it. Precision agriculture uses remote sensing in order to detect something on time such that relevant corrections can be made. It includes collection of sensor data from various sensors nodes and provides solution to the farmers from the collected data. This helps the farmer to provide the desired amount of water, fertilizers and pesticides to the plants. They have tried to analyse the nutrient requirements of tomato and potato plant using LoRa and cloud technologies thus alerting the farmer using the email notification. This was done by placing the sensors in the agriculture field and the data that was collected LoRa gateway will be uploaded to cloud for further analysis and depending on these data measures to increase the crop field can be taken. They used flow chart in order to explain the algorithm for client and gateway module.

In Future of Smart Farming with Internet of Things [7]mentioned the future of smart farming with IoT and open source and solutions for smart farming using kaa which is an open source IoT platform that allows walking safely to agriculture field.The projects they talk about are: Cold chain Management tracking, Remotely piloted equipment, Smarter irrigation, Storage Mapping, Soil Quality Checking, Auto Irrigation for Crop, Animal Tracking, Smart Dairy with IoT, Product recall/security, Home Gardening, Remote control of farm irrigation system, Automatic tractors and drones, etc. Hence this paper gives a brief review of the automation that is taking place in the field of Farming.

III. SYSTEM ARCHITECTURE

The below Figure:3.1 is the system architecture for the LoRa node to node communication with the help of LoRa RA-01 Module. The Transmitter section consists of various sensors, an Arduino UNO and a LoRa RA-01 Transmitter module. The Receiver section consists of the LoRa RA-01 Receiver module, ESP8266 (Wifi Module) NodeMCU, Android Application and the MQTT Broker. The Transmitter section demonstrates the sending of the sensor data to the receiver LoRa module with the help of various sensors and Arduino UNO. The sensors which are connected are Temperature & Humidity (DHT11), Motion (PIR), Moisture (Digital) and Light (LDR – Light Dependent Resistor). The Receiver section which has the Receiver LoRa Module and NodeMCU which is connected to the internet receives the data from the Transmitter LoRa Module and transports the sensor data to the Android Application through the MQTT Protocol.

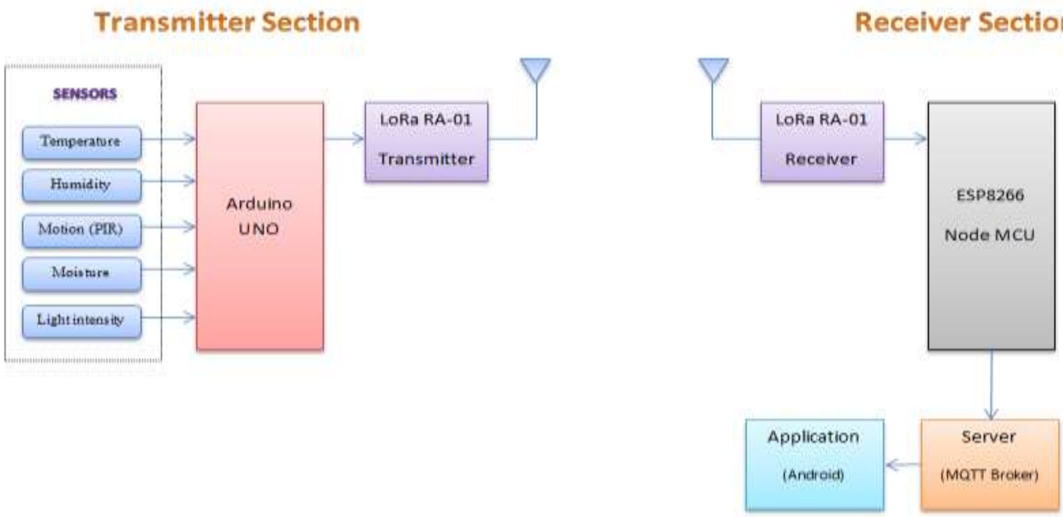


Figure:3.1 System Architecture

IV. METHODOLOGY

Smart irrigation system can optimize the water levels based on the soil moisture and weather conditions and determines whether the plant has to be watered or not.Irrigation management of the plants is by monitoring and calculating on Real time different values[8]. High production yield can be obtained depending on the temperature and humidity of the environment. Temperature conditions can be controlled by making use of cooling fan. Nutrient efficiency of the soil can be measured based on the Electrical Conductivity using LDR sensor. Detailed values of the sensor data's can be viewed in the mobile app and decisions can be made by the user accordingly. A significant amount of money is saved and hence the irrigation system optimizes the resources so that everything gets what it needs without needless waste.

4.1. LoRa Technology

LoRa (long range) is a spread spectrum modulation technique derived from chirp spread spectrum (CSS) technology. LoRa Technology [9]is a long range, low power wireless platform that has become the technology for Internet of Things (IoT) networks worldwide. LoRa Technology enables smart IoT applications that solve some of the biggest challenges facing our planet: energy management, natural resource reduction, pollution control, infrastructure efficiency, disaster prevention, and more[10]. The figure 3.1 represents the LoRa architecture and its elements.

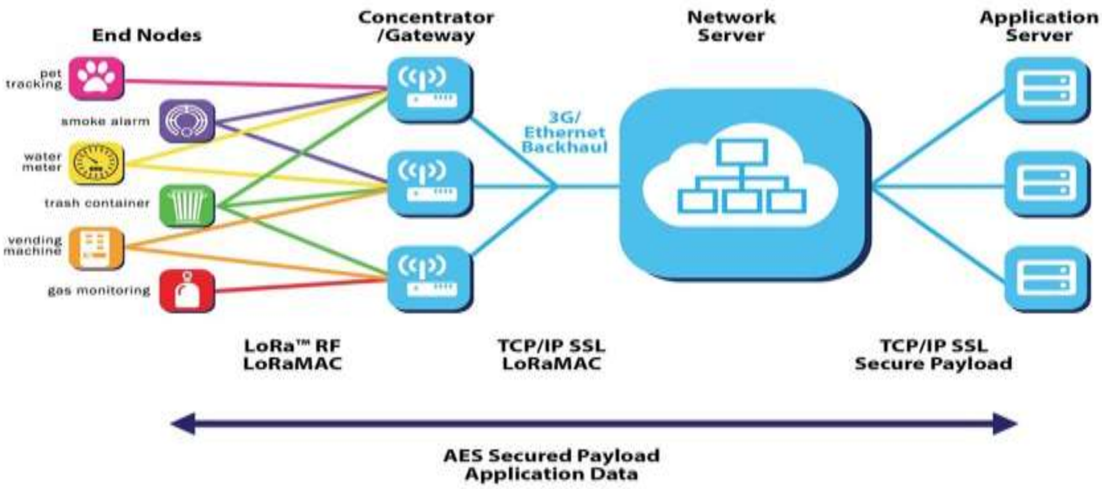


Figure: 4.1LoRa Architecture

This technology uses star topology which helps in increasing the battery lifetime for long range connectivity.Some of the important elements of this system are End-nodes, LoRa gateways and Network servers. The remotely placed node such as sensors or application sense and controls the system[11]
The data transmitted by the nodes is sent to the gateway and it sends the transmitted signal to the network server. Then the server sends the packet to the specific application.

Figure:4.2LoRa Ra-01

4.2 MQTT Protocol

MQTT[12] is a Client Server publish/subscribe messaging transport protocol. It is light weight, open, simple, and designed so as to be easy to implement. The MQTT protocol was invented in 1999 by Andy Stanford-Clark (IBM) and Arlen Nipper (Arcom, now Cirrus Link). MQTT nodes communicate in a one-to-many mapping model, where a message sent by one client (the publisher) is delivered to many clients (subscribers) through topic names. Messages are exchanged via a central node known as the broker[13].

4.2.1 Client and Broker

An MQTT client is any device (from a micro controller up to a full-fledged server) that runs an MQTT library and connects to an MQTT broker over a network. Both publishers and subscribers are MQTT clients.
The broker is responsible for receiving all messages, filtering the messages, determining who is subscribed to each message, and sending the message to these subscribed clients.The broker is at the heart of any publish/subscribe protocol.

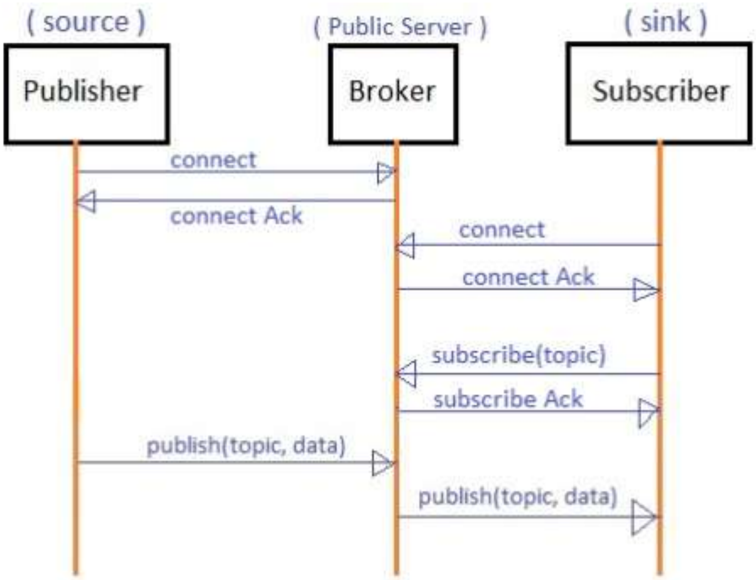


Figure: 4.2.1 MQTT PUBSUB model

4.2.2 Topics
MQTT packets sent by publishers are delivered to all subscribers registered for the same topic or matching topic filter. The topic name can be hierarchical with '/' as the delimiter in between to avoid collisions; e.g., temperature/city/state/country.

4.3Arduino Uno
Arduino Uno is a microcontroller board based on 8-bit ATmega328P microcontroller. Along with ATmega328P, it consist other components such as crystal oscillator, serial communication, voltage regulator, etc. to support the microcontroller. Arduino Uno has 14 digital input/output pins (out of which 6 can be used as PWM outputs), 6analog input pins, a USB connection, A Power barrel jack, an ICSP header and a reset button.
Arduino is an open-source electronics platform based on easy-to-use hardware and software. The Arduino board started changing to adapt to new needs and challenges, differentiating its offer from simple 8-bit boards to products for IoT applications, wearable, 3D printing, and embedded environments. All Arduino boards are completely open-source, empowering users to build them independently and eventually adapt them to their particular needs.

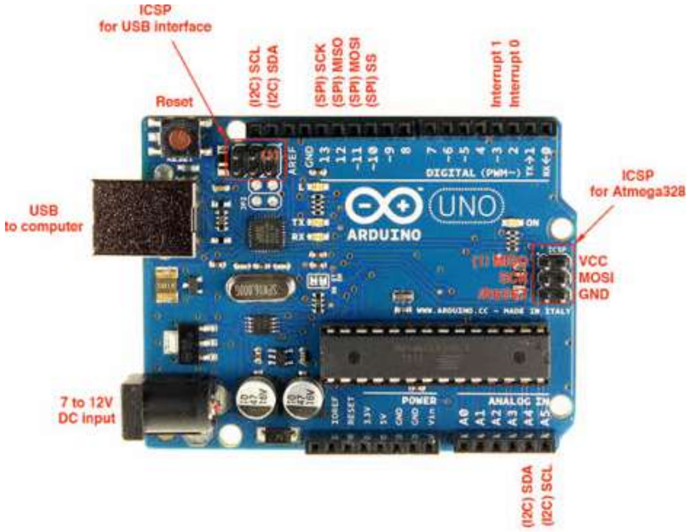


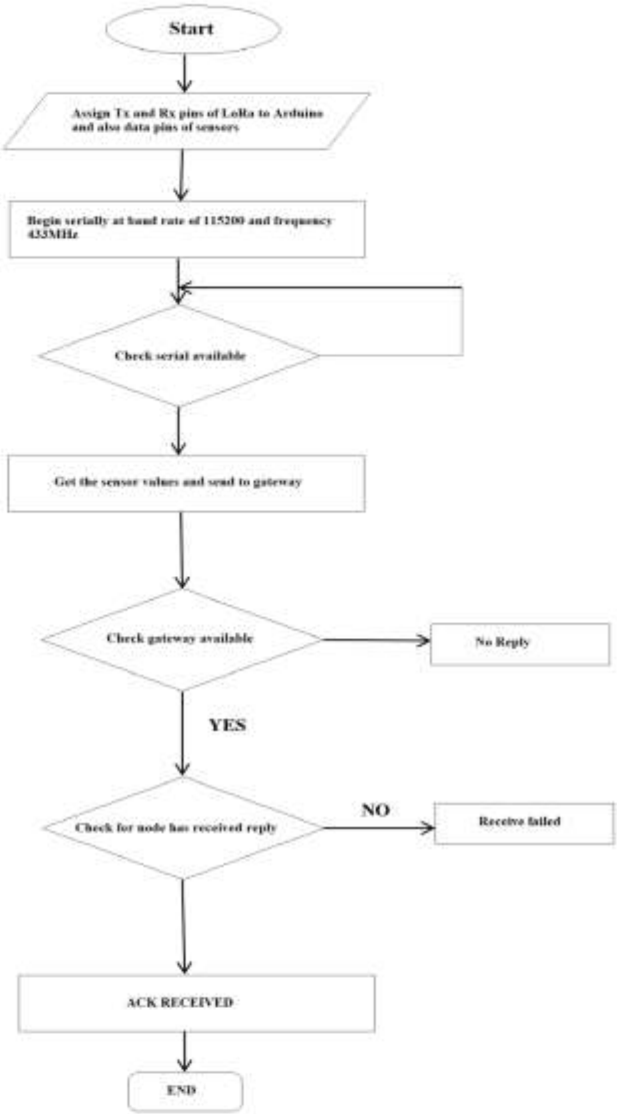
Figure:4.3.1Arduino UNO

4.4 ESP8266 Node MCU
NodeMCU is an open source IoT platform. Which includes firmware which runs on the ESP8266 Wi-Fi Module from EspressifSystems,and hardware which is based on the ESP-12 module. The term "NodeMCU" by default refers to the firmware rather than the dev kits. NodeMCU firmware was developed so that AT commands can be replaced with Lua scripting making the life of developers easier. So it would be redundant to use AT commands again in NodeMCU.
The ESP8266 is a low-cost Wi-Fi chip with full TCP/IP stack and microcontroller capability produced by Shanghai-based Chinese manufacturer, Espressif.

Figure:4.4.1 ESP8266 Node MCU

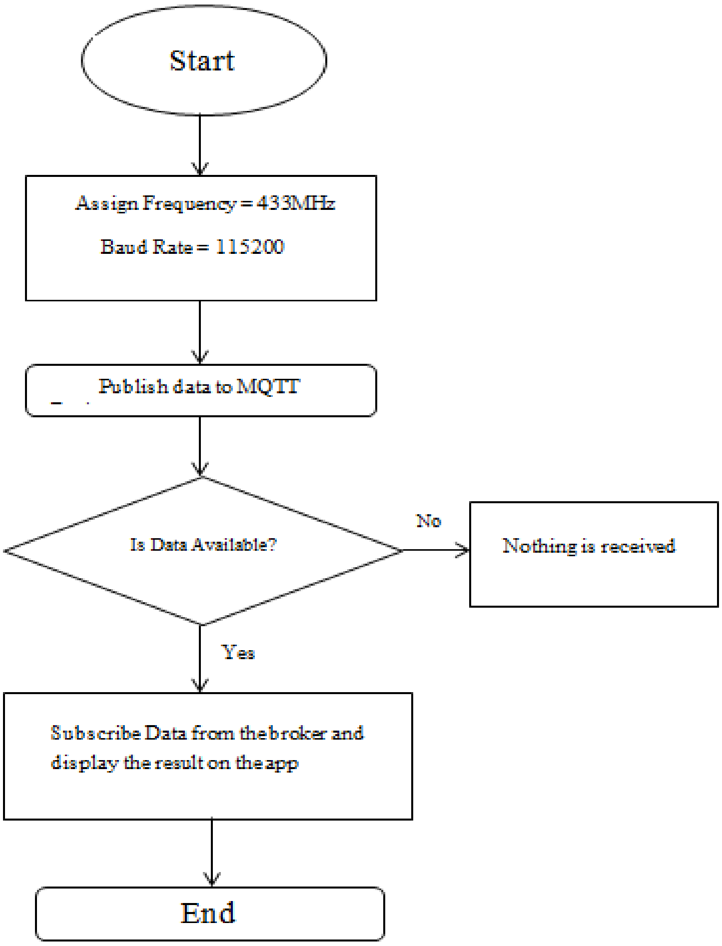
V. IMPLEMENTATION

The flowchart 5.1 illustrates the implementation of the system at client section.The below flowchart explains about the flow of the algorithm. Initial pin settings such as transmitter-receiver pins and data pins assignment has to be assigned properly. Then set the required Baud rate and frequency. Check for the serial communication since the algorithm uses serial communication. Once it is made sure that the serial pin is available move to the next step else continuously check for the availability. Now collect the sensor values and check for the availability of the gateway. If the gateway is available, check for the acknowledgement from the gateway and if the acknowledgement is received, it indicates successful communication between the LoRa and the Gateway.



Flowchart:5.1. Client mode

This algorithm explains the flow at the server side. Initially the required Baud rate and Frequency has to bet set and continuously check for the data set frequency. Now publish the data to the MQTT broker. Check for the availability of the data. If the data is received, then subscribe the data from the MQTT broker and display the obtained result on the application.



Flowchart:5.2 Server model

VI. RESULTS AND ANALYSIS

Figure: 6.1 illustrates the output of the sender LoRa in which the LoRa is initialized and the sensor values such as moisture, motion, humidity, temperature and light intensity are displayed along with the motor state.
Figure: 6.2 illustrate the output of the receiver LoRain which the LoRa is initialized, connected to Wifi network and then connected to MQTT server. The sensor data is retrieved from the LoRa transmitter and these data are sent to the MQTT server.

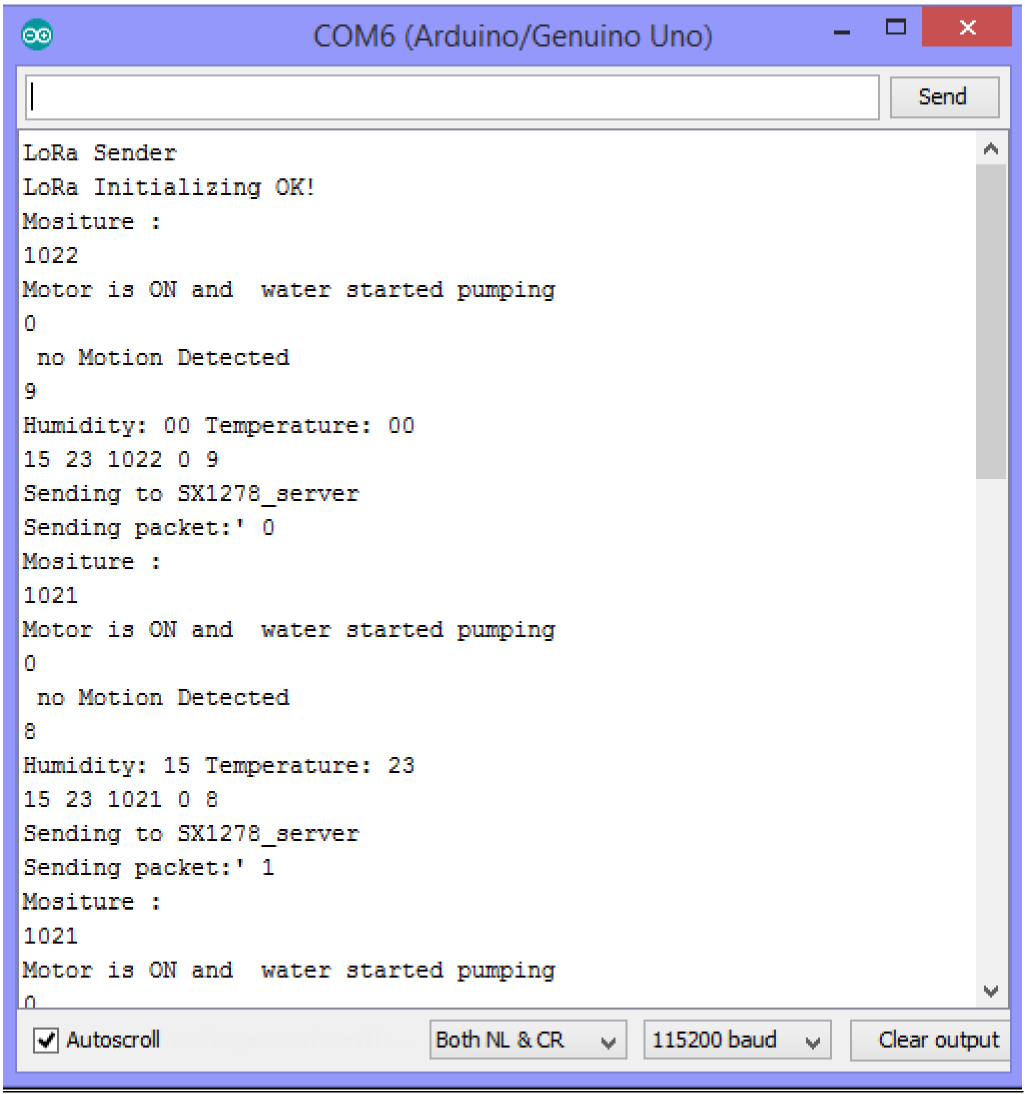


Figure: 6.1 LoRa Transmitter output on serial monitor

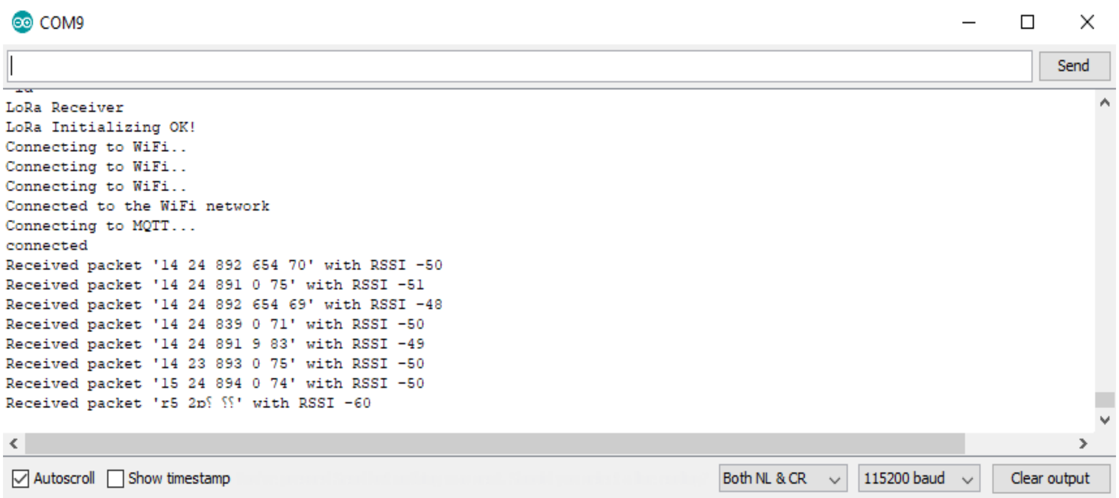


Figure: 6.2 LoRa Receiver output on serial monitor

Figure: 6.3 demonstrates the Lora testing using MQTT Lens where the data can be published and subscribed.The android application is shown in Figure :6.4.

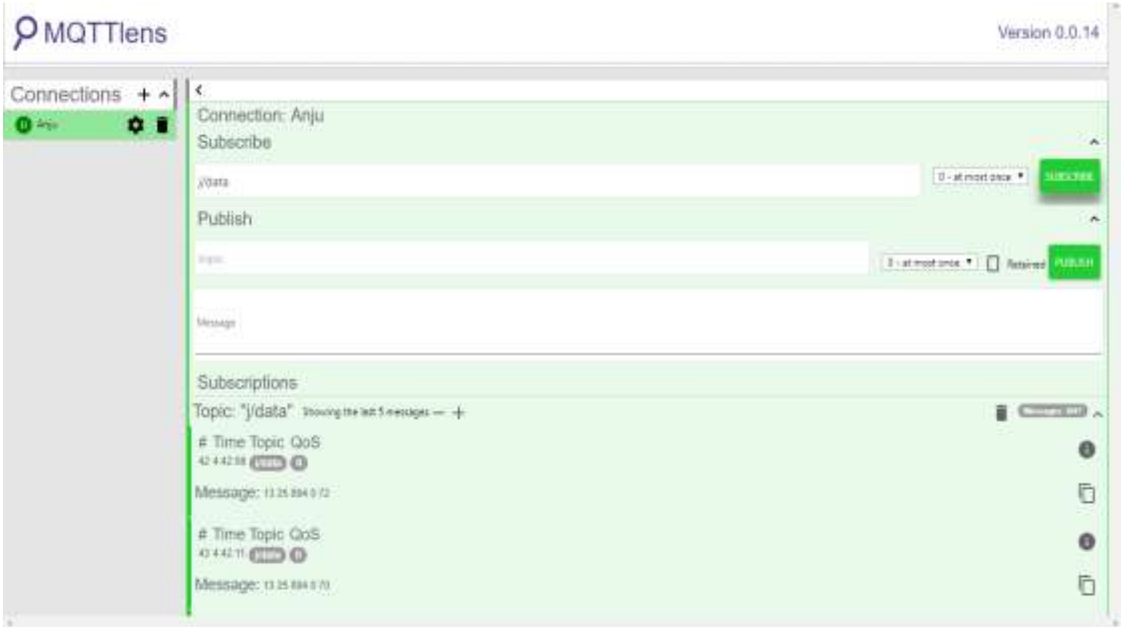


Figure: 6.3 LoRa testing using MQTT Lens

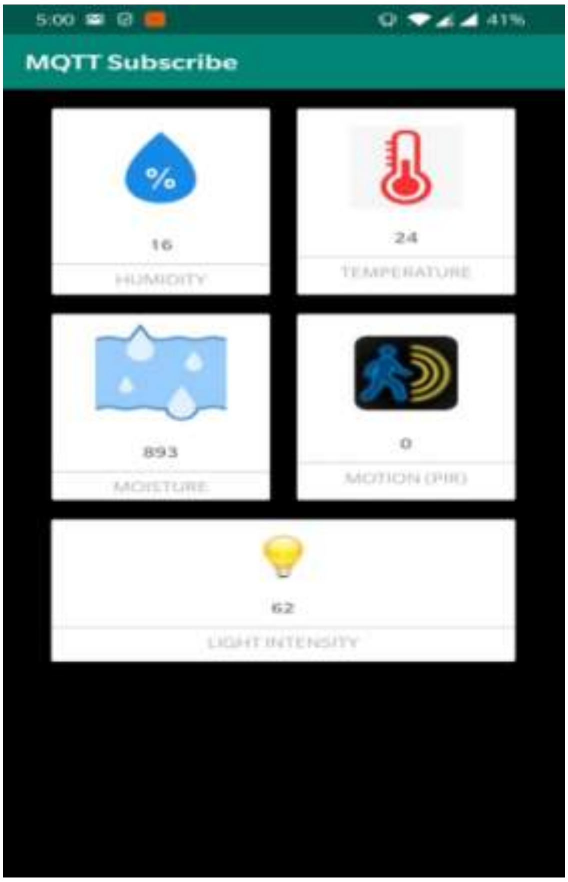


Figure: 6.4.Outlook and output obtained in Android application

VII. CONCLUSION

In this research paper, we have discussed about a novel methodology to improve the crop yield by monitoring certain parameters such as moisture content of the soil, light intensity, temperature and humidity of the environment and motion detection using LoRa technology. This methodology has been proposed using Arduino, Node MCU, LoRa Ra-01, MQTT Protocol[14] and Android Application. LoRa is a technology that can cover large area with low power consumption[15]. This helps the farmers to monitor a large area and thus increase the crop yield. The reliable delivery of the data from the sensor node to the user was done using a broker based publish/subscribe messaging protocol that is the MQTT protocol. The Android Application helps the farmer to get the real time data in their mobile phones and it helps them to take the decisions accordingly.

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