A Project Report on

SMART IRRIGATION SYSTEM USING IOT

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1. ABSTRACT

Agriculture plays a significant role in the Gross Domestic Product (GDP) of every country, especially India where it provides livelihood for almost 60% of the population. It is the backbone of the economy of our country. This Project helps in modernizing and to overcome the backwardness of traditional methods of Agriculture & Irrigation in order to solve some problem caused by them. The most severe problem is the excessive usage of water resources for irrigating the land leading to the scarcity of water for the future chores. With the increase of population, scarcity of water is increasing. This is where the Internet of Things pave its way by helping in efficiently utilizing water, energy resources and enhancing the crop production. It collects enormous number of real-time data from the agricultural field like moisture content of soil, temperature & humidity of the field with the help of sensors. The data collected by the sensors is sent to the AWS Cloud over WIFI. This recorded data is processed, stored, visualized and then, it is decided whether the field should be irrigated with the help of the water pump or not. The farmer is notified about the same periodically. The farmer can track changes in the soil moisture and other environmental factor from the comfort of his home. In this way, unnecessary wastage of water can be avoided. This Smart System also reduces the workload of the farmers. It shows the use of NodeMCU(ESP8266) microcontroller based monitored and controlled smart irrigation systems which will prove to be of immense help to the farmers. Advancement in agriculture is necessary in India to develop and help the farmers with increased production with the help of new emerging technology. The approach involved in this work can be considered as a suitable approach in irrigation field in terms of saving water, time, money, and man-power as compared to the traditional approaches.

Keywords: Smart Irrigation, Internet of Things, NodeMCU, WIFI, Sensors, AWS Cloud, Water pump, Notification

2. OBJECTIVE

The main aim of this project is to build a Simple, Efficient, Cost-effective & Automated irrigation system using Sensors, Internet, motors, and AWS Cloud. The system decides to when to turn ON/OFF the motor depending on the reading of the sensors.

3. MOTIVATION

Agriculture is the unquestionably the largest livelihood provider in India. It is observed that 60% of India’s population depends on agriculture for employment. Currently, there are very less farmers who use the technology advancement for improving their crop yield and save some money and labour work. IoT is helping the farmers to fight with most of the agriculture problems. With a rising population, there is a need for increased agricultural production.

In order to support greater production in farms, the requirement of the amount of freshwater used in irrigation also rises. Currently, agriculture accounts 83% of the total water consumption in India. Unplanned use of water during agriculture inadvertently results in wastage of water. We need to modernize the traditional irrigation practices and move towards the involvement of the technological advancement and implement them in our Agricultural field.

Internet of Things(IOT) is a technology which enables us to adopt the strategies to monitor the usage of water resources in the agriculture field. Generally, the main purpose of smart irrigation is to reduce man power, reduce the unnecessary use of water resources and lead to efficient power consumption. This proposed IOT solution also enables them to remotely monitor & control the irrigation process. Since the irrigation process is automated, chances of human errors also reduces. Using Cloud services also simplifies the project as no infrastructure is needed to store the values and all the internal operations are done using the AWS services keeping in mind the security of data exchanged over the network

4. EXPERIMENTAL SETUP

Farmers can start to use a variety of monitoring and control systems to increase yields by automating agricultural parameters such as temperature, humidity and soil moisture and controlling the system that can help farmers to improve yields. This plan involves an integrated irrigation control system. This project includes a wireless sensor network for an irrigation system in real time. This system provides the agricultural farm with an accurate sensor reading and allows farmers to utilize the water and energy efficiently. The module then automatically switches ON the motor if the moisture level in the soil crosses below the threshold level. The motor turns OFF automatically when the level of water reaches normal level. Also, the System takes care of watering the crops according to the temperature and humidity which crops are experiencing All the data is stored on the AWS Cloud and the user is notified regularly about the state of the motor and other parameters. The data uploaded to the Cloud can also be visualized graphically.

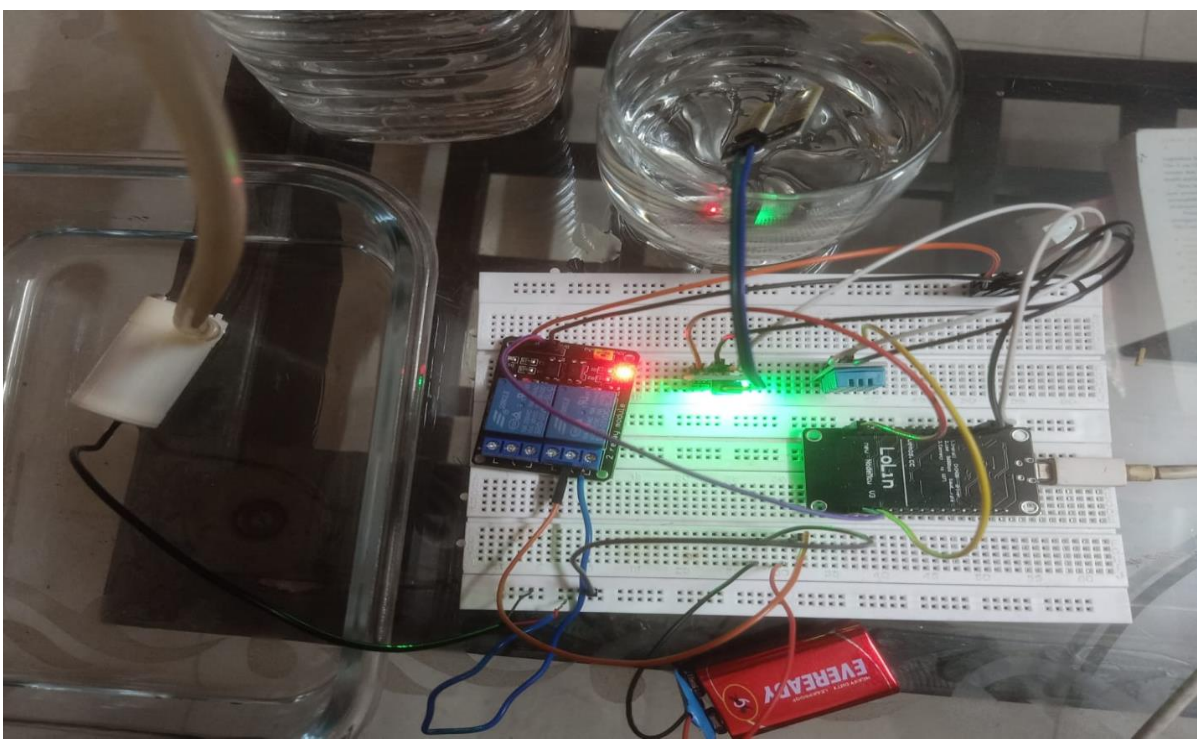


Figure 1. Experimental Setup

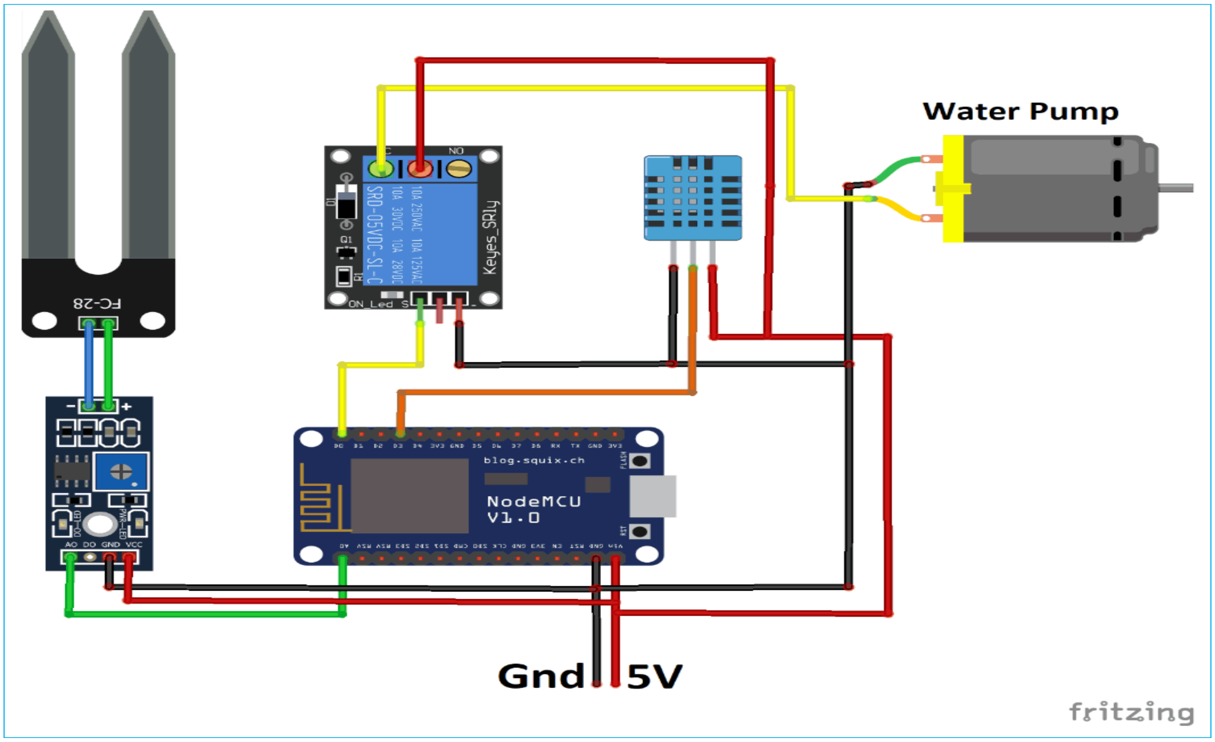


Figure 2. Circuit of proposed model

4.1 Architecture

For building up an insightful security gadget dependent on IoT – M2M framework, sensor network, and database management are the foundations. IoT Architecture is categorized in three-level architecture and five-level architecture. The working principle of the proposed system is based on three-level architecture. In the proposed system, there are three levels of architecture named as – perception layer that is used to differentiate the individual types of sensors; network layer is used for processing and transmitting the information over the network and the application layer which is responsible for various practical applications based on users need. The below shown figure 1 shows the system architecture in the form of block diagram.

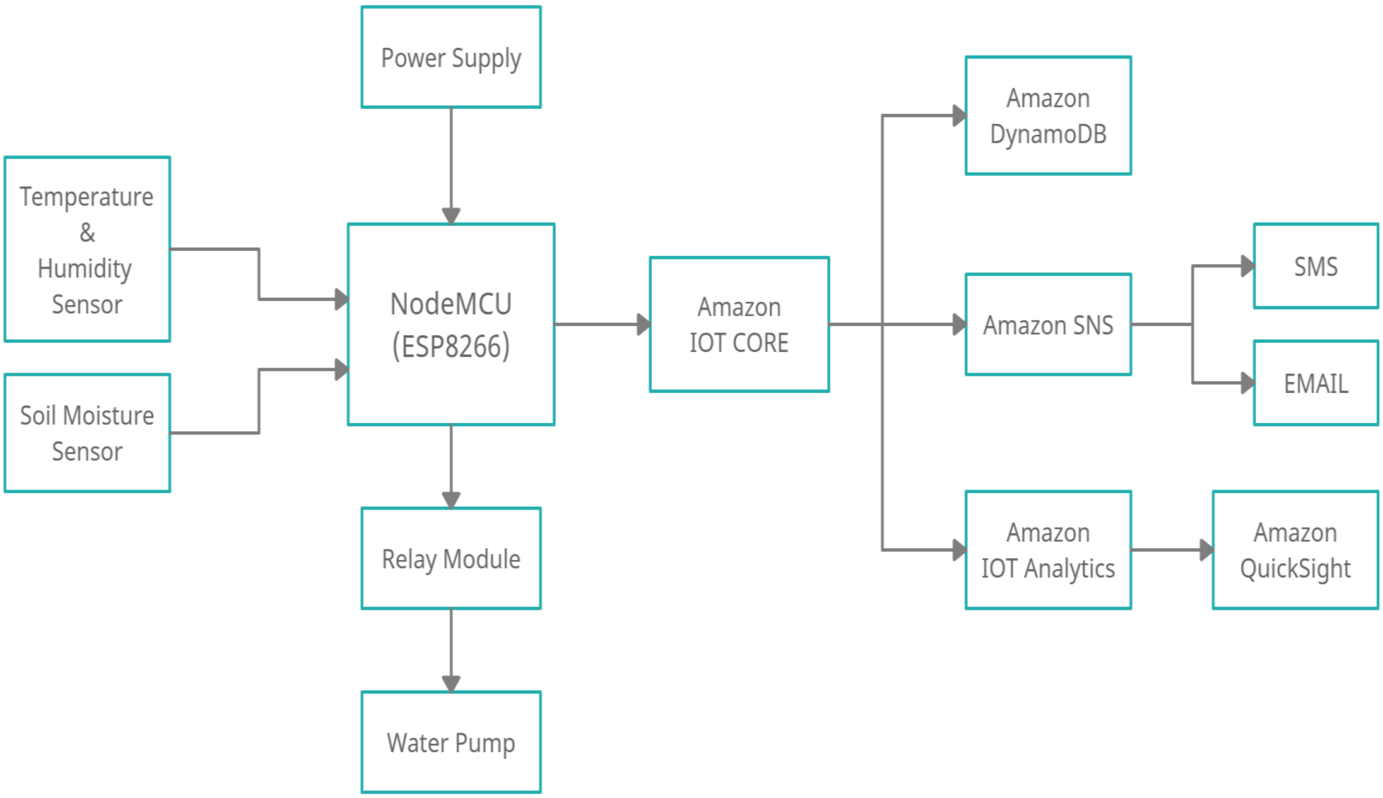


Figure 3 . Block diagram of Proposed System

4.2 Hardware Components Used

1. <u>NodeMCU(ESP8266):</u>

It is a low-cost, open-source software and hardware development board specially targeted for IOT applications. It includes firmware that runs on the ESP8266 Wi-Fi SoC from Espressif Systems, and hardware which is based on the ESP-12 module.

<u>NodeMCU ESP8266 Specifications & Features</u> -

- Operating Voltage: 3.3V
- Input Voltage: 7-12V
- Digital I/O Pins (DIO): 16
- Analog Input Pins (ADC): 1

- UARTs: 1
- SPIs: 1
- I2Cs: 1
- Flash Memory: 4 MB
- SRAM: 64 KB
- Clock Speed: 80 MHz
- USB-TTL based on CP2102 is included onboard, Enabling Plug n Play
- PCB Antenna
- Small Sized module to fit smartly inside your IoT projects

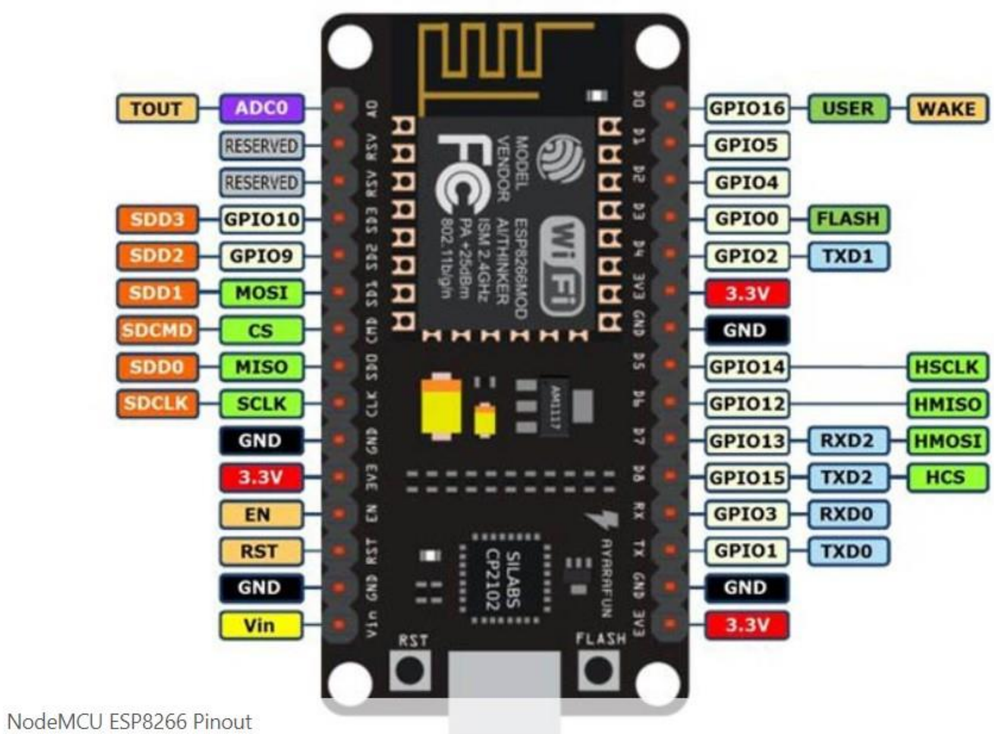


Figure 4. NodeMCU ESP8266 Pinout diagram

2. <u>Soil Moisture Sensor</u>:

The Fig.3 shows a sort of soil moisture sensor. It is a low-cost and simple gadget, which is used to observe soil moisture value. It is a low-power device operated in 3.3V-5V range. It contains two tests by methods for which current will go into the dirt, at that point scrutinizes the obstruction of the soil, which will peruse the dampness level. We know the nearness of the water makes the dirt more inclined to lead the power effortlessly, which implies R(resistance) is less in the such kind of soil, while dry soil has poor conductivity of intensity, in this way dry soil upholds more insurance than the wet soil. Sensor is structured on this property of intensity. There should be a point that believers the obstruction into voltage, this is done using circuit which show inside the sensor, which changes over the opposition into voltage.

3. Temperature & Humidity Sensor:

The DHT11 sensor is a basic, ultra low-cost, digital temperature and humidity sensor. It uses a capacitive humidity sensor and a thermistor to measure surrounding air. The sensor comes with +0.5 degree accuracy. DHT-11 sensor consists of a moisture sensing sensor, a temperature sensor and an IC on the back side of the sensor. It comes with 4 pins and 3 pins. In Figure 4, how to connect using DHT-11 sensor has been explained.

Specifications:

- Supply Voltage = +5V
- Temperature range: 0 to 50 C error of 2%
- Interface – digital system
- 3 to 5V power & IO
- 2.5mA max current during conversion
- Good for 20-80 % humidity reading

4. 5V Relay Module:

It is an electrically operated switch that allows you to turn on or off a circuit using voltage and/or current much higher than a microcontroller could handle. There is no connection between the low voltage circuit operated by the microcontroller and the high power circuit. Good in security, 1-channel high voltage framework yield, addressing the necessities of single channel control. Wide scope of controllable voltage. Being ready to control high load current, which can arrive at 240V, 10A. Comes with typically open(NO) contact and an ordinarily shut(NC) contacts.

5. Submersible Water Pump:

   Water pump responsible for supplying water to the plant. Operating voltage is +5V. It is connected to the Relay module.

6. Breadboard & Jumper wires

4.3 Software Used

1. **Arduino IDE**:

   It is an integrated development environment used for uploading code to the NodeMCU. It is a cross-platform application (for Windows, macOS, Linux) that is written in functions from C and C++. It is used to write and upload programs to Arduino compatible boards, but also, with the help of third-party cores, other vendor development boards. It contains a text-editor for writing code in C++ programming language, a message area to display errors, Console toolbar, serial monitor for printing necessary information regarding the project. It connects the hardware to the internet by uploading program and communicate with them

2. **Amazon IOT CORE**:

It is an AWS Cloud Service which provides various IOT services which can be integrated with the hardware devices and sensors to communicate the data recorded by the sensor to the AWS Cloud.

The communication between the IOT devices and AWS IOT Core is done using MQTT(Message Queuing Telemetry Transport) protocol. It is becoming a standard messaging protocol for IOT applications. AWS IoT clients identify the messages they publish by giving the messages topic names. Clients identify the messages to which they want to subscribe (receive) by registering a topic filter with AWS IoT Core. The message broker uses topic names and topic filters to route messages from publishing clients to subscribing clients. This exchange of information is secured by Transport Layer Security (TLS) and Secure Socket Layer (SSL) cryptographic protocols.

The Connection is secured by various Security certificated which are uploaded to NodeMCU for transfer of data over internet. IOT Core Service provides facility of Rules which help to integrate other Amazon Cloud services and use them according to our need. The data uploaded using MQTT Protocol can be used extensively for processing and analyzing if they are uploaded in JSON String format. SQL Query statements can be made use of for selective processing of the published messages and sending them to other AWS Services.

3. Amazon DynamoDB:

Amazon DynamoDB is a fully managed NoSQL database service that allows to create database tables that can store and retrieve any amount of data. It automatically manages the data traffic of tables over multiple servers and maintains performance. It also relieves the customers from the burden of operating and scaling a distributed database. Hence, hardware provisioning, setup, configuration, replication, software patching, cluster scaling, etc. is managed by Amazon.

Benefits of Amazon DynamoDB

- Managed Service
- Scalable
- Fast
- Durable & highly available
- Flexible
- Cost-effective

For the Proposed System, Data published to AWS IOT CORE is simultaneously uploaded to AWS DynamoDB using the RULES feature of IOT Core and stored onto the database for further analysis. The data uploaded must be in JSON String format in order to manage it in form of table.

The data is arranged and segregated according to the PARTITION KEY and sorted according to the SORTING KEY provided while creating the DynamoDB database table. DynamoDB provides very low latency and any amount of attributes can be added to the table.

4. **Amazon SNS**:

Amazon Simple Notification Service (Amazon SNS) is an AWS Cloud managed service that provides message delivery from publishers to subscribers. Publishers communicate with subscribers by sending messages to a *topic*, which is a logical access point and communication channel. Clients can subscribe to the SNS topic and receive published messages using HTTP, email, mobile push notifications, and mobile text messages (SMS). We can create specific RULE in IOT CORE which will trigger the Amazon SNS only when some specific condition is satisfied. This condition is declared using SQL query statement. One drawback of Amazon SNS is that for SMS service it charges a minimal amount for every message we send using Amazon SNS service.

5. **Amazon IOT Analytics**:

AWS IoT Analytics is a fully-managed service that makes it easy to run and operationalize sophisticated analytics on massive volumes of IoT data without having to worry about the cost and complexity typically required to build an IoT analytics platform.

There are 4 main sections of IOT Analytics Service – Channel, Pipeline, Data-Store and Data-Set. Pipeline processes the data coming from the channel and send it to data-store for further action. Channel takes the incoming data from the IOT Core.

It is the easiest way to run analytics on IoT data and get insights to make better and more accurate decisions for IoT applications and machine learning use cases. IoT data is highly unstructured which makes it difficult to analyze with traditional analytics and business intelligence tools that are designed to process structured data. IoT data comes from devices that often record fairly noisy processes (such as temperature, motion, or sound).AWS IoT Analytics automates each of the difficult steps that are required to analyze data from IoT devices. AWS IoT Analytics filters, transforms, and enriches IoT data before storing it in a time-series data store for analysis.

6. **Amazon QuickSight**:

Amazon Quicksight is “a fast, cloud-powered business intelligence service that makes it easy to deliver insights to everyone. QuickSight is all about the visuals. The basic visual presentations QuickSight offers are more stunning.

A typical visual presentation on the QuickSight platform features the following components: Analysis, Visuals, Insights, Sheets.

It is highly compatible with different types of data sources. Quicksight’s “AutoGraph” feature applies a set of algorithms to learn about your data. Then it recommends suitable graphics to make sure you're selecting the best visuals and analytics for the situation.

In the project, the Data-Set created by the AWS IOT Analytics service is used by QuickSight for creating visuals of the data uploaded on the AWS Cloud. These Data-Set can be visualized using various types of Graphs.

4.4 Working & Principle

Program run on NODEMCU board is to fetch the data from the soil moisture and DHT11 sensor and check the sensor data is greater than or less than the given threshold value to start the water Pump. If the data is less than the given threshold value the pump will automatically start & stop automatically if the sensor data is found higher than the threshold value. Threshold value is given according to the weather condition and soil moisture content of a particular area where the system is implemented.

The recorded data is then published to the AWS IOT CORE topic using MQTT protocol. This published data is sent in the form of JSON String format so that it can be used by other AWS Services as well. Now after reading the sensor, if the motor turns ON, then the RULE in IOT CORE is triggered which will Run the AWS SNS topic and notification will be sent to the user in form of SMS and Email.

All the sensor data which is published to the AWS IOT CORE is uploaded to the AWS DynamoDB database table and it stored there for further analysis. The uploaded data is selected by the SQL Query Statement of the RULES tab. The table is sorted according to the time it is uploaded to the AWS Cloud. Using this database, we can keep track of the parameters of agricultural farm over a long period of time.

Similarly the data received by the IOT CORE is transferred to the AWS IOT Analytics Service. IOT Analytics is responsible for enriching the data for many analysis which can be done on the data. Data travels through the Channel, then Pipeline where the preprocessing of the data is done. This processed is sent to data-store. Now the Data-set can be created by running complex analysis by writing the Query Statement.

This Data-Set is then used by AWS QuickSight for making it possible to visualize the dataset in the form of graphs.

5. RESULTS

Our experimental output, shows that automated working of water pump and data updating and retrieving operations in cloud server has been done by the proposed system. After the code is uploaded to the NODEMCU(ESP8266) board and power is supplied, the system reads the analog value of moisture content in soil using the soil-moisture sensor and temperature & humidity via the DHT11 sensor at regular intervals. This sensor data is sent/retrieved to the AWS Cloud using the Publish/Subscribe architecture of MQTT(Message Queue Telemetry Transport) Protocol. Published data is then checked each time with the threshold condition of soil-moisture and crop temperature. If the moisture content in soil is less than the threshold value or the crop temperature is more than required temperature then the water pump is turned ON via the relay module to water the plants/crops. Simultaneously the RULES of AWS IOT CORE are checked in order to send the notification to the user via SMS, email or mobile push notifications. Once the soil-moisture & crop-temperature is restored, the water pump is turned OFF and again the user is notified and the cycle continues. As the sensor data is uploaded to AWS Cloud via MQTT protocol, Simultaneously the data is send to AWS DynamoDB, AWS IOT Analytics as well. We recorded the same data stored in the database . These can be stored for a long period to look back at previous values. Also, the data-set which is processed by AWS IOT Analytics is used by the QuickSight in order to display the data-set visually in form of Graphs.

Below are the screenshots of various platforms working successfully:

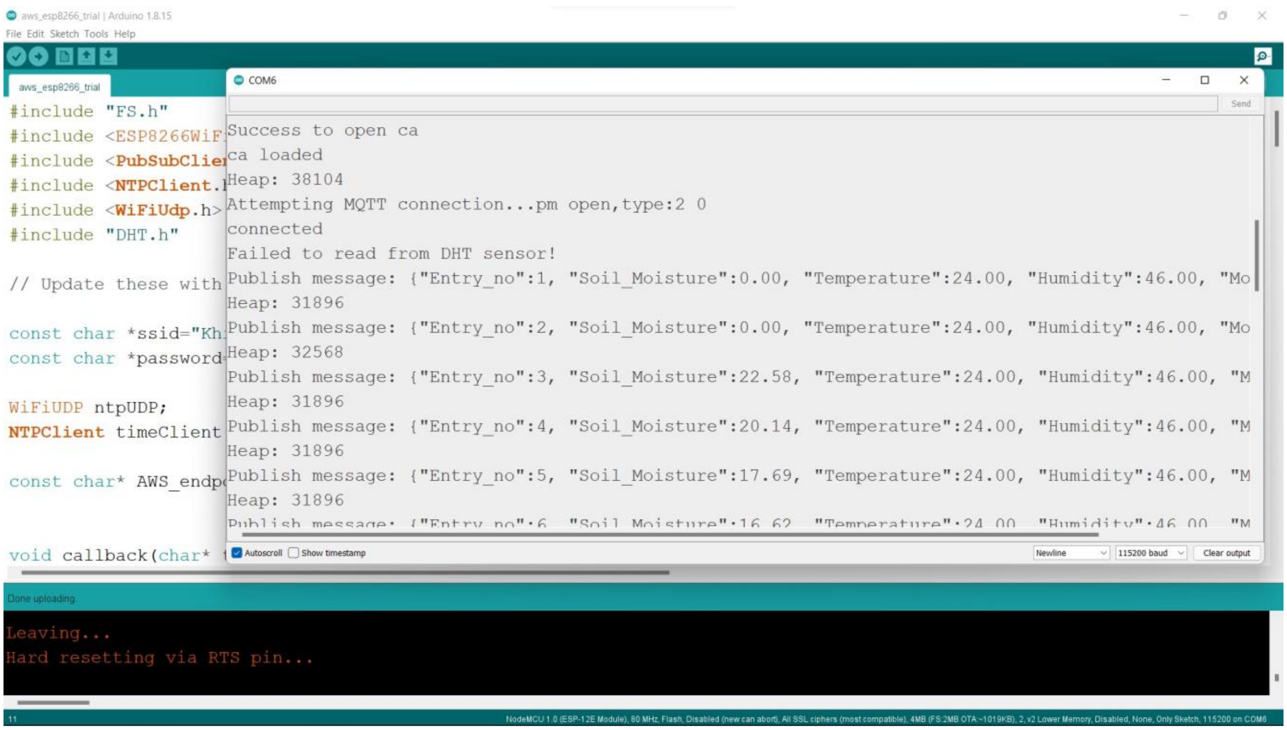


Figure 5. Serial Monitor Output

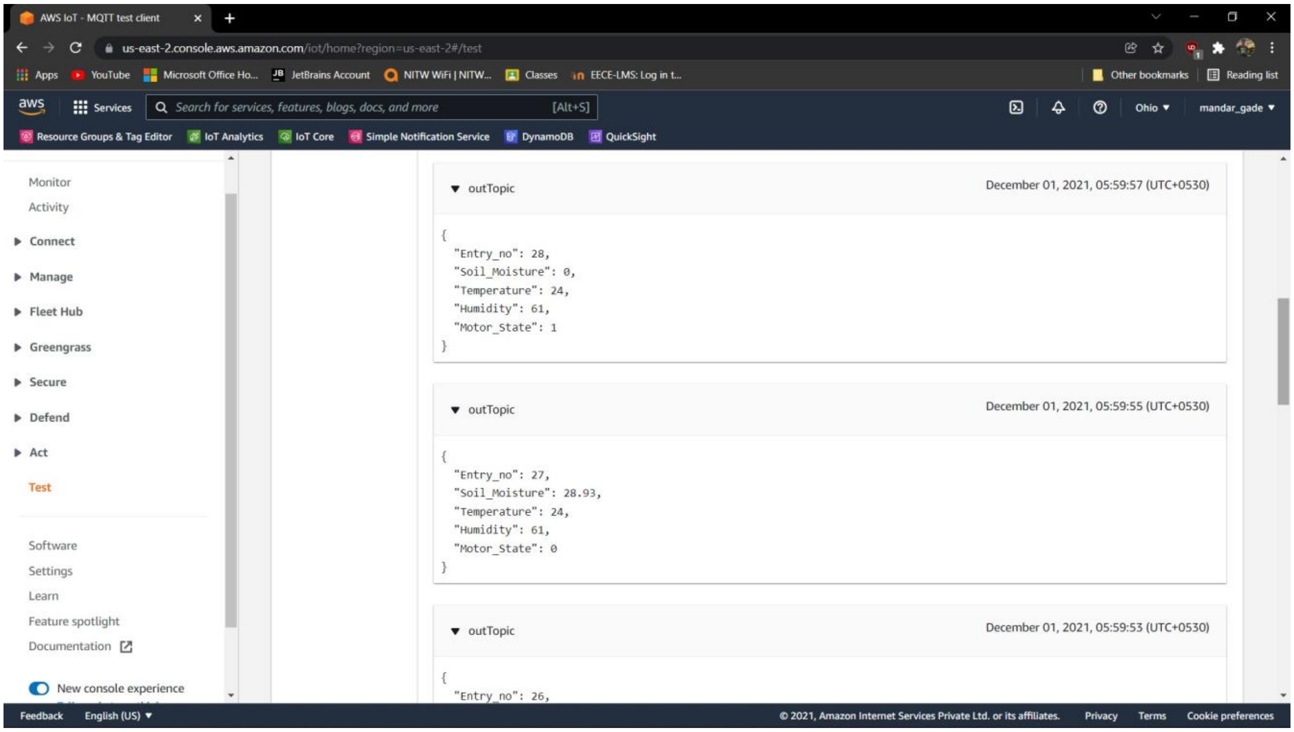


Figure 6. AWS IOT CORE(MQTT TOPIC)

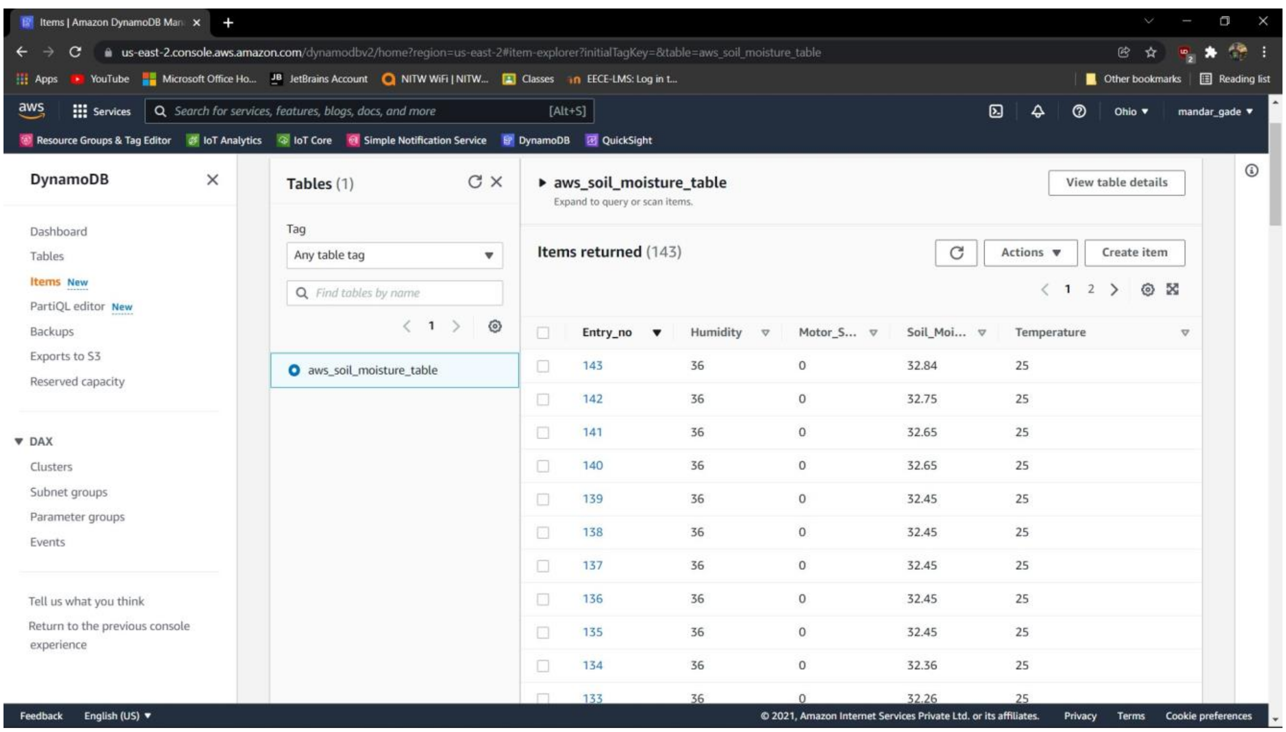


Figure 7. AWS DynamoDB table

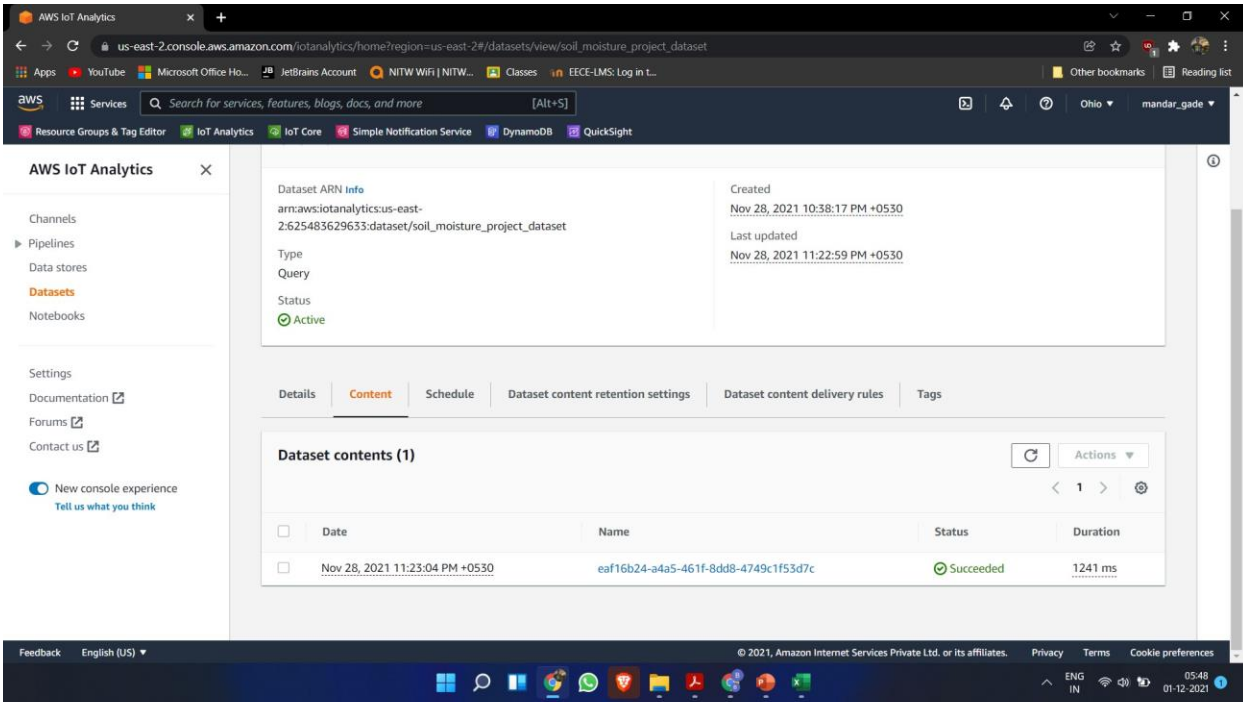


Figure 8. AWS IOT Analytics Data-Set created

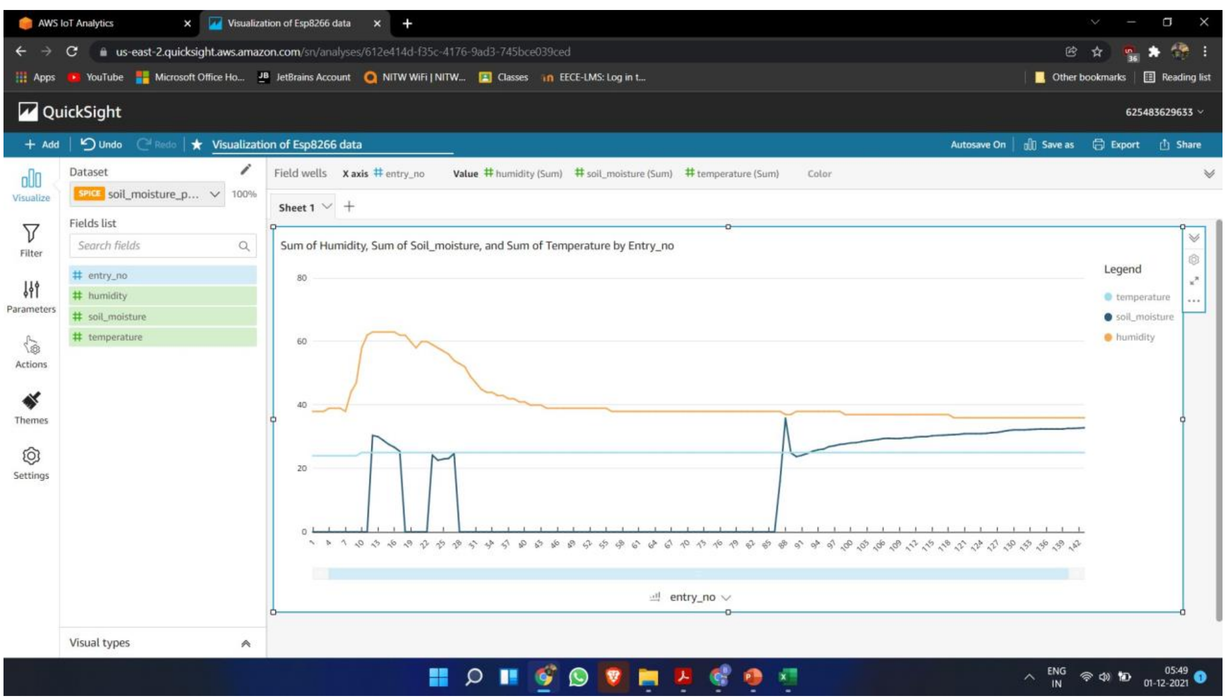


Figure 9. AWS QuickSight graph visualization

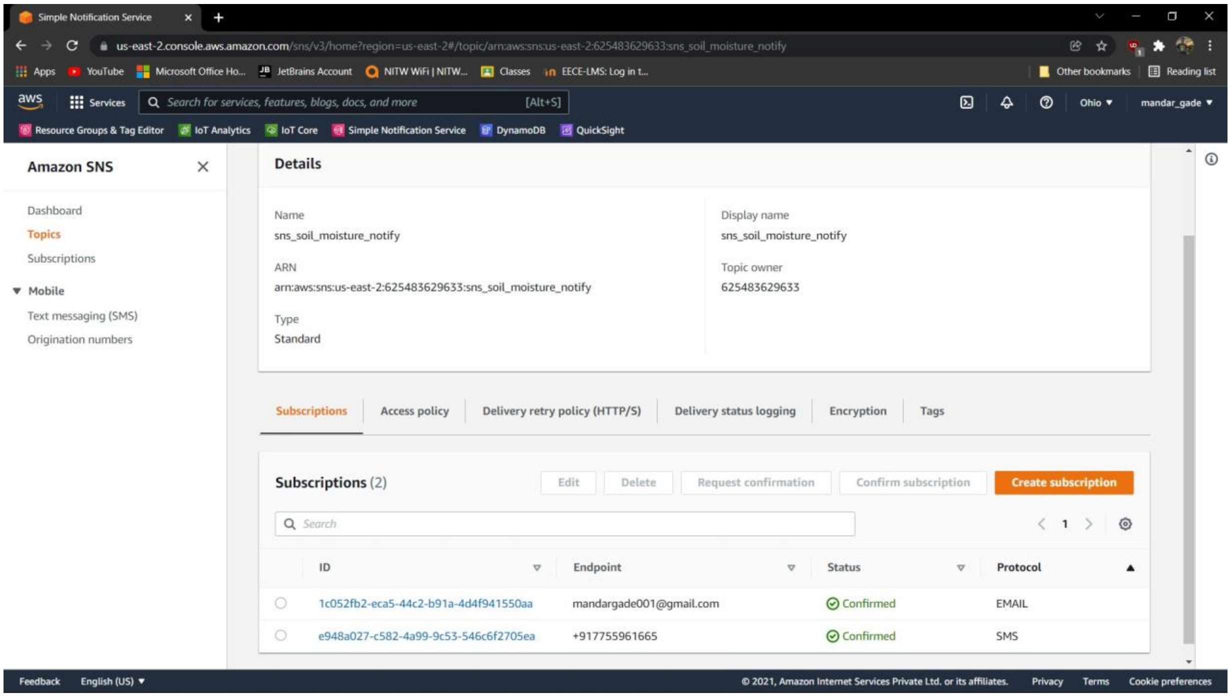
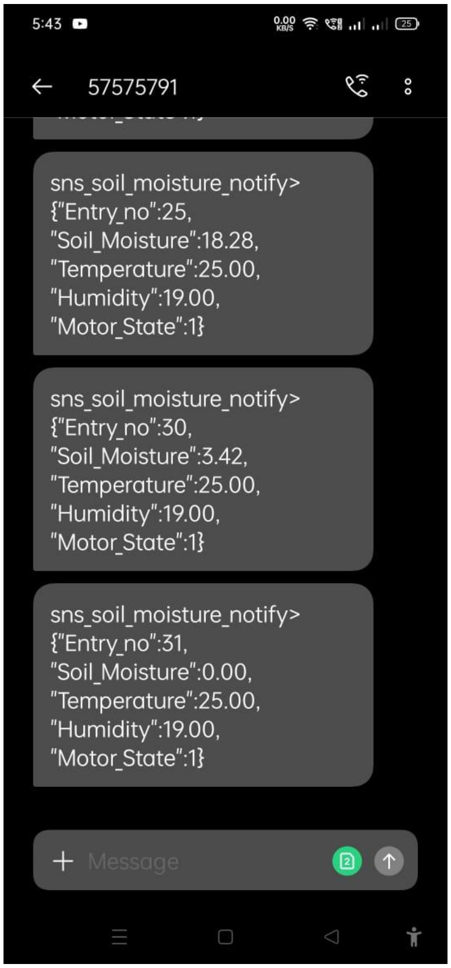


Figure 10. AWS SNS Topic details.



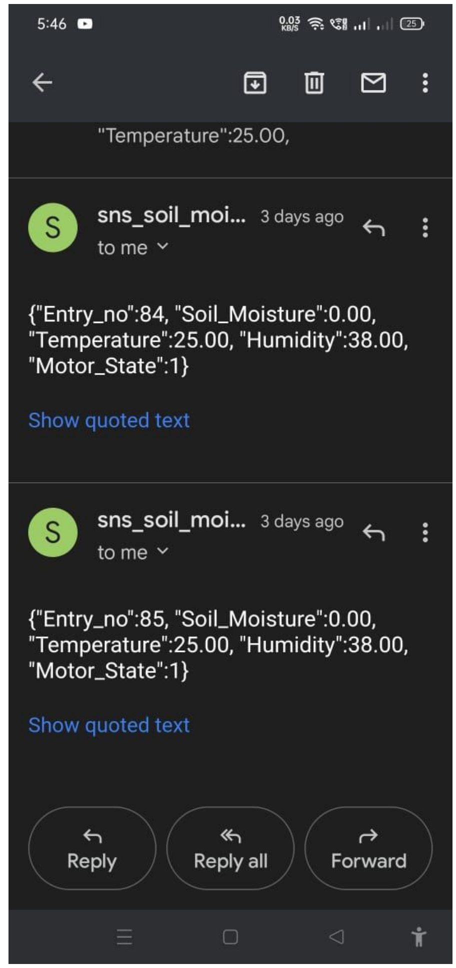


Figure 11. SMS & Email SS taken

6. CONCLUSION & FUTURE SCOPE

The developed system is beneficial for the users and works in a cost-effective manner. It reduces water consumption to a greater extent. The system can be used in green houses and also it will be very useful in areas where water scarcity is a major problem. The harvest efficiency will increment and wastage of yields will be diminished utilizing this water system framework. The created framework is progressively useful and gives increasingly doable outcomes. The smart irrigation system will prove itself as a cost-effective system for optimizing water resources for agricultural production. This system helps the farmer by working automatically and smartly. With placing multiple sensors in the soil, water can be only provided to the required piece of land. This system requires less maintenance so it is easily affordable by all farmers.

As per future perspective, this system can be the more intelligent system which predicts user actions, nutrient level of the plants, time to harvest, etc. With using Machine Learning algorithms more advancements can be done in the future which will help farmer a lot and water consumption can also be reduced in agriculture.

Farmland can be monitored by using cameras and sensors which can protect the farmland from human, rodents, mammals, etc.

Also, the data collected and stored on the cloud can be viewed on the Web App created using AWS along with the Graphical Representation of the data. An button can be provided in the App wherein the farmer can directly switch ON/ OFF the motor from any remote place.

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