

# Digital Agriculture; Utilizing Internet Of Things In Monitoring Farming Processes

## ABSTRACT

The Paradigm shift from primitive technology to modern wireless technology is rapidly becoming a revolution and this is leading to Internet of things, a network system where hardware components are able to communicate and exchange data with the use of embedded sensors. The project also looks into crop loss which is caused by misunderstanding of soil conditions and nutrient value. This paper is stipulated at designing and implementing an IoT based farm monitoring device using temperature and humidity sensors which can interact with GSM via SMS alert notification system.

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**Keywords:** Crop loss, IoT based farm monitoring device, GSM, SMS Alert notification system

Soil Conditions

## 1.0 INTRODUCTION

The Agricultural sector, over the years has proven to be a major factor contributing immensely to the economy of Nigeria, and other nations across the globes that are imbibing farming process. It has proven to be one of the major factors that have contributed immensely to the economy of the Nation. It happens to be the most versatile science which have stayed and evolved over the years. However there has always been a problem associated with the increased rise in the need for food points out the relevance of developments in agriculture. Putting into consideration, the world's growing population, the demand for more food has to be met; this poses a great threat to the agricultural sector. The demand for food, the current challenges of extreme weather conditions, rising climate change, farming environmental impact among other factors act as limitations to creating a stable farming environment. The process of growing a particular crop at a particular field cannot be complete without monitoring the growth from planting to cultivation and then finally, harvesting. In all of these farming processes, one major challenge in the agricultural activity is detecting soil properties such as humidity, moisture content, temperature, PH value among others. As the global climate decreases the source of water throughout the world, it is necessary to take steps for preserving it (*Damas et al, 2017*). It is also important to note that there are traditional methods for soil detection and management which is carried out manually. It requires continuous presence every time to monitor the soil properties. This creates a need for more labour work and maintenance, which will in turn result to more cost (*Liai et al, 2013*).

The importance of the agricultural system can't be over discussed, in Nigeria and the rest of the African states, so many government policies have been made to facilitate farming systems, and even after that, no significant change have been felt. Most farmers rely on crude ways to carry out every agricultural process that needs mechanized input even up to this current 21<sup>st</sup> century. The common challenge of agricultural system includes the pattern of farming which is found so tedious and stressful, as a human resources is needed in taking charge of both the plants and animals. When the plants requires water, a farmer is expected to go and water the farm land, and that makes it so tedious and demanding in farming, the modern day agriculture has based its roots mostly on the Internet of Things which is taking important and crucial role in improving the old and traditional technology adopted in agriculture. Unfortunately, many farmers still rely on the primitive methods of farming which have an after effect of low yields of crop. In providing solution to this, the implementation of automation have witnessed a paradigm shift

from the conventional farming system to smart farming systems. Crops can now be planted and harvested in high yields.

IoT is defined as a system of computing networks embedded with sensors, software and other technologies that allows the transfer of data and commands without human interference. Everything is provided with unique identifier which is designated to make information ordering and categorizing easier. The unique identifier can also detect and trail back information to an explicit user within the system. It is a progressed examination and mechanized frameworks which uses detecting, organizing, enormous information and man-made consciousness innovation to convey and carry out complete total framework for an administration of effective process.

Internet of things (IoT) is one of the fastest-growing technologies in the last few years. This technology might be used widely in real-life agriculture. In this study, we present a low-cost and easy accessible IoT-based smart agriculture monitoring system along with cloud data storage facility to store and secure such a huge volume of data by an IoT device. The device focuses on collecting data from different sensors and uploads them to cloud using Thingspeak as the medium. Farmers or analyzers can be able to monitor the actual condition of the agricultural field remotely using a mobile phone via SMS

The mobile phone unarguably is the most used consumer electronics. Not minding class and age, mobile phones can be used by everyone. Users of mobile phones across the world were in 2012, estimated to be about 4.5 billion. Accompanied with trends of updates and innovative features, mobile phones constitute a large part of today's existence through their ability to compute and process data. As a result of this, mobile phones can now effectively run applications originally meant for desktop computing devices, some of those applications include cloud computing, monitoring and tracking. The mobile and portable feature of mobile phones gives it a greater advantage over the desktop computing devices. While desktop computing still offers more pressing power, the mobile phone has the advantage of constant reach ability and mobility that desktop computing lacks with comparable rich user experience (Frank et al, 2008).

However noting the above prospects, there is a need to adopt an IoT based device that will monitor and communicate through short message service (SMS) via (Global System Mobile communication) GSM module. This project presents the design and implementation of an IoT

based farm monitoring device with GSM communication that will check and monitor six (6) soil properties; soil moisture, temperature, pressure, humidity, altitude and the Nitrogen-Phosphorus-Potassium (NPK). The IoT based smart farming system being proposed via this report is integrated with Arduino technology mixed with different sensors and modules to serve the purpose of its implementation.

We may decide to ask ourselves, what exactly is the significance of this study?

The significance of carrying out this paper research and development is to provide solutions to the obsolete method of practicing Agriculture. The importance of Agricultural monitoring is difficult to overlook, a smart method of monitoring the field data through the use of IoT technology is significant for the following reasons;

1. Farming and Agricultural practices need water as plants need them to grow, but depending on levels of soil humidity, the amount of water may differ. To check for and measure these levels, farmers have to set out to the field to take manual testing which are not so efficient on most basis – alternatively, they could adopt smart sensing technology which is highly efficient, convenient and accurate.
2. Soil temperature and moisture levels are key metrics farmers need to collect to estimate the state of crops and take appropriate action. Unfortunately, it's usually impossible to measure them correctly without IoT agriculture monitoring systems.

The modern generation of Agriculture often times rely on the Internet of Things. IoT in recent times is becoming a culture and playing a crucial role of reworking “Traditional farming” to “Smart farming”

## **2.0 THEORETICAL FRAMEWORK INTERNET OF THINGS IN AGRICULTURE**

Internet of Things have developed ability and features to impact the lives of people living in the World today. This impact is effective and efficient enough to bring positive changes to people, devices and activities happening all over the World. Recent study have proven that the ever growing population of the World is expected to reach 8 billion people in 2023 (U.S Census Bureau, September, 2020), a little above the 7.8 billion which is a figure estimated by the United

Nations Estimates and elaborated by Worldometer. Aside from counting the numbers, the most important focus is to feed such immense population.

Agriculture production is experiencing a modern revolution and has involved the use of communication and information technology. The technological revolution in agriculture farming led by the improvements in robotics and sensing technologies looks set to disrupt the advanced practices. Use of modern agricultural technologies is must because it can increase production and can reduce the input cost. Several aspects of modern autonomous machinery can give great benefit when applying them in agriculture, especially in smart farming. In the future, smart farming can be a powerful tool for farmers for the efficient use of resources and real-time management. But this is a sketch of farming controlled by a high input of revenue and technology. That might be difficult for some developing farming communities until they will be provided by subsidy. This relief can create a revolution in every part of the world and can secure food availability for the growing population

In recent years, many efforts have been taken to change the traditional agriculture system. For any smart agriculture system, it should operate in a systematic way to maximize quality and productivity. So by implementing a more reliable system can cut the cost, human labor, and wasting resources. But most of them are using the Wi-Fi module to transmit the sensor data to the server, in real life, which is difficult to find in an agriculture field. Also, most of them are using one tier data storage system either cloud database or local database to store data, and if database crush for any reason there will be no possibility to get all those data back. So unfortunately because of the complicity and other problems smart farming is not as widely used as it has to be.

The demand for more food has brought up the necessity to address the challenges and limitations which may include extreme climate conditions, temperature and moisture changes that may affect agricultural operations directly or indirectly. Agriculture in this part of the world must be worked with understanding and excessive ease in technology and innovations that will increase production, reduce the influence of pest and disease, create more awareness and regain the attention of farmers and the agricultural sector as a whole in the activities of the Nation. These smart farming methods would help farmers to enhance efficiency and reduce the scraps. It is a favorable and high tech capital intensive venture

that procures efficiency and effectiveness which can be applied for the planting and growing of crops that will sustain the masses. This technology can be implemented to assist the Farmer with the help of sensors monitor temperature and moisture condition of the soil from any geographical location and can also notify other workers through the help of an alarm system installed. It is the application of “higher levels” of Information and Communication Technology into the field of Agriculture. ICT based techniques have solved some problems but are not well enough for efficient and assured production. Recently, ICT has migrated to IoT which is also known as “Ubiquitous computing” (Patil et al, 2012)

### **3.0 OVERVIEW OF FARM MONITORING DEVICE IN RELATIONSHIP WITH INTERNET OF THINGS**

**Farm:** A farm is a geographical area of land which is primarily meant for agricultural purposes such as the planting and cultivation of crops, the rearing of animals and the rearing of fishes. It is the most basic and vital factor in food production.

**Monitoring:** Monitoring can be defined as the systematic process of collecting, aligning, analyzing, processing and the final usage of data or information gotten from an activity. To monitor is to keep watch and record of an activity.

**Device:** A device is a gadget, a tool or an instrument that performs a special role in a system. A system is composed of different devices working together to achieve a specific purpose.

Internet of Things is a transformation process of connecting smart devices and objects to network to perform efficiently and access remotely. This transformation are composed of seven components.

#### **3.1.1 Gateway**

This component feature of IoT is one which creates ease in data management and traffic which flows between protocols and networks. It performs a duo function which also includes translation of network protocol and establishing a secured and proper connection between the devices and their sensors.

### **3.1.2 Analytics**

Analytics in simple terms refers to conversion of data (devices and sensors), mostly analog into a format that is easily read, accessed and analyzed. Its possibility is due to the IoT ecosystem that helps in system improvement and management. Security is the main factor that is influenced. Innovative establishments collect large amount of data, analyze them and implement them to view future opportunities which they can innovate on to build business advancement and procure gains from it.

### **3.1.3 Connectivity of Devices:**

Connections are mostly possible and completed mainly by help of components like sensors and devices. Sensors as the name implies collects these information and send them to be processed. Through the advancement of technology, semiconductor technology is applied to produce these micro smart sensors which can be used for various and diverse applications. The main components through which connections are made possibly include all of the following; Proximity detection, humidity or moisture level, temperature sensors and thermostats, pressure sensors, and RFID tags.

### **3.1.4 Cloud**

Through the help of internet of things ecosystem, companies are able to collect large amount of data from the devices, applications and systems. There are various tools that are used for collection of these data. These tools have the ability to collect, process, handle and store the data efficiently in real time. It is also responsible for making decisions that can easily break the deal. All these operations are composed and carried out by the IoT cloud.

It is high-performance network that make connections between servers to optimize the performance of processing data that is being processed by many devices all at the same time. It also helps in controlling and regulating traffic and delivering accurate results of data analytics.

### **3.1.5 User Interference**

User interference is yet another factor upon which ecosystem of IoT depends immensely. It creates provision for a visible and physical part that can easily be accessed by the user. It is of utmost importance for the developer to lay platform for a user-friendly interface with easy access without putting extra efforts and also possess easy interaction.

### 3.1.6 Database

Proper and effective data base system is undoubtedly a very key component of the IoT ecosystem. Internet of Things are increasing changes and very dynamic at that. All of these changes are dependent on data used in data centers. It is of utmost essence to have an effective data system that can manage, store and create access to data that is being collected from different system and devices to end users.

### 3.1.7 Automation and Development

Automation can be seen as the end result of the application of Internet of Things. The result we get when home appliances can be controlled and connected to remote, smart phones and the likes is an evident feature of automation

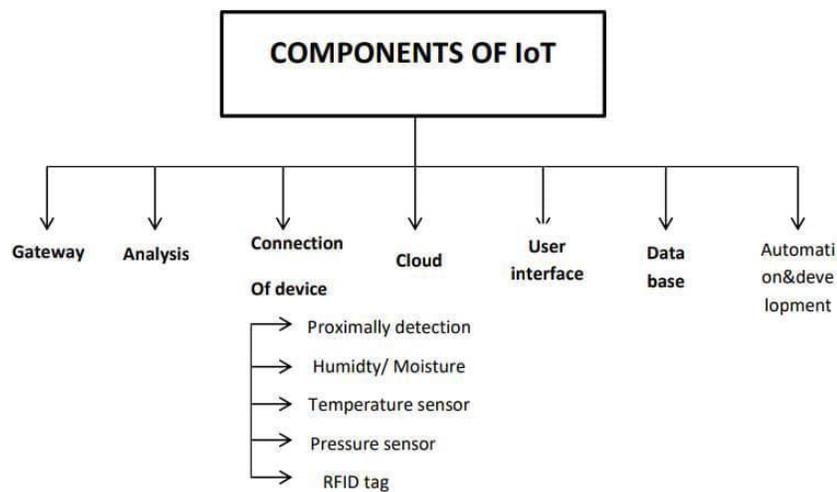


Figure 3.0: Component of IoT

## 3.2 Structure of Internet Of Things In Agriculture

This system contains basically three (3) layers which are; sensing layer, transporting layer and application layer. These different layers plays unique roles which are briefly analyzed below.

### **3.1.0 Sensing layer**

With the help of sensors, one of the challenges involved in the sensing layer is to obtain data which are automated. The sensors also obtain real time transformation of data collected in the actual world agricultural manufacturing into digital information which could still be furthermore processed in the real world manufacturing through various different means. Some of the data collected are: humidity, temperature level, gas concentration etc. The sensing layer is able to collect such information through some strategies such as; Radio frequency identification (RFID) tags, camera module, sensor modules etc.

### **3.1.1 Transport Layer**

The task assigned to this layer is to collate and summarize the information acquired from the sensing layer above for further processing. This layer is believed to be the Nerve Center of IoT because of the unique feature it possess. This layer also possess different centers numbering up to three which help in the effectiveness of its operation. The three different centers are; Smart processing centers, telecommunication management center, Internet network information center.

### **3.1.2 Application Center**

As the name implies, this layer is charged with the responsibility of analyzing and processing information which have been collected and collated from the first two layers for the cultivation of technology transfer and digital awareness of the virtual/real world. It is believed also to be the combination of Internet of Things and agricultural market intelligence.

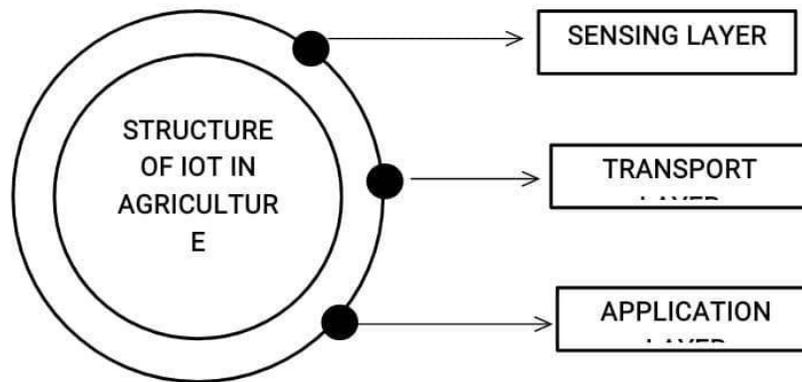


Figure 3.1: Structure of IoT in Agriculture

### 3.3 Applications of Internet of Things in Agriculture

The Applications of IoT in Agriculture based on the study in review have been placed in these categories which are listed below;

- Smart Green-House
- Precision Farming
- Agricultural drones
- Livestock Monitoring

#### 3.3.1 Smart Green House

The smart greenhouse is a revolution in the field of agriculture, creating a self-actualizing, microclimate suitable for plant growth through the use of sensors, actuators, monitoring and control systems that optimize growth conditions and automate the growing process. The automation in smart greenhouse helps to monitor the environment in the period when the farmer is absent; it eases the planting of crops. Temperature and humidity sensors are mostly used in smart green house

### 3.3.2 Precision Farming

Precision farming also regarded as Precision Agriculture (PA) is an approach to farm management that uses information technology (IT) to ensure that the crops and soil receive exactly what they need for optimum health and productivity. The goal of PA is to ensure profitability, sustainability and protection of the environment. Weather sensors, temperature and humidity sensors are applicable in precision farming/agriculture.

### 3.3.3 Agricultural drones

Agricultural drone is a modern application of smart Agricultural. Drones originally meant for coverage and pictures can now be implemented in smart agricultural through attachment of sensors to help optimize agriculture process.

### 3.3.4 Livestock Monitoring

Livestock monitoring is also implemented with an IoT based monitoring device. Smart livestock is a modern trend in the use of innovation technologies for animal health management and monitoring.

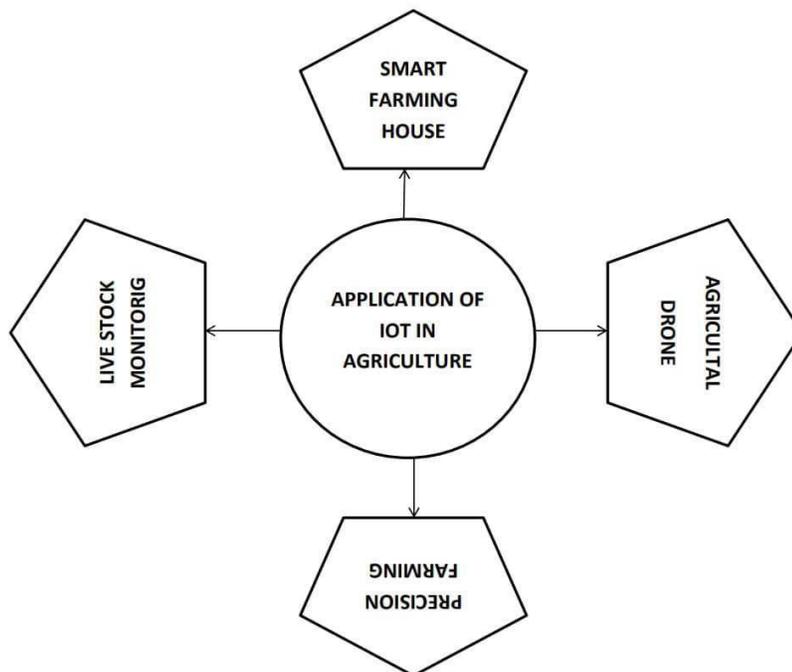


Figure 3.2; Application of IoT in Agriculture

#### 4.0 METHODOLOGY & EXPERIMENT

The core buildups of an IoT system are sensors, processors and applications such as cloud storage or mobile applications. The smart farm monitoring device is built upon communication of hardware and software configuration. The hardware configuration is the embedded systems while the software is the Arduino IDE. The Arduino IDE which is encoded in the microcontroller displays information from the sensors are inserted using the hardware.

Below is the block model of the project which lay out all the connections of the project. The sensors are connected to the microcontroller (which is the brain of the device), information gotten and read from the sensors are uploaded and viewed on the mobile phone via GSM communication. The information gotten with the aid of the sensors are sent to the Arduino UNO microcontroller; ATmega328. The GSM communication serves as a pathway to continuous information from the sensors and simultaneously assists farmers in planning and taking action with respect to the needs of the soil and the farm at large.

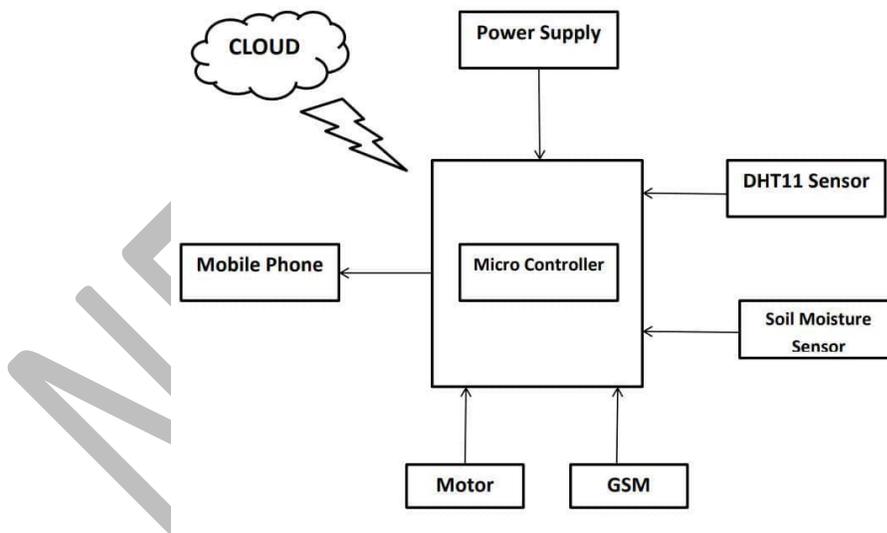


Fig 4.0 Block Diagram of Model

## 4.1 System design

Proteus simulation was used for the system design. As seen in Fig 3.2, the success or failure of the GSM communication is dependent on the SIM module. The SIM module has two pins connected to the pin 2 and pin 3 of the micro controller and the other two pins to the moisture sensor. The moisture sensor which is originally constructed with 3 pins will have 2 of those pins connected to the SIM module and the 3<sup>rd</sup> connected to the pin 11 of the micro controller. The function of the LCD is to display the results of the data collected by the sensors which is also programmed by the micro controller. In addition to the sensors, components such as resistors, capacitors, oscillators, transistor etc. was used to make the device function effectively.

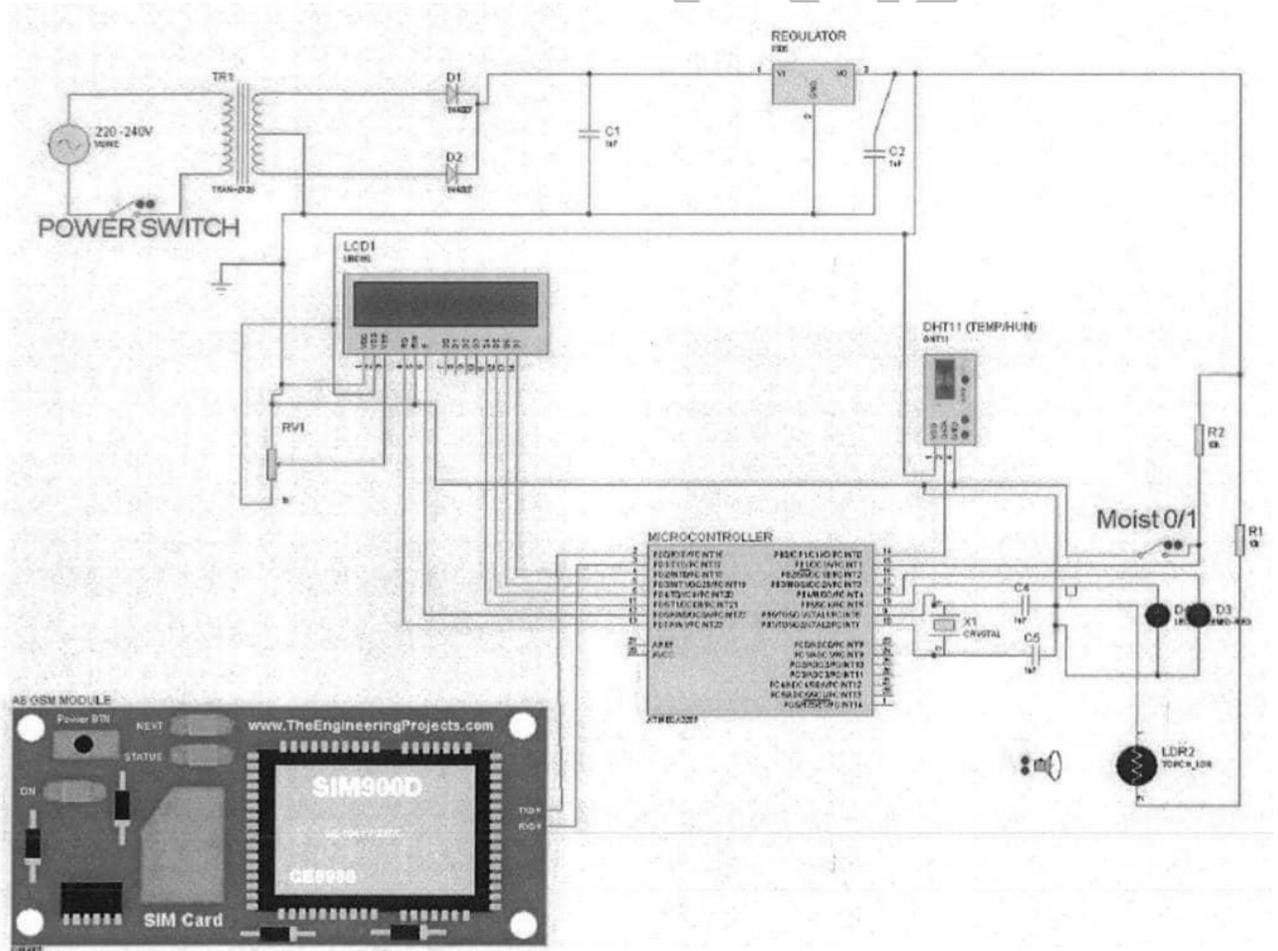


Fig 4.1 Circuit set up of device

## 4.2 Flow Chat

The flow of operation of our project which lay out all the operations of each module is shown in the chart below

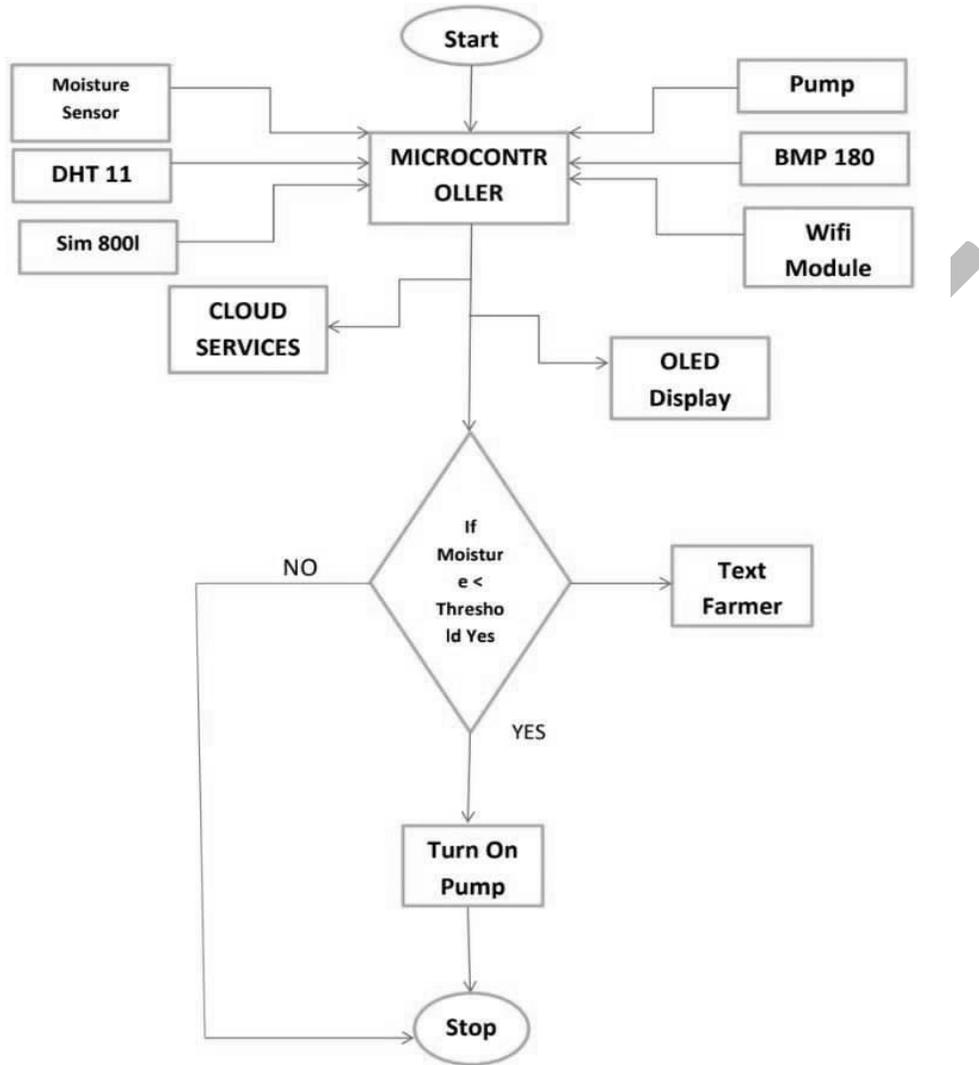


Fig 4.2 The flow chart of Model

When the information of the different parameters in consideration which are humidity, temperature and soil moisture are gotten. It is sent to the mobile phone of the user (farmer) and if the moisture content of the soil is beyond the threshold level, a warring notification is sent to the

mobile phone of the user automatically switches on the motor through the effect of the relay action.

### **4.3 Hardware Material Selection**

The development of this project is made possible with the aid of various hardware components. The technology is an embedding of different sensors, microcontroller and communication channel to help the famers access the usability and work on their farms.

#### **4.3.1 Arduino UNO**

Arduino is a microcontroller to control the working of the sensors and manage the working of the device. The UNO version of Arduino is implemented in this project. It was developed by Arduino CC. The Arduino board comes with various number of pins. The pins are categorized as output and input pins. The input pins accept digital as well as analog data. It has 14 digital pins and 6 analog pins. It accepts 7 to 20 volts of power for working. It also has an USB port. The U was the first version of Arduino to be introduced in the Arduino family.

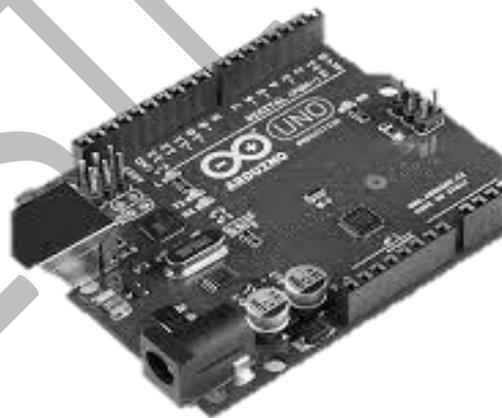


Fig 4.3 Arduino UNO

**Table 4.0 Parameters of Arduino UNO**

Parameter	Specification
Microcontroller	ATmega328P – 8 bit AVR family microcontroller
Operating voltage	5V
Recommended input voltage	7-12V
Input voltage limits	6-20V
Analog Input pins	6 (A0 – A5)
Digital Input pins	14 (Out of which 6 provide PWM output)
DC Current on I/O Pins	40Ma
DC Current on 3.3V Pin	50Ma
Flash memory	32 KB (0.5 KB is used for Bootloader)
SRAM	2KB
EEPROM	1KB
Frequency (Clock Speed)	16MHz

#### 4.3.2 DHT11 Temperature and Humidity Sensor

The DHT11 Temperature and Humidity sensor is used to sense temperature and humidity present in the atmosphere. It has 3 pins generally. One pin is used for transmitting signals, the next pin is used to receive signals and the last pin is data transfer. It can be used for prolonged time period. It gives approximate results. It regularly sends information to Arduino UNO. The information consists the signals which contain the values gathered about temperature and humidity. It is reliable on nature. It gives a very fast response.

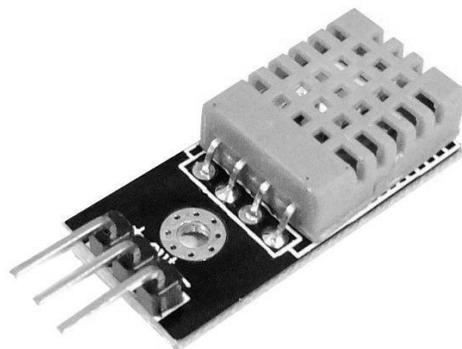


Fig 4.4 DHT11 Temperature and Humidity Sensor

**Table 4.1 Parameters of DHT11 Temperature and Humidity sensor**

Parameter	Specification
Input/Output Voltage	3V / 5V
Temperature range	0-50 degree Celsius
Humidity range	20-80%
Sensing Range	20-90% RH
Sampling rate	1HZ
Accuracy	+/-5%RH
Response time	50ms-
Temperature Accuracy	+/-2% degree Celsius

### 4.3.3 Soil Moisture sensor

The Soil Moisture sensor is used to sense moisture content in the soil. It checks the volume of water content or moisture present in the soil. The calculations are done in the soil moisture sensor through coefficients. It estimates the volume of water content in the soil. It detects the water content in the soil and gets and sends the analog signals which is shown digitally. It transmits the signals containing information or data or values of the condition of soil to Arduino to further process it and display.

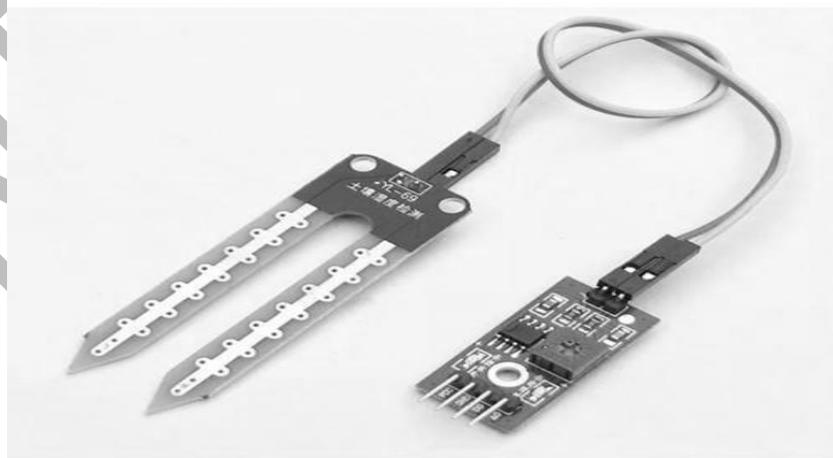


Fig 4.5 Soil Moisture sensor

Table 4.2 Parameters of Soil Moisture sensor

Parameter	Specification
Model	YL-38
Operating temperature	-40 to +60 degree Celsius
Sensing Range	0-35% Volumetric water content of soil
Operating Voltage	5V DC
Power consumption	3mA

#### 4.3.4 GSM Module

The GSM Module (SIM800L) is used as a method of communication in this proposed technology. The GSM Module is used to send text messages to the farmer's mobile phone about the conditions of the temperature, humidity soil and field area. A separate coding has to be done for GSM Module in Arduino.



Fig 4.6 GSM Module

Table 4.3 Pin Description of SIM800L

Pin name	Description
VCC	Power output (3.3V)
GND	Ground
RX	UART Receive pin
TX	UART transmit pin

#### 4.3.5 Wi-Fi Module

The ESP8266 Wi-Fi Module is a self-contained SOC with integrated TCP/IP protocol stack that can give any microcontroller access to your Wi-Fi network. The ESP8266 is capable of either hosting an application or offloading all Wi-Fi networking functions from another application processor. Connection to the cloud server is made possible through Wi-Fi.

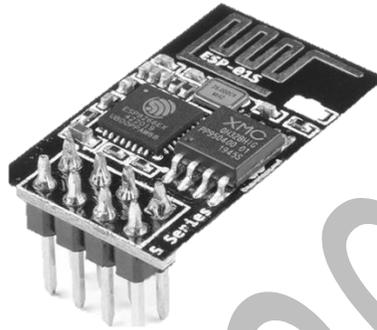


Fig 4.7 Wi-Fi module Low cost, compact and powerful Wi-Fi Module

#### Features of Wi-Fi module

- Power Supply: +3.3V only
- Current Consumption: 100mA
- I/O Voltage: 3.6V (max)
- I/O source current: 12mA (max)
- Built-in low power 32-bit MCU @ 80MHz
- 512kB Flash Memory
- Can be used as Station or Access Point or both combined
- Supports Deep sleep (<10uA)
- Supports serial communication hence compatible with many development platform like Arduino
- Can be programmed using Arduino IDE or AT-commands or Lua Script

### 4.3.6 BPM 180

The BPM 180 (Barometric sensor) is a high precision sensor designed for consumer applications. Barometric Pressure is real practical application is just weight of air with respect to everything else. It measures the absolute pressure of air around it in relation to altitude and air. BPM 180 senses pressure, altitude and provides output as information in its digital pins.

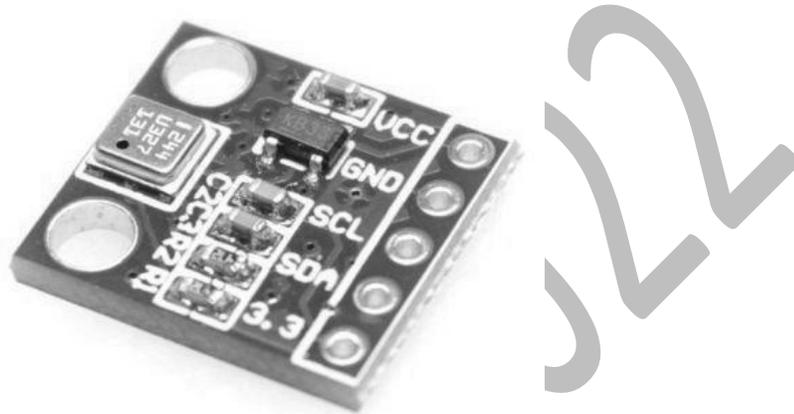


Fig 4.8 BPM 180 sensor

Table 4.4 Specification of BPM 180

Parameter	Specification
V <sub>in</sub>	3V / 5V
Logic	3 to 5V compliant
Pressure sensing range	300-1100 hPa (9000m to -500m above sea level)
Resolution	Up to 0.03hPa / 0.25m resolution
operational range & temp accuracy	-40 to +85°C operational range, +-2°C temperature accuracy

## 4.4 Software Material Selection

### 4.4.1 Arduino IDE (Integrated Development Environment)

The Arduino Integrated Development Environment - or Arduino Software (IDE) – is an open source software used to write, develop and compile codes (in C++) making use of an Arduino

board. It connects to the Arduino and hardware to upload programs and communicate with them. It contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menu bars. Arduino software can run on various operating systems such as Windows, MAC, Linux etc. Arduino generally is available in different forms such as UNO, mega, Leonardo and many more.

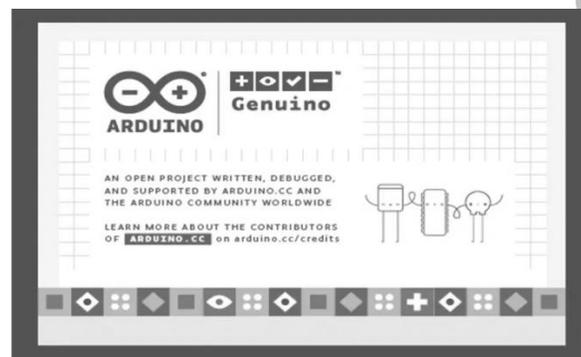


Fig 4.9 Arduino IDE

#### 4.4.2 Thingspeak Cloud server

Thingspeak cloud server is also an open source software. Thingspeak is an IoT analytics platform service that allows you to aggregate, visualize, and analyze live data streams in the cloud. It enables Internet of Things application and API to store and retrieve data from things using the HTTP and MQTT protocol over the Internet or via a Local Area Network.

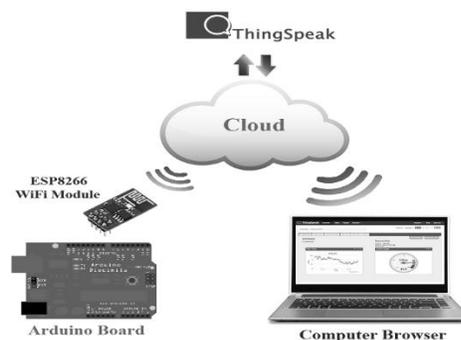


Fig 4.10 Thingspeak Cloud Server

The above diagram illustrates how the Thingspeak cloud work. The information gotten from the Arduino board and any other smart device which may include temperature, humidity, and moisture and so on are sent to the cloud where the information is stored and analyzed in real time. These information can also be retrieved through a MATLAB algorithm by other smart devices.

### **Features of Thingspeak**

- Through IoT protocols, devices transmit data to the cloud
- In real time, the data is visualized
- Thingspeak as a cloud server, collects the data and interprets IoT data through MATLAB algorithm

## **5.0 RESULTS AND DISCUSSIONS**

### **5.1 Testing and Results**

We have tested the parameters of the soil. The data below shows the results of the sensor readings while testing the parameters

#### **5.1.1 Uploading Data**

After a series of code have been compiled. The data was uploaded via the Arduino IDE and the output of the uploading status can be viewed in the figure below.



Fig 5.0 Data Upload

The data below depicts the sensor readings of temperature, moisture, humidity, Altitude, pressure and NPK on the serial monitor, LCD display and Thingspeak graph

#### 5.1.2 Sensor Readings

The parameters of the soil was tested and the result was shown in two forms; on the LCD display and a graph of series of slopes which is adequately viewed on the Thingspeak graph. From the graph, the various level of parameters can be viewed and analysed.

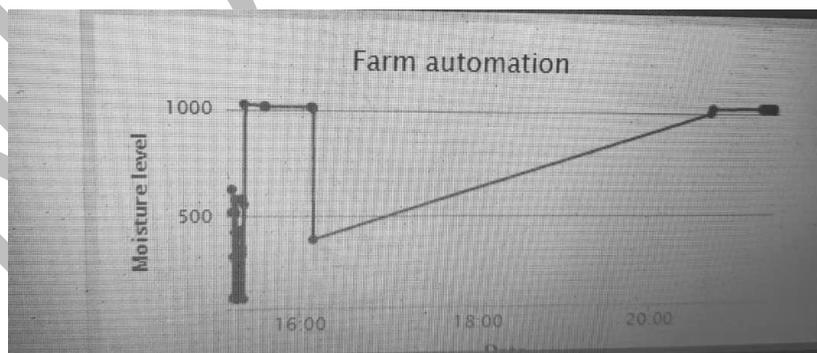


Fig 5.1 Thingspeak output of moisture level

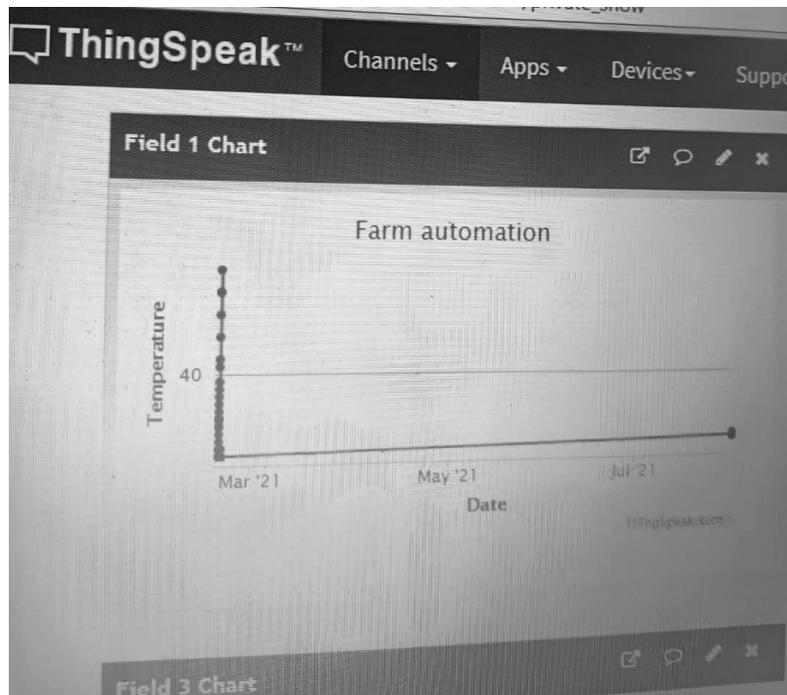


Fig 5.2 Thingspeak output of Temperature

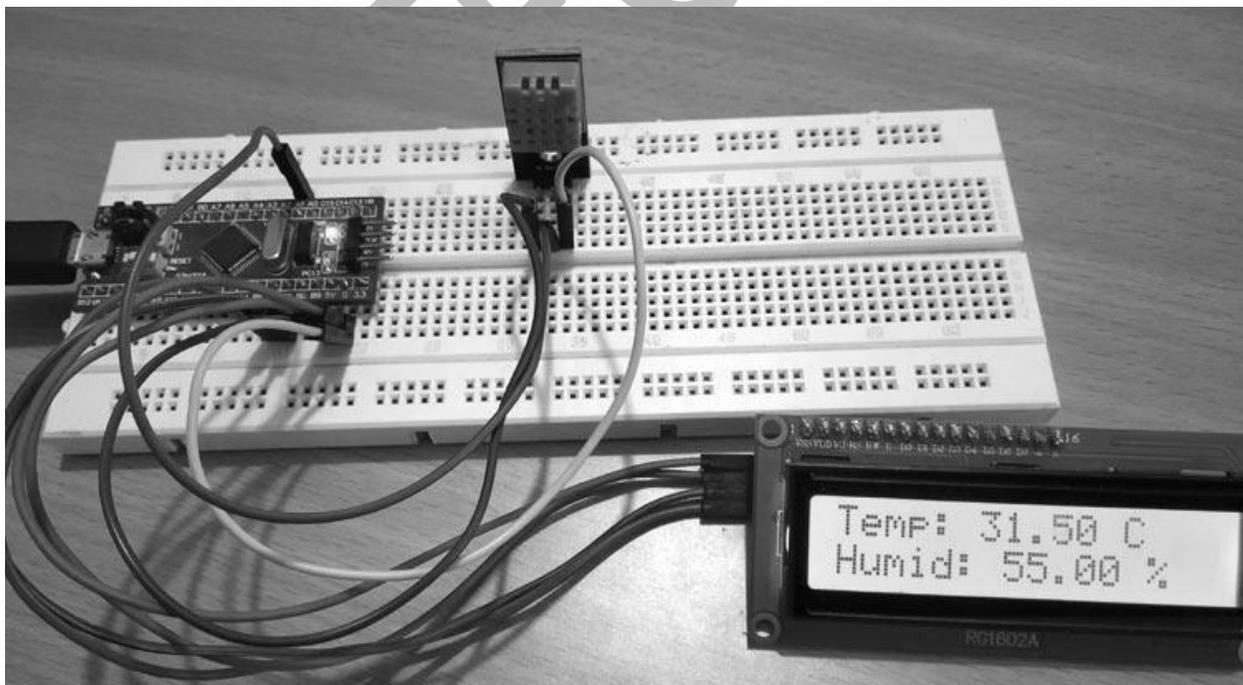


Fig 5.3 LCD output of Temperature and Humidity

## 5.2 Discussion

The above testing was done in order to ascertain the effectiveness of the device. The device accurately gave correct results to the different parameters and results was given as output from the LCD, and via a graphical illustration on Thingspeak Cloud service. In the aspect of threshold value reached, the device was said to have alerted the farmer through series of calls. In the section 4.4, the problems of SMS regulation in the country was explained and its role in affecting this project work

In this section, a functional evaluation was being created after due testing and results which have been highlighted above. The device was evaluated by using different mobile devices. The device responded very well to different mobile devices and SIM services. The device sent correct information to different mobile devices it was tested with. The table below discusses the functional evaluation of the device.

**Table 5.0 Functional Evaluation**

<b>Functional Evaluation</b>	<b>Yes</b>	<b>No</b>
Response to diverse mobile phones	Yes	
Correctness of information	Yes	
Read correct soil properties	Yes	
Data storage and management	Yes	
Post command action		No
Theft tolerance		No

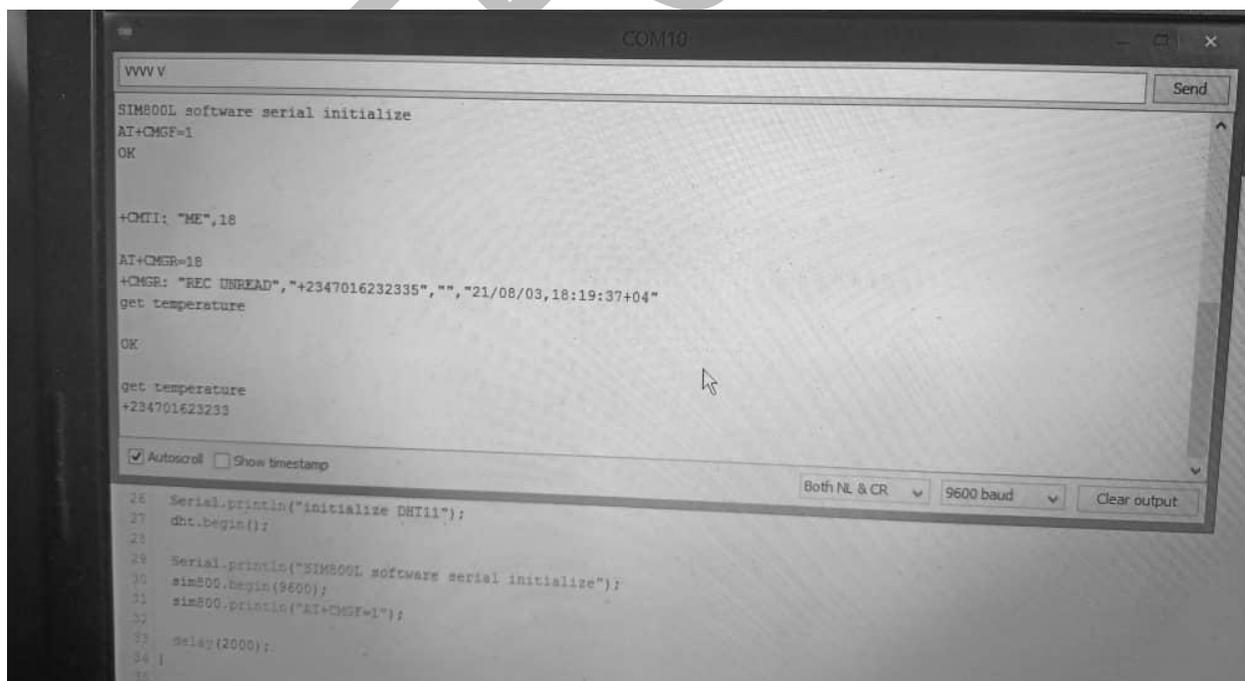
The system performance is excellent, user friendly and can be used even by the most illiterate ones. The scope of this project application also extends to other sections aside the agricultural sector.

## 6.0 LIMITATIONS OF STUDY AND PROBLEMS ENCOUNTERED

The major problem encountered during the construction of this device is the regulatory practice and glitch from the Nigerian service providers especially during this period of restructuring. This is not only concerned to us but also to bulk SMS platforms too. This is due to the SMS regulation in the country.

The figure below shows that the command “GET TEMPERATURE” was received by the SIM module and equally sent back but was not received as an SMS reply. This was resolved by adding a call feature which showed that the SIM, the code, and the module were all correct but the inactiveness of the service providers was a limitation.

This thoroughly explains also why one (1) means of communication in a technology can be disapproving.



```
COM10
www v
SIM800L software serial initialize
AT+CMGF=1
OK

+CMTI: "ME",18

AT+CMGR=18
+CMGR: "REC UNREAD","+2347016232335", "", "21/08/03,18:19:37+04"
get temperature
OK
get temperature
+234701623233

 Autoscroll  Show timestamp
Both NL & CR 9600 baud Clear output

26 Serial.println("initialize DHT11");
27 dht.begin();
28
29 Serial.println("SIM800L software serial initialize");
30 sim800.begin(9600);
31 sim800.println("AT+CMGF=1");
32
33 delay(2000);
34
35
```

Fig 6.0 Input command not responding

## 7.0 CONCLUSION

The system that has been designed and implemented in this paper is a Soil Monitoring Device making use of sensors such as DHT11, BMP 180, moisture sensor etc. with alert notification to notify the user (farmer) of the conditions of the soil and their properties. The scope explores the application of Internet of Things (IoT) in agriculture with the aim to increase crop yield by studying the conditions of the soil and environment. The farmer can request to know the current properties of the soil by sending an SMS to the detector system which in turn relates back the information via SMS. Also, whenever the threshold value of the different parameters is reached, there is an SMS communication to the farmer alerting him of the current soil status. Thingspeak helps in real time analysis of the soil conditions and the data recorded can be used in further statistics or analysis. Data on the cloud helps in improving, predicting and preventing further occurrences of illness, pest and disease occurrence.

This system is cost effective and can be used without prior knowledge of up to-date tech skill. It is dynamic and can find uses in poultry, nursery birds, aquariums etc. This study focuses on the great impact of IoT in agriculture and the solutions and methods deployed in this study can be innovated upon to increase productivity in its uses.

Special recommendations can be made in the future to build an efficient system. This scope can be innovated upon by including additional technologies to the scope such as Big data, Machine learning and Artificial intelligence. This will see models being trained to carry out immediate automated response when threshold values of these parameters are reached.

Improvements can also be made by powering the device with a dc battery and supported by another source such as photovoltaic (Solar) instead of relying on connection to a power source.

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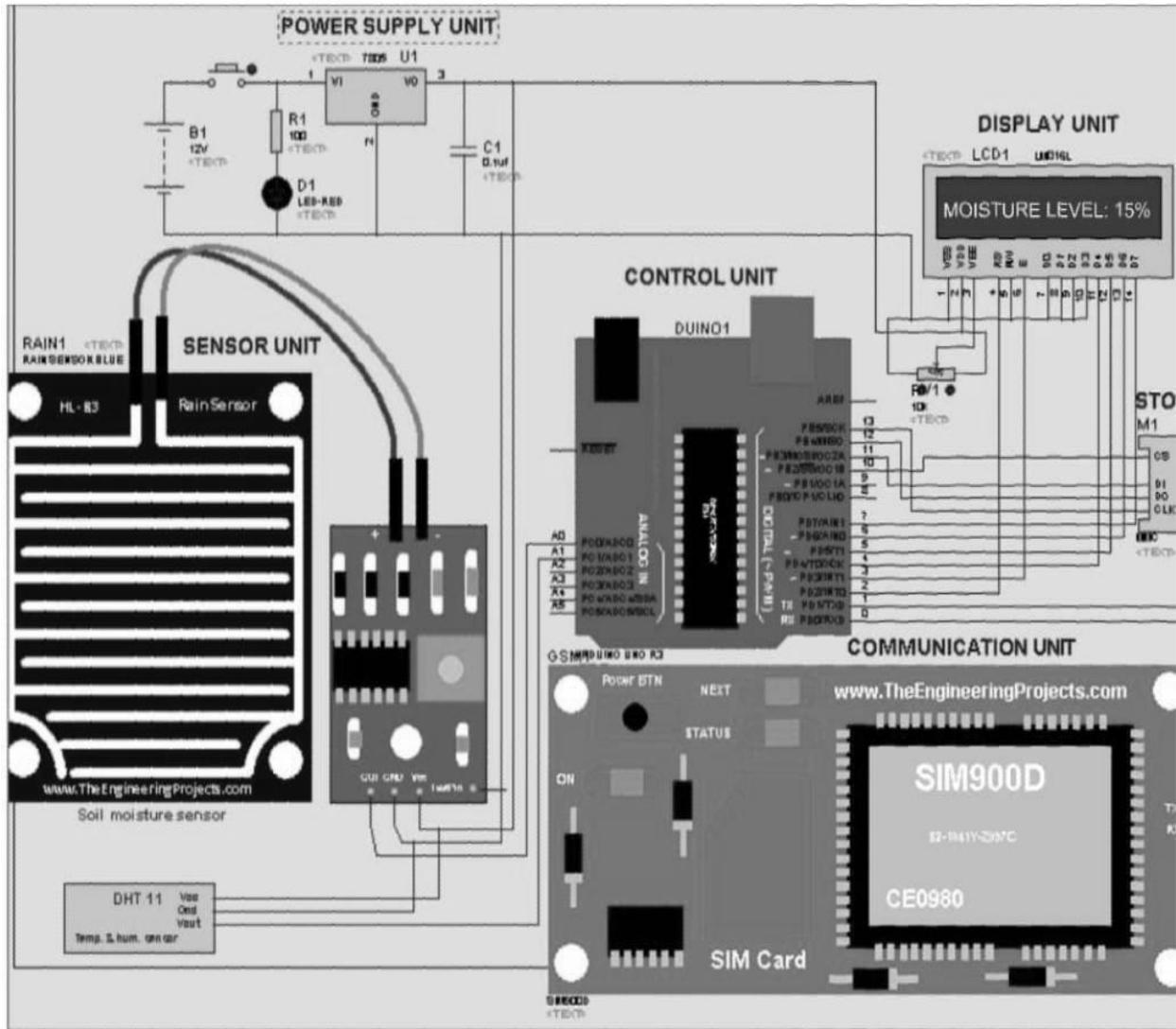
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# APPENDIX 1

## PROJECT CIRCUIT DIAGRAM



# APPENDIX 2

## DEVICE BEING PLUNGED INTO THE SOIL



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