AGRIPRENEURS – A MOTIVATIONAL APPLICATION TO GENERATE ENTREPRENEURS: Project ID - 2021-090

Thilekarathna P.D.M

IT18027334

B.Sc. (Hons) Degree in Information Technology

Department of Computer Systems & Network

Sri Lanka Institute of Information Technology

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Thilekarathna P.D.M

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Dissertation submitted in partial fulfillment of the requirements for the Bachelor of Science

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DECLARATION

We declare that this is our own work and this proposal does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any other university or Institute of higher learning and to the best of our knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

Name	Student ID	Signature
Thilekarathna P.D.M	IT18027334	

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The above candidates are carrying out research for the undergraduate Dissertation under my supervision.

Signature of the supervisor: Date:

Signature of the co-supervisor: Date:

ABSTRACT

Internet of Things act a major role in the technology while enhancing efficiency, effectiveness, and reliability of day to day activities which directly contributed with human life. IoT sensors, data processing/analyzing methods, microcontrollers, data transmission protocols and cloud based databases were discussed in this work. This is mainly talked about improvements and developments of IoT operations based on prediction and analysis. This document demonstrates about how to use the relevant methods such as sensor data retrieving, database handling, data analysis, real time updates in terms of enhance motivational facts of people.

The main purpose of the research is to gather data of selected crops and train a data analysis algorithm to outcome most reliable prediction. Using this system people are able to identify the suitable landscape and crop easily. This work actually motivates people by predicting income from their cultivation after specific duration.

Key words: *IoT, Smart farming, Motivation*

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I would like to express our appreciation and full-hearted gratitude to our supervisor **Mr. Dhammika De Silva** and co-supervisor **Mrs. Janani Tharmaseelan** who guide us to success this research and for sharing the experiences and expertise with the project matters. We extend our gratitude to the Sri Lanka Institute of Information Technology (SLIIT) for giving an opportunity to carry out this research project. A special thanks to the Agriculture department for providing datasets and our friends and families, who help us and gave suggestions for our research. We would like to appreciate the guidance given by other supervisors (especially for **Mr. Tharindu Dharmasena**) as well as the members of the panel.

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Abbreviation	Description
IoT	Internet of Things
JSON	JavaScript Object Notation
HTTP	Hyper Text Transfer Protocol
TCP	Transmission Control Protocol
MQTT	Message Queuing Telemetry Transport
RFID	Radio-frequency identification
MLR	Multiple linear Regression
IDE	Integrated development environment

1.0. INTRODUCTION

1.1 Background & Literature survey

In any developing country like Sri Lanka, becoming a successful entrepreneur has a considerate amount of risk. The main reason is that the lack of social support from the society and the lack of motivation through the government or any other external entity. Then in the most of developing countries, people are not aware of their working capabilities and potential. Because of that reason, they will probably miss great opportunities.

We believe that the easiest domain to excel in this aspect is through agriculture. It is almost certain that a significant number of families would be having a spare piece of land. According to the survey, most of the people are having considerable bare land which can be used for planting. The below figure clearly illustrate the bare land availability.

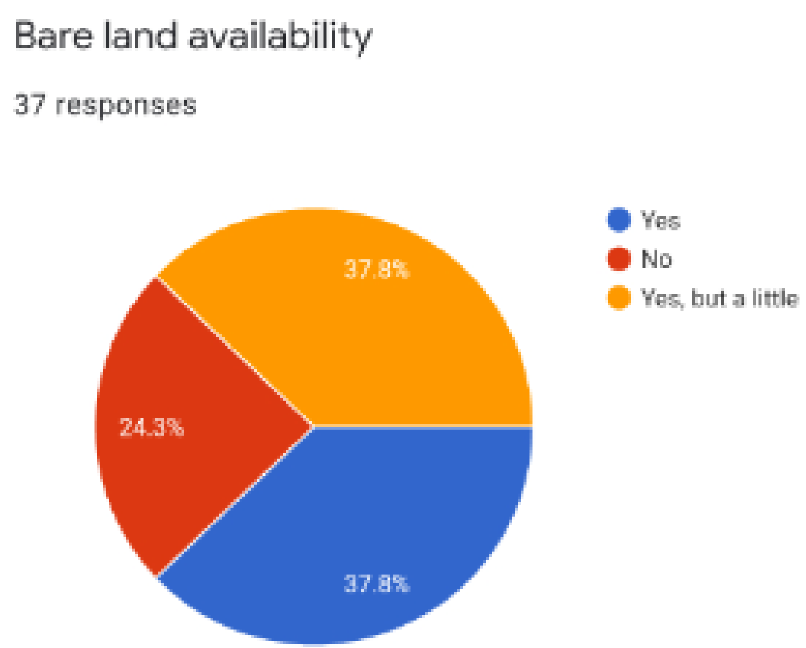

Figure 1.1 – Bare land availability

Therefore, around 74% of people have met the basic qualification. Not only has that but also if most of people being busied in weekdays, the considerable amount of spare time available on weekends. The below figure clearly illustrate the spare time in a week.

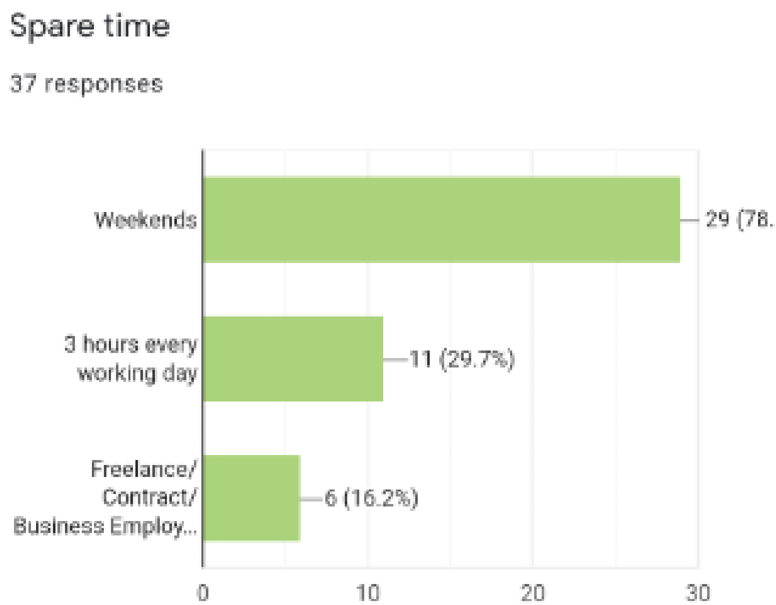

Figure 1.2 – Spare time in a particular week

However, just having a spare piece of land will not give the necessary drive for any individual to yield any type of crop or plant. The major problem we have figured out is the lack of motivation for those individuals[1]. The major outcome of the study is to generate self-made businessmen or entrepreneurs by boosting their mindset into positively. This project mainly focuses on busy individuals mainly residing in a more urbanized area with small free land spaces which are of no use. These lands have not been utilized to its full value. Hence, our methodology helps the owner of these lands to earn an extra income with minor effort. On the other hand, it directly affects to enhance foreign exchange of the country. According to the survey, around 66% same of people are earning below hundred thousand rupees. Most often that income not enough for survival of some large families. But this methodology stands for give hands and share knowledge in the specific area. The below figure clearly illustrate the average monthly family income from selected same.

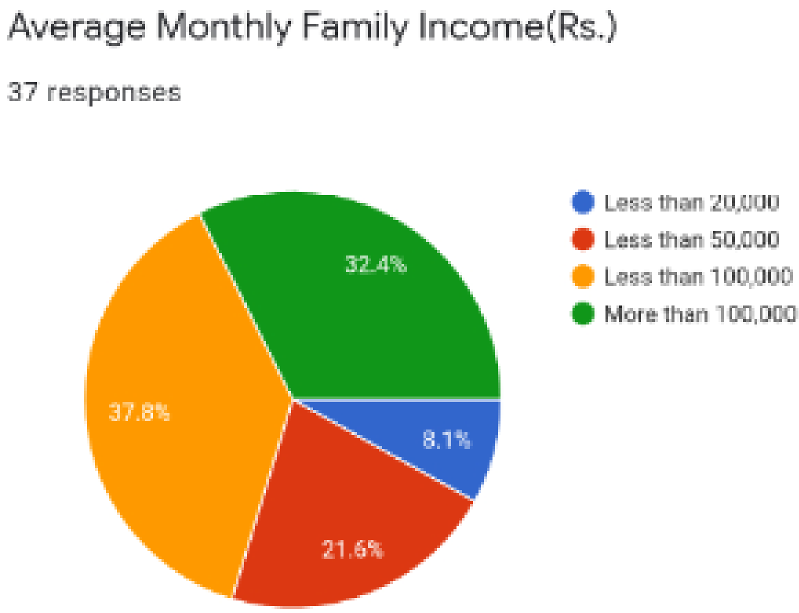

Figure 1.3 - Average monthly family income

There are 6 main factors which affects an individual from avoiding taking this entrepreneur risk in the agriculture domain. The main factors are Unfavorable Soil/Farm Conditions, Unavailability of Resources, Lack of social support, Policies, and regulations, Fluctuating prices and Climate changes[2].

IoT plays a major role in agriculture domain which have ability to feed 9.6 billion populations on the earth by 2050. To accommodate the requirements of that expanding population, the agriculture industry need to have align with new machinery to obtain a much-needed verge. Nowadays new agricultural functions in precision and smart farming via IoT enables the business to enhance production efficiency, decrease waste of resources, lower costs, and build-up the element of the yield. Smart farming is the most frequent word that can be heard while taking about IoT contribution in agriculture industry. So, what is smart farming? Smart farming is a perception which invokes to inspecting farms applying contemporary communication and information technologies to enhance the quality and quantity of final outcome during improving the human strive required [3]. Through the technologies that have been using in present day are; sensors (e.g. water, soil, humidity), software, connectivity (e.g. cellular and LoRa), location (e.g. GPS and satellite), robotics and data analytics. Equipped with such technologies, farmers are able to tracking field conditions without even attending to the yield and take critical decisions for the entire farm or for a particular single plant. In terms of environmental problems, farmers are able to obtain great benefits such as more efficient water/fertilizer usage, or gain inputs and treatments in more efficient. The below figure clearly illustrate the applications of IoT in agriculture industry.

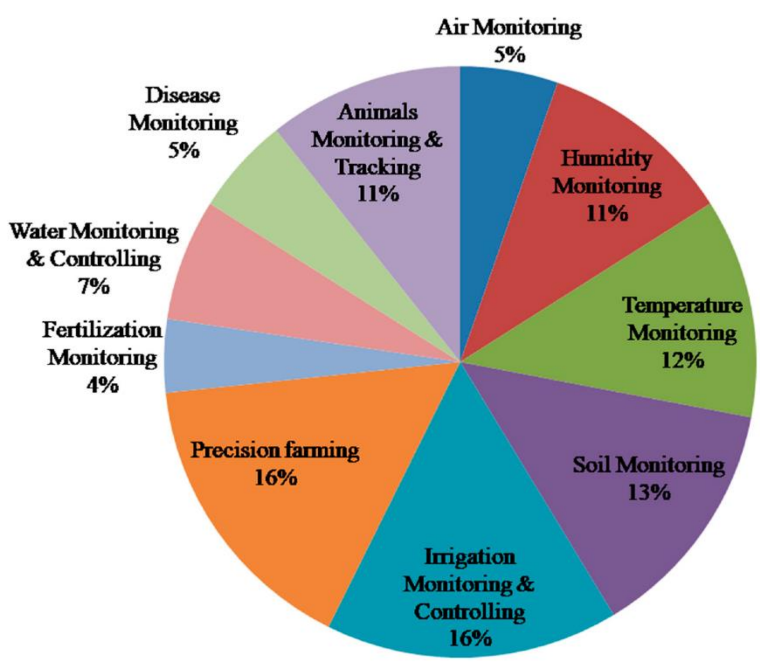

Figure 1.4 Applications of IoT based smart farming

The IoT phrase was fabricated by K. Ashton in the year of 1999 [4], as well as invented the communication and computing, where all the protests of the planet will be allowed to link each and every people, along with contribute the real time values and ambiences, eventually catering new methodologies to mankind[5]. Freshly, the modern world focused out assurance of enhancing agricultural productivity by ratifying IoT-associated methodologies[6]. Smart Agriculture supports to decrease desolation, efficient management of fertilizer and thereby accelerate the farm. Early study by Rajalakshmi.P and Mrs. Devi Mahalakshmi concerned in develop a system to analyze crop yield by IoT sensors such as soil moisture, heat, humidity, daylight and irrigation automation system. The data which is retrieved by IoT sensors were delivered to web server using wireless communication protocol. In the database the JSON format encodes values. The irrigation will be automated if the temperature as well as moisture of the crop yield comes down under the brink. Additionally, light fervency regulator can be automated to irrigation at green house environment. The messages are delivered to farmers' cellular phones frequently. The farmers can keep track of crop-field health from any place[7]. Temperature and soil moisture of the land will be the critical parameters. The electromagnetic devices can be operated to determine moisture of soil. This technique fulfill 52% of water assimilated to sprayer irrigation[8]. In order to accelerate the progress of productivity, many other industries deploy IoT and ICT. In detail, automated crop systems, implemented through actuators and wireless devices, helps to study the environmental estate and handle the implemented components corresponding to the gathered values via wireless and wireline access systems[9]. Lin and Liu demonstrated a casually controlled field which people are able to observe and handle using cellular phones without physically attending[10]. Akshay et. al demonstrated the parallel activity[11]. Yeo and Lee presented a pig farm supervising platform, that is able to productively handle a pig field by watching the substantial values using warmth, moisture sensors, and CCTV camcorders as well as respectively handle yield facilities like air conditioners as well as humidifiers[12]. Kawmard et. al proposed an automatic platform basis on Wi-Fi sensor system methodologies, implemented to check crop-field[13]. The same person also implemented and advanced some irrigation systems for assemble environmental information as well as enable distant control feature of the process through cellular phone. Nowadays, the entire world on the incline of a technical

revolution that called as IoT. Jaeseok Yun, Minwoo Ryu and Ting demonstrated an interconnected farm that focus on providing satisfactory environment for growing plants. In this project whole actuators and sensors for growing and monitoring plants are linked with a device software platform for IoT networks, called &Cube. Then gateway talks with an IoT service server called as Mobius. The Mobius not only communicate with remote farms, but also communicate with matured farming knowledge based systems [9]. K.L. Ponce-Guevara and J.A. Palacios-Echeverria introduced a system which uses big data and data mining techniques that aimed at inspecting elements that impact the growth of the crops as well as adjudicate a predictive miniature of soil moisture [14]. Ramesh et al. introduced an application which evaluates rice production based on the past rainfall data for particular geographical area. They have applied different machine learning algorithms such as multiple linear Regression (MLR) which is applied to predict on past data like year, rainfall, area of sowing, yield and fertilizers. Data mining methodology (Density – based clustering technique) is used to analyze and verify the result which was obtained from MLR [15].
As we discuss the data transfer protocol, there're MQTT based researches have been considered by many researchers. Luzuriaga and Cano have involved to enhance the performances of protocol by decouples the pure data. It was established on technology that termed as "intermediate buffering". That method helps for restoration during the delivery tunnel presents interruption durations, if these are persistent and closing for last moment, the position where TCP decline to reclaim from [16]. A. Saxena, M. Tyagi and P. Singh has proposed a system which aims to implement unique identification recording system of each individual based on RFID technology and MQTT protocol in order to make wireless connection between Raspberry-Pi and NodeMCU [17]. P. Alqinsi has involved on develop UPS monitoring system using MQTT protocol in terms of solving UPS monitoring issues [18]. R. Kawaguchi and M. Bandai has proposed an MQTT broker architecture which enhances system availability without broadcasting client data like broadcast notifications or subscriptions. In terms of numerical calculations, the

prospective method automatically decreases the number of shared notifications between brokers [19].

As we consider early works using NodeMCU microcontroller are,

Early work by Jayasinghe, David, Joel Morris, Daniel and Blessy Telagathoti was concerned with a system to frequently monitor the patient’s vital sign using NodeMCU [20].

1.2. Research Gap

There are many existing Smart farming systems have been implemented in different ways. According to the literature survey, already existing smart farming platforms could be increased by utilizing IoT methodologies in 2 aspects:

1) Make it smooth to boost systems by accepting new type of devices to be accurately and effectively integrated into smart farm yields (developed to automate irrigation process, temperature controlling and etc.);
2) Promote horizontal smart farm systems that enables all smart farms to be connected and take advantage of experts' (i.e., experienced farmers) farming proficiency.

Most of the researches conducted includes the,

- Agricultural activity automation (e.g. irrigation controlling, soil monitoring, light controlling, humidity monitoring and etc.)
- Connecting each other smart farms together
- Monitoring status of the growing crops

According to the reviewed research papers [7]-[14] and other resources there many kinds of researches evolved on the IoT based Smart farming methodologies for automating and monitoring the agricultural activities. Many researches are chiefly focused with the IoT applications related with the monitoring and controlling functions. Research A [9] has been concerned about connecting farms, which targets to grant all actuators and sensors turn communicate with IoT service server and make connection with expert farming knowledge platforms using the gateway. Research B [7] has involved about automate irrigation process using wireless sensor nodes which frequently senses the crop field based on the field conditions. Research C [14] has been concerned about Data Mining and Big Data on vegetable plants data from a greenhouse by implementing the 1st version of a software tool that called GreenFarm-DM. This tool was aimed to analyze crop factors and determine soil moisture.

But in this scenario, there is lack of generating/motivating new people to farming. In terms of atmospheric status keep changing expeditiously, farmers fall prey to the scarcity of knowledge that is required to measure what kind of farm conditions, methodologies as well as soil type is important for growing a type of crop. Furthermore, every so often it goes on that prolong use of a particular fragment of land to such a quantity that it leaves the land destitute of all minerals. Hence, it is essential to be able to predict and calculate the interpretation of the crop for all kinds of environmental status. On the other hand, these kind of systems only help for farmer who currently engaged in the profession. And these systems not contribute to motivate people to start business and keeping touch with until the final stage (success) in agriculture domain. Although IoT sensors and protocols are being used only for data gathering task and automate the farming activities. Then we need to have some kind of motivational platform for generate entrepreneur/ businessmen which helps to be success. There are various platforms which is based on IoT technology, available for automate farming activities with different ways. The comparison between existing systems and proposed system is given below.

	Yield forecast	Motivation model (generate new entrepreneurs)	Using IoT sensor data to best crop prediction	Real time update
Mobius using &Cube (Research A)	NO	NO	NO	YES
Smart Agriculture app (Research B)	YES	NO	NO	YES
Green Farm-DM (Research C)	YES	NO	NO	YES
Agripreneurs- A motivational app(proposed solution)	YES	YES	YES	YES

Table 2.1: Comparison between related works

1.3. Research Problem

This work is proposed to implement a system that provide solutions to the issues already present in the society that have no precise platform for generate and help people to be success. The main research problem is to help rural farmers to increase revenue from their cultivation without getting affected by industrial level farms and to reduce surplus marketing. In Sri Lanka, there are no implemented systems in usage so far, but agriculture department keeps some raw data in their website, but it is not helpful to farmers. The small-scale farmers have no knowledge of the activities of the large-scale farmers such as what are the crops they cultivate? And how many acres they cultivate? Etc. Small scale farmers cultivate according to their experience. When it's come to market, industry level farmers sell their whole product to all over the country at the same time rural farmers also bring their product, but they can't sell with reasonable price. In this situation industry level farmers have no huge loss, but rural farmers totally get affected and lose their investment also.

To overcome this problem, we developed an android application. We hope that will reduce rural farmer's problem and it will suggest more profitable crops. It will help farmers to take decision wisely.

We need to collect information of different kind of crops, and some techniques of agriculture. It's not an easy task to collect those data from experts in agriculture domain. Thus, it's better to collect those required data from user guides, official web site that have been publish by Agriculture Department of Sri Lanka. As well as it's better to visit Agriculture Department of Sri Lanka physical and collect the data.

1.4. Objective

The primary goal of this crop prediction component of our research is to learn from the soil and weather condition and obtain profitable crops list for a given location.

1.4.1 Main objective

The main objective is focused on implementing a motivational platform trough an Android mobile application which will provide the users or those specific individuals to run their own business. Hence to make them more confident on the risk that is going to be taken, this application provides clean statistics by applying it to different data sets beforehand. Hence the application keeps in touch with every single individual from the crop/plant growth or initial stage to the final and through to the export or selling state. This platform provides the users with real-time updates on the current market value of the specific crops that are to be sold and a guidance on how much time effort and investment they will have to put forward and the relative benefit they will gain. These results alone will cover up majority of the motivational model.

1.4.2 Specific objectives

1. Retrieve the condition of soil and air (moisture, humidity and temperature) from sensors.

2. IoT data analysis model to identify suitable areas of the land, which is most appropriate for a crop, humidity, temperature and moisture (dry or wet land).

3. Update the user of the platform according to the data analysis model of the suitable crops to be grown in a specific month of the year.

4. Updates sensor data into cloud database in real time.

    I. Program the WI-FI supported micro controller to push sensor data that retrieved from sensor nodes to relevant data base via http communication protocol.
    II. Define data communication protocol.

2.0 Methodology

The proposed “**Agripreneurs -** A motivational application to generate entrepreneurs” is a motivational application that has the outcomes of, making gamification model to motivate users by predicting suitable crop to be grown in specific area. The user is motivated in 5 main aspects; gamification model with reward schemes, crop/income prediction, integrated bidding platform enabling entrepreneurs to sell the crops on a price being bid by different buyers in the platform and diseases analysis model to provide fast and reliable solution.

In this work, IoT model holds the initial part which provides facility to check soil and weather condition of selected area by sending real time updates across all users in the platform. This IoT model will be come up as a single device which integrated humidity, temperature and moisture sensors with NodeMCU microcontroller to focus on enhance the portability and user-friendliness of the product. This is the initial physical product that interact with end users and make connection with real time cloud database directly. As the last operation of the model, the all gathered data will be sent to crop prediction model to make prediction of the best crop that need to be grown in the specific period of the year.

2.1 System Architecture

The system architecture is shown in the figure 2.1.1

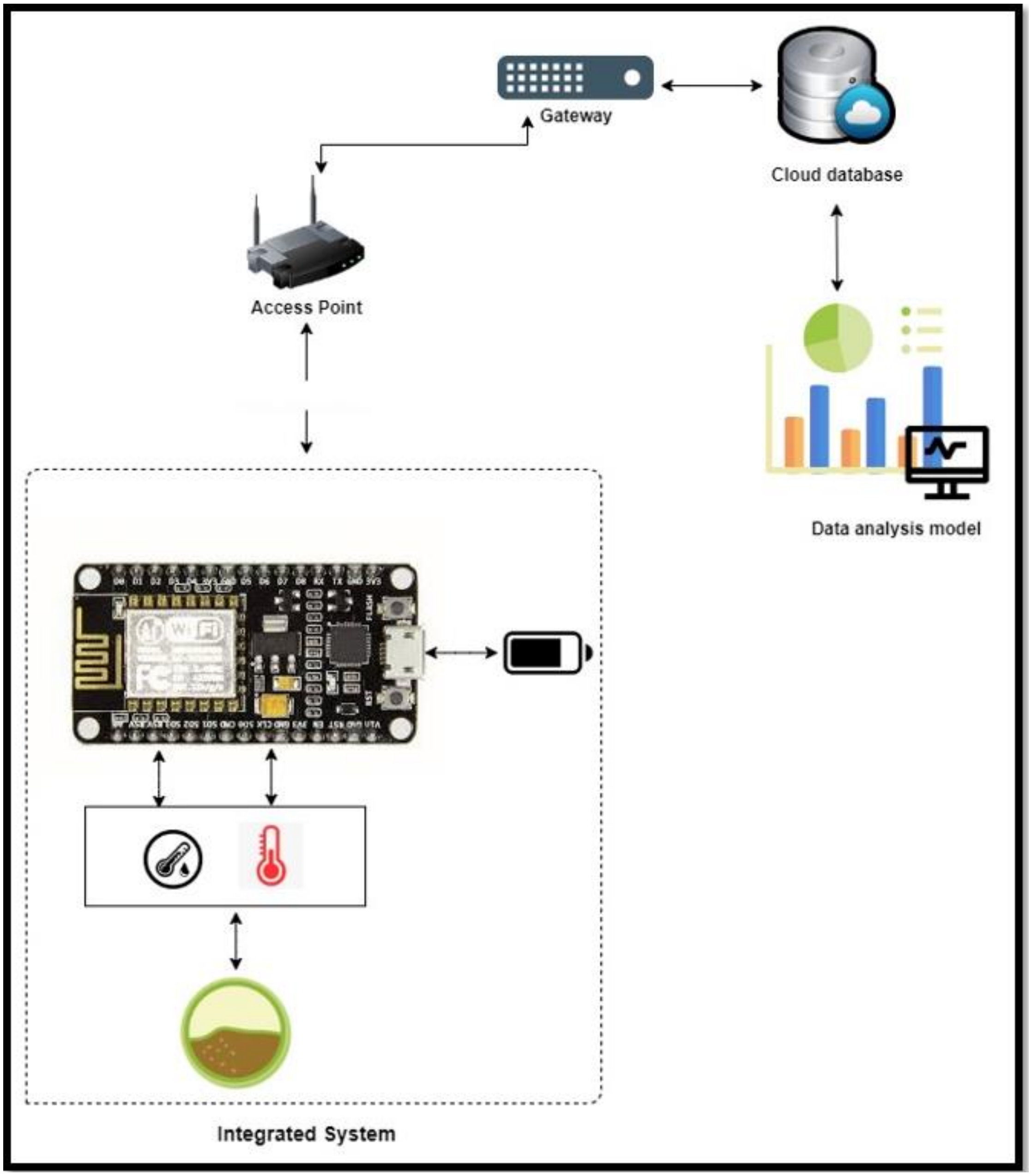

Figure 2.1.1- High Level System Architectural Diagram

2.1.1 Hardware Solution

The circuit diagram is shown in the figure 2.1.1.1.

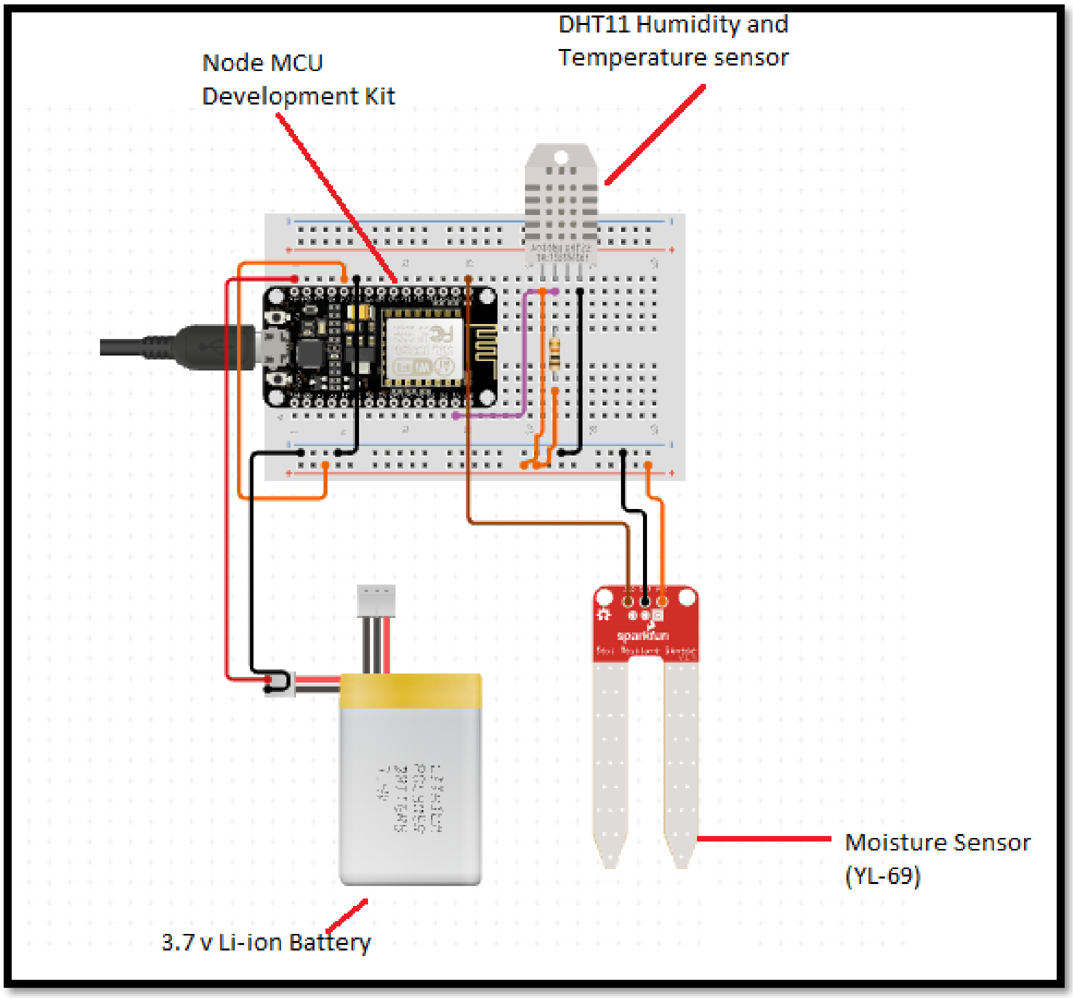

Figure 2.1.1.1- Circuit diagram of IoT model

The illustration of integrated IoT hardware solution is shown in the figure 2.1.1.2.

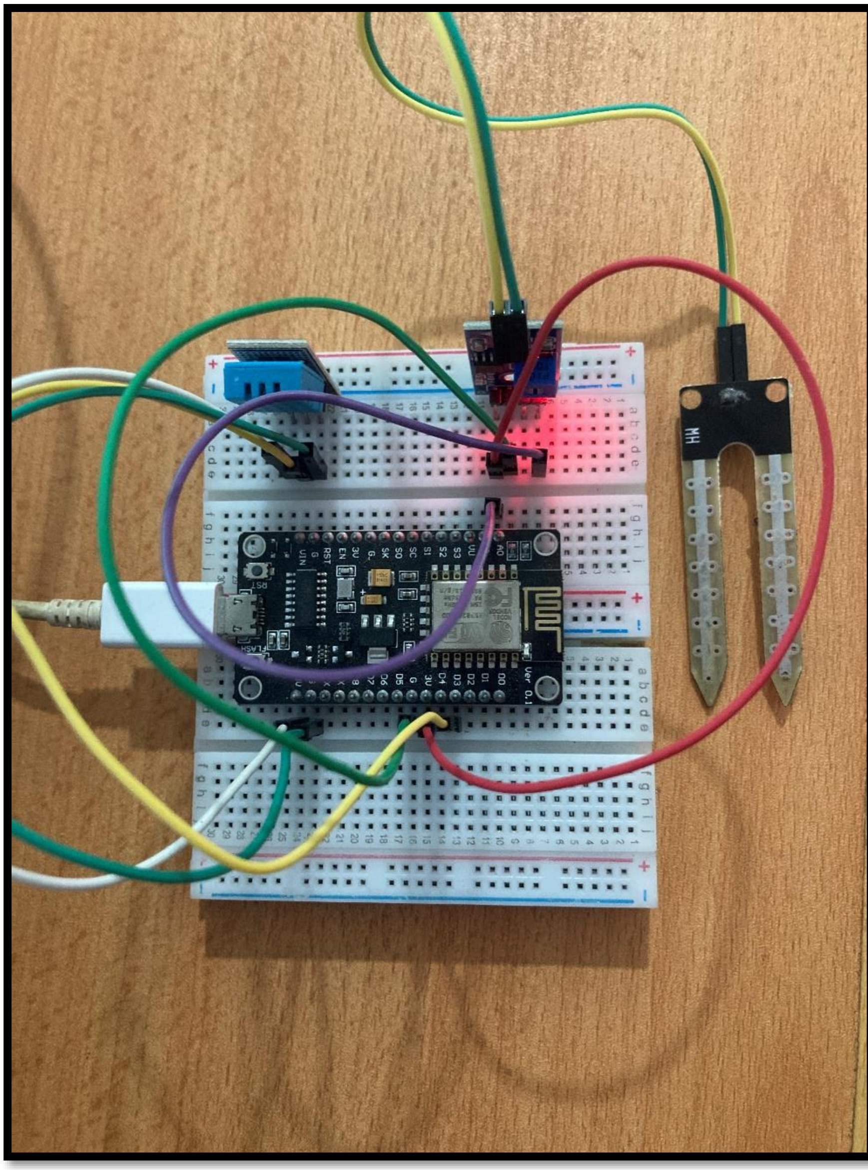

Figure 2.1.1.2 - integrated IoT hardware solution

2.2. IoT Devices

As the initial part of the project, the motivational mobile application need to collect accurate data from moisture, humidity and temperature sensors. As the next step, the collected data values sends to a centralized cloud real-time database to optimization. The IoT moisture, humidity and temperature sensors should be compatible with ESP8266 microcontroller to accomplish the data sending operation via Wi-Fi technology.

- **Soil Humidity Hydrometer Moisture detection sensor YL-69 module**

  This is a soil moisture sensor that can determine how much moisture is present in the soil. It's perfect for checking the water level of an inner city garden plant. The dual probes are used to flow current through the soil, and the resistance is then read to determine the amount of moisture. More water allows the soil to transmit electricity more freely (with less resistance), but dry soil does not (more resistance). It's composed of corrosion-resistant material, which means it'll last a long time. This module has an on-board voltage regulator that allows it to operate between 3.3 and 5.5V. It’s an ideal for both 3.3V and 5V low-voltage MCUs. The 3-pin "Gravity" interface on this soil moisture sensor may be directly linked to the Beam I/O expansion shield. The YL69 Soil Moisture Sensor has two forms of output: digital and analog. Immersion Gold is used in the soil moisture sensor to preserve the nickel from oxidation. The wiring details are given in table 2.2.1.

Wiring	
VCC	External 3.3V, 5V
GND	GND External (Connected to GND pin of NodeMCU dev. kit)
DO	Digital output interface (0 and 1)
AO	Analog output interface

Figure 2.2.1 – Wiring details of moisture sensor YL-69

The illustration of interfacing YL-69 sensor with NodeMCU is shown as figure 2.2.2.

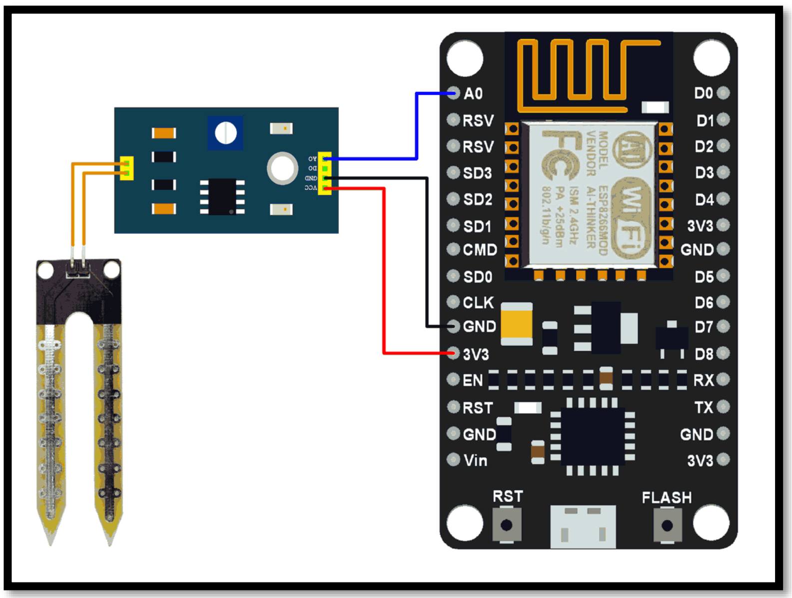

Figure 2.2.2 - illustration of interfacing YL-69 sensor with NodeMCU

The YL-69 Moisture detection Sensor Module is shown in figure 2.2.3.

Figure 2.2.3 – YL-69 Moisture detection Sensor Module

- **DHT11 Humidity and Temperature sensor**.

  The DHT11 is a temperature and humidity sensor that is widely used. The sensor has a dedicated NTC for temperature measurement and an 8-bit microprocessor for serial data output of temperature and humidity measurements. The sensor is fully calibrated, making it simple to connect to other microcontrollers. With an accuracy of 1°C and 1 percent, the sensor can detect temperature from 0°C to 50°C and humidity from 20% to 90%.

  The illustration of interfacing DHT11 sensor with NodeMCU is shown as figure 2.2.4.

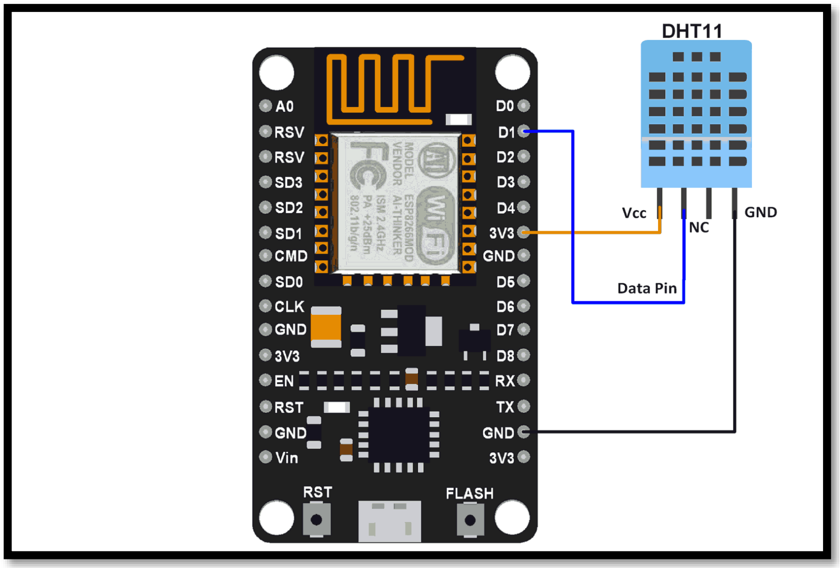

Figure 2.2.4 – Interfacing DHT11 sensor with NodeMCU

The DHT11 Humidity and temperature sensor is shown in figure 2.2.5.

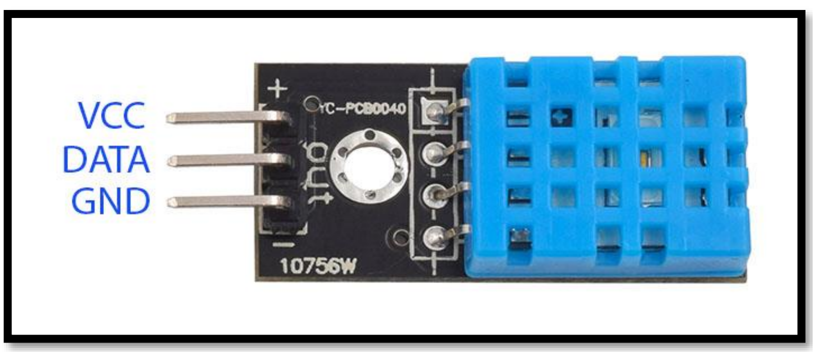

Figure 2.2.5 - DHT11 Humidity and temperature sensor

- **Microcontroller**

  The NodeMCU Lua CH340G ESP8266 WIFI Internet Development Board Module was used as the microcontroller for this work. This development kit consists of ESP-12E chip, 2.4 GHz antenna, IO pins, 3.3 output, and USB connector. The NodeMCU development kit is shown in figure 2.2.6.

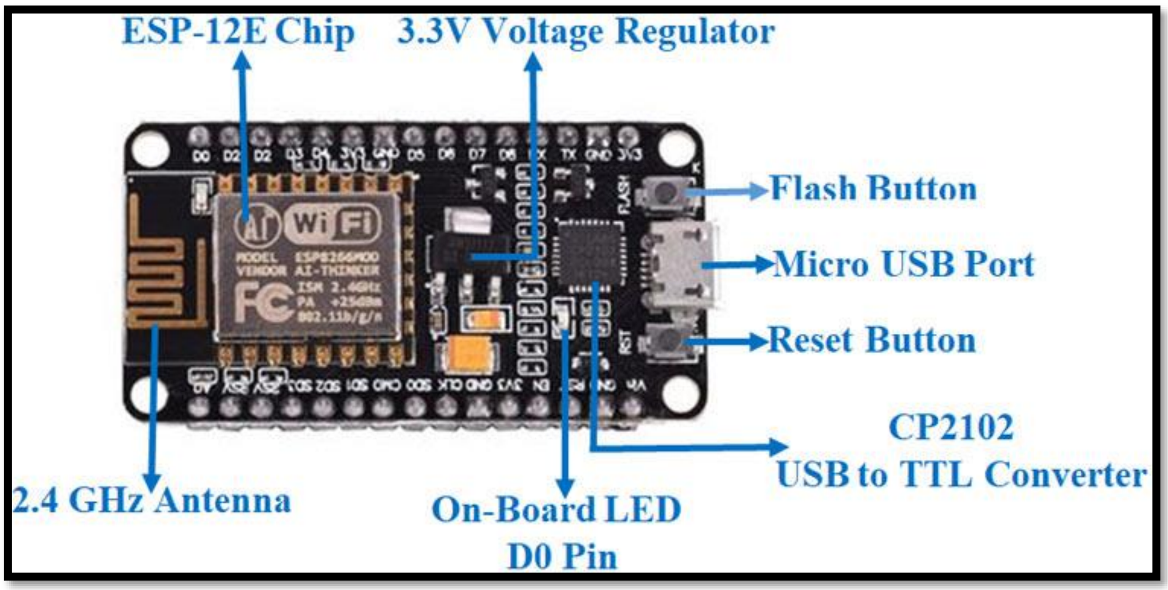

Figure 2.2.6 - NodeMcu Lua CH340G ESP8266 WIFI Internet Development Board Module

2.3. Database

In this work, the need of a real time database was essential. Thus the Google Firebase was selected as the database of the IoT model. The Firebase Real-time Database is a database that is hosted in the cloud. Data is saved in JSON format and synced in real time across all connected clients. When you use our iOS, Android, and JavaScript SDKs to create cross-platform apps, all of your clients share a single Real-time Database instance and are immediately updated with the most recent data.

The implementation between ESP8266 Wi-Fi module and firebase can be given as below.

- ✓ Step 01: Install ESP8266 board to Arduino IDE.

  Start Arduino and open the Preferences window.

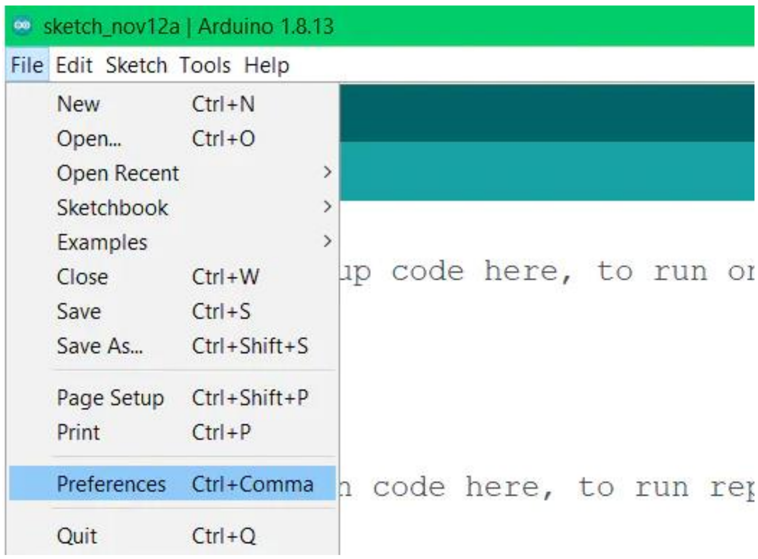

Figure 2.3.1 – Arduino Preferences window

Enter https://arduino.esp8266.com/stable/package_esp8266com_index.json into the *Additional Board Manager URLs* field.

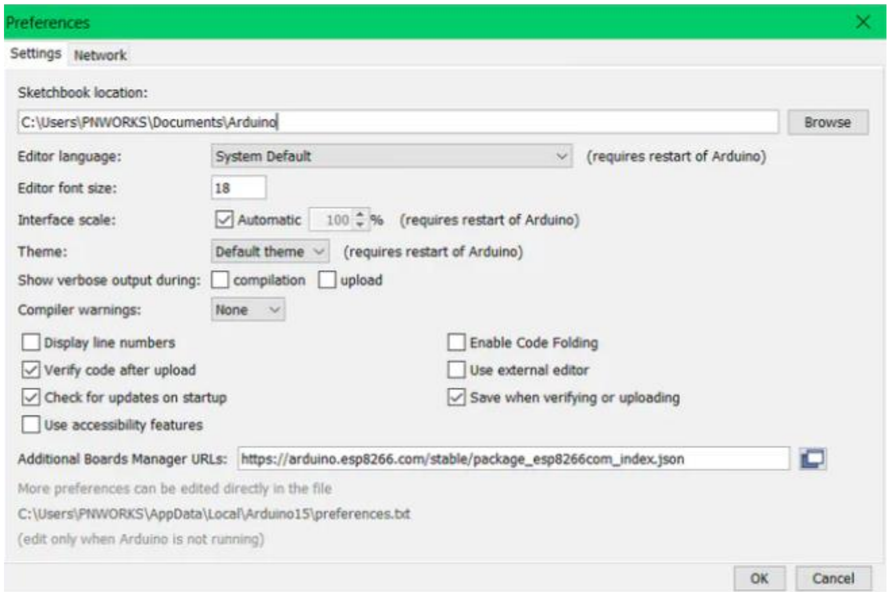

Figure 2.3.2 - Additional Board Manager URLs field

After that open Boards Manager from Tools section and select Board menu and install *esp8266* platform.

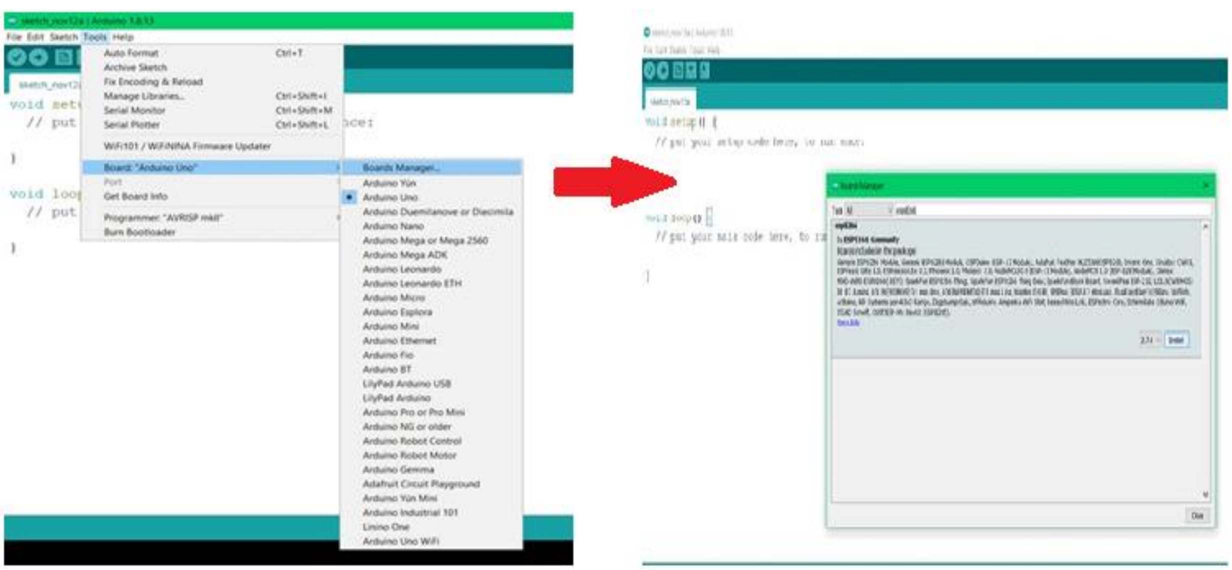

Figure 2.3.3 - Board menu selection and install esp8266 platform.

Select ESP8266 board from Tools section Board menu after installation as below.

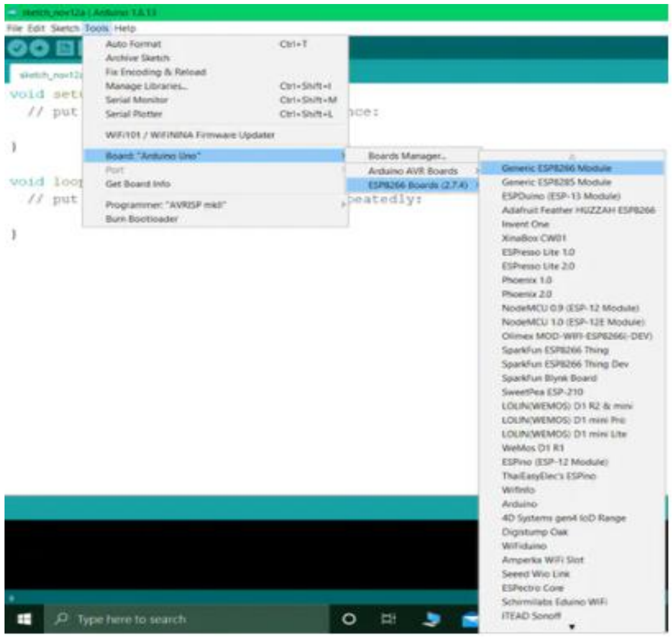

Figure 2.3.4 – ESP8266 board selection

✓ Step 02: Adding the Firebase library

The required firebase library which is downloaded from Git hub need to be added as below figure.

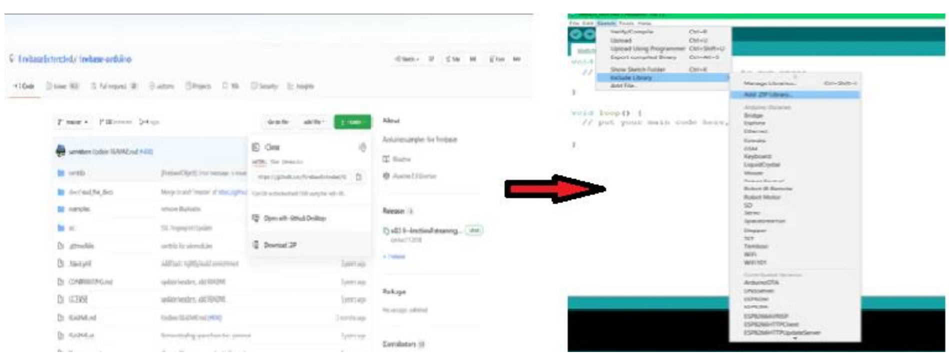

Figure 2.3.5 – Add firebase library from github

✓ Step 03: Adding the ArduinoJson library.

Open Tools section. Then navigate to Manage Library and install ArduinoJson **version 5.13.5** library.

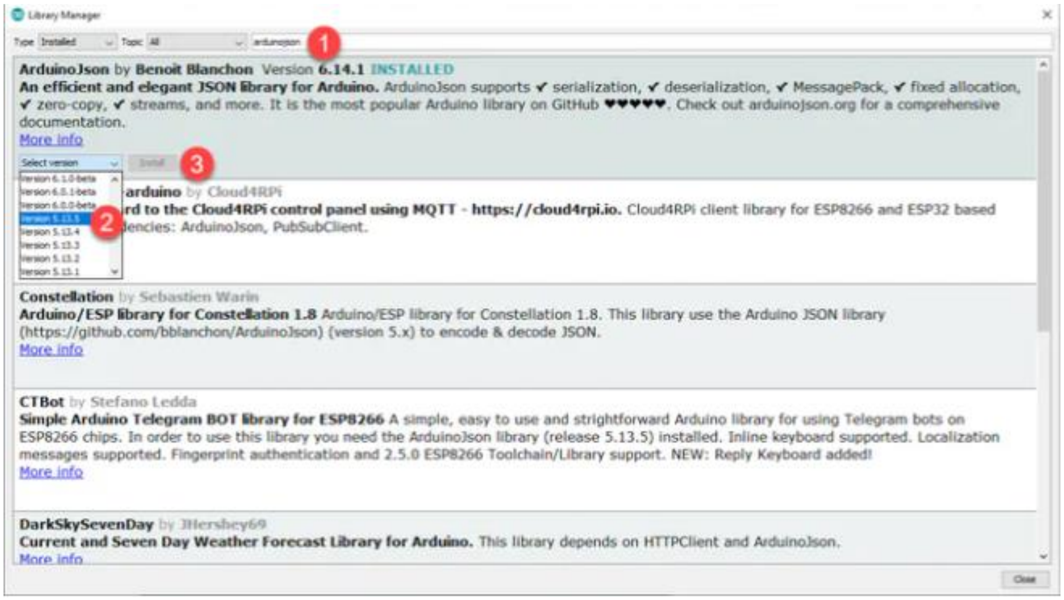

Figure 2.3.6 – ArduinoJson library installation

✓ Step 04: Setup Firebase real-time DB.

A new customized project can be created by using firebase console from following link. (https://firebase.google.com/)

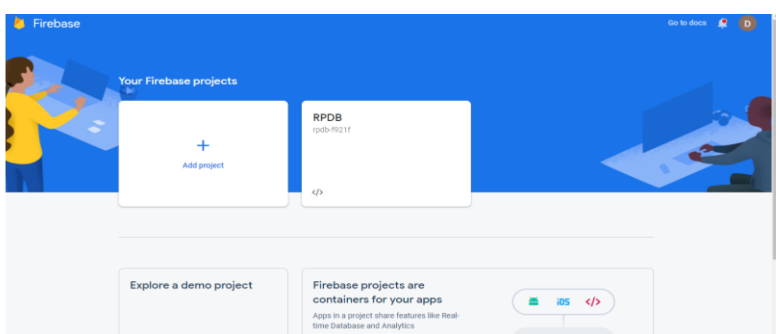

Figure 2.3.7- Firebase console

It's better to select Test mode as a security rule.

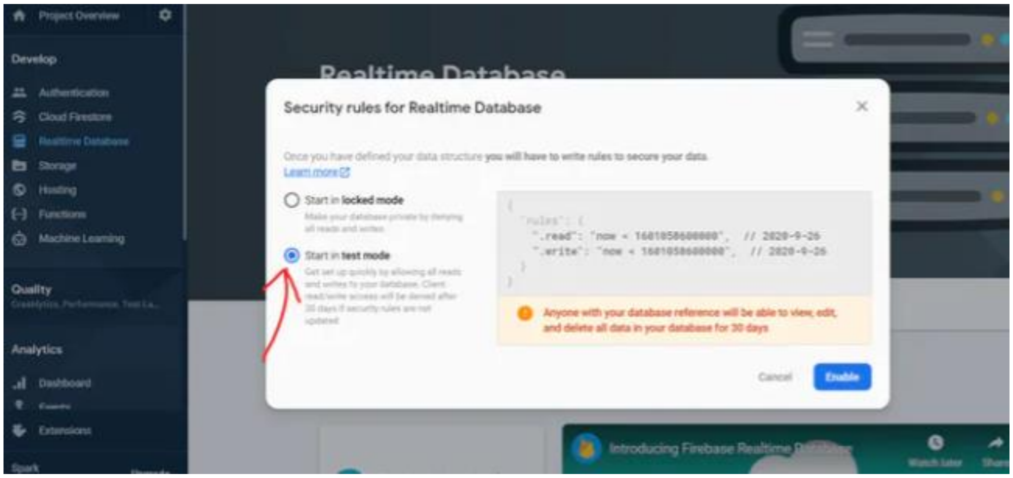

Figure 2.3.8 – Security rules of firebase

✓ Step 05: Setting Firebase host

Open real-time database and get copy of the firebase host in to the Arduino code.

Figure 2.3.8 – Firebase host name

✓ Step 06: Setting up Wi-Fi and Wi-Fi password

The Wi-Fi SSID and password need to be defined as follow.

```
#define WIFI_SSID " your WIFI SSID"
#define WIFI_PASSWORD " your WIFI PASSWORD"
```

Figure 2.3.9 – Set WI-FI_SSID and WI-FI_PASSWORD

- ✓ Step 07: Connecting to Wi-Fi code.

  The final stage of the making connection between ESP8266 and Firebase is given as below.

```
// connect to wifi.
 WiFi.begin(WIFI_SSID, WIFI_PASSWORD);
 Serial.print("connecting");
 while (WiFi.status() != WL_CONNECTED) {
   Serial.print(".");
   delay(500);
 }
 Serial.println();
 Serial.print("connected: ");
 Serial.println(WiFi.localIP());
 Firebase.begin(FIREBASE_HOST, FIREBASE_AUTH);
```

Figure 2.3.10 – Connecting to WIFI code

2.4. Jupyter Notebook

Jupyter Notebook is an open-source online tool that lets you create and share documents with live code, equations, visualizations, and narrative prose. Data cleansing and transformation, numerical simulation, statistical modeling, data visualization, machine learning, and many more applications are all possible.

In this work, Jupyter notebook is used for data preprocessing and AI algorithm training with the data set. This is the key tool for making decisions according to pre-defined data set and real-time data sets.

Jupyter notebook acts a major role in between real-time database and mobile application backend interface.

The sample work of implementations of connection between Firebase and Jupyter Notebook is given below.

- ✓ Step 01: Connect Firebase and Jupyter Notebook

  Go to Project settings > General > Your Apps, and add a Web App in any name as you wish. After that, get the copy of the details as given figure and paste it in to the python code.

Figure 2.4.1 - Connect Firebase and Jupyter Notebook

- Step 02: Retrieve data from Firebase

  As the below figure, the special function called "get" was used to revoke the real-time data to final predict final output.

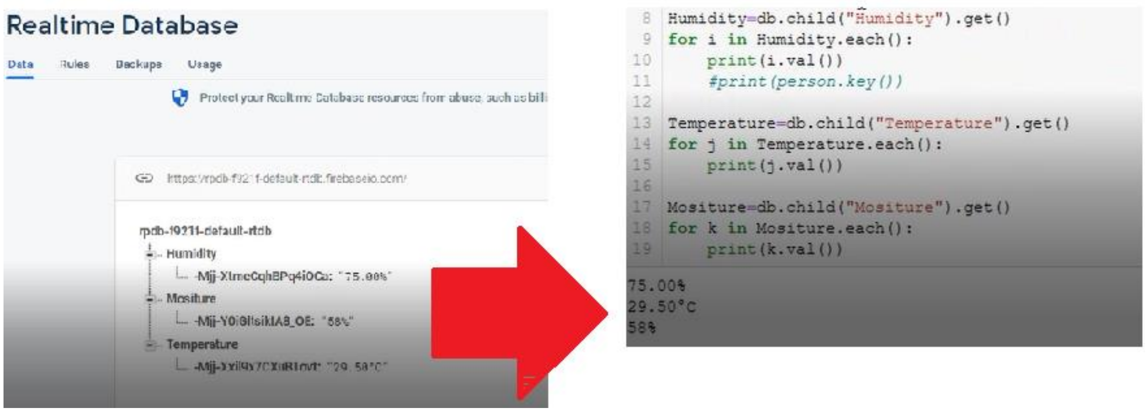

Figure 2.4.2 – Retrieve data from Firebase to last prediction

- Step 03: Final prediction

  According to accuracy level of the algorithms, NaiveBayes model was used to predict the best crop for the selected land.

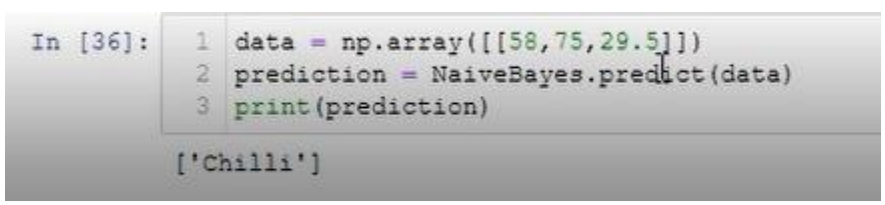

Figure 2.4.3 – Final crop prediction

2.5. Commercialization aspects of the product

2.5.1. Basic user

Agripreneurs application has four main components. As this research is to help rural farmers and new comers, the main components crop prediction and price prediction will be available for free. The mobile application can be download any user in android for free.

2.5.2. Premium user

As optimization is most useful for large scale farmers, we will be charging to use that component. And in diseases identification, a part of the component the solution about the infection will be available for premium users.

2.5.3. Advertisements

Here in Agripreneurs application we can advertise all agricultural products and can advertise about the agricultural demonstrations and meetings of local agricultural departments. Through all of this Agripreneurs can earn from the companies who sell agricultural products and from the agricultural departments of local areas.

2.6. Testing & Implementation

Software and hardware testing is very important in development lifecycle to point out the defects and errors that were made during the development phases. And also, it is very important to ensure the quality of the product. Testing is required for an effective performance of software application and IoT model. Testing is required each and every phase that we are following in software development life cycle like unit testing, integration testing, system testing, and user acceptance testing.

For this individual component testing is done for 2 main sections.

- ✓ IoT model (Frontend)
- ✓ Real-time database (Middleware)
- ✓ Machine learning model (Backend)

Front-end testing: Following are some test cases conducted to make sure the sensors are performing well without any failures.

Test case ID	001
Test case scenario	Check sensor output values at different environment conditions
Test steps	a. Wiring sensor nodes in proper manner (otherwise some circuits can be short) b. Power up the circuit with 3.3v or 5.0v c. Select the correct COM port from the Arduino IDE. (The COM port can be recognized in device manager section at control panel)

	d. Make changes of environment's condition (temperature, humidity and soil moisture)
Test Data	Humidity / Temperature / Soil Moisture
Expected Results	Output values need to vary due changes
Pass/ Fail	Pass

Table 2.6.1 – Front end test case 1

The sample output from the serial monitor is given below.

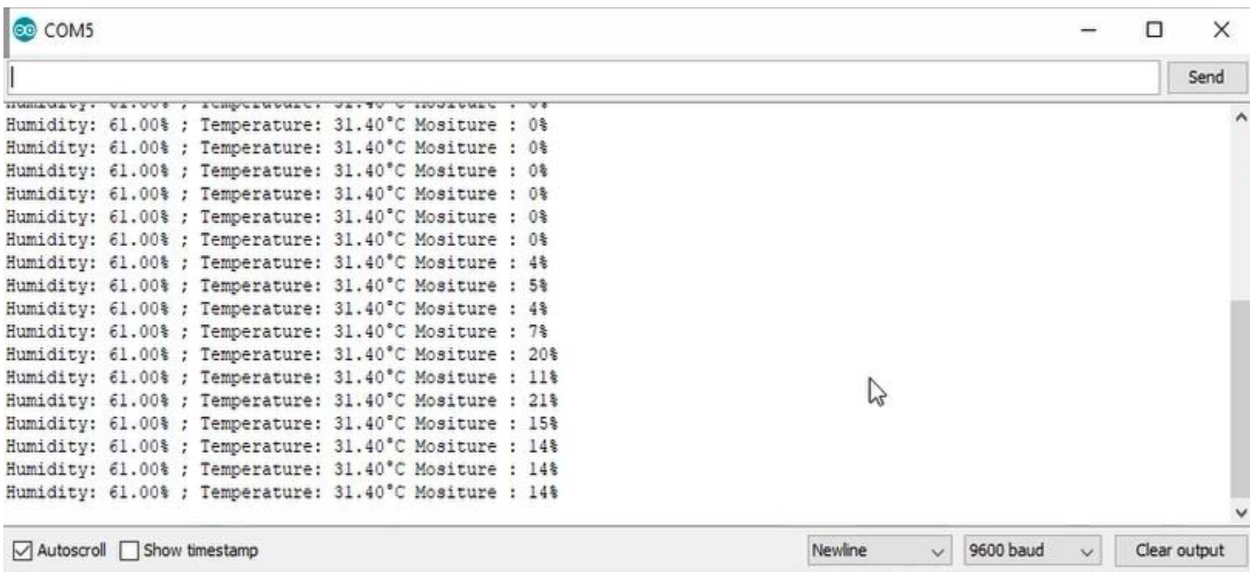

Figure 2.6.2 – Front end test case

Real-time database (Middleware): Real-time database (Firebase) need to be ensure that is being updated periodically due to input sensor values. The Firebase testing case is shown below.

Test case ID	002
Test case scenario	Check whether real-time database is functioning or not.
Test steps	a. Connect micro controller and Firebase via WI-FI. b. Make sure whether sensor values is being updates in serial monitor. c. Check whether input values from the IoT model is being updated in the Firebase monitoring display in real-time.
Test Data	Humidity / Temperature / Soil Moisture
Expected Results	Sensor values need to be updated in real-time
Pass/ Fail	Pass

Table 2.6.3 – Middleware test case

The sample output from the real-time database (Firebase) is given below figure.

Back-end Testing: For the selected machine learning models: Decision tree, Naïve Bayes, SVM, Logistic Regression, Random Forest, XGBoost testing is done using the test data and the accuracy is increased by adjusting the data sets and parameters. The real scenario testing case of selected crop prediction shown below.

Test case ID	003
Test case scenario	Check the best crop which is going to be grown in selected location
Test steps	a. Retrieve the sensor values at given time. b. Perform the different models with input values
Test Data	Humidity / Temperature / Soil moisture
Expected Results	Chili / Capsicum / Tomato / Brinjal / Bitter Gourd
Pass/ Fail	Pass

Table 2.6.4 – Back end test case

3.0. Results and Discussions

This section proofs that the accuracy of the developed model is increased through the given training. The model is refined through several ways to increase its performance. Earlier when the accuracy is checked against test dataset, it was quite lower. Then it is decided to train the model in several ways. Data is preprocessed and parameters of the model is tuned again and again to get higher accuracy.

3.1. Results

Evidences - Decision Tree

```
In [16]:
from sklearn.tree import DecisionTreeClassifier

DecisionTree = DecisionTreeClassifier(criterion="entropy",random_state=2,max_depth=5)

DecisionTree.fit(Xtrain,Ytrain)

predicted_values = DecisionTree.predict(Xtest)
x = metrics.accuracy_score(Ytest, predicted_values)
acc.append(x)
model.append('Decision Tree')
print("DecisionTrees's Accuracy is: ", x*100)

print(classification_report(Ytest,predicted_values))
```

```
DecisionTrees's Accuracy is:  74.17910447761194
              precision    recall  f1-score   support

Bitter Gourd       1.00      0.28      0.43       101
     Brinjal       0.95      0.92      0.94       184
    Capsicum       0.91      0.87      0.89       166
      Chilli       0.60      0.67      0.63       178
      Tomato       0.34      0.88      0.49        41

    accuracy                           0.74       670
   macro avg       0.76      0.72      0.68       670
```

Figure 3.1.1 – Accuracy checking for Decision Tree

Evidences – Naive Bayes

```
In [21]:
from sklearn.naive_bayes import GaussianNB

NaiveBayes = GaussianNB()

NaiveBayes.fit(Xtrain,Ytrain)

predicted_values = NaiveBayes.predict(Xtest)
x = metrics.accuracy_score(Ytest, predicted_values)
acc.append(x)
model.append('Naive Bayes')
print("Naive Bayes's Accuracy is: ", x)

print(classification_report(Ytest,predicted_values))
```

```
Naive Bayes's Accuracy is:  0.7597014925373134
              precision    recall  f1-score   support

Bitter Gourd       0.64      0.61      0.63       101
     Brinjal       0.94      0.90      0.92       184
    Capsicum       0.94      0.86      0.90       166
      Chilli       0.62      0.65      0.63       178
```

Figure 3.1.2 – Accuracy checking for Naïve Bayes

Evidences – Logistic Regression

```
In [27]:
from sklearn.linear_model import LogisticRegression

LogReg = LogisticRegression(random_state=2)

LogReg.fit(Xtrain,Ytrain)

predicted_values = LogReg.predict(Xtest)

x = metrics.accuracy_score(Ytest, predicted_values)
acc.append(x)
model.append('Logistic Regression')
print("Logistic Regression's Accuracy is: ", x)

print(classification_report(Ytest,predicted_values))
```

```
Logistic Regression's Accuracy is:  0.744776119402985
              precision    recall  f1-score   support

Bitter Gourd       0.52      0.44      0.48       101
     Brinjal       0.86      0.90      0.88       184
    Capsicum       0.92      0.91      0.91       166
      Chilli       0.60      0.78      0.68       178
      Tomato       0.00      0.00      0.00        41
```

Figure 3.1.3 – Accuracy checking for Logistic Regression

Evidences – Random Forest

```
In [29]:
from sklearn.ensemble import RandomForestClassifier

RF = RandomForestClassifier(n_estimators=20, random_state=0)
RF.fit(Xtrain,Ytrain)

predicted_values = RF.predict(Xtest)

x = metrics.accuracy_score(Ytest, predicted_values)
acc.append(x)
model.append('RF')
print("RF's Accuracy is: ", x)

print(classification_report(Ytest,predicted_values))

RF's Accuracy is:  0.6208955223880597
              precision    recall  f1-score   support

Bitter Gourd       0.35      0.30      0.32       101
     Brinjal       0.86      0.89      0.88       184
    Capsicum       0.90      0.84      0.87       166
      Chilli       0.42      0.46      0.44       178
      Tomato       0.04      0.05      0.04        41

    accuracy                           0.62       670
   macro avg       0.51      0.51      0.51       670
weighted avg       0.63      0.62      0.62       670
```

Figure 3.1.4 – Accuracy checking for Random Forest

Evidences – Accuracy comparison between models

```
In [35]:
plt.figure(figsize=[10,5],dpi = 100)
plt.title('Accuracy Comparison')
plt.xlabel('Accuracy')
plt.ylabel('Algorithm')
sns.barplot(x = acc,y = model,palette='dark')

Out[35]: <AxesSubplot:title={'center':'Accuracy Comparison'}, xlabel='Accuracy', ylabel='Algorithm'>
```

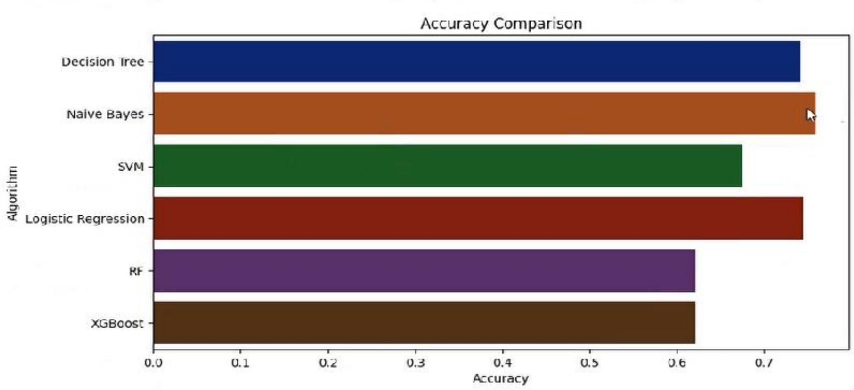

Figure 3.1.5 – Accuracy comparison between models

About the model and accuracy

According to the accuracy comparison graph, the 2 models which is called Logistic Regression and Naïve Bayes got closed high accuracy levels. Then these type of models can be considered as below.

- Logistic Regression – for this model the given data set is given 0.74 accuracy and 670 of weighted average level.
- Naïve Bayes - for this model the given data set is given 0.76 accuracy and 670 of weighted average level.

Comparison of the models

Both models are suitable for this prediction, but Naïve Bayes will be more accurate than Logistic Regression since higher accuracy level. For the data available now in Sri Lanka Naïve Bayes Regression is good enough to do the prediction.

3.2. Research Findings

The project's first goal is to create an Android application that would assist farmers in sowing profitable crops. It is necessary to employ numerous real datasets that affect productive vegetable farming in order to create such a prediction model. After a deep research, some data are finalized to be used for the prediction. Some data like weather data could not be directly used in the prediction model as we can't ensure the future weather for more than a month. Then, Soil moisture, humidity and temperature data are used developing prediction model.

Model training is critical for every type of machine learning model, as the performance of the model is determined by the experience it gains from the dataset. As a result, many methods for training the model have been explored and tested. On this model, certain techniques did not work. It was initially difficult to improve the model's accuracy. As a result, we read a lot of research papers to figure out the best approach to preprocess the data before creating the model.

Mainly there are 3 types of soil can be recognized in Sri Lanka.

1) Clay soil
2) Sandy soil
3) Loamy soil

According to the researched area (Colombo and Gampaha) and research papers, sandy soil was recognized as the best soil type for the work.

For a more precise and better output a 3cm sensor panel is sunk exactly perpendicular to the soil surface inside the soil. It consists of two probes (s1 and s2) that give analog voltage proportional to soil moisture content.

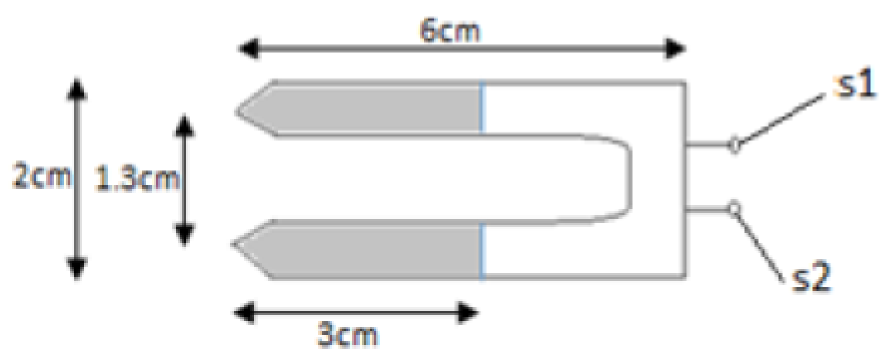

Figure 3.2.1- Dimensions of YL-69 Moisture sensor.

3.3. Discussion

Now the best crop prediction depends on few number of environmental conditions. But in the future, seasonal crop data / acidity value of the soil will be used to improve the realistic of the prediction more.

4.0. CONCLUSION

This research project is based on IoT methodologies for motivate non-farmers who lack of proper knowledge but interest on farming. The entire project comes up with a user-friendly gamification model that being with a customer until selling stage. This work mainly focuses with IoT, data analysis and prediction models. Finally, the IoT model has been planned to release to the market in high quality, user-friendly and resistance.

This research project initiated with the scope of serving the rural farmers and new comers. While the main motivation is service, Agripreneurs has commercialized components as well. This will bring interest to entrepreneurs to takeover this project. The main objective of this research project is to help farmers which is accomplished.

Assumptions:

Crop data gain from internet are correct.

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