PERFORMANCE ANALYSIS OF SMART FARMING SYSTEM BASED ON IOT

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This report is submitted in partial fulfilment of the requirements for the degree of Bachelor of Electronic Engineering with Honours

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DECLARATION

I declare that this report entitled "Performance Analysis Of Smart Farming System Based On IoT" is the result of my own work except for quotes as cited in the references.

Signature : ....

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Date : 21/6/2021

APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Bachelor of Electronic Engineering with Honours.

Signature : ....

Supervisor Name : ....

Date : 24. 6. 2021

DEDICATION

To all those who have supported, encouraged and inspired me and especially to my beloved parents, honourable lecturers and friends for their guidance, love & attention which has made it possible for me to make it up to this point as well to my final year supervisor Profesor Madya Dr Maisarah Binti Abu who bestowed me with the courage, commitment and the awareness to follow the best possible route, unmatchable style and best possible advices.

ABSTRACT

In this era of science and technology, the agricultural sector plays an important role in contributing to the economic field of a country. The field of agriculture based on the IoT leads to lucrative yields and there are various types of platforms used by farmers in increasing agricultural yields. Although there are many platforms related to modern agriculture, but less specific platform is used to study the types of crops suitable for planting based on the type of soil. Thus, this project system has introduced an IoT-based smart farming system based on the MIT App Invertor. The objective of this project is to develop a smart farming system that can help to monitor and analyzed data of temperature (29℃-35℃), humidity (70%-100%), soil moisture (50%-100%) and pH (5.5-7.0) of crops which been stored in ThingSpeak platform application. Besides monitoring, the actuator system also can be controlled by the application with developed in MIT 2 App Inventor. The system had been tested on okra plants and their vegetative traits were measured for 30 days. The result revealed good performance which proofs that the developed system is suitable for smart farming system.

ABSTRAK

Dalam era sains dan teknologi ini, sektor pertanian memainkan peranan penting dalam menyumbang kepada bidang ekonomi sesebuah negara. Bidang pertanian berdasarkan IoT membawa kepada hasil yang lumayan dan terdapat pelbagai jenis platform yang digunakan oleh petani untuk meningkatkan hasil pertanian. Walaupun terdapat banyak platform yang berkaitan dengan pertanian moden, tetapi platform yang kurang spesifik digunakan untuk mengkaji jenis tanaman yang sesuai untuk ditanam berdasarkan jenis tanah. Oleh itu, sistem projek ini telah memperkenalkan sistem pertanian pintar berasaskan IoT berdasarkan MIT App Invertor. Objektif projek ini adalah untuk mengembangkan sistem pertanian pintar yang dapat membantu memantau dan menganalisis data suhu (29℃-35℃), kelembapan (70%-100%), kelembapan tanah (50%-100%) dan pH (5.5-7.0) tanaman yang disimpan dalam aplikasi platform ThingSpeak. Selain pemantauan, sistem penggerak juga dapat dikendalikan oleh aplikasi yang dikembangkan menerusi MIT 2 App Inventor. Sistem ini telah diuji pada tanaman okra dan sifat vegetatifnya telah diukur selama 30 hari. Hasil kajian menunjukkan prestasi yang baik dengan membuktikan bahawa sistem yang dibangunkan sesuai untuk sistem pertanian pintar.

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Praise to God, the one and only, for giving us the strength to complete this final year project. The project delivered in this paper could not have been accomplished without the help of many individuals. I am extremely grateful to our supervisor, Profesor Madya Dr Maisarah Binti Abu for her support in putting together this final year project. Next, I would like to take this opportunity to extend our greatest gratitude to my family for their understanding and commitment during this crucial time researching and finishing this final year project.

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LIST OF SYMBOLS AND ABBREVIATIONS

MIT	:	Massachusetts Institute of Technology
IOT	:	Internet of Things
App	:	Application
PA	:	Precision Agriculture
SSCM	:	Site Specific Crop Management
EC	:	Electric Conductivity
UIDs	:	Unique Identifiers
GSM	:	Global System For Mobile Communication
LORA	:	Short For Long Range
CPS	:	Cyber-physical system
UI	:	User-Interface
API	:	Application Programming Interface
IP	:	Internet Protocol
SDA	:	Serial Data
SCL	:	Serial Clock

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter will discuss about the general background of the proposed project. It being with the introduction to scientific background and followed by the description of the problem that set the goals for this project. This chapter will end with the description structure of the thesis.

1.2 Background of Project

As advances in the internet of things (IoT) and big data analysis are increasingly used to the production, processing, and marketing of food and other agricultural goods, technology and agriculture have come together in an incredible scale in recent decades. [1]. Precision agriculture (PA), smart farming, satellite farming, and site specific crop management (SSCM) are some of the technological terminology that have developed as uses of IoT technologies for the development and improvement of agriculture potential

[2]. Several internet of things (IoT) strategies have already been used to address such procedures like data collection and farming properties [3].

Creating an IoT-based application will yield some fantastic results for this cutting-edge technology. Hence, it will enhance the technology and knowledge for the user. By this system farmer can monitor and on their field condition and control the water usage of the field.

1.3 Problem Statement

In this 21st century, modern agriculture extends well beyond the traditional production of food for human feeds. There is a massive change in agriculture application or method compare to previous decades. Although, the field of agriculture has become the key of development in the rise of sedentary human civilization especially among the farmer where they enable to supply food for people in the cities.

Even there are new technologies and modern technique of farming, but farmer still find difficulties in handling the problems that they faced in terms of controlling and monitoring the crops condition in the farming. Hence, the question rise is how to solve the problems that faced by the farmer in smart farming? In order to solve this issue, the researcher comes out with an application to provide efficient system using wireless sensor network which can be customized based on the needs and enhance the farmers knows based on IoT. It also gives a useful information regarding the parameters which is related to the farm field based on the plants.

1.4 Objective

- To develop smart farming system application which can monitor the temperature, humidity, soil moisture, pH and control the actuator system.
- To measure and analyze those parameters of plants using the application and ThingSpeak platform.

1.5 Scope of Project

i. This project primarily focusses on the development of smart farming system with integrate of IoT by creating application. The plants vegetative traits were analyzed with suitable temperature, humidity, soil moisture and pH.

- The usage of Arduino as a microcontroller which is the brain of this system. It will be interfacing with the cloud by the help of ESP 8266. Cloud data base acts as the hub for the whole system process where the data base contains all the information which was retrieved from the sensors. The LCD display been used to show the measured values.
- Plenty sensors been used in order to monitor the performances farming system. These sensor values are sent to the Arduino and cloud database from where the user will be updated with the real time information about the field. There is also an actuator system which had been designed to control the water flow.
- An application will be developed by using the MIT App Inventor which enable user to monitor the real-time condition of the farm and control the actuator system. This application also had a sub category where can obtain live stream graph from ThingSpeak platform. There will be a

specific channel for monitoring the parameters which been designed in ThingSpeak. The system will be implemented to monitor and control on okra plants.

1.6 Scope and Limitation

The proposed system may cause some uncertain situation. For an example, without the power supply this system will be not functioning due to it is fully dependent to the power supply sources. The application also can only be operated in Android operating system. Moreover, if there is any network problem the chances of transmitting or receiving data will be interrupted due to the wireless connection network.

1.7 Project Significant

This smart farming system will give an important part in farmer's life where they can identify the present farm field condition and can monitor the previous data based on their field. Moreover, farmer also can gain knowledge on IoT platform by this system. Therefore, farmer can predict on crops vegetative and environment of their field by implanting this system.

1.8 Structure of Thesis

Following this general introduction in this chapter, chapter 2 describes the background of this study followed by literature reviews about research articles related to the study objectives. Information extracted from methodologies, results and discussions from these research reviews will be used to lay the foundation required to conduct the research and writing the thesis. Research methodology is stated in chapter 3 while results and discussion are presented in chapter 4. Research conclusions, some recommendations for future work and some expected social impacts of this research are described in chapter 5.

CHAPTER 2

BACKGROUND STUDY

2.1 Introduction

Chapter 2 discussed about the review of the relevant literature and research paper related to of smart farming system based on IoT. The first part of this chapter discussed about the definition of Smart Farming System and IoT. The second part emphasized on many past research and studies that related to smart farming system based on IoT that was conducted in Malaysia and all over the world. At the ending of chapter 2, researcher came out with a conclusion based on the title of the research.

2.2 Smart Farming System

Malaysian agricultural sector needs structural changes on a large scale in order to improve and develop the life of the farmers. In order to achieve this, Smart Agricultural Revolution or Smart Farming was designed to revitalize this field. The Smart Farming System refers to the widespread use and integration of cutting-edge agricultural technologies with the goal of enhancing domestic food yields in both quantity and quality. For example, drones can be used to spray pesticides, analyze planting soil and monitor crop yields quickly and without the use of labor as said by [4].

Other than that, [5] stated that smart farming is a system that manages and provides the infrastructure for the agriculture sector for using new technology. Smart farming is becoming more important as the world's population grows, as does the desire for higher agricultural yields, the need to conserve natural resources, the increasing use and complexity of information and communication technology, and the growing need for climate-smart agriculture. According to [6] there are six type of technologies that can utilizes by the farmers in present day. It is shown in Figure 2.1.

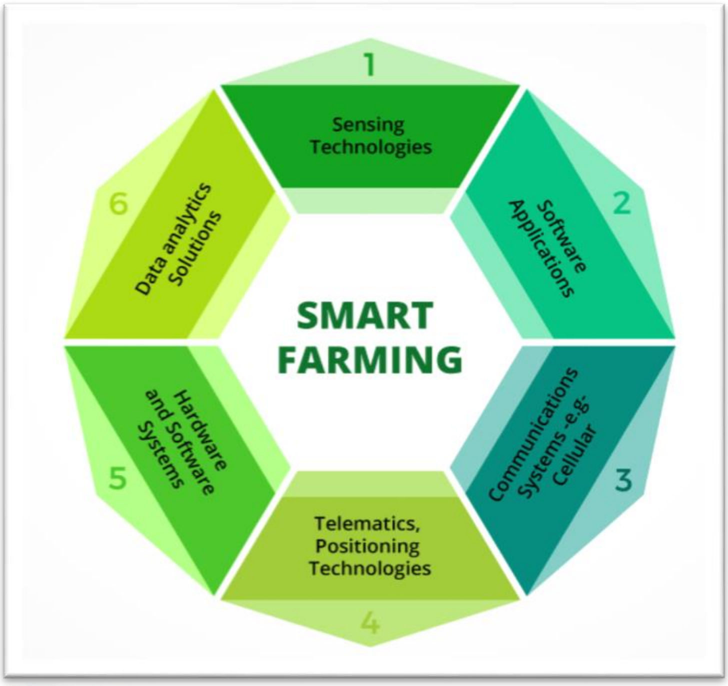


Figure 2.1: Technologies involved in smart farming [6]

On top that, smart farming is also known as the development that emphasizes on the usage of technologies in management of the crop yields in the farm. Figure 2.2 shows the model that researchers can refer and it may give practitioners with guidance on the components that make up IoT-based monitoring systems. [7]. There are four layers of architecture model such as Sensor Layer, the Network Layer, the Service Layer and the Application Layer as shown in Figure 2.2.

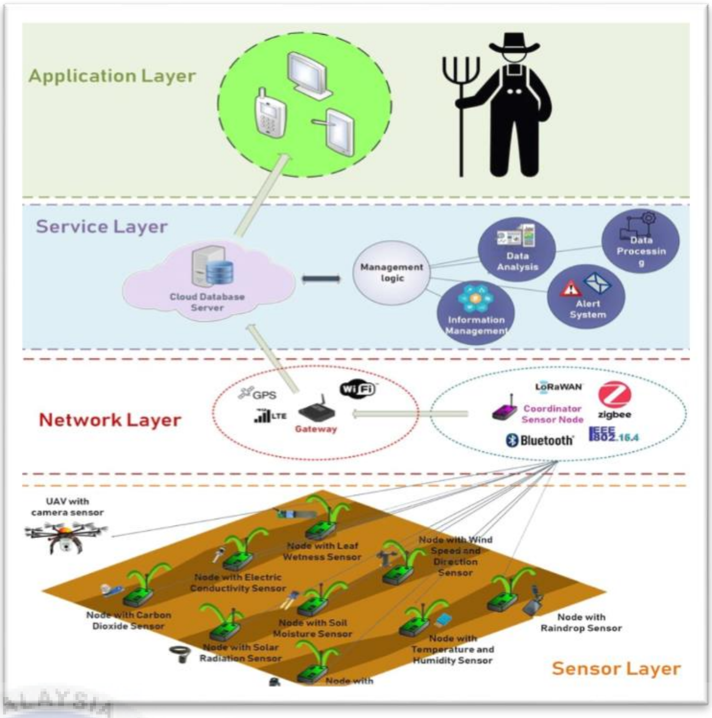


Figure 2.2: Farming architecture layer model [7]

There are many types of smart farming. First of all, smart farming involves the hydroponic system that automatically detect the farm temperature, humidity, EC, pH, light intensity, watering and fertilizing [8]. Aside from hydroponics, there is another sort of smart farming called aquaponics, which is a popular indoor farming method. It's a technique for rearing fish and growing plants. Farmers use this approach to raise fish in soilless plant culture tanks. Plants benefit from the nutrient-rich water used in fish farming because it acts as a natural fertilizer, and plants also help to clean the water for fish. This method combines traditional agriculture and hydroponics as shown in Figure 2.3. Other than that, aeroponics is another smart farming system where it is a method of growing plants without soil and with very little water.

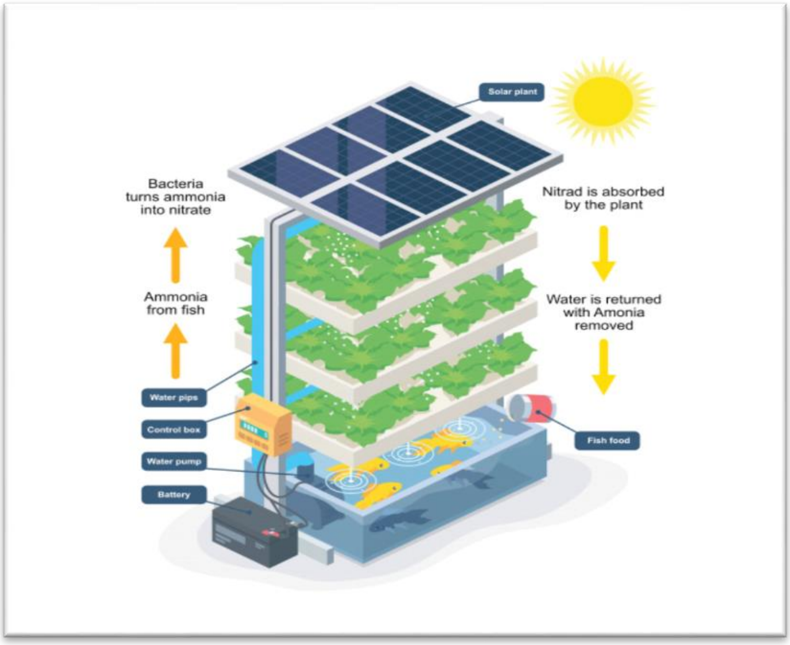


Figure 2.3: Smart Farming Using Aquaponics System [8]

2.3 IoT System (Internet of Things)

The Internet of Things (IoT) is a set of physical, internet-connected objects that can gather and transmit data without the need for human contact across a wireless network. Any natural or man-made object that can be assigned an Internet Protocol (IP) address and can transfer data over a network, such as a person with a heart monitor implant, a farm animal with a biosensor transponder, an automobile with designed sensors to warn the driver when tire level is reduced, or any other natural or man-made object with built-in sensors to alert the driver when tire pressure is low, are all examples of things in the internet of things (IoT) [5].

Besides that, an IoT ecosystem is made up of web-enabled smart devices that use embedded systems like CPUs, sensors, and computer systems to gather, send, and analyze the information from their surroundings. IoT devices link to an IoT gateway or other edge device to share sensor data, which is either routed to the cloud for analysis or examined locally. The internet of things (IoT) is a catch-all name for a rising number of gadgets that aren't standard computing equipment but are connected to the internet to send or receive data or instructions. [9].

As said by [10], explained that IoT is known as internet of things where all the physical devices in the world are connected to each another by collecting and sharing of data. The Internet of Things making up the fabric of the world to become smarter and responsive by merging the digital and physical universe. Based on the understanding regarding IoT system, internet connection is the main thing where enable the humans to communicate with the network independently result of human action [11].

Smart farming can benefit from the Internet of Things in five ways. To begin with, smart farming sensors capture a large amount of data, weather conditions, soil quality, crop growth progress, and livestock health are just a few examples. This information can be utilized to monitor the overall health of your company, as well as employee performance and equipment efficiency. Improved internal process control and, as a result, decreased production risks [12]. The ability to forecast production output provides for improved product distribution planning. Increased control over manufacturing allows for better cost management and waste minimization. Being able to spot anomalies in plant growth or livestock health enable to reduce the risk of losing the crop [13].

2.3.1 Application and Advantages of IoT in Agriculture

The application of smart farming system can be categorized as smart greenhouse, agricultural drones, livestock monitoring and precision farming as in Figure 2.4.

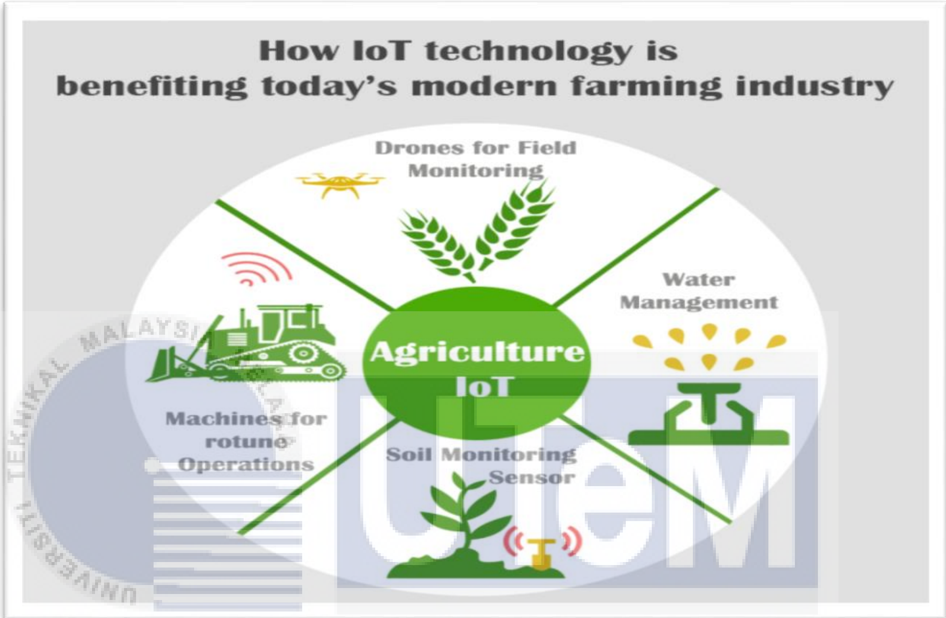


Figure 2.4: Application of IoT in Agriculture [14]

The advantages of using IoT in Agriculture can been seen clearly through the success of the research that was conducted by many researchers that will be discussed in section past studies of the chapter 2. The main benefits of IoT in agriculture are that it enables simple gathering and management of large amounts of data gathered from sensors, as well as the joining of distributed evaluating administrations such as cloud storage, farming field maps, and more information can be retrieved from any location and at any time, allowing for end-to-end monitoring and connectivity. [14].

In addition, IoT is seen as a key component for smart farming that, according to expert's farmers may increase output by 72 percent by 2050 by using precise sensors and smart gadgets. Expenses could be reduced to an incredible extent by utilizing IoT inventions, resulting in increased production and survivability. Last but not least, IoT efficiency level would be further expanded as far as utilization of water, soil, fertilizers, pesticides and others [4].

2.4 Related Studies about analysis of smart farming system based on IoT

Author [15] conducted a research entitled IOT Based Smart Farming E-monitoring System. This project aimed to monitor the modus operandi that was developed in order to be helpful in agriculture. Parameters of the related field area such as the temperature, humidity, moisture level, pH rate and also wavering detection within the farming area is used. Inundation is made based on the mugginess level. This project is based on the consignment of water needed and crop choice based on pH caliber where the pinnacle features that is on and off of the motor ESP-8266 MCU is used. Arduino software is used. These criterions are sensed by way of IoT to Blynk app. This Blynk app is used for controlling the parameters.

Other than that, [16] designed a project about The Smart Farming. The objective of the project is to update the farmer's business on the problems that they should alert with and need to solve when using the modern way of cultivating crops. The method used in this project is the Web Application where the farmers can login in the website provided and create their own profile. By having an account, farmers can communicate with agriculture officers about cultivation. Farmers can ask questions, view their profile and ask any doubts to the officers and other fellow friends. Normal feature also includes for them that can help them for their cultivation.

Furthermore, [17] designed a project entitled Smart Farming for Controlling And Monitoring Irrigation System Using Internet Of Things. This project was conducted on the year 2017 with the purpose to ensures the efficient use of water in the irrigation system and improve the productivity where the smart irrigation system which is fully automatic and is based on today's emerging technology that is the internet of things. Minimum human involvement or workforce is required by using the IOT. This system comprises of many sensors and devices, such as moisture sensors, water level sensors, Arduino UNO, and GSM Module, which send data from one device to another, allowing the irrigation system to begin working automatically. The farmer will be reminded on a routine basis based on threshold values such as moisture sensor and water level. When the water level falls below a certain level, the system starts a motor to fill the water tank, and it turns off automatically when the water level sensor reaches its maximum value.

Moreover, [18] designed a project entitled A smart monitoring and controlling for agricultural pumps using LoRa IOT technology. The objective of this project is to help the farmers to design and manufacture a remote control system that can switches irrigation pumps on and off using LoRa technologies. So, researchers created the LoRa (Great Range) intelligent device or technology, which may be used to control the functioning of irrigation pumps utilizing a robust means of communication to transport information over long distances for the lowest cost and longest battery life. The unit is divided into two circuits: one for turning the pumps on and off, and the other for controlling and monitoring their operation. The voltage can also be measured and used to monitor the pumps via smart phones.

In other hand, [19] conducted a project on IoT Based Smart Farm Monitoring System. The main purpose of the project is to design an IOT based agriculture stick in order to help the farmers to obtain the reading of the parameters such as temperature, soil moisture and humidity. In this way, farmers can increase their knowledge on the clever farming and also the production of the crop yields. GSM module is used to pass the information or data or values to the farmer via GSM network. Result of this project show that this system is very helpful to farmers in increasing the average crop yield ratings and plants quality. So can be concluded that the adoption of technology in smart farming has enabled farm operators to monitor and control important elements such as humidity levels, soil conditions and temperature which can ensure consistent production of high quality produce.

On the top of that, [20] did a project about the A Smart Farm Prototype with an Internet of Things (IoT) Case Study: Thailand. This project was conducted on the year 2019 with the aim to design for smart farm prototypes by using sensors for measuring the temperature and humidity using the Internet of Things (IoT). Based on this research, the hardware and the web-based application are the two major components used. The hardware system consists of two major devices: A Raspberry Pi board installed in a control box to collect data from the field using a DHT22 sensor, and a Raspberry Pi board installed in a control box to collect data from the field using a DHT22 sensor. This is utilized to collect temperature and humidity data from the plant's environment and send it to the control box's control unit. The second component is a web application that was created and implemented to collect and present users with meaningful, real-time data. This system is critical for the automatic control water system because it collects the information needed to control the ideal water quantity for plant growth.

Other than that, [21] designed a project entitled Agriculture Monitoring System Using Smart and Innovative Farming: A Real-Time Study. This project is aimed to develop an optimal crop agriculture system that work on a wireless sensor. Web application and smartphones are used in order to strategize and maintain a control organism utilizing crop sensor that senses with data managing. Three module application such as web application, hardware and mobile application was used in this research. To collect crop data, an initial module was designed and operated in the device of the associated control box. Soil moisture sensors are used to monitor the soil in comparison to a control unit. The second module has a web application that was created and implemented to manage all crop data and farming area information. Data mining was used to analyze the information in order to calculate the soil temperature, humidity, and optimal humidity for crop nutrition. A mobile device is used to keep crop irrigation running well, with data from the soil moisture sensor being processed electronically. For plant development, cost reduction, and higher agricultural yield, a sufficient soil moisture capacity has been maintained. Furthermore, this work represents the digital invention's driving power in agriculture.

Furthermore, [22] conducted a research entitled Design and Implementation of a Connected Farm for Smart Farming System on the year 2018. The aim of this study is to provide smart farming system for the end users. The researchers employed a connected farm based on IoT technology for smart farming systems as their strategy. In order to give Internet access to the linked farm's sensors and controllers, The Cube is a standardized (i.e., compliant with oneM2M requirements) device software platform for IoT devices that the researchers have implemented. Mobius, an IoT service platform that provides REST APIs for retrieving data from sensors (e.g., CO2 sensor) as well as sending control orders to controllers (e.g., air conditioner), was utilized in this project. The researchers also developed a smartphone app that allows customers to remotely monitor and control their connected farm, such as turning on the air conditioner by pressing a button on their phone. The connected farm service scenario highlights the feasibility of establishing a farm knowledge expert system that motivates people to work in agriculture.

Moreover, [23] conducted a project on Implementation of smart monitoring system in vertical farming. The goal of this project is to integrate CPS into a vertical farming system, with an Android-based remote monitoring and control (M&C) system based on CPS being developed for optimal plantation production using Arduino ESP32 and sensors via the Internet. Farmers can use a cyber-physical system (CPS) to remotely monitor and control the different parameters that affect plant growth. Experiments were conducted to determine the viability of incorporating CPS into the vertical farming process. Ambient temperature, water temperature, humidity, pH level, light, and carbon dioxide levels were all measured and regulated in the studies. An android application was created and tested in this study. The phone displayed the controlled parameters. The CPS system is feasible to use in plant growth monitoring (sensors and feedback system) and plant growth optimization, according to the evaluation results (sensors, feedback system and actuators).

Besides that, [24] conducted project on The future of farming through the IoT perspective on the year of 2019. The main objective of the project is to provide the correct information in advance to the farmer. Data mining would yield valuable information that farmers might use to determine the best circumstances for framing. Farmers have always used their knowledge to frame weather conditions and information on ideal farming circumstances, and this will be beneficial to them. The system will be analyzed and handle by some wireless connection as data mining.

Researchers [25] designed a project on the year of 2019 about Saving resources through smart farming - An IoT experiment study. The purpose of this thesis is to look into the advantages and disadvantages of using technology in agriculture, or agritech. The study is carried out by doing a literature review and an experiment. A prototype was developed to monitor soil moisture levels and calculate the average soil moisture value before watering the plants as needed. This was then compared to a manually watered container to see if agritech could minimize the amount of water used to keep plants alive. The experiment's findings suggest that it is possible to enhance resource utilization, such as human labor, time spent maintaining plants, and water usage. As a result, human workers can devote more time to other duties while maintaining the technology in place. Instead of studying the plants to see if they truly require watering, you can physically water them.

In addition, [26] conducted a project about Smart agriculture monitoring system using IoT. The goal of this project is to develop effective sensor innovation and remote system coordination of IoT innovation in the context of agricultural activities. Thing Speak is an application approach for building applications based on data collected by sensors. Water usage can also be reduced with the help of sensors that monitor the soil moisture level and water the plants only when they need it. The results demonstrated that the installed system not only aims to limit the use of traditional agricultural techniques, but also serves the community by providing new employment opportunities.

2.5 Platform used for Smart Farming using IoT

To conduct this project there were some research had been gone through to have a comparison between the similarities and gap as in Table 2.1.

Table 2.1: Comparison between related studies

Author/Year/ Title	**Methods**	**Results**	**Similarities**	**Gap**
P. Gomathy, et al, 2018. "IOT Based Smart Farming E-monitoring System".	Blynk Application as the controller of the parameters such as the temperature, pH level, soil moisture and wavering detection	system helps in maintaining the agriculture in a smart manner by performing more than three forth of the work for regulated farming process in an automated way.	No similarities	No MIT App Inventor been used.
Mohaimenul. et al, 2021."The Smart Farming".	The method used in this project is the Web Application where the farmers can login in the website provided and create their own profile.	There are many farmers using this application because of its good quality and it is well known as a better UI for interaction among farmers.	No similarities	No MIT App Inventor been used.
Riyaz Mohammed, 2017. "Smart Farming for Controlling And Monitoring Irrigation System Using	GSM Module is used to which transfer data from one device to another to communicate so that the	The farmer will be notified on a regular basis based on threshold values such as moisture	No similarities	No MIT App Inventor been used.

Internet Of Things”.	irrigation system start working automatically.	sensor and water level.		
P.Yadav et al, 2019. “IoT Based Smart Farming System”	GSM module is used to pass the information or data or values to the farmer via GSM network.	Adoption of technology in smart farming has enabled farm operators to monitor and control important elements such as humidity levels, soil conditions and temperature.	No similarities.	No MIT App Inventor been used.
Aktham Hasan.et al, 2019. “A smart monitoring and controlling for agricultural pumps using LoRa IOT technology”.	LoRa IoT technology is used and designed application using MIT App Inventor to control and monitor agriculture system.	Help the farmers to design and manufacture a remote control system that can switches irrigation pumps on and off using LoRa technologies.	MIT App Inventor	No ThingSpeak been used.
Pannee Suanpang & Pitchaya Jamjuntr, 2019. “A Smart Farm Prototype with an Internet of Things (IoT) Case Study: Thailand”.	The hardware system consists of two main devices, which includes a Raspberry Pi board and web application.	The results showed the system was useful for Agricultural 4.0, in which technology can help farmers to increase their productivity while significantly decreasing cost and monitor the	No similarities.	No MIT App Inventor been used.

		system by web based.		
Andzio Elion, 2019. “Agriculture Monitoring System Using Smart and Innovative Farming: A Real-Time Study”.	Three module application such as web application, hardware and mobile application was used in this research.	Plant evolution, cost reduction, and higher farmed yield have all benefited from a sufficient soil moisture capacity.	No similarities.	No MIT App Inventor been used.
Minwoo Ryu., et al, 2018. “Design and Implementation of a Connected Farm for Smart Farming System”.	Mobius, an IoT service platform (also oneM2M-compliant) that provides REST APIs with which the data collected from sensors (e.g., CO2 sensor) has been used.	Knowledge of the farm system that encourages people to work in the agricultural industry.	No similarities.	No MIT App Inventor been used.
Chuah, 2019. “Implementation of smart monitoring system in vertical farming”.	Android-based remote monitoring and control (M&C) system is developed based on CPS for optimal production of the plantation system using Arduino ESP32 and sensors through the Internet.	The automation of the plant growth observation process can help the agriculture business overcome its labor crisis.	No similarities.	No MIT App Inventor been used.
Chetan N Kulkarni & Ajay, 2019. “The future of	The available old-style methods are like sowing,	The farmers are traditionally applying their	No similarities	No MIT App Inventor been used.

farming through the IoT perspective".	digging, and irrigation system is used. Data mining method been implemented to observe the system.	knowledge for framing in term of weather condition and information about suitable conditions for farming, then it will be helpful to them in IoT term.		
Philip Tennevall & Susanne, 2019. "Saving resources through smart farming - An IoT experiment study".	The research is performed by conduction a literature study and an experiment that are the prototype can control by Bluetooth.	It is feasible to make better use of resources like human labor, time spent on plant maintenance, and water usage.	No similarities	No MIT App Inventor been used.
P. Lashitha Vishnu Priya, 2018. "Smart agriculture monitoring system using IoT".	ThingSpeak is an application method that use to construct an application around information gathered by sensors.	The developed method aims to not only decrease the use of traditional agricultural techniques, but also to benefit the community by providing new employment opportunities.	ThingSpeak is been used.	No MIT App Inventor been used.

2.6 Parameter Analysis

2.6.1 Soil pH

Okra can grow in a variety of soil pH levels, but it needs a pH of 6.0 to 6.8. Lime is used to increase the pH of the soil to 6.0 or higher if it is less than 5.8. Okra with poorly formed pods can be grown in soils with a pH of 5.8 or lower [27]. Okra grows best in full sun and well-drained, moist soil. Avoid areas that are muddy and badly drained. Okra thrives in slightly acidic to slightly alkaline soils (pH 6.5 to 7.5), so pH is unlikely to be a problem. [28]. According to various sources, okra can grow in soil with a pH as low as 5.8 and as high as 7.5. However, better conditions result in higher yields. For most varieties, a pH range of 6.5–7.0 should suffice [29]. Okra grows best in soil with a pH of 6.5 to 7.0, but it can grow in soil with a pH as high as 7.6. Okra plants have small vertical stems with spiky or hairless heart-shaped leaves. The leaves are 10 to 20 cm (4–8 in) long and have 5–7 lobes. The plants can grow flowers with five white to yellow petals that are 4 to 8 cm (1.6–3.1 in) in diameter. The seed pod is a long capsule containing several seeds that can be up to 25 cm (10 in) long. Okra can grow to be 1.2 to 1.8 m (4–6 ft) tall with the good condition of field [30].

2.6.2 Temperature

Temperatures in the soil should be at least 18.3°C, with 23.9°C to 32.3°C being ideal for plant development. Usually, okra is grown from seed. Seeds that have been soaked in water overnight before planting are more likely to germinate. Seeds are planted in rows 0.65–1.0 m (26–40 in) apart in commercial okra production [31]. The ideal soil temperature for seed germination is between 70 and 95 degrees Fahrenheit, so gardeners should check the temperature at a depth of 4 inches before planting [32]. Not only does soil temperature influence seed germination, but it also affects soil chemistry. The release (dissolution) of mineral nutrients in soil moisture is part of soil chemistry. Mineral nutrients are needed for the growth and maturity of vegetable plants before harvest. 65° to 75°F (18°-24°C) is the ideal or optimum soil temperature for planting and growing most vegetables [33].

2.6.3 Humidity and Soil Moisture

Relative humidity is the proportion of water vapor in the air to the amount of moisture that the air will hold at a given temperature. When the relative humidity level in a space is 75% at 80° F, it means that every kilogram of air in that space contains 75% of the maximum amount of water that it can carry at that temperature [34]. The average monthly temperature for the okra plant ranged from 22.1 to 32.2 ° C, with a relative humidity of 75.3 to 79.0 percent [35]. According [36], the amount of soil moisture with a percentage of 25% and 50% will higher affect okra plants growth if compare to 75% to 100% of soil moisture content.

2.7 Conclusion

Overall, chapter 2 emphasized on the smart farming system that developed by other researcher and being successfully conducted. In this chapter, readers will be given information based on the smart farming and the usage of IoT in agriculture. There are many platforms of IoT in field of agriculture been discussed where each platform is designed to make the farmers become knowledgeable in the farming field. Related past studies also included in this chapter to justify the need of smart farming for the farmers all over the world. Through this smart farming system using IoT applications, farmers will increase their crops and gain more ideas and technique to raise their farming skills. The MIT App Inventor will be new or an additional platform for this agriculture field.

CHAPTER 3

METHODOLOGY

3.1 Introduction

Methodology is a systematic, theoretical analysis of the methods applied to a field of study. Hardware and software are implemented in this project. Firstly, there will a discussion with supervisor to get a title for the project and how to proceed it. Then, different related work and literature reviews had go through to get a good information on the project. Next, designing the circuits and figure out the platforms which going to be used for develop the system. At the end, this system will be integrated with IoT platform. Soil moisture, humidity, temperature and pH value are the parameters that going to be analyzed for plants by using this system.

3.2 Research flow chart

The project process fully had planned well on how to execute from the beginning until ending as in Figure 3.1.

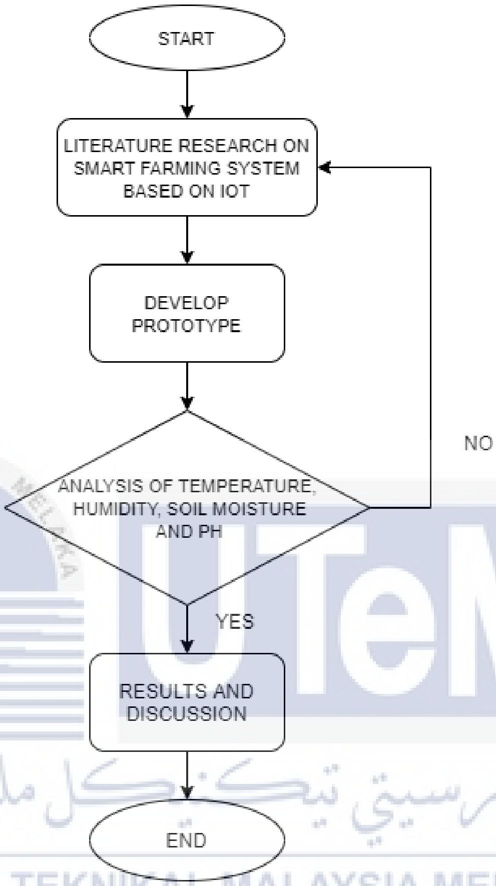


Figure 3.1: Research flow chart

The research had been started by doing literature survey and background studies which are related to smart farming system. The next stage will be to choose appropriate software and hardware for the investigation. The prototype was then developed utilizing the components and software. The farming method was also developed by arranging eight okra plants that were placed in a polybag. This farming system measured four parameters for vegetative traits dependent on the crop: pH, temperature, humidity, and soil moisture. If the analysis confirms the findings, the following step will be taken. Background investigations will be undertaken again if necessary in order to obtain the best performing smart farming system. The preceding step before the end process by discussion the best results which been obtain from the parameters.

3.3 System flow chart

To develop the prototype, there were some flow had been executed to make sure that the prototype works well as in Figure 3.2.

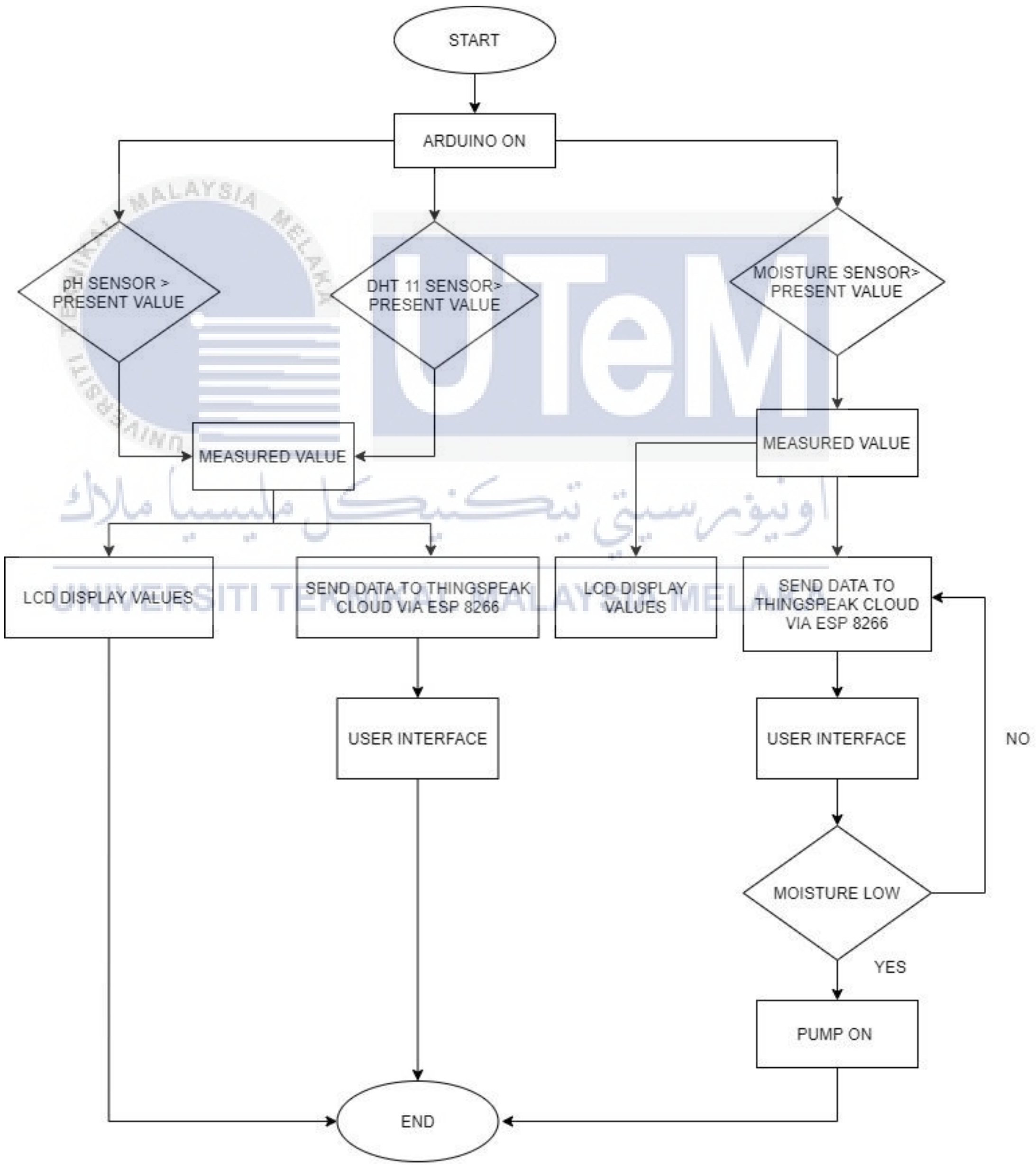


Figure 3.2: System flow chart

3.3.1 Hardware Requirement

3.3.1.1 Arduino Uno

The Arduino Uno is a microcontroller board based on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller and simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started. It is used in this project to interface with the sensors, NodeMCU ESP8266 and water pumps.

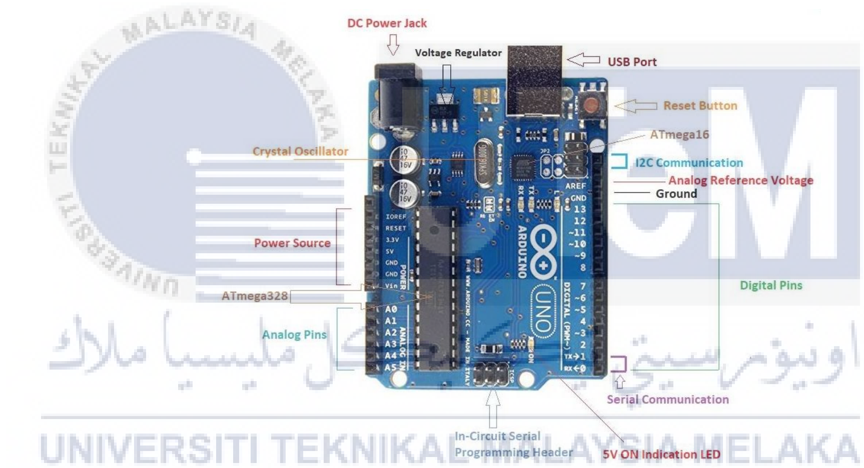


Figure 3.3: Arduino Uno [37]

3.3.1.2 ESP 8266 Module

The ESP 8266 is a low cost, compact and powerful WiFi module which only needs 3.3V power supply to operate. It supports serial communication which is compatible for Arduino Uno to communicate. It can be used as station or access point and easily can be programed with Arduino Ide. In this project, ESP 8266 had been used to transmit or receive data from the Arduino and Thingspeak cloud.

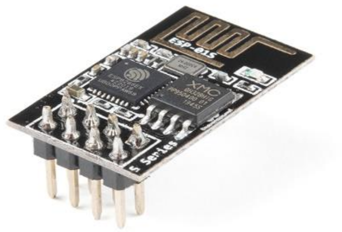


Figure 3.4: ESP 8266 [38]

3.3.1.3 Analog pH sensor

Analog pH sensor is specifically designed to measure the pH of solutions and reflect the acidity or alkalinity. The pH is a value that measures the acidity or alkalinity of the solution. Usually, the pH scale is between 0 to 14. Under the thermodynamic standard conditions, pH=7 which means the solution is neutral; pH7, which means the solution is alkaline.

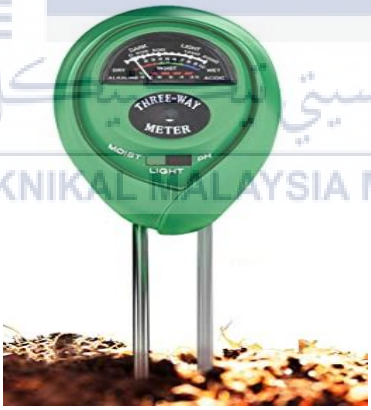


Figure 3.5: pH sensor [39]

3.3.1.4 DHT 11 sensor

DHT 11 is low-cost sensor which used for measuring temperature and humidity with the help of any microcontroller. This sensor consists of thermistor and capacitive humidity sensor to measure surrounding air. The sensor had been used to measure the temperature and humidity for this project.

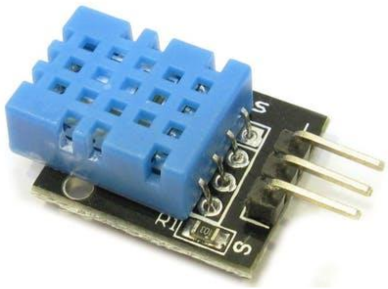


Figure 3.6: DHT 11 sensor [40]

3.3.1.5 Soil Moisture sensor

This sensor only consists of 4 pins which is AO, DO, VCC and GND. AO gives out analog signal which was connected to analog pin of Arduino and DO gives out digital output of internal comparator circuit. It used to identify moisture contain of the soil.

Figure 3.7: Soil Moisture sensor [41]

3.3.1.6 I2C LCD Display

LCD I2C is used to display the character which been programmed. There are 4 major pins which is VCC, GND, SDA and SCL. SDA used for transmit and receive in Arduino Uno. The timing signal was supplied by SCL and used to display the parameters value with the help of Arduino Uno.

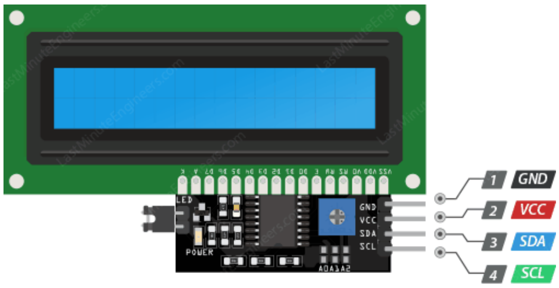


Figure 3.8: I2C LCD display [42]

3.3.1.7 Submersible Pump

It is used in this project to pump fresh water to the plants when the moisture is low. It can operate with 3-5V power supply.

Figure 3.9: Submersible Pump [43]

3.3.1.8 Relay Module 5VDC-240 VAC

The relay module is a digital switch to control much higher voltages and currents which are out of the abilities of the Arduino. Whenever switching a device with high voltage or draw high current, a relay will be needed. When a logic input is given, the relay will switch to allow current to flow or cut-off dependent on the wiring. In this project, it been used to cut-off and allow the current flow when needed.

Figure 3.10: Relay Module 5VDC-240VAC [44]

3.3.2 Software Requirement

3.3.2.1 Arduino Ide

It is an open source software which is used in this project for writing and compiling the code into the Arduino Uno and ESP8266 board. The main code, also known as a sketch, created on the IDE platform will ultimately generate a Hex File which is then transferred and uploaded in the controller on the board. It supports both C and C++ languages.

Figure 3.11: Arduino IDE [45]

3.3.2.2 ThingSpeak

ThingSpeak is a web-service platform that helps user to collect data from any sensors in the cloud and develop IoT application. It can work with any kind of microcontroller to visualize, analysis live data from cloud. All the sensor data can be transmitting to ThingSpeak from hardware that can exchange information using REST API and to monitor the data of the parameters [46].

Figure 3.12: ThingSpeak [47]

3.3.2.3 MIT 2 App Inventor

MIT App Inventor is a platform that chosen to develop an application for this system. MIT App Inventor is an online development platform where anyone can explore to get a solution based on developing a new application. It can be operated by using Android or iOS operating system. This platform uses block-based programming language which was built by Google. This platform also enables users to understand easily on creating an application and it is divided into two section which is designer and block part [48].

Figure 3.13: MIT 2 App Inventor [49]

3.3.3 Block Diagram and Process Flow

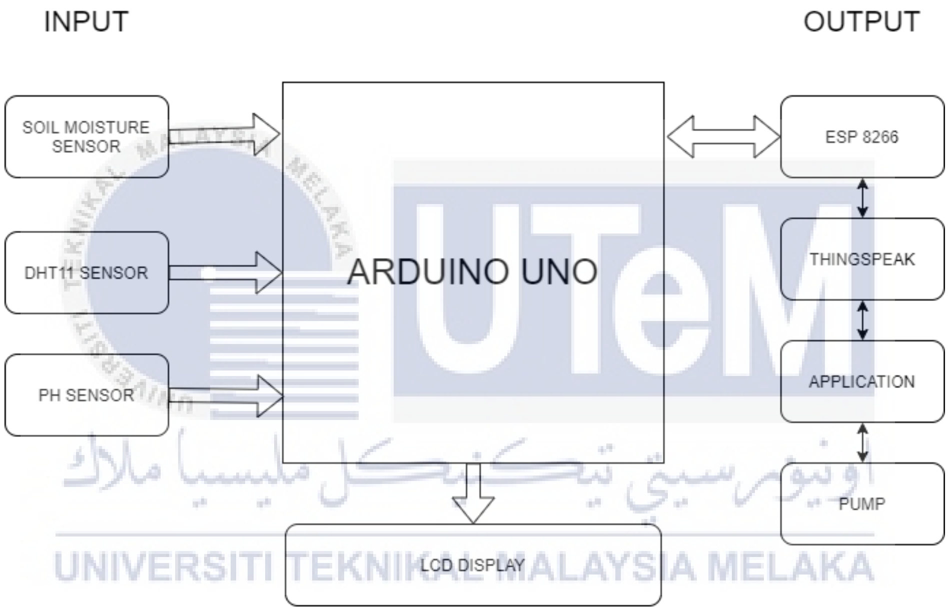


Figure 3.14: Block Diagram and Process Flow

I. Arduino Uno with the help of Atmega328 microcontroller used to collect data from the sensors as an input and transmit the data to ESP 8266 module as an output. It integrates with the IoT platform such as ThingSpeak to aggregate, visualize and analyze live data streams in the cloud. The data from cloud also will be appear in the user interface of an application which was been developed in the MIT 2 App Inventor web-based platform. Application had a monitoring and controlling system.

II. The pH sensor used to sense the pH level of the soil whether it is an acidic or alkaline condition. It gives out respective data to Arduino and store the data in ThingSpeak database via the ESP 8266 wifi module. If the pH value is less than the threshold value, there will be a notification that pop up in the application as a statement of *Abnormal pH*. The pH value of the plant can be referred from Figure 3.15 below.

III. DHT11 used to measure the temperature and humidity of the farming environment. It had a value from 0^{o}C to 50^{o}C and humidity from 20% up to 90% with the accuracy tolerances of $\pm$ 1^{o}C and $\pm$ 1%. This measured value will be transmitted to ThingSpeak cloud and the value also be appearing in the application.

IV. Soil moisture act as a variable resistor which can sense the water content in the medium. If the water contain is higher, the better conductivity and result in low resistance. Meanwhile, if the water contain in the medium is less, the poor the conductivity and result in high resistance. The measured values will be store in ThingSpeak platform and will be appear in the application as well. Besides that, there will be a notification in the application if the *Soil moisture is low.*

V. The pump can be turn on when the moisture level is then the threshold value or less than 50% as well. It will be controlled by using the application which been developed using MIT App 2 Inventor.

VI. The measured value from those parameters also will be display in the LCD 16x2.

Bacaan pH, EC dan PPM

TANAMAN	pH	EC	PPM
Sawi	5.5-6.0	2.0-2.1	1050-1400
Kailan		1.5-2.0	1050-1400
Kangkung	5.5-6.5	2.0-2.1	1050-1400
Pakchoy	7.0	1.5-2.0	1050-1400
Bayam	5.5-6.6	1.8-2.3	1260-1610
Salad	5.5-6.5	0.8-1.2	560-840
Daun Sup	6.5	1.8-2.4	1260-1680
Kacang Panjang		1.8-2.2	1260-1540
Terong	5.5-6.5	2.5-3.5	1750-2450
Bendi	6.5	2.0-2.4	1400-1680
Lobak Merah	6.3	1.6-2.0	1120-1400
Lobak Putih	6.0-7.0	1.6-2.2	840-1540
Kobis Bunga	6.0-7.0	0.5-2.0	1050-1400
Cili	6.0-6.5	3.0-3.5	2100-2450
Strawberry	5.5-6.5	1.8-2.2	1260-1540
Tembikai	5.8	1.5-2.4	1260-1680
Rock Melon	5.5-6.0	2.0-2.5	1400-1750
Tomato	5.5-6.6	2.0-5.0	1400-3500
Timun	5.8-6.0	1.7-2.5	1190-1750
Kacang Buncis	6.0	2.0-4.0	1400-2800
Broccoli	6.0-6.5	2.8-3.5	1960-2450
Lada Paprika	6.0-6.5	1.8-2.2	1260-1540
Bawang Merah	6.0-6.7	1.4-1.8	980-1260
Timun Jepun	6.0	1.8-2.4	1260-1680
Daun Pudina	5.5-6.0	2.0-2.4	1400-1680
Tatsoi (Pagoda)	5.5-6.5	1.5-2.0	1050-1400
Turnip	6.0-6.5	1.8-2.4	1260-1680

Figure 3.15: The reading of PH, EC and PPM [50]

3.4 Description of Application Design

3.4.1 MIT 2 App Inventor

The MIT 2 App Inventor consist of two section which is designer part to design the interface of the application as per need and the second section will be block part where the interface will be programmed.

3.4.1.1 Designer Part

MIT 2 App Inventor is a platform to design an application with comfortable way. In this project, the interface was designed in the designer section and it was divided into some elements. There was some important component that been organized in screen one and screen two. For screen one, there was an image inserted and some components under Vertical Arrangement which is Table Arrangement component for design the label of the parameters that going to be measured as in Figure 3.16.

Figure 3.16: Design of arrangement for image and parameters

There was also a Table Arrangement component which display the messages and alarms section in the Horizontal Scroll Arrangement. Besides that, a button component is dragged in the screen one to show the channel of ThingSpeak from the cloud which was been programmed as in Figure 3.17.

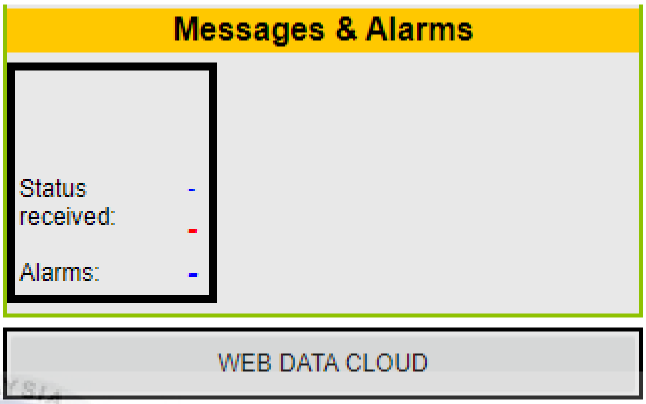


Figure 3.17: Design of display alert and data cloud

There were be two buttons had inserted to on and off the actuator system. This buttons will be turned on the feedback option in the properties to respond according to the needs as in Figure 3.18.

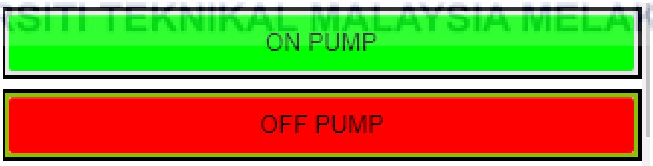


Figure 3.18: Design button for actuator system

In the screen two, there will be a Web Viewer component which load a data from Thingspeak to this application by pressing the web data cloud button as in Figure 3.19.

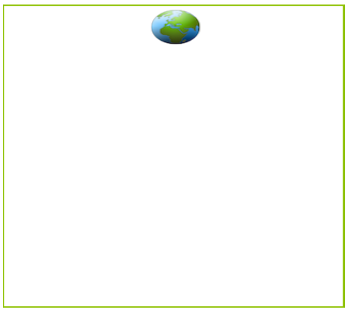


Figure 3.19: Design of Web Viewer

Finally, the interface is created by combining all the components and elements as shown in Figure 3.20.

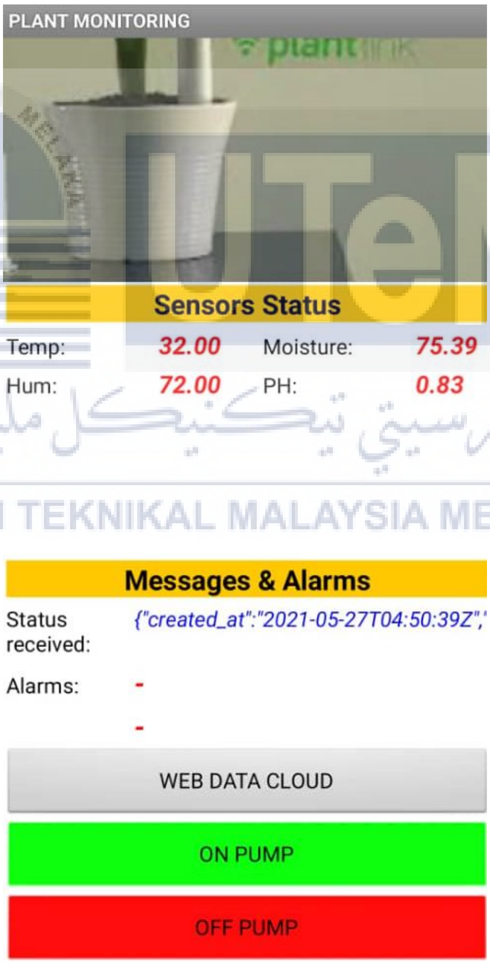
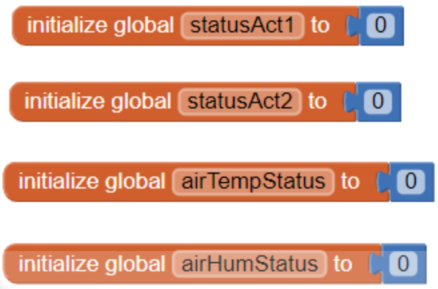
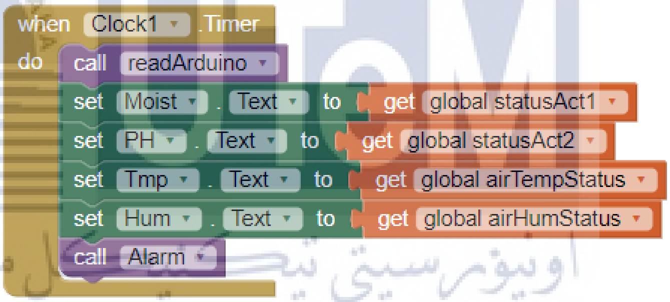
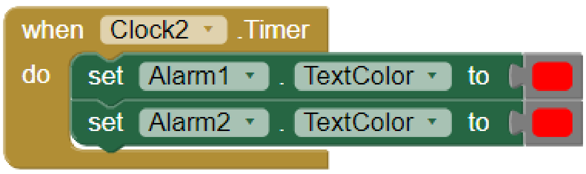


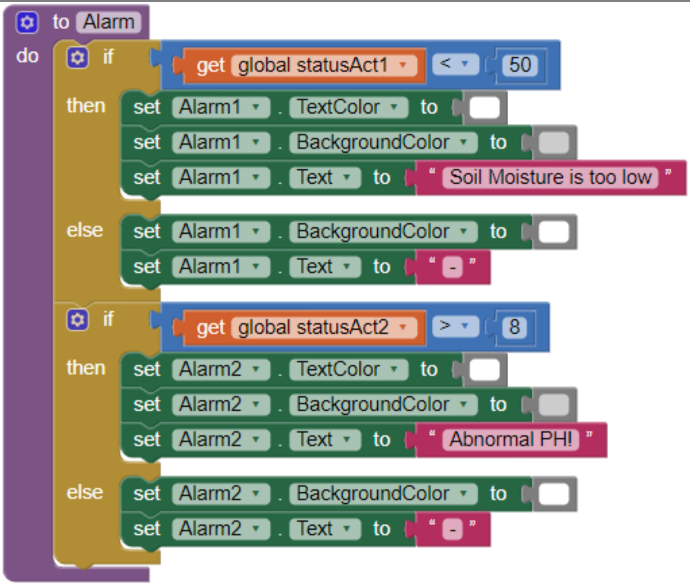
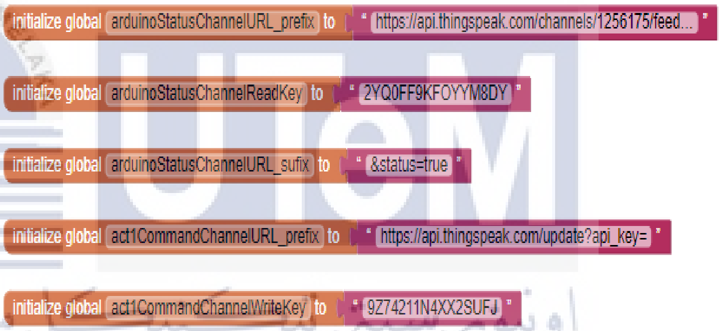
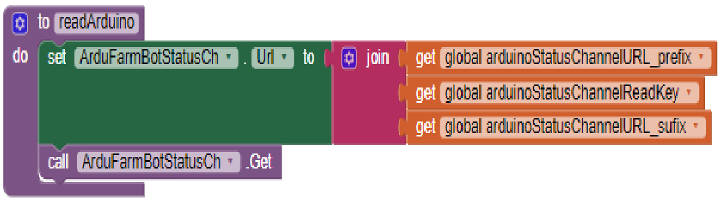
Figure 3.20: Application interface view

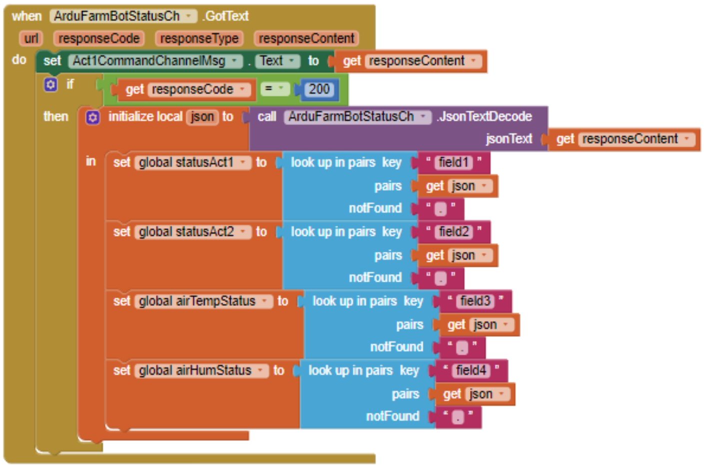
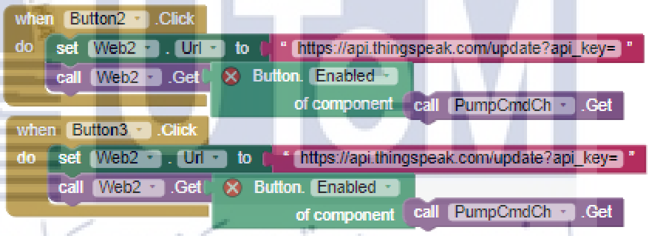
3.4.1.2 Block Part

All the components in the designer part will be activated or programmed at the blocks parts. It uses block-based programming language to function it. Table 3.1 will show the explanation on how it arranged.

Table 3.1: Description for Block Part

<table>
<tr><td>The parameter had to been initialize.</td><td>
</td></tr>
<tr><td>The clock timer had been inserted to call upon Arduino and set the parameter has been initialize.</td><td>
</td></tr>
<tr><td>The clock had been set to trigger alert.</td><td>
</td></tr>
</table>

<table>
<tr>
<td>The alarm been set according to threshold value, if the moisture is below than 50 it will notified in the application or the pH greater than 8 will notified too.</td>
<td>
</td>
</tr>
<tr>
<td>Initialize the Thingspeak channel by inserting Channelkey, Readkey,Writekey to monitor the parameters via cloud.</td>
<td>
</td>
</tr>
<tr>
<td>Set the channel by calling from Readkey.</td>
<td>
</td>
</tr>
</table>

The parameters had arrange according to field of ThingSpeak cloud data reading.	
The button 1 had set to open ThingSpeak channel	
The button 2 and button 3 had been set to control the actuator system.	

3.4.2 ThingSpeak

There was an account been created on ThingSpeak platform for this system. The channel had given a name of Plant Monitoring System. Besides, the channel setting had been configured in field section based on the parameters that going to be analyze which were be temperature, humidity, soil moisture and pH as shown in Figure 3.21.

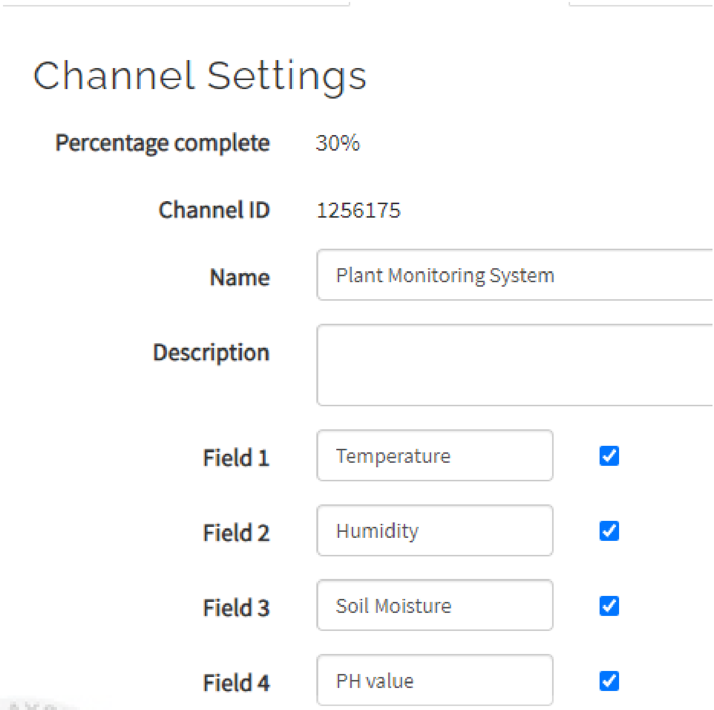


Figure 3.21: Channel setting for the parameters.

After setting up the field by the parameter that going to be analyzed, the parameters according to the field will be preview in the dashboard channel of the ThingSpeak platform as in Figure 3.22.

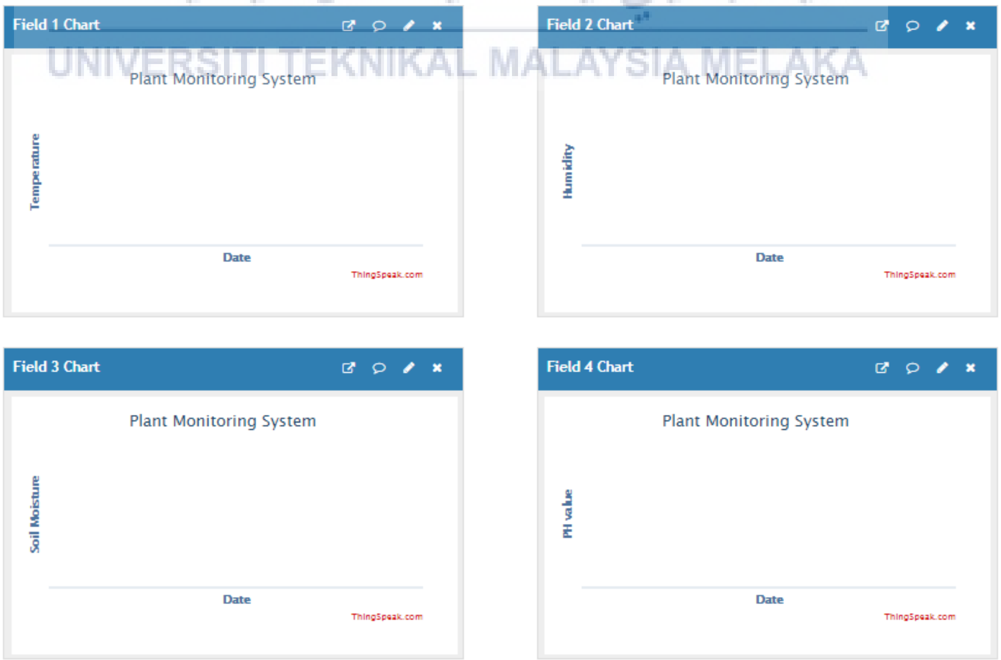


Figure 3.22: Dashboard parameters preview of Thingspeak

3.4.3 Arduino Ide

The Arduino IDE was used to write coding for Arduino and ESP 8266.Please refer to Appendix A and B for the coding details.

3.4.4 Setup for smart farming system

A small scale of farming and irrigation system had been set up with the system had been developed before as shown in Figure 3.23.

Figure 3.23: Set up for small scale farming system

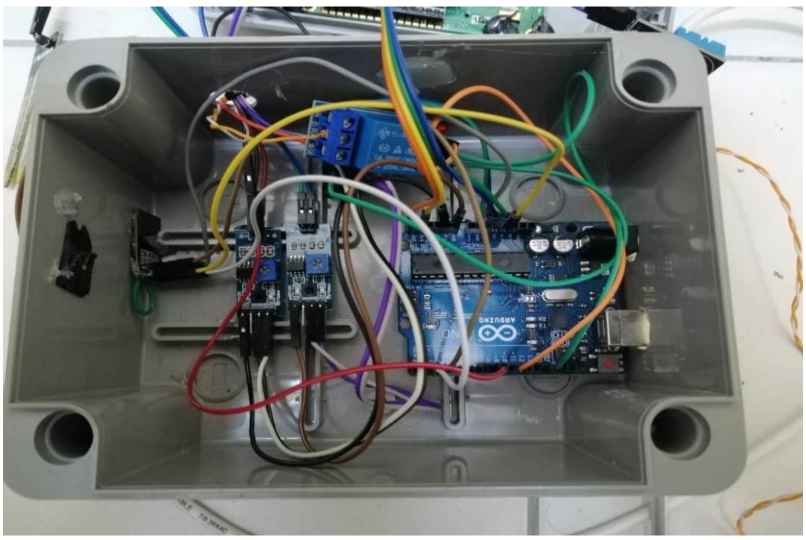


Figure 3.24: Circuit connection of the system

Table 3.2: Shows pin configuration of the system

Hardware Component	Hardware pins	Arduino pins
Soil Moisture sensor	A_0	A_0
	GND	GND
	VCC	5V
DHT11 sensor	Output	8
	VCC	5V
	GND	GND
PH sensor	Output	A_1
	VCC	5V
	GND	GND
LCD	SCL	A_5
	SDA	A_4
	VCC	5V
	GND	GND
Esp 8266	3v3	3.3V
	Rx	Tx 1
	GND	GND
Relay	Common Contact	Connect to pump
	VCC	Connect to power supply
	Input	A_{10}
Pump	Connect to relay module and power supply	

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

This chapter will discuss the results obtained from the project. The final outcome of this project is being shown and explained thoroughly. Data collecting and data recording were made for first 30 days to analyze the vegetative traits of plants with a suitable temperature, humidity, soil moisture and pH value. Furthermore, the usage of fresh water had been controlled. All the analysis of this project will be presented here to achieve the project goals which validates the performance of developed system.

4.2 Result and Discussion for the Analysis

The project had been designed and implemented in the okra plant to obtain data and monitor the parameters such as temperature, humidity, soil moisture and pH. The data had been tabulate and analyze the parameter which had fulfilled the needs of okra plant.

4.2.1 Analysis for the vegetative traits of the plant based on parameters.

The okra plants width and length of leaf had been analyzed based on parameters. The parameters had kept constant as the requirement of the plant for 30 days to have a better growth on the okra plant.

4.2.1.1 Results from IoT platform

The application interface which been designed by using MIT App Inventor as in Figure 4.1 shows the reading of the parameters such as temperature, humidity, soil moisture and pH value which been gain from the okra plant.

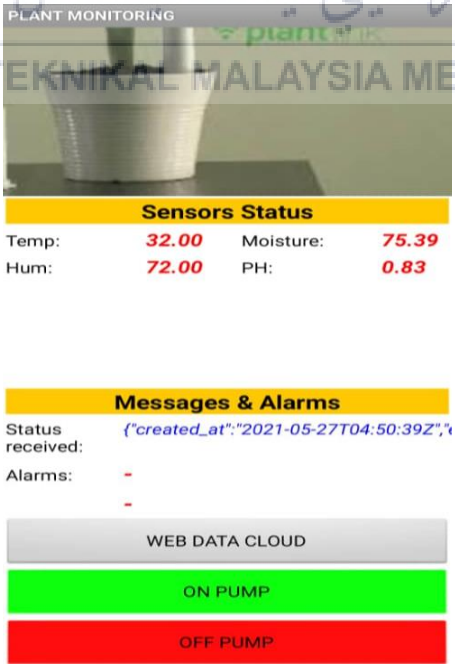


Figure 4.1: Parameters value from the application [51]

DHT 11, Soil Moisture and pH sensors were used to analyze the optimum parameter for the okra plant. Figure 4.2 shows the graphical representation of the values obtained and stored from the sensors via Thingspeak platform. The four field shows data for 30 days' analysis on temperature, humidity, soil moisture and pH.

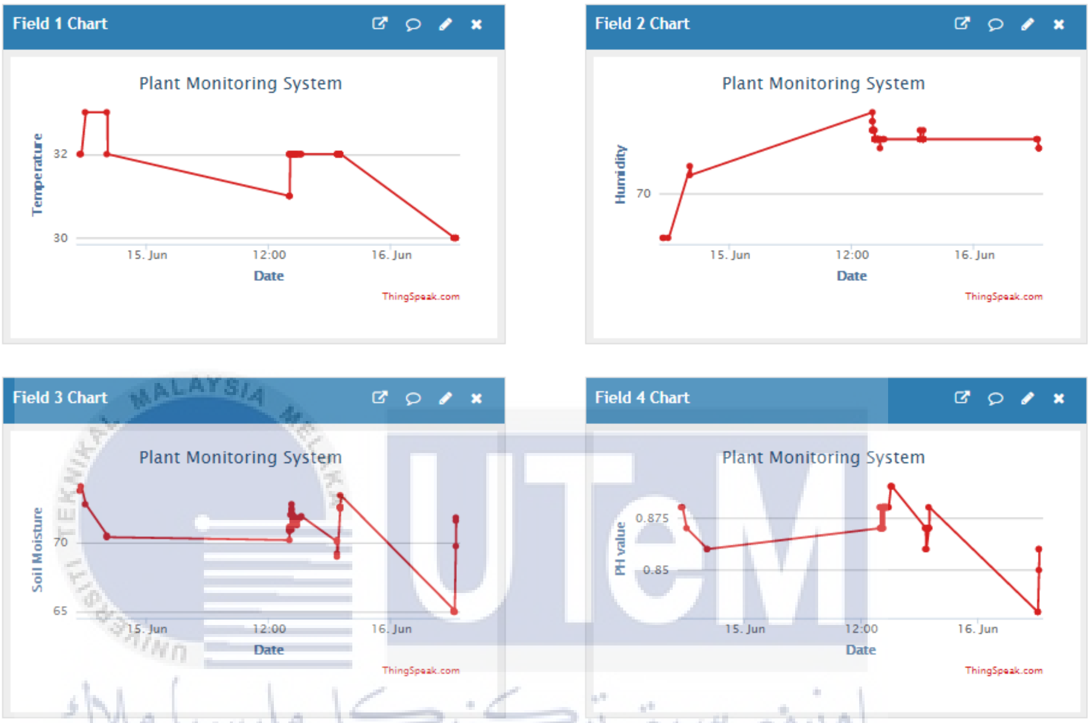


Figure 4.2: Reading of parameters value from Thingspeak platform

4.2.1.2 Graph based on surrounding temperature and humidity

The analysis based on suitable surrounding temperature and humidity value of okra plant for the first 30 days were tabulated and attached in Appendix A. The data analysis of the results attached shown in Figure 4.3 and Figure 4.4.

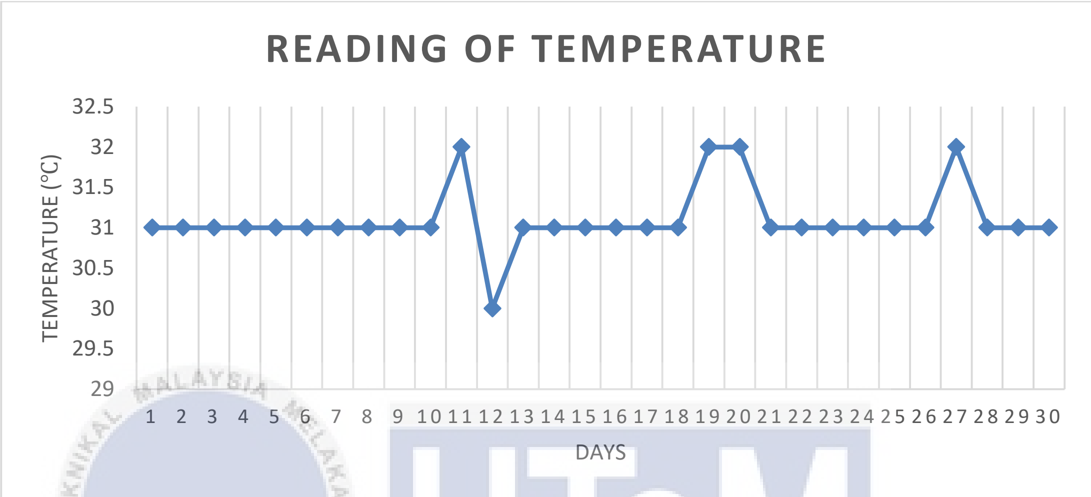


Figure 4.3: Graph for temperature value

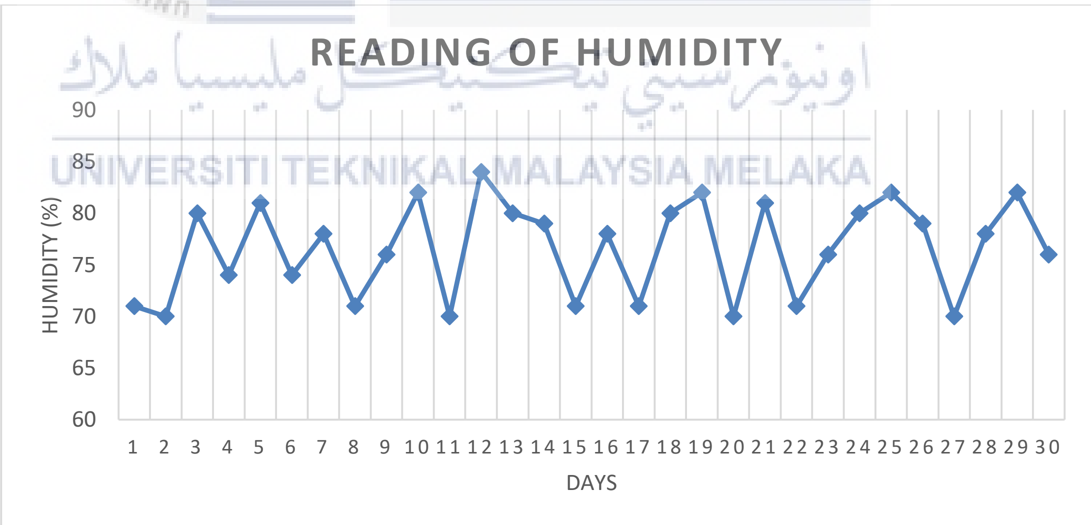


Figure 4.4: Graph for humidity value

During this project, the temperature value was keep constant for 30 days according to the okra plant requirement which is (29℃-33℃). The temperature had been slightly fluctuating when it comes to raining season. The good atmospheric occurs when the temperature have a constant value of 31℃ as shown in Figure 4.3. The highest temperature value reached was 33℃ which was on a warmer day and the lowest reading that been recorded was 30℃. As per the analysis, when the humidity level is more than 70% is consider as good level for the okra plant as in Figure 4.4. The highest recorded humidity level is 85% and the lowest measured level was 70%. To conclude, the best parameter value had been identifying through the analysis.

4.2.1.3 Graph based on soil moisture

The analysis based on soil moisture value of okra plant for the first 30 days were tabulated and attached in Appendix A. The data analysis of the results attached below:

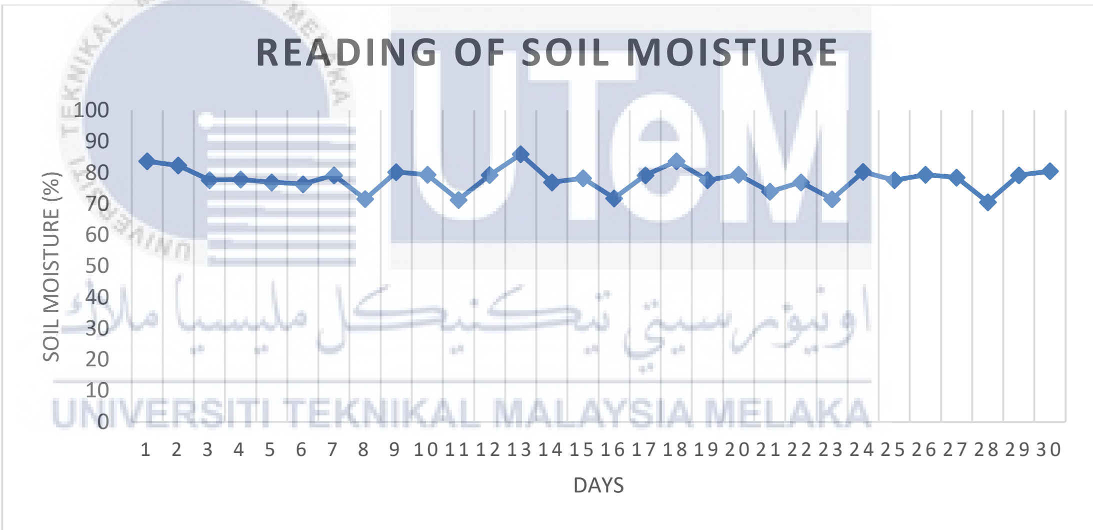


Figure 4.5: Graph for soil moisture value

Soil Moisture content is a crucial parameter when talking about farming system. Every plants need enough moisture in this soil to have a good healthy growth. According to the analysis, the amount of soil moisture for okra had retain more than 70% as shown in the Figure 4.5. The highest value been recorded was 90% and the lowest value was 70%. If the level of moisture is less than 40% the okra plant leaves will turn into yellowish due to lack of water for the roots. From this analysis, soil moisture depends on the amount of precipitation intensity of water consumption by plants. If soil having higher level of moisture it could help the crops to have a faster growth rate compare to before.

4.2.1.4 Graph based on pH

The analysis based on pH value of okra plant for the first 30 days were tabulated and attached in Appendix A. The data analysis of the results attached below:

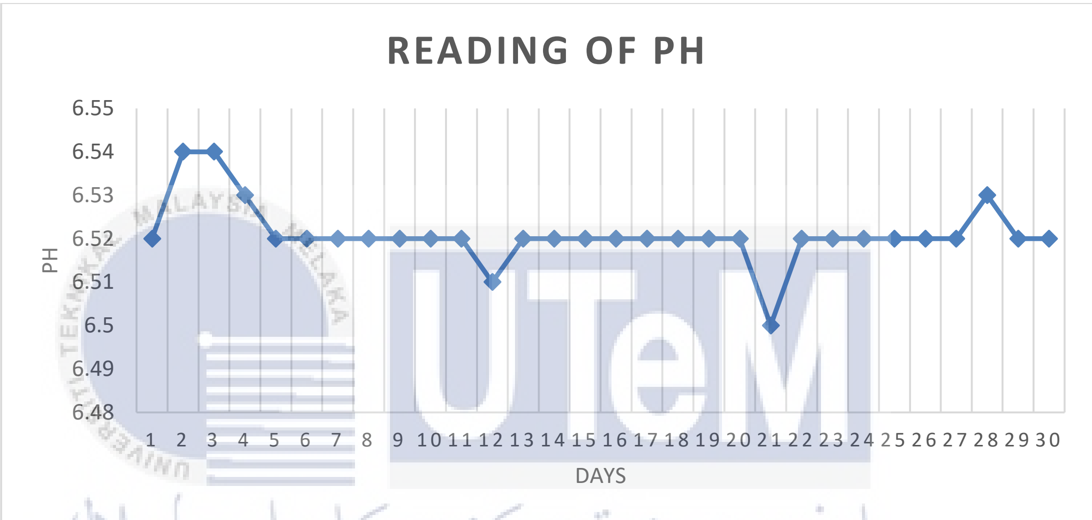


Figure 4.6: Graph for pH value

During this project, a range of pH value (5.5 - 6.5) was kept constant for 30 days as in Figure 4.6 to measure the vegetative traits of plants which is the leaf length and leaf width in cm. The vegetative traits of plant were gradually increased to the applied pH value. It was showed that the plants also get sufficient important nutrients from the nutrient solution (A+B). Based on the Figure 4.7, the chart shows essential nutrients for plants and the pH level where plants can absorb these nutrients. The thicker the line of nutrient is, the better the plants are able to take it up. According to the chart when pH moves to both ends, the ability for the plants to absorb the nutrients is severely affected. So, the ideal spot where plants can take up many minerals is in the middle, precisely from 5.5 – 6.5. This is also the range that is commonly used for crops in the farming system. Even though different plants may require different pH value, the okra plants in this farming system safely grew within this range.

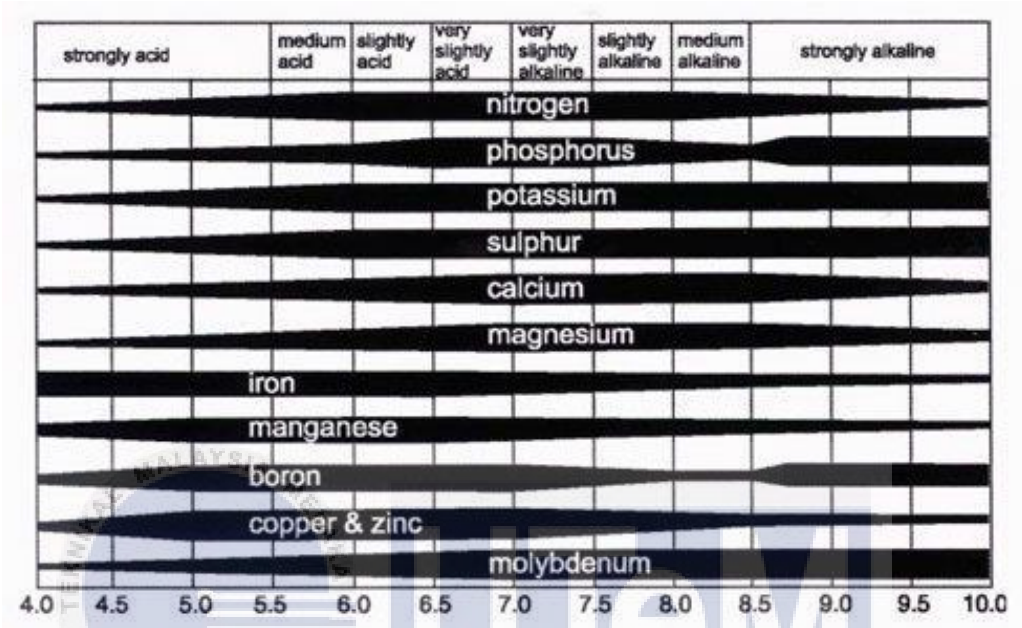


Figure 4.7: Chart for pH Vs Nutrient Availability [51]

4.2.1.5 Graph based on plant vegetative traits

The vegetative traits of an okra plant had been analyzed for 30 days and it gives out a well respond as shown in Figure 4.8 and Figure 4.9. This wireless system had helps to gives a good output which the leaf length and leaf width had a better in the growth compare to traditional farming. The average full growth of okra plant will be approximately 60 to 75 days but when using this system, the okra plant had a well growth within 55 days. The measurement of the vegetative was noted in centimeter unit because can easily observe.

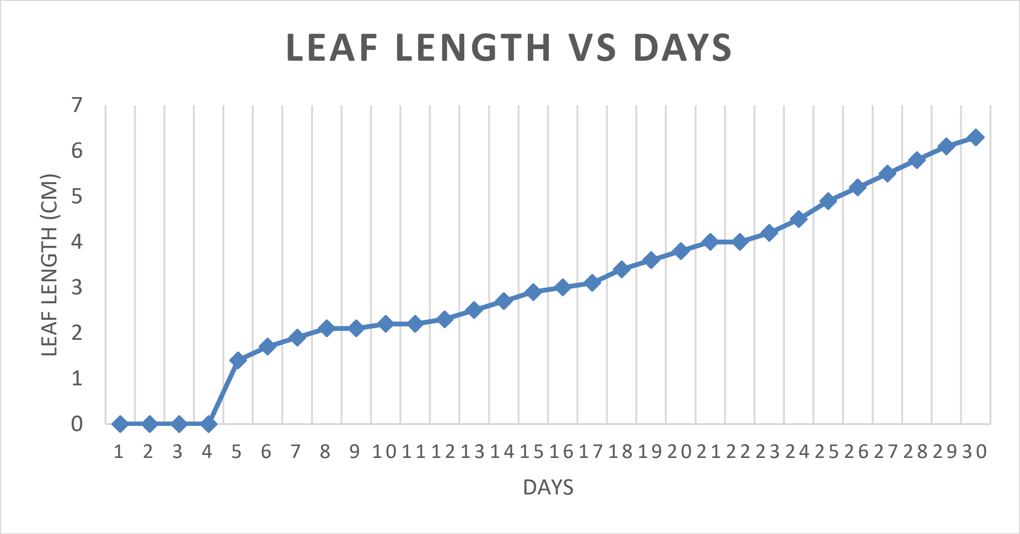


Figure 4.8: Graph of Leaf Length Vs Days

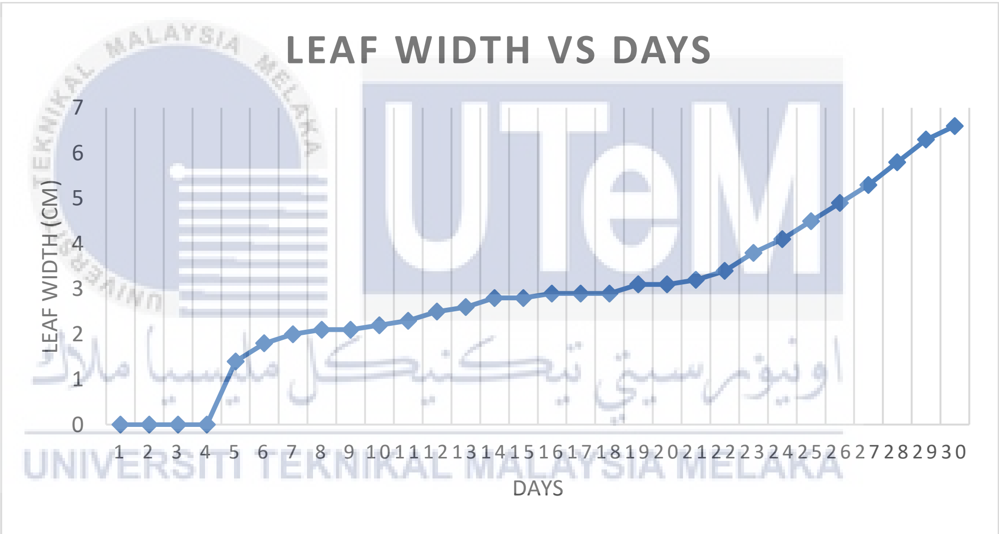


Figure 4.9: Graph of Leaf Width Vs Days

CHAPTER 5

CONCLUSION AND FUTURE WORKS

5.1 Conclusion

After completing this project, it can be concluded that the system works perfectly as planned. It fulfills the two objectives stated in the beginning of this project which are to develop a smart farming application which can monitor the parameters such as temperature, humidity, soil moisture and pH value, to optimize the use of water by using the controlling system and to analyze vegetative traits of plants using suitable value of temperature, humidity, soil moisture and pH using ThingSpeak. Furthermore, the smart farming system is an efficient method applying of nutrients solution in which the irrigation system used as carrier and the distributor for the plants. In a nutshell, the smart farming system using IoT is very suitable for commercial agriculture for maximize profit and yield.

5.2 Environmental and Sustainability

In this agriculture technology world, smart farming playing an important role by increasing the efficiency of water usage or optimization of inputs or treatment. Nowadays, IoT platform or application become one of the important aspect in smart farming. The farmer can monitor the yard or field condition from anywhere. This IoT system is highly effective way compare to manual approach. This project will give out a beneficial output for the farmers

5.3 Future Work

This system has its own potential for improvement and adaptation. Therefore, several recommendations would like to be proposed as part of future work. First and foremost, we can implement irrigation scheduling controllers include soil moisture sensor controllers. Soil moisture sensor controllers can be placed below ground in the root zone of plants known as root zone sensors (RZS) to determine their water needs. The soil moisture sensor estimates the soil volumetric water content. The controllers can be adjusted to open the valves and start irrigation once the volumetric water content reaches a user-defined threshold. Besides, the water and the nutrients solution are stored in containers in this project. Therefore, the user has to check the water content and nutrients solution content to make sure it is sufficient to irrigate to the plants. For further improvement, we can add up the water level sensor in the storage tank to indicate and monitor the water level and nutrients solution level in the IoT platform by interfacing the sensor with NodeMCU ESP8266. Lastly, we can implement a solar based smart fertigation system using IoT. Therefore, in future we can use solar pump combined with affordable drip irrigation kit in wide variety of high value crop to increase the irrigation efficiency.

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APPENDICES

APPENDIX A

ARDUINO CODING FOR UNO MODULE

```
#include <LiquidCrystal_I2C.h>

#include <Wire.h>  // Comes with Arduino IDE

#include <dht.h>

#include <SoftwareSerial.h>

//LiquidCrystal_I2C lcd(0x27, 2, 1, 0, 4, 5, 6, 7, 3, POSITIVE);  // Set the LCD I2C address

LiquidCrystal_I2C lcd(0x3F, 2, 1, 0, 4, 5, 6, 7, 3, POSITIVE);  //some address is different

SoftwareSerial ss(2, 3); //(RX,TX)

int Mode=0;

dht DHT;

#define DHT11_PIN 8   //Connect to pin A1

#define PUMP 10  //Define relay for the pump

int Timerx=0;

String Status="STOP";

float Hum,Temp,Sens1;

float Soil,PH,Sens2;
```

```
void setup(void)
{
  lcd.begin(16, 2);
  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("Initializing..");
  lcd.setCursor(0, 1);
  lcd.print("pls wait");
  delay(2500);
 Serial.begin(9600);
 ss.begin(9600);
 pinMode(PUMP,OUTPUT);
digitalWrite(PUMP,LOW);
}
void loop(void)
{
//--------------------------------Parameter Calculation--------------------------------------
    Sens1 = analogRead(A0);          // Define A0 pin and read the value from the sensor
  Soil= (5.0 * Sens1)/1024.0;  //convert the analog data to moisture level
Soil=110-((Soil/4.5)*100.0); // conversion within the range of 100
if (Soil<0){
  Soil=0;
}
    Sens2 = analogRead(A1);          //read the value from the sensor
  PH= (5.0 * Sens2)/1024.0;   //convert the analog data to moisture level
```

```
PH=100-((PH/5)*100.0); // convert the optimization value which is pH 6.5
if (PH<0){
  PH=0;
}
//----------------------------------PIR MOTION-------------------------------------------
 int chk = DHT.read11(DHT11_PIN); // define DHT11
  switch (chk)
  {
    case DHTLIB_OK:
    //Serial.print("OK,\t");
    break;
    case DHTLIB_ERROR_CHECKSUM:
    //Serial.print("Checksum error,\t");
    break;
    case DHTLIB_ERROR_TIMEOUT:
    //Serial.print("Time out error,\t");
    break;
    case DHTLIB_ERROR_CONNECT:
        //Serial.print("Connect error,\t");
        break;
    case DHTLIB_ERROR_ACK_L:
        //Serial.print("Ack Low error,\t");
        break;
   case DHTLIB_ERROR_ACK_H:
```

```
    //Serial.print("Ack High error,\t");
        break;
      default:
      //Serial.print("Unknown error,\t");
      break;
    }
Temp=DHT.temperature ;
Hum=DHT.humidity;
lcd.clear();            // set lcd cursor to display characters
lcd.setCursor(0, 0);
lcd.print("Moist:");
lcd.print(Soil,0);
lcd.print(" T:");
lcd.print(Temp,1);
lcd.print("C");
lcd.setCursor(0, 1);
lcd.print("H:");
lcd.print(Hum,0);
lcd.print("%");
lcd.print(" PH:");
lcd.print(PH,0);
if (Soil>30){
Timerx++;
if (Timerx>80){
ss.print("*");
```

```
ss.print(Temp);
ss.print("*");
ss.print(Hum);
ss.print("*");
ss.print(Soil);
ss.print("*");
ss.print(PH);
ss.print("#");
ss.println();
Timerx=0;
      }
delay(10);
 //######################################################
while (ss.available()) {            //set serialsoftware to control on and off pump
char inChar = (char)ss.read();
if (inChar =='3') {
digitalWrite(PUMP,HIGH);
delay(600);
 }
if (inChar =='2') {
digitalWrite(PUMP,LOW);
delay(600);
        }
      }
    }
```

APPENDIX B

CODING FOR ESP 8266 MODULE

```
#include <ESP8266WiFi.h>

#include "ThingSpeak.h"

// Set the channel's thingspeak API key,SSID and password

String apiKey = "9Z74211N4XX2SUFJ";

const char* ssid = "server";

const char* password = "12345678";

const char* server = "api.thingspeak.com";

String Temp1x="";    //Define the number of parameters

String Temp2x="";

String Temp3x="";

String Temp1y="";

String Temp3y="";

String Temp2y="";

String Temp4x="";

String Temp4y="";

int Timer=0;
```

```
int Mode=0;
int DataIn=0;
WiFiClient client;
unsigned long Channel = 1256175;     // define ThingSpeak channel
unsigned int field4 = 1;
unsigned int field5 = 2;
void setup()
{
Serial.begin(9600);
WiFi.begin(ssid, password);
Serial.println();
Serial.println();
Serial.print("Connecting to ");
Serial.println(ssid);
WiFi.begin(ssid, password);
while (WiFi.status() != WL_CONNECTED)
{
delay(500);
Serial.print(".");
}
Serial.println("");
Serial.println("WiFi connected");
ThingSpeak.begin(client);
}
void loop()
```

```
{
 while (Serial.available()) {
  //---------------------------
   // get the new byte:
   char inChar = (char)Serial.read();
 //  Serial.write(Serial.read());
   // add it to the inputString:
   // if the incoming character is a newline, set a flag
   // so the main loop can do something about it:


   if (inChar != '*' && inChar != '#' && DataIn==1) {
     Temp1x+=inChar
   }
   if (inChar != '*' && inChar != '#' && DataIn==2) {
     Temp2x+=inChar
   }
   if (inChar != '*' && inChar != '#' && DataIn==3) {
     Temp3x+=inChar;
   }
   if (inChar != '*' && inChar != '#' && DataIn==4) {
     Temp4x+=inChar
   }
   if (inChar == '*') {
     DataIn++;
   }
```

```
  if (inChar == '#') {
      DataIn=0;
     Temp1y=Temp1x;   Temp3y=Temp3x;      Temp2y=Temp2x;
     Temp4y=Temp4x;
     Temp1x="";
     Temp3x="";  Temp2x="";
     Temp4x="";
if (client.connect(server,80)) {


//---------------------------Think Speak Read---------------------------
String postStr = apiKey;
postStr +="&field1=";
postStr += Temp1y;
postStr +="&field2=";
postStr += Temp2y;
postStr +="&field3=";
postStr += Temp3y;
postStr +="&field4=";
postStr += Temp4y;
postStr += "\r\n\r\n";
client.print("POST /update HTTP/1.1\n");
client.print("Host: api.thingspeak.com\n");  //https://api.thingspeak.com/update.json
client.print("Connection: close\n");
client.print("X-THINGSPEAKAPIKEY: "+apiKey+"\n");
client.print("Content-Type: application/x-www-form-urlencoded\n");
```

```
client.print("Content-Length: ");
client.print(postStr.length());
client.print("\n\n");
client.print(postStr);
Serial.println("....Post data to server");
}
client.stop();
   }
 }
```

APPENDIX C

THE MEASUREMENT OF VEGETATIVE TRAITS AND PARAMETERS.

Notes:

A (cm) = Leaf Length

B (cm) = Leaf Width

Table A: The measurement of vegetative traits, temperature, humidity, soil moisture and pH value of the plant

Days	A (cm)	B (cm)	Temperature value	Humidity value	Soil Moisture value	pH value
1	0	0	31	71	83.63	6.52
2	0	0	31	70	82.27	6.54
3	0	0	31	80	77.59	6.54
4	0	0	31	74	77.78	6.53
5	1.4	1.4	31	81	76.91	6.52
6	1.7	1.8	31	74	76.26	6.52
7	1.9	2.0	31	78	79.13	6.52
8	2.1	2.1	31	71	71.49	6.52

9	2.1	2.1	31	76	80.18	6.52
10	2.2	2.2	31	82	79.29	6.52
11	2.2	2.3	32	70	71.26	6.52
12	2.3	2.5	30	84	79.20	6.51
13	2.5	2.6	31	80	85.90	6.52
14	2.7	2.8	31	79	76.90	6.52
15	2.9	2.8	31	71	78.19	6.52
16	3.0	2.9	31	78	71.75	6.52
17	3.1	2.9	31	71	79.13	6.52
18	3.4	2.9	31	80	83.63	6.52
19	3.6	3.1	32	82	77.58	6.52
20	3.8	3.1	32	70	79.29	6.52
21	4.0	3.2	31	81	73.84	6.50
22	4.0	3.4	31	71	76.91	6.52
23	4.2	3.8	31	76	71.44	6.52
24	4.5	4.1	31	80	80.21	6.52
25	4.9	4.5	31	82	77.56	6.52
26	5.2	4.9	31	79	79.32	6.52
27	5.5	5.3	32	70	78.41	6.52
28	5.8	5.8	31	78	70.49	6.53
29	6.1	6.3	31	82	79.13	6.52
30	6.3	6.6	31	76	80.42	6.52