FACULTY OF ENGINEERING

REPORT PROPOSAL

EPE 4036 PROJECT

Project Title: Integrated IoT Solutions for Smart Farms

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Abstract

Nowadays, food security is very important to overcome food shortage due to Malaysia still relying on the fruit and vegetables. Therefore, there is the need for local industry for fruit and vegetables and technology development can be complicated and there is the motivation to investigate possibility to implement some IoT solution to reduce and relying on manpower and enhance the efficiency for local farming industry. This integrated IoT solution for smart farms is expensive and complicated. It also redundant given to small area farm which do not need machine learning and costly technology for farming production. This can be solved by developing a simple IoT solution by sensor and low cost and using some of the ready app to achieve the technology for farming. Besides that, farm security is one of the main problems faced by farmers. There can prevent farmers' fruit and vegetables steal by other by using smart farm security solutions. One of the main objectives is development simple IoT integrated solution for fruit and vegetables farm which is used to improve fruit and vegetable productivity and growth. It is used with some sensor to monitor and control the fruit and vegetables to collect and record all the data needed. At the end of the project, the proposal also inspired low cost IoT solution which are fit for small area for food plantation farm.

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1. Introduction

1.1. Background Overview

Agriculture plays a vital role in improving farming lands through smart agriculture. To meet the increasing demand for food, many countries are investing more in these sectors. However, the global food production rate has declined since the late 20th century because of an increase in population and a decrease in cultivable land. According to the United Nations, the world population will reach 8.5 billion by 2030 and 9.7 billion by 2050. Furthermore, global warming is affecting agricultural production globally in a drastic way. With 75% of the world's population engaged in farming, the demand for a solution to this ongoing food production crisis and global warming has never been higher. To solve these problems, the agricultural sector must further develop and implement cutting-edge technologies. Real-time monitoring can be done using sensors that allow plantation areas to be monitored and statistical data to be viewed via smartphones, laptops, tablets, etc. Furthermore, implementing farm security solutions is essential to protecting farmers' crops. Through the Internet of Things (IoT), farmers can react in time and take further precautions to handle issues as they arise.

In the future, every industry will need to embrace Industry 4.0 to survive. Fourth industrial revolution is defined as the umbrella term for a new paradigm of industrial technology that encompasses such technologies as the Internet of Things (IoT), Artificial Intelligence (AI), Augmented Reality (AR), real-time communication, big data, remote sensing, monitoring, and control. Modern industries rely heavily on these technologies to increase productivity and reduce costs [1] [2]. Smart agriculture is transforming industrial farming with Industry 4.0 integration [3]. Over the last few decades, the population has exploded, creating a high demand for food, and the agricultural sector has become a necessity. A variety of solutions are available using IoT to ease the farmer's work and reduce food storage and production problems.

Automatic plant monitoring and controlling of the climatic parameters that affect the plant's growth and, therefore, the plant's production. The automation of industrial machinery and processes replaces human operators. A plant monitoring system technology is provided feedback to the user via a smart phone. Using an automated system will reduce the need for manpower, thus reducing errors. Using this technology, farmers can easily monitor the efficiency of the system using their smart phones in a large area where it is quite difficult for them to monitor it manually. Due to our busy lives, farmer is not able to maintain proper plant care, such as watering plants and checking if they receive enough sunlight. As a solution to this issue, developing an IOT based automation monitoring system that allows users to monitor plant parameters like temperature, humidity, moisture, rain as well as water them.

The Internet of Things has become a key technology for smart farming, especially in remote areas. It allows data to flow between backhaul and edge computing systems with sensors, actuators, and other on-the-ground devices [4]. Data transmission and communication is one of the crucial aspects of IoT in smart farming, so choosing the right communication technology is crucial. Much scientific research has been conducted on communication techniques and protocols used in smart farming. This research includes protocols and features for networking, reducing energy consumption, enhancing robustness and scalability, etc [5].Other widely used IoT technologies include low-power WiFi, Bluetooth Low Energy (BLE), DASH7, and LoRa/LoRaWAN [6]. Long-distance wireless connectivity technologies can transmit over 100 meters, such as cellular networks (2G/3G/4G/5G) and Low-power wide area networks (LPWANs). Low-power long-distance networking is a cutting-edge communication technology designed specifically for systems that require long-distance communication at low power.

Farming security solution also plays an important role for smart farming. Sticks and ropes are the only security measures available when building fences, which can be time-consuming and stressful and in turn limit farmers from farming on a large scale [7]. Install a surveillance video system and motion detector with an alarm. Intruders will be scared away from the farm premises as soon as an alarm is raised, whether they are birds, animals, or humans [7]. As a result, the owner of the farm will not have to rush to the farm immediately after receiving an alert [7]. This is because a normal alarm will scare many animals off.

1.2. Project Scopes and Objectives

1.2.1 Project Scopes

The general scope of this final year project would be to develop an embedded IoT system that would be used to read and analyze the farm environment and implement farm security system. The farm plantation would be in a fruit tree and vegetable scenario whereby the system would be used for farmer purposes.

The first main project would create an IoT system that monitors the moisture of soil, temperature surroundings, weather humidity and appears of rain. It has some sensor features to monitor and control the plantation that applies to collect and record all the data needed for growth of fruit tree and vegetable. All the data collected from the client's node will be sent to the master node through the Internet network. Data that is collected will be saved into the cloud. Then, the Blynk application is used for presenting the data and controlling the main system. The second scope is to build a farm security system that detects any intruders such as birds, animals, or humans at farm area and implement surveillance camera system to capture intruders' picture and real time monitor the situation happen in farm.

This project scope includes the ability of solar panels to power up whole system which lining up with Sustainable Development Goals (SDGs) goal number 7: Ensure access to affordable, reliable, sustainable, and modern energy for all [8]. Solar energy is a renewable resource that will never run out and no negative impact on the environment. In this recent years, solar technology becomes cheaper, more efficient and environment friendly. This project also let user easy access the plantation data and real time monitor at anytime and anywhere via mobile Blynk application and pc desktop. Additionally, the model allocates some variables such as soil water levels and environmental factors such as temperature and humidity for the purpose of measuring soil parameters. The most common use of these parameters is to keep track of the progress and changes being made to the crop field. The executive remarks on the project scopes can be summarised into the following:

- To enable IoT sensor to transmit and store data using firebase cloud database via the Internet network and LoRa.
- Using Blynk mobile application for real time plantation monitor.
- Implement solar energy as power supply for whole IoT smart farm system.

1.2.2 Project Objectives

The main objective of this project is to implement a low-cost affordable, high quality, high efficiency, and user-friendly autonomous integrated IoT-based solution for smart farm by using LoRa wireless technology. In this technology, sensors are implemented to read and record the data to monitor the farm plantation by applying IoT solution. This project also aims to design the packaging for the shield to protect the system by external or internal damage. To achieve these main objectives, there are several specific objectives which include:

1) To develop IoT-enabled plant sensor technology and upload the data to IoT Platform.

2) To design a solar power system to power the smart farm monitoring and farm security system.

3) Develop a mobile application to allow users to view information obtained from the sensor about the condition of fruit tree and vegetable, view real time video of farm and receive notification when detect any intruders via smart devices.

2. Literature Review

2.1. Introduction

In this chapter, the literature review of the project will cover development for agricultural and some technologies in farming industries. Section 2.2 covers agriculture and farming industries in globally and Malaysia. Section 2.3 describes several technologies has been implemented in farming industries and spilt into 5 minor section which are grow light technology, farm monitoring, farm security, drone technologies and machine learning. Also, current state of arts technology is covered in section 2.4 by examining the most recent ideas and methods for technologies in farming industries. Finally, in section 2.5 the problem statements are stated with the solutions to solve the problem are proposed.

2.2. Agriculture and farming industry

Agriculture encompasses all activities related to growing crops and raising animals, which provide food and materials for people to use and enjoy [9]. Farming, also known as agriculture, is the process of growing and harvesting food, fibre, and animal feed. In [10], the history of agriculture begins in the Fertile Cresent. The first irrigation is Egypt and Mesopotamia in the fourth millennium B.C. floods. British agricultural productivity increased dramatically between the 17th and 19th centuries during the British Agricultural Revolution. As agriculture technology evolved over time, it has continued to improve. In the 1830s, the mechanical combine harvester was invented, a machine that harvests grain. During the early 1900s, the horse-drawn plow sparked the introduction of more agricultural machinery. Agricultural equipment was hauled by steam-powered tractors, which were too expensive for most farmers. In 1892, the gasoline-powered tractor was invented. Agriculture was revolutionized by the development of hybrid seeds, particularly hybrid corn. Pesticides and fertilizers, as well as genetically modified organisms, have been the subject of a great deal of controversy over the past 10 years. There has been a significant impact of agriculture on human civilization throughout history.

Besides that, agriculture brings several good impacts to worldwide. Agriculture is one of the important industries to contribute GDP of the country all over the world. According to International Trade Administration data, U.S.-Malaysia agricultural trade in 2020 was $2.15 billion, with a $2.7 million trade deficit recorded by the United States [11]. In 2020, Malaysia's global agricultural trade was $45.5 billion, with imports totalling $18.7 billion and exports totalling $26.8 billion [11]. After Indonesia, Malaysia produces and exports the most palm oil in the world. Malaysia palm oil production accounted for 26 percent of world production and 34 percent of world exports in 2020 [11].

Major Products, Market Shares by Value, and Competitor Situations			
Product Category (2019)	**Major Supply Sources (2019)**	**Foreign Supplier Situation**	**Local Supplier Situation**
Dairy Products Net Imports: $1.56 billion	New Zealand: 29 percent Thailand: 12 percent U.S.: 10 percent Australia: 9.5 percent	New Zealand and Thailand are strong competitors in the market due to free trade agreements. The United States is one of the largest suppliers of whey.	Local production is insufficient to meet consumer demand.
Beef Net Imports: $5.29 million	India: 75 percent Australia: 14 percent New Zealand: 4.4 percent Brazil: 4.2 percent	Major foreign suppliers have a significant portion of their beef industry halal-certified for export to Malaysia. Beef from India is very cheap and serves low-end outlets. Australia dominates the higher-end market.	Inadequate supply of local beef.
Wheat and Wheat Flour Net Imports: $326 million	Australia: 34 percent U.S.: 24 percent Canada: 15 percent Ukraine: 12 percent	Australia is a strong competitor in the wheat and wheat flour market. Demand for high-quality U.S. wheat for the local baking industry is growing.	No local production

Processed Fruits Net Imports: $2.31 million	China: 28 percent U.S.: 17 percent Thailand: 11 percent Tunisia: 9 percent	Dried and processed fruits from China and Thailand are price competitive. U.S. raisins are currently in very strong demand in the retail and bakery industries.	Limited local production.
Tree Nuts Net Imports: $1.83 million	Indonesia: 38 precent U.S.: 19 percent China: 12 percent Vietnam: 5 percent	Imported nuts are in increasingly strong demand for use in the bakery and snack food industry.	Limited local production.
Potatoes (Fresh, Chilled and Frozen) Net Imports: $1.72 million	China: 52 percent Pakistan: 10 percent Bangladesh: 10 percent U.S.: 7 percent	Chinese potatoes are price competitive. High quality potatoes from the United States and other sources are in demand for the high-end retail market, the chipping industry, and for the manufacturing of snacks. U.S. frozen potatoes dominate the fast-food chain industry.	Limited domestic production.
Pork (Fresh, Chilled, and Frozen) Net Imports: $5.8 million	Germany: 42 percent Spain: 16 percent Singapore: 14.5 percent Netherlands: 12.4 percent	Currently E.U. prices are competitive and several E.U. plants are approved for export to Malaysia. Demand for U.S. pork has increased significantly in 2020 and multiple U.S. plants are now approved to export to Malaysia.	Domestic demand for pork has grown significantly over the past several years and local industry is limited.

Figure 2.1 & Figure 2.2: Malaysia's Food and Agricultural Market [11]

Moreover, agriculture plays the important role to solve the food security problem worldwide. In 2019, almost 690 million people went hungry, up by 10 million from 2018 and by nearly 60 million in five years, according to the latest UN estimates (SOFI 2020)

[12]. Moreover, billions of people do not have access to healthy or nutritious food due to high costs and low affordability.

In paper [13], economic growth and development are strongly influenced by agriculture. As a source of food, it is a cornerstone of human existence. In addition to providing industrial raw materials, it contributes to economic activity in other sectors as well. Agriculture consumes a significant number of natural resources, especially land and water. The quality and availability of these resources are greatly affected by its activities. In terms of biodiversity, agriculture has a major impact on ecosystems and non-agricultural plants and animals. In addition to soil degradation and erosion, air and water pollution, and loss of biodiversity, agricultural activities can negatively impact the environment (generate negative environmental externalities). Agricultural activities can also have positive externalities, such as creating and maintaining attractive landscapes, ensuring water supplies, and maintaining wildlife habitats.

2.3. Technologies in farming industries

In this section, we focus more on the technology development that was used in this project that had been developed and implemented by others worldwide over many years. It is referred to some different technologies in smart farming which consist of grow light technology, farm monitoring technology, farm security technology, drone technologies and AI & machine learning technology.

2.3.1 Grow light

A grow light emits a spectrum of electromagnetic radiation that is suitable for photosynthesis, making it an artificial source of light that stimulates plant growth [14].When natural light is lacking or additional light is needed, grow lights are commonly used. The use of grow lights can increase the speed of plant growth, for example, during the photosynthesis process of fruit and vegetables. Indoor farming operations can completely replace direct sunlight with grow lights. As well as fluorescent grow lights, HPS or HID grow lights, and LED grow lights are three basic types of grow lights available for indoor urban farming. In indoor gardens, fluorescent grow lights are used for growing fruits and vegetables. Many commercial and experienced indoor growers use high-pressure sodium (HPS) grow lights. Among all three basic types of grow lights, LEDs produce the least amount of heat and are the most energy efficient [14].

The author in reference [15], this paper aims to study an effective way of light using for plant growth. The author proposed an automatic plant nursey as figure 2.3.1 which user can automatically control system of plant nursey for panting shallot. It can water the plant automatically, controlled the temperature and controlled the light. Based on the block diagram, this paper chosen Arduino uno R3 as microcontroller. The input part consists of 2 components which are DHT sensor is used to detect the temperature and real time clock (RTC) to set time for watering the plant and cooling pad. For output part, the fan, first pump, second pump solenoid valve and LED lamp is implemented. Besides that, this paper controls the temperature by using PID control and detecting the temperature by DHT sensor. If temperatures are detected higher than the set point, fan will be activated for lower down the temperature. The evaporation technique is implemented in this paper for cooling system. For light control, LED and grow light will turn on and off at same time to observe the effectiveness of LED and grow light.

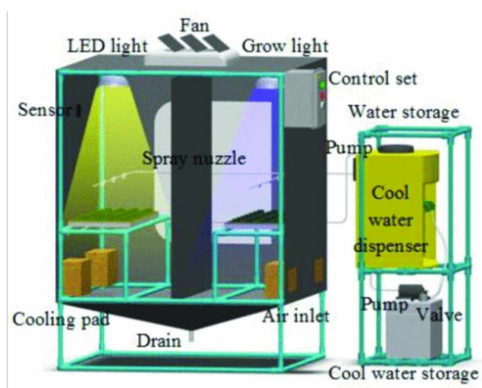

Figure 2.3: automatic plant nursey [15].

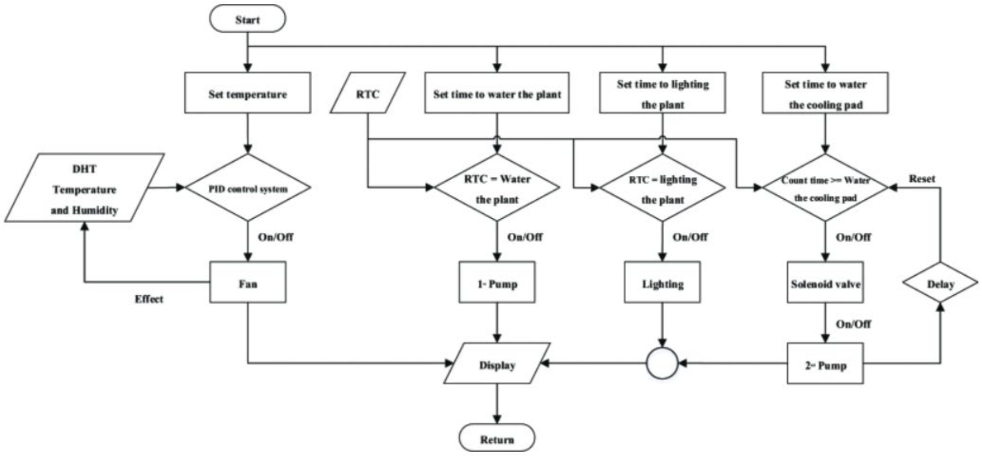

Figure 2.4: flow diagram of automatic plant nursey [15].

In paper [16], the author proposed a testbed for plant growth using supplemental LED lighting. It aims at providing an easy-to-use lighting system with adjustable photosynthetic photon flux density output. The testbed system will be used as a simple platform toward developing more sophisticated Internet of Things smart greenhouse systems. It aims at providing an easy-to-use lighting system with adjustable PPFD output and mixing colour ratios for creating customized light recipes. It has the capability to conduct testing for a wide range of research activities including lighting control, IoT monitoring and management. During development process, design of daylight harvesting-based lighting control strategy on a simulated environment in stage 1. Meanwhile, implantation of embedded lighting control system for energy-efficiency and daily light integral (DLI) control. Raspberry Pi controller with a 4G LTE cellular mobile router is chosen as microcontroller for this paper. The study in this paper addresses the applicability of a testbed with a intelligent LED lighting control system.

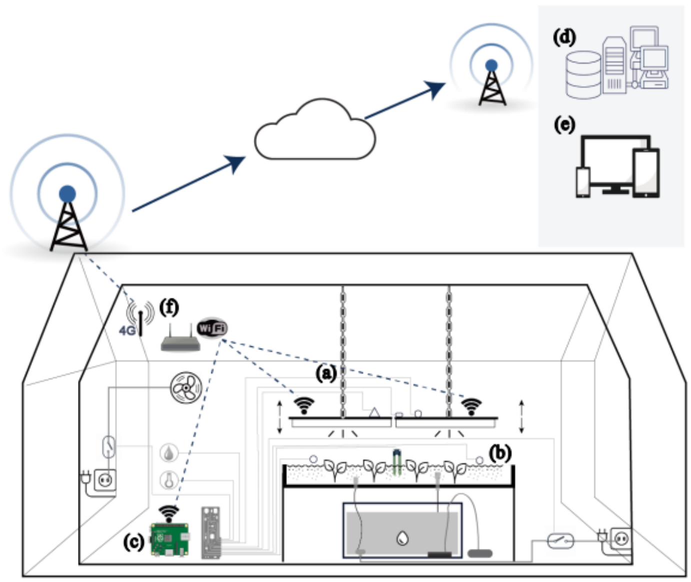

Figure 2.5: Overview of the testbed greenhouse environment: (a) An intelligent lighting control system, (b) Plant growth system, (c) Local controller, (d) Remote data server, (e) End-user with access through a cellular network, (f) A 4G cellular network [16].

In reference [17], the research had been performed on the growth and development of cherry radish using different arrangements of lamp beads as light sources. The experiments were conducted at Guangdong Province's Key Laboratory of Intelligent Equipment Technology Innovation. At 15 cm, the arrangement and combination of LED lamp beads significantly affected the uniformity of light intensity. Increasing the yield and quality of crops grown under artificial light can be accomplished through the regulation of the light environment. The aboveground and belowground organs of cherry radish grew more effectively under staggered or linear LED treatments. In the plant factory, the daytime temperature was 24 °C, the night-time temperature was 20 °C, and the relative humidity was 60%. From the day of transplanting, random sampling was carried out every 4 days, with the remaining samples evenly distributed.

In paper [18] , the author study investigated possibilities of using solar panels for powering low-power Internet of Things sensors in modern applications in agriculture. Autonomous energy harvesting smart sensors are promising research area in several application domains, such as agriculture or meteorology. LED grow lights are equipped with several red and blue light sources having various wavelengths that are dynamically configured over the course of the growing phase to maximize plant growth efficiency.

2.3.2 Farm monitoring

By the end of 2050, International Business Machines (IBM) predicts that IoT will enable farmers to increase production rates by 70% [19]. In the agricultural and farming industries, farm monitoring systems play a crucial role. Farm monitoring provides farmers with a range of metrics for managing these tasks effectively. Soil condition is an invaluable indicator for farmers who want to determine the most optimal time for planting and harvesting their crops [19]. By monitoring soil moisture and salinity with IoT sensors, farmers can be alerted instantly. In addition, farmers can now be alerted to changing weather conditions in terms of temperature, humidity, and rainfall by weather monitoring solutions located directly in the field.

The research article reviewed for this project is “Plant Monitoring System”. In this paper, the researchers are proposed to design an IoT based automation system in which user can monitor plant parameters such as temperature, humidity, moisture and watering the plant [20]. A system that consists of several sensors was proposed. In the system, DHT11 temperature and humidity sensor was used to monitor the temperature of humidity at farm area and moisture sensor is used to detect the moisture of the soil. The system was controlled using a Node MCU microcontroller. The system was also connected to a relay to switch on or off the enter water pump. It’s connected between the normally open terminal and the circuit ground. The values detected by sensor will be sent through API to database. The farm owner monitors several farm’s condition via mobile application. At the same time, the system will be watering the plant when moisture and humidity is at low value. By this work, the wastage of water and the consumption of power by motor can be reduced so that they are conserved for future use. Figure 2.6 shows the circuit diagram from the proposed system.

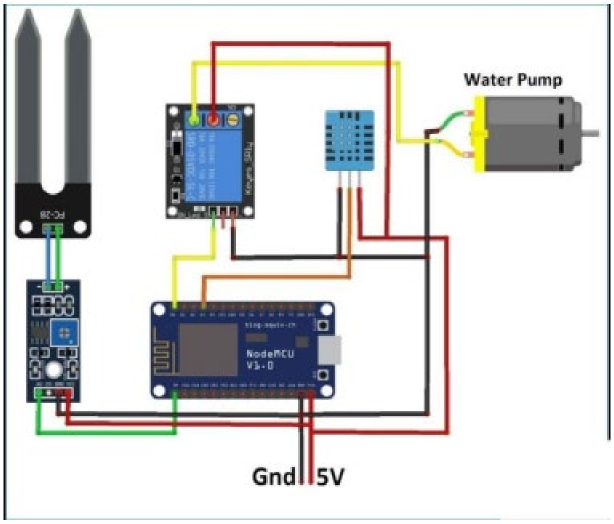

Figure 2.6: the circuit diagram from the proposed system [20]

The paper reviewed for this project is “Deployment of a LoRa-based Network and Web Monitoring Application for a Smart Farm” [21]. In this paper, the researchers were attempting to present a preliminary architecture for an IoT system with application in a smart farm environment. A web-based platform is developed to provide a user interface allowing the remote management of all the IoT network devices. The proposed system consists of four main parts, the sensor nodes, the control equipment, a cloud server, and a web application platform that allows the user to acquire data and control all the system remotely. This system consists of two networks which are control network by using Siemens S& PLC programmed located at warehouse and the monitoring network by using LoRa wireless located at farm.

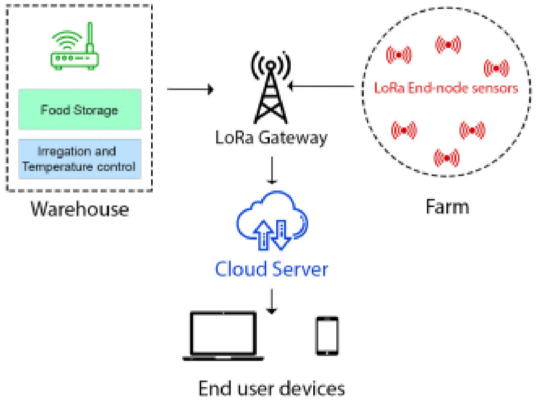

Figure 2.7: Smart farm system architecture overview [21]

In this project, several devices and sensors are controlled inside the warehouse and connected to the PLC [21]. In this system, water pumps are implemented to control the amount of water needed for irrigation. The lighting system is controlled by on/off programing for presence simulation and night activity. The intrusion alarms will activate when the intruders are detected, and LoRa Humidity sensor and LoRa Temperature sensor is used to detect soil humidity and temperature at farm base.

The paper reviewed for this project is “IoT Based Monitoring and Control in Smart Farming” [22]. In this paper, the researchers are proposed to design an IoT-based smart farming system based on internet technology to analyze and monitor the environmental parameter in an agricultural field. This system has implemented several sensors such as temperature and humidity sensor, flame sensor, soil moisture sensor, barometric pressure sensor. Unlike the other research paper, the flame sensor and barometric pressure sensor are implemented in this system. The flame sensor helps in generating fire alerts by indicating and reading infrared waves emitting from fire, flame, or spark and the capability of this sensor device to capture waves lies in the range of 760 to 1100 millimeters. BMP180 Barometric Pressure Sensor helps in capturing the pressure-related values of the farming environment and the capability of this senor device to capture pressure lies in the range of 300 to 1100 hPa. The system was controlled using an ATmega328 Arduino Uno microcontroller. Ubidots is chosen to act as cloud-based service in this system. Figures 3.3 and 3.4 show the block diagram and the flowchart of the system.

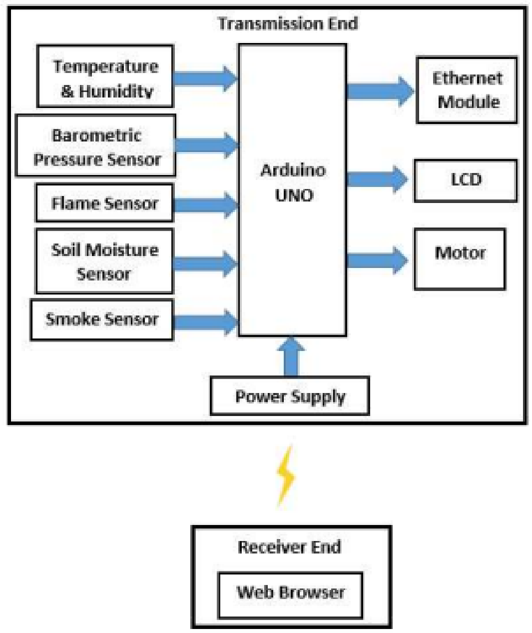

Figure 2.8: Block diagram of IoT Based control system [22]

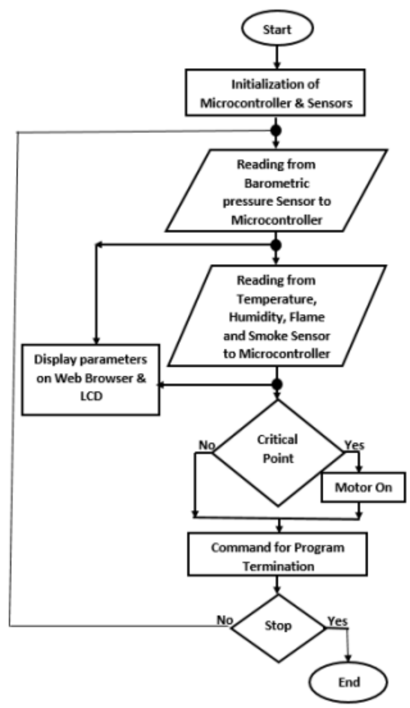

Figure 2.9: System Flowchart for IoT Based control system [22]

The paper reviewed for this project is “IoT Based Smart Farming: Are the LPWAN Technologies Suitable for Remote Communication” [23]. The researchers in this article show the comparison among LPWAN technologies such as weightless, LoRaWan and Sigfox to facilitate IoT over wireless communications for smart farming. LoRaWan is a a long-range low-power wide-area network technology as defined by LoRa Alliance. The NB-IoT is a narrow-band communications protocol for IoT applications, which uses 180 kHz of bandwidth. Sigfox is a uni-directional communication protocol and is a dedicated end-to-end approach for IoT connectivity. Figure 2.10 shows the comparison of LPWAN technologies.

Table I
COMPARISON OF LPWAN TECHNOLOGIES.

	LoRaWAN	SigFox	NB-IoT
Bandwidth	125 kHz	100 kHz	200 kHz
Frequency	ISM Band 433, 868, 915 MHZ (We used 915 MHz in Australia)	ISM Band 433, 868, 915 MHZ	Licensed LTE Frequency
Modulation technique	CSS	BPSK	QPSK
Coverage Range	5 km(urban), 11 km (open area)	10 km (urban), 40 km (open area)	1 km(urban), 10 km (open area)
Maximum Output Power	27dBm	14dBm	23dBm
Battery Lifespan	10 years	10 years	15 years
Maximum payload length	243 bytes	12 bytes (UL), 8 bytes (DL)	1600 bytes
Bidirectional	Yes/Half-duplex	Mostly unidirectional and limited half-duplex	Yes/Half-duplex
Standardization	LoRa-Alliance	SigFox company with ETSI	3GPP

Figure 2.10: the comparison of LPWAN technologies [23]

In this paper [23], it concludes that the LoRaWAN is better suitable for a IoT system that expects long battery life, lower power consumption, highly mobile end devices with very high coverage range. A LoRaWAN communication system increases the communication range of a IoT network to over 10 kilometres wirelessly, allowing the deployment of a large and complex wire-free sensor network in a remote farming land of 10 kilometres without being dependent on a LTE (4G/5G) or other backhaul network to be used.

The paper reviewed for this project is “Smart Farming: The IoT based Future Agriculture” [24]. The researchers in this article proposed a proposed an IoT system to monitor the plantation to let farmers monitor needs of the crop and soil by selective and effective use of fertilizers and pesticides. The smart farming application provides farmers with information such as temperature, water level in tank, soil moisture level and humidity to improve the quality of crops and production rate. The smart farm also reduces costs and improves efficiency of farming. In this project, the researchers used raspberry Pi as microcontroller for the system. DHT11 is used for detecting the temperature of the farm environment and YI-69 soil moisture sensor is used to measures the amount of water in the soil. The project implements thingsboard server as database to collect and save data from sensor and the data is published on the MQTT broker. All collected data form a large data set can be useful to train a learning model to predict future changes in the field attributes. The research mentions that machine learning can be used to detect unidentified objects like to prevent crops from animals using camera motion sensor and set the alert to farmer via MMS service. Figure 2.11 arrangement of modules of whole system [24].

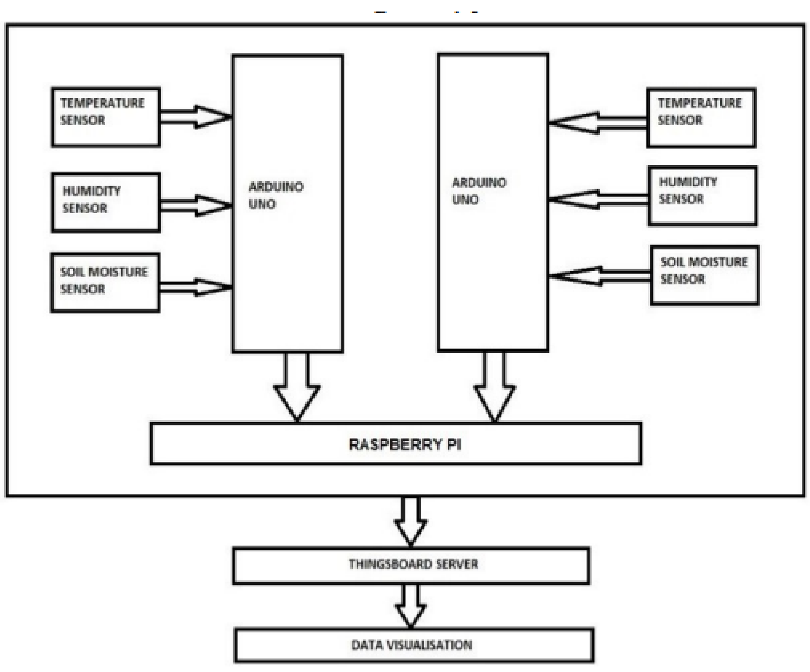

Figure 2.11: Arrangements of Modules [24]

The paper reviewed for this project is “Sensor Based Smart Agriculture with IoT Technologies: A Review” [25]. In this paper, various types of IoT sensors for smart agriculture is suggested. The IoT sensor include acoustic sensor, FPGA based sensor, optical sensor, ultrasonic ranging sensor, electrochemical sensor, electromagnetic sensor, mass flow sensor, weed seeker sensor, wind speed sensor, eddy covariance-based sensor, in smart agriculture soft water level-based sensor, light detection and ranging, telematics sensor, soil water content sensor, location sensor, leaf wetness sensor, temperature and moisture sensor, PH sensor and optoelectronic sensor. The challenges for adopting IoT for agriculture are lack of infrastructure, high cost and lack of security. Usually, the IoT integrated solution for farms is costly compared to traditional agriculture. The data might be stolen and manipulated if someone gains unauthorized access to IoT provider’s database. Figure2.12 describes the various types of IoT sensors in smart agriculture field.

Figure 2.12: Various Types of IoT Sensors in Smart Agriculture [25]

In journal report [26], The LM-393 sensor is used to monitor the amount of sunlight the plant is receiving. Based on this amount, it can be determined whether the crop is receiving an optimal amount of light. The project aims at helping the farmer be more at ease about his crops by giving him real time updates and complete control over his field from anywhere in the world. The application features a timer using which a farmer may set the duration for which he wants a particular state change.

2.3.3 Farm security

Farm security cameras monitor properties 24/7, alerting you to any intrusions or burglaries. Security cameras deter intruders from entering your farm and capture the identities of any thieves.

The paper reviewed for this project is “A Micro Controller based Monitoring System for Cattle Farm Security” [27]. The work done in this paper concludes that this can be an efficient security-providing system. It uses an ultrasonic sensor, a microcontroller, and a GSM module as the major components. In this paper, we propose a security system that utilizes a microcontroller to trigger an alarm when an unauthorized movement or intrusion is detected. Regardless of a person's presence, an intrusion can be detected every time it occurs. In a very efficient and low-cost manner, this can be used to maintain cattle farms and provide them security. In the proposed work, the user will be able to control intruder entry into his farm or cattle field. With the assistance of the approaching information from the ultrasonic sensor, the microcontroller has the capacity to trigger the buzzer. Figure 2.13 shows the proposed system architecture for farm security system.

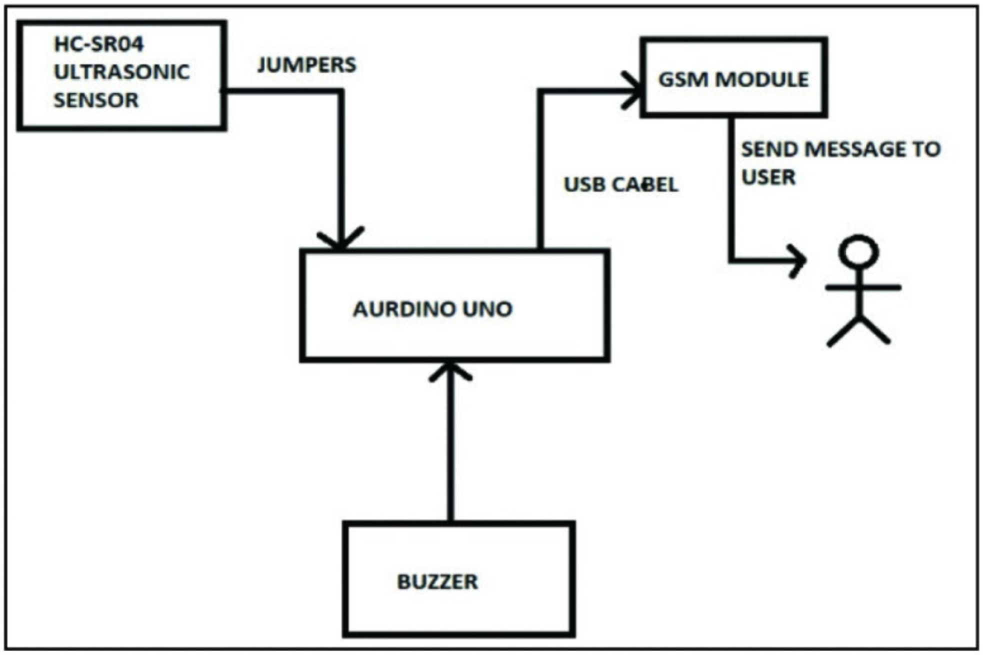

Figure 2.13: proposed system architecture for farm security system [27].

Another article paper [28], a IoT design of smart security system for farm protection from intruders had been proposed. The IoT system design consists of an Arduino Uno which is the heart of the system, a Relay module, an ultrasonic sensor, buzzer, camera for capturing image-based operation in security device as figure 2.14. The author developed localization algorithm-based model of farm security. Camera is using for capturing image of intruders that work as record as well as formation and use for further process of taking action. Animal recognition and verification phase where faces detected are directly send to farmers mobile for further action. The aim of our project is to detect the wild animals using ultrasonic sensor and send an alert to the authorized person via GSM module. If output is positive wild animal detected message send to the owner of farm using GSM. Figure 2.14 shows the proposed circuit diagram of farm security system in paper [28].

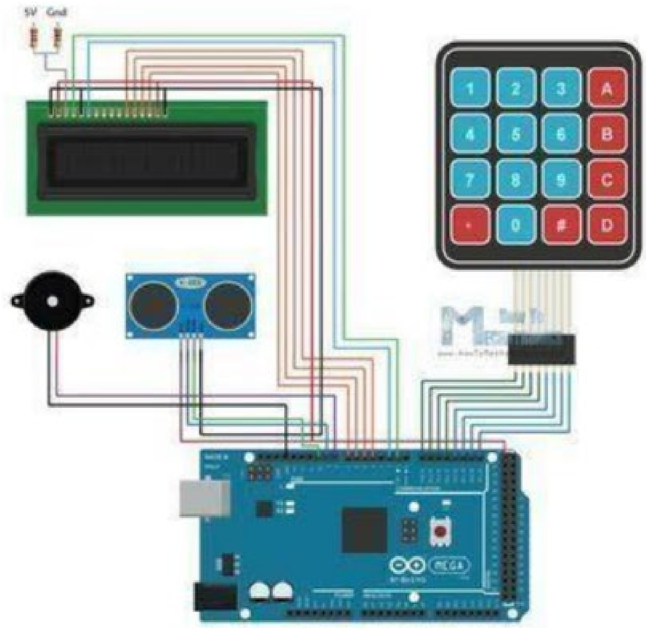

figure 2.14: Proposed circuit diagram of farm security system [28]

Based on Figure 2.15 below [28], it shows the detail of the project flowchart. The project consists of 3 main parts which are the sensing module, IoT platform, and mobile applications. The sensing modules are embedded with a single microcontroller and are separated into two parts which are the transmitter node and receiver node. A transmitter node is a place where the measurement for crop condition is observed. The microcontroller inside the transmitter node will work as its brains and do all the commands which are equipped with a sensing module such as the soil moisture sensor, environment humidity, and temperature sensor, and LoRa module. The requirement for the transmitter node is targeted suitable for outdoor use and it is powered by a solar panel power module.

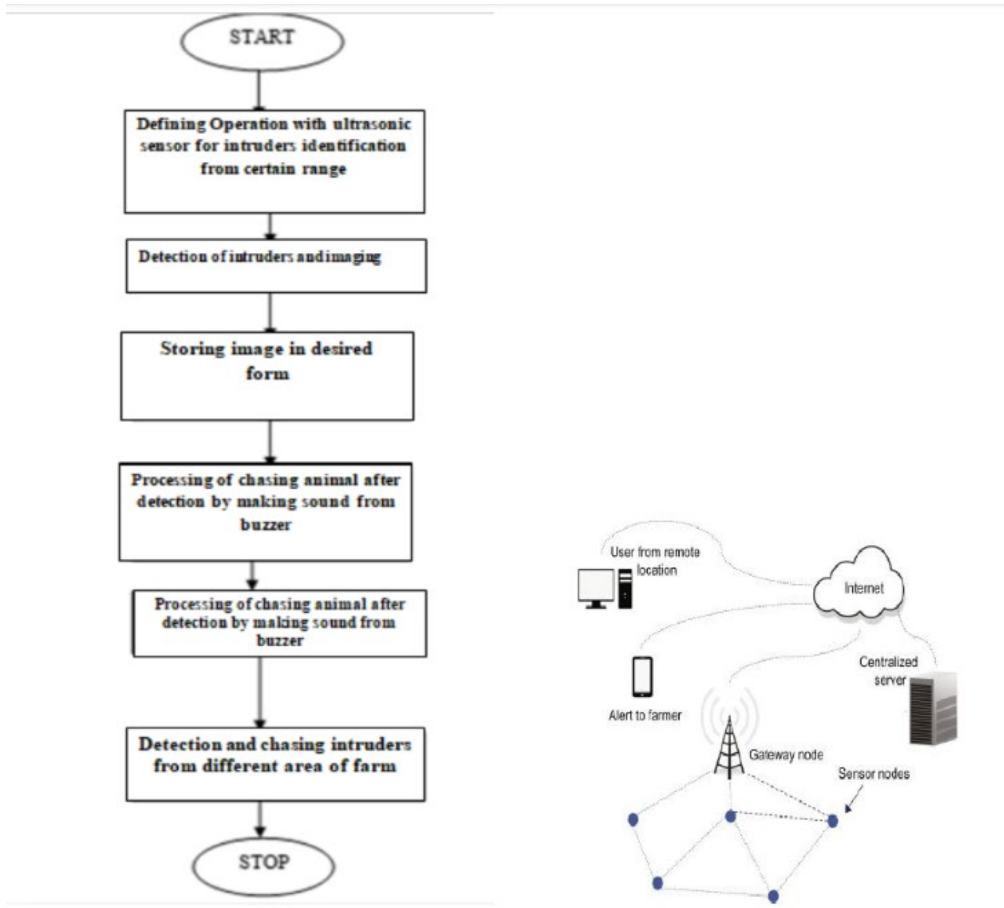

figure 2.15: Proposed working operation in flow chart of farm security system [28]

In paper [29], as part of the security surveillance framework proposed by the author, a digital twin-based anomaly detection model is used to address the security problems faced by the Cyber-Physical Systems ecosystem in the agriculture sector. With the integration of modern Cyber-Physical Systems into existing farming practices, farmers are shifting to smart farming techniques. Existing frameworks emphasize the application possibilities of CPS data. Three modules are proposed in this paper. The first step is to collect and process data. Secondly, there is an anthology of smart farms. A smart farm ecosystem is described using an existing ontology in this phase. The final phase is where the digital twin contains two sub-modules: knowledge graph and anomaly detection. Several anomalous use cases in the smart agriculture ecosystem are analysed by the author in real time. Various anomalous conditions can be identified on smart farms using the digital twin representation-based anomaly detection model. By continuously monitoring the data generated from physical sensors, our digital twin supports CPS security surveillance.

Authors in reference [30], Nigeria being an agricultural country needs some innovation in the field of agriculture and one such innovation is the use of wireless sensor networks (WSNs) to monitor and deter intruders. In 'Design and Implementation of Farm Monitoring and Security System', a research group led by Ibam Emmanuel at the Emmanuel Onwuka Ibam Federal University of Technology (2018) reported that farmlands and plantations in Nigeria and African countries are usually very large scale running into hundreds of acres. Fencing these large expanses of land can be prohibitively expensive and difficult. WSNs have the potential to transform the security of farming in the agricultural sector of any nation. Around the world, the economy of many countries is dependent upon agriculture. This work presents the design and the implementation of WSNs for farm monitoring and security, which are easy to install. This microcontroller-based circuit monitors and controls intrusions by alerting the farm owner after the use of an alarm.

Moreover, another paper named "Security systems for remote farm" [31]. The author shown that neural-based face recognition systems are invariant to changes in illumination for both background and illumination conditions. Using OpenCV's image processing operations, "false positive" pixels can be cleaned up. It is important to compare different face recognition systems. For both background and illumination conditions, a neural-based face recognition system is invariant to changes in illumination. Farmers are increasingly concerned about security. Electronic systems like alarms, access controls, video surveillance, and motion sensors-can be somewhat expensive, but the security that it provides is truly beneficial.

2.3.4 Drone Technologies

Drone agriculture is an effective approach to sustainable agriculture [32]. It allows agronomists, agricultural engineers, and farmers to streamline their operations and gain better insight into crops. Farming on a large scale has already adopted it. Drones have been used in almost every sector of the economy over the past few years. However, drone technology is booming in agriculture. In 2024, the agricultural drone market is expected to grow from $1.2 billion (USD) in 2018 to $4.8 billion (USD) [32].

In journal paper [33], the use of drones in agriculture and in smart farming is very effective because unmanned aerial vehicles (UAV) can give farmers a bird's eye view of their fields. The proposed system employs a commercial low-cost RGB-D camera, an Asus Xtion Pro, for the visual analysis of the soil. Future work will focus on the installation of the sensing component on an Unmanned Aerial Vehicle.

In references [34],the precision agriculture will be achieved by using drones that is used for monitoring the designated area, capturing images of the farming field, generating the data from image processing, identifying the problems, and solving the problems effectively in short interval of time. This paper explores the Unmanned Aircraft System steps in precision agriculture. The precision agriculture will be achieved by using drones that is used for monitoring the designated area. Crop Spraying of chemical, pesticide, and insecticides, fertilizer is more precise than a human. Unmanned Aircraft System (UAS) often called drone is one of the most exciting system that has been developed in the field of aviation. The drone used for precision agriculture follows certain steps to achieve the goal that the farmer desires. The precision agriculture is to implement data and images to solve the problem.

2.3.5 AI and machine learning

Machine Learning a broader approach of Artificial intelligence facilitates machines to learn and produce the output that we the users expect [35]. Water management, disease management, etc are some of the areas where we can find the implementation of Machine

Learning in the field of agriculture. The accuracy of this method was observed at 89.6%. DBSCAN: Density-Based Spatial Clustering of Application with Noise, is usually used for clustering in machine learning or in data mining.

In paper [31], the face recognition is implemented in farm surveillance system. A system of open-cv programming can be used to detect visual objects faster and more accurately. This is a versatile factor for image processing. Matlab and artificial intelligence (AI) can be used to recognize faces. The code is run at OpenCV and Virtual Studio. To improve the detection by ignore background noises from sudden charge in lighting, medium blurr threshold adjustments were added to code. To improve the face recognition, the author implements machine learning on matlab programming and artificial intelligence.

In article report [36], the author introduces farming guru is an application which educates the user with weather prediction, a good crop analysis and provides ways of earning a good capital through renting tools and providing a market survey. This application has a vast scope which can include species recognition, video calling with the farm specialists, machine vision to detect crop health etc. When machine learning came into use for crop production, it showed 80% to 90% growth in India. Few other countries like Indonesia, Columbia and Nigeria have shown a tremendous amount of growth in this sector.

2.4 Current state-of-the-arts technology

Currently, big farmer in Malaysia is using modern technology such as grow light and drone technology for farming purpose. Cameron Highlands is the largest tea-growing region in Malaysia with using grow light technology. Sime Darby and Boustead are focused on oil palm plantation. But small farms usually used traditional methods for farming. They usually used simple and simple and some small solar technologies for farming.

2.5 Problem statements and problem solving

This integrated IoT solution for smart farms is expensive and complicated. It is also redundant given to small area farm which do not need complicated and costly technology for farming production. This can be solved by developing a simple IoT solution with sensors and low cost and using some of the ready apps to achieve the technology for farming. Besides that, farm safety and security are one of the main problems faced by farmers. There can prevent farmers' fruit and vegetables steal by other by using smart farm security solutions.

Besides that, to provide an efficient decision support system using wireless sensor network which handles different activities of farm and gives useful information related to farm. [37]Information will be related to soil moisture, temperature and Humidity and rain. Due to the weather condition, water level increasing farmers get lot of distractions which is not good for Agriculture. The water level is managed by farmers in both Automatic and manual using that mobile application. It will make more comfortable to farmers. Performing agriculture is very time consuming.

Therefore, a plant monitoring and farm security system should be implemented to solve the problems that occurred in the smart farm. This project proposed some solutions to solve the problem occur in vegetable and fruit tree farm by using IoT technology. To fit the needs of smart farms, instead of monitoring soil moisture and temperature, rain appears, and weather humidity also must be monitor and analysis the data received to help our plant grow well. Besides that, farm security issues are also tackled in this project. Users will be able to monitor their plant and will be alerted when some intruders invade detected by the system for immediate action.

3. Methodology

3.1 Introduction

In this chapter, the research methodology of the project will be further elaborated into 7 sections. Section 3.2 discusses the building block diagram of smart farm is listed out. Section 3.3 covers the technology components used to build up the hardware system. Section 3.4 describes the development of hardware and software. Section 3.5 stated the flow chart of the system. Additionally, section 3.6 describes the project activities and the time allocated for each of them. In section 3.7, the description of the project deliverables in accordance with the targeted milestones is mentioned. In section 3.8, the projected timeline for the final year project is shown in the Gantt chart. Finally, section 3.9 stated the project costing analysis and the total estimated budget for the proposed project.

3.2 Building Blocks of the smart farm

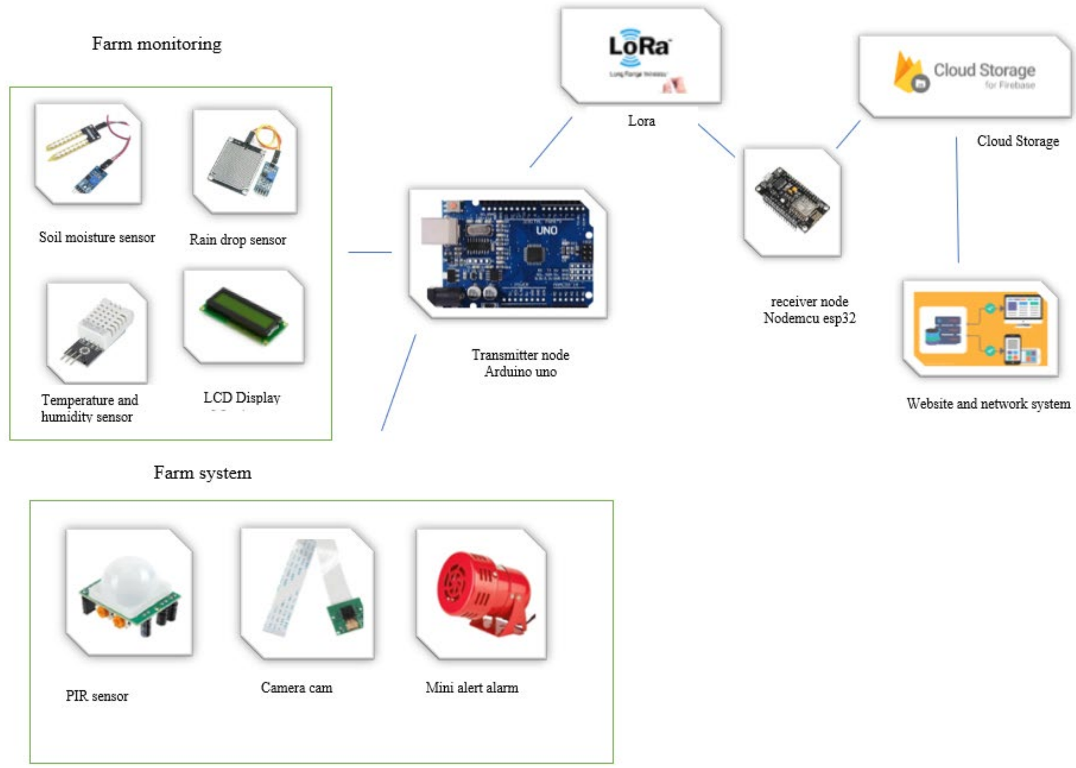

Figure 3.1: The building blocks of the smart farm system

Based on Figure 3.10 above shows the detail of solution implementation in smart farm system. The development of this technology can be explained into 3 major stages which are:

- Initialization stage

  Solar energy acts as a power source for the entire system. After the power supply is connected, the devices will communicate with each other to configure the initial value for sensing and actuator devices among farm monitoring and farm security. Lora is also included in this setup, which operates to transmit data between the transmitter and receiver using radio frequency modulation.

- Microcontroller stage

  In this stage, the actuator and sensor read the data and sends it to the microcontroller when the microcontroller issues a command. Essentially, the Arduino Uno and NodeMcu 8266 is the brain of the system and controls its overall activity. The IoT platform receives and uploads packets of data using Wi-Fi-based hardware connected to the internet network.

- Cloud and Applications stage

  Sensor data will be transmitted to a cloud server and stored there. In order to process the sensor data from the cloud, a mobile application called Blynk will be used. Firebase is chosen as the cloud database to store the data. Using the Bylnk application, you can monitor in real-time any electronic device, such as a smartphone, laptop, or tablet.

3.3 Technology Components

Temperature and Humidity Sensor [38]

The purpose of temperature and humidity sensor will be carried out by DHT22 sensor. DHT22 sensor is a low-cost digital temperature and humidity. It been chosen due to its optimal performance, simple and low cost. DHT22 uses a thermistor and a capacitive humidity sensor to measure the surrounding air and spits out a digital signal on the data pin and no analog input pins are required. It outputs calibrated digital signal. It utilizes humidity sensing technology and exclusive digital signal collecting technique and always assuring its reliability and stability. Its sensing elements relate to 8-bit single chip computer. Every sensor under DHT model is calibrated in an accurate calibration chamber, temperature compensated, and the calibration-coefficient is saved in OTP memory. It will cite coefficient from memory while the sensor is detecting some data.

Temperature and humidity sensor	DHT11	DHT22
Cost	Ultra-Low cost	Low cost
Power	3 to 5V power and I/O	3 to 5V power and I/O
Current	2.5mA max current during conversion	2.5mA max current during conversion
Humidity readings accuracy	20-80% with 5% accuracy	0-100% with 2-5% accuracy
Temperate readings accuracy	0 to 50°Cwith ±2°C accuracy	-40 to 80°Cwith ±0.5°C accuracy
Sampling rate	Less than 1Hz per second	Less than 0.5Hz per 2 seconds
Body size	15.5mm x 12mm x 5.5mm	15.1mm x 25mm x 7.7mm
Number of Pins	4 pins with 0.1" spacing	4 pins with 0.1" spacing

Table 3.1: Comparison between DHT11 and DHT22 [38].

Compared to DHT11, this sensor can detect a longer range of temperature and humidity, more precise and accurate but it’s larger and more expensive. First, DHT22 sensor is slightly more expensive than DHT11 sensor. Second, they have the same power which is 3 to 5V for both input and output, same current which is 2.5mA maximum current during conversion or requesting some data and works at 1Hz. In accuracy, DHT22 has higher humidity and temperature readings accuracy compared to DHT11. DHT22 able to detect from 0 to 100 percent with an average of 2-5 percent accuracy for humidity range and -40 to 80 degrees Celsius with an 0.5-degree accuracy for temperature range. DHT22 body size is slightly bigger than DHT11 which is 15.1mm x 25mm x 7.7mm. The number of pins for DHT22 and DHT11 are 4pins with 0.1” spacing. DHT22 sensor is chosen because it can detect in longer range of temperature and humidity with high performance, precise and accurate.

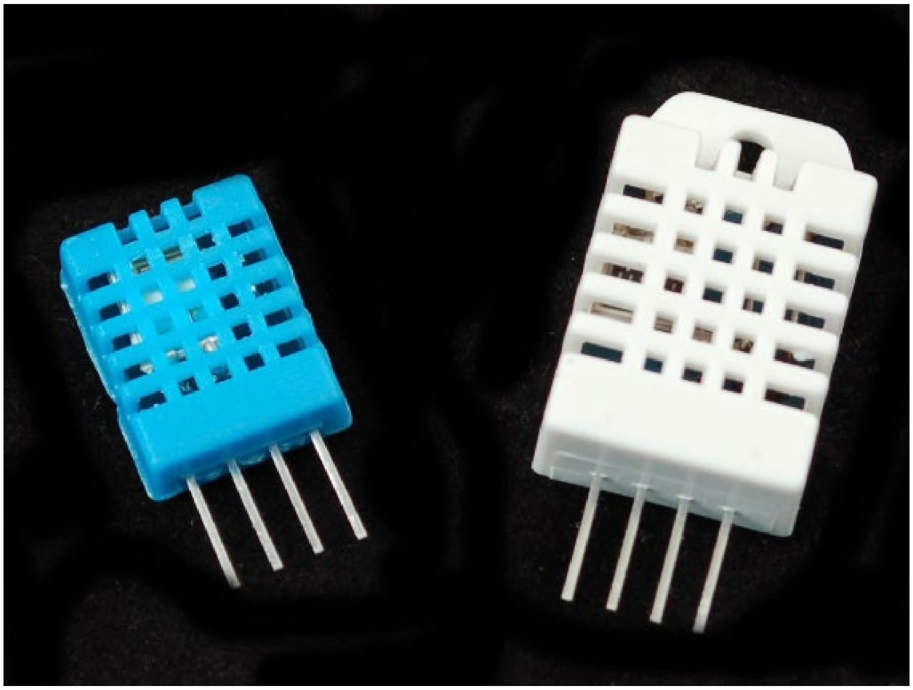

Figure3.2: DHT11 sensor and DHT22 sensor [38]

Soil Moisture Sensor [39] [40]**.**

FC-28 Soil Moisture Sensor measures the moisture content of soil and similar materials [39]. Easy-to-use soil moisture sensors are available. Sensor probes act as variable resistors when combined with the two large pads. Water in the soil will result in a higher AOUT and lower resistance since the soil will conduct electricity better.

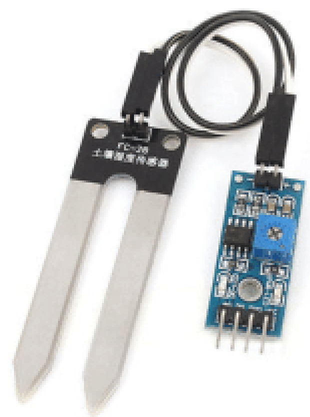

Figure 3.3: FC-28 Soil Moisture Sensor [39]

Moreover, FC-28 soil moisture sensor is a soil hygrometric transducer that can measure soil moisture. Through two probes, the module reads the resistance to get the soil moisture level. When soil is dry, electricity cannot conduct very well in more resistance, but when soil is wet, electricity can conduct more easily in less resistance. Aside from that, FC-28 can also provide enhanced ESD protection and under voltage protection. Fc-28 moisture sensor probes are coated with immersion gold to prevent nickel probes from oxidizing. To determine the moisture content of the soil, the sensor reads the resistance data as current passes through the two probes.

There are some specifications for Fc-28 Soil Moisture. It operates between 3.3V to 5V DC under 15mA. The output digital and output analog is 0V to 5V based on infrared radiation from fire flame falling on the sensor. It contains LEDs indication output and power. The size of FC-28 soil moisture is 3.2cm x 1.4cm and based on LM393 design. Besides that, the applications of Fc-28 soil moisture are used to estimate or measure the amount of water in the soil. It also mainly help to build up irrigation systems and determine the condition in the root zone of a crop or vegetation.

FC-28 Soil Moisture Sensor Pinout contains 4 pins:

Pin name	Pin Number	Description
VCC	1	The Vcc pin powers the module, typically with +5V
GND	2	Power Supply Ground
DO	3	Digital Out Pin for Digital Output
AO	4	Analog Out Pin for Analog Output

Table 3.3: Pin of FC-28 Soil Moisture

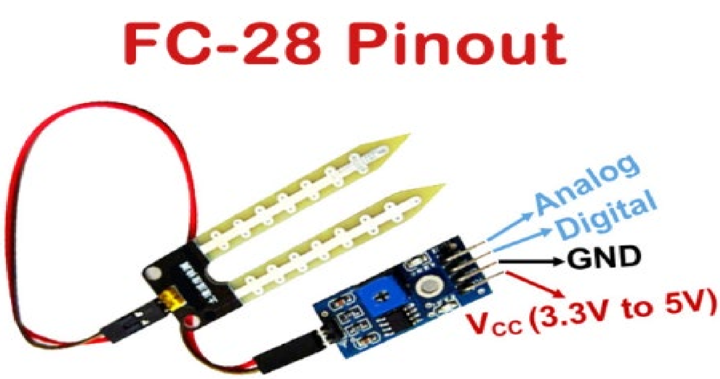

Figure 3.4: FC-28 Soil Moisture Pinout

I2C LCD Display [41]

I2C Liquid Crystal Display (LCD) display is an electronic screen display module that is commonly used in circuits or devices [41]. A 16x2 I2C LCD Display is chosen for display soil moisture level, temperature, and humidity level and plan to installed at transmitter part. It is used to display any text or character received from the sensing output data of the soil perimeter by projecting the desired data in the LCD. Additionally, it can display a maximum of 16 characters in columns and 2 lines in row. 5x8 pixel matrix x for each character and capable to detect and display a total of 224 data for different characters and symbols.

The specification of I2C LCD Display [41]:

- Compatible with Arduino Board or other controller board with I2C bus.
- Display Type: Negative white on blue backlight.
- I2C Address:0x38-0x3F (0x3F default)
- Supply voltage: 5V
- Interface: I2C to 4bits LCD data and control lines.
- Contrast Adjustment: built-in Potentiometer.
- Backlight Control: Firmware or jumper wire.
- Board Size: 80x36 mm.

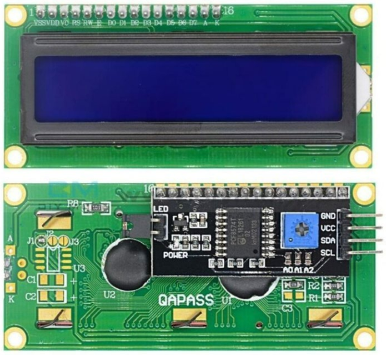

Figure 3.5: I2C LCD Display [41]

HC-SR501 PIR Sensor [42]

A passive infrared (PIR) sensor able to recognize infrared light emitted from nearby objects. [43] It is considering a low-cost sensor which able to detect the presence of animals and human begins.

In this project, it is used to detect the motion and presence of intruders, either human or animals for farm security purposes. When the motion is detected, the system alarm will be activated to run away intruders and the notification will be sent via our mobile application.

HC-SR501 PIR sensor module has three output pins Vcc, output and ground.

Pin Number	Pin Name	Description
1	Vcc	Input voltage is +5V for typical applications. Can range from 4.5V- 12V
2	High/Low Ouput (Dout)	Digital pulse high (3.3V) when triggered (motion detected) digital low(0V) when idle(no motion detected
3	Ground	Connected to ground of circuit

Table 3.4: PIR Sensor Module Pinout Configuration [42]

PIR Sensor Features [42]:

- Wide range on input voltage varying from 4.V to 12V (+5V recommended)
- Output voltage is High/Low (3.3V TTL)
- Can distinguish between object movement and human movement
- Has to operating modes - Repeatable(H) and Non- Repeatable(H)
- Cover distance of about 120° and 7 meters

- Low power consumption of 65mA
- Operating temperature from -20° to +80° Celsius

Normally, the PIR Sensor applications are implemented at automatic street, garage, warehouse or garden lights, burglar alarms, security cams as motion detectors and industrial automation control.

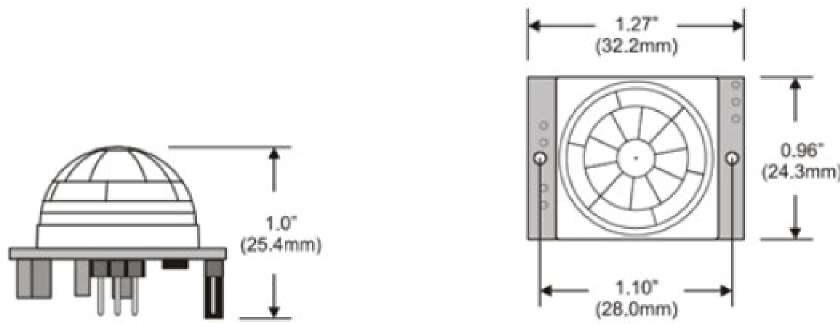

Figure 3.6: 2D model of the PIR sensor

Figure 3.7: PIR sensor

Rain drop Sensor Module [44]

Raindrop Sensor is used to detect the presence of rain in the agriculture sector. It consists of two modules, a rain board that detects the rain and a control module. It compares the analog value and converts it to a digital value. Raindrop sensors can be used in the automobile sector to control the windshield wipers automatically. It consists of 4pins:

S.No:	Name	Function
1	VCC	Connects supply voltage- 5V
2	GND	Connected to ground
3	D0	Digital pin to get digital output
4	A0	Analog pin to get analog output

Table 3.5: Pin Configuration of Rain Sensor [44]

Raindrop Sensor Features [44]:

- Working voltage 5V
- Output format: Digital switching output (0 and 1), and analog voltage output AO
- Potentiometers adjust the sensitivity
- Uses a wide voltage LM393 comparator
- Comparator output signal clean waveform is good, driving ability, over 15mA
- Anti-oxidation, anti-conductivity, with long use time
- With bolt holes for easy installation
- Small board PCB size: 3.2cm x 1.4cm

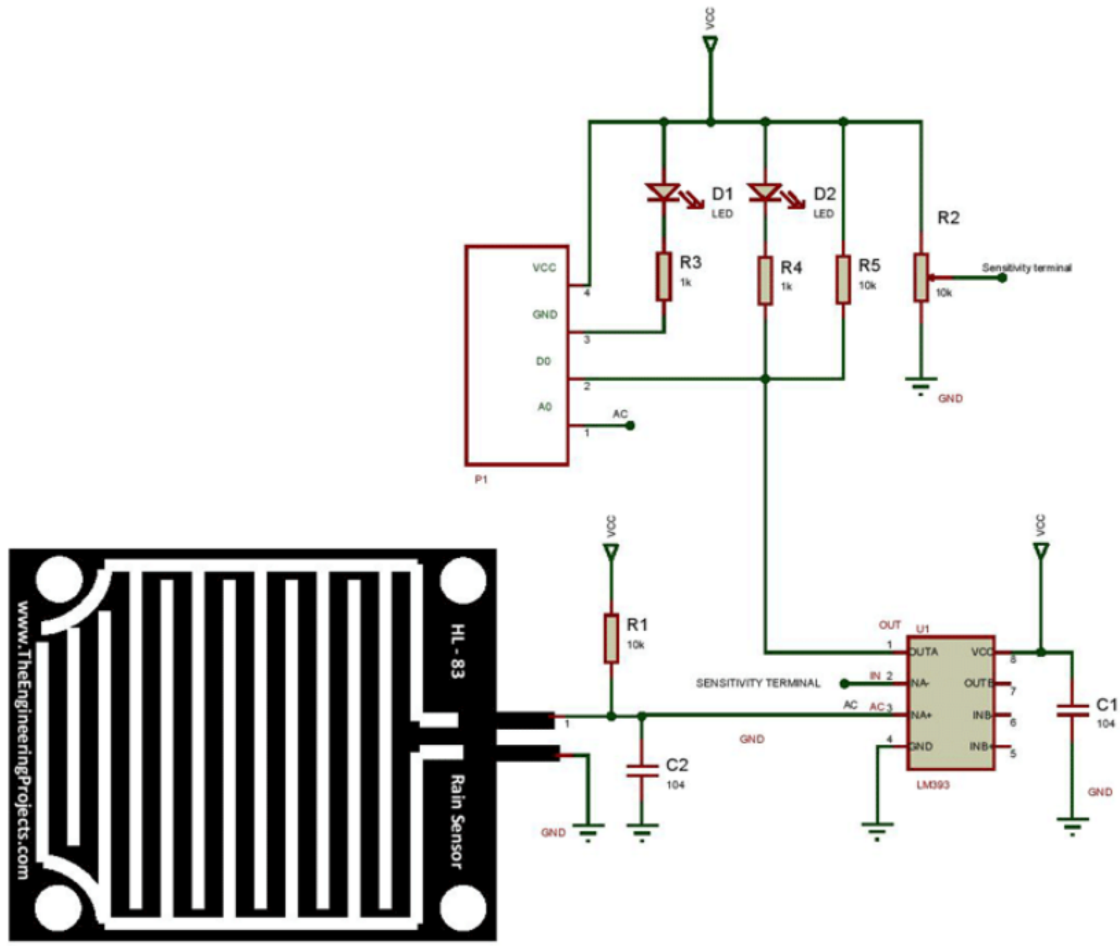

Figure 3.8: The circuit for rain drop sensor

R1 resistor and rain board module will act as voltage dividers in the figure above. C1 and C2 serve as biasing elements. R1 and the rain board module are connected to the non-inverting terminal. The A0 terminal of the control module receives another point from this connection.

The potentiometer (R2) is used to input the inverting terminal of the LM393. By varying R2, the sensitivity of the control module can be modified by varying the voltage input to the inverting terminal. When not in use, resistors R3 and R4 will act as current limiting resistors, while resistor R5 will act as a pull-up resistor.

By varying the potentiometer, the input to the inverting terminal is set and the sensitivity is adjusted. If the rain board module's surface is exposed to rainwater, it will be wet, offering minimum resistance to the supply voltage. Thus, the minimum voltage of the LM393 Op-Amp appears at its non-inverting terminal. Inverting and non-inverting terminal voltages are compared by the comparator. The Op-Amp output is digital LOW when the input of the inverting terminal is higher than the input of the non-inverting terminal. A digital HIGH output will be produced by the Op-Amp if the inverting terminal's input is lower than the non-inverting terminal's input. ADC circuits are used when the A0 pin is connected to the microcontroller.

Lora Module [45]

LoRa is an acronym for long-range [46]. Long-range wireless communication, low power consumption, and secure data transmission are characteristics of this technology. It can be used for Machine to Machine (M2M) and any other IoT applications that transmit data wirelessly. To encode data information, LoRa uses chirp spread spectrum (CSS) modulation and multi-symbol data formats. Sensors, radio communications, gateways, heavy machines, electronic devices, and others can be linked to the cloud by LoRa's characteristics. Depending on the region, LoRa Technologies operates in different frequency bands. It can be operated at 433-435 MHz in Malaysia, and at 919-923 MHz in Asia [47].

The Ra-02 Ai Thinker LoRa module, based on the SX1278 chip, is currently being selected for this project. There is a low sensitivity of -141dBm and a maximum output of +18dBm on this 433MHz device. Long-distance communication is possible with this device, and it is highly reliable. The LoRa module features excellent resistance blocking and preamble detection as well as half-duplex communication support. With a programmable bit rate of 300Kbs, it supports FSK, GFSK, MSK, and OOK modulation models. LoRa modules operate at temperatures between - 30 and 85 degrees Celsius and are powered by 3.3V power supplies.

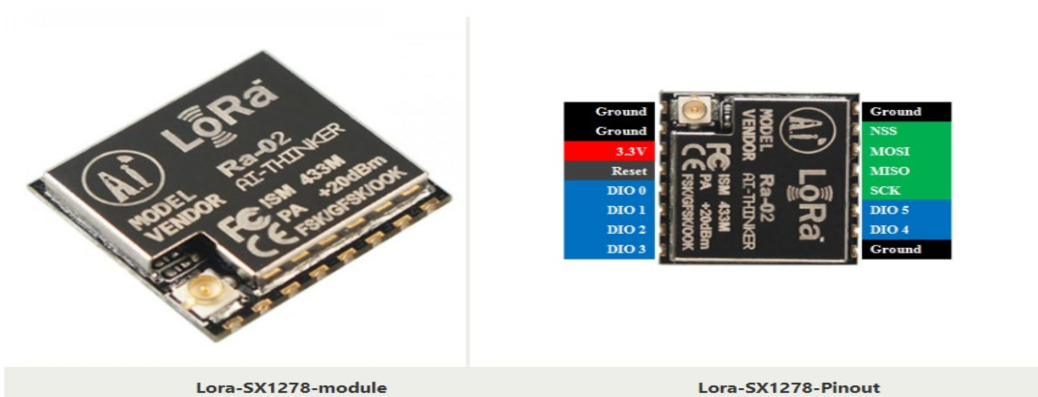

Figure 3.9: Ra-02 LoRa [45].

NodeMCU ESP32 [48]

ESP32 is chosen as the microcontroller for the receiver. This is one of the most powerful 32-bit microcontrollers that can be used in IoT projects. The ESP32 has a Wi-Fi module, is equipped with a full TCP/IP stack for internet communication and can be connected via Bluetooth 4.2. Economically, ESP32 is among the most cost-effective endpoint devices and network gateways. As a dual-core microcontroller, the ESP32 uses a dual-core Xtensa® LX6 microprocessor and runs up to 600 DMIPS (Dhrystone Million Instructions Per Second) at speeds between 160 and 240MHz, which is the speed suitable for most microcontrollers.

Component	**Specification**
ESP32 Microcontroller	• Microcontroller: Tensilica 32-bit RISC CPU Xtensa LX106 • Maximum Operating Frequency: 240MHz • Operating Voltage: 3.3V • Analog Input Pins: 12-bit, 18 Channel • DAC Pins: 8-bit, 2 Channel • Digital I/O Pins: 39 (of which 34 is normal GPIO pin) • DC Current on I/O Pins: 40 mA • DC Current on 3.3V Pin : 50 mA • SRAM: 520 KB • Communication: SPI (4), I2C (2), I2S (2), CAN, UART (3)

Table3.6: Specification of NodeMCU ESP32 [49]

Arduino Uno

Using a removable ATmega328 microcontroller, Arduino Uno R3 is an open-source programmable microcontroller board. [50] There are 14 digital input and output pins in total, including 6 PWM outputs, 6 analog inputs, and 16 MHz ceramic resonators. There is also a single reset button, USB and power jack connections, and an ICSP header on the microcontroller. It is easy to understand and can be easily integrated with sensors and other electronic devices thanks to the extensive support from the Arduino community. The Arduino Uno has two types of memory: program memory and data memory.

Component	**Specification**
Arduino Uno R3	• Microcontroller: ATmega328P – 8-bit AVR family microcontroller • Operating Frequency: 16MHz • Operating Voltage: 5V • Analog Input Pins: 6 • DAC Pins: 8-bit, 2 Channel • Digital I/O Pins: 14 (Out of which 6 provide PWM output) • DC Current on I/O Pins: 40 mA • DC Current on 3.3V Pin: 50 mA • SRAM: 32 KB (0.5 KB is used for Bootloader) • SRAM: 2 KB • EEPROM: 1 KB

Table 3.7: Specification of Arduino Uno R3 [51]

3.4 Hardware & Software development

Figure 4.2.1 shows the proposed system architecture for the project. The proposed IoT-based smart farm project include a lot of main components, including system unit, LoRa, IoT Cloud Platform, Bylnk Application. These main components are connecting and interacting with each other by radio frequency, wireless, and internet.

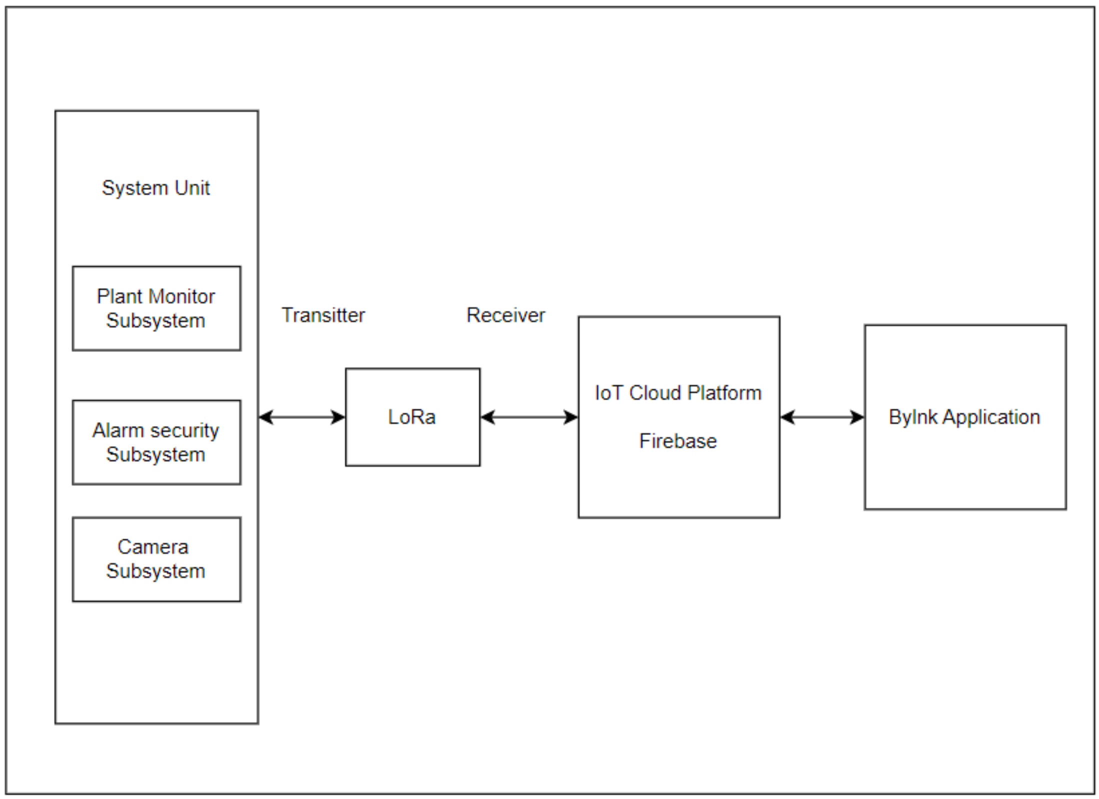

Figure 3.10: System architecture

System Unit

The system unit is divided into 3 subsystems, which are the sensor subsystem, alarm security subsystem and camera subsystem.

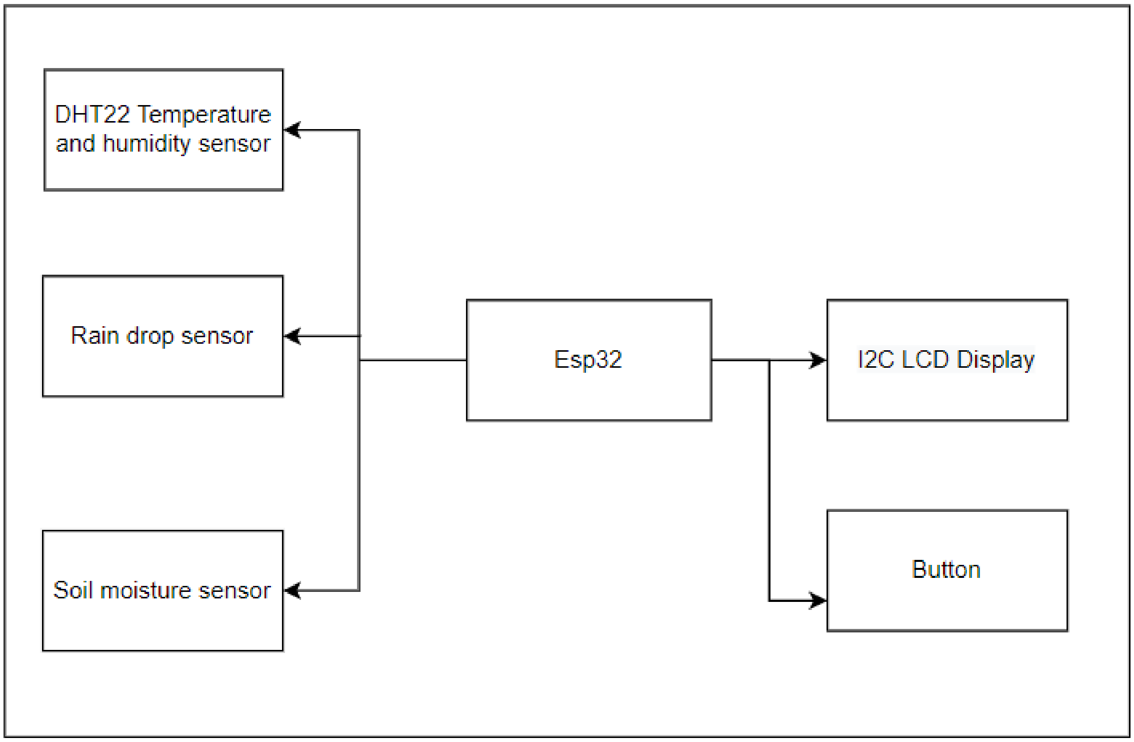

Figure 3.11: Plant Monitor subsystem

Figure 4.2.2 shows the plant monitor subsystem. The plant monitor subsystem is responsible to obtain the data information regarding the fruit tree and vegetable condition of the farm from the sensors. ESP32 is the microcontroller used in the plant monitor subsystem. The ESP32 microcontroller has built in Wi-Fi so it can interact with the IoT platform easily via Wi-Fi internet connection. In the sensor subsystem, there will be several sensors, each serving a different purpose. DHT22 Temperature and humidity sensor, rain drop sensor and FC-28 soil moisture sensor are used to detect the condition of environment of the fruit tree and vegetable. DHT22 Temperature and humidity sensor is used to detect the temperature and humidity in farm area. Rain drop sensor is detect the presence of the rain and FC-28 soil moisture sensor is used to sense the moisture level of underground soil in farm. I2C LCD display is used for showing all the data getting from these sensors.

Several buttons are also included in the subsystem to allow the user to manually on/off whole plant monitor subsystem.

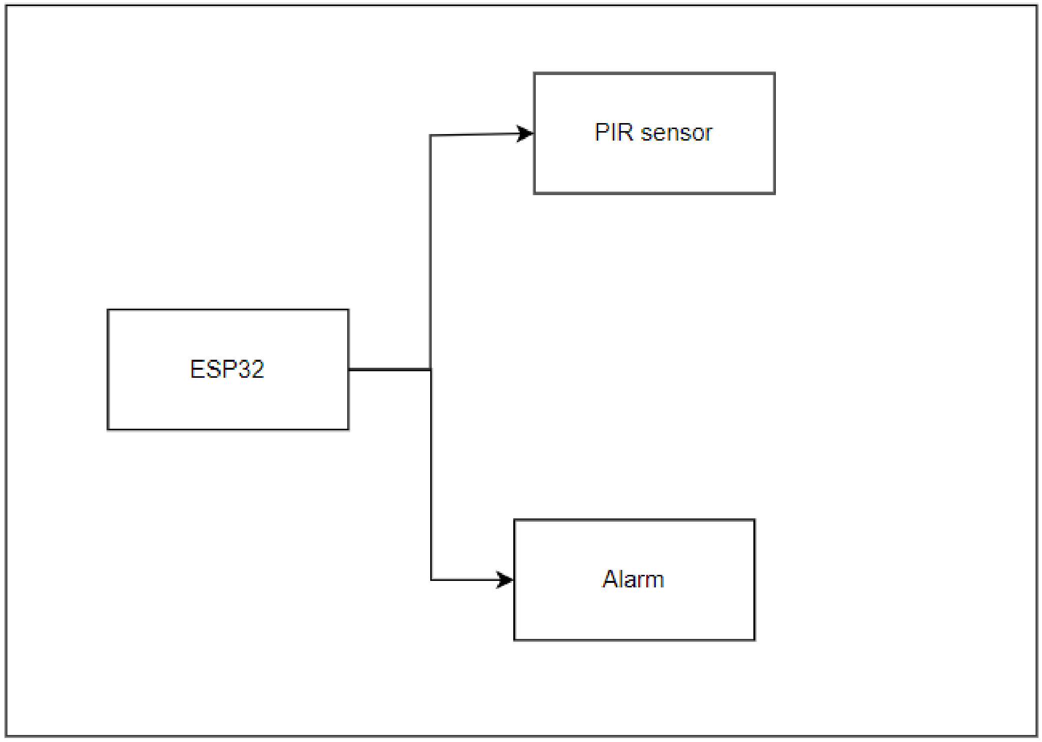

Figure 3.12: Farm security subsystem

Figure 4.2.3 shows the alarm security subsystem. The alarm security subsystem is responsible for improving the security in farms to prevent intruders. The alarm security subsystem is controlled with NodeMCU v2 ESP8266 microcontroller with integrated Wi-Fi. This subsystem has a PIR sensor to sense the motion presence of intruders, either human beings or animals. A warning siren alarm is included in this subsystem to run away from the intruders or alert the farmer that the intruders nearby.

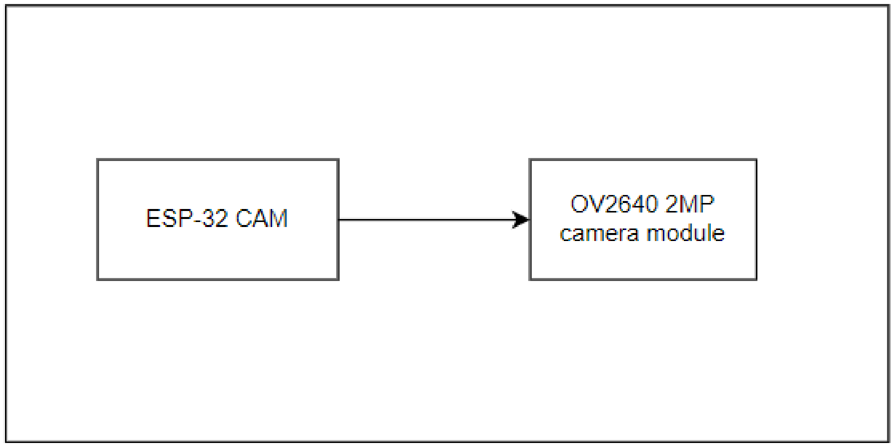

Figure 3.13: Camera subsystem

Figure 4.2.4 shows the camera subsystem design. The camera subsystem is responsible for capturing real-time visual information of the kitchen. ESP-32 CAM is a microcontroller with Wi-Fi capability. It comes with a 2MP camera module for capturing images and video. In this project, the camera subsystem acts as the video surveillance system. At the same time, farmers allow them to monitor their farm remotely via desktop. Besides that, the video captured by the camera subsystem will be sent to the cloud computing server as the input source for our computer vision model.

LoRa transceiver

LoRa module helps to transmit data from transmitter node to receiver node. LoRa has been implemented because the farm is wide area and without internet access, so the LoRa takes the important role to send data from system unit to receiver unit. The receiver unit will send data to IoT Cloud platform, firebase for store data. LoRa allows us to transmit data in long range by radio frequency technology.

IoT Cloud Platform

The IoT cloud platform used in this project is Firebase. All the data obtained by the system unit will then be uploaded and stored in Firebase Realtime Database via Wi-Fi. Firebase is able to use by the desktop and mobile application.

The Firebase Realtime Database is a cloud-hosted database in which data is stored as JSON. [52] Every connected client receives real-time data. In our cross-platform applications built with our iOS, and JavaScript SDKs, all our clients share one Realtime Database instance.

The Firebase Realtime Database is a NoSQL database that is used to sync data in real-time between our users. Developers can manage a large JSON object in real-time. It provides applications with current data values and updates using a single API. Mobile and web users can access their data immediately through real-time syncing. Besides hosting HTML, CSS, and JavaScript, it also hosts graphing, fonts, and icons provided by developers.

Mobile Application

The mobile application in this project will be built up with Bylnk IoT application. [53] Blynk is an internet-connected platform that controls Arduino, Raspberry Pi and NodeMCU via iOS and Android smartphones. Using this application, you can create a graphical user interface (GUI) or human machine interface (HMI) by compiling and providing the appropriate addresses. Blynk is designed for the Internet of Things. The software is capable of controlling hardware remotely, displaying sensor data, storing and visualizing data, and much more.

Mobile application, Bylnk will be used to display the data obtained from the sensors, such as the motion, rain presence, temperature and humidity and soil moisture. The user can see the real time sensor data from the farm in the Bylnk mobile application. The mobile application will also allow the user to on/off the IoT system and alert user when some motion been detected.

3.5 Flow Chart

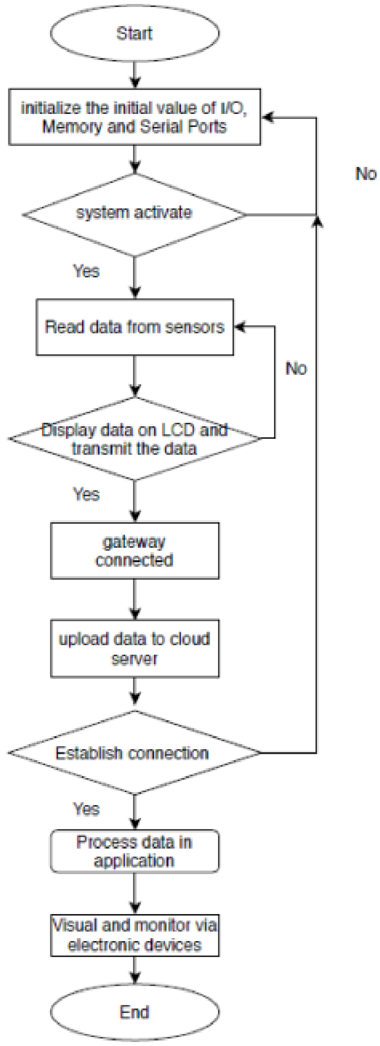

Figure 3.14: Project flowchart for plant monitoring

Based on Figure 3.5.1 above, it shows the project flowchart for plant monitoring system. In this project, there are three main parts: the sensing module, the IoT platform, and the mobile applications. There are two parts to the sensing modules, a transmitter node and a receiver node, which are embedded with a single microcontroller. The transmitter node is where farm conditions are measured. A microcontroller will function as the brain of the transmitter node. A sensing module will handle all commands. It is a solar panel-powered transmitter node that is designed to be used outside.

The middle platform acts as a gateway between the transmitter and receiver nodes for the receiver node. A LoRa module and an Internet-based microcontroller are included in the device. Sensor measurements from the transmitter node are collected and grouped into a packet of data that is transmitted wirelessly to the receiver node through the LoRa communication network. Sensing data will be read by the receiver and pushed through the cloud platform. A platform for IoT is being developed here to store and collect data for further processing.

The data that is being sent can be recognized and processed through the Internet network. Cloud technology is used to capture and process data in the cloud so it can be visualized on a mobile phone. The Blynk apps are mobile apps that provide and generate a monitoring system that users can control from anywhere at any time. The mobile apps can be accessed remotely and are able to display the required information regarding the crop field condition. Plantation farmers faced numerous obstacles in the plantation due to the use of IoT. Using IoT to collect, exchange, and process relevant information enabled them to overcome these obstacles. Plantation problems can be predicted early and wisely addressed by farmers.

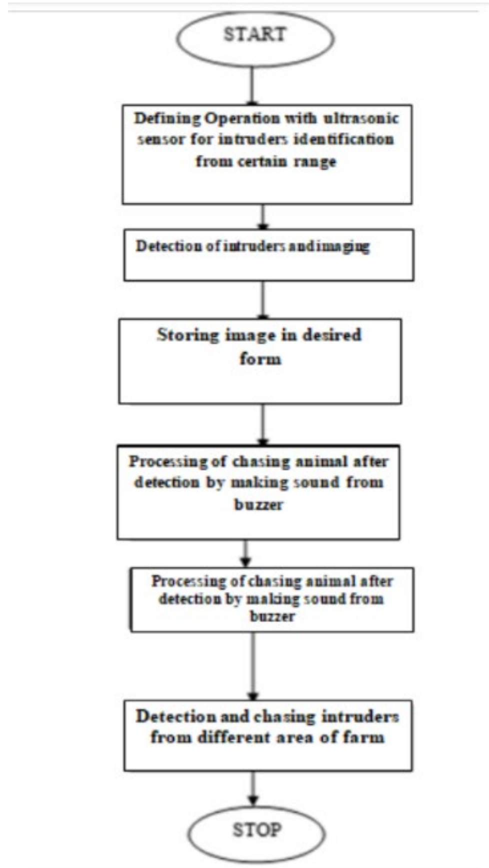

Figure 3.15: Project flowchart for farm security

First, at starting phase, the operation will define with ultrasonic sensor for intruders' identification from certain rage. Second, the IoT system will detect the intruders. Third, the system stored image in desired form. Forth, after detection, the processing of chasing animal activated by making sound from buzzer to run away the intruders. Last, the system will detect and chase the intruders from different area of farm.

3.6 Project Activities

This section will describe the activities along with their allocated duration for the project. The proposal writing and fundamental research findings associated with the Integrated IoT Solutions for Smart Farms was done in week 4 of trimester 1 2022/2023. The commencement of literature review on smart window was done using six weeks duration, which was from week 1 of trimester 1 2022/2023 to week 6 of trimester 1 2022/2023. Then, the activity relating to processing recipe on integrated IoT Solutions for smart farms and purchase of research materials was carried out from week 2 until week 6 of trimester 1 2022/2023. Furthermore, a six-week period, specifically from week 7 until week 12 of trimester 1 2022/2023 is allocated for the IoT based solution for smart farming via the determined or finalized synthesis technique. In addition, the preparation of presentation slides relating to the integrated IoT Solutions for smart farms will take place in week 12 of trimester 1 2022/2023.

In the second semester of final year project, the activities are mainly focusing on the implementation of Internet of Things (IOT) for smart farm project as well as the finalization of project inputs and outcomes. The preparation and development of IOT kits for the plant monitoring and farm security system was carried out from week 1 until week 4 of trimester 2 2022/2023. Prior to the preparation of IOT project, the activities on the integration of IOT based for smart farming was carried out from week 5 until week 6 of trimester 2 2022/2023. Lastly, the thesis writing task as well as the thesis publication, presentation and demonstration was performed will take over a six-week period which is from week 7 to week 12 of trimester 2 2022/2023. The activities are summarized and depicted in Table 4.3.1.

Table 3.8: Project Activities Summary

Project Activities	**MMU Academic Calendar**
Proposal Writing and Research Findings	Week 1- Week 4, Trimester 1 2022/2023
Literature Review	Week 1, Trimester 1 2022/2023 – Week 6, Trimester 1 2022/2023
Processing Recipe on integrated IoT Solutions for smart farms	Week 2 – Week 4, Trimester 1 2022/2023
Purchasing of research materials	Week 2 – Week 6, Trimester 1 2022/2023
Determined or finalized synthesis technique	Week 7 – Week 12, Trimester 1 2022/2023
Presentation Slides Preparation	Week 12, Trimester 1 2022/2023
IOT System Development	Week 1 – Week 4, Trimester 2 2022/2023
Integration of IOT kits into Smart Farm	Week 5 – Week 6, Trimester 2 2022/2023
Thesis Writing and Publication	Week 7 – Week 12, Trimester 2022/2023
Presentation and demonstration	Week 7 – Week 12, Trimester 2022/2023

3.7 Milestone

In this section, the description on the project deliverables in accordance to targeted milestones will be mentioned. Firstly, the literature review writing task and the purchasing of research materials are anticipated to complete by 6^{th} of November 2022. Furthermore, the development of breadboard prototype is expected to be completed by December 18, 2022. Additionally, FYP1 report/presentation g is anticipated to be done by $25^{th}$of December 2022. Next, completion of characterisation and result analysis of project will be finished by 30th of March 2023. Lastly, final presentation and demonstration, thesis writing and publication is expected to be submitted by 11th of June 2023. The table 4.4.1 below show the summary of descriptions of project milestones.

Table 3.9: Project Milestones Summary

Milestones	**Description**	**Deadlines**
1	Literature Review	6^{th} of November 2022
2	Purchase of research materials	6^{th} of November 2022
3	Breadboard Prototype	18^{th} of December 2022
4	FYP1 report/presentation	$25^{th}$of December 2022
5	Completion of characterisation and result analysis of project	30th of March 2023
6	Final presentation and demonstration	11th of June 2023
7	Thesis Writing and Publication	11th of June 2023

3.8 Gantt Chart

Figure 3.16: Gantt chart for the project

Task	Week																									
	Trimester 1 (FYP part 1)												Trimester 2 (FYP part 2)													
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Overview																										
• Literature review																										
• Project Proposal																										
2. Hardware 1																										
• Purchase component																										
• Build and code the prototype system																										
• Prototype testing and debugging																										
• IoT development																										
3. Analysis 1																										
• FYP 1 presentation																										
4. Software 1																										
• Mobile app development																										

• Mobile app and firebase system integration																										
• PHP local host																										
5. Hardware 2																										
• PCB design																										
• 3D printing																										
6. Analysis 2																										
• Thesis Writing																										
• Journal Writing																										
• Thesis Publication																										
• Presentation and demonstration																										
• Hardcover report submission																										

3.9 Project Budget

The part sourcing would be done locally for most of the material as it is generally preferred compared to sourcing part from oversea. The sourcing part from oversea would be costly and the shipping time would take considerably longer. Furthermore, it is preferred to purchase all the parts online instead of going to the store. Hence, local vendor that have been shortlisted to have the partsare as follow:

- Cytron Technologies (*www.cytron.io*)
- Lazada (*www.lazada.com*)
- Shopee (*www.shopee.com*)

Most of the parts would be sourced from Cytron technologies and shopee due to the high quality of component and seller reliability as the parts can be considered genuine and comply with all the RoHs standard with proper datasheet attach. The table below shows the estimated budget for IoT smart farm project.

Table 3.10: Estimated Budget for IoT smart farm project

Materials/Apparatus	**Qty**	**Shipping (RM)**	**Unit Price (RM)**	**Total Price (RM)**
Maker Soil Moisture Sensor (Capacitive)	1	4.9	19.6	24.5
DHT22 Temperature and Humidity Sensor	1	4.9	19.5	24.4
3V3 I2C and SPI 1602 LCD Display	1	4.9	15	19.9
Grove E5 LoRaWAN STM32WLE5JC Module	2	4.9	89	182.9

Arduino Uno ATmega328	1	4.9	45.9	50.8
NodeMCU ESP32	1	4.9	32.9	37.8
60W 18V Solar Panel	2	4.9	200	404.9
DN14007 Diode	1	4.9	0.7	5.6
TP4056 Charge Module	1	4.9	1.85	6.75
DC-DC Step Up Booster	1	4.9	12.9	17.8
3.7V 18650 Rechargeable Battery 4800mah	3	4.9	2.95	13.75
Antenna	2	4.9	11.11	27.12
18650 Battery Holder 3	1	4.9	3	7.9
Rain drop sensor	1	4.9	6.50	11.4
Dupont jumper wire	10	4.9	3.70	41.9
Breadboard	1	4.9	3.90	8.8
PIR sensor	1	4.9	8.4	13.3
EP32-CAM	1	4.9	35.9	40.8
PWM Digital I/O Output 5v Buzzer Piezo Module	1	4.9	5.6	10.5
3inch MS-190 Mini Warning Siren Alarm	1	4.9	27	31.9
Button	1	4.9	3	7.9
Total (RM)				**990.62**

4. Deliverable

To summarize the proposal, at the end of the project we hope to deliver a proposal also inspired low cost IoT solution which are fit for small area for food plantation farm. We expect to deliver a fully working android app that well help transfer the data and meaning advice to the user. The app would also be functioning as a User Interface so that the user can monitor the data of the current environment. The hardware would include a printed circuit board with the necessary sensor soldered to it. The PCB would be located inside a protected enclosure and would be powered by a solar energy. We expect to deliver a fully functional android app that will help transfer the user's data and meaning advice. As well as providing a user interface, the app would let the user monitor the current environment's data. Printed circuit boards with the necessary sensors would be included in the hardware. Powered by solar energy, the PCB would be enclosed within a protected enclosure.Lastly, we need to complete and publish a technical journal to a well-known online journal platform (e.g. Elsevier, IEEE Xplore, etc.) and the detail approach taken in developing this project. The project deliverables are further simplified as follows:

- Plant monitor and farm security with IoT connection
- Android app
- Thesis writing and publication

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