Remote Irrigation Monitoring For Smart Greenhouse

By

Muhammad Hafiz Isyraf Bin Abdul Razak

23286

Dissertation submitted in partial fulfilment of

the requirements for the

Bachelor of Information Technology (Hons)

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Universiti Teknologi PETRONAS

Bandar Seri Iskandar

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Perak Darul Ridzuan

CERTIFICATION OF APPROVAL

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UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

September 2021

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

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MUHAMMAD HAFIZ ISYRAF BIN ABDUL RAZAK

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ABSTRACT

As of recently, we are presented with the daunting possibility that we are in the possibility of facing a global shortage of food as the UN projects that the global population will reach 9.7 billion by 2050, which will cause global agricultural production to rise 69% between 2010 and 2050. This possibility can be turned around with proper development and investment into agriculture. Amongst many possible solutions, the utilization of technological advancements such as Internet of Things (IoT) can play a big role in increasing productivity, automating labor, and retrieving crucial analysis. The Malaysian agriculture sector has been declining for decades due to low soil fertility, fertilizer abuse, water waste and climate change. Smart Agriculture with IoT aims to find the suitable system to be applied in future agriculture systems. To reduce, mitigate and eventually overcome the issue, the aim of this project is to discuss and propose a solution by creating a network of devices which enables communication between machine and device, which can improve and enhance agriculture.

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CHAPTER 1: INTRODUCTION

1.0 INTRODUCTION

In the current era of ever-evolving technological advancement, farming and agriculture as a whole has become more popular and significant. Many new different tools and techniques are now available for farming and its development. According to recent studies, The UN projects that the global population will reach 9.7 billion by 2050, which will cause global agricultural production to rise 69% between 2010 and 2050 [1] . To meet this overwhelming rise in demand, farmers and agricultural companies are turning to the Internet of Things for analytics and greater production capabilities. Internet of Things (IoT) can play a big role in increasing productivity, automating labor, and retrieving crucial analysis about recent trends of crops. IoT is a network of interconnected devices which can transfer data efficiently without human involvement. Today many agricultural industries turned to IoT technology for smart farming to enhance efficiency, productivity and other features such as minimizing human intervention, time and cost. The advancement in technology ensures that the sensors are getting smaller, more sophisticated, and more economic. The networks are also easily accessed worldwide so that smart farming can be achieved and operated even if your crop is far from you or even in another country. Focusing on encouraging innovation in agriculture, smart farming is the most obvious solution to the problems that this industry is currently facing. All this and more can be done using smart phones and IoT devices by just having an internet connection. [2]

1.1 BACKGROUND

The term Internet of Things, or IoT, was first mentioned by Kevin Ashton in 1999, in his effort to explain how radio frequency identification (RFID) could be incorporated into the Internet. According to the International Telecommunication Union (ITU), the Internet of Things has been defined as “a global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies”. The radical evolution of the current Internet in to connect everything that not only converges the information from the environment and cooperate with physical world like actuation, command, and control, but also using the Internet to provide the services for information, transfer, analytics, applications, and communication. Along with other tech trends, an IoT system integrated with the latest technologies in data processing will potentially solve obstacles and bring advancements to various domains, such as manufacturing, healthcare, logistics, and agriculture. In recent years, governments throughout the world have greatly supported the research and application of IoT in agriculture. [3]

Malaysia was initially known to be a leading country on agriculture and fisheries, which of both contributed about 55 per cent of Malaysia’s Gross Domestic Product (GDP). The Malaysian agriculture sector has been declining for decades due to growth of the local industry and services sector. Almost 30 percent of GDP was contributed by agriculture in 1970 but this percentage has dropped drastically to 8.2 percent in 2017. The percentage drop is due to farmers still using traditional methods which affect the production rate of crops due to low soil fertility, fertilizer abuse, water waste and climate change, of which the latter poses the most threat [4] . Therefore, to improve and revitalize Malaysian agriculture, various technologies and innovations have been introduced, such as the concept of industrial revolution 4.0 or smart agriculture to keep the agricultural sector relevant and innovative.

In order to realize the industry of revolution 4.0 there are several things to keep in mind as one of them is the internet of things (IoT). IoT being a network of devices, enables communication between machine and device through internet connection. Obtaining communication technology is the key in order to successfully develop IoT system. Short-range and long-range communication standard is the part of communication standard. The purpose of this Smart Agriculture with IoT is to find the suitable system to be applied in future agriculture systems.

1.2 PROBLEM STATEMENT

With the apparent and rapid decline of the Malaysian agricultural sector over decades of the past, it is hard to just ignore and not overlook that the sector needs a revamp and rejuvenation to encourage existing farmers to continue their efforts and intrigue a new generation of farmers to enter and propel the success and strength of the sector back to its days of past glory and stability. It is not that hard to notice that amongst the problems include insufficient Research & Development (R&D) is done for crops, especially food crops due to the very vulnerable condition of agriculture. [4]

Relatively low growth rate compared to other sectors and the fact that agriculture itself as a sector has been on the decline for decades has been hurting Malaysian agriculture. A lack of capital halts its rapid transformation, structural change and integration with manufacturing, slow rate of technological development and innovation with regard to product development, process and packaging also contributed to low growth rate. Despite efforts to diversify, Malaysian agriculture has remained predominantly export-oriented. By 1990, about 70% of the total cultivated agricultural area and 75% of the gross crop output could be attributed to the perennial export crops of rubber, palm oil and cocoa. One of the most challenging problems in the Malaysian agriculture sector is noticeably the unpredictable weather with the variations and fluctuations of summer and monsoon seasons, high temperature (> 26° C), scattered rain and shortage of rainfall itself. This makes it very hard to ensure the most optimum amount of water is sourced to the crops. Therefore with the usage of technological advancements such as IoT, a technology infused irrigation system could very much aid the farmers to not only ensure optimum water is given to their crops but also semi-automate or even make the process of watering fully automated without the need for manual labour. It is also clear that the implementation of technology can propel agriculture back to the height of its glory days. [4]

1.3 OBJECTIVES

One of the most important objectives of this project is to develop a fully functional prototype irrigation system that is able to connect the user and the designated system through the utilization of IoT that eases and aids farmers to fully maximize the potential of their crops.
The intention of this project is to be able to create a more user friendly and convenient system that utilizes technological advancements in the form of IoT to reduce manual labor and increase productivity. It is intended for users to be able to schedule and monitor the temperature and requirements for their crops with reduced or no human intervention. The intended objectives are as follows:

- To conduct a feasibility survey and take in as much input possible from residing locals
- To design and develop a fully functional remote irrigation system with the aid of IoT
- To evaluate the prototype with potential users and develop improvements

These objectives are emphasized in order to reduce manual labour and monitor water consumption as well as maximizing agriculture product and to improve the efficiency of management and control for agriculture farm.

1.4 SCOPE OF STUDY

1.4.1 GENERAL PURPOSE AND RELEVANCY OF THE STUDY

The study is focused on the general consensus and the impact of implementing of smart technological advancements for the agriculture sector in Malaysia. The scope in terms of the user is in particular the local residents of my housing area and farmers and agriculture enthusiasts in general. The scope for the system development is on the prototype and system development, which technique that is selected to be used, tools and components used and also the feasibility of expanding and improving the system.

1.4.2 THE DURATION OF STUDY

The duration of the study will be spanning over 2 semesters which is about 28 weeks or around 7 months, with this project expected to be completed at the very least to the minimum requirements of a functional and working prototype. The whole duration of the Final Year Project 1 (FYP1) subject will focus more on the documentation and initial planning phase of the project throughout the entirety of the 12-week period of the semester. Meanwhile the Final Year Project 2 (FYP2) subject will focus more on the development and implementation phase of the project throughout the 12-week period of the semester.

1.4.3 GEOGRAPHICAL LOCATION COVERED IN THE STUDY

Figure 1 – Google Earth Ground View of Kebun Bandar Proton City

Due to the current ongoing COVID-19 pandemic, personally I feel there is not much feasibility and safety in conducting my study and project too far away from my housing area. Therefore it was decided that the area of study would be at Kebun Bandar Proton City which is situated nearby a road behind the At-Taqwa Mosque and Sekolah Agama Proton City, in my housing neighbourhood of Proton City, Tanjong Malim, Perak.

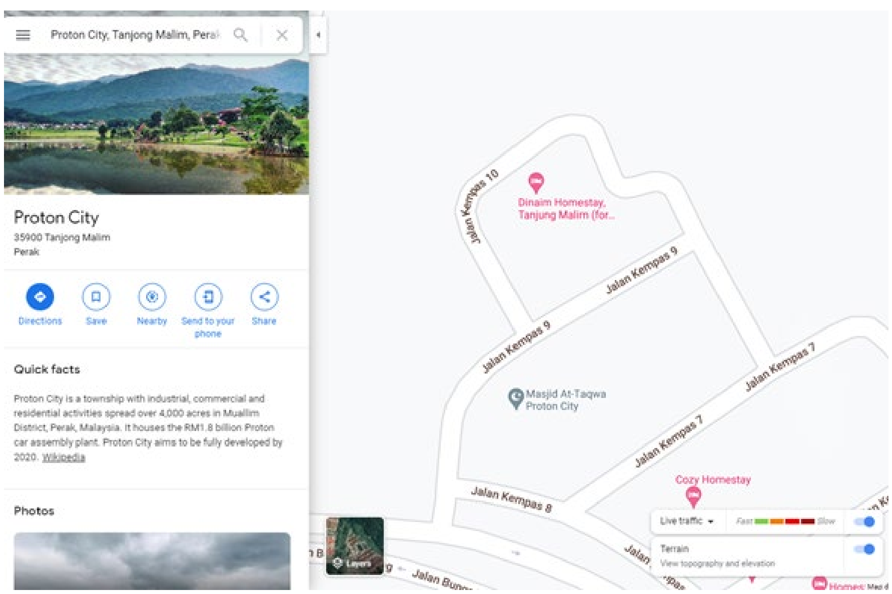


Figure 2 – Google Maps view of Kebun Bandar Proton City

CHAPTER 2: LITERATURE REVIEW

2.0 CHAPTER OVERVIEW

This chapter provides the background and related works and articles relating to the topic of agriculture, irrigation and the technological advancements which have allowed agriculture as a whole to be enhanced with the help of smart technologies such as Internet of Things (IoT), artificial intelligence, smart drones and designated sensors.

2.1 AGRICULTURE

2.1.1 DEFINITION OF AGRICULTURE

Figure 3 – Traditional Agriculture in Vietnam

Agriculture is a procedure of land management used to cultivate domesticated plants and animals for food, fiber, and energy. Agriculture was a significant factor in the rise of sedentary human civilization, as it enabled humans to live in cities by creating food surpluses from tamed species. Agriculture has a long history dating back thousands of years. Farmers began planting wild grains roughly 11,500 years ago, after harvesting them for at least 105,000 years. Plants were grown independently in at least 11 different parts of the world. In the 20th century, industrial agriculture based on large-scale monoculture grew to dominate agricultural output, despite the fact that about 2 billion people still relied on subsistence agriculture. [5]

2.1.2 SMART AGRICULTURE

Figure 4 – Smart Agriculture

Smart agriculture is a relatively new term, and the majority of farmers are unaware of what it entails. To shed some light on what it is, the use of technologies such as the Internet of Things, sensors, positioning systems, robots, and artificial intelligence on a farm or crop is referred to as smart agriculture. The ultimate goal is to improve the quality and quantity of crops while reducing the amount of human work required. Some of the processes that take place in smart agriculture include data collection, diagnostics, decision making and actions that can be to a certain extent be automated or even achieve full automation. Smart irrigation systems have been developed and utilized fairly widely nowadays and gaining more and more traction in terms of usage and popularity. Furthermore, research have shown that manual watering is an inefficient practice in this day and age with the emergence of technology, since it increases the risk of excessive/inadequate water consumption and the labour required to fulfill the number of plants is immense. Owners of vegetable crops fields must be vigilant in conserving water and the work needed due to collective water needs, expensive water charges, and a labour scarcity. Knowledge about adequate water requirements in the field is an essential aid in the planning of irrigation schemes, scheduling, and management. [6]

2.1.3 EXAMPLES OF SMART AGRICULTURE

Figure 5 – Smart Farm Weather Monitor

With smart agriculture seeing a surge of interest and investment allocated into over the past few years, we can already some readily available smart agriculture gadgets and applications. Notable examples of Smart Agriculture include the following [7]:

- Greenhouse Automation – Implementation of IoT sensors to gather real-time information and automate adjustments to greenhouse conditions such as lighting, temperature, soil condition and humidity. Examples include: Farmapp, Growlink and GreenIQ.
- Climate Condition Monitor – One of the most popular gadgets, of which uses a small-scale version of a weather station by combining. Examples include: allMETEO, LX AgTech and Pycno.
- Crop Management Device – Similar to climate condition monitor which are placed to collect data, this type of device can detect anomalies and prevent the spread of diseases and infestations. Examples include: Arable and Semios.
- Cattle Monitoring and Management – Like most agricultural smart sensors, livestock can also be tagged to monitor health, well-being and well basically their location. Examples include: SCR by Allflex and Cowlar.

- Precision Farming – Usage of IoT sensors to be increase efficiency in production by using analytics and predictive analysis to deduce the best course of action through accurate data-driven decisions. An example: CropX.

2.2 IRRIGATION

Figure 6 – Irrigation system

2.2.1 DEFINITION OF IRRIGATION

Irrigation is the technique of applying controlled amounts of water to land artificially in order to aid agricultural production. In arid places and during seasons of below-average rainfall, irrigation aids in the growth of agricultural crops, the maintenance of landscapes, and the revegetation of damaged soils. Irrigation also has other uses in crop cultivation, such as frost protection, weed suppression in grain fields, and soil compaction prevention. Rain-fed agriculture, on the other hand, is defined as agriculture that relies solely on direct rainfall**.** In agriculture, irrigation is an important method that has an impact on food production, which is a vital source of nourishment for the growing human population. The labor-intensive approach of providing sufficient water to vegetable crops is being supplanted by the demands of automation systems. For example, current technology and the availability of microcontrollers, which are often ideal for this autonomous service due to their highly programmable platform. [8]

2.2.2 SMART IRRIGATION

Figure 7 – Smart Irrigation

Smart irrigation systems combine sophisticated technology sprinklers with nozzles that improve coverage with irrigation controllers that monitor moisture-related circumstances on your property and automatically adjust watering to ideal levels. Weather-based irrigation and soil moisture-based irrigation are the two main types of smart irrigation technology. Both can assist you in conserving water, but there are some key differences. A weather-based irrigation system, also known as ET-based technology, consists of either a mini on-site weather station or a weather sensor capable of monitoring conditions such as temperature, rainfall, and solar radiation on your property, or this information is broadcast to the irrigation controller from a remote weather site. A moisture-based irrigation system is the other sort of smart irrigation system. Sensors are used in this technology to determine the real moisture content of the soil. Based on this information, it modifies the irrigation watering time. Moisture-based systems, like weather-based systems, are sold as both integrated controllers and add-on technologies. Technologies of an irrigation system are being developed and have been developed with an emphasis on smart management of water, advanced features, and automatic or remote control of an irrigation system. [6]

2.2.3 SMART IRRIGATION EXAMPLES

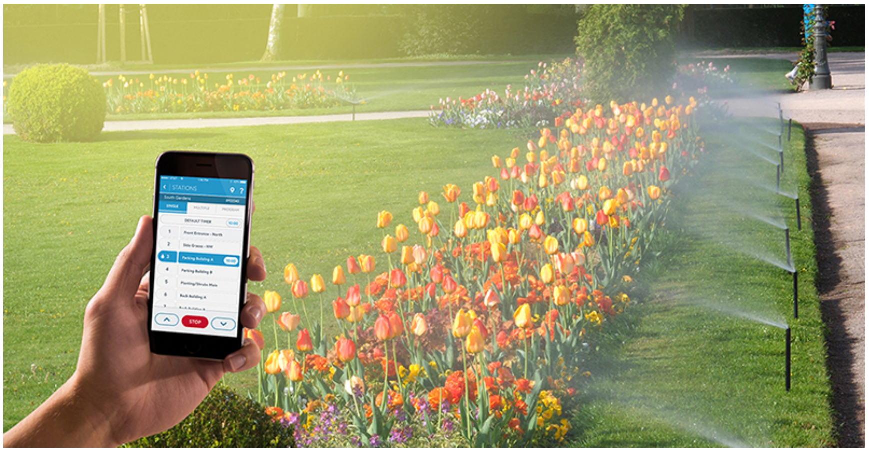


Figure 8 – Smart Irrigation Example

- Signal-based controllers - Utilizes meteorological data from publicly available source and the ET (Evapotranspiration) value is calculated for a grass surface. ET data is then sent to the controller through wireless connection. Example: WaterSense
- Historic ET controllers - Uses a pre-programmed water use curve, based on historic water. The curve can be adjusted for temperature and solar radiation. Example: RainMaster
- On-site weather measurement controllers - weather data collected on-site is used to calculate continuous ET measurements and water accordingly.
- Suspended cycle irrigation systems - Set like traditional timer controllers, with watering schedules, start times and duration. The difference is that the system will stop the next scheduled irrigation when moisture in the soil is adequate. Example: Turf-Tec
- Water on demand irrigation - Requires no programming of irrigation duration (only start times and days of the week to water). It has a user-set lower and upper threshold, irrigation starts when the soil moisture level fails to meet those levels. [9]

2.3 GREENHOUSE

2.3.1 GREENHOUSE DEFINITION

Figure 9 – Traditional Greenhouse

A greenhouse is a structure with mostly transparent walls and roof in which plants that require controlled climatic conditions are grown. These structures come in a variety of sizes, from modest sheds to large industrial constructions. The term "cold frame" refers to a tiny greenhouse. When a greenhouse is exposed to sunshine, the interior temperature rises significantly above the outside temperature, shielding the contents from the elements of cold weather. Greenhouses in general allow farmers and gardeners to grow and cultivate plants that are deemed not suitable with the local climate and conditions.

Despite greenhouses itself is considered being an advancement in agriculture itself, modern technological advancements have made it possible for greenhouses to be further enhanced and include smart technology which furthers the possibilities and improvements for cultivating plants in climate and conditions that are unfavourable for it. [10]

2.3.2 SMART GREENHOUSE DEFINITION

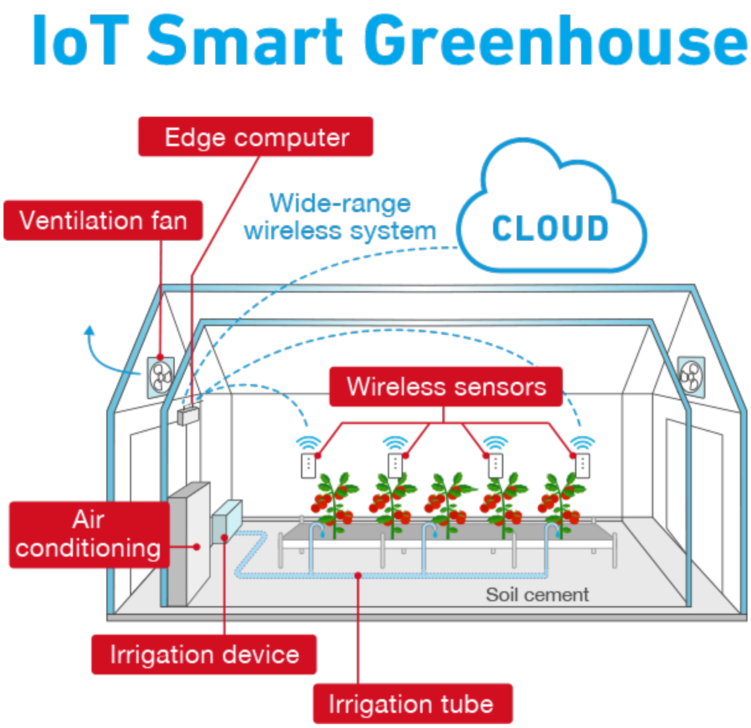


Figure 10 – IoT Smart Greenhouse

The smart greenhouse is a revolution in agriculture, with sensors, actuators, and monitoring and control systems that optimizes growth conditions and automates the growing process to create a self-regulating, microclimate suited for plant growth. Between 2017 and 2022, the global smart greenhouse market is predicted to increase at a CAGR of around 14.12 percent, from USD 680.3 million in 2016 to USD 1.31 billion in 2022. Due to rising population, climate change and urbanization, the industry is likely to increase significantly. Smart farming is projected to grow at a rapid pace as well. High installation costs and initial investment expenditures, on the other hand, may stifle expansion in developing regions like the Middle East and Africa. [11]

Based on type, smart greenhouses [11,12,13] can be segmented into hydroponic and non-hydroponic:

- Hydroponic greenhouses grow plants without soil.
- Non-hydroponic smart greenhouses dominate the market and have the highest growth potential over the forecast period.

The key technologies used in the smart greenhouse market are HVAC, LED grow lights, communications technology, irrigation systems, materials handling, valves and pumps, and control systems. The LED grow light segment dominated the market in 2016, used as an artificial light source to stimulate plant growth

2.3.3 BENEFITS & REASONS TO CHOOSE SMART GREENHOUSE

- Maintain Ideal Micro-Climate Conditions
- Enhance Irrigation and Fertilization Practices
- Control Infection and Avoid Disease Outbreak
- Prevent Thefts and Improve Security
- Increase Production while minimizing production risks
- Ability to grow produce all year-round, regardless of season
- Remote monitoring and control

2.3.4 TECHNOLOGIES FOR SMART GREENHOUSE

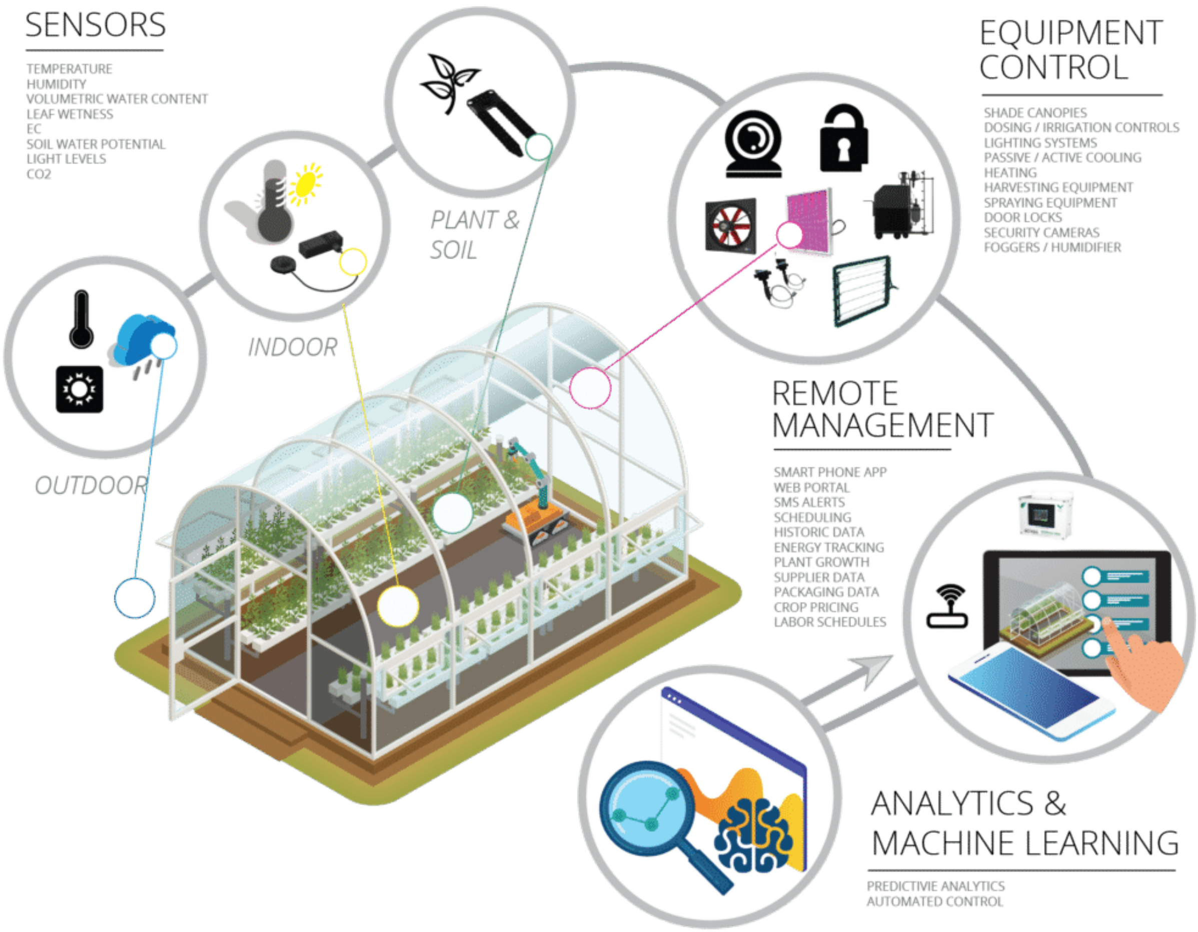


Figure 11 – Technologies For Smart Greenhouse

Many technologies can be adapted and implemented to be used in smart greenhouses through using IoT, including the following:

figure 12 – AI

- AI – Artificial Intelligence can be used to automate instances such as watering plants when the temperature increases a certain amount or to immediately signal the farmer when the pH balance of a crop is not at its optimum balance.

Figure 13 – Smart Drone

- DRONES – Drones are increasingly being used in agriculture as part of an effective approach to sustainable agricultural management that allows agronomists, agricultural engineers, and farmers to assist streamline their operations and acquire useful insights into their crops utilizing strong data analytics. Crop monitoring, for example, is simplified by the use of drone data to precisely plan and implement ongoing adjustments, such as ditch placement and fertilizer application changes. Instead of more typical time and labor-intensive data collecting, products can be properly traced from farm to fork utilizing GPS positions for every stage along the path.

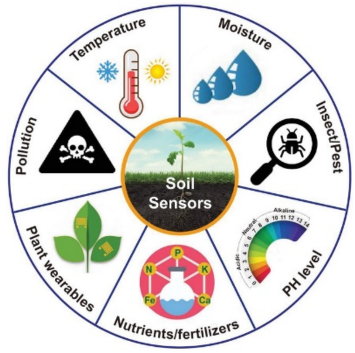


Figure 14 – Types of Smart Sensors

- SMART SENSORS – The five types of sensors are usually employed in the sensor network of a smart greenhouse include humidity and temperature sensors, light sensors, and CO2 sensors (in the air), EC and pH sensors, and the dissolved oxygen sensors (in the water).

2.3.5 EXAMPLES OF SMART GREENHOUSE

Most smart greenhouses generally have the same features and aim to achieve the same efficiency and conditions [14] :

- Commercial Smart Greenhouse System examples: Sensaphone, Growtronix and Monnit Greenhouse Monitoring.
- Greenhouse Monitoring Software example: Climate Manager
- Intel Edison and AWS Greenhouse
- Raspberry PI Vivarium Controller
- Arduino Greenhouse

CHAPTER 3: METHODOLOGY

3.0 PROJECT METHODOLOGY

Research of this project was done with my supervisor, Dr Dayang Rohana Bt Awang Rambli and also through self-study with the help of research papers and articles on the internet. Milestones and planning are outlined as to make sure the delivery of objectives is achieved over the time period of FYP1 and FYP2. As a start, a methodology was chosen to ensure the delivery of the project is according to how it supposed to behave and looks. This supports the overall objective which is from the commencement of FYP1 up until the conclusion of FYP2, from the planning phase until the prototyping phase and the penultimate prototype of the project.

3.1 AGILE METHODOLOGY

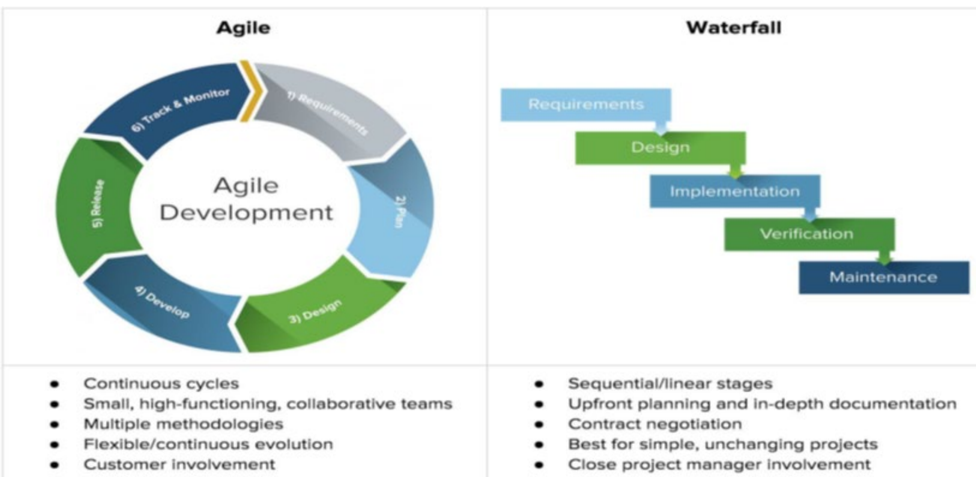


Figure 15 – Agile vs. Waterfall Method

As for this project, Agile methodology is chosen as it is the most suitable and compatible as Agile methodology has more involvement from the user and it is much more flexible compared to the Waterfall technique. The main reasons for choosing Agile over Waterfall includes [15] :

- A more predictable end product and less risky with lower error tendency
- More open to changes and/or additions due to its flexibility
- Development is more user-focused rather than developer-focused

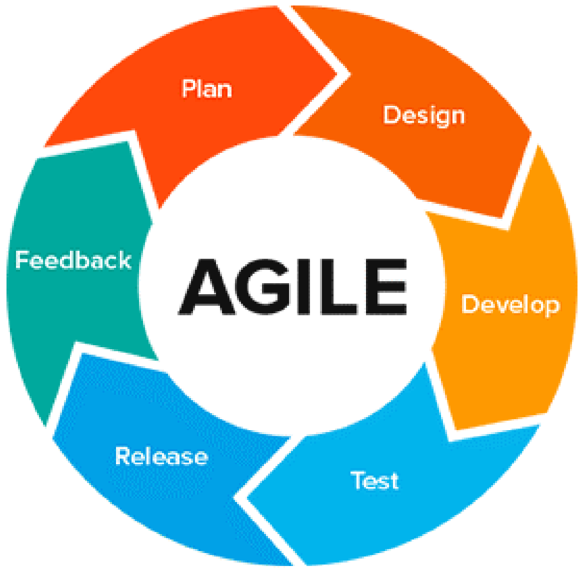


Figure 16 – Agile Methodology

- Plan – The appropriate project title will be determined during the planning stage of the project in order to provide a clear indication of the project's progress throughout the research and project. The type of platform and foundation for the project is decided in the planning phase of the project in order to have a clear understanding of how the project will develop. During this planning phase, data is gathered through surveys and interviews to gauge public opinion on the project.

- Design & Develop – During the design and development phase, the data gathered is analyzed and categorized to verify that the application is designed in accordance with public opinion and suitability in order for the prototype to be effective and achieves all objectives.

- Test, Release & Feedback – During the testing phase, the prototype will be thoroughly tested across all of its main functions. This is the most crucial step since it helps us to determine whether all of our efforts in designing and testing the prototype were worthwhile. Extensive testing and analysis must be performed prior to finalizing the prototype with ongoing feedback from users. Modifications to the prototype can be made in accordance with the user needs and preferences.

3.2 GANTT CHART

	MAY 2021 – JULY 2021												SEPT 2021 – NOV 2021											
TASKS	FINAL YEAR PROJECT 1												FINAL YEAR PROJECT 2											
PROJECT PLANNING																								
DATA COLLECTION & ANALYSIS																								
PLANNING & REQUIREMENT GATHERING																								
DESIGN PHASE																								
PROTOTYPE DEVELOPMENT																								
PROTOTYPE TESTING & MAINTENANCE																								
PROTOTYPE FINALIZATION & DOCUMENTATION																								

Table 1 – Gantt Chart

3.3 PROTOTYPE & DEVELOPMENT

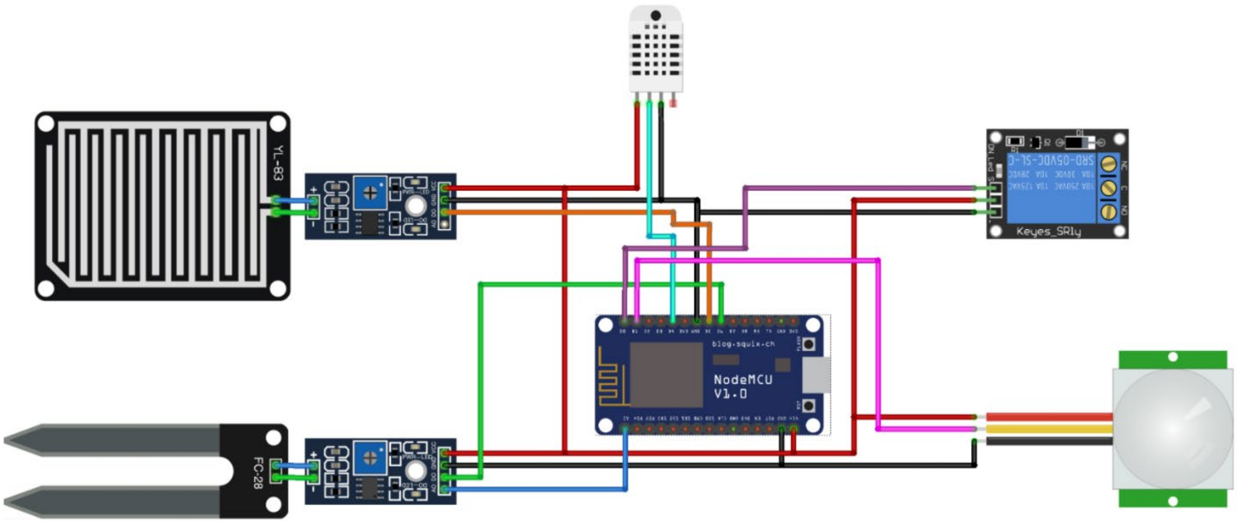


Figure 17 – System Diagram

The initial proposed prototype was to be made using the following components:

- Nodemcu ESP8266
- Soil Moisture Sensor
- PIR Motion Sensor
- Rain Drop Sensor
- Relay Module
- Solenoid Water Valve
- BreadBoard
- Jumpers
- 12V Battery
- Smartphone with access to Blynk application

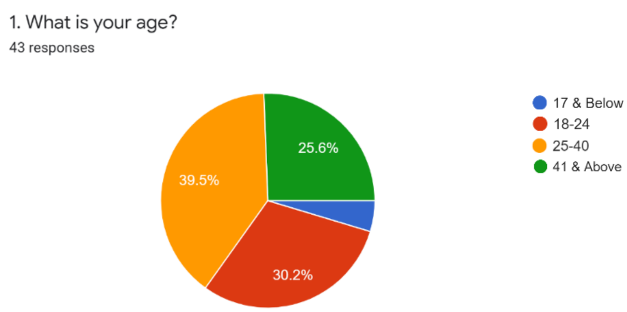
As shown in the circuit diagram, this project will be expected to be made by utilizing the Nodemcu ESP8266 board with sensors being a soil moisture sensor, PIR motion sensor and a raindrop sensor. The components will be connected as shown in the diagram. After constructing the system, it will be connected to a computer and on a smartphone, the Blynk application will be need to be downloaded. Inside the Blynk application it is then required to open the application and to create a new project. Here the user will decide what they want to name their system or project. The system will be preferably be connected through a wifi internet connection. Once done, the sensors will have to be mapped onto the system by linking and connecting them one by one and determining the values they will track and record. The relay module will act as an on/off button for the system which also will allow the user to turn on and off the irrigation system remotely from their smartphone.

Figure 18 – Blynk Application Interface

CHAPTER 4.0: DISCUSSION & RESULTS

4.1 SURVEY FINDINGS

In order to further gauge the suitability and feasibility of implementing a remote irrigation system for smart greenhouse, I made a 10-question survey to generally what the level of understanding and acceptance towards enhancing gardening/agriculture using IoT would stand. A total of 43 participants who responded with most of them being from my neighborhood and the results are as follows:



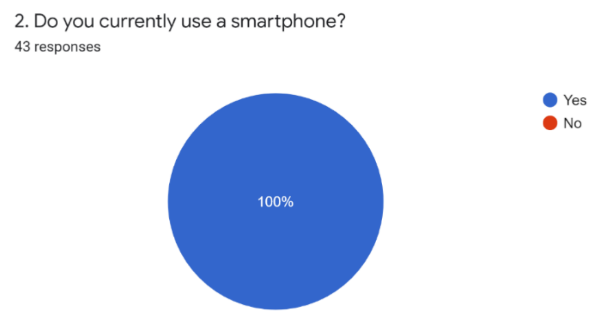


Figure 19 – Question 1 & 2

It can clearly be deduced that based on the survey conducted, a general consensus has been identified that the majority of the respondents know very little or only have had heard of what IoT is, with every respondent having and using a smartphone. For question 1, which was regarding the ages of the respondents, was fairly evenly spread with most being in the age range of 25-40 at 39.5%, followed by 30.2% being 41 & above, 25.6% being between 18-24 and 2 of the 43 respondents being the age of 17 & below.

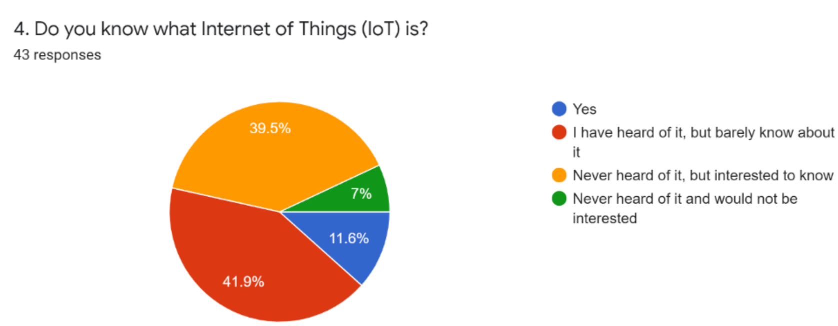


Figure 20 – Question 3 & 4

A huge majority of the respondents indicated that they do any form of gardening with a resounding 88.4% of them who do gardening on question 3. The general response on question 4, regarding whether the respondents have any knowledge on IoT gave a fairly telling result, showing that only 11.6% are well-versed in what it is. This shows that despite most respondents only have heard of and/or not know about IoT, most of them are open to learning or at the very least, knowing what IoT is and what it is about. Surprisingly, 7% of respondents were not interested in knowing what IoT us despite not knowing what it is.

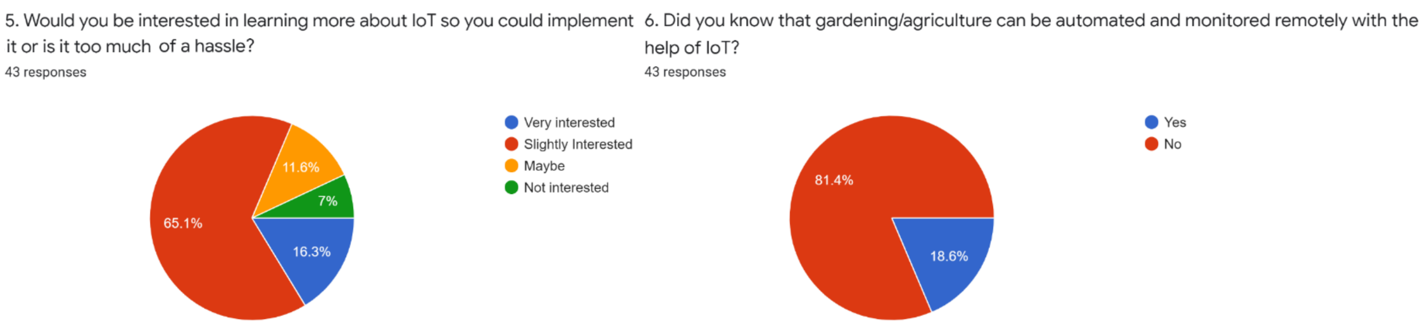


Figure 21 – Question 5 & 6

Question 5 was in regards of whether participants would be interested in learning more about IoT in order to implement it or if it was too much to learn. 81.4% of the participants (16.3% very interested and 65.1% were slightly interested) were at the very least keen on learning how to implement IoT for agriculture. 11.6% were undecided and answered "maybe" and again the same 7% were uninterested. What also comes as a shock in the whole survey was the fact that a staggering 81.4% of the respondents did not know that agriculture can be automated and remotely controlled through IoT in question 6, with only 18.6% knowing that it can be automated.

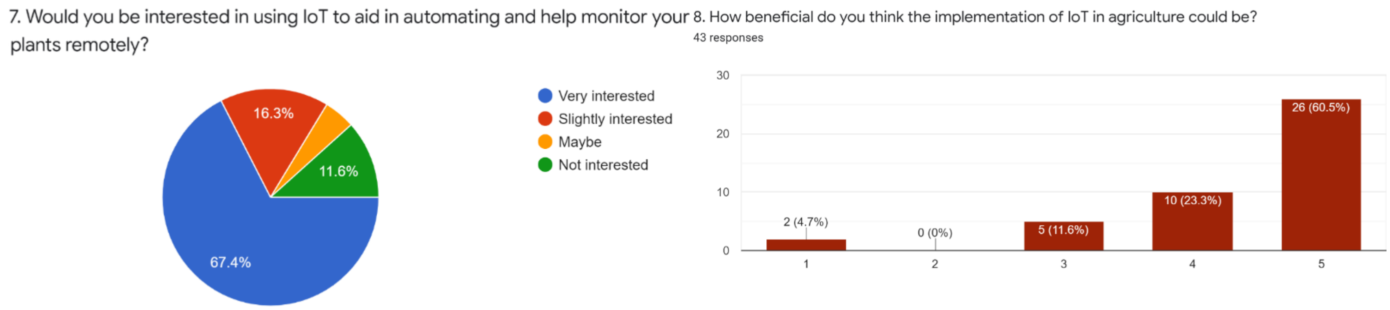


Figure 22 – Question 7 & 8

Despite a large number of participants being clearly unsure of what IoT brings in terms of innovation and aiding agriculture becoming more manageable and easier, by the time they have reached question 7, we can assume the large number of participants being “Very Interested” (67.4%) for using IoT to help their agricultural needs is due to the fact that they have likely have found out by the arrangement of questions alludes to the fact that IoT is capable of aiding in monitoring and automating growth management of their plants. Although that is the case, the non-believers and uninterested few somehow have increased, with 11.6% being uninterested. Unsurprisingly, 60.5% of participants believe that IoT implementation is very beneficial to agriculture, with 26 of them rating it as a “5” on a scale of 1 to 5. 2 participants remain skeptical of the usefulness of IoT by answering a “1” on the scale.

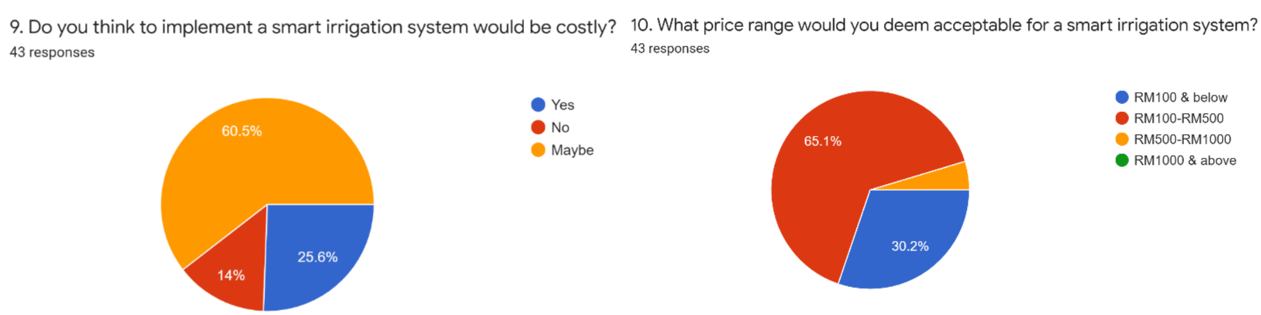


Figure 23 – Question 9 & 10

Questions 9 and 10 were in regard of the cost of implementing IoT in agriculture. Being something most of the respondents were unsure of, the range of answers were not that hard to expect, with a resounding majority (60.5%) settling with the answer “Maybe” when asked on whether a smart irrigation system would be costly to implement. Roughly a quarter of the respondents (25.6%) believe it would be costly to implement and 14% of respondents who likely already know the cost of a smart irrigation or at the very least know of its price range, answered “No”. The last question asks on the range of price respondents would deem to be acceptable to spend on. Interestingly, none of the respondents believed a smart irrigation system above

RM1000 to be acceptable. The majority (65.1%) believed the range of RM100-RM500 to be acceptable.

4.2 LITERATURE REVIEW FINDINGS

Based on the literature review, some findings were identified:

- IoT is widely being used in many sectors, not just agriculture but also healthcare, logistics and energy to name a few.
- IoT not only aids in precise data analysis but also aids in management and automating some processes and/or actions.
- IoT is becoming more and more affordable to implement as more and more development on it is acquired.
- The implementation of IoT could indeed be costly, but the benefits and outcomes far outweigh the initial investment made to implement it.

4.3 PROTOTYPE HARDWARE

The prototype model needs every sensor to be associated with the control unit which is an IoT module. The ESP8266 takes data and control every one of the sensors and its capacities. When the soil dampness is distinguished to be insufficient through the soil moisture sensor, the engine will be signaled to siphon the water to the soil. Same applies to the DHT11 temperature and humidity sensors identify insufficiency, water will be pumped. The utilization of IoT in this project makes manual intervention at a minimum and also provides data for future analysis which proves to be crucial in future planning, detection of anomalies, causes of failure and determining optimum irrigation scheduling and amount of water pumped.

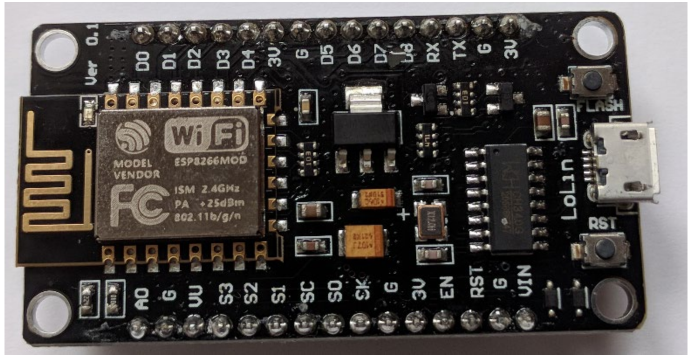


Figure 24 – ESP8266 Module

ESP8266

Espressif Systems developed this low-cost Wi-Fi microchip with built-in TCP/IP networking software and microcontroller functionality. Using Hayes-style commands, this small module allows microcontrollers to connect to a Wi-Fi network and make rudimentary TCP/IP communications. The inexpensive price of the module is due to the fact that it contained very few external components.

Specifications:

- Processor: L106 32-bit RISC microprocessor core based on the Tensilica Xtensa Diamond Standard 106Micro running at 80 MHz
- Memory:
  32 KiB instruction RAM
  32 KiB instruction cache RAM
  80 KiB user-data RAM
  16 KiB ETS system-data RAM
- External QSPI flash: up to 16 MiB is supported (512 KiB to 4 MiB typically included)
- IEEE 802.11 b/g/n Wi-Fi
- Integrated TR switch, balun, LNA, power amplifier and matching network
- WEP or WPA/WPA2 authentication, or open networks
- 17 GPIO pins
- Serial Peripheral Interface Bus (SPI)
- I^2C (software implementation)
- I^2S interfaces with DMA (sharing pins with GPIO)
- UART on dedicated pins, plus a transmit-only UART can be enabled on GPIO2
- 10-bit ADC (successive approximation ADC)

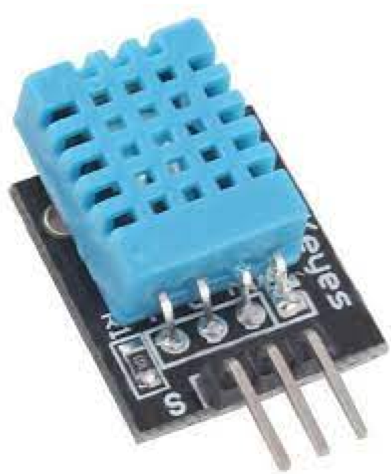


Figure 25 – DHT11 Sensor

TEMPERATURE & HUMIDITY SENSOR

The DHT11 Temperature and Humidity Sensor has a computerized signal yield that is linked with the temperature and humidity sensor capacity controlled by an advanced 8-piece microcontroller. It is very secure and highly dependable. It possesses exceptional properties, such as quick reaction time and blockage resistance. Each DHT11 sensor has a moistness alignment chamber that may be adjusted to an incredible degree of precision.

Specifications:

- Supply of Voltage: +5 V
- Temperature of range :0-50 °C error of ± 2 °C
- Humidity :20-90% RH ± 5% RH error
- Interface: Digital system
- Low cost
- 3 to 5V power and I/O
- 2.5mA max current use during conversion (while requesting data)
- Good for 20-80% humidity readings with 5% accuracy
- Good for 0-50°C temperature readings with ±2°C accuracy
- Body size 15.5mm x 12mm x 5.5mm 4 pins with 0.1” spacing

Figure 26 – Soil Moisture Sensore

SOIL MOISTURE SENSOR

Soil Moisture sensors are helpful in measuring the water content in the soil. Examining soil dampness requires expelling, drying, and weighing. Soil moisture sensors measure the volume of water content by utilizing properties of the soil, such as electrical opposition, dielectric, or reaction with neutrons, as an intermediary for the dampness content. The link between the deliberate property and soil wetness must be established, and it may vary depending on ecological elements such as soil type, temperature, and electric conductivity. The moisture of the ground can be influenced and reflected by microwave radiation, which is used for remote detection in hydrology and horticulture.

Figure 27 – Submersible Water Pump

SUBMERSIBLE WATER PUMP

Also known as a sub pump or an Electric Submersible Pump (ESP), a submersible pump is a device which incorporates a hermetically sealed motor tightly linked to the pump body. It is submerged in the pumped fluid. The main benefit of this type of pump is that it eliminates pump cavitation, a problem caused by a large difference in elevation between the pump and the fluid surface. As opposed to jet pumps (which produce a vacuum and rely on atmospheric pressure), submersible pumps push fluid to the surface. Submersibles are utilized in heavy oil applications using hot water as the motive fluid, and they employ pressured fluid from the surface to drive a hydraulic engine downhole rather than an electric motor. For better and efficient results, the pump must be submerged in water because if it is not submerged or not operated with water, it will be prone to damage.

4.4 SOFTWARE

The two softwares I found most suitable for my prototype are Blynk application and ThingSpeak.

Blynk

ThingSpeak™

Figure 28 – Blynk & ThingSpeak Logos

BLYNK APPLICATION

The Blynk application is made by the company of the same name known for providing infrastructure for IoT, providing a platform that allows you to rapidly and easily build interfaces for controlling and monitoring your hardware projects from any device with iOS or android operating system. The no-code approach to IoT app building was pioneered by Blynk in 2014, quickly garnering global prominence. Just simply download the Blynk app and then you can instantly create a project dashboard through simplified widgets on the screen. Using the widgets, you can turn pins on and off or display data from sensors.

Blynk Application Architecture:

- Application for IOS and android
- Blynk server
- Hardware libraries

Blynk application allows developers to build their application display according to their immediate needs using various easy to use drag-and-drop widgets available on the application.

Once account is being created a develop can start building an application by choosing the hardware device that is being used and the connection type. The creation of new project will be done once the user gets an Authentication token to his/her email mentioned while creating this account.

Microcontrollers that can be used with Blynk:

- Arduino: Arduino MRK1000, Arduino UNO, Arduino MRKZero, Arduino Yun, Arduino 101, Arduino Zero, Arduino MO, Arduino MO Pro, Arduino MO Pro mini, Arduino Nano, Arduino due, Arduino Leonardo, Arduino Mega 2560, Arduino Mega 1280, Arduino Mega ADK, Arduino Micro, Arduino Pro micro, Arduino Mini, Arduino Pro Mini, Arduino Fio, Arduino Decimilia, Arduino Ethernet etc.

- Espressif: ESP8266, ESP32, NodeMCU, WeMos D1, Adafruit HUZZAH, SparkFun Blynk Board, SparkFun ESP8266 Thing.

- Raspberry Pi: Raspberry Pi 2/A/A+/B+, Raspberry Pi 3B, Raspberry Pi A/B (Rev2), Raspberry Pi B (Rev1). Particles: Particle core, particle photon, particle electron.

Blynk Server:

When the user develops an application through Blynk various messages would be forwarded between the application and the type of microcontroller used in the project, made possible by an open-source Netty based java server, known as Blynk server, where it is a NIO client server framework that excels in enabling a quick and easy way to develop network apps.

Blynk libraries:

The data exchange between the hardware component, Blynk cloud and the user created project and all the connection routines is ensured and handled by Blynk libraries. This ensures the connectivity between the user developed application and the hardware component.

THINGSPEAK PLATFORM

ThingSpeak is a simple and free IoT platform developed by MathWorks that is ideal for fast prototyping. Furthermore, for simple applications, ThingSpeak already has generally good data visualization tool capabilities. Being able to execute MATLAB code in ThingSpeak, online analysis and processing of the data can be done in ThingSpeak. Often used for prototyping and IoT system concepts which require analytics. However, the channels themselves, with a mere eight data fields and very limited data processing and data forwarding choices, can quickly prove to be too restrictive and may bring complications for expanding a project or prototype.

ThingSpeak aids developers in visualizing, aggregating and analyzing live data on the cloud.

Key capabilities of ThingSpeak include the following:

- Configures devices with ease to send data using popular IoT protocols.
- Real-time data visualization.
- Third-party sourced on-demand data aggregation.
- MATLAB compatibility to enumerate collected data.
- Automatically run IoT analytics based on schedules or data through third-party services
- Make IoT systems with the absence of server set-up or developing web software.

BLYNK VS. THINGSPEAK

Feature \ Name	Blynk	ThingSpeak
Application Development	✓	✗
Big Data Analytics	✓	✗
Configuration Management	✓	✓
Connectivity Management	✓	✓
Data Collection	✓	✓
Data Management	✓	✓
Device Management	✓	✗
Performance Management	✓	✗
Prototype Creation	✓	✓
Visualization	✓	✓

Table 2: Comparison of Features Between Blynk & ThingSpeak

Deployment / Name	Blynk	ThingSpeak
Cloud, SaaS, Web-based	✓	✓
Desktop – Mac	✗	✗
Desktop – Windows	✓	✗
Desktop – Linux	✓	✗
Desktop – Chromebook	✗	✗
On-Premise – Windows	✗	✗
On-Premise – Linux	✗	✗
Mobile – Android	✓	✗
Mobile – iOS	✓	✗

Table 3: Comparison of Deployment Between Blynk & ThingSpeak

Based on the observations made in comparing Blynk and ThingSpeak [28], it can be deduced that between the two, Blynk is the more superior software due to it sizably having more features and its ability to be deployed on mobile devices and iOS/Android OS capable devices, allowing for better and easier remote control. ThingSpeak also has many different working parts compared to Blynk, rendering a bit more complicated unless you are tech savvy.

4.5 CODE

The coding used in this project is as follows:

```
#include <DHT.h>
#include <SimpleTimer.h>
#include <SPI.h>
#define BLYNK_PRINT Serial      // Comment this out to disable prints and save space
#include <BlynkSimpleEsp8266.h>
char auth[] = " Ko04KCwj5Rbg396UXhK5nsKJTD5n9RMf"; //Enter the Auth code which was send by Blink
DRY_SOIL = 100
// Your WiFi credentials.

char ssid[] = "Razak@unifi"; //Enter your WIFI Name char pass[] = "1234ABCDE"; //Enter your WIFI Password
#define DHTPIN 2 // Digital pin 4
#define SOIL_MOIST_1_PIN A0 //Analog pin A0
DHT dht(DHTPIN, DHTTYPE);
SimpleTimer timer;
void sendSensor()
{
float h = dht.readHumidity();
float t = dht.readTemperature(); // or dht.readTemperature(true) for Fahrenheit
if (isnan(h) || isnan(t)) {
Serial.println("Failed to read from DHT sensor!");
return;
}

Blynk.virtualWrite(V5, h); //V5 is for Humidity
Blynk.virtualWrite(V6, t); //V6 is for Temperature
}

void getsoilmoist(void)

{
int i=0;
int soilmoist=0; for (i=0;i<100;i++)
{

soilmoist +=analogRead(SOIL_MOIST_1_PIN);
delay(20);
}

soilmoist = soilmoist / (i);

soilmoist = map(soilmoist, 1023, 0, 0, 1000);
Blynk.virtualWrite(V7,soilmoist);
}
void turnPumpOn()

{

pumpStatus = 1; aplyCmd();
delay (TIME_PUMP_ON*1000); pumpStatus = 0;
aplyCmd();

}
```

Figure 29 – Coding Part 1

```
Blynk.virtualWrite(V7,soilmoist);
}
void turnPumpOn()

{

pumpStatus = 1; aplyCmd();
delay (TIME_PUMP_ON*1000); pumpStatus = 0;
aplyCmd();

}

void turnPumpOff()

{

pumpStatus = 0;

}

void relaymode(void)

{

if (soilMoister < DRY_SOIL)

{

turnPumpOn();

}
else
turnPumpOff();
void setup ()
{

Serial.begin(9600); // See the connection status in Serial Monitor
Blynk.begin(auth, ssid, pass);
dht.begin();

timer.setInterval(1000L, sendSensor);
timer.setInterval(1000L, getsoilmoist);
 Timer.setInterval(1000L,relay);
}

void loop()

{

Blynk.run(); // Initiates Blynk
timer.run(); // Initiates SimpleTimer
}
```

Figure 30 – Coding Part 2

4.6 RESULT

A huge limitation in the project is found when using Blynk application due to the fact that during the duration of the project, the version of the Blynk application I was using during the whole development phase was rendered useless due to the fact the company released a separate new version of the application, in which the migration to the new application was such as hindrance and cause a lot of complications to the overall effectiveness and result of the project due to the incompatibility of the old application (along with the coding done on it) with the new application. It indeed was a shame as the old application was ceased of development and support as of July 2021.

The soil moisture sensor functions as intended by sending data and parameters related to soil moisture and quality to the microcontroller, whilst the DHT11 Temperature and Humidity Sensor does well to detect the level of humidity and temperature of the soil. The microcontroller then sends a signal to the transfer module, which activates the water pump and delivers a set amount of water to the plant when the level of soil wetness falls under the specified threshold. Once enough water has been pumped, the pump will stop releasing water. The power supply has the responsibility of controlling the whole module, and the predetermined voltage for the microcontroller should ideally be between 7 and 12 volts. ESP8266 is considered an ideal microcontroller for this reason thanks to its measurements and its effective reliability.

4.7 PROTOTYPE HARDWARE OUTCOME

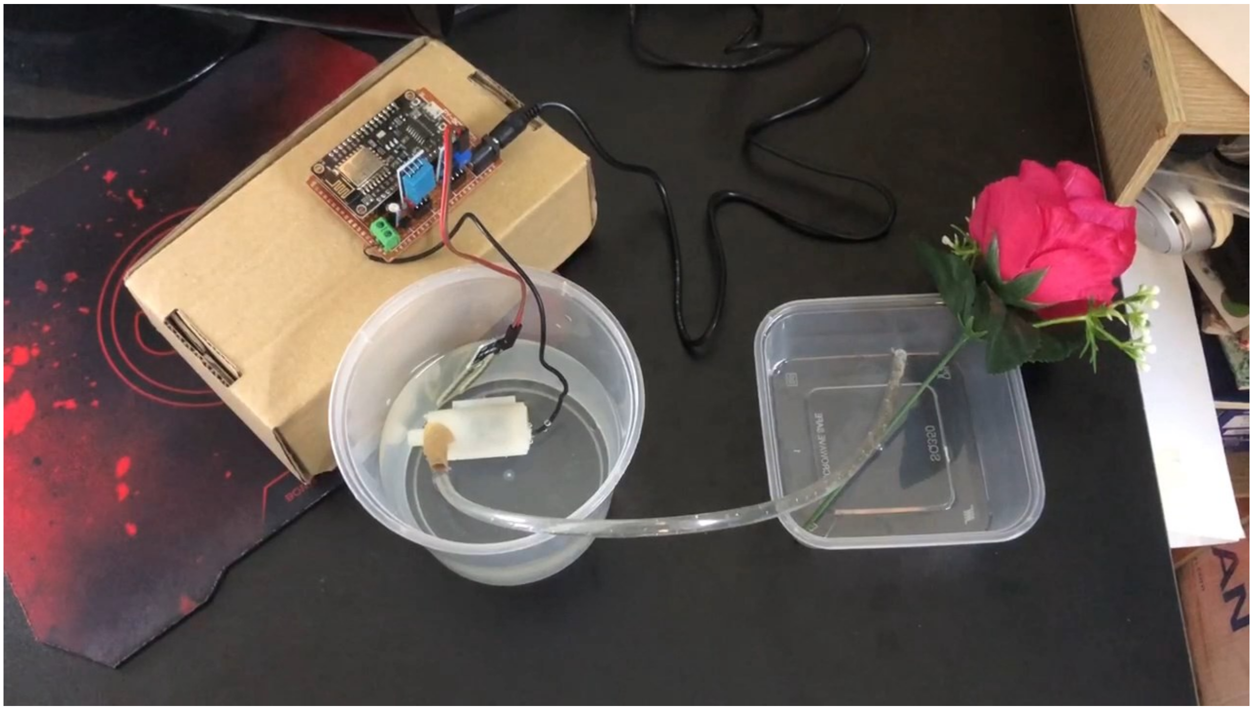


Figure 31 – Prototype Hardware Outcome

The components used in the final prototype include the following:

- ESP8266 Module
- DHT11 Temperature & Humidity Sensor
- Soil Moisture Sensor
- Submersible Water Pump
- Rubber Pipe
- Power Supply

4.8 CONNECTING BLYNK APP TO ANDROID DEVICE

Figure 32 – Connecting ESP Module With Android Device

The steps taken to connect the blynk application with the designated android device include the following:

1. Download blynk app from Google playstore in the designated android phone
2. After installed, create an account and login into the app
3. Then click on the tab created for the project
4. To connect with the wifi, you have to set your phone hotspot setting to the settings made in your coding for the project to connect with the hotspot
5. After turning on the hotspot, power the project and check whether the project has been connected or not
6. Once the project is connected, click on the play icon in the blynk app on the designated android device

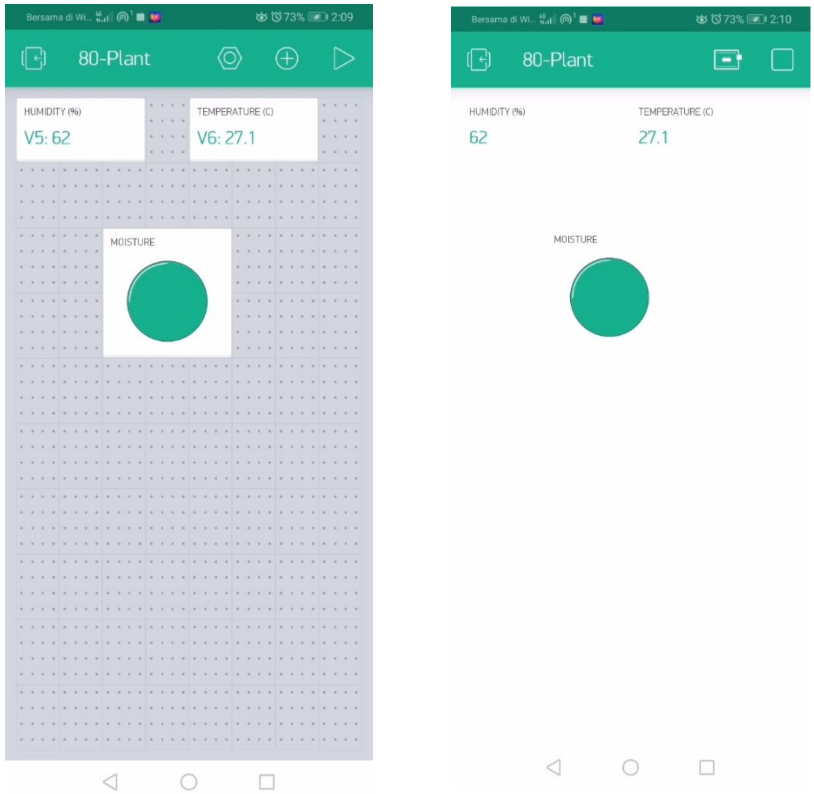


Figure 33 – Reading Display On Blynk App Once Connected

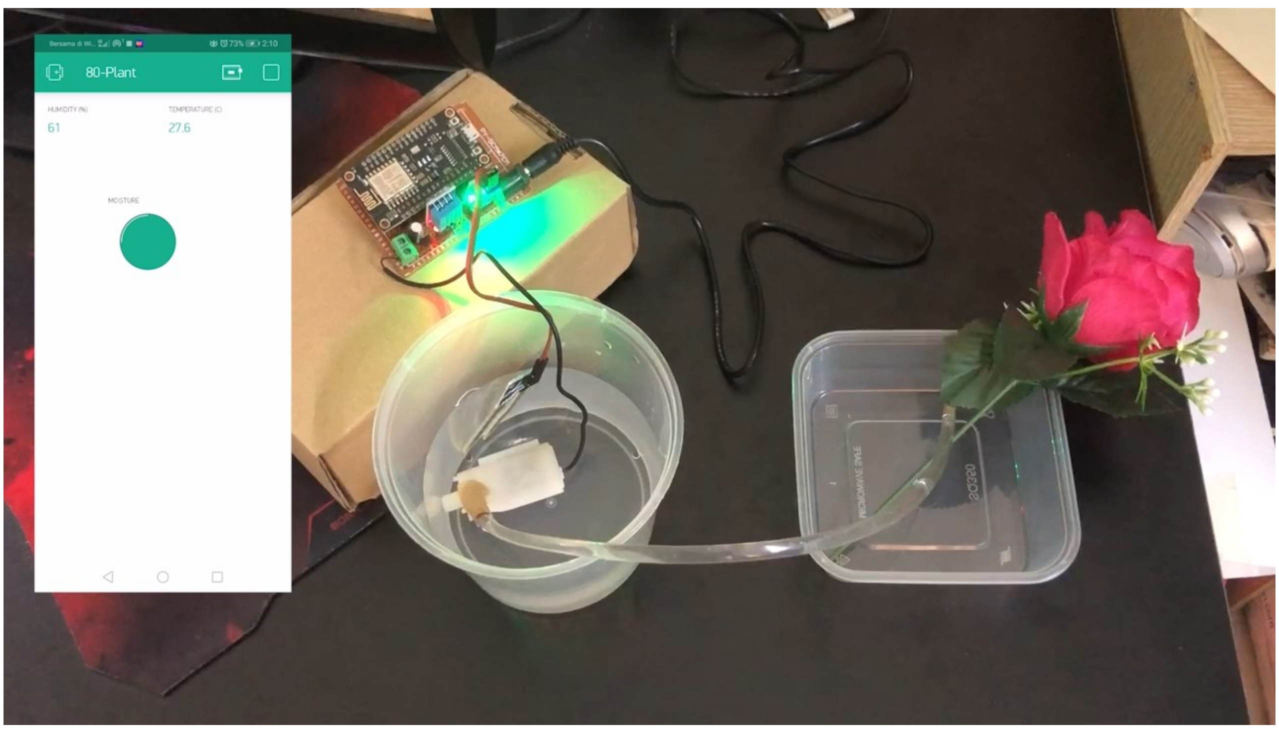


Figure 34 – Powering Up The Project

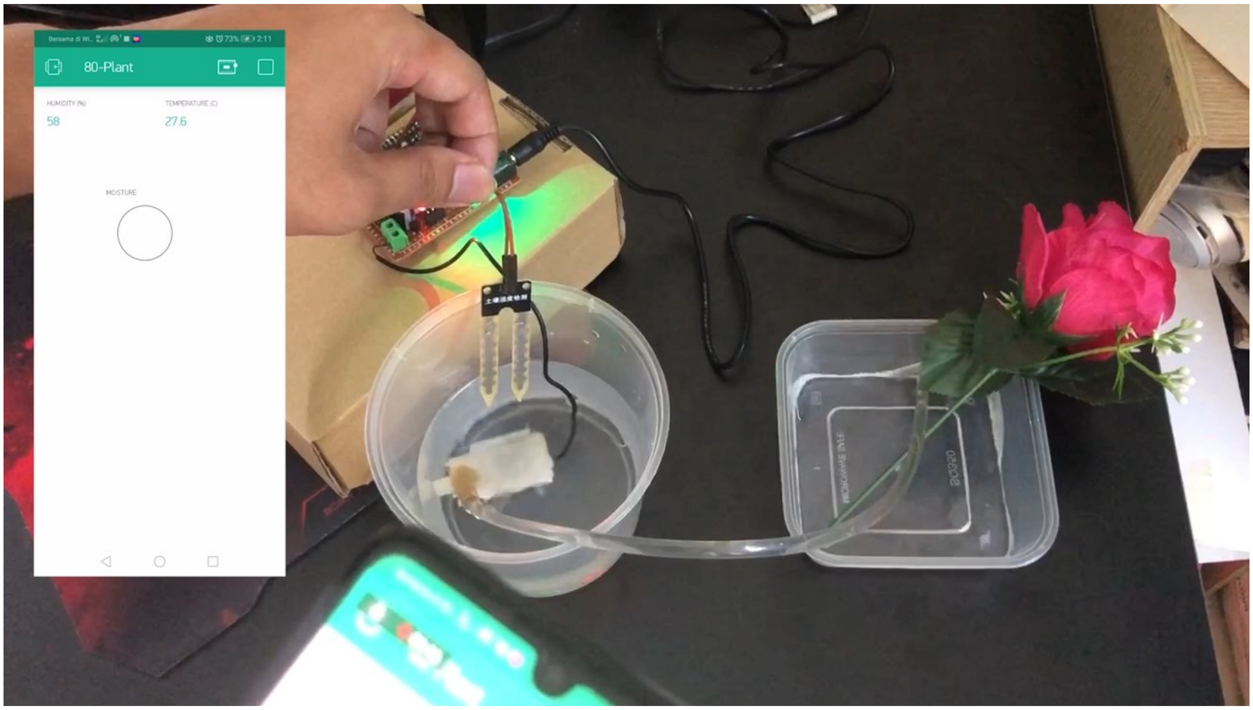


Figure 35 – The System Detects Low Humidity, Pumps Water Automatically

CHAPTER 5: CONCLUSION & FUTURE WORK

5.0 CONCLUSION

With the emergence of the Industrial Revolution 4.0, the whole world is shifting to implementing digital and technological advances into everything. More and more technology has been developed to support and enhance our daily life. The continuous evolution of technological advancement has allowed us to reduce manual labour, increase productivity and minimize risks and unfavourable situations which is all for the betterment of mankind.

This study and project is hope to have successfully implemented a smart water irrigation system which meets the target of water-saving purposes and provide adequate and optimum irrigation by the conclusion of the project. Consequently, it is also hoped that authorities would start to put more emphasis on research and support on agriculture-related projects to revamp the agriculture sector in Malaysia.

Farming and agriculture will play a vital role in the coming years not only in the country but also on a global scale as a shortage of produce can directly affect the survivability of mankind as a whole. Thus there is definitely a need for smart farming. Internet of Things will definitely help to enhance smart farming. IoT is used in agriculture to increase time efficiency, water management, crop monitoring, soil management, and insecticide and pesticide control, to mention a few. It also reduces human work, simplifies farming procedures, and aids in smart farming. With these capabilities, smart farming can assist farmers in expanding their market with a single click and no work.

The application of technology in agriculture is a huge necessity in order to pursue modern agricultural development. After developing the prototype and project, it is clear that the cost and skill level needed to develop an IoT based system is becoming more and more cheaper and more accessible thanks to the ever-evolving advancement in technology. It also has to be admitted that it is crucial to invest in IoT due to its hugely beneficial advantages, whilst in order to implement it on a commercial scale might be costly, the initial investment will prove to be worth every single cent, as you not only manage to save and reduce excessive waste but also monitor and automate resource management, with the added incentive that you are able to analyze the data picked up by the system in order to formulate better measures in order to garner the most optimum results.

5.1 ADVANTAGES OF THE PROJECT

The advantages found from this project are:

- The usage of the smart irrigation system would aid in conservation of water
- The system would allow an increase in production thanks to the automation and analytics
- Operation costs can also be lowered over the longer course of time
- Ease of use is a highlight as IoT is now developed to be more easier
- Higher quality in produce
- Ability to monitor and control plant growth from virtually anywhere as long as there is Wi-Fi

5.2 LIMITATIONS OF THE PROJECT

The limitations of this project include the following:

- Unforeseen circumstances could hugely affect the outcome of the project
- The move from the old Blynk application to the new Blynk application caused many complications
- The system works best under well-lit conditions, or rather below a direct light source
- Due to the scale of the project and prototype, it is uncertain if it could be feasible at a commercial level or on a larger scale
- Unexplainable difference in usage of iOS based device and android device

5.3 RECOMMENDATIONS

There are several recommendations that apply to making the system more efficient and better, but were not able to be achieved due to time constraints and unforeseen circumstances:

- Develop a solution for migration of code from the old Blynk application to the new one
- Develop a solution in order to ensure lighting does not affect the effectiveness of the system
- Develop and add more features to both the prototype and overall system

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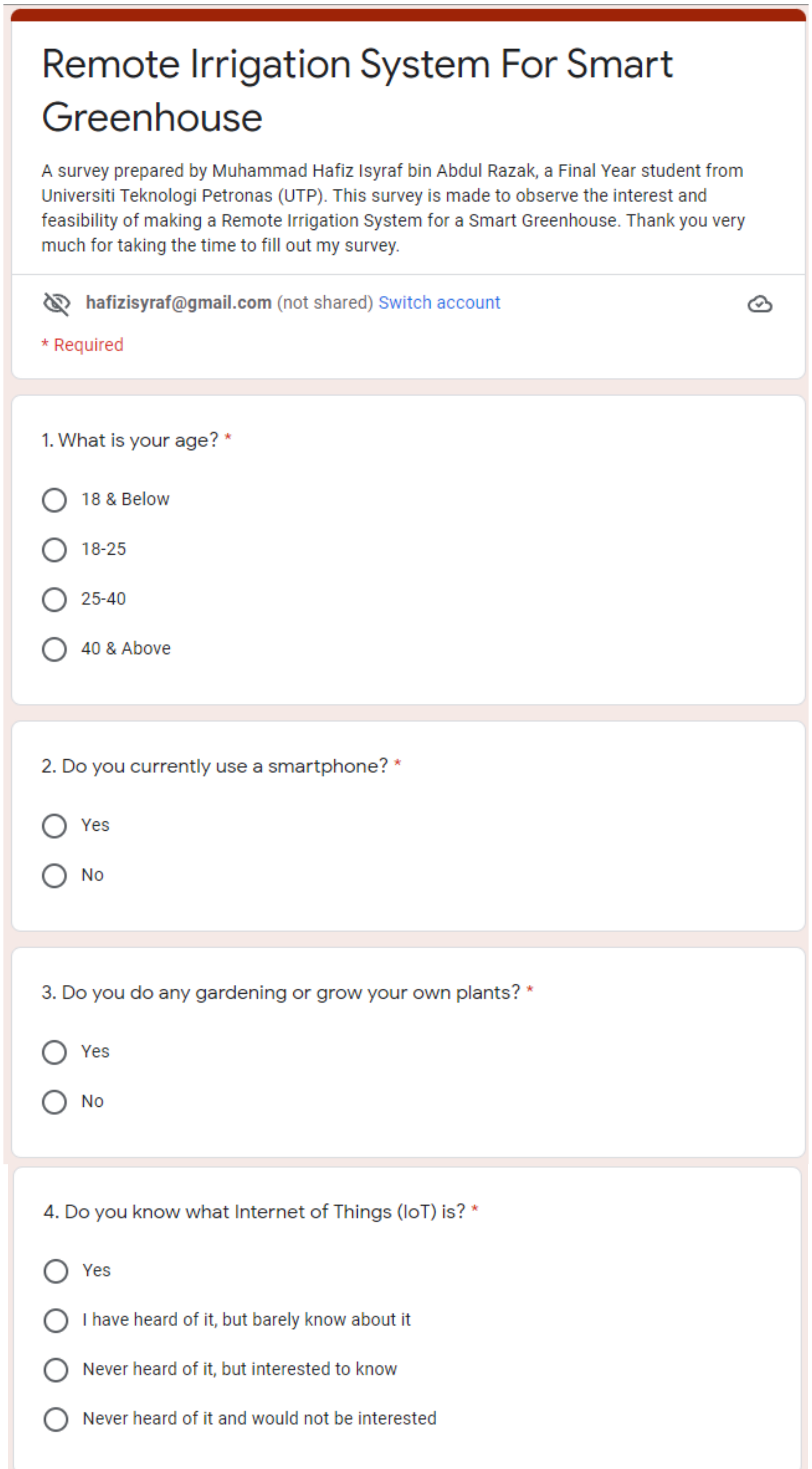
APPENDICES



Remote Irrigation System For Smart Greenhouse

A survey prepared by Muhammad Hafiz Isyraf bin Abdul Razak, a Final Year student from Universiti Teknologi Petronas (UTP). This survey is made to observe the interest and feasibility of making a Remote Irrigation System for a Smart Greenhouse. Thank you very much for taking the time to fill out my survey.

hafizisyraf@gmail.com (not shared) Switch account

* Required

1. What is your age? *

- ○ 18 & Below
- ○ 18-25
- ○ 25-40
- ○ 40 & Above

2. Do you currently use a smartphone? *

- ○ Yes
- ○ No

3. Do you do any gardening or grow your own plants? *

- ○ Yes
- ○ No

4. Do you know what Internet of Things (IoT) is? *

- ○ Yes
- ○ I have heard of it, but barely know about it
- ○ Never heard of it, but interested to know
- ○ Never heard of it and would not be interested

Appendix 1: Survey Prior To Project Part 1

5. Would you be interested in learning more about IoT so you could implement it or is it too much of a hassle? *

- ○ Very interested
- ○ Slightly Interested
- ○ Maybe
- ○ Not interested

6. Did you know that gardening/agriculture can be automated and monitored remotely with the help of IoT? *

- ○ Yes
- ○ No

7. Would you be interested in using IoT to aid in automating and help monitor your plants remotely? *

- ○ Very interested
- ○ Slightly interested
- ○ Maybe
- ○ Not interested

8. How beneficial do you think the implementation of IoT in agriculture could be? *

	1	2	3	4	5	
Not beneficial at all	○	○	○	○	○	Very beneficial

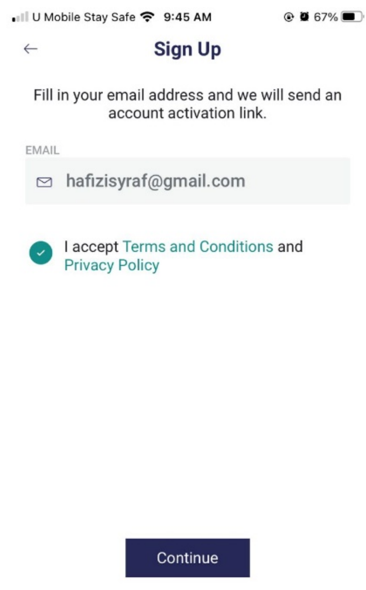
9. Do you think to implement a smart irrigation system would be costly? *

- ○ Yes
- ○ No
- ○ Maybe

10. What price range would you deem acceptable for a smart irrigation system? *

- ○ RM100 & below
- ○ RM100-RM500
- ○ RM500-RM1000
- ○ RM1000 & above

Appendix 2: Survey Prior To Project Part 2



Appendix 3: Blynk Interface