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Comparative Analysis of Soil Characteristics and Environmental Monitoring Using IoT

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DECLARATION

I declare that this thesis entitled 'Comparative Analysis of Soil Characteristics and Environmental Monitoring Using IoT' is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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Date: 29 FEBRUARY 2024

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ABSTRACT

IoT is to enable these connected devices to collect and share data, facilitating communication and automation. This data exchange allows for improved efficiency, real-time monitoring, and the development of smart systems that can make informed decisions without human intervention. Sensors can be deployed in the field to monitor various environmental factors such as soil moisture, temperature, humidity, and nutrient levels. These sensors provide real-time data, allowing farmers to make informed decisions about irrigation, fertilization, and crop health. The objective of this research is to To develop the IoT device with soil characteristics monitoring for smart farming and also to apply the IoT devices by providing real time data on soil moisture, temperature, PH level, and other environmental factors. Soil samples were collected from two distinct locations: Ayer Lanas and University Malaysia Kelantan. Three samples were obtained from each location, labelled as UP1, UP2, UP3, AP1, AP2, and AP3. Subsequently, these samples were subjected to a furnace at 800 degrees Celsius for a duration of 6 hours. Before the firing process, the weight of each soil crucible was recorded, and after the firing, the post-process weights of the samples were determined. The fired samples were then sent for XRD analysis. To simulate the natural conditions of both locations, the raw soil was exposed to the environment. The primary influencing factors were weather conditions, including humidity and temperature fluctuations. To monitor these changes, moisture and DHT11 sensors, along with an LCD display, were incorporated. The sensors were programmed using the Arduino IDE software, and the soil characteristics were observed over a period of 7 days. This comprehensive approach aimed to investigate the impact of environmental factors on the soil properties from Ayer Lanas and Universiti Malaysia Kelantan.After 7 days of monitoring, it was observed that the humidity level in UMK soil is superior to Ayer Lanas. This is attributed to the lower content of rocks and clays in UMK soil, allowing better water flow. Additionally, during peak heat hours (12 pm-4 pm), Ayer Lanas soil exhibits higher temperatures than UMK soil due to the lingering humidity in UMK soil. In conclusion, UMK soil is healthier and more conducive to a successful harvest compared to Ayer Lanas soil.

ABSTRAK

IoT bertujuan untuk membolehkan peranti terhubung mengumpul dan berkongsi data, memudahkan komunikasi, dan automasi. Pertukaran data ini membolehkan peningkatan kecekapan, pemantauan secara masa nyata, dan pembangunan sistem pintar yang boleh membuat keputusan tanpa campur tangan manusia. Pengesan boleh dipasang di ladang untuk memantau pelbagai faktor alam seperti kelembapan tanah, suhu, kelembapan, dan tahap nutrien. Pengesan ini menyediakan data secara masa nyata, membolehkan petani membuat keputusan yang berasaskan maklumat mengenai penyiraman, pemupukan, dan kesihatan tanaman.Objektif penyelidikan ini adalah untuk membangunkan peranti IoT untuk pemantauan ciri tanah bagi pertanian pintar dan mengaplikasikan peranti IoT dengan menyediakan data secara masa nyata mengenai kelembapan tanah, suhu, tahap pH, dan faktor alam sekitar lain. Sampel tanah dikumpul dari dua lokasi berbeza: Ayer Lanas dan Universiti Malaysia Kelantan. Tiga sampel diperoleh dari setiap lokasi, diberi label UP1, UP2, UP3, AP1, AP2, dan AP3. Kemudian, sampel-sampel ini dikenakan pada dapur pada suhu 800 darjah Celsius selama 6 jam. Sebelum proses pembakaran, berat setiap bekas tanah direkod, dan selepas pembakaran, berat selepas proses sampel ditentukan. Sampel-sampel yang telah dibakar kemudiannya dihantar untuk analisis XRD. Untuk mensimulasikan keadaan semula jadi di kedua-dua lokasi, tanah mentah dibiarkan terdedah kepada persekitaran. Faktor utama yang mempengaruhi adalah keadaan cuaca, termasuk fluktuasi kelembapan dan suhu. Untuk memantau perubahan ini, pengesan kelembapan dan DHT11, bersama-sama dengan paparan LCD, digunakan. Pengesan-pengesan ini diprogram menggunakan perisian Arduino IDE, dan ciri-ciri tanah diperhatikan selama tempoh 7 hari. Pendekatan komprehensif ini bertujuan untuk menyelidik impak faktor alam sekitar ke atas sifat tanah dari Ayer Lanas dan Universiti Malaysia Kelantan. Selepas 7 hari pemerhatian, didapati tahap kelembapan tanah UMK lebih baik berbanding Ayer Lanas. Ini disebabkan oleh kandungan batu dan tanah liat yang lebih rendah dalam tanah UMK, membolehkan aliran air yang lebih baik. Tambahan pula, semasa waktu panas puncak (12 pm-4 pm), tanah Ayer Lanas menunjukkan suhu yang lebih tinggi berbanding tanah UMK disebabkan kelembapan yang masih ada dalam tanah UMK. Kesimpulannya, tanah UMK lebih sihat dan lebih sesuai untuk menuai berbanding tanah Ayer Lanas.

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C	Carbon
O	Oxygen

LIST OF SYMBOLS

α	Alpha
%	Percentage
ºC	Celcius

CHAPTER 1

INTRODUCTION

Agriculture is considered as the basis of life for the human species (Gondchawar & Kawitkar, 2016) as it is the main source of food grains and other raw materials. It plays vital role in the growth of country's economy. It also provides large ample employment opportunities to the people. Growth in agricultural sector is necessary for the development of economic condition of the country. Unfortunately, many farmers still use the traditional methods of farming which results in low yielding of crops and fruits.

With growing adoption of the internet of things (iot), connected devices have penetrated every aspect of our life from health and fitness, home automation, automotive and logistics, to smart cities and industrial iot. Thus, it is only logical that IoT, connected devices, and automation would find its application in agriculture, and as such, tremendously improve nearly every facet of it.

Farming has seen several technological transformations in the last decades, becoming more industrialized and technology-driven. By using various smart agriculture gadgets, farmers have gained better control over the process of raising livestock and growing crops, making it more predictable and improving its efficiency from this research farmers can identify the quantity of water in the soil so they can be aware of the water level needed by the plant because too much of water can destroy their plantation. Not just the water level also can define how many pesticides and fertilizers they have been used and many more.

Using smart agriculture sensors to monitor the state of crops, farmers can define exactly how many pesticides and fertilizers they must use to reach optimal efficiency. The same applies to the smart farming definition.

1.1 Background of Study

The applications of IoT in the agriculture market are expected to revolutionize the speed of agricultural affairs. Livestock monitoring, fish farming management, precision farming, and intelligent greenhouses are all IoT in agriculture examples that can be used to address nearly every agricultural issue. Namely, COVID-19 has had a positive impact on IoT in the agriculture market share. Disruptions in the supply chain, and the shortage of qualified workers, has propelled its compound annual growth rate (CAGR) to 9,9%. In fact, as per recent reports, the smart framing market share is set to reach $28.56 billion by 2030.

1.2 Problem Statement

Farmers facing several challenges that can significantly impact their productivity, profitability, and sustainability (V, 2021). One of the most significant challenges is the lack of real-time data on crop health, soil moisture, weather patterns, and other environmental factors that can affect crop growth and yield. Without this information, farmers may make decisions based on assumptions or incomplete data, which can result in overwatering, under-fertilizing, or missed opportunities for planting or harvesting.

Another challenge faced by farmers without smart farming technology is the risk of crop failure due to unpredictable weather patterns, pests, or disease. Without the ability to monitor crops in real-time and respond quickly to potential issues, farmers may be more vulnerable to crop losses and reduced yields.

Overall, the use of smart farming technology can help farmers overcome these challenges by providing real-time data, automating labour-intensive tasks, and enabling more precise and efficient management of crops and livestock (Mehta & Patel, 2016). By embracing smart farming practices, farmers can increase productivity, reduce waste, and improve the sustainability of their operations

1.3 Objectives

In this research, there two objective which need to be achieved. The objectives are:

i) To develop the IoT device with soil characteristics monitoring for smart farming.

ii) To apply the IoT devices by providing real time data on soil moisture, temperature, and other environmental factors.

1.4 Scope of Study

The scope of smart agriculture devices is vast and includes a wide range of technologies and applications that can be used to improve farming practices. Smart agriculture devices can monitor and collect data on environmental factors such as temperature, humidity, rainfall, and soil moisture (Said Mohamed et al., 2021). This data can be used to optimize crop growth and yield. Farmers can apply fertilizers and pesticides more precisely, reducing waste and improving crop health. It's also can make farmers to determine the best planting time, seed variety, and crop rotation patterns.

Smart agriculture devices automate routine tasks such as watering, fertilizing, and harvesting. This reduces labour costs and improves productivity. With having those devices farmers also can monitor the health and behaviour of livestock, track their movements, and optimize feed and water intake.

1.5 Significances of Study

The significance of smart agriculture devices lies in their ability to revolutionize traditional farming practices by providing farmers with real-time data, automation, and precision farming techniques.

Smart agriculture devices enable farmers to monitor and control crop growth conditions such as temperature, humidity, and soil moisture, resulting in higher crop yields and better-quality produce. Farmers can optimize resource usage, such as water and fertilizer, reducing waste and promoting sustainable agriculture practices.

Smart agriculture devices enable precision farming techniques such as variable rate irrigation, fertilization, and pesticide application. This improves crop health and reduces the negative impact of farming practices on the environment. Smart agriculture devices can automate routine tasks and reduce labour costs, leading to increased profitability for farmers. Its will be helpful for them to make sure their routine task be done on time without miss a day. Even though they not able to do it, they can control those activities from far. Devices generate large amounts of data that can be analysed to identify trends, patterns, and insights, enabling farmers to make data-driven decisions and optimize their farming practices.

In summary, the study of smart agriculture devices is significant because they provide farmers with the tools and data needed to make informed decisions, increase efficiency, and promote sustainable agriculture practices. This can lead to increased crop yields, cost savings, and improved food safety, all while reducing the negative impact of farming practices on the environment.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter has introduced the Internet of Things (iot) and its physical component in developing smart farming. There are four types of sensors mostly used in smart farming is MQ 135 sensor, DHT 11 sensor, soil moisturize sensor and NPK sensor. All sensors become an input to the microcontroller, where the action of another component has been programmed based on it. The reliability of the sensor has been explained based on its working principle. Other than that, the existing smart farming devices from another research is also reviewed.

2.2 Internet of Things (iot)

Definitions for the Internet of Things vary. According to McKinsey (2015) sensors and actuators embedded in physical objects are linked through wired and wireless networks, often using the same Internet Protocol (IP) that connects the Internet (Knud & Lueth, 2015). Currently, IoT is made up of a loose collection of disparate, purpose-built networks.

Today, cars, for example, have multiple networks to control engine function, safety features, communications systems, and so on (Ezechina et al., 2015). Commercial and residential buildings also have various control systems for heating, venting, and air conditioning (HVAC); telephone service; security; and lighting. As IoT evolves, these networks, and many others relate to added security, analytics, and management capabilities. This allow IoT to become even more powerful in what it can help people achieve. Interestingly, this situation mirrors what the technology industry experienced in the early days of networking. In the late 1980s and early 1990s, Cisco, for example, established itself by bringing disparate networks together with multi-protocol routing, eventually leading to IP as the common networking standard. With IoT, history is repeating itself, albeit on a much grander.

In this study, a smart farming system embedded with intelligent physical devices like Arduino UNO R3 provides a function suited to the smart farming process. This system is programmed in Arduino IDE software to control and create instruction for all the components in circuit.

2.2.1 Arduino UNO R3

is an open sources microcontroller based ATmega328P (datasheet). The shape of Arduino UNO R3 is shown in Figure 2.1. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator (CSTCE16M0V53-R0), a USB connection, a power jack, an ICSP header and a reset button (Badamasi, 2014). It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. Tinker the Uno without worrying too much about doing something wrong, worst-case scenario it can be replaced by the chip for a few dollars and start over again.

The Arduino platform has become well acquainted with people into electronics. Unlike most previous programable circuit board. Arduino does not have a separate piece of hardware in order to load new code onto the board, you can simply use a USB cable to upload. The software of the Arduino uses a simplified version of C++, making it easier to learn to program, and it provides with an easier environment that bypass the functions of the micro-controller into a more accessible package (Cameron, 2019).

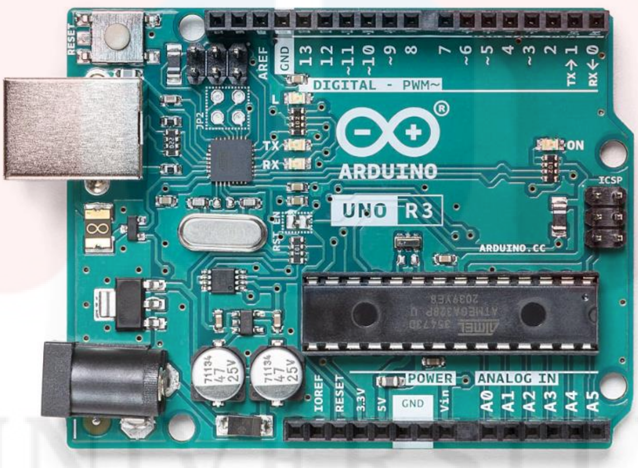

Figure 2. 1: Arduino UNO R3

Sources: (Gondchawar & Kawitkar, 2016)

2.2.2 Arduino Integrated Development Environment (IDE) Software

The Arduino Integrated Development Environment - or Arduino Software (IDE) contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. It connects to the Arduino hardware to upload programs and communicate with them (Fezari & Al Zaytoona, 2018). Programs written using Arduino Software (IDE) are called sketches. These sketches are written in the text editor and are saved with the file extension. The editor has features for cutting/pasting and for searching/replacing text. The message area gives feedback while saving and exporting and also displays errors. The console displays text output by the Arduino Software (IDE), including complete error messages and other information.

2.2.3 Sensors

The driving concept of IOT is to learn about an environment, the condition of objects, the users position, and their behaviours. Sensors play a pivotal role in the internet of things (IoT). They make it possible to create an ecosystem for collecting and processing data about a specific environment so it can be monitored, managed, and controlled more easily and efficiently (Yamasaki, 1996). IoT sensors are used in homes, out in the field, in automobiles, on airplanes, in industrial settings and in other environments. Sensors bridge the gap between the physical world and logical world, acting as the eyes and ears for a computing infrastructure that analyses and acts upon the data collected from the sensors.

2.2.3.1 MQ 135 Sensor

The MQ135 **Error! Reference source not found.** Gas Sensor is an all-in-one sensor for detecting ammonia, alcohol, benzene, smoke, CO_2, and a myriad of other gases. It is the best available multipurpose gas sensor on the market. The MQ135 is connected to an Arduino Uno board, and an output is derived in AQI (air quality index). The data received from the Gas Sensor (in AQI) is monitored, if it crosses greater than 150 degrees, the buzzer will ring. The Things board API cloud stores all the data that is received from the microcontroller via the Wi-Fi module that keeps the data updated over the internet and it's transferred into the webpage created (Rani et al., 2020). Sensitive material of MQ135 gas sensor is SnO_2, which with lower conductivity in clean air. When the target combustible gas exists, the sensor's conductivity is higher along with the gas concentration rising. Please use simple electro circuit, convert change of conductivity to correspond output signal of gas concentration.

Figure 2. 2: MQ 135 Sensor

Source: (Rani et al., 2020)

2.2.3.2 DHT 11 Sensor

DHT11 **Error! Reference source not found.** is a low-cost digital sensor for sensing temperature and humidity. This sensor can be easily interfaced with any micro-controller such as Arduino, Raspberry Pi and many more to measure humidity and temperature instantaneously.

DHT11 humidity and temperature sensor is available as a sensor and as a module. The difference between this sensor and module is the pull-up resistor and a power-on LED. DHT11 is a relative humidity sensor (Srivastava et al., 2018). To measure the surrounding air this sensor uses a thermistor and a capacitive humidity sensor. DHT11 sensor consists of a capacitive humidity sensing element and a thermistor for sensing temperature. The humidity sensing capacitor has two electrodes with a moisture holding substrate as a dielectric between them. Change in the capacitance value occurs with the change in humidity levels. The IC measure, process this changed resistance values and change them into digital form.

For measuring temperature this sensor uses a Negative Temperature coefficient thermistor, which causes a decrease in its resistance value with increase in temperature. To get larger resistance value even for the smallest change in temperature, this sensor is usually made up of semiconductor ceramics or polymers.

The temperature range of DHT11 is from 0 to 50 degree Celsius with a 2-degree accuracy. Humidity range of this sensor is from 20 to 80% with 5% accuracy. The sampling rate of this sensor is 1Hz it gives one reading for every second (Shrestha, 2019).

DHT11 is small with operating voltage from 3 to 5 volts. The maximum current used while measuring is 2.5mA.

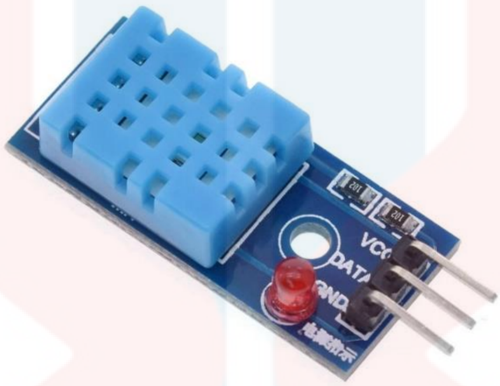

Figure 2. 3**:** DHL 11 Sensor

Source: (Srivastava et al., 2018)

2.2.3.3 Soil Moisturizer Sensor

The soil moisture sensor **Error! Reference source not found.** is one kind of sensor used to gauge the volumetric content of water within the soil. As the straight gravimetric dimension of soil moisture needs eliminating, drying, as well as sample weighting. These sensors measure the volumetric water content not directly with the help of some other rules of soil like dielectric constant, electrical resistance, otherwise interaction with neutrons, and replacement of the moisture content (Eller & Denoth, 1996). These sensors normally used to check volumetric water content, and another group of sensors calculates a new property of moisture within soils named water potential. Generally, these sensors are named as soil water potential sensors which include gypsum blocks and tensiometer.

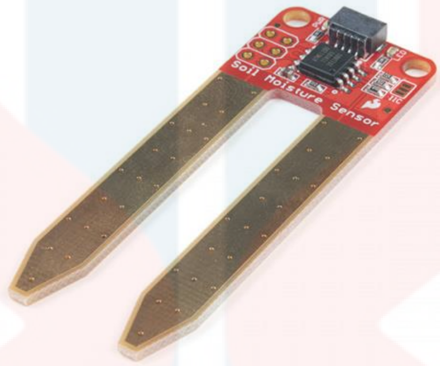

Figure 2. 4: Soil Moisturizer Sensor

Source (Gondchawar & Kawitkar, 2016)

2.3 Smart Farming using IoT

The following are some similar research field and studies of literature from books, journals, and online articles that led to the creation of the topics mentioned in this study, which covers all aspects or direction of this innovative research. Firstly, sensors are responsible for measuring and monitoring all factors in the smart system **Error! Reference source not found.** for example, soil health monitoring has special sensors such as nutrients contents, phosphate contents, soil moisture, and compaction. The smart irrigation system included many sensors for monitoring water levels, irrigation efficiency, climate sensors, etc. The sensors can measure and monitor the changes in soil and yield properties and local weather on-farm sites. So, the sensors can gather the different data to be used for the analysis of the farm statutes and for making a suitable decision (Said Mohamed et al., 2021). These smart sensors monitor the variation in soil, crop, livestock health, in addition, contribute to enhance the agricultural product in terms of quantity and quality. The standard sensors used in smart farming networks are soil moisture sensors that use to measure the change in soil moisture, soil temperature used to measure the monitor the temperature in soil, air temperature, soil pH value, humidity, N, P, K sensors (Kumar et al., 2021).

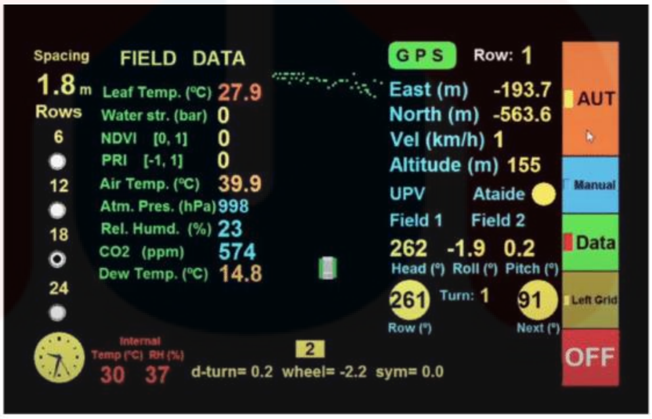

Figure 2. 5: Graphical user interfaces (GUI) for agricultural DSS.

Source: (Badamasi, 2014)

Smart farming using automation and IoT technologies. Smart GPS based remote controlled robot was performed the operations like weeding, spraying, moisture sensing etc. It includes smart irrigation with the help of smart control and intelligent decision making based on accurate real time field data and smart warehouse management. It monitors temperature and humidity(Swami et al., 2019). It also provides theft detection in the warehouse. All the operations were controlled by smart devices and performed by interfacing the sensors, ZigBee modules, camera and actuators with microcontroller and raspberry pi.

2.3.1 Soiling Monitoring

Soil monitoring using IoT (Internet of Things) is a technique that involves using sensors and internet connectivity to collect and analyse data related to soil conditions. This technology enables farmers, gardeners, and researchers to obtain real-time information about soil moisture, temperature, nutrient levels, and other parameters that are crucial for plant growth and agricultural practices. Sensors equipped with various probes are placed in the soil at different locations within the field or garden. These sensors can measure parameters such as moisture, temperature, pH level, electrical conductivity, and nutrient levels.

2.4 Soil treatment

A suitable planting medium was considered essential for fostering rapid plant growth (Gorli, 2017). Fertile soil, being the primary requirement for plants, significantly influenced plant growth. Various types of soil, including sandy soil, red soil, alluvial soil, and humus soil, were identified as suitable for different plant growth needs.

In the past, the use of a DHT11 sensor played a crucial role in monitoring environmental conditions. This sensor, when inserted into the soil, measured factors such as temperature and humidity. The detected results were transmitted as data to Nodemcu, which processed and displayed the information on the screen. Nodemcu, serving as the control unit, facilitated efficient data collection and presentation.

This tool, utilizing the DHT11 sensor, was designed to measure and transmit data related to environmental factors for citrus seedlings. The data collected, including temperature and humidity levels, were sent to the Thingspeak web platform for comprehensive monitoring and analysis.

The results of tests conducted in the past revealed that the nutrient content in wet soil was higher compared to dry soil. Moreover, the accuracy rate of the DHT11 sensor, as determined from past tests, was found to be 90%, showcasing its reliability in providing essential environmental data for efficient citrus seedling cultivation. This shift to DHT11 technology demonstrated advancements in monitoring soil conditions, ensuring optimal growth conditions for citrus seedlings.

2.4.1 Treatment using organic

Soil treatment using organic fertilizer involved the application of natural, organic materials to enrich the soil with nutrients and improve its fertility. Organic fertilizers, derived from plant or animal sources, provided a slow release of nutrients to plants. Compost, a rich, dark organic matter created through the decomposition of plant and animal waste, contained a balanced mix of nutrients, including nitrogen, phosphorus, potassium, and micronutrients.

The addition of compost to the soil in the past improved its structure, water-holding capacity, and nutrient content. This organic soil treatment was recognized for its sustainable and environmentally friendly approach, enhancing soil health while avoiding the use of synthetic or chemical inputs. The practice of utilizing organic fertilizers contributed to promoting long-term soil fertility and supporting healthy plant growth in the past.

2.4.2 Treatment using Fertilizer

Soil treatment using chemical fertilizers involved the application of synthetic or inorganic substances to provide essential nutrients to the soil. Chemical fertilizers were manufactured to contain specific concentrations of nutrients **Error! Reference source not found.** making them a precise and readily available source of plant nutrition. Chemical fertilizers typically contained three primary macronutrients: nitrogen (N), phosphorus (P), and potassium (K), often referred to as NPK fertilizers. These nutrients were crucial for plant growth and development.

Chemical fertilizers allowed for precise control over the nutrient ratios to meet specific plant requirements. Different chemical fertilizers came in various formulations to meet the specific needs of different plants and soil conditions. For example, there were specific fertilizers designed for acid-loving plants or those suited for particular soil types. The use of chemical fertilizers in the past provided farmers and gardeners with a tool to tailor nutrient supplementation according to the specific demands of their crops, contributing to enhanced agricultural productivity and optimized plant growth.

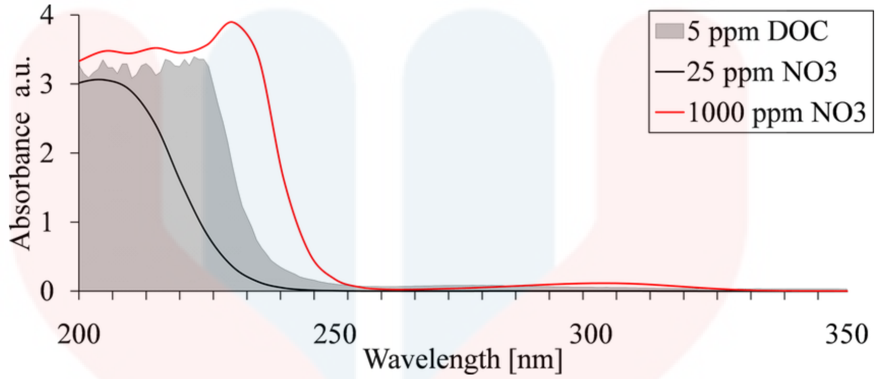

Figure 2. 6**:** Conceptual analysis of nitrate sensors development status

Source from (Sinfield et al., 2010)

CHAPTER 3

MATERIALS AND METHODS

3.1 Materials and Electrical Components

This chapter has discussed the flow in the developing smart agriculture devices from powerful computing tools Table 3. 1 through cloud computing and it finds the best practicing channel based on IOT. Agricultural information cloud is constructed based on cloud computing and smart agriculture is constructed with combination of IOT.

Table 3. 1: Hardware requirement in Smart Farming System

Hardware name	Description
Arduino UNO R3	Arduino UNO R3 is an open sources microcontroller based on ATmega328P datasheet
DHT 11 Sensors	DHT11 is a low-cost digital sensor for sensing temperature and humidity
Soil Moisture Sensor	To sense the moisturizer in soil.
Jumper and wires	To connect the circuit with sensors

LCD display	Displaying the percentage of soil moisture, ph level and many more

3.2 Projects Developments

Figure 3.1 illustrates the strategies used for smart farming development, consisting of electronic design and software design elements. These parts are combined to build a efficient smart farming system. Smart farming, also known as precision agriculture, encompasses a range of strategies and technologies that optimize agricultural practices for increased efficiency, productivity, and sustainability.

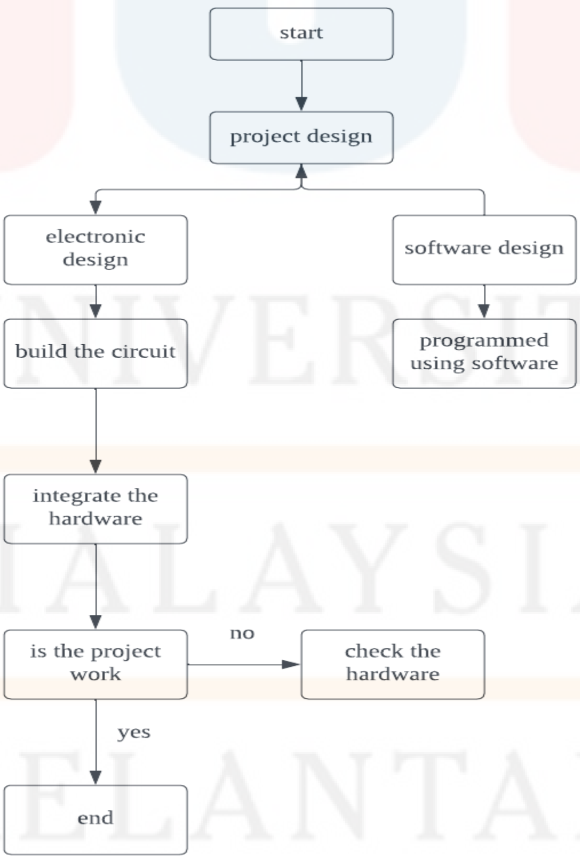

Figure 3. 1: Project development of smart farming

3.3 Soil Preparation

Representative soil samples were collected from two different locations in Jeli, Kelantan. During the collection process, meticulous care was taken to ensure that the samples were free from any debris, stones, or foreign objects. Approximately 1.5 kg of soil was collected from each location using a hoe.

Upon collection, the soil samples were spread on a clean, flat surface, such as a tray or a plastic sheet. This was done to allow the samples to dry naturally, ensuring the absence of moisture imbalance in the soil. The drying process continued until a constant weight was achieved.

Subsequently, the completely dry soil samples underwent a sieving process to eliminate any large particles or clumps. This step was crucial to achieving a uniform texture, thereby ensuring accurate test results.

A specific quantity of the dried and sieved soil was then measured using a balance or scale. The amount of soil required varied based on the specific requirements of the humidity test. Distilled water was gradually added to the soil samples while thoroughly mixing them. The amount of water added was standardized across all samples based on the test specifications.

Following the mixing process, the samples were allowed to equilibrate for a specific period. This facilitated the even distribution of moisture within the soil, reaching a stable condition. Once the equilibration period was completed, the desired tests were performed on the prepared soil samples.

Throughout the testing phase, readings were monitored on an LCD display, and these data were diligently saved in a cloud file for future reference. This comprehensive soil testing process ensured the collection of accurate and reliable data to analyze the soil characteristics of the respective locations in Jeli, Kelantan.

3.4 Soil Organic Content

To identify soil organic content, scrape was fired at 800 ºC for 6 hours. this is to remove the organic content, alterations in the initial soil weight were observed. These changes were meticulously documented and organized into a table for the purpose of calculating the standard deviation.

Formula: $\sigma = \sqrt{[\Sigma (x_i - \mu)^2 / (n - 1)]}$

Table 3. 2 Soil Organic Content

point	weight	initial weigh (g)	final weight(g)	weight loss (g)	weight loss wt%	standard deviation wt%
UP1	3.5 g	70	66.5	3.5	5	0.76
UP2	3.83g	70	66.1	3.83	5.47	0.84
UP3	3.67	70	64.8	3.67	7.4	0.66
AP1	5.8	70	64.1	5.6	8.3	1
AP2	5.5	70	64.5	5.5	7.86	0.67
AP3	5.16	70	64.8	5.16	7.4	1.37

3.5 Electronic Design

The project development with the electronic design component involved the meticulous selection and connectivity of physical devices in various network topologies to meet performance specifications, environmental requirements, power and cost budgets, operating life requirements, and other design criteria within the constraints of the overall schedule. Specific requirements for the smart farming project were determined, focusing on designing an automated irrigation system. Factors such as soil moisture sensing, water pump control, and communication with the Arduino board were considered.

In the process of designing the automated irrigation system, careful consideration was given to the sensors and actuators essential for the smart farming application. Commonly used sensors included soil moisture sensors, temperature and humidity sensors, light sensors, and pH sensors. Actuators encompassed water pumps, valves, motors, and relays. To complement these, appropriate electronic components such as resistors, capacitors, transistors, and diodes were selected based on the project's requirements. Special attention was paid to ensure that power supply and ground connections were properly implemented.

The next step involved connecting the sensors and actuators to the Arduino board according to the circuit design. The appropriate pins on the Arduino were utilized for interfacing with the components. It was ensured that proper voltage levels were maintained, and, if necessary, suitable level-shifting circuits were employed. The necessary code was then written in the Arduino IDE or any compatible programming environment to control the sensors and actuators based on the data collected.

The implementation of the smart farming system's desired functionality, including reading sensor values, making decisions, and controlling actuators, was carried out in the past tense. Once a working circuit and code were achieved, the system was enclosed in a suitable housing to protect it from environmental conditions. Subsequently, the smart farming system was deployed in the target environment, adhering to best practices for installation and maintenance.

3.5.1 Block Diagram of Smart Device

The

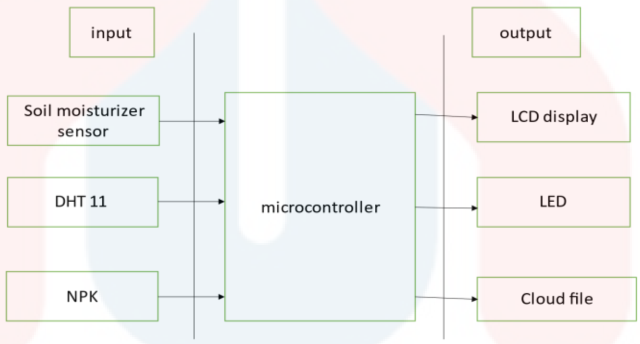

Figure 3. 2: block diagram of smart devic shows the system through the block diagram. There are consisting of input, microcontroller, and output. The proximity sensors become an input for this circuit. At first, when the soil moisturizer sensor detects the soil moisture will be shown in LED screen. Then, the information will receive and process by a microcontroller (Arduino UNO R30). It collects the data from every sensor and save it in cloud file. As programmed in software low moisturizer will be detected and will be alarmed to users' phone by seing them SMS.

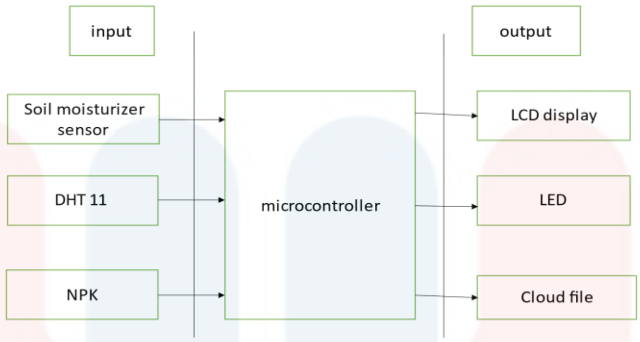

Figure 3. 2: block diagram of smart device

CHAPTER 4

RESULT AND DISCUSSION

4.1 Introduction

This chapter presents the findings of this study, which were obtained from the various analyses. This chapter starts with soil organic content, followed by TGA analyses XRD, IoT products and coding's. For the testing section, the data from several test was presented to prove the sensors' reliability and completed system function.

4.2 Soil Organic Content

A total of nine soil samples were gathered from both the UMK Pineapple Farm and the Ayer Lanas Pineapple Farm, comprising nine samples from each location. Each sample was carefully collected at 10-meter intervals, a strategy employed to account for potential variations in soil temperature and composition across different distances within the respective locations.

To ensure precision in the analysis, each soil sample was meticulously measured, with approximately 70 grams allocated to each crucible. shows consequently, a comprehensive set of 18 samples was obtained from both pineapple farm locations.

Following the sample collection, an exhaustive firing test was conducted, subjecting all 18 samples to a consistent temperature of 800 degrees Celsius for an extensive period of six hours.

The aftermath of the firing process revealed discernible changes in the weight of each soil sample. These weight variations serve as crucial data points, offering insights into potential differences in the thermal and structural properties of the soil from both the UMK Pineapple Farm and the Ayer Lanas Pineapple Farm. This thorough approach to soil analysis aims to provide a detailed understanding of the diverse characteristics inherent in the soils of the two distinct pineapple farm locations.

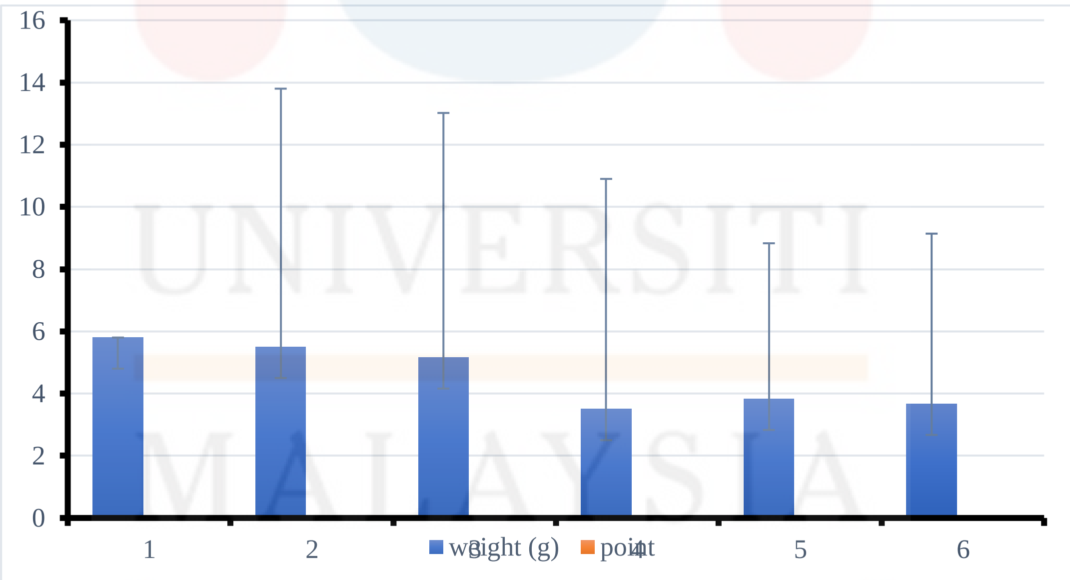

Figure 4. 1: Soil Organic Content

4.3 Soil Component Properties

4.3.1 X-Ray Diffraction Analysis of University Malaysia Kelantan soil

In Figure 4. 2 shows the peak at around 7600 cm^-1 is characteristic of the C=C bond stretching vibration. The peak at around 7000 cm^-1 is characteristic of the C-H bond stretching vibration in the Figure 4.2. This indicates the presence of the carbon in the soil. To improve soil aggregation, carbon aids in the binding of soil particles. Better drainage, aeration, and water-holding capacity result from this, all of which are essential for the growth of healthy plants.

The specific molecule responsible for the peaks in the spectrum you sent me cannot be determined without more information. However, the presence of peaks at around 1600 cm^-1 and 3000 cm^-1 suggests that the molecule contains C=C and C-H bonds.

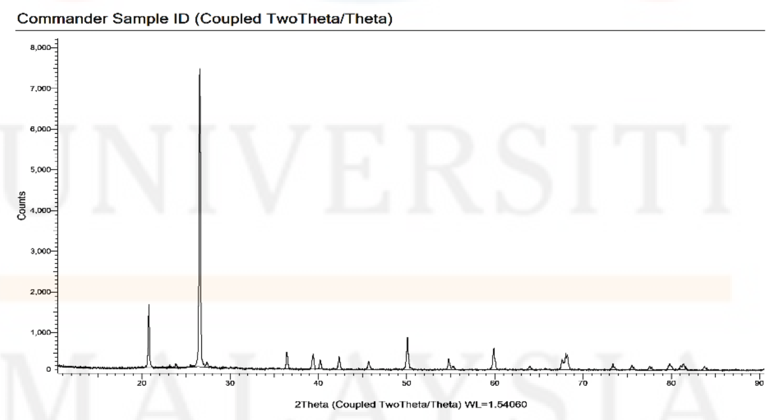

Figure 4. 2:X-Ray Diffraction Analysis of University Malaysia Kelantan soil

4.3.2 X-Ray Diffraction of Ayer Lanas soil

This analysis, known as X-ray diffraction (XRD), acts as a detective, meticulously examining the arrangement of atoms within the soil sample in Figure 4. 3. This information unveils the types of minerals present, like identifying the building blocks of a magnificent castle.

However, just like studying the castle's bricks wouldn't tell us about the furniture inside, XRD doesn't directly measure the total carbon content. While some minerals might contain carbon as an element, the technique focuses on their crystallographic structure, not the overall carbon abundance in the entire soil sample.

The graph with peaks that might seem enticing. However, these peaks represent the "2Theta" angles, which tell us the specific angles at which X-rays bounce off the minerals. By analyzing these angles and their corresponding intensity levels (represented by the "counts"), we can identify the types of minerals present in the soil. Higher counts indicate a more abundant mineral type.

Techniques like Loss on Ignition (LOI) mimic a controlled fire, measuring the weight loss of the soil as organic matter, which includes carbon, burns off. Alternatively, elemental analysis directly measures the amount of different elements present, including carbon, offering a more accurate picture of the soil's carbon content.

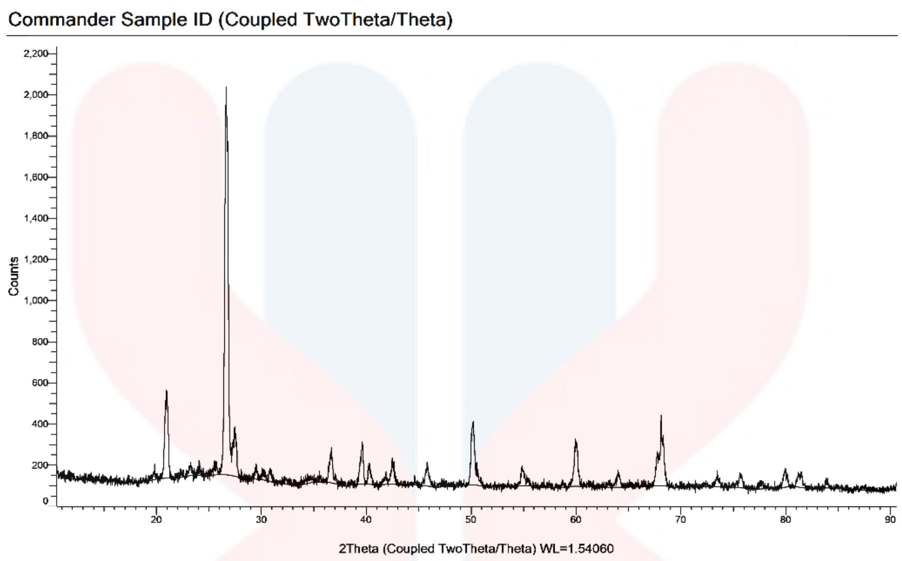

Figure 4. 3: X-Ray Diffraction of Ayer Lanas soil

4.4 Internet of Things (IOT) Prototype

Firstly, the sensor was powered to connect other connections of sensor with Arduino, like ground GND connected to negative port in breadboard, and Analog Pin A0. Without these Pins Sensor cannot work properly. If any mistake during connection, the whole wiring connection before turn it on. Vcc Pin connected to positive side of breadboard.

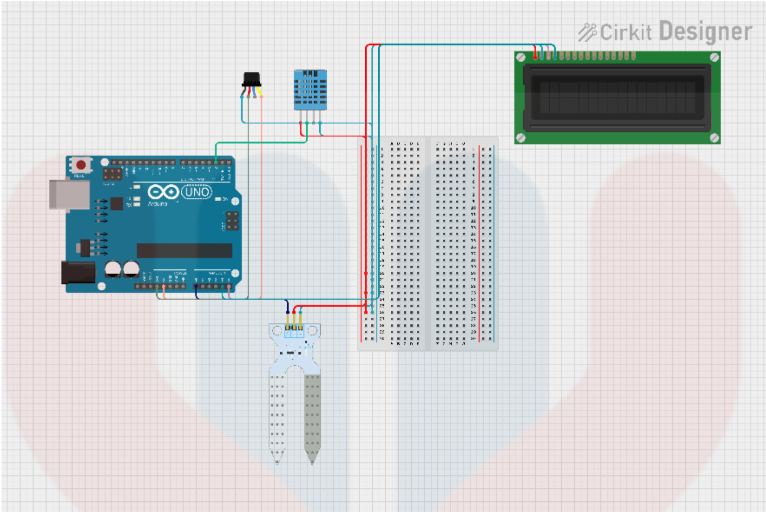

Figure 4. 4: Schematic diagram of the connected sensors

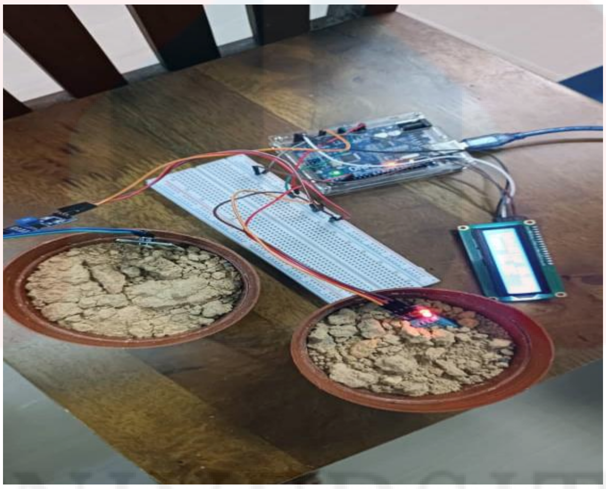

Figure 4. 5: Device connection of sensors during soil testing

4.4.1 Coding For Moisture

In Figure 4. 6 build in potentiometer is available with sensor. From this potentiometer it can easily set the threshold voltage of sensor. If the maximum threshold voltage was set, it means that sensitivity is LOW but if threshold voltage is minimum it means that sensitivity is HIGH. If sensitivity is HIGH, it means that sensor easily caught any small change in moisture level otherwise it will take more time to sense the moisture level.

During circuit running it can adjust the threshold voltage according to our needs and requirements. After completing setup our sensor is ready for measure the moisture level

Figure 4. 6: Coding for moisture

4.4.2 Coding For Humidity and Temperature DHT 11

Firstly, Sensor is energized through Arduino or an external power source. In ordered like above sensors connected sensor pins with arduino. Like: Vcc, Data and Ground. In Figure 4. 7 with the combination of +5V and Ground sensor is now powered on and start working. But with Data Pin of sensor give some inputs to arduino as a voltage of gathered data or values. In this way sensor working. After this, now sensor is able to measure the Temperature and Humidity level.

Figure 4. 7: Coding for humidity and Temperature

4.5 Soil Temperature, humidity and moist study

The data collection process commenced at 8 am, with subsequent readings recorded at intervals of every 4 hours. These readings were displayed on an LCD screen, allowing for real-time monitoring and observation. The acquired data was then translated into a comprehensive graphical representation, enabling a visual analysis of the changes and variations observed in the soil composition over the specified time frame. This methodological approach aimed to provide a detailed insight into the dynamic interactions between the soil samples and the environmental conditions to which they were exposed.

4.5.1 Soil Temperature of Ayer Lanas, Kelantan

Figure 4. 8 shows on the first day, at 8 am, the soil temperature stood at 27.10 degrees Celsius. By noon, it rose to 29.00 degrees Celsius and maintained a relatively stable temperature of 29.05 degrees Celsius at 4 pm. The evening saw a slight decrease to 28.50 degrees Celsius at 8 pm and further cooling to 27.00 degrees Celsius by midnight.

The second day started with a slightly lower temperature of 26.15 degrees Celsius at 8 am, followed by a modest increase to 27.25 degrees Celsius by noon. However, a significant drop occurred in the afternoon, reaching 26.00 degrees Celsius at both 4 pm and 8 pm. The midnight temperature recorded a minimal uptick to 26.01 degrees Celsius, likely influenced by rainy conditions.

The third day witnessed a morning temperature of 26.50 degrees Celsius at 8 am, followed by a decrease to 26.15 degrees Celsius by noon. Throughout the afternoon at 4 pm and into the evening at 8 pm, the soil temperature remained stable at 26.00 degrees Celsius. A noteworthy rise to 27.10 degrees Celsius occurred at 8 pm, with a subsequent midnight temperature of 27.50 degrees Celsius, indicating another day of rain. On the fourth day, the soil temperature began at 27.00 degrees Celsius at 8 am, rose to 28.00 degrees Celsius by noon, and experienced a significant spike to 31.00 degrees Celsius at 4 pm, coinciding with rainfall after 5:30 pm. The temperature at 8 pm settled at 28.10 degrees Celsius, with a slight decrease to 27.50 degrees Celsius at midnight.

The fifth day began with a morning temperature of 27.50 degrees Celsius at 8 am, gradually increasing to 28.00 degrees Celsius by noon. A notable rise to 31.00 degrees Celsius at 4 pm marked a sunny period. Evening temperatures at 8 pm and midnight recorded 29.00 degrees Celsius and 29.05 degrees Celsius, respectively.

Day six exhibited a morning temperature of 28.00 degrees Celsius at 8 am, escalating to 30.00 degrees Celsius by noon.. A further increase to 32.00 degrees Celsius at 4 pm was interrupted by rainfall after 6:30 pm, leading to a notable drop in soil temperature to 28.00 degrees Celsius at 8 pm and a subsequent decrease to 27.10 degrees Celsius by midnight. The rocks and dense soil trap heat, causing the soil to retain high temperatures for extended periods. This, in turn, leads to low sustainable humidity levels in the soil.

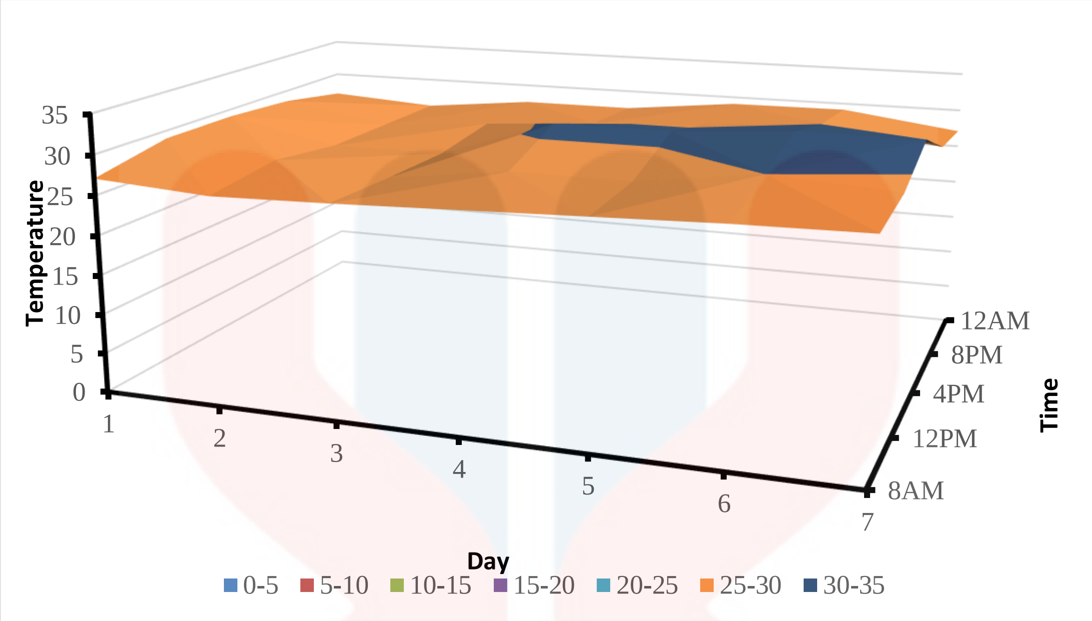

Figure 4. 8: Temperature of Soil in Ayer Lanas from Day 1 to Day 7

4.5.2 Soil Temperature of Universiti Malaysia Kelantan

On the initial day, the soil temperature at 8 am was 27 degrees Celsius. By noon, a slight increase to 27.50 degrees Celsius was noted, reaching 28.05 degrees Celsius at 4 pm. The evening hours saw a marginal decrease to 28 degrees Celsius at 8 pm, and by midnight, the temperature had settled back to 27.50 degrees Celsius. In the Figure 4. 9, the second day commenced with a cooler morning temperature of 26 degrees Celsius at 8 am. However, as the day progressed, the temperature rose to 28.25 degrees Celsius by noon. A sudden drop to 26 degrees Celsius occurred at 4 pm, followed by a rise to 27.10 degrees Celsius at 8 pm. The midnight reading reflected a further decrease, recording 26.01 degrees Celsius, indicative of rainy weather conditions.

Moving on to the third day, the morning temperature at 8 am registered at 26.15 degrees Celsius, escalating to 26.20 degrees Celsius by noon. However, a noticeable dip to 25 degrees Celsius was observed at 4 pm. The evening temperature at 8 pm climbed back to 27.10 degrees Celsius, remaining consistent at midnight, signifying persistent rainy conditions as in the Figure 4.5.

The fourth day presented variations in soil temperature dynamics. At 8 am, the temperature measured 27.05 degrees Celsius, rising to 29 degrees Celsius by noon. A subsequent drop to 26.50 degrees Celsius was recorded at 4 pm, followed by rainfall after 5:30 pm. The evening temperature at 8 pm plummeted to 24.60 degrees Celsius, with a modest increase to 25.50 degrees Celsius by midnight.Day five commenced with a morning temperature of 26 degrees Celsius at 8 am, reaching 27 degrees Celsius by noon. The afternoon temperature at 4 pm registered at 28 degrees Celsius, maintaining a steady level at 27.10 degrees Celsius by 8 pm. A return to a cooler 26 degrees Celsius was observed by midnight, coinciding with a sunny day as sown in Figure 4.5.

The sixth day started with a morning temperature of 27 degrees Celsius at 8 am, rising to 28 degrees Celsius by noon. The afternoon temperature at 4 pm exhibited a slight elevation, reaching 28.10 degrees Celsius. By 8 pm, the temperature increased further to 30 degrees Celsius, and by midnight, it settled at 27 degrees Celsius. On the seventh day, the morning temperature at 8 am was 26.10 degrees Celsius, ascending to 27.50 degrees Celsius by noon. The afternoon temperature at 4 pm recorded 28.10 degrees Celsius, followed by rainfall after 6:30 pm, causing a decrease to 27.50 degrees Celsius at 8 pm. The midnight temperature remained stable at 27.10 degrees Celsius

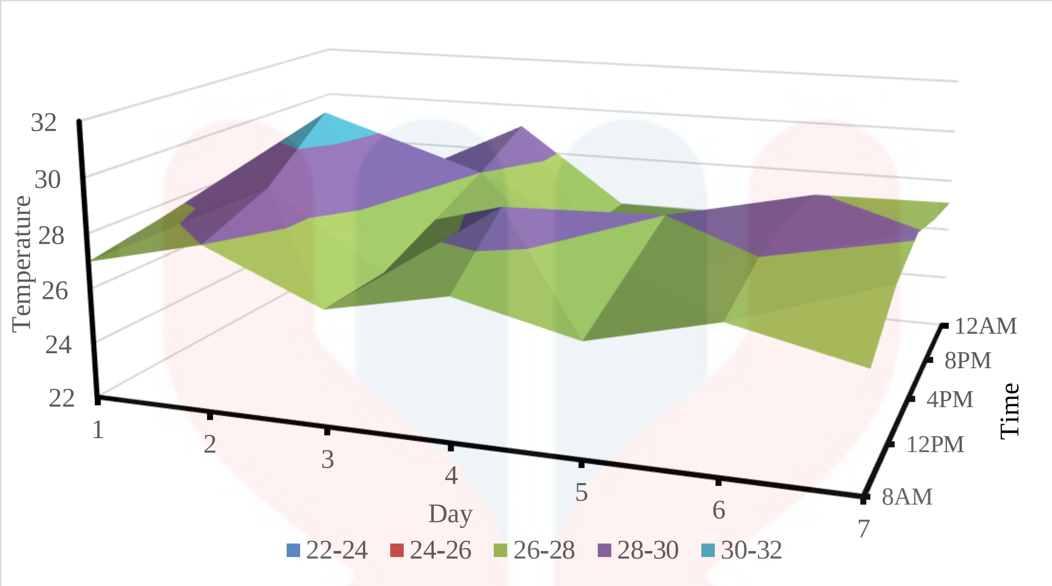

Figure 4. 9: Temperature of Ayer Lanas from Day 1 to Day 7

4.5.3 Ayer Lanas Soil Humidity

In Figure 4. 10 the graph is a line graph that shows the average humidity levels over a period of seven days. The x-axis represents the days of the week, and the y-axis represents the humidity level as a percentage. The graph also includes a color-coded scale that indicates different humidity ranges.

The graph shows that the overall humidity level in the room is moderate, ranging from around 40% to 60% for most of the week. However, there are some fluctuations in humidity throughout the week. Day 3 is the most humid day of the week, with humidity levels reaching up to 70%. This could be due to a number of factors, such as increased activity in the room, the presence of moisture-producing appliances, or changes in outdoor weather conditions.

Day 5 is the least humid day of the week, with levels dropping down to around 30%. This could be due to factors such as lower outdoor humidity, increased ventilation, or the use of a dehumidifier. There is a general upward trend in humidity from Day 1 to Day 3, followed by a downward trend from Day 3 to Day 7. This could be due to a number of factors, such as changes in weather patterns or changes in human activity in the room.

It is important to note that the graph only shows the average humidity level for each day. The actual humidity level in the room may have fluctuated throughout the day. Additionally, the graph does not provide any information about the temperature in the room, which can also affect humidity levels.

Overall, the graph provides a general overview of the humidity levels in over a period of seven days. However, it is important to consider the limitations of the graph when interpreting the data.

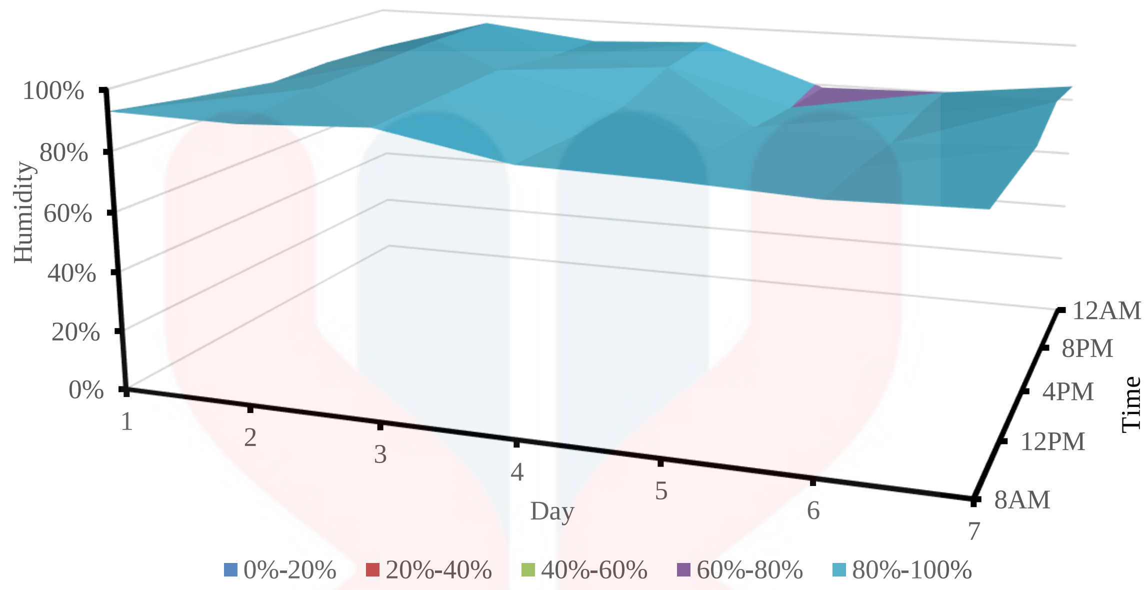

Figure 4. 10: Humidity Level of Ayer Lanas Soil

4.5.4 Humidity of University Malaysia Kelantan Soil

The Figure 4. 11 graph we delve into today holds an intriguing humidity across a seven-day span. While seemingly simple, this visual narrative reveals patterns and fluctuations that paint a picture of the environment's moisture dynamics. Predominantly, the place seems to favor a moderate climate, with humidity levels comfortably nestled between 40% and 60% for most of the week. However, within this seemingly serene canvas, pockets of deviation emerge, hinting at underlying influences.

Day 3 Like a sudden downpour, humidity surges on this day, reaching a peak of 70%. Was it a burst of activity within the place, perhaps vigorous cleaning or the presence of moisture-generating appliances? Or did the weather outside orchestrate this shift, unleashing a wave of humid air? The graph, unfortunately, remains silent on these possibilities. Day 5 In stark contrast, humidity plummets to 30%, marking the driest day of the week.

Furthermore, a subtle trend takes shape across the week. Starting on Day 1, humidity gently ascends until Day 3, its peak, before embarking on a gradual descent that reaches its nadir on Day 7. It's crucial to remember that the graph only unveils average daily humidity. The reality within each day might have been a rollercoaster of moisture fluctuations, hidden from our view.

In essence, the graph provides a valuable glimpse into the humidity dynamics of a place over a week. By incorporating additional data and context, we can unlock the full potential of this visual narrative and truly understand the forces that shape the air's moisture content.

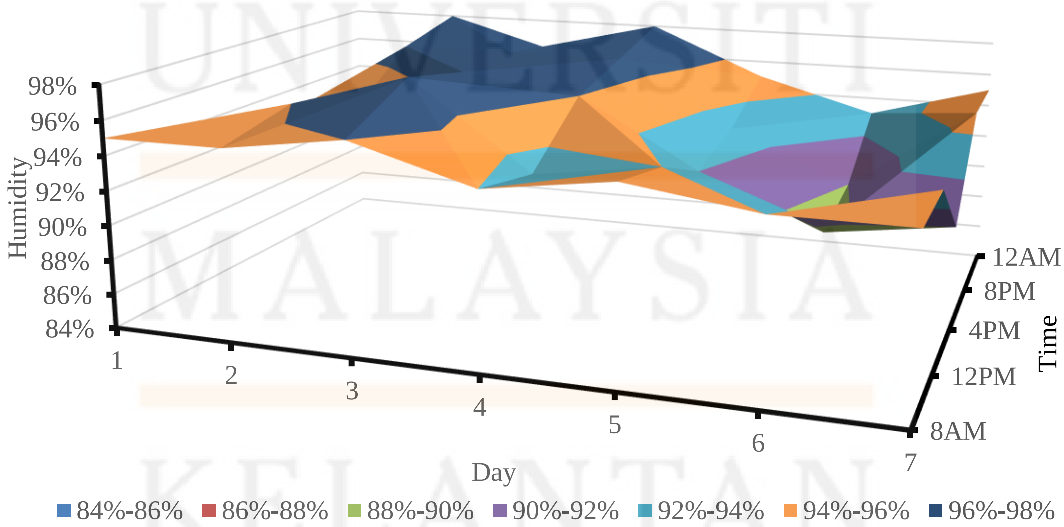

Figure 4. 11: Humidity level of University Malaysia Kelantan

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

In conclusion, the IoT-based smart agriculture monitoring system presents a practical and effective solution for farmers seeking to monitor and optimize crop growth. Through my research, I analyzed soil samples from different locations, revealing that soil samples from the University Malaysia Kelantan are of higher quality compared to those from Ayer Lanas. The research clearly indicates that the presence of rocks, clays, and compact soil hinders soil humidity maintenance. Elevated soil temperatures pose a threat to root growth, while low humidity combined with high temperatures can lead to the depletion of soil nutrients.

Furthermore, the system facilitates the automation of various tasks, such as irrigation and fertilization, providing farmers with time and resource savings while enhancing crop yields. Looking ahead, there is substantial potential for advancements in smart agriculture technology. Integrating artificial intelligence and machine learning algorithms holds promise for improving the accuracy of data analysis and predicting crop growth and yield. Additionally, the incorporation of drone technology for aerial crop monitoring could offer more detailed insights into crop health and growth.

5.2 Recommendation

This research effectively employed an Internet of Things (IoT) approach to monitor soil characteristics in two distinct locations. By utilizing moisture and temperature sensors, the study successfully identified differences in soil health between the two sites. However, to further refine and enhance the research, several key recommendations can be implemented.

Expanding the sensor array is crucial. While the current setup provides valuable data on moisture and temperature, incorporating sensors for soil pH, electrical conductivity (EC), and specific nutrients (NPK) would offer a more comprehensive understanding of the soil environment. This expanded data set allows for a deeper analysis of nutrient availability, potential salinity issues, and overall soil health.

Furthermore, integrating data logging and visualization capabilities is essential. Logging sensor readings over time enables trend analysis, facilitating the identification of patterns and changes in soil characteristics. This data can then be compared across different locations or soil samples, providing valuable insights. Additionally, the collected data can be utilized for machine learning and decision support, potentially leading to the development of algorithms that optimize irrigation and fertilization practices.

The research can be further enhanced by incorporating communication and automation. Connecting the system to an IoT platform allows for remote monitoring and the establishment of automated alerts for critical conditions. Additionally, the system could be integrated with irrigation systems to automate water delivery based on real-time sensor readings, minimizing resource waste and ensuring optimal water management.

Expanding the research scope to encompass a wider range of environmental factors is another key recommendation. Monitoring sunlight exposure and rainfall provides a more holistic understanding of the factors influencing soil moisture and temperature. Additionally, exploring advanced techniques like X-ray fluorescence (XRF) or near-infrared spectroscopy (NIRS) could offer more detailed insights into soil composition and nutrient levels.

Finally, collaboration with agricultural scientists and soil experts would be instrumental in interpreting the collected data and understanding its implications for crop growth. Their expertise can provide invaluable guidance in analyzing the data set and translating the findings into actionable insights for farmers.

By implementing these recommendations and exploring future directions, this research can evolve into a powerful tool for data-driven smart farming. This approach has the potential to significantly improve crop yields, resource utilization, and overall agricultural efficiency, leading to a more sustainable and productive future for the agricultural sector.

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APPENDIX

Appendix A

The Code of Moisture Sensor

```
#include <Wire.h>

#include <LiquidCrystal_I2C.h>


// Set the LCD address to 0x27 for a 16 chars and 2 line display

LiquidCrystal_I2C lcd(0x27, 16, 2);

int sensor_pin= A0;

void setup() {

Serial.begin(9600);

pinMode (sensor_pin, INPUT) ;

}

void loop() {

int sensor_data= analogRead(sensor_pin);

Serial.println(sensor_data);

if(sensor_data>=1000)

Serial.println("No moisture, soil is dry");

else if (sensor_data>=700 && sensor_data<=500)

 Serial.println("There is some moisture, soil is medium");

 else if (sensor_data<=400)

 Serial.println("soil is wet");
```

Appendix B

The Code of DHT 11 sensor

```
#include <LiquidCrystal_I2C.h>
LiquidCrystal_I2C lcd(0x27,16,2
#include <DHT.h>
DHT dht(2, DHT11); //Pin, Jenis DHT

int powerPin = 2// untuk pengganti VCC/5vOLT

void setup () {
  lcd.begin();
  // Print a message to the LCD.
  lcd.backlight();
  // jadikan pin power sebagai output
  pinMode(powerPin, OUTPUT);
  // default bernilai LOW
  digitalWrite(powerPin, LOW);
 Serial.begin(9600);
 dht.begin();
}
void loop(){
 digitalWrite(powerPin, HIGH);
 float humidity = dht.readHumidity();
 float temperature = dht.readTemperature();
```

```
Serial.print("humidity: ");
Serial.print(humidity);
Serial.print(" ");
Serial.print("temperature: ");
Serial.println(temperature);
 lcd.clear();
 lcd.setCursor(0,0);
 lcd.print("humidity: ");
 lcd.setCursor(11,0);
 lcd.print(humidity);
 lcd.setCursor(0,1);
 lcd.print("temperature: ");
 lcd.setCursor(5,1);
 lcd.print(temperature);
 delay(1000);
}
```