Faculty of Technology and Electrical Engineering

Development of Solar-Powered Smart Farm System With Blynk Application

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Development of Solar-Powered Smart Farm System With Blynk Application

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DEDICATION

I dedicate this report with deep gratitude and affection to all who contributed to my journey in successfully completing this project. To my beloved mother, father, and younger sister, your unwavering love, countless sacrifices, and steadfast belief in me have served as my foundation and primary motivation. This accomplishment is as much yours as it is mine.

I would like to express my gratitude to Puan Kamilah Binti Jaafar, my lovely with brain final-year project supervisor, for your crucial advice, tolerance, and support. Your knowledge and commitment have greatly influenced this project and my development as a learner. I will always be appreciative of your guidance, which has motivated me to pursue greatness.

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ABSTRACT

The Development of Solar-Powered Smart Farm System with Blynk Application is a novel solution aimed at tackling significant difficulties in contemporary agriculture, such as resource inefficiency, environmental sustainability, and labour-intensive operations. This initiative integrates solar energy with advanced IoT technologies to provide an automated and intelligent agricultural system. Solar panels function as the principal energy source, guaranteeing sustainable and economical operation, even in isolated regions, by supplying power to an ESP-32 microprocessor and an array of sophisticated sensors. These sensors, including soil moisture, pH, and DHT22 modules, deliver real-time data on essential environmental factors like soil health, temperature, and humidity. The Blynk program processes and visualises this data, allowing effortless remote monitoring and management of agricultural activities using an intuitive smartphone interface. The technology optimises irrigation and fertigation by automating water and nutrient delivery schedules according to real-time sensor data, therefore minimising waste and improving resource efficiency. The system specialises in chilli production, a crop characterised by significant demand and economic value, utilising precision fertigation techniques to guarantee maximum plant development and output. This project utilises IoT technology, renewable energy, and smart automation to convert conventional agricultural methods into a sustainable, efficient, and scalable paradigm, therefore enhancing food security and promoting environmental conservation.

ABSTRAK

Pembangunan Sistem Ladang Pintar Berkuasa Suria dengan Aplikasi Blynk ialah penyelesaian baharu yang bertujuan untuk menangani kesukaran ketara dalam pertanian kontemporari, seperti ketidakcekapan sumber, kelestarian alam sekitar dan operasi intensif buruh. Inisiatif ini menyepadukan tenaga suria dengan teknologi IoT termaju untuk menyediakan sistem pertanian automatik dan pintar. Panel solar berfungsi sebagai sumber tenaga utama, menjamin operasi yang mampan dan menjimatkan, walaupun di kawasan terpencil, dengan membekalkan kuasa kepada mikropemproses ESP-32 dan pelbagai penderia yang canggih. Penderia ini, termasuk modul kelembapan tanah, pH dan DHT22, menyampaikan data masa nyata tentang faktor persekitaran yang penting seperti kesihatan tanah, suhu dan kelembapan. Program Blynk memproses dan memvisualisasikan data ini, membolehkan pemantauan jauh dan pengurusan aktiviti pertanian yang mudah menggunakan antara muka telefon pintar yang intuitif. Teknologi ini mengoptimumkan pengairan dan fertigasi dengan mengautomasikan jadual penghantaran air dan nutrien mengikut data sensor masa nyata, oleh itu meminimumkan sisa dan meningkatkan kecekapan sumber. Sistem ini mengkhususkan diri dalam pengeluaran cili, tanaman yang dicirikan oleh permintaan dan nilai ekonomi yang ketara, menggunakan teknik fertigasi ketepatan untuk menjamin pembangunan dan pengeluaran tumbuhan yang maksimum. Projek ini menggunakan teknologi IoT, tenaga boleh diperbaharui dan automasi pintar untuk menukar kaedah pertanian konvensional kepada paradigma yang mampan, cekap dan berskala, oleh itu meningkatkan keselamatan makanan dan menggalakkan pemuliharaan alam sekitar.

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TABLE OF CONTENTS

DECLARATION		**iv**
DEDICATION		**vi**
ABSTRACT		**vii**
ABSTRAK		**viii**
ACKNOWLEDGEMENTS		**ix**
TABLE OF CONTENTS		**x**
LIST OF TABLES		**xiii**
LIST OF FIGURES		**xiv**
CHAPTER 1		
INTRODUCTION		**1**
1.1	Introduction	1
1.2	Background	1
1.3	Problem Statement	2
1.4	Project Objective	3
1.5	Scope of Project	4
CHAPTER 2		
LITERATURE REVIEW		**6**
2.1	Introduction	6
2.2	Type of Farming	6
	2.2.1 Fertigation System	7
	2.2.2 Greenhouse Agriculture	8
	2.2.3 Hydroponic System	9
	2.2.4 Aquaponic System	10
2.3	Type of Plant Suitable in the Fertigation System	11
	2.3.1 Chili	11
	2.3.2 Pineapple	12
	2.3.3 Lettuce	13
2.4	Sensor used in Fertilizer System	14
	2.4.1 Soil Moisture Sensor	14
	2.4.2 pH Module Sensor	15
	2.4.3 DHT 22	16
	2.4.4 DS 3231	16
2.5	Types of Nutrient	17
	2.5.1 Nutrient Solution A	18
	2.5.2 Nutrient Solution B	18
2.6	Type of Microcontroller	19
	2.6.1 ESP-32	19
	2.6.2 NodeMCU Wi-Fi Module (ESP8266)	20

2.7 Solar-Powered for Fertilizer System 20
2.7.1 PV Solar Panel 21
2.7.2 Solar Charger Controller 21
2.7.3 12V Lead Acid Rechargeable Battery 22
2.8 Past Studies 23
2.8.1 Smart Farming Fertigation Using IoT Application 23
2.8.2 Smart Farming with Soil Moisture Sensor and ESP-32 using Blynk Application 24
2.8.3 Farming System with Water Level Sensor and Nutrient Level 25
2.8.4 Smart Farming for Lettuce with Solar Panel to monitor Soil Moisture, pH and Water Level Sensor using NodeMCU ESP-8266 27
2.8.5 Smart Farming Chili with Soil Moisture and pH using GSM Module and Blynk Application 29
2.9 Evaluation of Infrastructure 31
2.9.1 Table comparison Types of Farming 31
2.9.2 Table comparison Type of Planting 33
2.9.3 Table comparison Types of Microcontroller 34
2.9.4 Table comparison Types of Nutrient 35
2.10 Summary 36

CHAPTER 3

METHODOLOGY 38
3.1 Introduction 38
3.2 Flowchart and Explainantion 40
3.2.1 Flowchart of Project 40
3.2.2 Flowchart of System 42
3.2.2 Flowchart of Blynk 44
3.3 Block Diagram 45
3.4 Schematic Diagram 46
3.5 Hardware 47
3.5.1 Tank 48
3.5.2 Submersible Pump 48
3.5.3 Water & Fertilizer Sprinkler 49
3.5.4 Fertilizer A & B 50
3.5.5 Solar Panel 51
3.5.6 Solar Controller 52
3.5.7 12V Lead Acid Rechargeable Battery 53
3.5.8 Soil Moisture Sensor 54
3.5.9 pH Module 55
3.5.10 DHT22 56
3.5.11 DS3231 57
3.6 Software 59
3.6.1 Blynk Application 59
3.7 Summary 62

CHAPTER 4

RESULTS AND DISCUSSIONS **64**
4.1 Introduction 64
4.2 Project Design 64
4.3 Result and Analysis 69
4.3.1 Solar System 69
4.3.2 Soil Moisture 73
4.3.2 Water Pump 75
4.4.3 pH Value 77
4.4.5 Storage Battery 79
4.4.6 Power Generation and Storage Capacity 81
4.4.7 Energy Consumption Data 83
4.4.8 Blynk Application 84
4.4 Summary 85

CHAPTER 5

CONCLUSION, RECOMMENDATIONS & PROJECT POTENTIAL **87**
5.1 Conclusion 87
5.2 Recommendations 88
5.3 Project Potential 89

REFERENCES **91**

APPENDICES **95**

LIST OF TABLES

TABLE	TITLE	PAGE
Table 2.1	Various Types of Farming Comparison	30
Table 2.2	Various Type of Planting Comparision	32
Table 2.3	Various Type of Microcontroller Comparison	33
Table 2.4	Various Type of Nutrient Comparison	34
Table 4.1	Result for Solar System	70
Table 4.2	Result for Soil Moisture	73
Table 4.3	Result for Water & Fertilizer Pump	75
Table 4.4	Result for pH Value	77
Table 4.5	Result for Discharge Time	79
Table 4.6	Result for Recharge Time	80

LIST OF FIGURES

FIGURE	TITLE	PAGE
Figure 2.1	Fertigation System	7
Figure 2.2	Greenhouse Agriculture	8
Figure 2.3	Hydroponic System	9
Figure 2.4	Aquaponic System	10
Figure 2.5	Chili Plant	12
Figure 2.6	Pineapple Plant	12
Figure 2.7	Lettuce Plant	13
Figure 2.8	Soil Moisture Sensor	15
Figure 2.9	pH Module	15
Figure 2.10	DHT 22	16
Figure 2.11	DS 3231	17
Figure 2.12	Fertiliser Solution A & B	17
Figure 2.13	ESP-32	19
Figure 2.14	NodeMCU ESP-8266	20
Figure 2.15	Solar Panel	21
Figure 2.16	Solar Charger Controller	21
Figure 2.17	12V Lead Acid Rechargeable Battery	22
Figure 3.1	Flowchart of Project	40
Figure 3.2	Flowchart of System	42
Figure 3.3	Flowchart of Blynk	44
Figure 3.4	Block Diagram	45
Figure 3.5	Schematic Diagram	46
Figure 3.6	Tank	48

LIST OF FIGURES

FIGURE	TITLE	PAGE
Figure 3.7	Pump	49
Figure 3.8	Water & Fertilizer Sprinkle	50
Figure 3.9	Fertilizer A & B	51
Figure 3.10	Solar Panel	52
Figure 3.11	Solar Controller	53
Figure 3.12	12V Lead Acid Rechargeable Battery	54
Figure 3.13	Soil Moisture Sensor	55
Figure 3.14	pH Module	56
Figure 3.15	DHT 22	57
Figure 3.16	DS 3231	58
Figure 3.17	Blynk Application	59
Figure 4.1	Design of Project	65
Figure 4.2	Part of Component Project	65
Figure 4.3	Chilli Plant for Project	66
Figure 4.4	Water & Fertilizer Sprinkle	66
Figure 4.5	Control Box of System	67
Figure 4.6	Connection of System	67
Figure 4.7	Graph of Solar System Data	71
Figure 4.8	Graph of Solar System Data	72
Figure 4.9	Graph for Soil Moisture Data	74
Figure 4.10	Graph of Water & Fertilizer Pump Data	76
Figure 4.11	Graph of pH Value Data	77
Figure 4.12	Display System on LCD	84
Figure 4.13	Display System on Blynk	84

CHAPTER 1

INTRODUCTION

1.1 Introduction

In the face of escalating global challenges, there is an imperative requirement for the implementation of sustainable agricultural methodologies. Given the growing demands for food production and the limited availability of natural resources, the integration of solar electricity with Internet of Things (IoT) technologies offers a promising and feasible solution for improving farming efficiency and productivity. By utilizing Blynk Apps for IoT connectivity, the objective of this endeavor is to construct a comprehensive intelligent farming system that optimizes the utilization of resources, monitors crucial parameters such as soil moisture and crop health, and facilitates remote management and automation of agricultural operations. This initial section provides the foundation for a detailed discussion on the project's aims, methodology, and anticipated outcomes.

1.2 Background

The growing demand for food production, environmental concerns, and resource constraints are posing problems for traditional farming practices. Productivity and resource efficiency must be given top priority in sustainable agriculture approaches to meet these issues. Using Internet of Things (IoT) technologies in agriculture in conjunction with solar electricity is one viable approach. While IoT allows for real-time data management and monitoring, solar power provides a green energy source. The goal of developing a solar-powered smart farm system with IoT integration and connectivity via Blynk Apps is to maximise productivity, optimise resource use, and better crop management. The goal of this project is to investigate the viability and efficacy of such a system in order to solve the changing issues facing the agricultural industry and promote sustainable agricultural practices.

1.3 Problem Statement

Modern agriculture struggles with inefficient agricultural monitoring and management. Manual procedures and inadequate resources hinder crop management in the business. To address these issues, agriculture needs IoT technology to boost productivity and efficiency. This transformation requires a sophisticated smart farming system with IoT components for real-time agricultural process monitoring and management. Remote farm management and access require agricultural-specific internet and mobile interfaces. Sensor networks that monitor soil conditions, pH module and DHT 22 are essential for crop health and resource efficiency. This scenario requires a resilient intelligent agriculture system to transform agricultural practices and meet farming needs.

In today, food security is a significant issues that threateans millions of people in Malaysia. Climate change exacerbates the issue by reducing crop productivity and impeding individuals' ability to sustain themselves financially. Ensuring food security necessitates the development of innovative, cooperative, and all-encompassing solutions. Through the empowerment of marginalised communities and the adoption of sustainable methods, we can develop robust food systems that provide universal access to nourishing food. Home agriculture has the capacity to enhance food security, expand availability of fresh produce, and foster sustainable and health-conscious food systems.

The efficient monitoring and regulation of farm activities pose challenges for the agriculture sector. Conventional farming methods often do not have the capability to remotely retrieve data and offer immediate analysis, leading to inefficiencies in resource utilisation and crop management. To properly address these challenges, it is imperative to develop a sophisticated agricultural system that integrates Blynk application.

Modern agricultural practices often rely on human involvement and physical presence for monitoring and management, which limits the ability to expand and adjust operations. Furthermore, the absence of intuitive interfaces for remote access and management impedes farmers' ability to oversee their crops from any place and at any time. Developing intuitive internet and mobile interfaces tailored for agricultural application is crucial for enabling seamless remote monitoring and control of farm operations.

Lack of precise information about soil conditions, temperature, rain sensor and nutrient levels prevents farmers from making well-informed decisions on crop management. Sensors that can monitor these variables in real-time must be integrated to provide precise data insights to improve crop health and resource utilisation. Therefore, the development of sensor networks is a key component of the proposed smart farming system.

1.4 Project Objective

- To develop a smart farming system using solar panel as power supply.
- To design user-friendly mobile interfaces with Blynk application for efficient monitoring soil conditions, pH module sensor and DHT 22
- To analyse performance of the fertigation farm system based on their responsiveness and efficiency.

1.5 Scope of Project

The main objective of the project is to create a smart agricultural system that uses solar energy and Internet of Things (IoT) technology to improve agricultural efficiency. This scope includes some important parts.

First of all, the project will involve combining IoT tehnology with solar power. This includes designing and building solar-powered systems to give smart farming systems clean energy in the future. For this project the plant that will be used is chili. Chili is one of the main production that have very high demand every year in Malaysia. For this plant its produces low maintenance cost because once established, chili pepper plants don't require a ton of attention. They need regular watering, but are generally resistant to pests and diseases

Second, the project will involve IoT technology through Blynk application. The analysis explores the application's user-friendly interface and powerful features, with the goal of demonstrating its adaptability and simplicity in connecting physical devices to mobile platforms. The project explores Blynk's capabilities, focusing on user experience, security, and scalability, and its potential for intelligent environments, analyzing its performance in various scenarios, including home automation and IoT installations.

Thirdly, the construction of a sensor network will be an important part of the project. Important factors such as soil moisture is monitoring and managing soil moisture levels are key pratices for maximizing agricultural productivity and sustainability. Next factor is pH modular sensor, This sensor can provide real-time insights into water conditions, which could revolutionise agricultural methods. Determining the ideal circumstances for crop growth requires knowledge of pH, which is a measure of the acidity or alkalinity of water. Additionally, this project used a DHT22 sensor, which accurately measures temperature and humidity. These characteristics are essential for establishing ideal environmental conditions for crops, facilitating improved growth and output. Other than that, this project will use fertilizer AB.

This fertilizer will make plant growth will be balanced and fertile because it gets a complete supply of nutrients. This all factors will be tracked in real time by the sensor network. These sensors will collect accurate data that can be used to make better use of resources, improve plant health, and improve overall output.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

A fertigation system, a particular sort of sensor for system operation, a water pump for ideal water flow, solar energy for powering all the electrical parts, and a plant species suitable for the region and culture.

In this chapter, the literature review will include a concise overview of the existing research on the issue, as commonly employed in research projects and academic articles. It will be employed to formulate the research question or hypothesis, identify trends, discrepancies, and inconsistencies in the existing literature, and provide background information and context for this study.

2.2 Type of Farming

Modern agriculture involves a variety of techniques designed to promote sustainability and maximize efficiency. Several methods employed in Malaysia.

a) Fertigation System

b) Greenhouse Agriculture

c) Hydroponic System

d) Aquaponic System

2.2.1 Fertigation System

Fertigation, a hybrid term derived from the terms "fertilisation" and "irrigation," is an innovative farming method in which crops are simultaneously irrigated and fertilised with fertilisers through irrigation systems. Farmers can precisely manage the supply of nutrients with this technology, enabling them to customise fertilisation to their crops' unique requirements at various phases of growth. Nutrients and water are necessary for farmers to guarantee optimal crop productivity[1]. Fertigation is the practice of efficiently nourishing crops by combining water with a soluble nutrient solution through an automated irrigation system[1].

Fertigation reduces fertiliser waste and minimises environmental impact by optimising plant nutrient uptake through irrigation integration. Fertigation also improves crop productivity and uniformity, which raises yields and improves quality. This method ensures adequate nutrient availability for plant growth while promoting effective water use, making it especially helpful in regions with limited water resources.

Figure 2.1 Fertigation System

2.2.2 Greenhouse Agriculture

Greenhouse agriculture revolutionises conventional farming methods by creating controlled settings that maximise plant growth and safeguard crops from unfavourable weather conditions. A house-like structure made of glass or plastic is used in greenhouse farming to grow a variety of crops year-round[2] . The roof is often coated with transparent material to maintain the necessary climatic conditions for plant development[2]. Greenhouse agriculture optimises growing conditions, resulting in improved crop quality and yield, while minimising the likelihood of pest infestations and diseases.

Moreover, Greenhouses encourage the adoption of resource-efficient techniques like drip irrigation and soilless cultivation, which effectively reduce water consumption and prevent fertiliser runoff. Greenhouse agriculture is especially advantageous in areas with severe weather or little arable land.

Figure 2.2 Greenhouse Agriculture

2.2.3 Hydroponic System

Hydroponic systems revolutionise conventional agriculture by allowing plants to thrive without soil, instead utilising water solutions that are rich in nutrients. Plants will thrive as long as they receive the appropriate quantity of essential nutrients[3]. Hydroponics improves growth rates and yields by directly supplying nutrients to plant roots, while also reducing the likelihood of soil-borne illnesses.

In contrast to conventional farming, a hydroponic system uses continuous water circulation enabled by a pump to provide water media with regulated nutrient intake. Therefore, it requires a pump that runs continuously to make sure the plants get enough nutrients to thrive[4]. This system regulate pH levels and nutrient concentrations, optimizing plant health and reducing resource waste. They're especially beneficial in urban areas with limited arable land and offering a sustainable solution for locally grown produce

Figure 2.3 Hydroponic System

2.2.4 Aquaponic System

Aquaponics is an advanced agricultural technique that combines aquaculture and hydroponics, resulting in less dependence on breeding and water replacement for growing vegetables and fish livestock. This strategy promotes mutually beneficial links between fish, plants and microorganisms, which boosts sustainable and nutritious food production [5].

Because of its extreme adaptability, aquaponic systems can be used at any scale, from large-scale commercial operations to backyard setups. They have many benefits, such as increased yields, effective water use, less of an adverse effect on the environment, and the possibility of year-round cultivation.

Figure 2.4 Aquaponic System

2.3 Type of Plant Suitable in the Fertigation System

Diverse plant species have been analysed to determine their compatibility with this unique farming technique. These plants demonstrate encouraging reactions to fertigation, displaying enhanced growth, productivity, and quality in comparison to conventional soil-based techniques.

a) Chili

b) Pineapple

c) Lettuce

2.3.1 Chili

Due to its great demand, particularly from market wholesalers and the food sectors, the chilli plant is one of the most popular plants among farmers. For a healthy growth, the plant needed a regulated environment with an effective irrigation and fertilisation system[6] .

In a fertilizer system, taking care of chilli plants requires managing the nutrients as well as the surrounding environment, especially the temperature. Like any plants, chilli plants require certain conditions to flourish and produce their fruits at their best. These plants are susceptible to cold and do best in warm weather. The ideal temperature range for chilli plants is 70°F to 85°F (21°C to 29°C) during the day and 60°F (15°C) at night. Abrupt temperature dips, particularly below 50°F (10°C), might impede fruit development and inhibit growth.

Figure 2.5 Chili Plant

2.3.2 Pineapple

Pineapple plants grown in a fertilizer system require special attention and environmental conditions to thrive. Optimal care entails selecting appropriate fertilizer formulations rich in essential nutrients required for pineapple growth and fruit development. Pineapple trees grow in high humidity circumstances, with optimal levels reaching up to 90%. Inappropriate humidity levels can disrupt tree development and diminish fruit yield.

Thus, contemporary "smart farming" techniques have the potential to improve production efficiency and optimise the utilisation of water and fertilisers. Smart farming has revolutionised agriculture, turning it into a contemporary industry. [7] The ideal temperature range for optimal growth of pineapples is 65°F to 95°F (18°C to 35°C). Nevertheless, they have the ability to endure slightly lower temperatures for brief durations, particularly at night.

Figure 2.6 Pineapple Plant

2.3.3 Lettuce

Lettuce is a rapidly growing crop that can be cultivated in a fertilizer system with minimal maintenance, making it an excellent option for both beginners and experienced fertilizer farmers. Consistent watering and proper nutrient management are crucial for lettuce plants grown in fertilizer-based systems to prevent root rot and diseases [8].

As a cool-season crop that grows best in moderate temperatures, lettuce typically prefers 60°F to 70°F (15°C to 21°C). Overheating can cause lettuce plants to bolt, or develop flowers and seeds early on, which decreases the quality and gives the leaves a harsh taste [9].

Figure 2.7 Lettuce Plant

2.4 Sensor used in Fertilizer System

In fertilizer systems, a variety of sensors are used to enable accurate and automatic nutrient management. This type of sensor includes an optical sensor, an electrical conductivity sensor, and an ion-selective electrode.

a) Soil Moisture Sensor

b) pH Module

c) DHT22

d) DS3231

2.4.1 Soil Moisture Sensor

A soil moisture sensor monitors the soil's moisture level and notifies the user when irrigation should be started or stopped. Since moisture is one of the three main elements influencing crop growth, it is significant to the development of a crop [10].

The sensor functions based on the open short circuit principle and offers both analogue and digital outputs. The LED in this system indicates the state of the output, either high or low. When the soil becomes desiccated, it will result in the absence of electrical current, leading to the formation of an open circuit. When the soil is moist, electrical current can flow through it, resulting in a short circuit and a zero output. Levels give rise to the emergence of sensor information. Due to its rust resistance, the sensor has a prolonged lifespan, resulting in cost-effective control for the farmer [11].

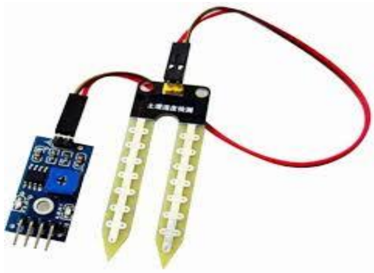

Figure 2.8 Soil Moisture Sensor

2.4.2 pH Module Sensor

pH sensor is an essential component of the Internet of Things fertigation system since it measures the water's acidity or alkalinity, which is vital for fish and plant health. Since the pH of polluted water tested in the system was higher than that of natural water, which normally displays a reading of 7, a standard pH value of 9 was established for the sensor [12].

A pH sensor in the form of a glass electrode is employed to measure the pH of the water in the fertigation system. This glass electrode is specifically designed to be responsive to hydrogen ions (H+). The electrode generates a voltage that is directly proportional to the concentration of H+ ions in the water. This voltage is subsequently utilised to determine the pH of the water. The glass electrode pH sensor is a precise, dependable, and versatile measurement device[12].

Figure 2.9 pH Meter

2.4.3 DHT 22

The DHT 22 is a vital sensor for measuring temperature and humidity, crucial for optimal plant development conditions. It uses a capacitive humidity sensor to precisely measure atmospheric moisture levels and generates digital signals for seamless integration with microcontrollers such as the ESP-32. The DHT 22 regulates temperature and humidity to promote crop health and growth, enabling real-time monitoring and automatic reactions in the gardening system. [13]

Figure 2.10 DHT 22

2.4.4 DS 3231

DS 3231 is a real-time clock (RTC) module that provides precise timekeeping for automated systems. It regulates the timing of the project system. The DS3231 offers automated system management by activating relays at specific intervals, hence improving the efficiency and uniformity of the plant's growth environment. [14]

Figure 2.11 DS3231

2.5 Types of Nutrient

Nutrients are crucial for facilitating the growth and development of plants. These nutrients typically consist of vital macronutrients and micronutrients that are necessary for promoting healthy plant growth. Two types of nutrient solutions are commonly used in agriculture that are often used in hydroponic and fertigation systems.

a) Nutrient Solution A

b) Nutrient Solution B

Figure 2.12 Nutrient Solution A & B

2.5.1 Nutrient Solution A

Solution A typically include macronutrients, including nitrogen (N), phosphorus (P), and potassium (K), which are vital for plant growth and overall well-being. Nitrogen is essential for the development of leaves and stems, phosphorus promotes the growth of roots and the generation of flowers, and potassium contributes to the development of fruits and overall plant vitality[15].

Solution A may also include secondary macronutrients such as calcium (Ca), magnesium (Mg), and sulphur (S), which are necessary in smaller amounts but nonetheless vital for plant development. The required concentrations for a fertiliser chilli plant system usually depend on a number of variables, including the plant's growth stage, the kind of soil, the surrounding conditions, and the requirements for particular nutrients.

- Nitrogen (N) : 10% - 20%
- Phosphorus (P) : 5% - 10%
- Potassium (K) :10% - 15%

2.5.2 Nutrient Solution B

Solution B generally comprises micronutrients or trace elements that are required for diverse biochemical activities within the plant. Micronutrients encompass elements such as iron (Fe), manganese (Mn), zinc (Zn), copper (Cu), boron (B), and molybdenum (Mo), among other elements.

These micronutrients play a vital role in processes such as photosynthesis, enzyme activation, and hormone synthesis. Although they are needed in lesser amounts than macronutrients, they are as essential for the growth and development of plants[16].

2.6 Type of Microcontroller

Microcontrollers are an essential part of many electronic devices, acting as the central processing unit. These small integrated circuits are made up of an input/output peripheral, memory, and a processing core all combined into one chip.

a) ESP-32

b) NodeMCU Wi-Fi Module (ESP8266)

2.6.1 ESP-32

The ESP-32 is a multipurpose microcontroller with built-in Bluetooth and Wi-Fi that is renowned for its low cost and low power architecture. Numerous peripherals are available, including GPIO, I2C, SPI, UART, and ADC. It facilitates development by supporting development platforms like Arduino, MicroPython, and ESP-IDF and is programmed in languages like C and C++. The ESP32 is well-known for its strength and adaptability and is widely utilised in Internet of Things applications such as smart agriculture, industrial automation, and home automation[17].

Figure 2.13 ESP-32

2.6.2 NodeMCU Wi-Fi Module (ESP8266)

The ESP-8266 operates as the primary controller of the system, executing microcontroller operations and establishing connectivity between IoT devices and the internet through WiFi. The NodeMCU ESP-8266 allows for the transmission of data and reception of commands from applications, making it possible to remotely monitor and control the process of watering plants. The NodeMCU ESP-8266 has an easy connection with the Blynk platform, offering a user-friendly interface for efficiently monitoring and operating the system[18].

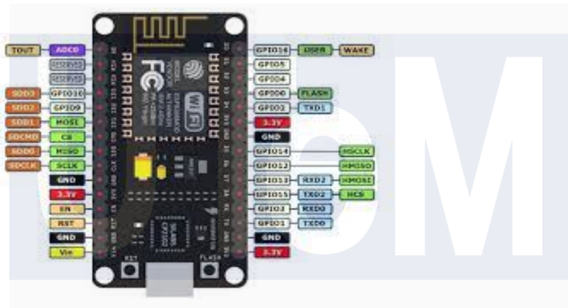

Figure 2.14 NodeMCU ESP-8266

2.7 Solar-Powered for Fertilizer System

An environmentally responsible and sustainable method of farming can be achieved by integrating solar electricity into fertiliser systems. Solar-powered fertiliser systems minimise carbon emissions and lessen reliance on fossil fuels by using solar energy to power their operations independently of conventional grid power sources.

a) PV Solar Panel

b) Solar Charger Controller

c) 12V Lead Acid Rechargeable Battery

2.7.1 PV Solar Panel

Solar panels, or photovoltaic cells, are devices that directly turn sunlight into electricity. Within the study's framework, the solar cell system encompasses solar panels, a solar charger, and a battery for the production of direct current (DC) [19].

Solar panels are essential for providing electricity to many components of the system, including sensors, actuators, and communication devices. The IoT farm can achieve effective and sustainable operation by using solar energy, thereby decreasing dependence on conventional energy sources and promoting environmental preservation[19].

Figure 2.15 Solar Panel

2.7.2 Solar Charger Controller

Solar charger controller is essential for managing the voltage and current from the solar panel to optimise the charging process of the battery. It is also utilised to enable the battery to be charged using the electricity supplied by the solar PV cell [20].

This controller facilitates the regulation of the charging process to avoid excessive charging and draining of the battery, hence extending battery lifespan and enhancing overall system efficiency[20].

Figure 2.16 Solar Charger Controller

2.7.3 12V Lead Acid Rechargeable Battery

This battery may be charged with a DC power supply that provides the right voltage to guarantee correct charging. It can be used for a variety of applications, including motors, controllers, circuits, and appliances [21] .

Figure 2.17 12V Lead Acid Rechargeable Battery

2.8 Past Studies

2.8.1 Smart Farming Fertigation Using IoT Application [1]

This study focuses on the automatic mixing process for fertigation systems in rock melon cultivation, emphasizing the importance of precise nutrient delivery to enhance crop productivity.

Another pertinent research article is by J. E. Mohd Salih et al., titled "Solar powered automated fertigation control system for Cucumis Melo L. cultivation in a greenhouse" published in APCBEE Procedia . This study delves into a solar-powered automated fertigation control system designed for Cucumis Melo L. cultivation in a greenhouse, highlighting the integration of solar energy to optimize fertigation processes.

Moreover, D. Rupa et al. conducted a study on "A novel approach for soil testing using an embedded system" . This research explores innovative methods for soil testing using embedded systems, which could be relevant for enhancing nutrient composition control in fertigation systems.

Additionally, M. M. E. Azmi and S. A. Jumaat's work on the "Development of a prototype nutrient automation system for a hydroponic system" could provide valuable insights into developing automated systems for nutrient control, potentially applicable to fertigation systems.

In summary, the literature review on the development of automated nutrient composition control for fertigation systems using IoT applications can benefit from these studies, which collectively shed light on the advancements, challenges, and potential applications of integrating automation and IoT technologies in optimizing nutrient delivery for crop cultivation.

2.8.2 Smart Farming with Soil Moisture Sensor and ESP-32 using Blynk Application[17]

"An (IoT) Low-Cost Monitoring System for Smart Farming," the study focuses on developing a cost-effective system for collecting precise data in smart farming applications. The research utilizes the ESP32 microcontroller, known for its versatility and integration with various programming languages and development platforms like Arduino and MicroPython. The system leverages the Blynk app for real-time sensor data display and manual irrigation control, along with ThingSpeak for data collection, storage, and analysis from connected devices.

The study outlines the research methodology, emphasizing functional and non-functional requirements essential for system effectiveness, including measuring temperature and soil moisture, displaying sensor readings, calculating date and time, and irrigating soil as needed. Hardware components like the ESP32 microcontroller, relay, DC-DC converter, soil moisture sensor, rain sensor, and DHT11 sensor are crucial for system operation.

The implementation of the proposed smart farming system design involves meticulous hardware and software integration. The Blynk app enables remote control and monitoring of IoT devices, while ThingSpeak facilitates data storage and analysis. The system's flow chart illustrates the decision-making process for irrigation based on soil moisture levels and rainfall predictions, ensuring efficient water usage and crop health.

In conclusion, the study highlights the benefits of IoT technology in agriculture, emphasizing the importance of monitoring soil conditions for optimal crop growth. Real-time data collection and analysis through ThingSpeak enable informed decision-making on irrigation practices, with the ESP32 microcontroller ensuring up-to-date data transmission. The system's design offers a comprehensive solution for monitoring and optimizing crop performance in smart farming applications.

2.8.3 Farming System with Water Level Sensor and Nutrient Level [3]

Hydroponic farming is an agricultural technique that utilizes water or aqueous nutrient solutions to grow plants without soil. It allows for more efficient use of space and resources compared to traditional farming. However, hydroponic systems require careful monitoring and regulation of environmental conditions to optimize plant growth and yield.

Bhargava et al. propose a sensor fusion based intelligent hydroponic system to automate the monitoring and control of key parameters in hydroponic farming. Their system employs multiple sensors to measure ambient conditions like light intensity, temperature, humidity, water level, and nutrient concentration. The sensor data is aggregated and sent to a central server for processing.

A key feature of the proposed system is the use of the Random Forest machine learning algorithm to intelligently determine which environmental parameter needs to be adjusted based on the sensor inputs. This allows the system to prioritize control actions and reduce sensor crowding. The algorithm selects the parameter that requires regulation through a majority voting scheme applied to decision trees trained on randomized subsets of the data.

The system is designed to automatically regulate the identified parameters to their optimal ranges for the specific crop being grown, in this case spinach. For example, it can control light intensity by switching grow lights on/off, adjust temperature via fans or air conditioning, and maintain water levels and nutrient concentrations by actuating pumps.

Another novel aspect is the implementation of a mathematical curve-fitting technique to control the addition of water and nutrients to the hydroponic solution based on electrical conductivity measurements. This allows the system to precisely regulate nutrient levels to match the plants' requirements.

Experimental results show that the intelligent sensor fusion system is able to save 20-82% of peak power consumption compared to manual control methods, by only activating the necessary components. The automated regulation of environmental parameters also helps ensure optimal growing conditions and reduces the need for human intervention.

In summary, the sensor fusion based intelligent hydroponic system proposed by Bhargava et al. demonstrates the potential for automation and optimization in hydroponic farming using IoT sensors and machine learning techniques. Such systems can help improve the efficiency, sustainability and yields of hydroponic agriculture.

2.8.4 Smart Farming for Lettuce with Solar Panel to monitor Soil Moisture, pH and Water Level Sensor using NodeMCU ESP-8266 [4]

Hydroponic lettuce farming has become increasingly popular due to its high productivity and suitability for farm-to-table restaurants and salad bars. However, the electric pumps used in hydroponic systems consume a significant amount of energy, with an estimated 70,350 kW-Hr per month consumed by hydroponic lettuce farms in Thailand. To address this issue, researchers have explored the use of Internet of Things (IoT) technologies and solar panels to improve the efficiency and sustainability of hydroponic lettuce farming.

Several researchers have proposed IoT-based hydroponic systems to improve monitoring and control of the growing environment. M. A. Triawan et al. studied IoT communication using a Cloud-based publish and subscribe method for monitoring and controlling parameters in a Nutrient Film Technique (NFT) hydroponic system. T. Wu et al. presented IoTtalk, a scalable and configurable software for hydroponic vegetable growers to easily add, remove, and exchange sensors and actuators. S. Ruengittinun et al. developed an Internet of Things for Smart Hydroponic Farming Ecosystem (HFE) to help new growers manage their farms. Manju. M applied IoT to remotely access an aquaponic system via wireless sensors for temperature, pH, ammonia, water level, and moisture. J. Chaiwongsai presented an IoT-based system to automatically control humidity, temperature, water level, pH and EC for tropical hydroponic cultivation.

To improve the efficiency of IoT-based hydroponic systems, researchers have focused on monitoring the internal factors of the plants themselves. P. Pipitsunthonsan et al. designed a leaf sensor consisting of a thermocouple, humidity sensor, and microcontroller to detect stomatal transpiration by measuring the temperature difference between the leaf and surrounding atmosphere. By monitoring the transpiration status of the plants in real-time, the duty cycle of the electric pumps can be optimized to reduce power consumption.

To further improve the sustainability of hydroponic farming, researchers have explored the integration of solar panels as an alternative energy source. P. N. Crisnapati presented the concept of using solar panels to convert sunlight into electricity for use in a smart farming system. O. Chieochan et al. introduced a prototype of a smart Lingzhi mushroom farm that applied solar cells to an irrigation system, using 2 modules of 40-watt solar panels with a 45 Ah battery for energy storage.

The authors of the paper propose an IoT-based hydroponic system that integrates leaf sensors and solar panels to optimize power consumption and reduce installation costs. The system uses an infrared temperature sensor as a leaf sensor, along with a light sensor, ESP8266 NodeMcu controller, and OLED display. The difference between leaf temperature and ambient temperature is used to determine the transpiration status and adjust the duty cycle of the electric pumps accordingly. By monitoring the internal factors of the plants and controlling the pumps based on transpiration, the authors claim that the power consumption can be reduced by 67% compared to conventional methods.

In summary ,the integration of IoT technologies, leaf sensors, and solar panels shows promise for improving the efficiency and sustainability of hydroponic lettuce farming. By monitoring the internal factors of the plants and optimizing the use of electric pumps, researchers have demonstrated significant reductions in power consumption. Further research is needed to validate the performance of these systems in real-world farming conditions and explore the potential for scaling up to larger commercial operations.

2.8.5 Smart Farming Chili with Soil Moisture and pH using GSM Module and Blynk Application [6]

Proper monitoring and control of irrigation and fertilization systems is crucial in agriculture to ensure sufficient nutrients and moisture are supplied to plants at all times. Two key parameters that need to be monitored are soil moisture and pH level. Smart farming incorporating Internet of Things (IoT) technology is being increasingly implemented to help farmers remotely monitor soil conditions.

Several IoT-based systems have been developed for smart irrigation and fertilization:

- Bluetooth enabled sensors to remotely monitor soil conditions from smartphones.
- Multi-Agent systems and Wireless Sensor Networks to monitor crop irrigation using a complex architecture of multi-agent open source platforms.
- GPS to remotely control and monitor soil properties and environmental factors, with sensors sending data to a website using GSM modules.

The authors propose designing a smart irrigation and fertilization system for chili plants using Fuzzy Logic and IoT. The system uses Wi-Fi for connectivity and Fuzzy Logic to control the flow rate of water, alkali and acid solutions into the soil to maintain moisture and pH levels.

Two input memberships are used - moisture and pH value. Three output memberships control the flow rate of alkali, neutral and acid solutions. Fuzzy rules are programmed into an Arduino to control the water pump and valves. The system stores data and displays it on a mobile phone through the Blynk app.

In summary, the proposed system was tested on a chili plant, showing better growth performance compared to traditional methods. The authors conclude that customized irrigation and fertilization systems are important for specific plant types based on environment and location. Correct fertilizer amounts are crucial to ensure plants receive adequate nutrients for healthy growth.

2.9 Evaluation of Infrastructure

Comparative analyses provide insights into regional discrepancies, showcase exemplary approaches, and tackle existing difficulties. An analysis is conducted to explore the incorporation of cutting-edge technology such as smart grids and environmentally friendly materials to improve both resilience and efficiency. This extensive analysis provides a thorough examination of the efficacy of different infrastructure strategies and the policy ramifications they entail.

2.9.1 Table comparison Types of Farming

Table 1 shows the comparison between four types of farming:

fertigation , greenhouse agriculture, hydroponics and aquaponics with a comment.

Table 2.1: Various Types of Farming Comparison

Type of Farming	Fertigation System [1]	Greenhouse Agriculture [2]	Hydroponic System [4]	Aquaponic System [5]
Method	Fertilizer is an innovative farming method in which crops are simultaneously irrigated and fertilised with fertilisers through irrigation systems .	Greenhouses are controlled environments where plants are physically examined and monitored. The temperatures are regulated, and the use of pesticides and fertilisers is carefully managed. The cultivation	Hydroponics is a soilless agricultural system that relies on nutrient-rich water for plant growth. The System NFT employs fertiliser solutions to effectively remove excess water from the root zone.	Aquaponics is an integrated farming method that combines the cultivation of plants with the rearing of fish in a specialised system. Fish excrement serves as nourishment for the plants, while the plants purify the water for the fish. It

		process is closely observed and tested .		functions as a self-sustaining ecosystem in which fish and plants mutually support each other's growth .

Each style of farming has unique benefits and drawbacks, as seen in Table 1. the Fertigation System, Greenhouse Agriculture, Hydroponic System, and Aquaponic System. The Fertigation System enhances the efficiency of fertiliser distribution to crops via irrigation, while Greenhouse Agriculture rigorously regulates environmental variables such as temperature and insect control. Hydroponic farming replaces soil with nutrient-rich water to nourish plants, employing techniques such as NFT to maximise efficiency. Aquaponics is a method that combines the growing of plants with fish farming, resulting in a self-sustaining environment where fish waste serves as fertiliser for plants and plants cleanse the water for the fish. These methods provide efficient use of resources and promote sustainability, addressing a wide range of agricultural requirements.

2.9.2 Table comparison Type of Planting

Table 2 shows the comparison between three types of planting:

Chilli,Pineapple and Lettuce with a comment

Table 2.2: Various Type of Planting Comparision

Specification	Chili [6]	Pineapple [7]	Lettuce [9]
Growth Time (Days)	60-150	500-700	40-80
pH Range	5.5-7.0	4.5-6.5	6.0-7.0
Temperature Range	20-30°C	25-32°C	15-25°C
Nutrition Level	High in vitamins A and C, as well as capsaicin, providing its spicy flavor.	Contains vitamin C, manganese, and bromelain, with potential health benefits.	Low in calories but rich in vitamins A and K, folate, and fiber.
Soil Moisture Level	Moist but well-drained	Well-drained	Consistently moist
Space Requirement	Small	Large	Small

According to table 2, In a fertilizer system, chili,pineapple and lettuce each have distinct characteristics. Chili thrives best in temperatures between 20° to 30°C, while pineapple prefers a range of 20°C to 32°C in typical of tropical climates. Lettuce, on the other hand, grows optimally in cooler temperatures, ideally between 15°C to 22°C. These temperature preferences reflect the varied ecological needs of each plant species.

2.9.3 Table comparison Types of Microcontroller

Table 3 shows the comparison between 2 types of microcontroller:

ESP32 and NodeMCU Wi-Fi Module (ESP8266) with a comment.

Table 2.3: Various Type of Microcontroller Comparison

Specification	ESP-32 [17]	NodeMCU Wi-Fi Module (ESP8266) [18]
Processor	Dual-core Tensilica LX6	Single-core Tensilica L106
Clock Speed	Up to 240 MHz	Up to 80 MHz
Wi-Fi Connectivity	Dual-band 802.11 b/g/n/ac	Single-band 802.11 b/g/n
Bluetooth Connectivity	Integrated Bluetooth 4.2 and BLE	No Bluetooth connectivity
GPIO Pins	Up to 36 GPIO pins	17 GPIO pins
Analog Pins	18	1 (10-bit ADC)
Memory	Up to 520 KB SRAM, 16 MB Flash	Up to 160 KB SRAM, 4 MB Flash

According table 3, The processor aspect distinguishes between the ESP-32, which features a dual-core Tensilica LX6 processor, and the NodeMCU Wi-Fi Module (ESP8266), which incorporates a single-core Tensilica L106 processor. The ESP-32's dual-core design offers increased processing power, enabling it to handle more complex tasks efficiently. In contrast, the single-core processor of the NodeMCU Wi-Fi Module (ESP8266) is suitable for simpler applications but may face limitations when handling more demanding tasks.

2.9.4 Table comparison Types of Nutrient

Table 4 shows the comparison between 2 types of Nutrient

Nutreint Solution A and Nutrient Solution B with a comment

Table 2.4: Various type of Nutrient Comparison

Aspect	Nutrient Solution A [15]	Nutrient Solution B [16]
Composition	Primary + secondary macronutrients, micronutrients	Balanced blend of micronutrients, trace elements, organics
Use	Base nutrient solution	Supplement or additive
N-P-K Ratio	Varied, crop-dependent	Tailored formulation
pH Level	Neutral (6.0-7.0)	Adjusted to plant requirements

According table 4, comparing the pH levels, Nutrient Solution A usually keeps a neutral pH of 6.0 to 7.0 to ensure that plants absorb nutrients as best they can, while Nutrient Solution B's pH level is generally adjusted to meet the needs of individual plants and can vary based on formulation and plant requirements. In both treatments, maintaining the proper pH level is essential to fostering healthy plant growth and aiding nutrient absorption.

2.10 Summary

The literature review offers a thorough summary of many topics pertaining to fertigation systems and contemporary farming methods. It discusses several farming techniques, emphasising their special qualities, benefits, and things to keep in mind. These techniques include fertigation, greenhouse agriculture, hydroponics, and aquaponics.

The review looks at plant species that work well in fertigation systems, like lettuce, chile, and pineapple, and talks about how their particular environments such as humidity, temperature, and nutrient requirements work. Additionally, it explores the use of sensors to track soil moisture, pH level , temperature and humidity environment for maximising plant development and resource efficiency.

The type of nutrient , which are divided into two categories which is Solution A (macronutrients and secondary macronutrients) and Solution B (micronutrients and trace elements) in supplying vital nutrients for plant growth and development is also covered in this review of the literature. It also covers the integration of microcontrollers for automation, remote monitoring, and control of fertigation systems, such as the ESP-32 and NodeMCU (ESP8266).

In order to encourage sustainability and lessen dependency on traditional energy sources, the assessment also looks into the integration of solar power components, such as batteries, charge controllers, and solar panels. It also emphasises how crucial water pumps are to maintaining ideal plant nutrition and water flow. A comparison of various farming techniques, plants, microcontrollers, and nutritional solutions using detailed tables is also included in the literature review's assessment of the infrastructure.

Lastly, it provides an overview of relevant previous research on subjects including intelligent hydroponic farming, rain detection devices, automated nutrient composition control, and Internet of Things-based irrigation and fertilisation systems. It will helps this project get insight into the most recent developments and their uses in the field.

CHAPTER 3

METHODOLOGY

3.1 Introduction

The process of creating a solar-powered smart farm system using the Blynk application requires a thorough and organised approach that combines renewable energy with advanced Internet of Things (IoT) technology to transform farm management methods. The development process is divided into multiple crucial phases, each carefully planned to guarantee the smooth integration and functionality of the system.

The initial stage is dedicated to the development and implementation of a resilient solar power system, which acts as the foundation of the intelligent agricultural facility. This entails the careful selection of suitable solar panels, batteries, and inverters to ensure a dependable and environmentally-friendly energy source that can effectively power the complete system. The focus is on optimising the positioning and alignment of the solar panels to maximise energy capture and efficiency, considering the precise geographic and climatic parameters of the farm's location.

During the second phase, a system of sensors and actuators is installed across the farm to consistently observe and control important agricultural factors, including soil moisture , temperature and pH. The placement of these sensors is carefully planned to ensure complete coverage and precise data collection, which is crucial for accurate farm management.

Subsequently, the gathered data is relayed to a central hub, which functions as the central processing unit of the intelligent agricultural system. This hub is linked to the Blynk application, which is a flexible and user-friendly Internet of Things (IoT) platform. It allows for real-time visualisation of data, remote monitoring, and control through a mobile app interface. The Blynk application is programmed to accept data from the sensors, analyse this data, and activate automated replies or send notifications to the farmer's smartphone. This feature enables farmers to make well-informed choices and promptly implement actions, such as modifying irrigation schedules, managing greenhouse conditions, or implementing pest management strategies.

Furthermore, the system not only enables real-time monitoring but also facilitates data logging and analysis, thereby offering significant insights into long-term trends and patterns. This analytical capacity enables farmers to maximise resource utilisation, enhance agricultural productivity, and save operational expenses. The incorporation of these elements is intentionally planned to be scalable, enabling effortless growth and adaptation according to the distinct requirements of various agricultural activities.

During the development phase, the focus is on user-centric design concepts to guarantee that the system is intuitive and accessible to farmers, irrespective of their technical proficiency. This encompasses furnishing unambiguous guidelines for installation and functioning, alongside supplying assistance and teaching to aid consumers in optimising the advantages of the technology.

In summary, this methodology not only focuses on the technical aspects of developing a solar-powered smart farm system, but also emphasises the significance of providing a practical and efficient solution that empowers farmers, improves agricultural output, and supports environmental sustainability.

3.2 Flowchart and Explainantion

A flowchart is an essential visual aid that simplifies the depiction of processes, systems, or algorithms. It employs standardised symbols to represent different activities, decisions, and the sequence of control, so improving clarity and comprehension. Flowcharts simplify the understanding of intricate procedures by dissecting them into visual elements, facilitating the comprehension of each individual stage, the identification of interdependencies, and the resolution of potential problems. They facilitate efficient communication and documentation, ensuring that both the project team and stakeholders can readily comprehend the process. The fundamental components of a flowchart comprise of initiation/conclusion points, procedures, choices, inputs/outputs, flow lines, and connectors

3.2.1 Flowchart of Project

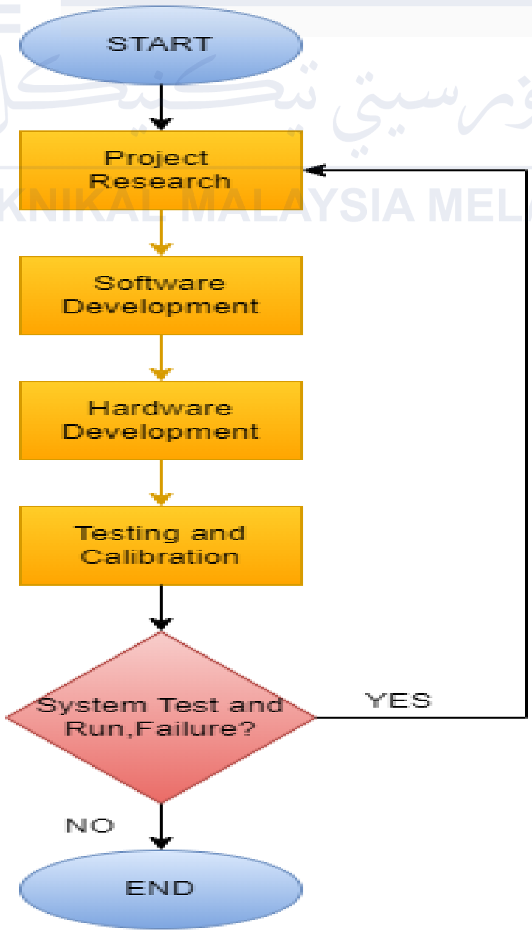

Figure 3.1 Flowchart of Project

Based on figure 3.1, flowchart presents a systematic methodology for a software development project, with a focus on an iterative procedure. The process commences with "Project Research," during which preliminary inquiries and strategic preparations take place. Following this step is "Software Development," during which the coding and construction of the software occur. Next, the focus is on "Hardware Development," which involves the creation or integration of the required physical components. In the subsequent phase, known as "Testing and Calibration," there is a thorough examination and adjustment of both software and hardware to guarantee their proper functioning and compliance with the project specifications. At the "System Test and Run Failure?" decision step, the system is assessed for any potential failures. If any errors are found ("YES"), the process will return to the starting point, enabling more refinement and debugging. If there are no failures detected ("NO"), the process terminates at the "END" stage. This flowchart demonstrates a systematic and recurring process for project management, which guarantees ongoing enhancement and tackles possible problems through repeated cycles.

3.2.2 Flowchart of System

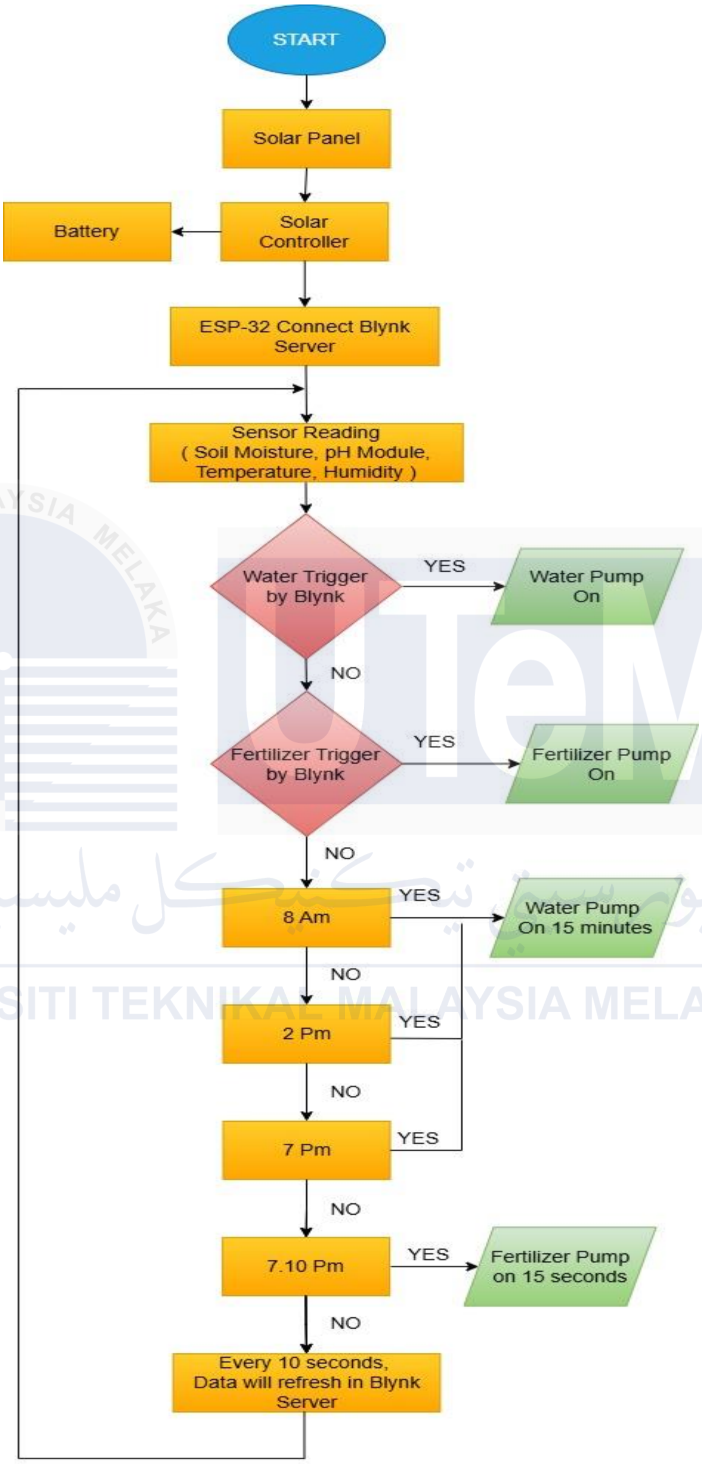

Figure 3.2 Flowchart of System

This flowchart delineates the procedure for Development of Solar-Powered Smart Farm with Blynk Application, highlighting the incorporation of solar energy, sensors, and automation for effective and sustainable agricultural management. The system initiates with solar panels capturing solar energy, which is stored in a battery and managed by a solar controller to maintain a stable power supply to all components. The ESP-32 microcontroller interfaces with the Blynk server, facilitating real-time monitoring and remote control via a mobile application. The system incorporates sensors that quantify essential environmental characteristics, such as soil moisture, pH levels, temperature, and humidity. The aggregated data is relayed to the Blynk server, which evaluates the information to ascertain the necessity of particular operations, such as irrigation or fertilisation.

The system independently initiates steps to sustain ideal agricultural conditions based on the obtained data. When the soil necessitates hydration, the water pump is engaged; conversely, the fertiliser pump is actuated when fertilisation is required. The system adheres to a predetermined schedule for consistent operations, activating the water pump at 8:00 a.m, 2:00 pm and 8:00 p.m. for 15 minutes, while the fertiliser pump operates at 8:10 P.M. for 15 seconds. The system refreshes sensor data every 10 seconds, updating the Blynk server for real-time monitoring and decision-making. This automation optimises water and fertiliser use, diminishes human labour, increases output, and fosters sustainability, rendering it an ideal solution for smart agricultural applications.

3.2.2 Flowchart of Blynk

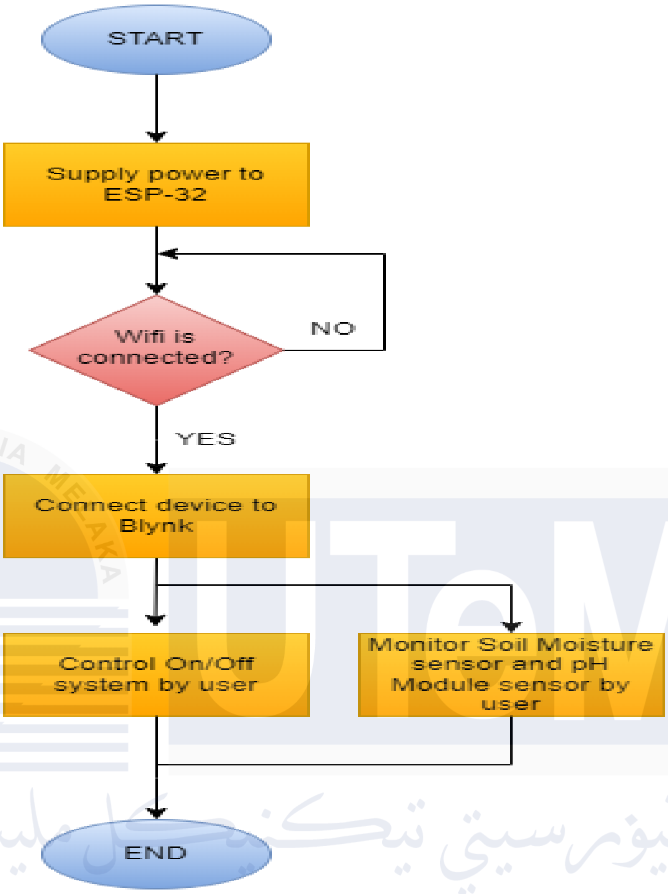

Figure 3.3 Flowchart of Blynk

Following figure 3.3, flowchart illustrates the sequential procedures for operating a soil monitoring system utilising an ESP-32 microcontroller and the Blynk platform. The process commences by providing electricity to the ESP-32. At the subsequent stage, there is a pivotal moment where the system verifies the connectivity of the WiFi. In the event that the WiFi is not connected, the system continuously reverts back to the process of verifying and searching for a connection. After establishing a WiFi connection, the ESP-32 gadget establishes a connection with the Blynk platform. Blynk is an Internet of Things (IoT) platform that enables customers to remotely control and monitor their devices.

Once the user establishes a connection with Blynk, they gain the ability to manipulate the system's On/Off capability and observe the readings from the soil moisture sensor and pH module sensor. The process concludes following these steps. This flowchart offers a concise and visually appealing depiction of the procedures required to establish and operate On/Off system, monitoring soil moisture and pH module system. It highlights the significance of WiFi connectivity in enabling remote monitoring and control.

3.3 Block Diagram

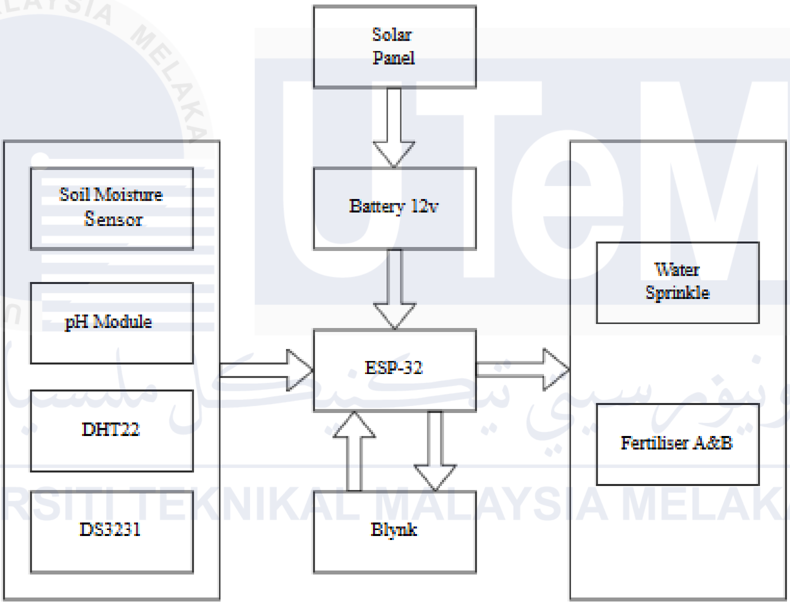

Figure 3.4 Block Diagram

Block diagram based on figure 3.4 represents a Development of Solar-Powered Smart Farm System With Blynk Application. powered by a solar panel that charges a 12V battery, allowing for long-term and independent operation, particularly in isolated places. The ESP-32 microcontroller analyses data from a variety of sensors, including a soil moisture sensor, a pH module, and a DHT22 sensor (which measures temperature and humidity). It also has an RTC (Real-Time Clock) module for precisely timing irrigation and fertiliser applications. The technology links to the Blynk IoT platform, allowing farmers to make remote modifications via real-time monitoring and control via a smartphone app.

The ESP-32 employs sensor data to autonomously control a water sprinkler system, ensuring ideal soil moisture and accurate release of fertilisers A and B for effective nutrient delivery. This automation optimises resource use by saving water and fertilisers while increasing crop output. The technology, which combines renewable energy, smart monitoring, and precise control, encourages sustainable agriculture, decreases labour needs, and promotes environmental responsibility, making it a perfect alternative for contemporary precision farming.

3.4 Schematic Diagram

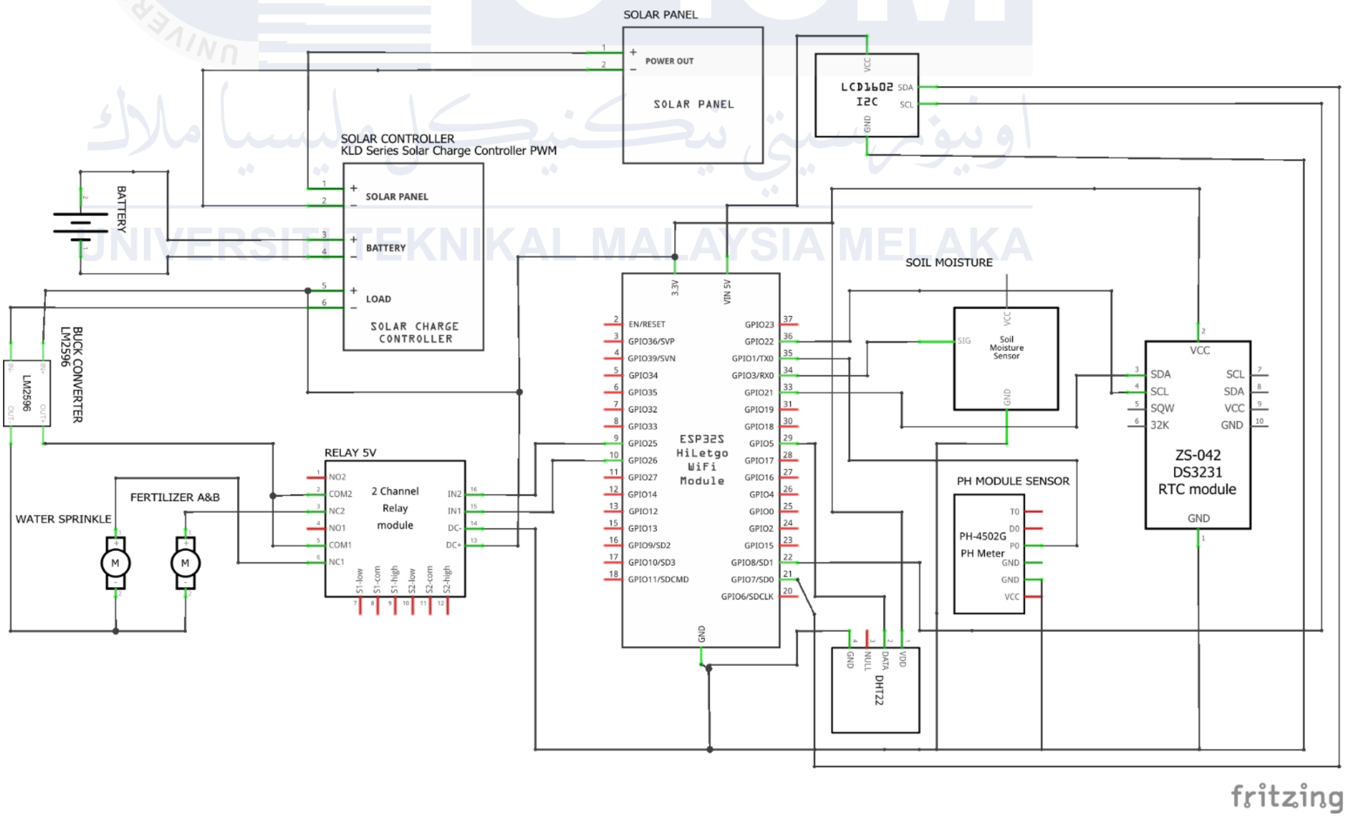

Figure 3.5 Schematic Diagram

Figure 3.5 represents a Development of Solar-Powered Smart Farm System With Blynk Application’s schematic diagram. A solar charge controller controls the energy produced by the system's solar panel, which powers the circuit and charges a battery. Fundamentally, the ESP32 microcontroller processes data from several sensors to coordinate all activities. A pH sensor determines how acidic or alkaline the soil is, while a soil moisture sensor tracks the amount of water in the soil. The precise scheduling of irrigation according to time and date is guaranteed by an RTC (Real-Time Clock) module. To run output devices like a fertilizer dispenser for soil feeding and a water fountain for irrigation, the microcontroller manages a relay module. An LCD panel shows the sensor readings and the condition of the system. By using renewable energy sources and automating the supply of fertilizer and water depending on current soil conditions, this design guarantees effective and sustainable irrigation.

3.5 Hardware

Hardware development of the solar-powered smart farm system entails the establishment of a solar power infrastructure, which encompasses the installation of photovoltaic (PV) panels, charge controllers, batteries, and inverters, in order to guarantee a dependable energy source. A network of sensors, including those for soil moisture, pH, temperature and humidity is implemented to oversee and regulate agricultural conditions. A microcontroller, such as an Arduino performs tasks such as processing sensor data, controlling actuators, and communicating with the Blynk programme for remote management. Every element is contained within enclosures that are resistant to weather, guaranteeing long-lastingness. The primary objective of this development phase is to design and implement a highly reliable, adaptable, and effective system that enhances agricultural methods by utilising the Internet of Things (IoT) and renewable energy sources.

3.5.1 Tank

Tank is crucial for holding and supplying a steady supply of water and fertilizer for irrigation. The tank is made of sturdy materials such as metal, fibreglass, or polyethylene, and its size is customised to meet the demands of the farm taking climate, area, and crop type into account. The tank is integrated with an automated irrigation system and optimises irrigation schedules based on information about soil moisture. In general, the water and fertilizer tank is essential to maintaining productive and environmentally responsible farm operations.

Figure 3.6 Tank

3.5.2 Submersible Pump

A DC 12V pump is a small and efficient device that operates on a 12V direct current. It is well-suited for a range of uses, including automobile cooling systems, solar water systems, aquariums, and small-scale irrigation. These pumps generally have a flow rate ranging from 2 to 20 litres per minute, a maximum head of 1 to 5 metres, and power consumption ranging from 5 to 30 watts. These products are constructed using resilient materials such as ABS plastic and stainless steel. They are specifically engineered to function silently and endure various temperature conditions. These pumps are adaptable and may be used in both submersible and non-submersible types. They are suitable for setups that are powered by batteries or solar energy. These pumps provide reliable solutions for transferring and circulating water.

Figure 3.7 Submersible Pump

3.5.3 Water & Fertilizer Sprinkler

In a solar-powered smart farm system, water sprinklers are crucial because they allow for accurate and effective irrigation based on data on soil moisture in real time. These hardy, programmable sprinklers provide even water distribution, cutting down on waste and avoiding incorrect watering. They are economical and energy-efficient since they are run by a solar pump system. Farmers can optimise water usage and promote sustainable farming practices for healthier crops and increased output by integrating the sprinklers with the Blynk application, which enables remote monitoring and control of the sprinklers.

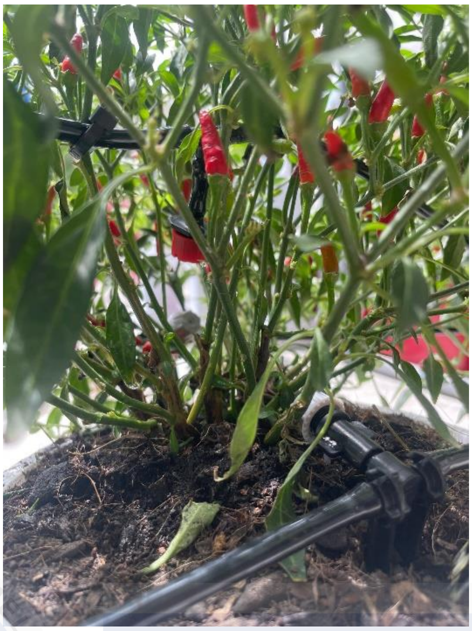

Figure 3.8 Water & Fertilizer Sprinkler

3.5.4 Fertilizer A & B

Fertilizers A and B are essential elements of the solar-powered smart farm system, specifically designed to promote the robust growth and maximum productivity of chilli plants. Fertiliser A contains a well-proportioned mixture of nitrogen (N), phosphorus (P), and potassium (K), while Fertiliser B supplements this with additional macronutrients like calcium (Ca), magnesium (Mg), and sulphur (S), as well as essential micronutrients such as iron (Fe), manganese (Mn), zinc (Zn), copper (Cu), boron (B), and molybdenum (Mo).

Both fertilizers are soluble in water and have their pH adjusted to ensure they are compatible with the ideal pH range for chilli plants, which is normally between 6.0 and 6.5. This helps the plants efficiently absorb nutrients. The determination of application rates is dependent on criteria such as growth stage, soil conditions, and environmental factors. The primary focus is to achieve a balanced nutrient supply in order to minimise deficiencies or excesses. These fertilisers are available in many sizes, ranging from small sachets to large containers, providing options for application that can meet the requirements of both individual gardeners and commercial agribusiness. Fertilisers A and B are crucial for encouraging robust growth, flowering, and fruiting of chilli plants. They provide the necessary nutrients in balanced proportions, leading to increased farm productivity and sustainability in the smart farm system

Figure 3.9 Fertilizer A & B

3.5.5 Solar Panel

The 12V solar panel is the fundamental component of the solar-powered smart farm system, providing sustainable energy by converting sunlight into electrical power. This power is then used to operate essential farm components. Usually, these solar panels have power outputs that vary from 10 watts to 300 watts, designed to match the precise energy requirements of the system. Their voltage rating of 12 volts is well-suited for charging 12V batteries that are widely used in off-grid systems. These panels mostly consist of monocrystalline or polycrystalline silicon-based photovoltaic cells that are well-known for being highly efficient and long-lasting.

They achieve optimal energy conversion and space utilisation with efficiency rates ranging from 15% to 20%. Typical measurements can vary, but frequently include sizes such as 1 metre by 0.5 metres for smaller panels and 1.6 metres by 1 metre for bigger ones. Constructed with durable materials such as tempered glass and aluminium frames, these panels are designed to withstand challenging weather conditions, guaranteeing long-lasting performance. With warranties ranging from 10 to 25 years, these products provide assurance and confidence in their long-term performance and reliability. The 12V solar panel, with its given specs, serves as a reliable and environmentally friendly energy option, effectively and sustainably powering the smart farm system.

Figure 3.10 Solar Panel

3.5.6 Solar Controller

Solar controller is an essential part in the solar-powered smart farm system that uses 12V solar panels. Its main function is to regulate the flow of solar energy, ensuring efficient charging and optimal performance of associated batteries and electrical components. The device is specifically engineered to manage input voltages that usually fall within the range of 16V to 24V from the solar panels. It converts these voltages into a steady 12V output voltage that is compatible with the batteries and loads of the system.

The controller efficiently regulates the charging process by maintaining a maximum charging current between 5A and 30A. This prevents the batteries from being overcharged, ensuring their health and longevity. In addition, it is compatible with a range of battery types such as lead-acid, gel, AGM, and lithium-ion batteries. It provides the option to choose charging patterns that are specifically designed to optimise battery management. With a high efficiency, typically exceeding 95%, the conversion of solar energy to electrical energy is maximised, resulting in minimal energy losses. The controller incorporates temperature compensation to alter charging parameters according to the ambient temperature, thus providing optimal charging efficiency in various environmental situations.

Additionally, it incorporates integrated safety measures such as overcharge, over-discharge, reverse polarity, short circuit, and overheat protection, hence improving the system's safety and dependability. Certain controllers are equipped with LCD screens or LED indicators that allow for immediate monitoring of the charging status and system operation. These controllers provide user-friendly interfaces for configuring and adjusting settings. The solar controller functions as the central control unit, overseeing the distribution of solar energy, charging of batteries, regulation of loads, and protection of the system. Its main purpose is to ensure the smart farm system operates reliably and efficiently, while optimising energy usage and extending the lifespan of the batteries.

Figure 3.11 Solar Controller

3.5.7 12V Lead Acid Rechargeable Battery

A key element of the solar-powered smart farm system is the 12V lead-acid rechargeable battery, which acts as the main energy storage option for continued operation at night or during periods of low sunlight. These lead-acid batteries, which come in a range of capacities from 7Ah to 200Ah, provide dependable and affordable energy storage. They provide durability and long-term reliability with a low self-discharge rate and a cycle life of hundreds to thousands of charge-discharge cycles. Easy compatibility and installation are ensured by standardised terminal types and dimensions. These batteries function effectively in a wide temperature range and have safety measures, making them suitable for a variety of climatic settings. Their dependable power backup makes them vital for off-grid agricultural applications, even though they may require periodic maintenance. This adds to the sustainability and efficiency of the smart farm system.

Figure 3.12 12V Lead Acid Rechargeable Battery

3.5.8 Soil Moisture Sensor

Soil moisture sensor is necessary for accurate irrigation control and enhanced crop productivity. This system utilises a capacitive soil moisture sensor that functions within a voltage range of 3.3V to 5V and has a current consumption of less than 20mA. The device offers a voltage output that spans from 0V to 3V, representing soil moisture levels from 0% to 100%. It has an accuracy of ±3% and responds in less than one second. The sensor's sturdy construction, with dimensions of 60mm x 20mm x 5mm, and its capacity to function within a temperature range of -10°C to 60°C, guarantee dependable operation in diverse agricultural settings.

Capacitive sensors, in contrast to resistive sensors, gauge the dielectric constant of the soil, thereby preventing corrosion and improving longevity. These sensors are strategically positioned at various depths and places to constantly monitor soil moisture levels. They then transmit analogue signals to the microcontroller. The purpose of processing this data is to enable the automation of the irrigation system, allowing for remote monitoring and control using the Blynk application. This integration enables farmers to effectively manage soil moisture levels, so avoiding excessive or insufficient watering, conserving water resources, and eventually fostering improved crop development and enhanced production.

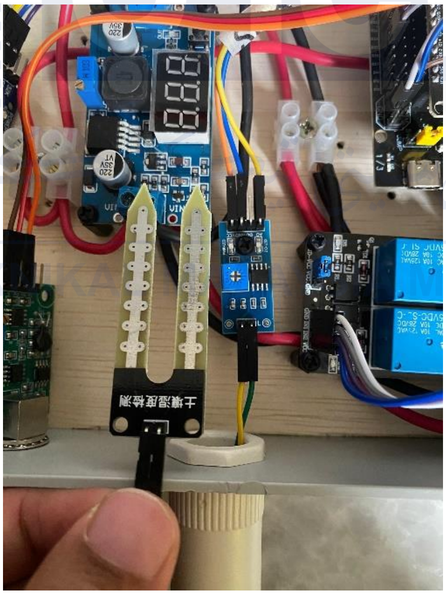

Figure 3.13 Soil Moisture Sensor

3.5.9 pH Module

The pH module is provides accurate monitoring and management of soil pH levels, which are critical for ensuring optimal crop growth. It is common for pH levels to be measured within a range of 0 to 14 with a high level of precision, usually within ±0.1 pH unit or even better. This ensures precise data that can be used to make well-informed decisions regarding agricultural management.

Guaranteed seamless integration with microcontrollers or data recording systems is ensured due to rapid response times in seconds and compatibility with both analogue and digital interfaces. Designed with a focus on long-lasting quality, incorporating probes that are resistant to corrosion and enclosed in weather-proof casings, this product guarantees dependable operation in a wide range of climatic situations. Due to its modest maintenance needs and low power consumption, typically ranging from 3.3V to 5V DC, it is compatible with battery-powered devices.

Figure 3.14 pH Module

3.5.10 DHT22

DHT22 sensor is an essential element of the solar-powered smart farm system, used for precise measurement of temperature and humidity levels. It functions within a broad voltage range of 3.3V to 6V, ensuring compatibility with the microcontroller used in the system. The sensor offers great precision, with a temperature accuracy of ±0.5°C and a humidity accuracy of ±2%, so assuring dependable environmental monitoring. The DHT22 transmits data digitally to the microcontroller, obviating the need for supplementary analog-to-digital conversion. Its durable construction accommodates an operating temperature range of -40°C to 80°C and humidity ranges from 0% to 100%, making it appropriate for diverse agricultural settings.

To keep an eye on environmental factors that impact crop health, the DHT22 is strategically placed across the smart farm system. Real-time monitoring and notifications when temperature or humidity levels depart from optimal ranges are made possible by the integration of the sensor's data with the Blynk application. This feature enables farmers to make well-informed choices about things like modifying irrigation schedules and installing greenhouse climate control systems. The DHT22 helps to maximise agricultural operations, preserve resources, and boost crop output by offering accurate and trustworthy data.

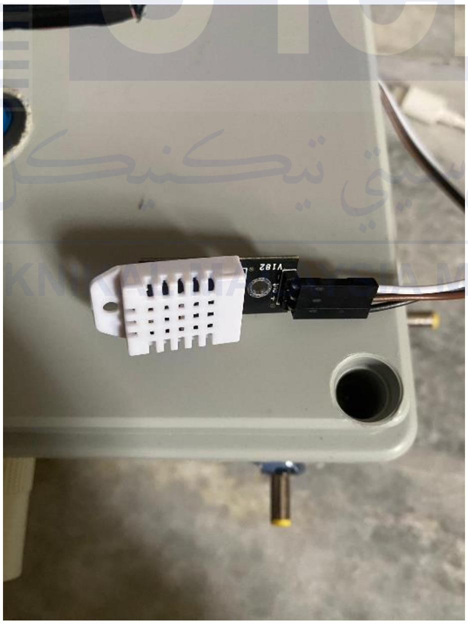

Figure 3.15 DHT 22

3.5.11 DS3231

DS3231 is a high-precision real-time clock (RTC) module essential for the solar-powered smart farm system, providing precise timekeeping for automated functions. It incorporates a crystal oscillator and a temperature sensor to provide remarkable time precision, exhibiting a drift of about ±2ppm, which corresponds to around ±1 minute annually. The DS3231 operates within a supply voltage range of 3.3V to 5.5V and interfaces with the microcontroller using the I2C protocol, facilitating seamless integration into the system. The module has an integrated battery backup, usually a CR2032 coin cell, enabling it to maintain timekeeping during power outages, hence assuring continuous operation of time-sensitive activities.

In this smart farm system, the DS3231 is utilised to plan and automate functions including irrigation, lighting, and data collection. For example, it ensures that irrigation systems turn on at specified times to conserve water and improve crop health. The module's exact timestamps also improve the dependability of data captured by sensors such as soil moisture and temperature, allowing farmers to analyse trends and make educated decisions. With its excellent precision, low power consumption, and smooth integration, the DS3231 considerably improves the system's efficiency and dependability.

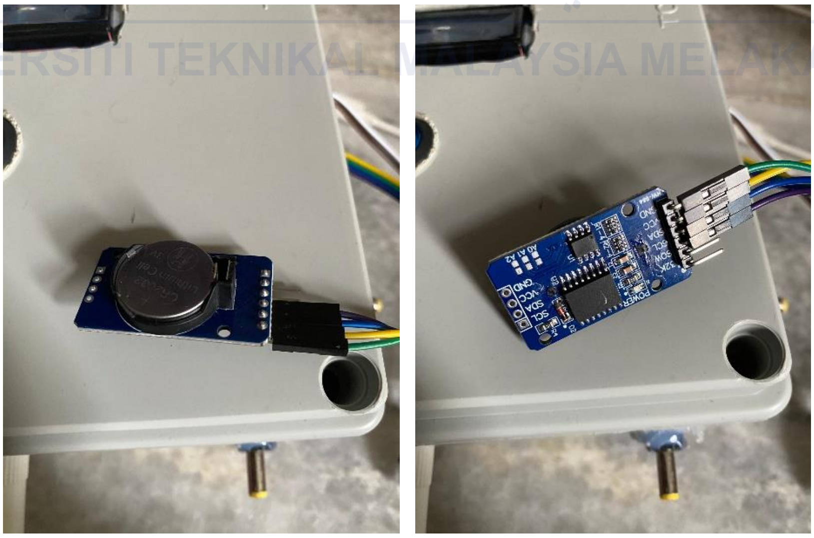

Figure 3.16 DS3231 Sensor

3.6 Software

Optimal operation and seamless integration of the solar-powered smart farm system with Blynk application are guaranteed by the software development process. Gathering requirements is the first step, and then system architecture design and implementation are the next. To guarantee security, efficiency, and dependability, thorough testing is done. With its focus on scalability and adaptability, the technique allows for future improvements. All things considered, it provides a stable and easy-to-use agricultural Internet of things solution that optimises farm management by integrating renewable energy sources and using cutting-edge software development methodologies.

3.6.1 Blynk Application

With its user-friendly interface for remote monitoring and control, the Blynk programme is a crucial component of the solar-powered smart farm system. It offers customisable alarms, real-time data visualisation, and remote control of sensors and actuators on iOS and Android smartphones. Secure data storage and device accessibility are guaranteed by the application's cloud connectivity. Utilising its energy-efficient design and smooth interaction with IoT technology, Blynk gives farmers the ability to efficiently optimise agricultural operations, save resources, and increase crop yields.

Figure 3.17 Blynk Application

Table 3.1 Coding Development of Solar-Powered Smart Farm System With Blynk Application

FULL_CODING_PSM_MZF.ino

```
// FULL CODING PSM ZUHAIRI
// 19/12/2025
#define BLYNK_PRINT Serial
#define BLYNK_TEMPLATE_ID "TMPL6k2L4xWsi"
#define BLYNK_TEMPLATE_NAME "PROJECT MZF"
#define BLYNK_AUTH_TOKEN "FVZAoqWVC3gCCnfJPaia6UZwny9HkujY"

#include <WiFi.h>
#include <BlynkSimpleEsp32.h>
#include <DHT.h>
#include <Wire.h>
#include <RTClib.h>
#include <LiquidCrystal_I2C.h>

LiquidCrystal_I2C lcd(0x27, 16, 2);

#define PH_SENSOR_PIN 35
#define SOIL_MOISTURE_PIN 32
#define DHT_PIN 5
#define WATER_PUMP_PIN 26
#define BAJA_PUMP_PIN 25

RTC_DS3231 rtc;
#define DHT_TYPE DHT22
DHT dht(DHT_PIN, DHT_TYPE);

char auth[] = BLYNK_AUTH_TOKEN;
char ssid[] = "Zuhairi";
char pass[] = "Zuhairi00";

#define VPH_PIN V1
#define VTEMP_PIN V2
#define VMOISTURE_PIN V3

float voltage = 0.0;
float pHValue = 0.0;

unsigned long previousSendDATA = 0;
unsigned long sendInterval = 10000;

const int timeSet[][2] = {
  {17, 28},  // Time for Water Pump 1
  {17, 31},  // Time for Water Pump 2
  {17, 35},  // Time for Water Pump 3
  {17, 39}   // Time for Baja Pump
};

int Aiir = 0, Bajja = 0;
int soilMoisture;
float temperature, humidity;


void setup() {
  Serial.begin(115200);
  lcd.init();
  lcd.backlight();
  lcd.clear();
```

FULL_CODING_PSM_MZF.ino

```
  lcd.backlight();
  lcd.clear();

  dht.begin();
  pinMode(PH_SENSOR_PIN, INPUT);
  pinMode(SOIL_MOISTURE_PIN, INPUT);
  pinMode(WATER_PUMP_PIN, OUTPUT);
  pinMode(BAJA_PUMP_PIN, OUTPUT);

  digitalWrite(WATER_PUMP_PIN, LOW);
  digitalWrite(BAJA_PUMP_PIN, LOW);


  lcd.backlight();
  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print(" Solar--Powered  ");
  lcd.setCursor(0, 1);
  lcd.print("  Smart System  ");
  delay(2000);

  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print(" WIFI CONNECTING ");
  lcd.setCursor(0, 1);
  lcd.print("  TO SERVER      ");

  Blynk.begin(auth, ssid, pass);
  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print(" WIFI CONNECTED");
  delay(1000);

  for(int i = 0; i<16; i++){
    lcd.setCursor(i,1);
    lcd.print(">");
    delay(200);
  }

  delay(100);

  if (!rtc.begin()) {
    Serial.println("RTC not found!");
    while (1);
  }

  lcd.clear();
  Serial.println("Setup complete!");
}

BLYNK_WRITE(V4) {
  Aiir = param.asInt();
}

BLYNK_WRITE(V5) {
  Bajja = param.asInt();
}
```

FULL_CODING_PSM_MZF.ino

```
  for (int i = 0; i < 3; i++) {
    if (hour == timeSet[i][0] && minute == timeSet[i][1] && second < 7) {
      isPumpTime = true;
    }
  }

  if (hour == timeSet[3][0] && minute == timeSet[3][1] && second < 7) {
    isBajaPumpTime = true;
  }

  if (isPumpTime && soilMoisture > 50) {
    Serial.println("Water pump ON!");
    digitalWrite(WATER_PUMP_PIN, HIGH);
    delay(60000*2);
    digitalWrite(WATER_PUMP_PIN, LOW);
    Serial.println("Water pump OFF!");
  }

  if (isBajaPumpTime) {
    Serial.println("Baja pump ON!");
    digitalWrite(BAJA_PUMP_PIN, HIGH);
    delay(10000);
    digitalWrite(BAJA_PUMP_PIN, LOW);
    Serial.println("Baja pump OFF!");
  }
}

void manualPumpControl() {
  if (Aiir == 1) {
    digitalWrite(WATER_PUMP_PIN, HIGH);
  } else {
    digitalWrite(WATER_PUMP_PIN, LOW);
  }

  if (Bajja == 1) {
    digitalWrite(BAJA_PUMP_PIN, HIGH);
  } else {
    digitalWrite(BAJA_PUMP_PIN, LOW);
  }
}

void sendDataToBlynk() {
  Serial.println("Sending data to Blynk...");
  int soilMoisture = map(analogRead(SOIL_MOISTURE_PIN), 0, 4095, 0, 100);
  Blynk.virtualWrite(VPH_PIN, pHValue);
  Blynk.virtualWrite(VTEMP_PIN, temperature);
  Blynk.virtualWrite(VMOISTURE_PIN, soilMoisture);
  Blynk.virtualWrite(V8, humidity);
}

void displayDataOnLCD() {
  int soilMoisture = map(analogRead(SOIL_MOISTURE_PIN), 0, 4095, 0, 100);
  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("T:");
  lcd.print(temperature, 1);
```

FULL_CODING_PSM_MZF.ino

```
}

void loop() {
  Blynk.run();
  unsigned long currentMillis = millis();

  DateTime now = rtc.now();
  int second = now.second(), minute = now.minute(), hour = now.hour(),day = now.day(), month = now.month(), year = now.year();

  readSensors();
  handleTimedPumpOperation(hour, minute, second);
  manualPumpControl();
  displayDataOnLCD();

  if (currentMillis - previousSendDATA >= sendInterval) {
    previousSendDATA = currentMillis;
    sendDataToBlynk();
  }
}

void readSensors() {
  int pHRead = analogRead(PH_SENSOR_PIN);
  voltage = pHRead * (3.3 / 4095.0);
  pHValue = 7 + ((voltage - 2.5) / 0.18);

  temperature = dht.readTemperature();
  humidity = dht.readHumidity();

  if (isnan(temperature)) temperature = 0.0;
  if (isnan(humidity)) humidity = 0.0;
  int soilMoisture = map(analogRead(SOIL_MOISTURE_PIN), 0, 4095, 0, 100);

  // Display sensor data on Serial Monitor
  DateTime now = rtc.now(); // Get current time
  Serial.println("Sensor Readings:");
  Serial.print("Current Time: ");
  Serial.print(now.hour());
  Serial.print(":");
  Serial.print(now.minute());
  Serial.print(":");
  Serial.println(now.second());

  Serial.print("pH Value: ");
  Serial.println(pHValue);
  Serial.print("Temperature: ");
  Serial.print(temperature);
  Serial.println(" °C");
  Serial.print("Humidity: ");
  Serial.print(humidity);
  Serial.println(" %");
}

void handleTimedPumpOperation(int hour, int minute, int second) {
  int soilMoisture = map(analogRead(SOIL_MOISTURE_PIN), 0, 4095, 0, 100);
  bool isPumpTime = false, isBajaPumpTime = false;

  for (int i = 0; i < 3; i++) {
```

```
  lcd.print("T:");
  lcd.print(temperature, 1);
  lcd.setCursor(8, 0);
  lcd.print("H:");
  lcd.print(humidity, 1);

  lcd.setCursor(0, 1);
  lcd.print("S:");
  lcd.print(soilMoisture);
  lcd.setCursor(8, 1);
  lcd.print("ph:");
  lcd.print(pHValue, 1);
  delay(500);

  // Display data on Serial Monitor
  DateTime now = rtc.now(); // Get current time
  Serial.println("--------------------------");

  Serial.print(now.year());
  Serial.print('/');
  Serial.print(now.month());
  Serial.print('/');
  Serial.println(now.day());
  Serial.print("Current Time: ");
  Serial.print(now.hour());
  Serial.print(":");
  Serial.print(now.minute());
  Serial.print(":");
  Serial.println(now.second());

  Serial.print("Soil Moisture: ");
  Serial.print(soilMoisture);
  Serial.println("%");
}
```


3.7 Summary

The methodology for a solar-powered smart farm system using the Blynk application merging sustainable energy with IoT technology to improve agricultural administration. The process commences by constructing a resilient solar power system, which involves meticulously choosing and strategically placing solar panels, batteries, and inverters to guarantee a consistent and dependable energy provision. Subsequently, sensors and actuators are strategically placed across the farm to oversee and regulate crucial agricultural parameters, such as soil moisture, pH module and DHT22. The data collected by these sensors is transmitted to a central hub that is linked to the Blynk application. This enables the visualisation of real-time data, remote monitoring, and the implementation of automated reactions using a mobile interface. The system additionally facilitates data logging and analysis to obtain long-term insights, with the objective of optimising resource utilisation and enhancing production. The methodology prioritises user-friendly design, offering explicit instructions for installation and operation to ensure that farmers, regardless of their technical proficiency, may easily access the technology. The hardware components include of solar panels, microcontrollers, sensors, water tanks, pumps, and sprinklers, which are specifically engineered to be long-lasting and highly efficient. Software development prioritises the smooth integration and ability to handle increased workload, guaranteeing a strong Internet of Things (IoT) solution for contemporary agriculture.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Introduction

This section assesses the efficiency and influence of a solar-powered smart farm system using the Blynk application The objective of the system is to improve agricultural output and maximise the efficient utilisation of resources by utilising renewable energy sources and continuously monitoring data in real-time. The findings encompass the energy efficiency, reliability, and practical implementation aspects of the system, including cost and scalability. The discussion focuses on important discoveries, such as energy usage, system speed, difficulties in implementation, and possible enhancements, offering valuable information on the practicality and advantages of this groundbreaking agricultural technology.

4.2 Project Design

Figure from 4.1 until 4.6 show the design, part of component project and sensors are used in Development of Solar-Powered Smart Farm System With Blynk Application.

Figure 4.1 Design of Project

Figure 4.2 Part of Component Project

Figure 4.3 Chilli Plant for Project

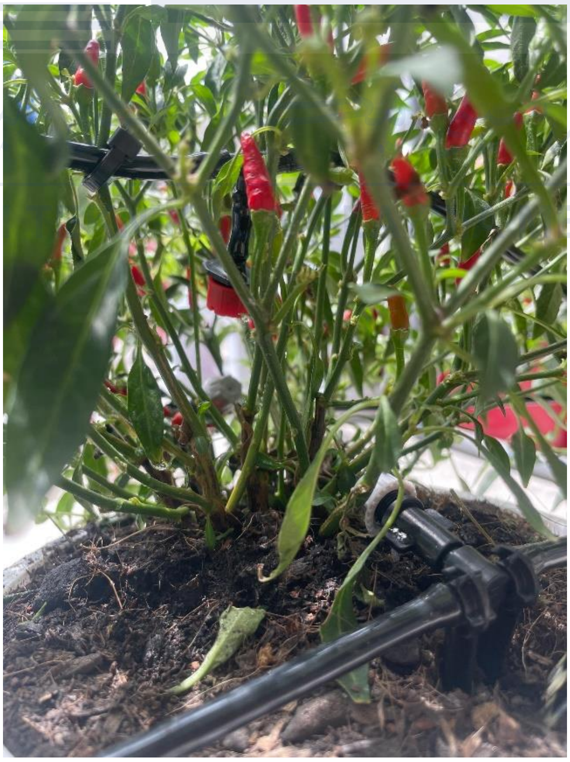

Figure 4.4 Water & Fertilizer Sprinkle

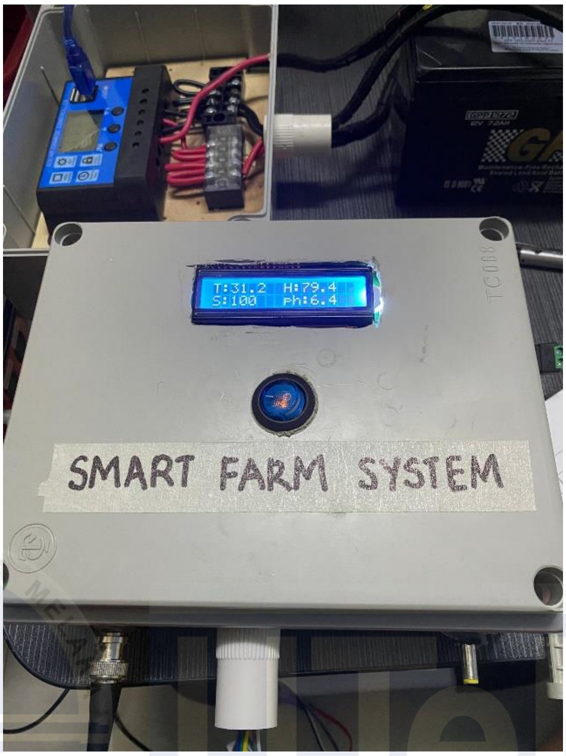

Figure 4.5 Control Box of System

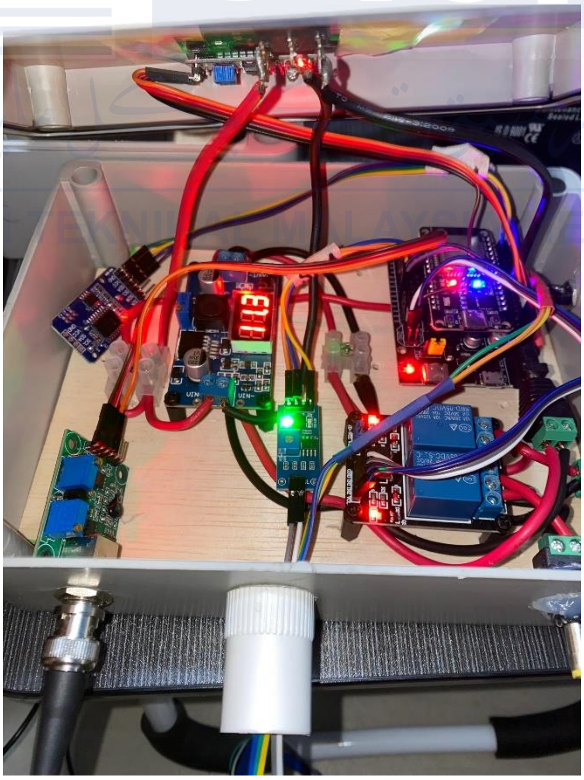

Figure 4.6 Connection of System

Development of Solar-Powered Smart Farm System With Blynk Application has been created to automate the maintenance of optimal soil conditions for plant growth. The process begins with a solar panel that captures sunlight and converts it into electrical energy. The energy is then regulated by a solar controller to provide a consistent and secure transmission of electricity to a battery, where it is stored for future use. The stored energy is used to power an ESP-32 microcontroller, which serves as the main processing unit of the system.

The ESP-32 gathers data from various sensors, including the soil moisture sensor, pH module, and DHT22, to ensure optimal farm management. The soil moisture sensor monitors the soil's moisture content, and when levels fall below 50%, the system checks the current time to trigger irrigation. The pH module measures the water and fertiliser's pH level, providing critical information on its acidity or alkalinity to maintain plant health. The DHT22 sensor monitors temperature and humidity with high precision, offering ±0.5°C for temperature and ±2% for humidity accuracy. This data helps manage environmental conditions, ensuring the farm remains within optimal ranges for plant growth. Combined, these sensors provide real-time, actionable insights that enhance resource efficiency and crop productivity.At the specific times of 8am, 2pm, and 8pm for water and 8.10 for fertiliser, the ESP-32 initiates the activation of the water pump as well as the fertiliser pumps A and B. This ensures that the soil is irrigated and fertilised at specific intervals, maintaining optimal conditions for plant growth. The device continuously monitors the soil conditions and adjusts the irrigation and fertilisation methods accordingly.

4.3 Result and Analysis

Preliminary data is needed to investigate and ascertain whether the Development of a Solar Powered Smart Farm System With the concept of the Blynk Application method in this framework can perform as expected. In order to identify the level of power consumption of solar energy to supply the battery to the system, the raw input data is recorded and evaluated to determine the nature of the criteria.

4.3.1 Solar System

The solar system analysis is carried out in the actual environment based on the data collected. The outdoor testing will take place in Taman Belatuk Mas, Melaka, on 8/12/2024 – 17/12/2024. A hour was spent analysing the decision from 7.00 a.m. to 8.00 p.m. The goal is to analysis power output from solar panel to makesure battery can support this project. The results are shown in Table 4.1 from 7.00 a.m to 8.00 p.m.

Table 4.1: Result for Solar System

SOLAR PANEL				
PLACE : TAMAN BELATUK MAS, MELAKA				
DATE : 8/12/2024 - 17/12/2024(10 DAYS)				
MEASUREMENT DATA (AVERAGE)				
TIME	IRRADIANCE (W/M^2)	VOLTAGE (V)	CURRENT (A)	POWER (W)
7.OO A.M	109	16.52	0.43	7.85
8.00 A.M	117	15.65	0.40	7.14
9.00 A.M	193	15.75	0.37	6.62
10.00 A.M	230	16.17	0.39	7.04
11.00 A.M	391	18.10	0.50	10.07
12.00 P.M	517	18.48	0.53	10.99
1.00 P.M	530	17.66	0.46	9.35
2.00 P.M	213	16.13	0.41	7.53
3.00 P.M	177	15.54	0.42	7.27
4.00 P.M	111	15.69	0.42	7.32
5.00 P.M	95	15.34	0.41	7.00
6.00 P.M	70	14.89	0.36	5.97
7.00 P.M	55	14.61	0.39	6.23
8.00 P.M	50	14.35	0.39	6.14

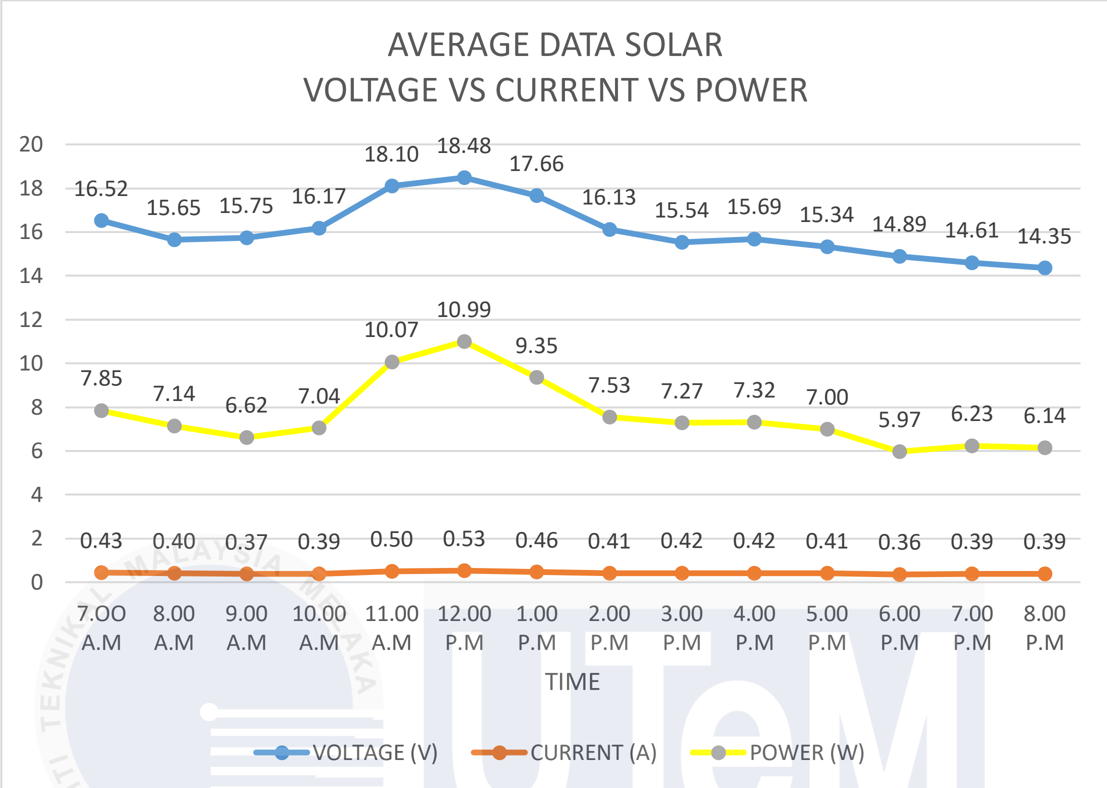

Figure 4.7 : Graph of Solar System Data

The performance study of the solar-powered smart farm system, shown in the graph, demonstrates clear patterns in the correlation among voltage (V), current (A), and power (W) throughout the course of the day. The voltage stays consistently constant, reaching a maximum of 18.48 V at 11:00 A.M., signifying ideal sunshine conditions. This aligns with the rise in current and power throughout the same timeframe, with the current attaining a high of 10.99 A and power peaking at 10.07 W. The data indicate that the system operates efficiently under elevated solar irradiance, successfully converting solar energy into electrical energy during noon when sunlight intensity peaks.

Nonetheless, a reduction in current and power is seen after 2:00 P.M., but the voltage remains at moderate levels. This decline may be ascribed to less solar irradiance when the sun's angle decreases throughout the afternoon. At 7:00 P.M., both current and power decrease markedly to 0.39 A and 6.14 W, respectively, due to inadequate sun energy for optimum system functionality. The findings demonstrate that while the solar system produces enough energy during peak sunshine hours, its production significantly declines in the early morning and late afternoon, requiring energy storage or other power sources for uninterrupted farm operations. This trend highlights the need of optimising solar panel placement and using energy storage systems to enhance efficiency in smart agriculture applications.

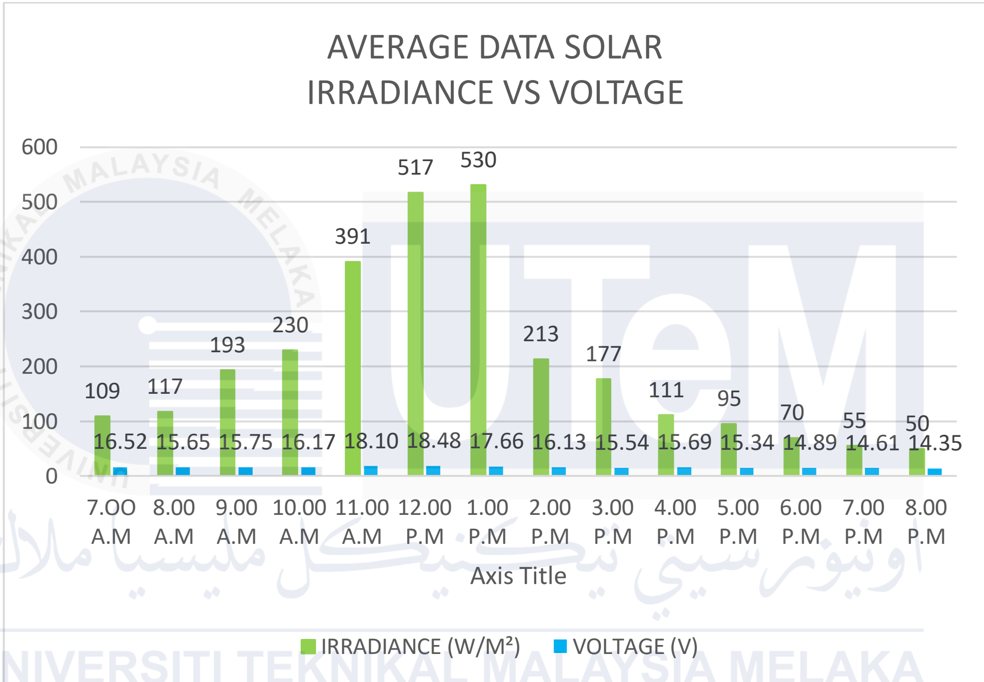

Table 4.8 : Graph of Solar System Data

The examination of the solar-powered smart farm system, linked with the Blynk application, demonstrates a correlation between irradiance (W/m²) and voltage (V), emphasising the system's efficacy under diverse sun circumstances. Between 7:00 A.M. and 8:00 A.M., irradiance begins at a modest 109 W/m², accompanied by a voltage of 16.52 V. As the day advances and solar irradiance escalates, voltage exhibits a modest rising trajectory, culminating at 18.48 V at 12:00 P.M. when irradiance attains its high of 530 W/m². This signifies that voltage output is affected by sunlight intensity, however it stays somewhat constant in contrast to the more pronounced variations in irradiance. In the afternoon, irradiance consistently diminishes, reaching 213 W/m² at 2:00 P.M. and further decreasing to 50 W/m² by 7:00 P.M., while the voltage progressively drops to 14.35 V by dusk.

The data indicates that the system effectively transforms solar irradiance into electrical energy, with voltage output stabilising as a result of the design of the solar panels and system components. Nevertheless, the voltage is not precisely proportional to irradiance, suggesting possible system constraints or losses in energy conversion. This analysis highlights the essential significance of peak sunlight hours (10:00 A.M. to 2:00 P.M.) for optimal energy production and the necessity for an effective energy storage solution to guarantee the continuous operation of the smart farm, particularly during low irradiance periods in the early morning and late evening.

4.3.2 Soil Moisture

To optimise crop development in the smart farm, soil moisture was measured from 8/12/2024 to 14/12/2024. Daily testing revealed the soil's water retention under different situations, assessing the solar-powered irrigation system's performance. This study was crucial for crop moisture, water efficiency, and sustainable farming in the project. The results are shown in Table 4.2.

Table 4.2: Result for Soil Moisture

SOIL MOISTURE DATA				
PLACE : TAMAN BELATUK MAS, MELAKA				
DATE : 8/12/2024 - 14/12/2024 (7 DAYS)				
MEASUREMENT DATA				
TIME	TIME	TEMPERATURE (°C)	SOIL MOISTURE (%)	CONDITION
8/12/2024	8.00 A.M (raining)	20	35	WET
	2.00 P.M	38	100	DRY
	8.00 P.M	30	95	DRY
9/12/2024	8.00 A.M	27	100	DRY
	2.00 P.M	35	90	DRY
	8.00 P.M	29	93	DRY
10/12/2024	8.00 A.M	25	80	DRY
	2.00 P.M	35	100	DRY
	8.00 P.M	29	95	DRY
11/12/2024	8.00 A.M	25	45	WET
	2.00 P.M	34	100	DRY
	8.00 P.M	30	96	DRY
12/12/2024	8.00 A.M (raining)	20	30	WET
	2.00 P.M (raining)	23	25	WET
	8.00 P.M	26	46	WET
13/12/2024	8.00 A.M	26	80	DRY
	2.00 P.M	35	100	DRY
	8.00 P.M	26	68	DRY
14/12/2024	8.00 A.M	28	98	DRY
	2.00 P.M	35	100	DRY
	8.00 P.M	27	96	DRY

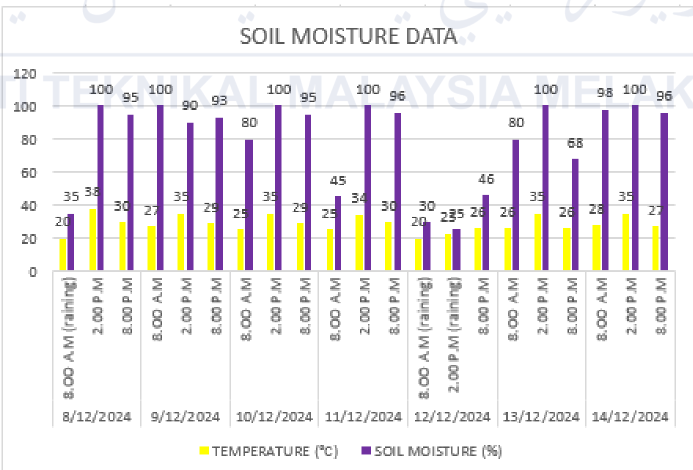

Figure 4.9 : Graph for Soil Moisture Data

Analysis of soil moisture and temperature data collected from 8/12/2024 to 14/12/2024 at Taman Belatuk Mas, Melaka, highlights the complex relationship between climatic conditions and soil moisture levels in the smart farm. On 8/12/2024 at 8:00 a.m. and 12/12/2024 at 2:00 p.m, soil moisture levels reached 35% and 25%, respectively, in wet conditions, with temperatures between 20°C and 26°C. This resulted in a "wet" soil condition, ensuring sufficient water availability for crops without the need for further irrigation. During the dry interval, which was around 2:00 p.m., temperatures reached a maximum of 38°C (on 8/12/2024) and 36°C (on 14/12/2024) leading to a "dry" soil condition. This pattern indicates a large evaporation rate with increasing temperature, resulting in less soil moisture available.

Research shows an inverse relationship between temperature and soil moisture, with higher temperatures accelerating moisture loss. These fluctuations highlight the importance of solar-powered irrigation systems, which, when combined with the Blynk app, allow for real-time monitoring and automatic adjustments to maintain ideal soil conditions. The system's ability to quickly adapt to weather fluctuations ensures stable soil moisture levels, fostering robust crop development while reducing water waste. This investigation confirms the effectiveness of smart farm design and underscores its potential to improve agricultural sustainability.

4.3.2 Water Pump

Water Pump analysis is out in the actual environment based on the data collected. The outdoor testing from 8/12/2024 – 14/12/2024. This data was collected only once a day. The goal is to analysis power output from water pump to makesure the smart farm system runs consistently and can support this project. The results are shown in Table 4.3

Table 4.3: Result for Water Pump

WATER PUMP & FERTILIZER PUMP		
PLACE : TAMAN BELATUK MAS, MELAKA		
DATE : 8/12/2024 - 14/12/2024 (7 DAYS)		
MEASUREMENT DATA		
DATE	**VOLTAGE (V)**	**CURRENT (A)**
8/12/2024	12.10	0.35
9/12/2024	12.20	0.36
10/12/2024	12.00	0.37
11/12/2024	11.90	0.34
12/12/2024	12.10	0.35
13/12/2024	12.00	0.36
14/12/2024	11.80	0.34
AVERAGE	**12.01**	**0.35**

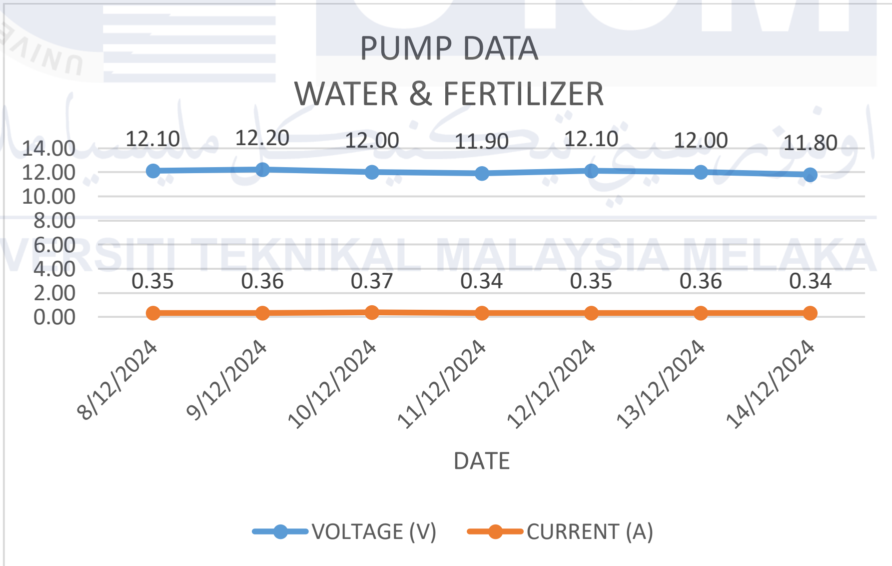

Figure 4.10 : Graph of Water & Fertilizer Pump Data

Comparison of the data from the water and fertilizer pumps between 8/12/2024 and 14/12/2024, shows steady performance in terms of voltage and current. Throughout the testing time, the voltage was comparatively constant, ranging between 11.80 V and 12.20 V, suggesting a dependable power source for the pump system. Likewise, there was little variation in the current utilization, which stayed between 0.34 A and 0.37 A. This electrical parameter stability demonstrates how effective and dependable the solar-powered system is at supplying steady energy to run the water and fertilizer pump, which is necessary to maintain ideal irrigation and fertilization procedures.

The findings imply that the solar-powered smart farm system is adequately engineered to manage the pump's energy requirements in a variety of scenarios. A constant supply of water and fertilizer for the crops is ensured by the low fluctuation in current and voltage, which shows effective energy use and reliable pump operation. These results confirm how well the solar-powered pump system supports the irrigation and fertilization requirements of the smart farm while preserving energy efficiency, which is essential for the project's overall sustainability and dependability.

4.4.3 pH Value

pH Value analysis is out in the actual environment based on the data collected. The outdoor testing from 14/12/2024 to 21/12/2024. Day by day was spent to testing to get result. The goal is to analysis quality of water to makesure tank catchment water in perfect quality for this project. The results are shown in Table 4.4 .

Table 4.4: Result for pH Value

pH Value		
PLACE : TAMAN BELATUK MAS, MELAKA		
DATE : 14/12/2024 – 21/12/2024		
MEASUREMENT DATA		
DAY	**pH VALUE**	
	WATER TANK (6.0)	**FERTILIZER TANK (6.0-7.0)**
1	6.10	6.70
2	6.10	6.70
3	6.00	6.60
4	6.00	6.50
5	5.90	6.50
6	5.80	6.50
7	5.80	6.30
AVERAGE	**5.96**	**6.54**

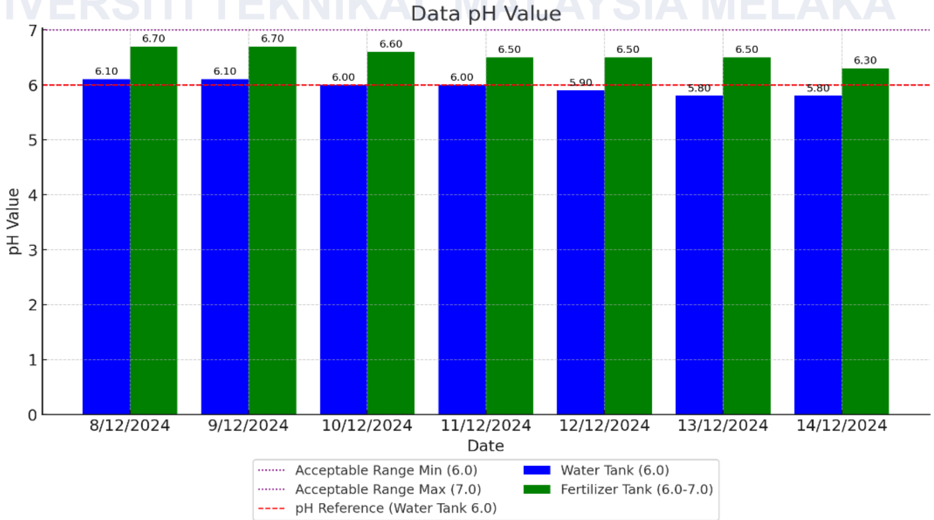

Figure 4.11 Graph of pH Value Data

Consistent water quality in the fertiliser and water tanks is shown by the study of pH value data from 8/12/2024 to 14/12/2024. This ensures ideal circumstances for the solar-powered smart farm. While the fertiliser tank had pH values ranging from 6.1 to 6.7, the water tank's pH readings were constantly in the region of 6.0. The water and fertiliser combination is appropriate for crop development and soil health maintenance since both values are within the approved range for chili plant (6.0 to 7.0).

Significant findings include minor fluctuations in the pH of the fertiliser tank, which peaked at 6.7 on 9/12/2024 and fell to 6.1 on 14/12/2024. The system's ability to control and maintain pH balance is shown by these little variations that stay within allowable bounds. The results demonstrate how well the solar-powered smart farm system monitors and regulates water quality, making sure that pH levels promote the growth of healthy plants and are in line with the project's sustainability objectives. The water and fertiliser management system's dependability for steady agricultural yield is confirmed by this investigation.

4.4.5 Storage Battery

The storage battery's performance is evaluated through discharge and recharge cycles under real-world working circumstances. The data was acquired during outdoor testing from 25/11/2024 – 30/11/2024. The battery's discharge and recharge time were measured at regular intervals throughout the day to assess its effectiveness in managing the system's energy storage. The results are shown in Table 4.5 & 4.6

Table 4.5 : Result for Discharge Time

DISCHARGE BATTERY							
PLACE : TAMAN BELATUK MAS, MELAKA							
DATE : 25/11/2024 & 29/11/2024							
MEASUREMENT DATA							
DATE	START			END			
	TIME	VOLTAGE (V)	PERCENTAGE BATTERY (%)	TIME	VOLTAGE(V)	PERCENTAGE BATTERY (%)	TIME TAKEN
25/11/2024	7.OO P.M	12.5 V	100%	10.43 A.M	9.6 V	BELOW 10%	15 H 43 MIN
29/11/2024	1.00 A.M	12.4 V	100%	3.20 P.M	11.5 V	10%	14 H 20 MIN

Determining the battery's handling capacity to power smart farm tools critically depends on its discharge characteristics. In the analysis of this section, a 5W LED bulb is used as the test material powered by a 12V, 7.2Ah rechargeable sealed lead-acid battery. The following formula is used to determine the current drawn by the bulb:

$$I = \frac{P}{V}$$

where P is the power (5W) and V is the voltage (12V). This results in $I = \frac{5}{12} \approx 0.42\ A$. To avert harm and prolong the battery's longevity, it is depleted to just 10% of its capacity, preserving 90% as useable capacity, computed as $90\%\ x\ 7.2\ AH = 6.48\ AH$. The discharge time is then determined using the formula:

$$\text{Discharge Time} = \frac{\text{Usable Capacity (AH)}}{Load\ Current\ (A)} = \frac{6.48}{0.42} \approx 15.43\ \text{hours.}$$

This indicates that before needing to be recharged, the ideal battery can run the LED bulb for around 15 hours and 43 minutes.

Table 4.6 : Result for Recharge Time

RECHARGE BATTERY								
PLACE : TAMAN BELATUK MAS, MELAKA								
DATE : 27/11/2024 & 30/11/2024								
MEASUREMENT DATA								
DATE	START			END				
	TIME	VOLTAGE (V)	PERCENTAGE BATTERY (%)	TIME	VOLTAGE(V)	PERCENTAGE BATTERY (%)	TIME TAKEN	
27/11/2024	11.OO A.M	9.6 V	BELOW 10%	12.41 P.M	12.5 V	100%	1 H 41 MIN	
30/11/2024	5.00 P.M	11.5 V	10%	7.30 P.M	12.7 V	100%	2 H 30 MIN	

The recharging features guarantee that the battery is effectively refilled with energy produced by the solar panel. A charge controller regulates the panel's maximum charging current of 6A to match the battery voltage. With a charging efficiency of 85%, the effective capacity to recharge is:

$$\text{Effective Capacity} = \frac{\text{Battery Capacity (AH)}}{\text{Efficiency}} = \frac{7.2}{0.85} \approx 8.47\text{Ah}.$$

The recharge time is then :

$$\text{Recharge Time} = \frac{\text{Effective Capacity (AH)}}{\text{Charging Current (A)}} = \frac{8.47}{6} \approx 1.41\text{hours}.$$

This means it takes approximately 1 hour and 41 minutes to fully recharge the battery under ideal sunlight conditions.

4.4.6 Power Generation and Storage Capacity

The results and analysis of power generation and storage capacity evaluated the efficiency of the solar panels and the storage battery under diverse environmental circumstances. Daily energy production, battery charging and discharging cycles, and overall system efficiency were observed during systematic outdoor testing. This assessment evaluated the system's capacity to fullfil energy requirements, maintain power under low-light conditions, and guarantee continuous operation, yielding critical insights into the dependability and optimisation of the solar-powered smart farm system.

1. Solar panel
   - Number of panel : 1
   - Power rating per panel : 100 W
   - Peak sun hours (psh) : 5 Hours
   - Total power generation from solar panel :

     Power = Power rating per panel × Number of panels

     = 100 W × 1= 100 W

- Total energy generated per day:

  Energy = Power × Peak sun Hours

  = 100 W × 5 Hours = 0.5 kWh

2. Battery

   - Number of batteries : 1
   - Voltage : 12 V
   - Amp-hour rating per battery: 7.2 AH
   - Total energy storage capacity of batteries:

     Energy = Voltage × Amp-hour rating per battery × Number of Batteries

     = 12 V × 7.2 AH × 1 = 0.0864 kWh

So, the solar panels generate approximately 0.5 kWh of energy per day, while the battery system has a storage capacity of 0.0864 kWh.

Based on the analysis, the power generation and storage battery capacity is well-suited for this Development Solar-Powered Smart System with Blynk Apps's requirements. With ideal sunlight, the solar panel produces about 0.5 kWh of energy per day, which is far more than the system's daily energy demand of 0.039 kWh. A total of 0.027 kWh is consumed by the system's two 12 V/4.5 W water pumps, which run for less than three hours every day, and an ESP-32 microcontroller, which uses around 0.012 kWh while running constantly for twenty-four hours. Both the energy production of the solar panel and the storage capacity of the battery can readily meet the combined energy need of 0.039 kWh.

The 0.0864 kWh rechargeable sealed lead-acid battery offers more than twice the daily energy usage, guaranteeing adequate backup power in low-light or nighttime settings. Furthermore, the solar panel's daily energy production supports continuous system operation and enables rapid battery recharge. Because of its excess energy production and sufficient storage, the system is very dependable and effective for managing the smart farm, satisfying all operational requirements while preserving energy sustainability.

4.4.7 Energy Consumption Data

The evaluation of the system's energy consumption and efficiency during operation is the main goal of the findings and analysis for energy consumption data. Over the course of a week, data was gathered on the energy produced by the solar panels, the energy stored in the battery, and the energy used by different parts such as sensors, pumps, and the ESP-32 microcontroller. To find trends, times of peak use, and general energy efficiency, daily measurements were taken. This study aims to maximize the usage of renewable energy sources while preserving a balance between energy output and consumption in order to guarantee the system runs sustainably. The results offer guidance on maximizing energy use and locating possible areas for system performance enhancement.

1. Water Pump
   - Number of pump : 2
   - Power rating per pump : 4.5 W
   - Operation hour per day = 3 Hours (Minimum)
   - Energy per pump :

     Power x Time = 4.5 W × 3 Hours = 13.5 W

     Energy for 2 pump :

     13.5 W × 2 = 27 W

The energy consumption of the pumps constitutes a substantial fraction of the system's daily energy demands. The solar panel, generating around 0.5 kWh daily, and the battery with an 0.0864 kWh storage capacity, are both adequately equipped to meet this need. The pumps operate efficiently, successfully performing their irrigation functions while preserving sustainability within the system's total energy budget.

4.4.8 Blynk Application

Display uses an LCD screen and the Blynk application to monitor and operate the Solar-Powered Smart Farm system in real-time. It makes it simple for users to monitor environmental conditions by displaying vital information like temperature, humidity, soil moisture, and pH levels. The results are shown in Figure 4.12 and 4.13

Figure 4.12 : Display System on LCD

Figure 4.13 : Display System on Blynk

Figure 4.12 illustrates a "Smart Farm System" developed for the monitoring and management of agricultural conditions via real-time data collecting and visualisation. The initial picture has an LCD panel displaying essential environmental and soil metrics, such as temperature, humidity , soil moisture, and water pH level. This enables users to track essential parameters straight from the device.

Figure 4.13 illustrates the system's connection with the Blynk application on a smartphone, where the data presented on the app corresponds with the values on the LCD. The application provides control functionalities, including the activation of water and fertiliser pumps, which is particularly advantageous in emergencies, such as when water levels are inadequate to maintain proper soil moisture. The technology guarantees that sensor data is concurrently processed and shown on both the LCD and the application, facilitating a smooth and user-friendly experience. This configuration is especially advantageous for precision agriculture, facilitating effective resource management and enhancing yield.

4.4 Summary

This chapter presents the results and discussions of a solar-powered smart farm system using the Blynk application. The solar panel, solar controller, battery, ESP-32 microcontroller, pH sensor, soil moisture sensor, water pump, fertiliser pumps and a few other component are all part of the system design. The ESP-32 is powered by the solar panel, which transforms sunlight into electrical energy that is stored in a battery. When soil moisture falls below 50%, the ESP-32 gathers data from the pH and soil moisture sensors and triggers the water and fertiliser pumps at predetermined intervals. Tables for gathering information on the solar system, soil moisture, water pump, pH and storage battery are included in this chapter. Temperature, voltage, current, power, irradiance, pH values, power generation and energy consumption are all measured and recorded in these tables at various testing intervals and durations.

Data gathered from measurements of solar system, soil moisture, water pump, pH and storage battery is presented in the results and analysis section. Data on the solar system, including irradiance, voltage, current, and power output from the solar panel at different times of the day, was gathered in Taman Belatuk Mas, Melaka, on 12/12/2024 to 17/12/2024, from 7 a.m to 7 p.m. Next, soil moisture data was collected from 8/12/2024-14/12/2024 at different time based on this project setup which is on 8 a.m, 2 p.m and 8 p.m. On the same, data for water and fertiliser pump also collected to analysis. This included voltage and current measurements across ten testing intervals. Moreover, data on the pH value was gathered at the same day too and it displayed the average pH value as well as daily pH value observations.

CHAPTER 5

CONCLUSION, RECOMMENDATIONS & PROJECT POTENTIAL

5.1 Conclusion

Using the Blynk application to construct the Solar-Powered Smart Farm System has shown to be a creative and effective way to tackle contemporary agricultural issues. This system effectively combines cutting-edge Internet of Things (IoT) technology with sustainable solar energy to produce an intelligent, automated agricultural solution that improves sustainability and production. By using sensors to track vital indicators like soil moisture, pH, temperature, and humidity, agricultural operations may now be precisely controlled, improving crop growth conditions and resource efficiency.

The system is an economical and environmentally friendly option since it uses solar energy as its main power source, which also lessens reliance on non-renewable energy sources and lowers operating expenses. The study demonstrates how IoT-based apps may offer remote administration and real-time monitoring, greatly minimising the need for human intervention and empowering farmers to make well-informed decisions from any location.

Additionally, the system's use on chilli plants shows how well it works to increase agricultural productivity for commodities with high demand, guaranteeing steady growing conditions and higher yields. The findings support the system's ability to make a substantial contribution to sustainable agriculture by tackling problems like environmental impact and food security. This smart farming system is a prime example of how technology can transform conventional farming methods to make them more sustainable, scalable, and effective for coming generations.

5.2 Recommendations

1. **System Expansion**
    - Incorporate light intensity sensors to track the amount of sunshine received and offer guidance on the best locations for plants or whether more artificial lighting is required.
    - Install pest detection devices, including motion or infrared sensors, to spot and stop pest activity and perhaps lower crop loss.
    - Incorporate water quality sensors to track variables like dissolved oxygen and salinity, which might improve fertigation and irrigation procedures even further.
2. **Durability and Cost-Optimization**
    - To extend the longevity and dependability of sensors and controllers in outdoor settings, use weather-resistant enclosures.
    - Investigate using lithium-ion batteries and other alternative energy storage technologies, which may have longer lifespans and require less maintenance than conventional lead-acid batteries.
3. **Integration with External Systems**
    - Make it compatible with other agricultural equipment, such autonomous tractors for planting and harvesting or drones for crop monitoring.
    - Give farmers a single platform to manage their activities by providing APIs or connection options for integrating with other agriculture management software.

5.3 Project Potential

1. **Economic Benefits**

   By automating labour-intensive operations, this system reduces the need for manual monitoring and management, resulting in significant cost savings. Accurate fertilisation and irrigation reduce waste, lowering input costs and guaranteeing effective use of resources. Optimised growing conditions lead to higher crop yields and better-quality products, which increases farmers' profitability. Even though the initial investment can appear high, small-scale farmers can compete with bigger enterprises thanks to long-term labour, energy, and operational cost reductions that enable economic sustainability.

2. **Food Security**

   By improving agricultural output through regular monitoring and automation and guaranteeing ideal growing conditions for large yields, the system directly addresses food security. It provides resilience in food production by reducing the risks associated with unpredictable weather and climate change, and its versatility in growing different crops guarantees a consistent supply of a wide range of food goods. By increasing farming efficiency, expanding access to food, and lowering post-harvest losses through accurate monitoring and lower spoiling risks, it benefits underserved areas and eventually helps create a more secure food supply chain.

3. **Market Potential**

   The system's adaptable architecture provides a broad market reach by serving smallholders, commercial farms, and urban agricultural settings. Its versatility for urban farming projects, such as vertical agriculture and rooftop gardens, satisfies the rising need for environmentally friendly urban food production. The technique is attractive for implementation in both emerging and established economies because to its relevance to global agricultural concerns. Large-scale operations may be scaled because to its modularity, and partnerships and institutional support are increased by its connection with government and non-governmental organisation initiatives in sustainable farming and food security.

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APPENDICES

Appendix A Project Planning BDP 1

PROJECT PLANNING BDP 1														
	2024													
Project Activity	01	02	03	04	05	06	07	08	09	10	11	12	13	14
FYP														
Proposal Project														
• Meet Supervisor														
• Decide Title of Project														
• Write an Abstract	B													
• Research journal	D													
Chapter 1	P													
• Begin Chapter 1														
• Project background	B													
• Discussio n with supervisor	R													
	I													
Chapter 2	E													
• Begin Chapter 2	F													
• Hydroponic method study	I													
• Journal study	N													
• Discussion with supervisor	G													
Chapter 3														
• Software research														
• Hardware decision														
• Supervisor approval														
Chapter 4														
• Project design														
• Circuit design														
• Analysis of component														
Presentation Slide														

Appendix B Project Planning BDP 2

PROJECT PLANNING BDP 2														
	2024													
Project Activity	01	02	03	04	05	06	07	08	09	10	11	12	13	14
FYP														
Meet SV discuss about planning PSM 2.														
Explain to SV things to buy to proceed build project.														
Do the claim form for PSM expenses.														
Proceed to do the coding for this project.														
Proceed to do the circuit of the project and implement the code into circuit.														
Develop the hydroponic system of the project.														
Present result of the project to SV and do some improvement														
Collect data for analysis.														
Proceed to complete PSM 2 reports.														
Prepare for presentation with do poster for PSM 2														