Development Of Smart Greenhouse Farming Based On Internet Of Things

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Abstract**.**

This project aim is to develop smart greenhouse farming based on IoT system for monitoring the quality for the plant which use sensor and Node-RED as a website for monitoring. The monitoring system using microcontroller such as humidity sensor,soil moisture to control the condition of soil moisture level. The phenomenon of greenhouse plants is particularly significant since it has the potential to help improve the economy and cut manufacturing costs. Given the agricultural industry's lack of human resources, one of the cultivation techniques that have to be improved is hydroponic plants, also known as greenhouse plants. Hydroponic plant technology can be used in conjunction with hydroponic plants. Tropical greenhouses have various advantages in plant cultivation as well as practical manufacturing potential.This technology can be utilized to apply according to plant demands to maximize yield in agriculture. The project employed is a tool for monitoring soil moisture that is based on a prototype using an online platform for monitoring humidity and plant quality, and it can assist farmers in decreasing the budget for production.

Keywords*: Soil Moisture, Node-RED, Smart Greenhouse, IoT, and Monitoring System.*

I. INTRODUCTION

The development of Industry 4.0 represents a disruptive combination of cyber technology and automation inside numerous sectors. Often dubbed the "cyber-physical system," Industry 4.0 revolves around the primary premise of automation. By integrating information technology into operational frameworks, dependency on human labor in industrial processes is considerably decreased. Consequently, this integration leads to considerable increases in both effectiveness and efficiency within work situations. Such a paradigm shift in the industrial environment bears enormous ramifications for work quality and production costs, heralding a new era marked by creative manufacturing and production processes. [1] Indonesia, renowned as an agricultural powerhouse, caters to both domestic and international markets with its array of agricultural products. Within this sector, greenhouse technology plays a pivotal role, catering to the specific environmental needs conducive to plant growth, such as temperature, sunlight exposure, soil moisture, and air humidity. As technology continues to advance, particularly in the realm of information and communication technology (ICT), innovations such as the Internet of Things (IoT) are gaining prominence. A study highlighted by F. Siddiqui in "Secure and lightweight communication in heterogeneous IoT environments" underscores the significance of IoT in modernizing agricultural practices.

The research, outlined in the title "Design and implementation of a low-cost IoT-based agroclimatic monitoring system for greenhouses," aims to tackle pivotal factors influencing crop production by introducing an IoT-based environment monitoring system customized for greenhouses. The primary objectives revolve around detecting soil moisture, humidity levels, and temperature variations within the greenhouse setting. Leveraging IoT technology, the proposed system offers a cost-effective, efficient, and user-friendly solution for monitoring agroclimatic variables. Through continuous surveillance, the system delivers real-time data on environmental conditions, empowering farmers to proactively address undesired climatic shifts and ensure optimal growing conditions for their crops. The integration of a website interface for monitoring facilitates seamless access to crucial data, enabling informed decision-making in greenhouse management. Ultimately, this innovative solution holds immense potential to significantly boost agricultural productivity by minimizing losses attributed to adverse environmental conditions while maximizing crop yields. [2] The main contribution of this project is focused on developing smartgreen house farming based on IoT using integrated sensors that can monitoring in the online platform and this project can help farmer to reduce the cost and the system can help for plant growth for the better product and reliable to increase the economy with the product quality.

A. Problem Statement

According to a 2017 BPS survey, rural regions had a higher poverty rate than urban areas. Rural poverty is represented by 13.47% of the population, and urban poverty is represented by 10.27% of the population. This demonstrates that rural areas endure poverty at a higher rate than urban ones. Most of the agriculture production, although, remain known to take place in rural regions. Poverty experienced by farmers is a challenge in realizing one of the SGDs (Sustainable Development Goals) goals, namely zero hunger [3].The strategic role of the agricultural sector contributes in various ways, one of which is as the main source of rural household income and a foreign exchange earner. With this technology, it can assist farmers in reducing the budget for production costs from human labor it can be faster and more efficiently because, in rural areas, it is very difficult for human resources to become farmers. Therefore, more efficient technology is needed to cut agricultural costs because agricultural costs are currently expensive. The development of smart greenhouse it will able that it can help farmers control greenhouses, of course monitor growth and quality of plants regularly with the help of technology such as the Internet of Things, the agriculture field will attract the younger generation to become successful modern farmers. To realize this, a prototype of smart green house farming based on IoT will be able to monitor for the green house area.

B. Objective of The Project

The aim of this research is:

1.To create and design the prototype of smartgreenhouse farming based on IoT.

2.To develop a prototype of smartgreen house for monitoring and controlling of smart farming based on IoT.

C. Scope of the Project

The scope of this project is to develop a prototype of smart greenhouse farming based on IoT for crop the budget and increase the quality of the product. The system consisting of LDR sensor, Soil moisture sensor, Temperature and Humidity sensor and CO2 dioxide Sensor, those all sensor is for monitoring the plant, the LDR sensor functions to detect the intensity of incoming light, because this is also included in the factors supporting plant growth, excessive light intensity can cause the greenhouse room temperature to increase and allow the plants to wilt, and the humidity temperature functions to monitor the existing air humidity and read the value temperature, Soil moisture for detecting under normal, dry or wet conditions. The temperature and humidity sensor using DHT 22 is for monitoring in the greenhouse area to maintain the stability of the temperature in greenhouse area, CO2 dioxide sensor is for better productivity and higher quality plant growth also for security system of this project using fingerprint sensor, for controlling and monitoring system if the temperature in high condition the exhaust fan will be turn on and if the soil moisture in dry condition also the water pump will be turn on, the data will be shown on the LCD and will be shown and send the data through website in Node-RED.

D. Significant of The Prorject

The significance of the project is to help farmers for monitor the soil moisture for the plant, to assist farmers in reducing the budget for production costs.to Conform Sustainable Development Goals (SDGs) number 2 to resolve zero hunger and number 9 which is Industry, Innovation, and Infrastructure. Soil moisture sensors can be used to help farmers monitor soil moisture levels remotely, enabling them to optimize irrigation practices, reduce water waste, and promote healthier crop growth. Precision agriculture techniques can optimize resource usage, while crop diversification and rotation can reduce pests, diseases, and dependence on chemical inputs. Efficient machinery and equipment can lead to cost savings, and cooperative farming and collective purchasing can leverage collective bargaining power. Achieving Sustainable Development Goals (SDGs) number 2 (Zero Hunger) and number 9 (Industry, Innovation, and Infrastructure) can be facilitated through promoting sustainable agriculture practices, improving agricultural infrastructure, providing access to information and technology, and strengthening agricultural value chains. By focusing on these strategies, farmers can address both SDGs while supporting their soil moisture monitoring and budget reduction efforts.

E. Assumption and Limitations

The assumption (rational) is something that is considered true by researchers as the basis of the project so far, with this prototype it is hoped that it will make it easier for farmers in the greenhouse instead of using men power. Use a prototype smartgreenhouse to check soil moisture for monitoring plant and help tradionally farmers turn to modern era to digitize the area.The focus of this project is limited to the energy of this prototype using Adaptor 5v and this prototype only focuses on greenhouse area. By concentrating on these features, the prototype is able to adjust to satisfy the specific requirements of greenhouse monitoring while resulting in against the restricted energy supply provided by a 5V adaptor.

II. LITERATURE REVIEW

A. Review of Current Situation

Greenhouse plant phenomenon is particularly important since it may assist improve the economy and lower manufacturing costs, particulary in Indonesia a country with large agriculture sector. The concern must be discussed in order to meet daily needs because higher population density leads to higher food demand and naturally, higher food ingredient costs. Given the lack of human resources in the agricultural industry, hydroponic plants, sometimes referred to as greenhouse, are one of the cultivation techniques that need to be improved. Hydroponic technology for plants can be utilized in conjunction with hydroponic plants. Greenhouses for tropical regions offer several advantages in plant cultivation as well as practical manufacturing potential. To maximize agricultural production, this technology can be used to apply according to the demands of plants. The project utilized is a used for monitoring the soil moisture that is based on prototype using website platform for monitoring the humidity and the quality of the plant, it can assist farmers in reducing the budget for production.

B. Review of Related Review

The project's goals are to create a prototype of a greenhouse system that can use an IoT system to measure temperature, humidity, and soil moisture in order to grow the best plants, which will have a positive effect on the economy growth in the agriculture sector. This is based on research by Mohammad Zulhakimi (2021) called "Performances Analysis of IoT Based Smart Greenhouse System." Farmers can use IoT for tracking with Mit App Inventor and NodeMCU for the wifi module to make things work well and quickly. It is the best way to help cut down on water use. tracking on a website is better than tracking on a mobile app.Scope that is too broad Khan Mahammad Noor and Mohammad Zulhakimi, 2021).According to Muhammad Rosni's research in 2021, titled "Smart Greenhouse based on IoT Application," the goal of this project is to create an effective automatic irrigation system using a wireless network and a server client web service as the computer's main interface. This will allow for monitoring and management of plant growth and care with glass walls and a roof. To keep things the same and solve the problem. As a result of the project, the output-linked equipment can run itself. Four sensors can adapt to changes in the environment and keep an eye on things like soil moisture, humidity, temperature, and light. Simple to use The mobile app is easy to update everywhere. Radio frequency will be used to send the information. Not automation, because it still needs help from people (Muhammad Muqri Rosni, 2021).

As Vijitha Ananthi's (2019) study on "Automation using IoT in Greenhouse Environment" shows, the goal of this project is to use the Arduino 3 in a greenhouse environment to boost production while minimizing the farmers' discomfort. As part of this project, monitors are being used to measure humidity, temperature, sunlight, and moisture. NetDuino's Wi-Fi connection makes it easy to move to the cloud computer system. It's better to use NodeMCU ESP8266 instead of Netduino3 (J.Vijitha Ananthi, 2019). This project is informed by various prominent works in the field of greenhouse monitoring and control systems. Pranshu Dubey's 2021 work, Notably, Pranshu Dubey's 2021 study, "IoT-based greenhouse environment monitoring and controlling using Arduino," stands as a cornerstone in the field. Dubey's objective centered on establishing precise control over plant conditions and assessing soil pH to mitigate the potential for human error in maintaining optimal temperature and humidity levels within the greenhouse. Leveraging a suite of hardware including temperature, light, humidity, and soil moisture sensors, alongside an Atmega328-based greenhouse control system, Dubey's project exemplifies efficient and cost-effective greenhouse management. The integration of the Bylink Application and SMS Gateway facilitates seamless monitoring and operation, ensuring optimal resource utilization.Additionally, Shablu Deb Nath's 2021 work, "Design and Implementation of an IoT Based Greenhouse Monitoring and Controlling System," underscores the importance of accessible internet platforms for greenhouse management.

Nath's project prioritizes efficient monitoring and control through IoT technology, utilizing Arduino Uno, Wi-Fi modules, and an array of sensors including humidity, temperature, and moisture. Nath's advocacy for the superior efficiency of NodeMCU ESP8266 over Arduino Uno further enriches the discourse.Furthermore, Aghus Sofwan's 2020 study, "Smart Greenhouse Based on the Internet of Things (IoT) for environmental engineering," sheds light on the transformative potential of smart greenhouse technology. Sofwan's research aims to enhance plant growth by incorporating sensors and internet connectivity to collect accurate real-time data, which aligns perfectly with the overall goals of this project. Edwin Collado's 2021 study, titled "Design and implementation of a low-cost IoT-based agroclimatic monitoring system for greenhouses," highlights the crucial importance of IoT-based systems in agricultural development. Collado's research demonstrates the efficacy of IoT technology in monitoring and detecting soil moisture, humidity, and temperature levels. This technology provides a cost-effective option for managing greenhouses and reducing production losses caused by unfavorable weather conditions. Together, this important research offers vital knowledge and motivation for creating an advanced greenhouse monitoring and management system that aims to improve agricultural operations.

C. Review of Related Product

1. Smart Greenhouse

In the paper titled "Automation Using IoT in Greenhouse Environment," J. Vijitha Ananthi performed research that found that traditional greenhouse buildings are made up of walls and a translucent top. These structures are designed to preserve specific climatic conditions. Nevertheless, traditional greenhouse systems commonly depend on human supervision, necessitating regular visits by farmers to maintain accurate control of temperature and humidity levels. The manual management strategy can require a significant amount of labour and may result in lower crop yields if environmental conditions are not carefully managed. In order to tackle these difficulties, greenhouse automation solutions that utilise the Internet of Things (IoT) and embedded technologies have been created.

These systems provide automatic control and monitoring of the greenhouse environment, reducing the requirement for constant human interaction. Ananthi's project utilises the Netduino 3 microcontroller and a range of sensors to automate tasks by detecting characteristics such as humidity, temperature, sunshine, and soil wetness. The integration of IoT technology in the greenhouse setting seeks to optimise production rates and promote farmer productivity. Although greenhouses provide substantial advantages to farmers by enhancing crop yields and production rates, the need for consistent monitoring can cause inconvenience for farmers. Inadequate management of climatic conditions in the greenhouse can lead to crop damage and reduced yield. The advent of sensors and IoT technologies has transformed greenhouse management procedures, providing a more streamlined and automated approach to growing. It has bought in the automation into the controlling and the surveillance of green house by employing the sensors, internet of things and the embedded technology [4].

III. METHODS

A. Research Methodology

Research methodology encompasses the specific procedures or techniques employed to identify, select, process, and analyze information pertaining to a given topic. One notable methodology within this framework is the Waterfall method, categorized under the Software Development Life Cycle (SDLC). The Waterfall model represents a classical approach utilized in the system development life cycle, aiming to construct a system through a linear and sequential progression. Aptly named for its cascading nature, this model advances systematically from one phase to the next in a downward trajectory. Each phase is distinct and discrete, with the output of one phase serving as the input for the subsequent phase. Strict adherence to this model dictates that each phase must be fully completed before the commencement of the subsequent phase, thereby eliminating any potential overlap between phases. [5].

B. Development Methodology

This research metodology used in this project is the waterfall method where this has the benefit of allowing for segmentation and management. In order to reduce potential errors throughout the one-by-one phase model generation process.

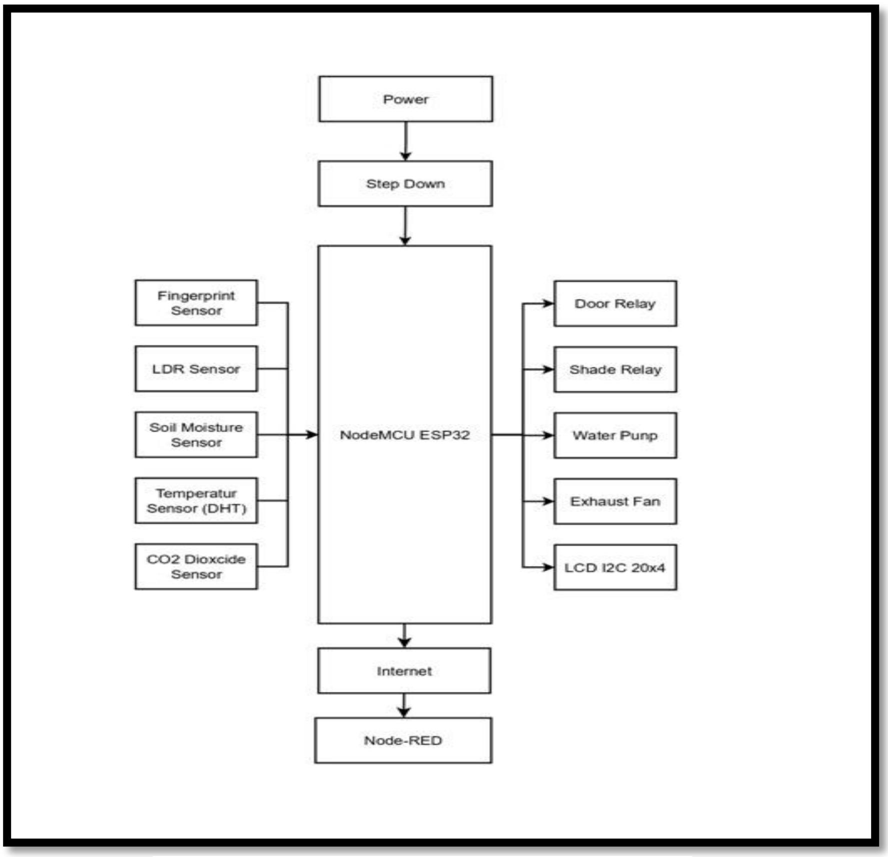

Fig 1. Block Diagram

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1. NodeMCU ESP 32

Data will be sent from the NodeMCU Arduino IDE base it will send to the website.

2. Fingerprint sensor

Fingerprint sensor as the input that will be security system for the greenhouse, fingeprint sensor will be detect only for the owner.

3. Soil mositure sensor

Sensor whose function is to measure soil moisture, its operating principle is to detect moisture around the soil.

4. Temperature Sensor

To detect the ambient temperature of the greenhouse.

5. CO2 Sensor

It functions as an indicator for the air's quality after production that can determine the quality of the plants.

6. Door Relay

As a fingerprint sensor connector to open door access.

7. Shade Relay

Light-dependent resistor is a specific type of resistor that are frequently employed as light detectors or as indicators of how much light is being converted.

8. Water Pump

The function as the output to watering the plant if the soil moisture in dry condition.

9. Exhaust Fan

The output of the system if the temperature is in high condition the fan will be turn on.

10. LCD

As the primary viewer, liquid crystals are used in liquid crystal displays, also known as LCDs. The lcd will show the output of the data.

11. Stepdown sensor

Step-down transformers are transformers created to lower the voltage from primary to secondary.

In this picture describe and show that flowchart system that compile all component into one flowchart that include NodeMCU Esp 32, fingerprint sensor,LDR sensor, DHT sensor, soil moisture sensor, CO2 sensor and MQTT server, first step is start and the second step is analyzing all the component that used in this project the next step is read the component, next step is processing the data if the proccess is sucessfully recognize it will be connect into the other component according the conditions if the procces can't be detect and failed it will be turn back into read and process the data and it will be finish by end process.

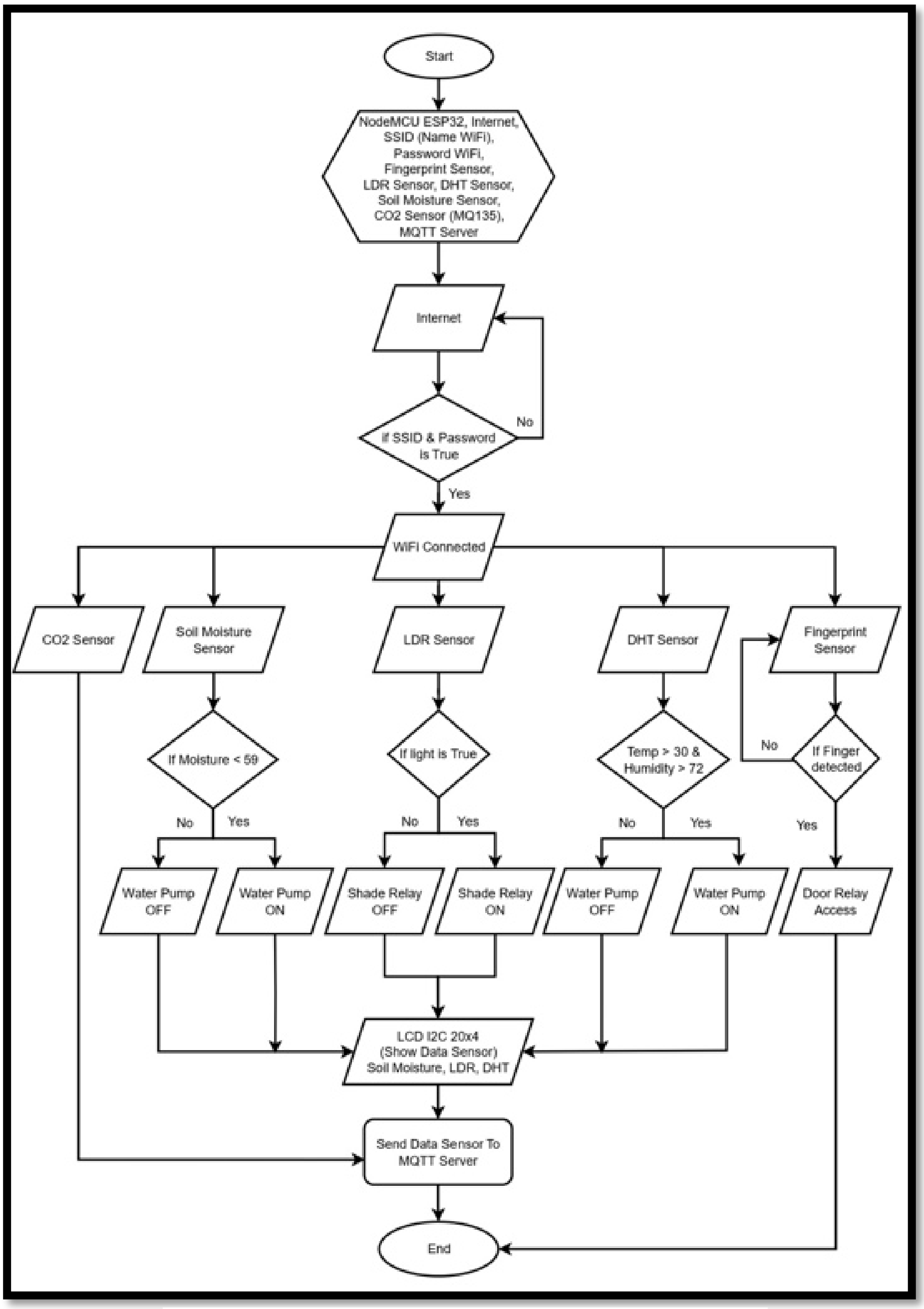

Fig 2. Flowchart

In this above picture show that the prototype design of smart greenhouse on the side facing straight ahead, the right side, left and rear view, this design using AutoCAD software with length 50 cm x width 50cm x height 30 cm.

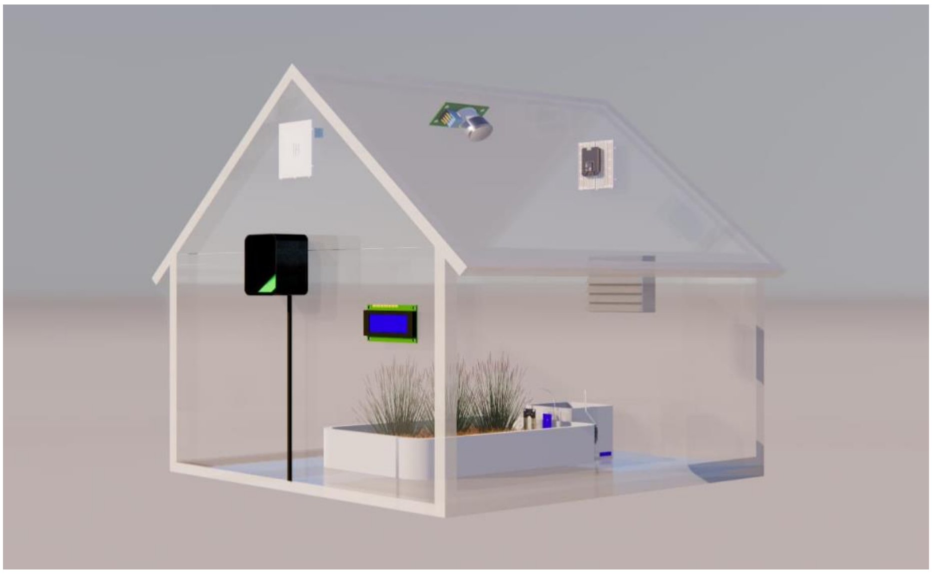

Fig 3. Prototype Design by Author

In the image provided, we are presented with a comprehensive prototype design of a smart greenhouse, showcasing multiple perspectives including the front, right side, left side, and rear views. The meticulous detailing and precision evident in the design indicate the use of advanced design software, namely AutoCAD, to conceptualize and create the structure. With dimensions measuring 50 cm in length, 50 cm in width, and 30 cm in height, the design demonstrates a compact, yet functional layout optimized for efficient space utilization. Each perspective offers valuable insights into the structural integrity and spatial arrangement of the greenhouse, highlighting its suitability for accommodating various plants and environmental control systems. The front view provides a clear depiction of the entrance and ventilation mechanisms, essential for regulating temperature and airflow within the greenhouse. Meanwhile, the side views offer a comprehensive understanding of the greenhouse's overall form factor, showcasing its proportions and design symmetry. Finally, the rear view provides insights into the back-end infrastructure and accessibility features, crucial for maintenance and operational purposes. Overall, this prototype design represents a significant step forward in the development of smart greenhouse technology, promising enhanced efficiency and productivity in agricultural practices.

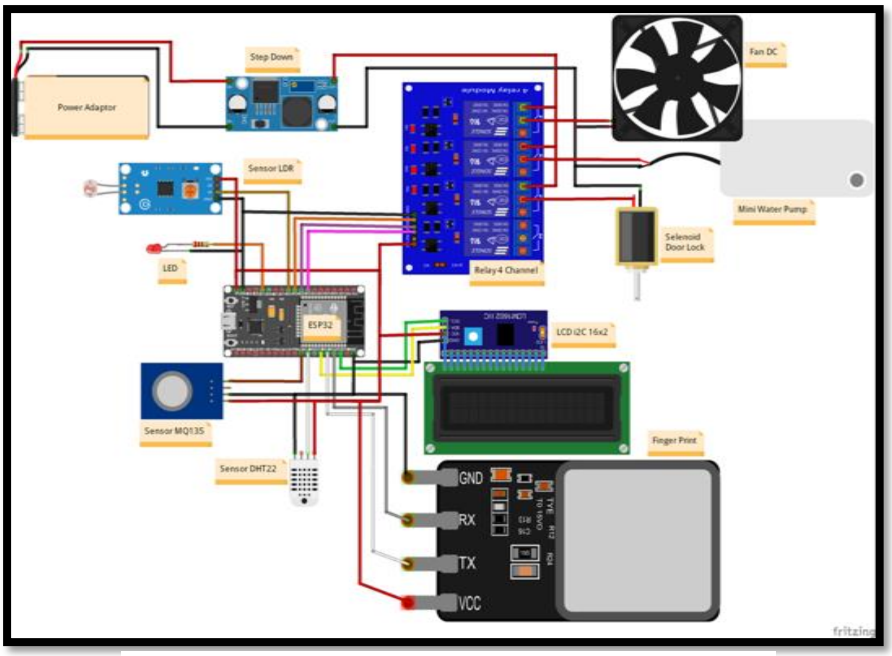

Fig 4. Schematic Diagram

The circuit design show that how to connect all the component in one project board, this design is using fritzing, tools that help build the circuit, the design is show how all the component and microcontroller NodeMCU ESP 32 is connect and gonna work run the program.In the meticulous orchestration of greenhouse environments, the integration of advanced monitoring tools stands as a cornerstone for precision agriculture. Through a meticulous interplay of sensor technologies and sophisticated display mechanisms, growers gain unparalleled insights into the microclimatic nuances crucial for nurturing thriving crops. At the heart of this monitoring framework lies a trio of sensors, each with a distinct role in capturing vital parameters essential for plant growth and development. Among these, the DHT sensor emerges as a sentinel, meticulously tracking temperature and humidity levels within the greenhouse's confines. Meanwhile, the LDR sensor diligently measures ambient light levels, ensuring optimal illumination for photosynthesis to flourish. Complementing these, a third sensor, engineered with precise threshold detection capabilities, safeguards against potential leaks or anomalies, thereby fortifying the greenhouse's integrity.These sensor nodes serve as vigilant sentinels, tirelessly collecting data that is then seamlessly disseminated across dual platforms: LCD screens conveniently positioned within the greenhouse and a dedicated website accessible remotely. This amalgamation of local and remote display interfaces offers growers unprecedented visibility into the dynamic interplay of environmental factors shaping their cultivation efforts.

Through the LCD screens' crisp visuals or the website's intuitive dashboards, users can effortlessly monitor the real-time status of soil, plants, and the ambient atmosphere.Central to this monitoring paradigm is the system's proactive response mechanism, triggered by deviations from predefined thresholds. For example, should the DHT sensor register temperatures dipping below the 30°C mark or humidity levels descending below the 72% threshold, the system swiftly springs into action. Automated commands are relayed to the water pump, initiating a precise irrigation regimen that replenishes soil moisture and sustains optimal growing conditions.This symbiotic integration of sensor data, display technologies, and automated responses heralds a new era of efficiency and productivity in greenhouse management. By empowering growers with granular insights and facilitating timely interventions, this monitoring system not only optimizes resource utilization but also cultivates an environment conducive to abundant yields and sustainable agricultural practices. Moreover, the transparency and accessibility afforded by the LCD displays and web interface foster collaboration, knowledge-sharing, and continuous improvement within the agricultural community. Thus, as agriculture ventures into an increasingly digitized landscape, these sophisticated monitoring solutions serve as indispensable allies in the quest for food security and environmental stewardship.

IV. RESULT AND DISCUSSION

This chapter presents all the test results and findings in a table to support the title analysis. The theory is discussed in relation to the study findings. This part should go over the outcomes and give a comprehensive review of the research's findings and analysis. The test device also explains how the hardware and software function as well as any problems that were encountered while this project was being completed.

A. Microcontroller Testing

In this part, testing of the microcontroller is carried out which aims to find out the running of a program and testing to uncover any bug,errors, or unintentional systemic paths. Because on this project is IoT-based, testing is required for this application in order to program the system is running well and to produce the results. In this project for build the program using Arduino IDE 1.8.20 ver, and for the monitoring using Node-RED for analyze the data that will be send into the Google spreedsheet.

	Microcontroller test	Value	Action (result)	Function status
1.	Temperature HIGH	33.1°C	If the temperature is in high condition the waterpump will take an action into on condition and watering the plants	v
2.	Temperature LOW	25.1°C	If the temperature in low condition the waterpump will be off and the exhaust fan will be turm on.	v
	Soil Moisture HIGH	70ppm	In the condition that show up if soil moisture in high condition, it describe that the soil moisture in good condition, that means enough, and no need to add water in the plant.	v
4.	Soil Moisture LOW	64ppm	If the soil moisture in low condition in range value 50-64 ppm, it means that the soil moisture in dry condition and need to watering the plants.	v
5.	Green House Humidity HIGH	94.3% RH	In the table show up that the humidity in high condition which means the temperature in low condition, so the soil moisture in good condition not in dry condition, watering enough.	v

Fig 5. Result of the testing

Based on the results of the test table above, it can be deducted that the soil moisture level detection reading is affected by temperature and humidity. If the temperature is high or increasing, the resulting humidity will also be lower, but if the temperature is low, between 20°C and 26°C, the humidity that will be produced will be higher. this is due to how closely humidity is related to air density. Humidity rises in direct proportion to air density. On the other hand, if the air density is low, the humidity is high. This results in sensors, like soil moisture sensors, detecting the amount of soil moisture produced; if the soil is too wet or has enough water, the water pump will shut off, if it detects a condition where the temperature is too high, the exhaust fan will detect this condition and turn on according to conditions, but if the soil is not sufficiently wet or dry, the water pump will stay on. The water pump will activate and irrigate the plants if the soil is extremely dry.

6.	Green House Humidity LOW	56,5% RH	Green house humidity in low condition it can describe that the temperature in hot/high condition it can trigger the another sensor like exhaust fan to be turn on and waterpump will be watering the plants	v
7.	Fingerprint YES (successfully open)	Fingerprint detect	Owner can access the greenhouse	v
8.	Fingerprint NO (failed)	Fingerprint no detect	Not allow to enter the green house because not the owner.	v
9.	CO2 MQ-135 HIGH	64ppm	This indicates that in mild settings, the quality of the plants produced by the intensity of light coming from indoors is good, and the air is not polluted.	v
10.	CO2 MQ-135 LOW	50 ppm	The quality of the plants produced is quite good, and the air quality level is very good	v

Fig 6. Result of the testing

B. Web Application Testing

Node-RED is a programming tool for connecting hardware and web services in an easy method to present project results. It has a browser-based editor that simplifies the process of combining hardware connections by utilizing a wide range of nodes that can be deployed to its runtime with a single click**.**In this research, the system created for monitoring and controlling greenhouses employs node-red and the MQTT protocol, allowing information on green house plants to be received directly in terms of value and percentage on the website, while farmers can measure, monitor, and detect early deficiencies of the main components in the greenhouse, allowing farmers to efficiently monitor the development of their plants as well as manage and control the energy requirements used in the greenhouse. MQTT, or Message Queuing Telemetry Transport, is a transport protocol that supportsclient-server publishing/subscribeMQTT is a transport protocol that is straightforward, open, and lightweight, and it is additionally simple to set up. As a consequence of this, MQTT is applicable in a wide range of contexts, such as connections between machines (also known as M2M) and the Internet of Things (IoT).

Using TCP/IP, the MQTT protocol is able to function. Node-RED is utilized for the design of the website system, as opposed to the Thingspeak platform, which can only send data every 15 seconds and takes three minutes for the sensor to submit data to the website. This makes the Thingspeak platform less effective for monitoring in real time. The visual programming environment of Node-RED, which is a browser-based tool for developing Internet of Things (IoT) applications, makes it simple for users to develop applications in the "flow" format. There is a wide variety of programming paradigms and styles to choose from, and the landscape of programming languages is extremely extensive. Despite the fact that object-oriented imperative languages are currently the dominant language in theworld of programming, there are still other options available for the development or production of software, as well as for rapidly prototyping thoughts. The software development process is approached in this alternate manner by Node-RED. At the outset, it is a programming language that is visual. Instead of constructing applications in the form of lines of code, Node-RED focuses on producing programs in the form of flows.

Fig 7. Node RED view

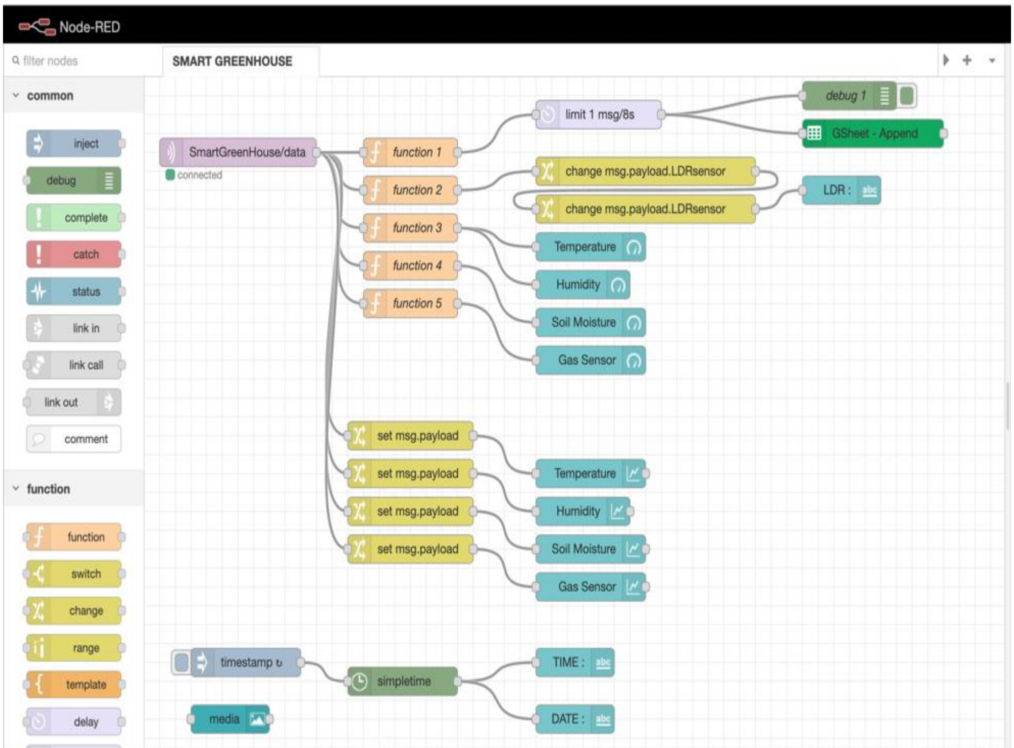

Fig 9. Flow NodeRED

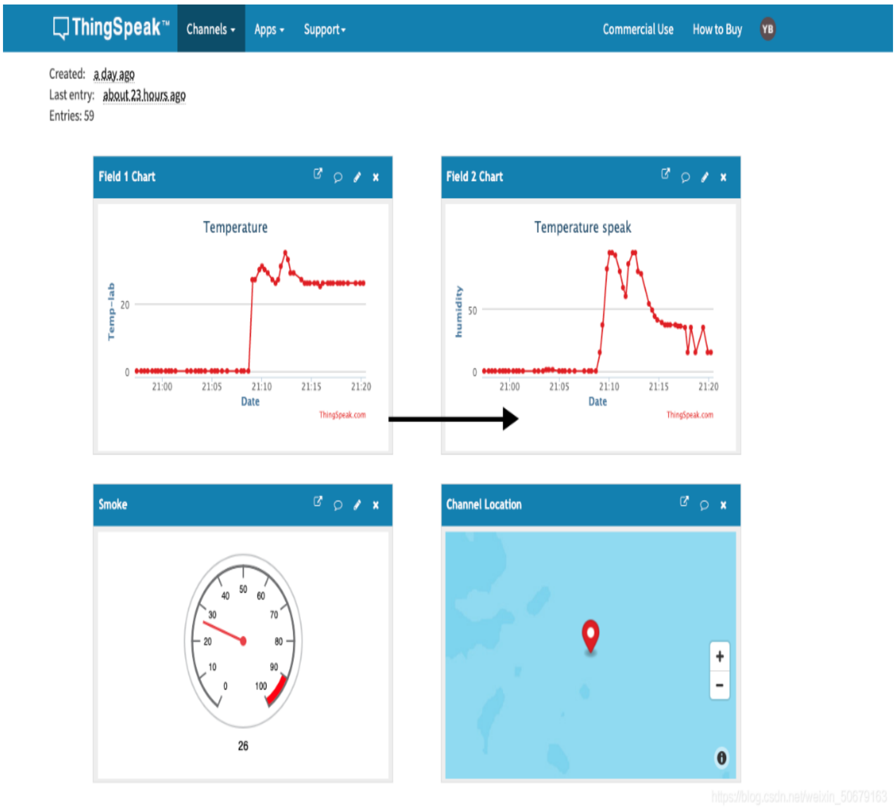

Fig 8. Thingspeak Dashboard

According to the explanation above, the main reason why the Node-RED website is more fascinating than the Thinkspeak platform is that in terms of the appearance of the UI / UX interface, Node RED is more appealing to the eye, and in terms of sending data, there is no minimum of seconds, it can be sent in real time, whereas Thinkspeak can only send data in 15 seconds (Sri Mulyono,2018).

C. Prototype Product

In the image provided, it is evident that the prototype has been successfully assembled and set up, showcasing a significant milestone in its development process. The dimensions of the product, measuring 50 cm in length, 50 cm in width, and 30 cm in height, highlight its compact yet functional design. Notably, all components are integrated into a single project board, demonstrating an efficient use of space and resources. However, for future iterations and enhancements, transitioning to a printed circuit board (PCB) project board is recommended for several reasons. Firstly, employing a PCB board will contribute to a more organized and professional appearance, enhancing the overall aesthetics of the product. Additionally, a PCB board offers greater reliability and durability compared to traditional project boards, ensuring stable performance over time. Moreover, utilizing a PCB board facilitates scalability and ease of replication, allowing for mass production and widespread adoption of the product. By adopting this approach, the prototype can undergo further development and refinement, ultimately paving the way for its successful commercialization and widespread deployment in various applications.

Fig 10. Prototype Product

V. SUMMARY AND CONCLUSION

A. Summary

This project using NodeMCU ESP 32 for the microcontroller to connect to the website Node-RED that used for monitoring and controlling the soil moisture and the temperature of the greenhouse area to detect plant growth quality. Node-RED is used for analyzing the data through website and through google spreadsheet to see the data. This is user-friendly and the website has features and functions that are easy to use.

B. Conclusion

Considering the agricultural sector's lack of human resources, one of the methods of agriculture that must be improved is hydroponic plants, also known as greenhouse plants. Tropical greenhouses have various advantages in plant production as well as practical manufacturing potential. This technology can be implemented to apply according to plant demands to maximize crop production.

VI. RECOMMENDATION

In addition to the door lock, a buzzer sensor is required so that it can initialise whether the fingerprint has been successfully detected, so the owner is able to identify if the buzzer sounds, it means that access to the door is successful, if the buzzer does not sound, it means that fingerprint. access failed or was not recognized. In addition, regarding the website as a system for monitoring soil moisture levels, greenhouse temperature and so on, combining additional features such as notifications that integrate the user's mobile devices from the greenhouse, notifications are needed so that the owner can find out directly without constantly monitoring the website.

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