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Monitoring and controlling humidity and pH use of LoRa in IoT-Based hydroponic planting

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ABSTRACT

Indonesia, a tropical country with a growing population, has significant potential for food production but faces challenges in meeting this demand. Factors such as generation change, industrialization, food production monopolies, climate change, food security measures, and a lack of technological progress affect productivity. Governments must address these problems by implementing cost efficiency, supply chain management, minimum labor consumption, and adequate food distribution. Food security is vital to the health and well-being of the population, and food is a vital food source to consume. Vegetables, a popular food source, are vital for health and growth. Salad, a plant used for food production, is beneficial to food production and is the leading food in the modern market. Technologically speaking, food security is vital to the health and well-being of the population. Governments should focus on improving food security and ensuring that food is accessible to all. The proposed system consists of five sensors: the DHT11 sensor, the TDS meter, the humidity sensor (DS18B20), the water height sensor, and the pH meter. Data from the sensor will be stored in a cloud database via the LoRa communication network, allowing users to access data through Android applications.

1. Introduction

As an agrarian country with a tropical climate, Indonesia has a high potential for agricultural resources. However, the field statement indicates a decline in agricultural resources and national food resilience. Importing certain food products became a routine to meet national food needs, in line with the Malthus Theory concept that population growth and food production were inconsistent. Moreover, socio-cultural change is changing the working patterns of the people from farmers to other sectors. Factors such as agricultural land transfer, agricultural corporate monopolies, and climate change also affect agricultural productivity [1].

With a population of 278,696 million by 2023, Indonesia has a potential market share of agricultural products. Due to significant and repeated demand and other considerations, vegetables have become a promising agricultural commodity in urban areas. Modern agricultural technology, especially vertical hydroponic cultivation, is a suitable solution to meet the needs of urban communities for fresh vegetables. However, this technology must be integrated with digital information technology (IT) for maximum accuracy and efficiency [2], [3].

Given the continuously rising demand and high sales value, salad cultivation with a vertical hydroponic system is the right choice [4]. However, these cultivation techniques require accurate monitoring and control, especially regarding temperature, humidity, and soil pH. In this case, the use

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of the Internet of Things (IoT) is the key to optimizing this vegetable cultivation [5]–[7]. Previously, researchers have successfully developed a device to monitor temperature, humidity, and pH in crops and oranges using LoRa technology, enabling real-time remote data acquisition. In addition, a pH monitoring system in hydroponic vegetable crops has also been successfully developed [8]–[10].

In this context, the study aims to develop a system for monitoring and controlling temperature and pH humidity using LoRa on IoT-based hydroponic plants. This research will provide an alternative solution to hydroponic crop cultivation using IoT technology that allows automatic plant control and monitoring. Problems in this study include monitoring moisture, temperature, and pH in IoT-based hydroponics and controlling nutrients and water in IoT-based hydroponics. The research limitations include using LoRa technology for IoT communication, using Arduino Uno as a microcontroller controller, focusing on cell culture, and utilizing the Blynk cloud framework. The benefits of this research include both theoretical and practical contributions. Theoretically, this research will be a reference for future research in information technology. In practice, the results of this research can benefit farmers, governments, and urban communities by increasing vegetable production, reducing dependence on labor, and improving urban spatiality. This research could also inspire the parties involved in developing modern urban agricultural technology.

2. Literature Review

2.1. Hydroponic

Hydroponics is the cultivation of agriculture that does not use soil media, so hydroponics is an agricultural activity that uses water as a substitute for soil. Therefore, hydroponic systems can be rooted in narrow soils. That is why hydroponic systems can be considered done in the field, on the roof, or other land. The human need for food, such as vegetables and fruits, increases as the population grows, but it does not go hand in hand with the increasingly narrowing development of agricultural land. Land transfer into settlements is inevitable, especially in large cities and agricultural centers. While the hydroponic system is best suited to the agribusiness model, it is one of the solutions to be considered to address the food problem. Hydroponic systems can grow all kinds of plants, but generally, many seasonal, horticultural plants are commonly planted with this system, including vegetables, fruits, ornamental plants, and medicinal plants [11]–[13].

There are several important factors to consider, such as nutrition, appropriate pH elements, water, salinity level not exceeding 2500 ppm, oxygen, and others. The Measurement of average temperature is 30° Celsius, and humidity is 70%, using a ventilator that is set to light if the room temperature of the plant exceeds 35° Celsius so that it can keep the plant from getting hot [13], [14].

Nutrients in hydroponic plants are the substances that are needed by hydroponic plants for plants to grow well. The purpose of nutrition in hydroponic plants is to add the nutrients plants need to their growing media. Usually, nutrients such as nitrogen can be obtained from the soil, but since the hydroponic method does not use the soil, it requires particular nutrients to ensure that plants can grow well. Nutrition or nutrients in Hydroponics plants are provided in Part Per Million (PPM). PPM is the unit for measuring the concentration of a solution [15], [16]. Table 1 below shows the nutritional requirements of each plant.

Table.1 Plants Nutrition

Plants	**Nutrition (PPM)**
Spinach	1260 - 1610
Broccoli	1960 - 2450
Kailan	1050 - 1400
Kangkong	1050 - 1400
Pakcoy	1050 - 1400
Mustard	840 - 1680
Celery	1260 - 1680
Salad	560 - 840

Table 2 shows the pH requirements of the plant.

Table.2 Plants PH

Plants	pH
Spinach	6.0 - 7.0
Broccoli	6.0 - 6.8
Kailan	5.5 - 6.5
Kangkong	5.5 - 6.5
Pakcoy	7.0
Mustard	5.5 - 6.5
Celery	6.5
Salad	6.0 - 7.0

In a hydroponic system, the most important aspects to consider are temperature, humidity, and nutrient management, where measurements are based on EC (Electro Conductivity) and pH. EC (Electrical Conducting) for measurement using TDS/EC meters. Each plant requires a solution with different EC values [17], [18].

2.2. Salada

Salad (Lactuca sativa L) is a plant that can grow in cold areas or high plains. Salad is one of the leafy vegetables loved by society. Salad is usually consumed in fresh form as a snack. Restaurants and hotels also use salad in their cooking, such as salads, hamburgers, and gado-gado. With the increase in population and public awareness of nutritional value and health benefits, consumer demand for salad is increasing [18], [19]. Fig. 1 shows the type – a type of salad.

Fig. 1. Types of Salad Plants

Selenium is one of the vegetable plants whose leaves are consumed, and the prospects for market absorption will continue to increase as the population grows. Salad leaves are leafy vegetables often grated into salads with various vegetables and other fruits. Salad leaf vegetables generally consumed in these raw conditions have light green to yellowish white. Salad leaves are also a good source of vitamin A and vitamin K, which are very high. Even a cup of salad leaf can meet 82% of vitamin A and 60% of vitamin K requirements that are so much needed in our bodies. In fact, according to the data page on the Indonesian Food Composition Data of the Ministry of Health RI, 100 grams (g) of celandine leaves contain the composition according to Table 3 below.

Table.3 Nutritional Content per 100 Grams of Salad

Composition	Total
Energy	15 kal
Protein	1,2 gr
Fat	0,2 gr
Carbohydrate	2,9 gr
Calcium	22 mg
Fosfor	25 mg
Phosphorus Iron	1 mg
Vitamin A	540 mg
Vitamin B1	0,04 mg
Vitamin C	8 mg

Salad is rich in carbohydrates, proteins, fiber, and low fat and contains essential nutrients such as iron, potassium, calcium, folate, and fiber that can help meet nutritional requirements. According to the National Central Statistical Agency of the year (2019), the need for production of celery crops in Indonesia from 2015 to 2018 was 600.200 tons, 601.204 tons, 627.611 tons, and 630.500 tons.

2.3. Internet of Things

The Internet of Things (IoT) is a concept where an object can transfer data through a network without requiring human-to-human or human-to-computer interaction. The Internet of Things (IoT) has evolved from the convergence of wireless technology, micro-electromechanical systems (MEMS), and the Internet. According to Casagras (Coordinator and support action for global RFID-related activities and standardization), IoT is a global network infrastructure connecting physical and virtual objects by exploiting data capture and communication capabilities [20], [21].

2.4. Blynk Applications

Blynk is a platform for iOS and Android operating systems to control Arduino, Raspberry Pi, ESP8266, and other similar devices over the Internet. The Blynk application is straightforward to use. It can use both Android and iOS. The blynk app is not tied to any component or chip but must support the board by communicating with the hardware. The Blynk application has three main components: applications, servers, and libraries [22], [23].

2.5. LoRa (Long Range)

LoRa, an abbreviation for "Long Range", is a remote wireless communication system promoted by the LoRa Alliance, which has designed a built-in protocol for the communication system. The system is intended to be used on low-energy battery-powered devices so it can last a long time. LoRa's physical layer, developed by Sentech, enables low-speed, low-power remote communication. Depending on the application area, LoRa operates on ISM bands of 433 MHz, 868 MHz, or 915 MHz. The load of each transfer can range from 2 to 255 bytes, and data speeds can reach up to 50 Kbps. LoRa modulation techniques are Sentech technology [24], [25].

LoRa WAN, an Abbreviation for Long Range Wide Area Network, was first released in 2015 by the LoRa Alliance as a wireless standard. LoRa and LoRa WAN cannot be exchanged, and they are different. LoRa describes modulation on the physical layer, and LoRa WAN is the MAC protocol that supports low power, long range, and high capacity in the Low Power Wide Area Network (LPWA) network has met the goals of the main design: long distance, cost-efficient, low energy, high scalability, and QoS. (Quality of service). In general, system architecture and communication standards determine the technical performance of technology, such as energy efficiency to save battery power, network capacity, and data speed for various applications. Lora WAN is a network protocol created for wireless communication that connects battery-operated devices to the Internet in an extensive network. The protocol supports low-cost, mobile, secure communication for IoT and machine-to-machine (M2M) applications [26], [27].

2.6. Relay

Relay is a current-controlled switch. Relay has a low-voltage curve that is bound to a core. There is an iron armature that will be attracted toward the core when the current flows through the curve.

This armor is mounted on a rush pulley. When the joint path contacts will change their positions from normal-closed contacts to normal-open contacts. Relays use the electromagnetic principle to move the switch contacts so that a small electric current can deliver higher-voltage electricity [27], [28].

2.7. Arduino Uno

Arduino Uno is a microcontroller board based on Atmega328. Arduino Uno can take power from the USB port of a computer using a USB charger or can also take power by using an AC adapter with a voltage of 9 volts. If it cannot power supply that through the AC adaptor, the Arduino board will take the power from a USB port.

2.8. Temperature and Humanidity Sensor

Temperature and humidity sensors are the temperature and moisture sensors that use the DHT11 type. The DHT 11 sensor is a sensor that can measure two parameters of the environment at the same time, namely temperature and Humidity. In this sensor, there is a thermistor type NTC (Negative Temperature Coefficient) to measure temperature, a resistive-type fluidity sensor, and an 8-bit microcontroller that processes both sensors and sends the results to the output pin in single-warble-directional format [29].

2.9. PH Sensor

PH sensor is an object's acidity or acidity level measured using a pH scale between 0 – 14. Acid properties have a pH between 0 - 7, and base properties have a pH value of 7 - 14. To measure an object's acidity level, use an auxiliary device, a pH meter. The pH of a solution can be detected in several ways, among other things, using nitration of the solution with acid, an indicator, or a pH meter. The measurement of the acid pH level and the water base works digitally. The pH of the water is acidic if less than 7, the water pH is called base (alkaline) if more than seven, and the pH water is called neutral if the pH is equal to 7 [30], [31].

2.10. Total Dissolved Solid Sensore

Water quality plays a vital role in agriculture to indicate the water quality level parameters using Total Dissolved Solid (TDS). It is essential to know the TDS level because high levels of TDS show a negative relationship that allows contamination of hazardous substances in the water. The acquisition of sensor data is one of the stages in the monitoring system using IoT technology, and this step is crucial because it produces data that will be processed in such a way as to make the right strategic and operational decisions. TDS is measured in ppm (parts per million). TDS provides information about calcium, magnesium, potassium, and sodium content. The TDS sensors used in this study are TDS sensor kits produced by DF-Robot that are used for Arduino microcontroller with input voltage specifications of 3.3 ~ 5.5 volts, output voltage 0 ~ 2.3 volts, working capacity of 3 ~ 6 mA, TDS measurement of 0 ~ 1000 ppm [32], [33].

2.11. Water Temperature Sensor DS 18B20

Temperature is the magnitude indicating the degree of heat or coldness of an object and the device used to measure the temperature, the higher the temperature of the object, the warmer the object. On the contrary, the DS18B20 sensor is one of the kinds of Arduino-based measuring instruments commonly used because of its water-resistant advantages, so it is suitable for temperature measurement in difficult or wet places [34], [35].

2.12. Water Level Sensor

A water level sensor is a sensor that can measure the altitude limit of a container or other water storage. The water level itself is a device used to measure water height. This sensor functions to read the water condition in a hydroponic irrigation bathtub. If the irrigated tap water declines and the water level sensor is at its lower limit, then the data sent by the microcontroller will be processed and automatically turned on by the actuator. If a bathtub is filled, the pump will automatically drive the water crane to the upper limit, reading the resistance produced by the water touching the plate line on the sensor. The more water touches the plate, the smaller the resistance value, but the less water reaches the sensor plate line, the greater the resistance value [36], [37].

2.13. Literature Review

As for some journals and research related to this research, we have summarized them in Table 4 belows:

Table.4 Literature Review

Researchers	Title	Equation	Difference
Richad Gilang Wisduanto,Adhitya Bhawiyuga and Dani Primanita Kartikasari [2019] [38]	Implementation of Agricultural Sensor Data Acquisition System Using LoRa Communication Protocol	1. LoRa communications are used as a sensor data transmission medium. 2. Each uses sensors, temperature, humidity, and Ph. IoT-based	1. Using Raspberry Pi 3 as data storage. 2. Using soil humidity and rain humidity sensors
Syafei Karim,Ida Maratul Khamidah, and Yulianto (2021) [39]	Hydroponic Plant Monitoring System using Arduino UNO and NodeMCU	1. Using Arduino Uno as a Microcontroller 2. IoT-based	Testing is done by connecting NodeMCU to a wi-fi network or access point that provides internet access.
Purnawarman Musa and Adinda Nurul Huda (2018) [40]	Application of Smart Monitoring and Regulatory Systems for Nutrients in the NFT Hydroponic System	IoT-based	The EC meter sensor and the DS18B20 sensor were placed inside the nutrient solution container.
Nofriadi, Dahriansyah and Adi Prijuna Lubus (2022) [41]	Water Ph Measuring System for Hydroponic Plants	IoT-based	Using the ESP8266 microcontroller
Kenetrian Garindaru, Achmad Ali Muayyadi, and Gandeva Bayu Satrya. (2022) [42]	Monitoring And Control of Based Floating Raft Hydroponic Plants	1. IoT-based 2. Using monitoring and distribution on hydroponic plants	Using Raspberry Pi 3 as data storage.
Ciptadi & Hardyanto (2018) [43]	Application of IoT Technology to Hydroponic Plants using Arduino and Android Blynk	1. DHT11 sensor for temperature and humidity. 2. YF-S201 sensor to measure the intensity of nutrients flowing through the gully. 3. Application of IoT technology	Using YF-S201 Sensor

3. Method

The approach used in this study is a quantitative approach that relates to measuring something on a numerical scale. This approach comes from the natural sciences and relates to the understanding of “how something is built, used or worked [44].

The type of research used is experimentation on applied research. An applied study is often done with experimentation and implementation, proofing principles, and gathering experience from users. This applied project aims to gain experience in applying algorithms.

This research goes through several stages, where each stage is interrelated, but the research stage can be seen in Fig. 2 below:

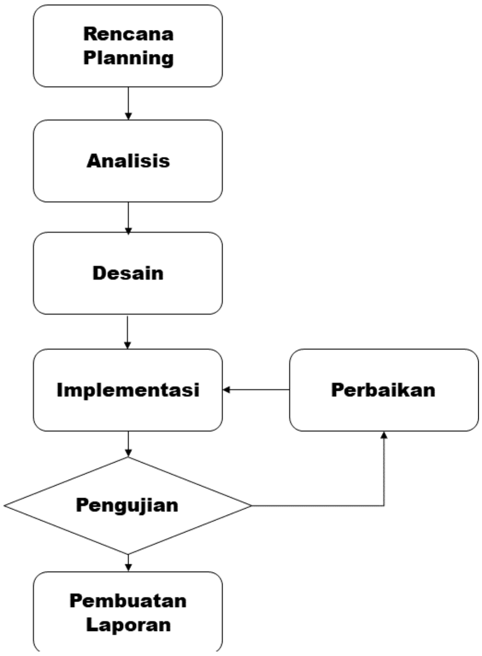

Fig. 2. Research Stage

3.1. Startup Plan

The research began with the search for the necessary data related to building a temperature and Ph moisture monitoring and control system using LoRa on IoT-based hydroponic plants, such as tools and materials required such as Arduino Uno, LoRa, DHT11 temperature and humidity sensors and Ph sensors, in addition to taking also related theoretical references and journals with similar topics.

3.2. Analysis

Analysis of the technical design and problems related to the topic through a review of previous research literature to obtain an overview of the systems that will be designed and built.

3.3. Design

The system's design consists of two parts, namely, a monitor and an automatic controller of hydroponic plant solutions. The central part of the monitor is LoRa, and the sensors used are temperature and humidity sensors of the DHT11 and Ph sensors. Both sensors are inserted into the hydroponic plant's nutritional water tub to measure the water's condition. The sensor measurement results will be processed and sent using the LoRa module. Fig. 3 below is a block diagram of the hardware design consisting of three parts: inputs, processes, and outputs.

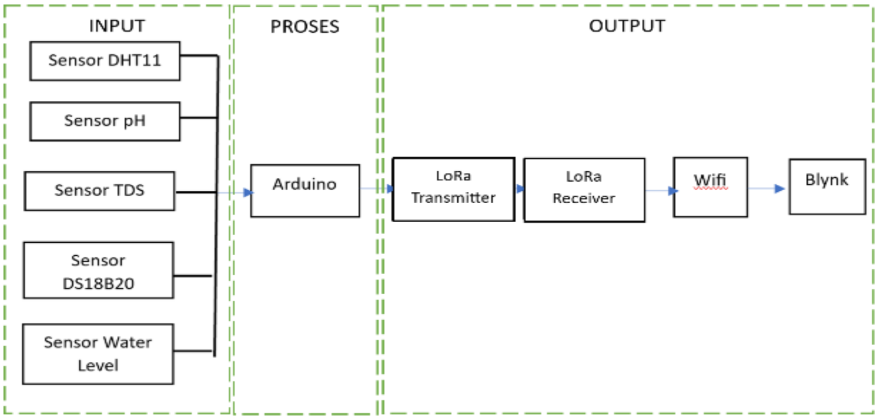

Fig. 3. Hardware Design Block Diagram

Fig. 4 below is a diagram of the design of the monitoring system on hydroponic plants using the NFT method. (Nutrient Film Technique). This system uses five types of sensors: DHT11 moisture sensor, TDS Meter sensor, water temperature sensor (DS 18B20), float water level sensor, and pH Meter sensor. Five sensors are connected to Arduino Uno and placed on an NFT hydroponic reservoir.

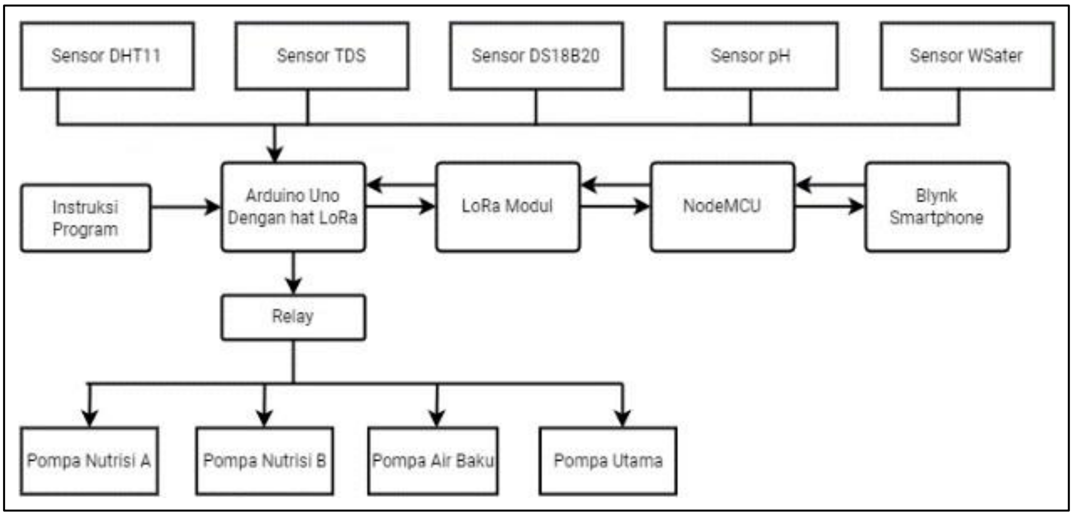

Fig. 4. System Design Diagram

The first step is data processing, which defines each variable used. Where all the data collected will be processed at this stage. The second step is the reading of the float water level sensor. When the water is below 25 cm, the sensor will activate the pump actuator according to the indicator specified in this stage. The third step is the reading of the TDS sensor. When the blynk has already entered the 560 – 840 ppm setpoint, and if the PPM value is less than the set, the AB mix pump will be activated. The AB Mix pump will automatically turn on if the nutritional value reads that the sensor is more significant than the setpoint. The AB mix pumps will die if the nutrients read by the TD sensor match for the next step equals the second stage, where the actuator will die, and the live actuator is only the primary pump for hydroponic circulation. The program will be repeated in the second step: read the float water level sensor and run it sequentially. For more clarity, it can be seen in Fig. 5 below:

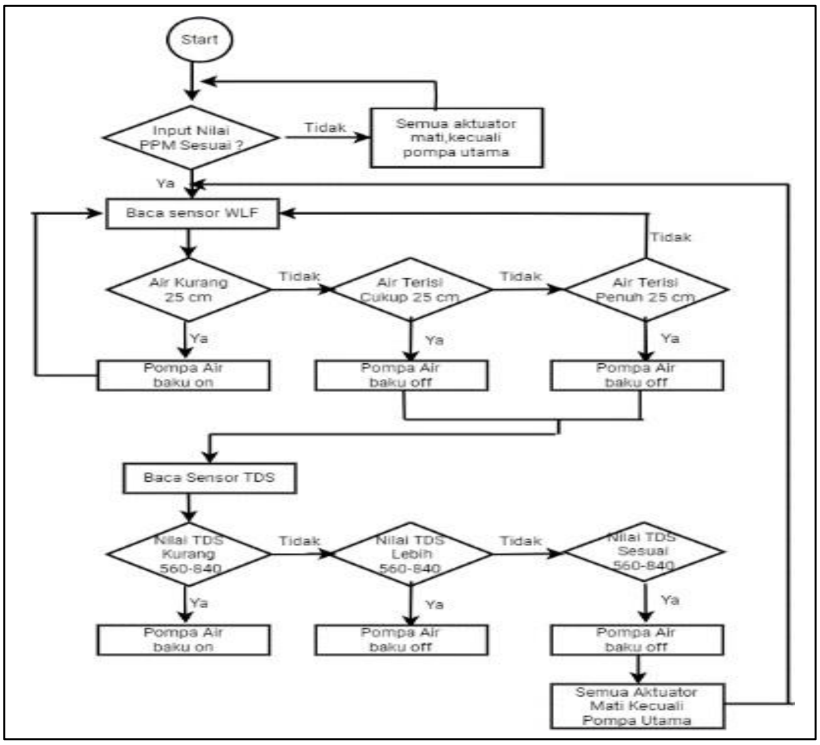

Fig. 5. Flowchart Control System

Steps to monitoring the pH can be seen in Fig. 6 below, i.e., pH sensor readings. If the pH sensor reads a pH value greater than seven, then pump two will be on to flow the solution. Otherwise, it will send data to the blynk. If the sensor reads the pH value less than 7, then pump two will be off; otherwise, it will send the data to Blynk and finish.

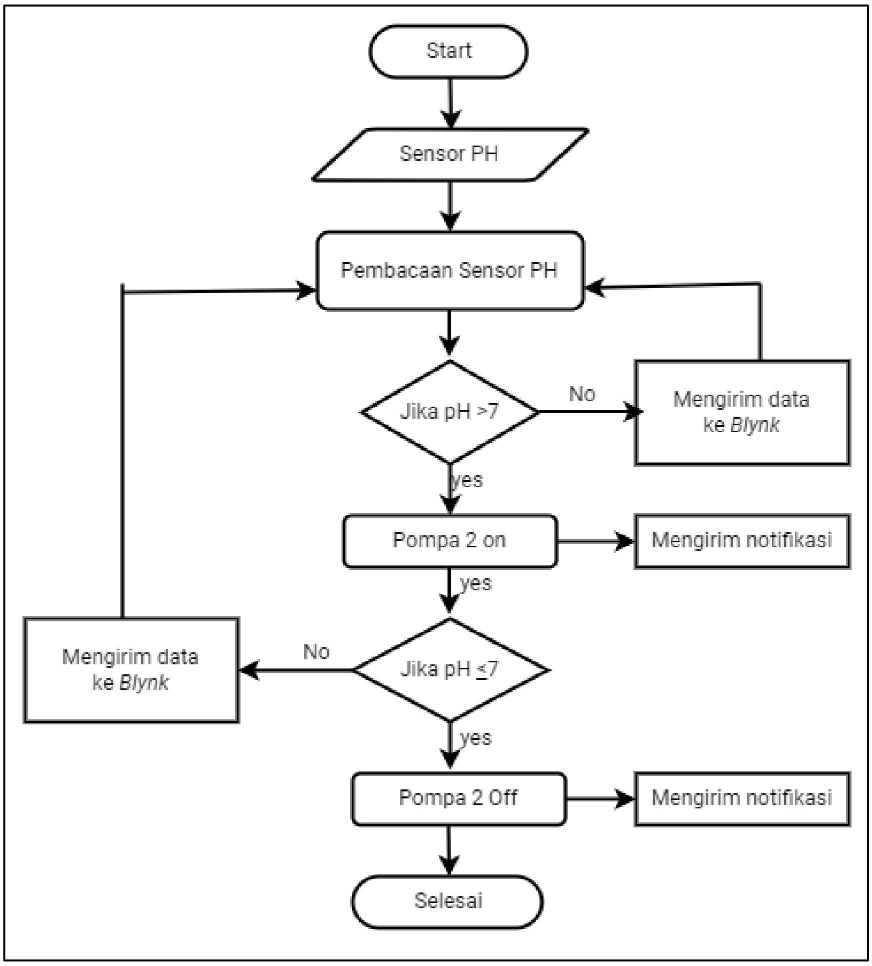

Fig. 6. Flowchart Monitoring pH

3.4. Implementation

After completing the planning, analysis, and design steps, the moisture, temperature, pH monitoring system, and the control of nutrients and water using LoRa on IoT-based hydroponic plants will be tested in person.

3.5. Testing

The whole system must be tested to make sure that the whole system has been working and running as expected. The results of these tests will be documented and included in the results report.

3.6. Reporting

The final stage of this research is the preparation of reports. All the activities in this research will be compiled in the form of reports and submitted as a sign that this research activity has been completed.

4. Results and Discussion

4.1. Results

The objectives to be achieved have been produced from several stages of the design. Namely, the System Monitoring of Humidity, Temperature, pH, and Nutrient and Water Temperature Control using LoRa on IoT-based hydroponic plants. Fig. 7 below is the result of the overall system design.

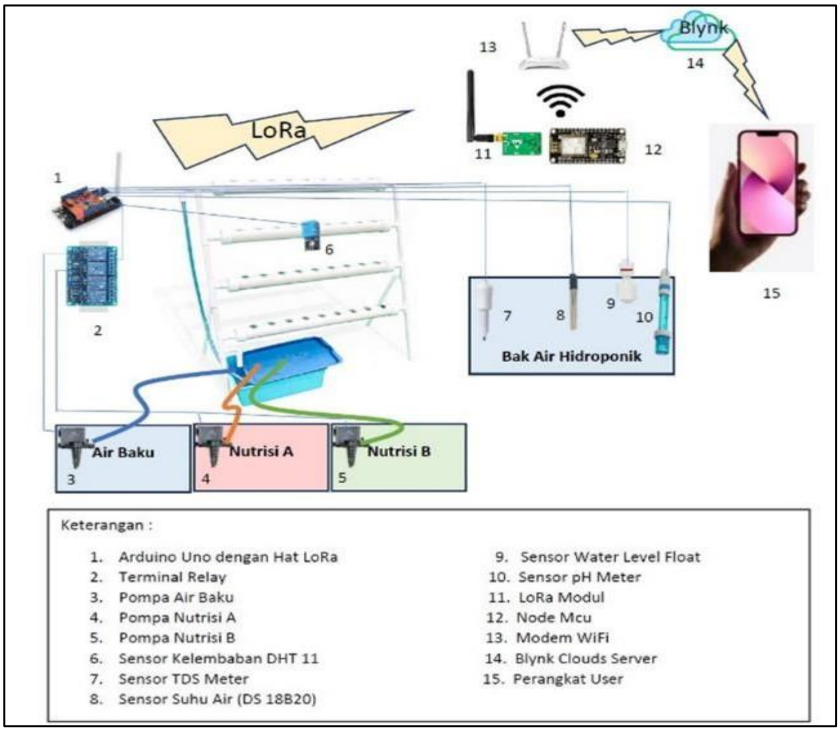

Fig. 7. System Design Output Scheme

The DHT11 sensor consists of a capacitive moisture-sensing element and a thermistor for temperature sensing. The humidity sensing capacitor has two electrodes with a moisture retention substrate as a dielectric between them. Changes in capacitance values occur with changes in humidity levels. The IC processes these resistance values into digital forms and then transmits them to the microcontroller via the data pin to the GPIO (General Purpose Input Output) on the microcontrollers. These values will be displayed on the Arduino serial communication, forwarded from the LoRa transmitter to the Lo Ra receiver, and sent using the NodeMCU WiFi to the Blynk server. The DS18B20 temperature sensor is a water temperature sensor that works using the one-wire communication protocol, which, according to its datasheet, only needs one data path (and one ground) to communicate with the microprocessor. The VDD will be connected by 5V, and the DQ (Data) will connect with the Arduino pin, which will be displayed on the Arduino serial communication and then forwarded from the LoRa transmitter to the LoRa receiver and then sent using the NodeMCU WiFi to the Blynk server. The TDS (Total Dissolved Solids) sensor connects to the microcontroller using three pins, namely VCC (Power), GND (ground), and OUT (output). In reading the analog output through the OUT pin using the analog pin on the AO pin, the A1 analogous output needs to be converted to a digital value using an inherent Arduin function such as 'analog()Read' This value will represent the level of conductivity of the solution, about the number of particles solved, the value that will be shown on the series communication of the Arduino then continued from the loRa transmitter to LoRa recipient then sent by Node using the WiFi MCU to the blink server.

The pH Meter is connected to the Arduino Uno microcontroller using three pins: VCC (power), GND (ground), and OUT (output). pH sensor generates an analog output through the pin out on Arduinos A0 and A1. Before use, it needs to be calibrated. The result of this calibration will give the necessary conversion result to change the analog read value to the actual pH value, i.e., with the standard pH scale (0 to 14) value to be displayed on the Arduino serial communication then forwarded from LoRa transmitter to LoRa receiver then sent using NodeMCU WiFi to the Blynk server.

A water level sensor is a sensor that consists of fluorescent objects that will go up or down as the volume of the water changes. This sensor will be connected to a switch that can detect and read the water condition in a hydroponic irrigation bathtub if the water in the irrigating bathtub is down. When the water level sensors are at their lower limit, the data sent to the microcontroller will be processed and automatically turned on by the actuator. If the bathtub is fully charged, the pump will automatically die, and the water crane reaches the top limit of the sensor. In performing the control of water altitude using the Water Level Sensor, where the network of Water Level sensors works when the altitude is not suitable for the desired altitude, then the sensor will activate, whatever the planned water height limit is 22 cm when the height of the water is lower than 17 cm then Arduino will order the pump to carry out the water charging. When the water's height is equal to or higher than 22 cm, it will be ordered to stop the pump from working.

A hydroponic PPM system is used to adjust the need for nutrients following the growth of the hydroponic plant to measure and control the concentration level in the nutrient solution. When nutrients are less than the specified nutrients, a nutrient pump will be activated, channeling the nutrients to the shelter. In carrying out the nutrient filling, a nutrient pump takes 3 seconds to fill 680 ml of nutrient fluid mixed with 40 liters of raw water. Fig. 8 shows the result of the hardware design of the system created.

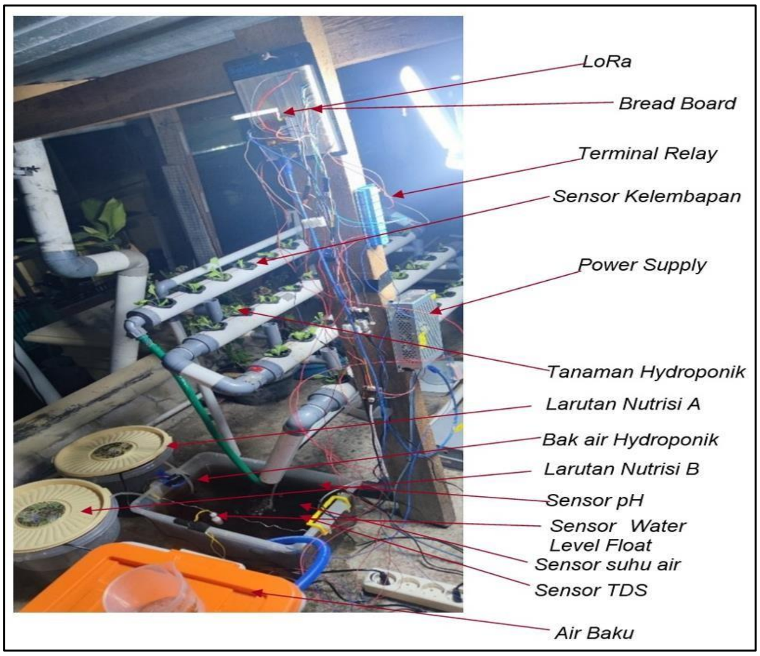

Fig. 8. Hardware Design Results

Fig. 9 below shows the software design outcome from the system built.

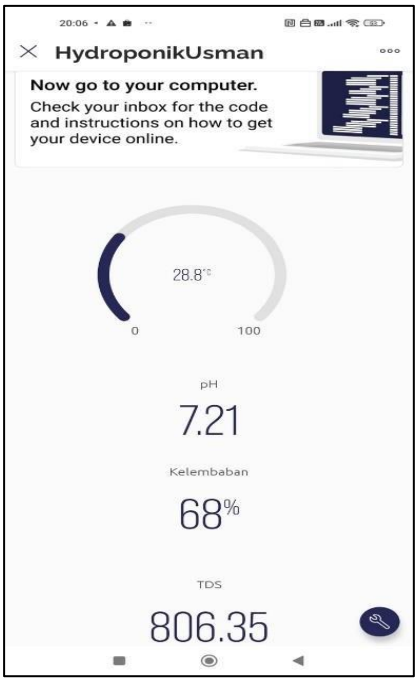

Fig. 9. Software Design Results

4.1.1. LoRa Testing

This test aims to test whether the receiver will receive the transmitter sending the data, who will also receive the values of the results: Delay, jitter, throughput packet Loss, and total index Quality of Services of the LoRa network. These results can be found in Table 5, Table 6, Table 7, Table 8, Table 9.

Table.5 Throughput Observation Results

No.	Measurement Distance	Long Observation (Seconds)	Throughput (bps)	Description	
				Index	*Category*
1	100 Meters	315	87	3	Good
2	500 Meters	367	86	3	Good
3	1.000 Meters	408	82	3	Good

Table.6 Results of Delay Observations

No.	Measurement Distance	Long Observation (Seconds)	Delay (ms)	Description	
				Index	*Category*
1	100 Meters	315	169	3	Good
2	500 Meters	367	168	3	Good
3	1.000 Meters	408	179	3	Good

Table.7 Observation Jitter

No.	Measurement Distance	Long Observation (Seconds)	Jitter (ms)	Description	
				Index	*Category*
1	100 Meters	315	5	3	Good
2	500 Meters	367	4	3	Good
3	1.000 Meters	408	4	3	Good

Table.8 Observation Packet Loss

No.	Measurement Distance	Long Observation (Seconds)	Packet Loss (%)	Description	
				Index	*Category*
1	100 Meters	315	0,0%	4	Very Good
2	500 Meters	367	0,0%	4	Very Good
3	1.000 Meters	408	5,0%	2	Currently

Table.9 Percentage and QoS Value

No.	Measurement Distance	Values	Percentage (%)	Indeks
1	100 Meters	3,25	75%	Satisfy
2	500 Meters	3,25	75%	Satisfy
3	1.000 Meters	2,75	69%	Less Satisfactory

If you look at the average QoS measurement, the results are promising. Only for packet losses at a 1,000-meter distance is there a moderate result, while at 100 and 500 meters.

4.1.2. Overall Testing

The system will be tested on each sensor to see if the sensor is working correctly or not. Testing is done on the entire component by combining hardware and software, and testing is done by giving a program on each of the sensors that will be tested. Table 10 shows the overall monitoring test results.

Table.10 Monitoring Test Results

Aktivitas	Hasil	Keterangan
Detect Nutrition using a TDS Sensor	Succeeded	Testing from sensor to display on blynk application
Detecting water temperature using water sensor DS18B20	Succeeded	Testing from sensor to display on blynk application
Detect the water height limit using the Float Water Level sensor	Succeeded	Testing from sensor to display on blynk application
Knowing the acidity level using the pH sensor	Succeeded	Testing from sensor to display on blynk application
Knowing the humidity using the DHT11 sensor	Succeeded	Testing from sensor to display on blynk application

Table 11 shows the control test results of this system.

Table.11 Water and Nutrition Control Testing Process

No.	Date	Testing	Time (second)	Results	Information
1	July 22 th 2023	Fresh Water Filling	145	Freshwater = 42 litters	Empty Water Initial Position
		Nutrition Satisfaction (Liquid A and B)	258	TDS Value 609	Initial TDS value < 500
2	July 23th 2023	Fresh Water Filling	125	Freshwater = 42 litters	Empty Water Initial Position
		Nutrition Satisfaction (Liquid A and B)	265	TDS Value 610	Initial TDS value < 500
3	July 26th 2023	Fresh Water Filling	115	Freshwater = 42 litters	Empty Water Initial Position
		Nutrition Satisfaction (Liquid A and B)	248	TDS Value 605	Initial TDS value < 500
4	July 29th 2023	Fresh Water Filling	116	Freshwater = 42 litters	Empty Water Initial Position
		Nutrition Satisfaction (Liquid A and B)	250	TDS Value 602	Initial TDS value < 500
5	July 30 th 2023	Fresh Water Filling	131	Freshwater = 42 litters	Empty Water Initial Position
		Nutrition Satisfaction (Liquid A and B)	252	TDS Value 609	Initial TDS value < 500
6	August 5th 2023	Fresh Water Filling	127	Freshwater = 42 litters	Empty Water Initial Position
		Nutrition Satisfaction (Liquid A and B)	249	TDS Value 603	Initial TDS value < 500
7	August 6th 2023	Fresh Water Filling	142	Freshwater = 42 litters	Empty Water Initial Position
		Nutrition Satisfaction (Liquid A and B)	262	TDS Value 607	Initial TDS value < 500
8	August 9th 2023	Fresh Water Filling	105	Freshwater = 42 litters	Empty Water Initial Position
		Nutrition Satisfaction (Liquid A and B)	251	TDS Value 611	Initial TDS value < 500
9	August 12th 2023	Fresh Water Filling	115	Freshwater = 42 litters	Empty Water Initial Position
		Nutrition Satisfaction (Liquid A and B)	248	TDS Value 604	Initial TDS value < 500
10	August 13th 2023	Fresh Water Filling	117	Freshwater = 42 litters	Empty Water Initial Position
		Nutrition Satisfaction (Liquid A and B)	263	TDS Value 607	Initial TDS value < 500

It can be seen from both tests for both monitoring and control that the system has been working wel.

4.2. Discussion

In the research conducted by Syafei Karim, Ida Maratul Khamidah, and Yulianto obtained the results of the monitoring system on hydroponic plants consisting of the sensor DHT-22 to monitor the temperature and humidity of the air, the pH sensor to monitor pH values and the TDS sensor for monitoring the nutritional values dissolved in water, there is no control system and monitoring should be done directly at the location connected to the internet cannot be remotely. The research conducted by Nofriadi, Dahriansyah, and Adi Prijuna Lubis obtained results that are capable of controlling the pH of the water well according to the sensor readings and set points that have been specified are 6.0 – 7.0 minimum and maximum pH levels, and 560 for the minimum level of nutrients (PPM), monitoring is limited to only the pH and TDS there is no monitoring of water temperature and humidity. Monitoring should be done directly at the location connected to the internet and cannot be done remotely.

The research conducted by Richad G Fabric Wisduanto, Adhitya Bhawiyuga, and Dany Primanita Kartikasari obtained results that successfully took data on the sensor side of the node, where the sensor node takes data using temperature and humidity sensors, soil moisture sensors, and rain sensors. While research by Purnawarman Musa and Adinda Nurul Huda M obtained the results of a system that can monitor nutrients, temperature, and humidity with a stability rate measurement between 70% to 80% for nutrient control, monitoring should be done directly at a location connected to the Internet, not remotely.

In the Prahenusa Wahyu Ciptadi and R. Hafid Hardyanto study, the system uses two sensors: the temperature and humidity sensor DHT-11 and the TDS sensor. There is no control, and the system can only be monitored directly at locations connected to the Internet and cannot be monitored remotely. While researchers Kenetrian Garindaru, Achmad Ali Muayyadi, and Gandeva Bayu Satrya have developed systems that can monitor nutrients, temperature, and pH, there is also control of nutrients, temperature, and pH by controlling nutrient pumps. Fluid pumps pH up and down, and raw water that has been cooled is used to control the temperature of water. The disadvantage of this system is that it can only be monitored at locations connected to the Internet, not remotely.

It can be seen from the above discussion that although controls are only carried out on raw water pumps in this system, the nutrition of hydroponic plants in this system has 2 (two) advantages. The first advantage is that the monitoring system has been completed, covering water temperature, humidity, pH, and plant nutrients. The second advantage is that this system can retrieve sensor data remotely using LoRa communications with a range of up to 1 km so that it can be applied to locate without a direct internet connection.

5. Conclusion

This study implemented a system that can monitor humidity, water temperature, nutrients, and hydrogen potential (pH) in IoT-based hydroponics with communication networks using LoRA. Tests have been carried out both separately on each sensor and as a whole, and the system is working well. This research has completed a system that can control nutrition and water on IoT-based hydrophone plants with communications networks with LoRA. For further research, it could be done using more complex controls that include temperature and humidity controls. It can also be done using a more advanced microcontroller like the Raspberry Pi.

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