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Development of IoT Based Aquaponic Monitoring System for Agriculture Application

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Abstract: Agriculture's disadvantages include micronutrient imbalance, nitrogen pollution, and eutrophication. Pesticides increase resistance, extinction, biological proliferation, ammonia, algae, and acidity. Aquaculture and agriculture necessitate manual monitoring and management. Humans have a limited amount of time before measuring and regulating it. Water supply in agriculture will be harmed due to population growth, urbanization, and climate change. To improve water management and security, agriculture's water consumption must be reconsidered. This initiative focuses on aquaponic monitoring. The IoT aquaponics parameters will be monitored through the system design. Besides, the prototype will be tested and validated. The soil moisture sensor indicates the schedule for watering the plants. The indication of Sawi Plant receives enough sunlight is based on the DHT11 temperature sensor. The pH level sensor maintains a constant pH in the tank by feeding hydroponic fertilizers A and B. As a result, the project improves the current manual system, thus, promote this initiative to save money and time.

Keywords: Aquaponic System, Hydroponic Green House, pH Level Sensor, DHT11 Sensor, Soil Moisture Sensor, Motor Pump, Blynk Application.

1.0 INTRODUCTION

Our predecessors practiced agriculture thousands of years ago. Everything has pros and cons. Agriculture has downsides, such as using plant nutrients that cause micronutrient imbalance, nitrate pollution, and eutrophication. Agricultural pesticides cause pest resistance, extinction of non-target species, and biological multiplication. In regular aquaculture, animals excrete in rivers. It can increase water ammonia, algae growth, and water acidity. Aquaponics uses animal excrement as fertilizer. Third parties in an aquaponics system are microorganisms and nitrifying bacteria. It turns animal manure into nitrites. It turns nitrites into nitrates. Vermicomposting is a plant nutrient. Water is returned to the aquarium or aquaculture system. Aquaponics is chemical-free and natural. Pesticides, herbicides, and fertilizers can kill fish. Aquaponics food is 100% chemical-free. No chemical waste. We can monitor the aquaponics system's water level, temperature, pond pH, and soil moisture. Internet of Things sensors captures and transmit data. The Internet of Things in Aquaponics can alter agriculture by monitoring and managing system parameters for plant growth. Aquaponics Monitoring system for agriculture uses the Internet of Things to continuously show system metrics and information on a webserver.

Aquaculture and agriculture require manual monitoring and control, which takes time. On the ground, check plant water and wetness. As a human, time is restricted before measuring and managing it physically. Daily watering of plants, for example. The task is easily automated. Overwatering the plant is another major risk. Population growth, urbanization, and climate change will increase competition for water resources, affecting agriculture. Future issues need rethinking how water is managed in agriculture to improve water resource management and water security. Avoiding such calamities is crucial for preserving future water resources. Pesticides and fertilizers damage water. Hydroponics and aquaculture produce waste. Waste goods, such as fertilizer, will seep underground into the river and modify the composition of the river water, threatening the aqua life environment. This problem can be solved by using the Internet of Things in the Aquaponics Monitoring system for agriculture instead of manually monitoring. This project focuses on the best idea for an intelligent aquaponic system that few Malaysians use. Aquaponics uses the Internet of Things to monitor anywhere. This technique helps farmers record data and monitor their ponds and farm. This project uses a prototype for any sort of shrimp and fish in a pond to collect fertilizer for a farm's aquaponics system. The project's limitations. We all know it has limits. This project's the same. First, coverage is restricted. WIFI's range is too small to cover the area. Next, check WIFI stability. WIFI connection problems can cause connection faults during the signal's outage.

This paper examines shrimp farming and the environment. It studies and discusses the environmental repercussions of shrimp farming and environmental change. Environmental influences on shrimp production have caused serious economic losses for growers. According to the report, shrimp farming's economic sustainability is tied to how it tackles environmental concerns. The polluting industry may impair shrimp farming and coastal residents. For sustainability, farm planning, site selection, and management must respect the ecosystem's carrying capacity and the needs of other coastal resource users. Shrimp culture can help many developing countries' economies. [1]

Explained Animal antibiotic use is a risk factor for antimicrobial resistance (AMR), a global health problem. Shrimp farming's strong international trade and connection to the aquatic environment may contribute to AMR's global expansion. Untreated rubbish is often deposited in shrimp-growing areas. These hazards differ from many other important global aquaculture commodities, such as salmon, which are produced in higher-income nations with stricter laws and well-established management systems. AMR refers to microorganisms resistant to medications and chemicals designed to kill them. It's a major threat to human and animal health. An example of intensive, extensive, and integrated shrimp farming. [2]

The papers explored shrimp farming's water management and R&D. This review examines shrimp farming water quality parameters to improve survival rates and reduce illness outbreaks. This review study analyses the potential of membrane technology in shrimp farming based on separation performance and prior aquaculture deployments. This project aims to assess the possibility of establishing an integrated recirculating aquaculture system employing membrane technology to improve aquaculture water quality, reduce wastewater outflow, and increase water reuse. Shrimp farm wastewater, which is highly polluted, poses a major environmental concern. Proper water management in shrimp farming is crucial for a healthy culture and sustainable shrimp farming. [3]

The monitoring system in this paper combines microcontroller-based devices, the internet of things, and web apps to allow users to remotely monitor a shrimp farm and receive alerts when an out-of-range water parameter (such as temperature, pH, dissolved oxygen, salinity level, and turbidity) is detected. This system contains sensors that measure shrimp farm water quality. Agriculture is shrinking as the industry grows to meet human requirements. Humanity must maximize every inch of agriculture. "SAM-IoT" collects data on shrimp pond pH, temperature, and dissolved oxygen. On-site equipment sent radio frequency data to the ground station. The ground station retransmitted recorded data using TCP/IP. An app monitors real-time data. [4]

This review of Aquaponics, combining hydroponics and aquaculture, may help solve these challenges. Scientific research to produce economically successful aquaponics systems is lacking. Despite several scientific studies, commercial application has received little attention. The research-to-commercial aquaponic system implementation gap has been found. From the fish tank, water is routed through filtration machines and into hydroponic beds, which reprocess the water. Mechanical filtration devices remove solid particles, and biofilters nitrify. [5]

Therefore, this project is focusing on designing an aquaponic monitoring system, developing an IoT aquaponics monitoring prototype and finally, to test and validate the IoT-based Aquaponic Monitoring System for Agriculture.

2.0 MATERIALS AND METHODS

The experiments have been conducted in order to meet the specification of sawi plant.

2.1 THE DESIGN OF AN AUTOMATIC AQUAPONIC MONITORING SYSTEM IN AGRICULTURE.

The aquaponics system based on IoT is designed to collect the data from all sensors. Therefore, users can upload all the data to the Blynk Application Database. The Motor Pump will move fertilizer from the Aquarium to the small plant.

2.2 THE DEVELOPMENT OF AN IOT AQUAPONIC MONITORING SYSTEM PROTOTYPE

The system is created using Blynk application to monitor the activities of this system. Following that, the NodeMCU ESP8266 was used as the microcontroller and the WIFI Module. Finally, users can test the Blynk Application by creating a database to monitor all the sensors.

2.3 THE EVALUATION AND VALIDATION OF IOT BASED AQUAPONIC MONITORING SYSTEM

The suitable devices is created to ensure the system could be implemented and all sensors could capture the real time data.

2.4 Standard operation procedure (SOP) of Sawi Plant

NO	Measure	Detail
1	Planting	Germinate from seed
2	Harvesting	Full harvest
3	Yield	0.7-0.9lbs / Foot of Tower / Harvest
4	Pests and diseases	most common are aphids and powdery mildew
5	Ph range	4.0-8.4
6	Ec/ppm	1.5
8	Temperature	Range: 16–24 °C

2.5 BLOCK DIAGRAM

The block diagram in figure 2.1 displays the aquaponic system's control and monitoring the process flow. NodeMCU ESP8266 monitors and controls three sensors: water level, temperature, pH, and soil moisture. Including NodeMCU ESP8266, two 12V 5W Motor Pump outputs, and Blynk. The water level sensor measures the water level in a container, while the pH level sensor measures the pH in sample solutions by detecting the activity of hydrogen ions. The sensor measures water temperature. All three sensors provide data to the NodeMCU ESP8266 and Blynk. While the soil moisture sensor collects data, NodeMCU ESP8266 controls the 12V 5W motor pump.

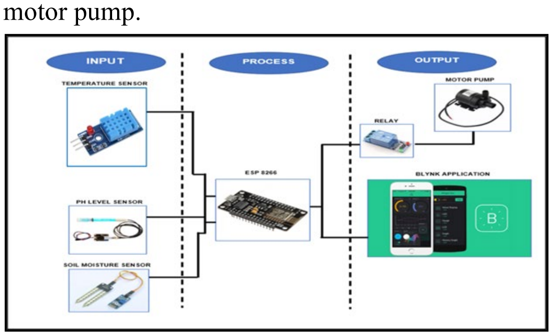

Figure 2.1: Block Diagram of Automated Control for Aquaponic System

2.6 FLOWCHART

Figure 2.2 shows the overall component and sensor, the flow chart starts by initializing and reading all the parameters utilized in this project, such as soil moisture, DHT11, and pH level sensors. Sensors detect dry coco peat soil above 50%. The aquarium pump will pump water to the plant. Wet coco peat soil indicates less than 50%. The motor pump will turn off and send data to Blynk. The temperature sensor measures the plant's temperature. The plant's temperature will be communicated to the cloud Blynk app. pH sensor measures the alkalinity and acidity of aquarium water. Every plant needs ammonia from aquarium fish. The owner will monitor the pH sensor's Blynk data.

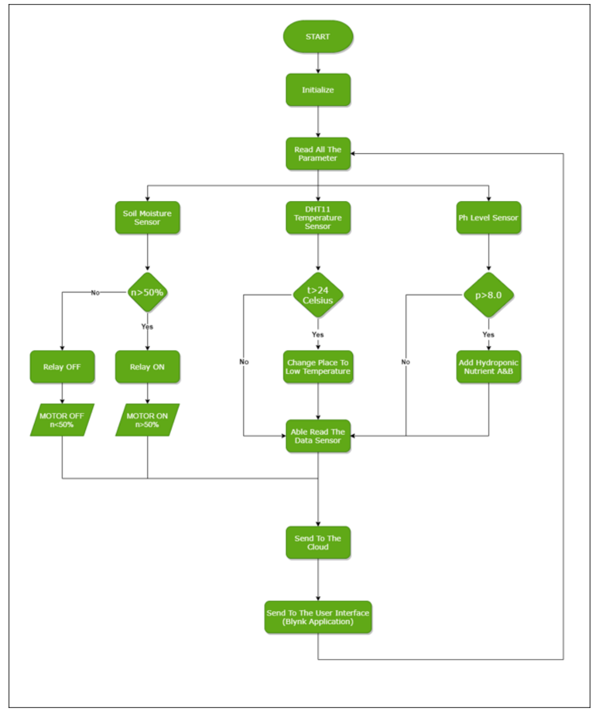

Figure 2.2: Flowchart

2.7 CIRCUIT DIAGRAM

The circuit diagram for this prototype is developed by using circuito.io, incorporating all the main components together with it, Figure 2.3.

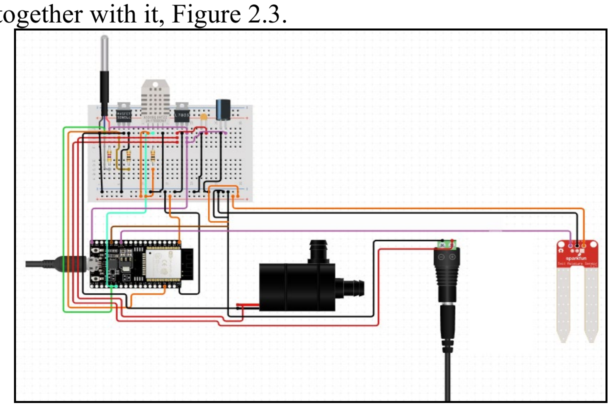

Figure 2.3: Circuit Diagram

3.0 RESULTS

3.1 RESULTS FOR EXPERIMENT 1

Table 3.1 until figure 3.5 show the project's findings following early tests and setups. Sawi plant height in 1 month using soil and hydroponics. The height of the plant is used to measure A and B nutrients, water, and sunlight.

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DAY	Type of Plant	
	Soil	Hydroponic
Day 1	0.0	0.0
Day 2	0.5	1.5
Day 3	1.5	2.0
Day 4	2.0	3.0
Day 5	3.0	3.7
Day 6	3.8	4.4
Day 7	4.6	5.2
Day 8	5.4	5.9
Day 9	5.9	6.7
Day 10	6.6	7.4
Day 11	6.9	8.2
Day 12	7.4	8.9
Day 13	7.4	9.7
Day 14	8.0	10.5
Day 15	8.5	13.5
Day 16	12.6	14.3
Day 17	13.4	15.0
Day 18	14.2	16.5
Day 19	14.9	17.3
Day 20	15.6	18.0
Day 21	16.3	18.8
Day 22	17.0	19.5
Day 23	17.7	20.3
Day 24	18.4	21.0
Day 25	19.1	21.8
Day 26	21.7	22.5
Day 27	22.5	23.3
Day 28	23.3	24.0
Day 29	24.0	24.8
Day 30	25.5	28.0

Table 1 The height comparison of the plant in one month

Figure 3.1: The height of the plants in 2 days

Figure 3.2: The height of the plants in 5 days

Figure 3.3: The height of the plants in 1 week

Figure 3.4: The height of the plants in 1 month

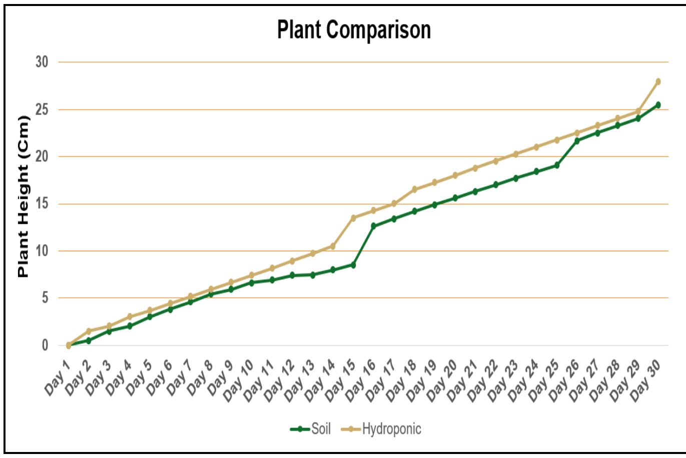

Figure 3.5: The Graph of Plant Comparison in 1 month

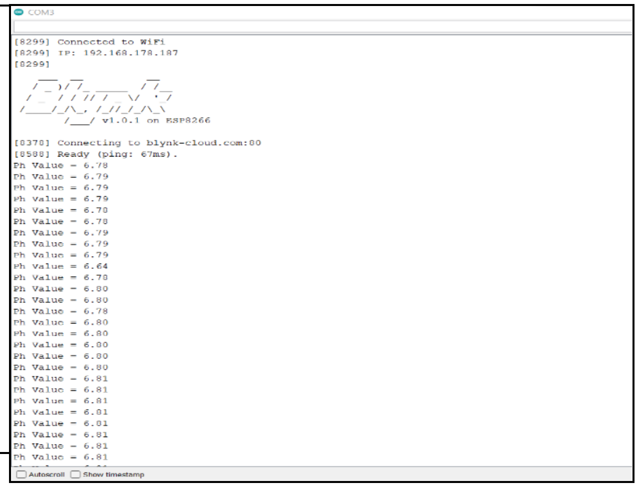

Figure 3.7: pH Level Sensor Reading on Arduino IDE

3.2 RESULTS FOR EXPERIMENT 2

Figure 3.6 and figure 3.7 show the NodeMCU ESP8266 microcontroller has undergone hardware testing. This hardware testing also includes Soil Moisture Sensor, DHT11 Temperature Sensor, and pH Level Sensor. Testing hardware ensures that it can be utilized for this project. This testing must prove that NodeMCU ESP8266 can communicate with all attached sensors. This sensor testing verifies that NodeMCU ESP8266 can communicate with the associated sensor. It also verifies the sensor's health. To check sensor operation, examine its serial monitor. Soil Moisture Sensor, DHT11 Temperature Sensor, Motor Pump module readings. As illustrated, Soil Moisture Sensor, DHT11 Temperature Sensor, and Motor Pump module real-time readings. pH sensor reading. The pH Level Sensor shows the midway pH between alkali and acidic.

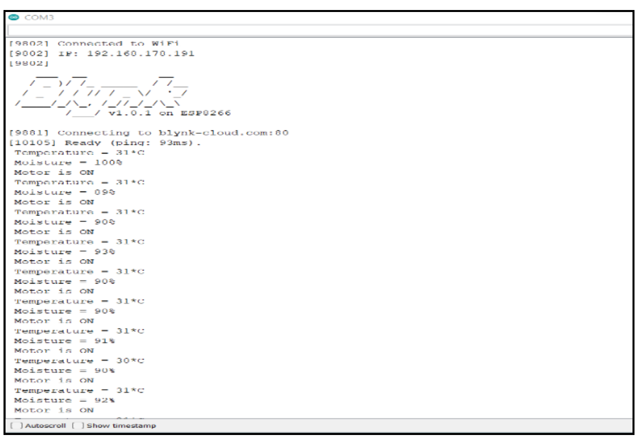

Figure 3.6: Soil Moisture Sensor, DHT11 Temperature Sensor, and Motor Pump Reading on Arduino IDE

Figure 3.7 shows the software testing is determined if a programmer met the criteria and checks for flaws. It involves evaluating software or system components with manual or automated mechanical equipment. Software testing identifies flaws, missing, or lost requirements. Practical and non-practical software testing are distinguished. Software testing uses a server-to-client connection to check database networks. Server testing improves performance, at least. Early investment helps complete the project more skillfully, accelerates progress, and improves product quality. All sensors used in this project output comparable to Arduino IDE serial monitor. The sensor can be utilized without faults or defective parts. The database showed soil moisture, temperature, and pH level.

Figure 3.8: The database by using the Blynk Application.

3.3 RESULTS FOR EXPERIMENT 3

Figure 3.9 and figure 3.10 is show the whole prototype design and circuit. The prototype of a combined hydroponic and aquaponic system is presented. This project is for farmers who want to farm fish and grow hydroponically grown plants.

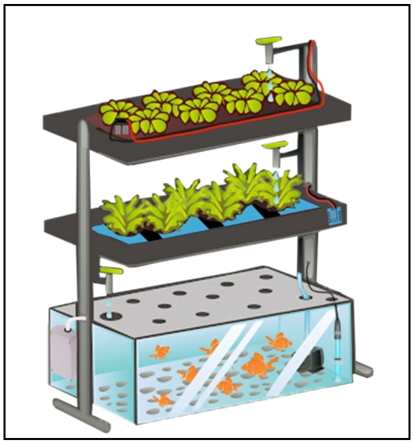

Figure 3.9: The Prototype of the Project

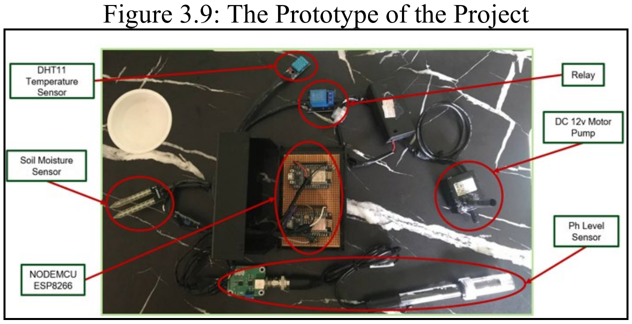

Figure 3.10: The Circuit of The Project

4.0 DISCUSSION

In this section, we look at our current system's shortcomings and make some projections for the future. The results are collected, as well as the output data. A sensor that detects soil moisture level indicates that container plants are receiving adequate amounts of water. Users can use the fully functional DHT11 temperature sensor to determine whether the Sawi Plant receives enough sunlight to thrive. The pH level sensor measures the pH of the water to ensure that it is suitable for plants and fish by adding hydroponic nutrients A and B to the tank and following the standard operating procedure. Users were able to meet all of our objectives by utilizing the IoT approach. This chapter contains a lot of information.

5.0 CONCLUSION

The project's goals were met. Three goals drive this project's growth. This project aims to build an aquaponic monitoring system for agriculture. Second, create an IoT Aquaponic monitoring system prototype. Third, validate the IoT-based Aquaponic Monitoring System prototype. This project's system and prototype operate well. This project's design was generated in Circuit IO and coded in Arduino IDE. The flowchart shows that this design works well. The breadboard circuit diagram was translated to stripboard. The strip board's jumper and components were soldered to look clean. This project also developed an access control prototype. Some project components are installed on the hardware, while others are in the casing. Each component attached to the enclosure has a distinct purpose, such as the NodeMCU ESP8266 microcontroller. Components not installed on the casing, such as DHT11 temperature, motor pump, soil moisture, and pH level sensor, were placed at the appropriate hardware location. All the wiring and components were neatly arranged to look decent. Next, one month of testing ensured that this technique can be applied at a hydroponic farm to save money and raise fish and plants for the market. Hydroponic and soil systems were tested for height and fertility. The test results are listed. All tests grow more accurate as the flowchart progresses. This project is better than the present one. Because the old method is still used and doesn't keep up with technology. This initiative can be publicized and promoted. This project could save money and time.

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