WATER CIRCULATION AND CONTROL OF HYDROPONICS USING THE INTERNET OF THINGS

Analyn S. Morite, Robert R. Bacarro, Gregorio Z. Gamboa Jr., Vinn Jayson Vincent D. Angob, Earl Mar P. Goñabo, Elton John M. Manzo

[1]Surigao del Norte State University, Surigao City, Philippines

Correspondent author: amorite@ssct.edu.ph

ABSTRACT: *The Internet of Things and sensors have had a significant influence on agriculture in recent years. Hydroponics, a method of growing plants without soil, makes it feasible. In order to give the proper control action for the hydroponic environment, this study develops an intelligent Internet of Things-based hydroponic system. a database the user may use to run the system created especially for this project on. The temperature, humidity, and ignition in hydroponics of the water pump are then shown. These data are kept in the Raspberry Pi database and retrieved by the website via the web server. This research takes advantage of the more affordable nutrition film technology (NFT). Surveys and web searches were utilized by researchers to gather information. In order to evaluate the data, the study makes use of a Proteus Simulator, sensors, a Raspberry Pi 3 Model B Plus, electrical parts, and statistical techniques including frequency count and mean. The findings of this investigation show that lower centimeter measurements point to a greater water level in the reservoir (remaining). Larger centimeter readings (remaining) indicate a lower water level since the ultrasonic distance sensor used to detect the water level is used. Furthermore, the pH level must be between 6.0 and 8.0. When it is higher than 8.0, it has a drawback since it could harm the plants. The study gave the device's performance a "Very Good" rating.*

Keywords: Hydroponics, IoT, Raspberry Pi, Nutrient

I. INTRODUCTION

Hydroponics is a subset of hydroculture that grows plants, often crops, without soil by using mineral fertilizer solutions that have been dissolved in water. Hydroponics is more efficient in areas with a lack of green space. [1] It is also used by amateurs to create food at home. With the Nutrient Film Technique, a type of hydroponics, plants are grown in channels with nutrient solutions continuously pumping through them and running down the bottom of the channels. When the solution reaches the end of the channel and enters a central reservoir, the system is then returned to its initial phase. It produces a system of recirculation akin to deep-water culture. [2]

The influence of hydroponics is significant. Effectiveness is improved by up to 90% water usage. Production increases by three to ten times in a particular location. Many crops may grow twice as quickly in a hydroponic system when it is effective and well-managed. The longer the time between harvest and ingestion, the higher the nutritional content of the final product. There is no need for chemical weed or insect control when using a hydroponic system. Due to indoor farming in a climate-controlled environment, farms may be established in places with unsuitable weather and soil conditions for conventional food production. [3, 4]

The persistent problem of climate change shared land and water pollution threats from overland flow and runoff, and the expenses of cultivation that open the door for sustainable agriculture are still evident today. As a result of changing temperatures and growth conditions, growing seasons and geographic areas are currently undergoing major changes. Even in the best of conditions, there are certain places where the soil is simply unsuitable for farming. Currently, most vegetables you buy at a store have been shipped in from abroad, losing part of their nutritional value in the process. [5]

By using a hydroponics system and the Internet of Things, hyper-local food systems may be developed. [5] Carefully regulated hydroponic systems were used to grow the plants. There is no longer a need to worry about the weather thanks to this technology. This technique will monitor and control the circulation of hydroponic systems and follow the growth of hydroponic plants when the weather is poor by employing sensors attached to the plant's growth components to measure temperature, humidity, and level in hydroponic reservoirs.

Humans have used agriculture to create civilizations, eradicate world hunger, and work to address problems like population growth and climate change. Researchers are interested in creating and advancing this technology since doing so will allow the community to benefit more.

1.1 Related Literature

A number of creative solutions have been developed as alternatives to the traditional gravel-filled bed. When determining which system to install, it is important to consider the type of crop planted, the required space, the duration of the growing season, the support system, and the cost. These systems can be installed in a growing room or a greenhouse.[6]. Some farmers use the greenhouse to finish the crop's growing cycle and the growth room for seed germination and seedling development. The excess heat generated by the growth room lights may be used to warm the greenhouse. One of the most cutting-edge technologies is hydroponics. [7]

Food production is usually hampered by environmental factors, which is why interest in alternative agricultural techniques is expanding. Hydroponic farming is a viable solution to a number of key problems that agricultural production faces, including a shortage of arable land, climate change, deforestation, rising fossil fuel prices, ecosystem degradation, and growing food and water scarcity.

When selecting a hydroponics method, it is important to consider the following factors: the available resources, the accessible space, the desired productivity, the growth medium, and the number of hydroponics methods that will be used.

Because of its relatively simple construction, the Nutrient Film Approach (N.F.T.) technique is also quite popular among amateur hydroponically growing aficionados. N.F.T. methods, however, are most effective and widely used for cultivating smaller, swiftly developing plants, such as several varieties of Chinese cabbage (Pechay) [8]. In addition to Pechay, or, by its scientific name, "Brassica rapa," some commercial producers also cultivate several kinds of herbs and young greens

Machine-to-machine connection and autonomous, intelligent control of the hydroponic system is made possible by the Internet of Things. According to this study, an intelligent IoT-based hydroponic system should be developed. [10, 11] [12]. Based on the many input parameters acquired, the system developed is clever enough to deliver the appropriate control action for the hydroponic environment.

The data to display the temperature, humidity, and ignition of the water pump in hydroponics is stored in the Raspberry Pi database, which is then accessed by the website via the web server. A database that may be used by the user as the host to run the system was specifically built for this project and installed.

1.2 Theoretical Framework

Plants and vegetables may grow well without soil or water. Contrary to what many people think, plants only need the nutrients in the soil. Hydroponic systems provide direct nutrient-rich water supply to the plant's root. Plants save energy since they don't have to spend any time searching for nutrients in the soil. Plants concentrate their energy on their healthy vegetative development.

The "Internet of Things" (IoT) is a network of real-world items that may connect and share data with other systems and devices over the Internet by way of sensors, software, and other technologies. [13]

Sensors are used in everyday objects like touch-sensitive elevator buttons and lamps that may be dimmed or brightened by touching the base, in addition to the innumerable uses that most people are ignorant of. Thanks to improvements in micromachinery and user-friendly microcontroller platforms, sensors are now used in many applications than only the traditional ones of temperature, pressure, and flow measurement [14]. The gathering of information on temperature, precipitation, humidity, wind speed, insect infestation, and soil composition are only a few of the numerous IoT uses in agricultural [15].

For instance, farmers may now use IoT-acquired data to implement precise fertilization regimens and remotely monitor soil temperature and moisture. With the use of this information, farming procedures may be automated, and knowledgeable choices can be made to increase yield and quality while lowering risk and waste.

The Raspberry Pi is a cheap, credit-card-sized computer that connects to a computer display or TV and makes use of a standard keyboard and mouse. It's a capable small device that lets people of all ages learn about computing and how to code in numerous languages. On this device, you can do whatever a desktop computer can do, including play high-definition video games,

1.3 Conceptual Framework

The following figure 1, shows the input-process-output diagram of the project.

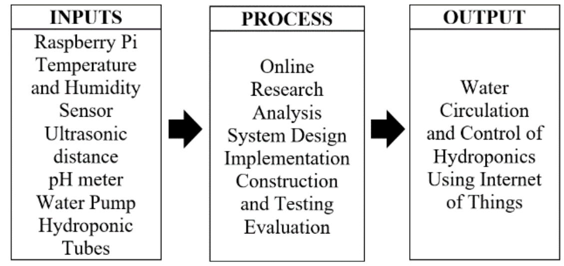

Figure 1. Input- Process- Output diagram of the project

The system flow is explained and the main idea is illustrated in the block diagram. The supplies required to carry out a power supply project are known as the input block. Systems for controlling and monitoring water circulation are created employing sensors for temperature, humidity, pH, ultrasonic distance, and proximity (HC-SR04). The raspberry pi's database stores the sensor data, which is subsequently accessible by the website via the web server on the raspberry pi in order to show the data. We constructed a scheduler to operate from the raspberry pi's real-time clock in order to calculate the timing of the water pump's activation in hydroponics. Relays are used as switches to regulate whether the water pump is on or off.

The steps that make up the process block include online research, analysis, system design, implementation, building, testing, and system assessment, to name just a few. Researchers employ approaches known as online research methodologies (ORMs) to collect data online. A detailed examination of a thing's parts or structure is called an analysis. System Design The process of defining the components, modules, interfaces, and data for a system in order to satisfy preset criteria is known as system design. Implementation is the carrying out, execution, or practice of a plan, a method, or any design, idea, model, specification, standard, or policy for doing something. Construction and testing are the testings of materials used to build new projects, add to existing projects, or amend existing construction projects. Evaluation measures a project's quality and accomplishment of its objectives and reveals the data gathered for the project's outcomes and activities.

The project's creative result, created by the input and process, will be Water Circulation and Control of Hydroponics Using the Internet of Things. A project's quality and the achievement of its goals are measured during evaluation, which also provides information on the project's activities and outcomes.

1.4 Objectives

This project aims to create and install an automated hydroponics system utilizing sensors and a Raspberry Pi, reducing the need for human involvement and supporting local farmers in giving up the cumbersome and time-consuming traditional farming method.

1. To monitor the temperature and humidity, water level, and pH level of the plants in hydroponics using the IoT.
2. To control the flow of water into the pipes where the plants were placed.

3. To supply the ideal nutritional environment for optimum plant performance.
4. To evaluate the performance level of the project.

II. METHODS

2.1 Research Design

The design employed in this study is the nutritional film technique (NFT), which is easier to build than alternative designs. These systems are reliable and low-maintenance, and they only need one checkup every day. This hydroponics arrangement produces excellent results. A sensible option for organic hydroponic growing systems, NFT is a straightforward hydroponics design. Again, the components, layout, and operation are all straightforward.

This project required substantial knowledge of farming and hydroponics. Creating a definition of a hydroponic system was the first goal. Using the hydroponics method, plants are grown in a nutrient-rich water-based solution. Hydroponics supports the root system with water rather than dirt. The next stage was to choose the type of water that would be used for comparison and to figure out how much water was needed.

2.2 Project Design

The project's block diagram, Figure 2, is displayed in the picture below.

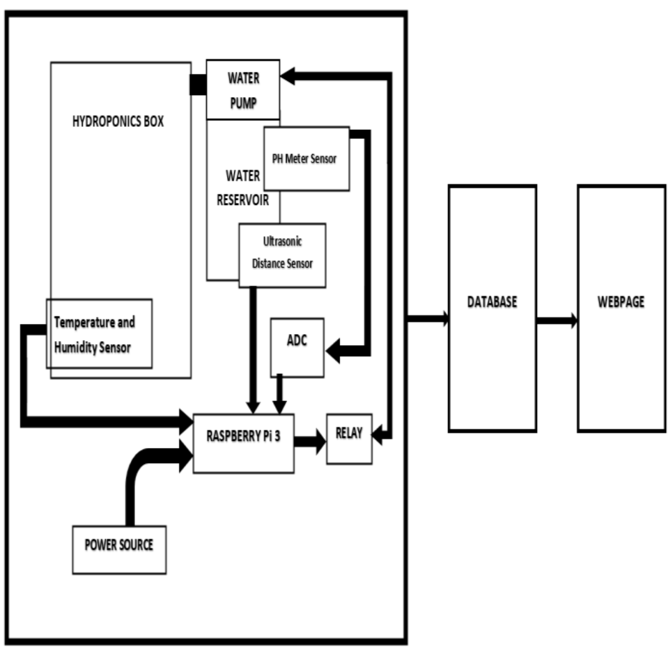

Figure 2. Block Diagram of the project

Three boxes are shown in the project's design, the first of which stands in for the hydroponic system and the sensors that are connected to the Raspberry Pi, which serves as the system's central processing unit. The Raspberry Pi is equipped with a number of sensors, including temperature, humidity, and an ultrasonic sensor with an ADC (analog to digital). The output data from the sensors will then be input into the database, and presented on the webpage, and the connection between the webpage and the hydroponic system where the sensors are situated will be monitored. The data on the internet, where the sensor data are shown and can be manipulated even if the user is far away, will be the final product.

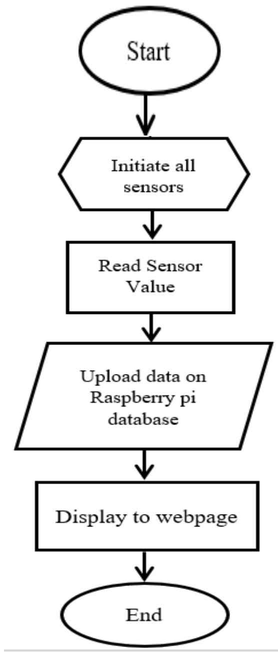

Figure 3. Flowchart of the system

The flowchart for the study, which is shown in Figure 3, served as the researchers' instruction manual on how to carry out the data-collecting procedure. The project starts with all the sensors initializing, as indicated in the diagram, and uses sensor readings as input. Data from the sensor will be processed by the Raspberry Pi before being sent to the database. When the data is shown on the webpage, the procedure will be complete.

2.3 Project Development, Figure 4.

The first stage in finishing a project study is conducting online research. At this time, almost everything a person needs or desires is presently available online. At this stage, the researcher will be able to take up some knowledge and ideas that may help them put together a solid study.

The next stage of this research study's development is system design. The complexity of system design results from the necessity to consider a wide range of variables, such as materials, finances, sizes, the project's mechanism, packaging, and many other things. So that there are less problems in the later phases of implementation, everything should be carefully planned. Programming also produces instructions that describe to a computer how to complete a task and how the project works.

The third phase comprises making material purchases. All materials for the project's construction should be ordered or available as soon as feasible.

The remaining two processes are construction and testing. After completing the necessary materials, the researcher may now start putting the project into practice. The internal parts will be the first to be developed, including the solar panel, stepper motor, Bluetooth device, etc. Trial and error is also necessary to establish whether or not the project is operating effectively.

The project's packaging should also be neat and professional. The final phase of this research study is the system evaluation. Performance, usability, aesthetics, and features of the project will all be evaluated. The researcher will employ paper-based techniques like surveys and in-person interviews to gather data from the participants' opinions.

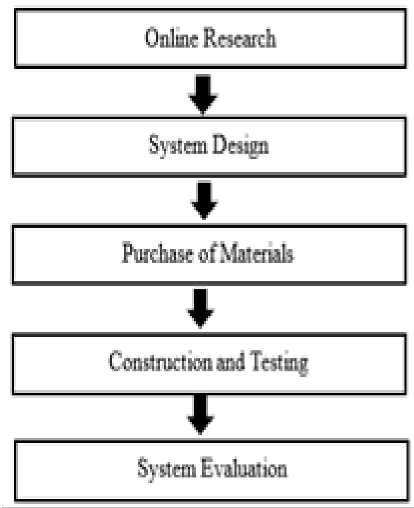

Figure 4. Project Management Diagram

2.4 Project Implementation

The project must be completed in a setting that enables testing and performance. Researchers run a test and survey with participants, farmers, and experts. The researchers and participants will manage and monitor the project if it can meet the process expectations and the project's declared result. Farmers and industry experts will test the idea to determine whether it can be utilized with contemporary hydroponic systems and the Internet of Things (IoT). If the project doesn't yield the required results, the researchers will make the necessary corrections and retest the project until it does.

2.5 Project Settings

A hydroponics system may be installed almost anywhere, both inside and outside. The aforementioned project will be put up and tested in Surigao City, at Barangay Purok Mariposa, Narciso St. Professionals, and farmers are invited to participate in, watch, and offer input on the hydroponic farming utilizing IoT project by the researchers. However, since a survey is easier to conduct, the researchers chose to do so.

Figure 5. Location of the place

2.6 Participants of the Study

The participants in this study project are the project beneficiaries, which comprise professionals and farmers. Competent assessors are selected based on their knowledge to determine whether the framework's implementation is agreeable enough for the correct implementation. The framework is then assessed by ranchers, users, and evaluators to see whether it should be used in the proposed project.

Table 1. Participants of the Study

PARTICIPANTS	f(n=10)	%
Gardener	**4**	**40%**
Farmer	**5**	**50%**
Agricultural Engineer	**1**	**10%**
TOTAL	**10**	**100%**

2.7 Instruments

The following tool was used in this study to carry out the research:

The Proteus Design Suite, which includes the Proteus Simulator, is a group of unique software tools mostly used for automating electrical design. Electronic design experts and technicians use the application to create schematics and electronic prints for printed circuit boards.

The DHT22 Temperature and Humidity Sensor uses a thermistor and a capacitive humidity sensor to monitor ambient humidity and provide a digital signal on the data port.

Raspberry Pi 3 Model B Plus: The most recent version of the Raspberry Pi 3 includes a 64-bit quad-core CPU operating at 1.4GHz, dual-band 2.4GHz and 5GHz wireless LAN, Bluetooth 4.2/BLE (Bluetooth Low Energy), faster Ethernet, and PoE functionality through a separate PoE connector (Power over Ethernet).

Ultrasonic distance sensor: An electronic device that measures the separation between a target item and itself using ultrasonic sound waves, then converts the sound reflection into an electrical signal.

It is often used in many different contexts, such as aquaponics, aquaculture, and environmental water monitoring. pH Meter Sensor: Designed particularly to detect the acidity or alkalinity of a solution's pH.

Ads1115: A multiplexed 16-bit ADC with the precision of four inputs.

They are used to switch or operate 5V single relays that need more power than most microcontrollers, such as Arduino or Raspberry Pi, can provide. This single-channel relay module operates at 5 volts. This particular relay module has the ability to control up to 10A of typical household appliances.

Hydroponics System Pot: Made of strong plastic mesh, hydroponic net pots are typically reusable and designed to promote drainage and airflow. Net pots are also known to encourage strong plant growth and root development. Plants may readily get moisture and nutrients thanks to the holes that are dispersed along the sides of the pots.

Using a motor, provide energy for fluid movement or flow by converting rotational or kinetic energy (hydrodynamic energy).

LCD: Used in calculators, microwaves, and many other electronic devices to display data.

2.8 Research Ethics

When conducting this study, the researcher takes care to comply with all applicable laws and environmental requirements. They will have voluntarily agreed to participate in this study, so they are free to withdraw at any moment and for any reason. Complete details on the objectives of the study were also provided to participants. Participants' safety was also ensured throughout the trial; neither they nor anyone else was physically or emotionally abused. On the other hand, the researcher made an effort to create and maintain a warm atmosphere.

2.9 Data Collection Procedure

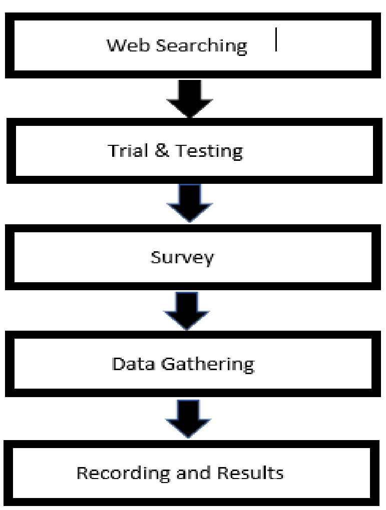

Figure 6. Data Collection Procedure Diagram

The procedure for acquiring data for this research project is shown in Figure 6 above. Web browsing is one of them, as well as experimentation and testing, polls and interviews, data collection, recording, and outcome analysis.

The first thing a researcher does is search the internet for information that will help them comprehend the project and how to accomplish it. In order to avoid mistakes during project execution, researchers focused on the concerns and problems related to the area of interest. Conclusions and recommendations are also given.

Through the answers to survey questions from a sample of people, researchers collected data.

To gather data, researchers employed questionnaires and web searches. There were a lot of experiments and assessments. The participants respond to a variety of questions, and the researchers conduct a survey to gather data on the project's efficacy. Additionally, a record of every piece of data obtained through survey questions and in-person interviews was kept.

2.10 Statistical Tool

The mean is the statistical method applied in the project investigations. The percentage of males and females in the sample, for example, is only counted once in frequency statistics. The mean, for example, is the single number that aggregates all of the scores in a measure of central tendency.

As an alternative, "Mean" is the average, which is determined by dividing the total number of data points by their sum. A helpful statistical tool is the mean, especially when comparing different data sets.

2.11 Financial Analysis

How many hydroponics systems with IoT are sold over a month, quarter, or other time frames serves as the foundation for the device's break-even analysis. For this initiative to be viable, the researchers must sell at least five planters each month.

III. RESULTS AND DISCUSSIONS

Figure 7. Prototype of the Design

Shows the horizontal plantation of the project.

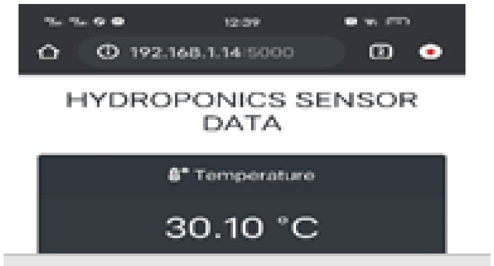

Figure 8. Measured Values displayed on the Webpage

The measurements were made, and the website published the findings (IP address: 192.168.1.14:500), Figure 8. The temperature reading is in the top box, Figure 8, followed in that order by readings for humidity, water level, and pH.

Table 1. Temperature and Humidity of the Hydroponics system (Week 1-2)

NO	WEEK 1		WEEK 2	
	T	H	T	H
1	29.6°C	74.3%	29.6°C	75.1%
2	28.8°C	80.3%	29.9°C	77.6%
3	29.5°C	76.1%	28.1°C	77.2%
4	29.2°C	78.9%	30.2°C	81.3%
5	29.7°C	77.8%	29.2°C	80.4%
6	28.9°C	79.7%	31.5°C	76.2%
7	29.8°C	80.3%	31.3°C	75.2%
R	**29.3°C**	**78.3%**	**29.9°C**	**77.6%**

Table 2. Temperature and Humidity of the Hydroponics system (Week 3-4)

NO	WEEK 3		WEEK 4	
	T	H	T	H
1	29.9°C	80.5%	31.2°C	90.1%
2	31.5°C	80.9%	30.4°C	92.3%
3	31.1°C	78.2%	28.8°C	95.6%
4	30.4°C	77.6%	29.7°C	90.8%
5	29.3°C	79.4%	30.1°C	92.1%
6	31.4°C	76.7%	31.2°C	91.8%
7	29.2°C	81.1%	31.3°C	93.6%
R	**30.4°C**	**79.2%**	**30.4°C**	**92.32%**

Table 3. Temperature and Humidity of the Hydroponics system (Week 5-6)

NO	WEEK 5		WEEK 6	
	T	H	T	H
1	30.3°C	93.7%	29.5°C	91.6%
2	30.1°C	90.3%	30.1°C	92.3%
3	31.8°C	94.1%	31.1°C	94.7%
4	29.1°C	92.3%	31.8°C	90.1%
5	29.3°C	90.3%	30.4°C	91.5%
6	31.1°C	90.9%	29.4°C	95.5%
7	30.9°C	92.9%	29.2°C	94.7%
R	**30.2°C**	**92%**	**30.07°C**	**91.9%**

T – Temperature
H – Humidity
R – Average

The alternate data for the Brassica rapa, which is healthy and normal and will be seen in around 6 weeks, are shown in Tables 1, 2, and 3.

Table 4. Water Level of the Reservoir consumed by Brassica Rapa

WEEK	cm (consumed)	cm(remaining)
1	1.7cm	3.4cm
2	1.9cm	5.3cm
3	2cm	7.2cm
4	1.9cm	9.1cm
5	1.9cm	11.1cm
6	1.9cm	13cm

A greater water level in the reservoir is indicated by lower centimeter measurements (remaining). Due to the use of an ultrasonic distance sensor to measure the water level, larger centimeter values (remaining) reveal a lower water level.

Table 5. pH level of the Water Reservoir

PLACEMENT	MACHINE RESULT MEAN
April 1-10, 2021	
Week 1	**6.75**
Week 2	
April 11-23, 2021	
Week 3	**7.15**
Week 4	
April 25- May 15, 2021	
Week 5	**7.4**
Week 6	

The pH must range from 6.0 to 8.0. It has a disadvantage when it is higher than 8.0 since it could hurt the plants.

Table 6. Flow of water into the pipes

WEEK	Time		LITRES
	A.M	P.M	
1	7:00-7:30	5:00-5:30	14 L
2	7:00-7:30	5:00-5:30	
3	7:00-7:30	5:00-5:30	
4	7:00-7:30	5:00-5:30	8 L
5	7:00-7:30	5:00-5:30	
6	7:00-7:30	5:00-5:30	

The moment the system is going to start working is shown in Table 6. Both the morning and the afternoon have a 30 minute period. Up to the third week, the Brassica Rapa absorbs the first week's 14 L. From the fourth to the sixth week, researchers add 8 L of water to the reservoir.

Table 7. Nutrient Solution putted to the reservoir

WEEK	
1	60 mL
2	
3	
4	40 mL
5	
6	

The nutrients that were applied in the first week are shown in Table 7, and the Brassica rapa was moved to a hydroponic system until the third week when it was utilized once again from the fourth week to the sixth week.

Table 8. Evaluation of Performance Level of the project

Criteria	Mean	QD
Accuracy in terms of:		
Minimum use by the sensors to the hydroponics system	3.25	**Very Good**
Accurate values of the results when tested the hydroponics	3.00	**Very Good**
Dimensions of the water quality monitoring device.	3.25	**Very Good**
Total Mean	**3.17**	**Very Good**
Durability in terms of:		
Device portability and weight.	2.50	**Good**
Can be used to dry and wet environments.	3.00	**Very Good**
Packaged according to use and function.	3.00	**Very Good**
Total Mean	**2.83**	**Very Good**
Efficiency in terms of:		
Operation and function of the device.	3.25	**Very Good**
Less work in monitoring the hydroponic plant	3.00	**Very Good**
Wireless network is efficient to combine with the device.	3.25	**Very Good**
Total Mean	**3.16**	**Very Good**
Grand Total Mean	**3.05**	**Very Good**

The rating scale for the gadget is bad (1 to 1.5), good (1.6 to 2.5), very good (2.6 to 3.5), and excellent (3.6-4).

With an overall grade of 3.28, or what is referred to as a "Very Good" gadget in terms of accuracy, durability, and efficiency, Table 8 displays the evaluation of the project's performance level that was provided by the project's participants.

IV. CONCLUSIONS

The paper derives the following findings from the researchers' experiments on monitoring and managing water circulation in hydroponics using sensors on a Raspberry Pi and the Internet of Things:

For improved environmental management, all sensor data, including temperature and humidity, pH and ultrasonic distance, and water level, should be tracked continually on a mobile device or computer. It has been observed that this technique effectively develops Brassica Rapa without the need for soil. Plants grow more quickly in a hydroponic system than they do on soil.

The water circulation in the hydroponics system is monitored, scheduled to start, and constantly under control. Easy-to-use IoT has been beneficial. The right amount of water was delivered to Brassica rapa by the flow of water containing fertilizer solution.

Brassica Rapa is supplied with nutrients for system nutrition monitoring, which greatly speeds up and enhances the growth of Brassica Rapa.

With the assistance of the participants, it is determined that managing and keeping an eye on the Brassica Rapa is fundamental to the project's success. The device's performance was rated as "Very Good" as a consequence.

V. REFERENCES

[1] J. Heinrich Lieth, Asher Bar-Tal, Michael Raviv “Hydroponics Soilless Culture” 2019 https://doi.org/10.1016/C2015-0-01470/
[2] Asher Bar-Tal, Michael Raviv “Hydroponics Soilless Culture Nutrient Film Technique” 2019
[3] Brown, Lester R. "Struggling to Raise Cropland Productivity" In State of the World: 1998
[4] J. Dianne Dotson 2018 “Agriculture Modern Cultivation”
[5] John W. Bartok, Jr. Agricultural Engineer “Innovative Hydroponics System” NRME Department, University of Connecticut, Storrs CT 06269-4087 2009
[6] Ines Hajdu Agronomy Expert “Greenhouse Farming Exceeds Weather Limitations” 2019
[7] Kevin Espiritu “Epic Gardening Hydroponic System” 2011
[8] Asher Bar-Tal, Michael Raviv “Hydroponics Soilless Culture Nutrient Film Technique” 2019
[9] Tagalog Lang. Petsay [Online] Available: https://www.tagaloglang.com/petsay/#:~:text=It%20is%20a%20subspecies%20of,pechay%20wombok%20in%20the%20Philippines
[10] Rouse, Margaret (2019). "Internet of things (IoT)." *IoT Agenda*. Retrieved August 14, 2019.
[11] Brown, Eric (September 20, 2016). "21 Open-Source Projects for IoT". *Linux.com*. Retrieved October 23, 2016.
[12] Hendrik, Alfendo, 2016, “Design and Construction of IoT Based Automation System Prototypes in Hydroponic Agriculture.”
[13] Meola, A. (December 20, 2016). "Why IoT, big data & smart farming are the future of agriculture." *Business Insider. Insider, Inc*. Retrieved July 26, 2018.
[14] S. Kothari, D Kadam “Internet of Things Sensors” 2015 – *academia.edu*
[15] Channe “Smart Agriculture using Internet of Thing Sensors” *academia.edu* – 2015