Chapter 1

BACKGROUND OF PROJECT

This chapter includes the background of the study, objectives of the study, theoretical and conceptual framework, significance of the study, scope and limitations of the study, and the definition of terms.

Background of the Study

The Philippine agriculture economy has been the foundation in terms of contributing to the country's development. The agricultural industry is obliging to introduce and implement new systems, practices, and technologies. Crop Health Monitoring System is developing. A system that uses the application of advanced technologies in providing data-driven approach with the use of different sensor devices, gateway connectivity, and user-friendly dashboard to monitor the crops in real-time to increase the number of good quality crops. Some crop health monitoring system applications are bound with Precision Agriculture, which provides measuring and responding to inter and intra-field variability in crops.

Farming methods make its way to betterment as modern technologies developed rapidly through the years wherein every aspect of farming can benefit from watering, planting, and focusing on crop health. When applying crop health monitoring to this research, the researchers come up with a solution to integrate modern types of technologies in this device wherein the crops will be monitored as well as gather its data. This application of Crop Health Monitoring System is called Smart Crop Monitoring. This device has been proven to be effective and useful in reducing the labor costs and human effort

The automated system will minimize the need of manpower, and reducing the error. For a largescale area, it is quite impossible for a certain farmer to monitor the efficiency of the system by implementing this technology, the farmers can easily monitor the system using their smart phone. The goal of installing an automated system or field service is to increase farm efficiency. This method is recommended for constantly monitoring plant health and controlling soil parameters such as temperature, humidity, and soil moisture. The system device is made up of various sensors, control, and communication units. A sensor circuit will collect, send and monitor this data for the farmers.

The study of J. Roper, et al. (2021) stated that the global population is expected to reach 9.8 billion people by 2050. Farmers, on the other hand, face numerous challenges, including extreme temperatures, soil degradation, and drought, all of which are expected to get worse as the climate changes. Increased sustainable agricultural practices are required to ensure high yields with minimal inputs and minimal environmental impact. They examine the use of Nanotechnology in plants has the potential to create more productive systems of agriculture. It can improve farming in several ways, including formulation of Nano fertilizers and agrichemicals, Nano sensors for disease or pest detection and technology for postharvest crop.

On the other hand, H. Jeong, et al (2016) looked at measuring salinity, an important factor in plant health and crop yield. Salinity refers to the concentrations of salts in water or soils. They developed a real-time monitoring system to detect salinity in a nondestructive manner through electrical conductivity inside the stems of tomato plants. They designed a self-contained unit, including a microneedle electrode and electrode pad that can be inserted into the stem of a tomato plant. This device was tested in greenhouse conditions and in field conditions. In field conditions, there was a decrease in signal noise and a decrease in electrical conductivity measurements, though the authors believe that decreased signal can be fixed by redesigning the electrical components to make it more practical for in-field use. A similar methodology, employing a thermal microneedle probe, was used to measure xylem sap movement in tomato stems.

However, S. Siddagangaiah (2016) stated in his study Plant Monitoring System is the science of understanding and overcoming the progression of biotic and abiotic factors that restraint the plants from reaching their full genetic potential as crops. The implementation of the study will check the environment parameters like temperature, humidity, light intensity and soil moisture that has effects on plants. Lighting is important because the color of the leaves shows how much light is needed. All the information is sent to Arduino boards to IoT cloud platform then if there are any alteration in the sensors value then alert message is sent to the user's smartphone.

As has been noted in a study conducted by R.K. Kodali, et al. (2017) A functional and dynamic language is ported to the ESP8266 board that is interface to the temperature and humidity sensor that sense the conditions of the said parameters. Humidity is important to make photosynthesis, when the temperature is high and humidity is normal, more stomates will open, letting in carbon dioxide for active photosynthesis. Monitoring properly will be used to plan for such variations in the future, therefore, an automated system is need to measure these weather parameters.

Moreover, the study of A. Kohli, et al. (2020) stated that plants play a vital role in maintaining the bionomic cycle, and thus, to sustain the plant's proper growth and health, suitable monitoring is required. They create a smart plant monitoring system using automation and internet of things technology. It has the feature of smart decision based on soil moisture real-time data. Signals will send to the Arduino board when the moisture level drops, which triggers the solenoid valve. When the moisture level reaches certain value, the solenoid will turn off.

In additional, M. Teogangco (2022) study seek on providing innovated system to automatically monitor, sense and control the parameter of a plant. The Philippines' environment is constantly changing, there are unexpected disasters, and some crops are in their off-season, which has an impact on the quality of the crops. Crops are turning into waste that cause changes in prices. They use Raspberry PI for the automated nurturing. Sensors attached are for temperature, humidity and moisture level of the plant, with the help also of a camera, they are able to view the current physical status of the crop. Gathered data from sensors will send to the IoT Cloud to show current information from the input devices.

According to S. Dizon et al., (2020) to monitor crops, there are technologies with sensors available which are embedded with microcontrollers in monitoring and measuring plants and vegetables. Interfacing devices with sensors have been reported but an embedded system for monitoring, measuring and controlling plants and vegetables required proper system implementation. Likewise, the data display should be available to farmers in a manner that is easy to access. This can be in a form of handheld devices which can be operated without great effort by a non-technical person like farmers.

The development of plant monitoring system help minimizes the water loss and reduces the constant supervision required for soil where plants grow. This prototype was developed as a low cost and provides alternative solution for efficient water management.

As Stated by Philippine Statistics Authority (2020), the agricultural production statues in the Philippines managed to grow 0.5 percent. 5.0 percent growth in production. It shared 53.7 percent of the total agricultural output, where palay went up by 7.1 percent and corn by 15.4 percent. At current prices, the value of agricultural production amounted to Php. 439.8 billion. This was 4.6 percent higher than the previous year’s level.

In building the Smart Crop Monitoring Device, this research shall consider the following legal basis that is related in this study. As mandated in Republic Act 10915 or also known as "An Act Strengthening, Modernizing and Aligning the Practice of Agricultural Engineering in the Country into the Internationally Recognized Practice of Agricultural and Bio Systems Engineering, and for Other Purposes". In Article 1 Section 2. Statement of Policy:

> “It is hereby declared a policy of the State to promote, strengthen and regulate the practice of agricultural and bio systems engineering profession in the Philippines by instituting measures that will result in relevant agricultural and bio systems engineering education and enhanced roles and better career prospects for agricultural and bio systems engineers.”

The Smart Crop Monitoring Device promotes organic method of farming so therefore, according to the Section 2 of Republic Act No. 10068, "An Act Providing for the Development and Promotion of Organic Agriculture in the Philippines and for Other Purposes";

> "It is hereby declared the policy of the State to promote, propagate, develop further and implement the practice of organic agriculture in the Philippines that will cumulatively condition and enrich the fertility of the soil, increase farm productivity and farmers' incomes, reduce pollution and destruction of the environment, prevent the depletion of natural resources, encourage the participation of indigenous organic farmers in promoting their sustainable practices, further protect the health of farmers, consumers, and the general public, save on imported farm inputs and promote food self-sufficiency”.

When it comes to monitoring the health of their certain crops, different factors such as excessive heat from the sun and heavy rainfall

Farmers need to be vigilant in observing their crops to ensure that they can take timely action to prevent or minimize any potential damage. For instance, if a farmer observes that their crops are being affected by excessive heat, they may need to irrigate the crops more frequently or use shade cloth to protect them from the sun.

Given all the scenarios and data gathering, the researcher come up to the development of the Smart Crop and Health Monitoring System for Cucumber Farming: Innovating Techno – Ecological Awareness.

<u>Objectives of the Study</u>

Generally, this study aimed to develop Smart Crop and Health Monitoring System: Innovating Techno-Ecological Awareness.

Specifically, this study sought answers for the following objectives:

1. To design a sensory device that creates a sustainable platform of sensing for cucumber farming.

2. To test the level of acceptability of the developed system in monitoring soil moisture, temperature and humidity of the cucumber in terms of:

    2.1 Functional Suitability;

    2.2 Performance Efficiency;

    2.3 Reliability;

    2.4 Maintainability; and

    2.5 Portability.

3. To develop user's manual for the operation and maintenance of the developed device.

Theoretical Framework

Different theories and engineering principles that are related in this research. The following are as follows:

As cited in CCNA Wireless 640-722 Official Cert Guide. (n.d.) "Basic Wireless Theory" indicates that to send data across a wired link, an electrical signal is applied at one end and is carried to the other end. The wire itself is continuous and conductive, so the signal can propagate rather easily. A wireless link has no physical strands of anything to carry the signal along.

Wireless technology is a major factor for this research. Monitoring the health of a vegetable crop using smart phone, helps the farmer to know whether his/her crop is in good condition to grow and when something requires extra observation in order to achieve desired result.

The wireless technology that we will be using this study is a NodeMCU. NodeMCU is an open-source platform based on ESP8266 which can connect objects and let data transfer using the Wi-Fi protocol. NodeMCU was built so that the AT command can be replaced with the Lua Scripting.

Process monitoring theory is the process of monitoring that ensures machines run more efficiently. It signals users any problems so they can be immediately resolved. This essentially results in increased production time, quality control, and machine efficiency. It compares performances of systems, equipment, and software and how they integrate and work within a whole process. Monitoring means to observe and check the progress or quality of something over a period of time; keeping under systematic review.

Process monitoring has a unique benefit, it is applied continuously by computer systems and makes short-term, temporary changes to the system to keep it at the desired value or data in the face of process disturbances. Rather than wait till the end of the process to discover poor quality product, we should be monitoring, in real-time. When we discover unusual variability, the aim is to make small process adjustments to avoid that variability from ever occurring again.

To monitor the process and the parameters condition in the system we will use DHT22, a basic, ultra-low-cost digital temperature and humidity sensor. This sensor can be easily interfaced with any micro-controller such as Arduino. Sensor is a device that detects the level or any changes in a physical stimulus and turns it into a data signal which can be measured or recorded.

Conceptual Framework

The conceptual framework of the study is designed relative to coombs system approach. This includes input, process, output, and feedback.

The research aimed to implement a Smart Crop and Health Monitoring System for Cucumber Farming: Innovating Techno – Ecological Awareness. The model of this system helped the users to understand the purpose and procedure of this research.

Figure 1 shows how the monitoring of the data and different factors affect one's crop inside the Smart Crop System. The inputs were the value of temperature and humidity, soil moisture that can be gathered with certain environment of one's crop or plant. These inputs undergone different procedures such as, detecting and gathering the values of the data parameters through different sensors, transmitting a data signal to the Arduino platform and displaying the data values to the main system.

The output of the research was the developed technology of Smart Crop and Health Monitoring System for Cucumber Farming: Innovating Techno – Ecological Awareness. Lastly, feedback served as the illustration of the outcome that affect or prove the process.

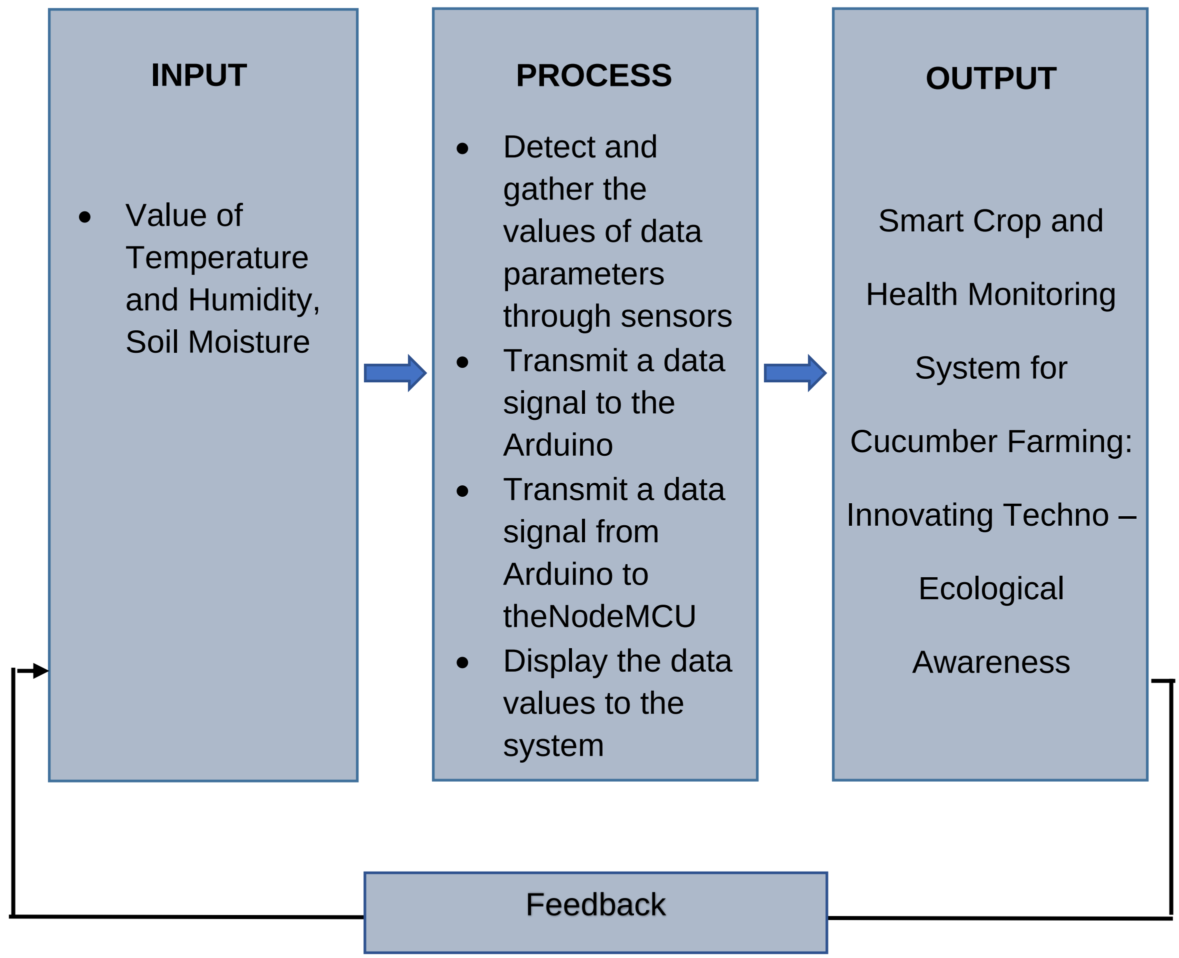

Figure 1

Conceptual Framework of the Smart Crop and Health Monitoring System for Cucumber Farming

Significance of the Study

This study mainly focused on the design and development of Smart Crop and Health Monitoring System for Cucumber Farming: Innovating Techno-Ecological Awareness. The proponents of this study believe that conducting this research will give benefits to the following concerns.

Farmers. This system will be significant in helping the farmers to improve the methods of farming and to lessen the labor hour of the farmers. This study will contribute to the innovation of smart farming, it automatically shows and display to the user and the accuracy in monitoring the soil temperature, soil moisture, humidity, and temperature may have a high percentage.

Community. This research will be a big support to farmers who were planting carrots in increasing the rate of the crop in a community. The community may also benefit in this study when the production of carrots is high, that can provide the demand of the residences in a community.

Researchers. This study will help the researchers to strengthen and improve their capabilities in their chosen field. To be able to utilize the whole process of the system involve in this study.

Future Researchers. This research study may be a valuable reference for the researchers who would plan to pursue a related study.

Scope and Limitations of the Study

This research study focused on the monitoring the health of a certain crop, especially cucumber. Different factors may vary depending on the said parameters inside the device. The collection of the data was performed to 10 farmers in Barangay Quisao, Pililla, Rizal and 30 students from the University of Rizal

System. This study is limited to monitor and record the data values of temperature, humidity, and different parameters inside the device and no longer includes the infestation of pests. The main objective of this research is to observe and track the condition of farmers' cucumber crops. The study would be done through the utilization of questionnaire checklist to the farmer as a survey and reference.

Definition of Terms

To facilitate the understanding of the study, the following terms are defined operationally;

Accuracy. The quality of being correct and error-free. The point which the result of a measurement, calculation, or statement match up to the correct value.

Appearance. The condition, state, feature and style in which the system appear whether both the internal and external appearance of the system.

Crop. Plant or plant product that can be grown and harvested for profit or subsistence.

Effectiveness. The stage in which the system is successful in processing the desired result and capable of monitoring the temperature and humidity values.

Functional Suitability. This characteristic represents the degree to which a product or system provides functions that meet stated and implied needs when used under specified conditions. It is a critical factor that directly impacts user satisfaction, brand reputation, and overall business success, and must be given careful attention and priority throughout the product development and deployment lifecycle.

<u>Maintainability.</u> This characteristic represents the degree of effectiveness and efficiency with which a product or system can be modified to improve it, correct it or adapt it to changes in environment, and in requirements. It reflects the ease with which updates and enhancements can be made to the product or system, without causing adverse impacts on its performance, reliability, or quality.

<u>Performance Efficiency.</u> This characteristic represents the performance relative to the number of resources used under stated conditions. It is also the ability of a product or system to accomplish its intended functions within specified resource constraints.

<u>Portability.</u> Degree of effectiveness and efficiency with which a system, product or component can be transferred from one hardware, software or other operational or usage environment to another. It measures the effectiveness and efficiency with which a system, product, or component can be transferred from one hardware, software, or operational environment to another, without requiring significant modifications to its design or codebase.

<u>Reliability.</u> Degree to which a system, product or component performs specified functions under specified conditions for a specified period of time.

<u>Smart Farming.</u> A farming management concept using modern technologies in planting, harvesting and growing crops to increase the quantity and quality of agricultural products.

Chapter 2

DESIGN METHODOLOGY

This chapter discusses the research technical design, research instrument, the procedure, and method of the study, the project design models, and the statistical treatment that are used to throughout this study.

Research Technical Design

The study entitled "Smart Crop and Health Monitoring System for Cucumber Farming: Innovating Techno – Ecological Awareness" is a system that built and developed for the purpose of adaptation of smart farming technology. This system has soil moisture, humidity and temperature monitoring that was used for cucumber farming. In that case, the type of research method that was used by the researchers in this study is the descriptive and developmental research methodology.

According to Seels and Richey (n.d) Developmental Research is defined as the systematic study of designing, developing and evaluating instructional programs, processes and products that must meet the criteria of internal consistency and effectiveness. It often serves as a vehicle for dissemination of model techniques and processes, especially as new technologies, new procedural changes, and new programmatic trends emerge. Moreover, developmental research can provide a basis for both model construction and theorizing, one which is rooted in the experiences of practitioners as well as researchers. Developmental Research purpose in this study is to understand how well the developed system works and how it changes over an extended length of time.

Calderon (2016), defined descriptive research as a purposive process of gathering, analyzing, classifying, and tabulating data about prevailing conditions, practices, processes, trends, and cause-effect relationships and then making adequate and accurate interpretation about such data with or without or sometimes minimal aid of statistical methods. Also, this method ascertains prevailing conditions of facts in a group under study that gives either qualitative or quantitative, or both, descriptions of the general characteristics of the group as results.

Survey research method is one of the examples of descriptive research and this method involves participants who will be given a set of questionnaires to answer or may be administered through an interview concerning to this study. Descriptive research method is used to determine, describe and identify what is the findings in this research.

Research Instrument

To know if the study entitled "Smart Crop and Health Monitoring System for Cucumber Farming: Innovating Techno-Ecological Awareness" is a successful application or needs development for innovation of technologies into farming, questionnaire checklist was used by the researchers to gather data. The respondents were chosen and gave their opinions regarding to their findings to the study being conducted.

The researchers made a questionnaire that includes necessary factors to ensure the acceptability of the opinions of the respondents regarding to the conducted research. Questionnaire checklist was divided into three parts. First, the respondent's information is required. The next part consists of questions regarding the systematic opinions about the concept of smart crop and health monitoring device base of its maintenance, reliability and appearance. The third part is where the comments and suggestions of the respondents regarding this study lies.

To make sure the accuracy of the questionnaire checklist, the researchers used a 5-point Likert Scale. Likert scale is a scale which rates are often found on survey forms that is widely used when it comes to conducting a certain approach. This scale was also used to obtain the respondent's preference about the system. The following scale interval will be used by the respondents:

The respondents were asked to rate each item with the given scale as follows:

Scale	Interval	Verbal Interpretation
5	4.21 – 5.0	Very much Acceptable
4	3.41 – 4.20	Much Acceptable
3	2.61 – 3.40	Acceptable
2	1.81 – 2.60	Least Acceptable
1	1.0 – 1.80	Not Acceptable

Figure 2 shows the block diagram of a system that represents and determine the use of health monitoring of one's crop. Applying advanced and modern technology in farming that supports and analyzed the methods of determining whether the crop is healthy or not is done by this research.

In this study, sensor units were used for sensing the soil moisture, temperature, and humidity values. The DHT22 sensor monitors soil moisture, temperature and humidity were sensors that are ideal for smart farming in crop and health monitoring system. The sensors detect the status or any changes happened in a physical stimulus and turns into data signal that was measured and recorded. Also, if the system detects that water is needed in the field by the soil moisture sensor, the solenoid valve is turned on.

The researchers made a dashboard with the data obtained for the complete and simple visualization of the data. The data signal was sent to the processing unit which is the Node MCU ESP8266 or Arduino Uno that is programmed to transmit the data values of the soil moisture, humidity and temperature into the system.

Figure 3 shows the system flowchart of the Smart Crop and Health Monitoring System for Cucumber Farming: Innovating Techno–Ecological Awareness. The system starts by displaying the main page, showing the initialization of the values of parameters such as temperature, humidity and soil moisture. If the value of the temperature is greater than the threshold value, an alert message box appears showing that the crop is getting too much sunlight/heat. On the other hand, when the value of humidity falls below the threshold value, the system is programmed to display an alert message box indicating that the crop is low on humidity. This alert message can help farmers to take immediate action, such as increasing the humidity levels in the greenhouse or adjusting the ventilation system to prevent the crop from drying out.

Similarly, when the value of soil moisture falls below the threshold value, the system is designed to display an alert message box indicating that the crop is low on soil moisture. This alert message can prompt farmers to irrigate the crop or adjust the watering schedule to ensure that the crop receives adequate moisture.

Finally, the statement mentions that the "about us" page contains information about the researchers. This suggests that the system is likely to have been developed by a team of researchers, and the "about us" page provides background information on the team.

Figure 4 shows the system flowchart of a Smart Crop and Health Monitoring System designed for cucumber farming, which aims to promote awareness and innovation in the use of technology and ecology. The system consists of a device that uses a solenoid valve and sensors for temperature, humidity, and soil moisture.

When the device is initiated, the solenoid valve and sensors were activated. The sensors gather data on temperature, humidity, and soil moisture, and the values of these parameters were displayed on an LCD screen along with the IP address of the device. This allows farmers to monitor the environment and conditions of their crops in real-time.

If the value of the soil moisture falls below a certain threshold level, indicating that the soil is too dry, the solenoid valve was turned on automatically. The solenoid valve is responsible for supplying water to the crop, and it remain on until the soil moisture reaches the required level for the crop.

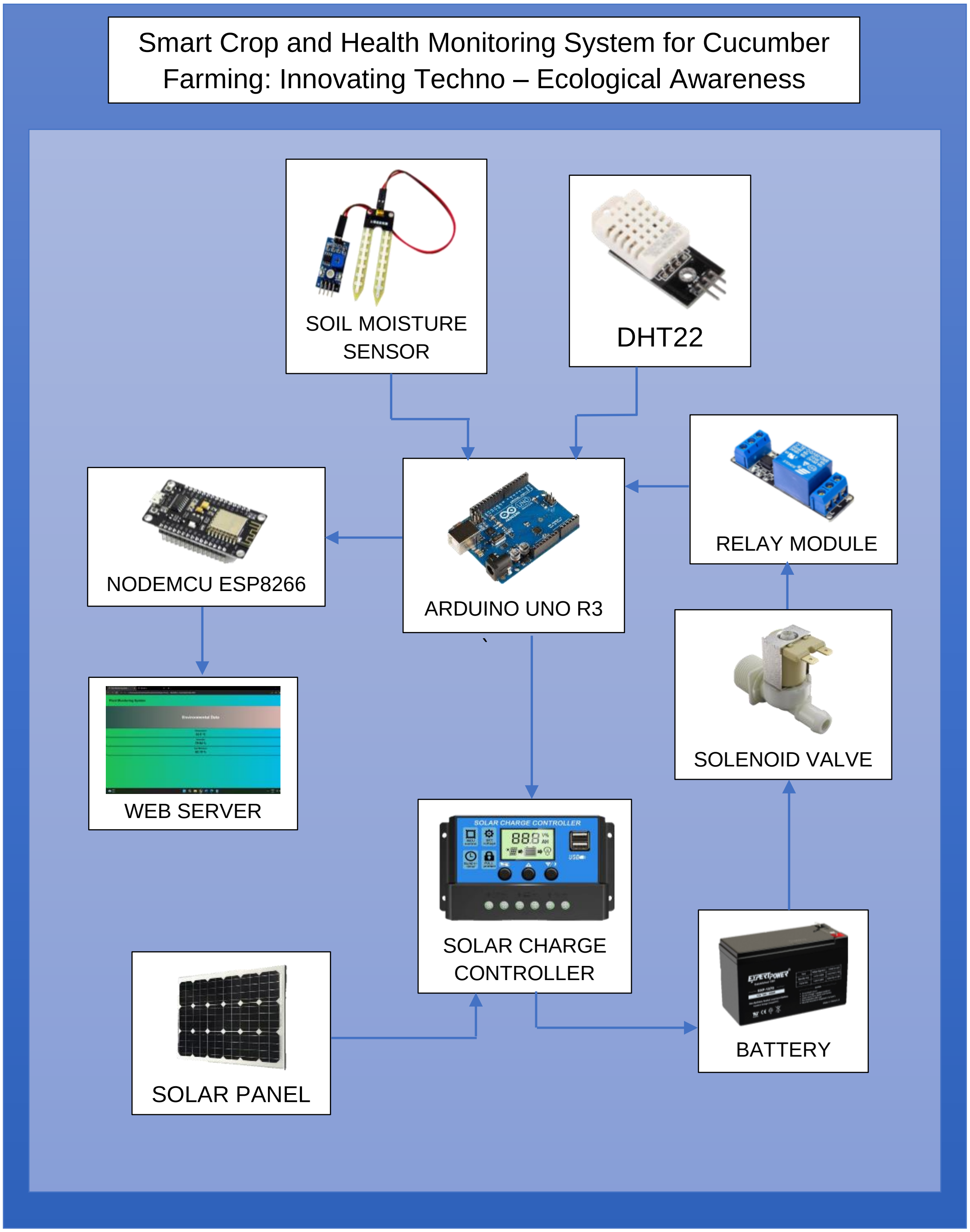

Figure 2

System Device Block Diagram for the Smart Crop and Health Monitoring System for Cucumber Farming

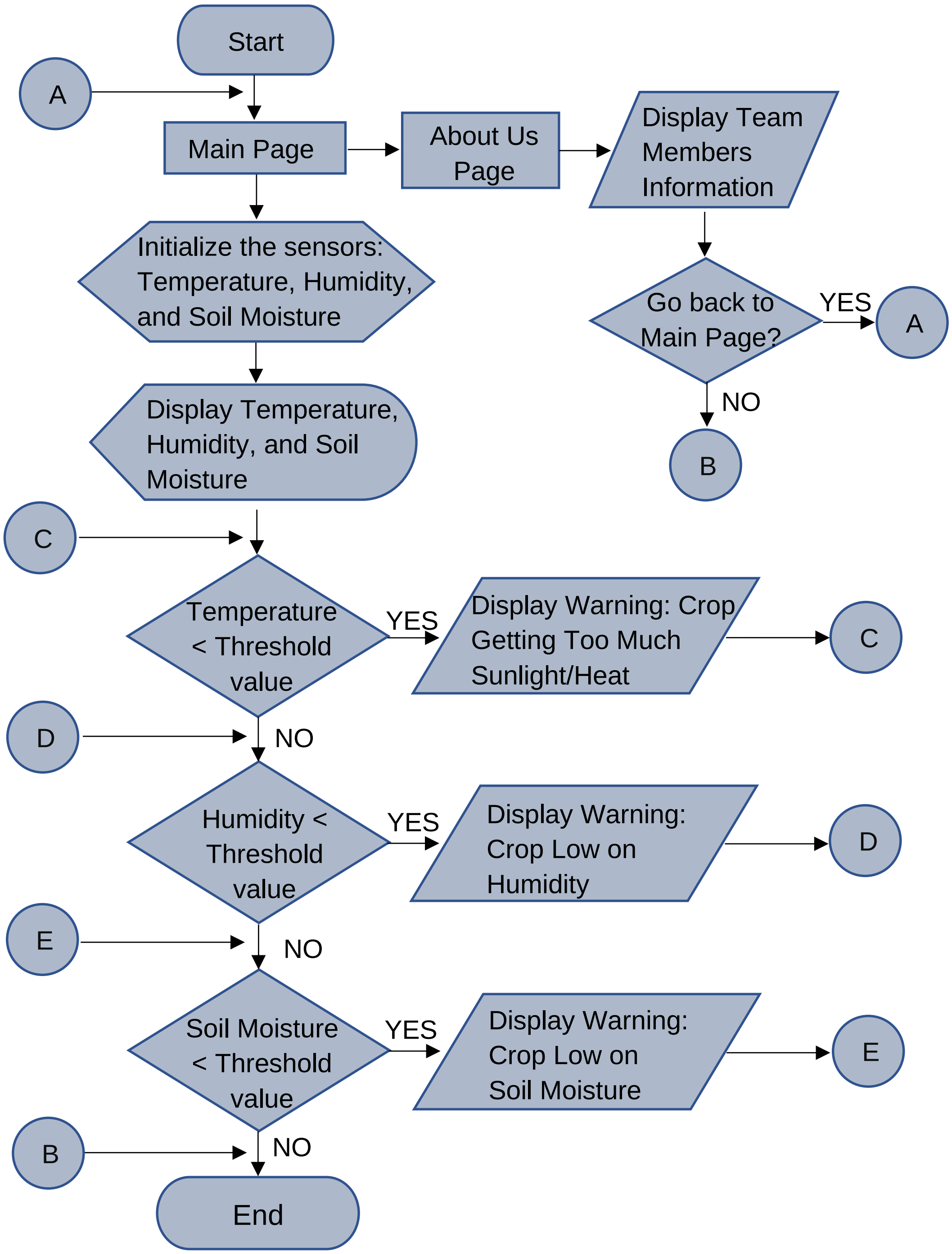

Figure 3

System Flowchart of the Smart Crop and Health Monitoring System for Cucumber Farming

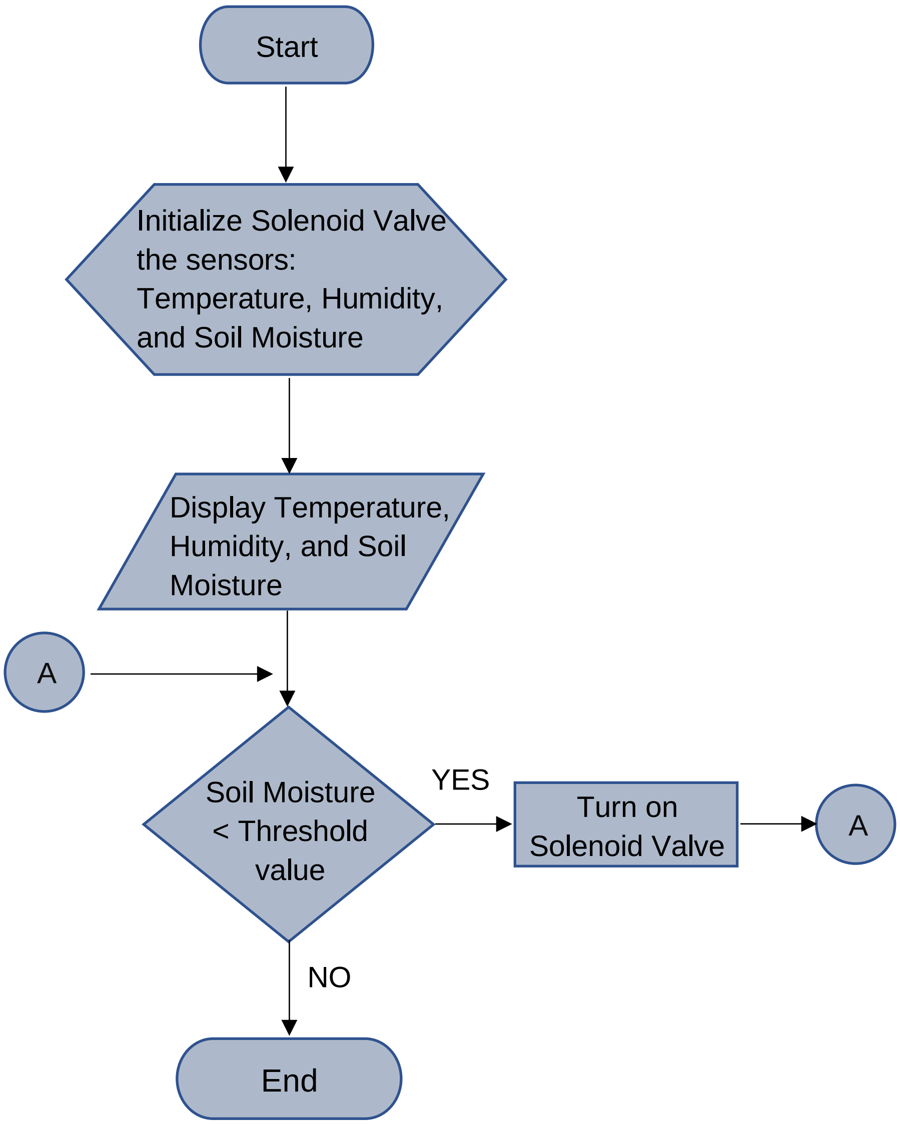

Figure 4

System Flowchart of the Smart Crop and Health Monitoring System for Cucumber Farming

Procedure and Methods of the Study

This is the timeline of activities followed by the researchers. It started by the groupings and planning of this research. The researchers made a total of thirteen proposed titles that are associated with different areas and field. Then, the researchers came up with titles regarding to agricultural field. The topics that were approved are the “Wireless Control for Home Appliances” and “Smart Crop and Health Monitoring System for Cucumber Farming: Innovating Techno-ecological Awareness”. The researchers chose to proceed with the title about Smart Crop and Health Monitoring System.

The procedure of this study started by planning, focused group discussion and brainstorming. Followed by the analyzation of the problems that occur in cucumber farming. Then, the researchers further studied about the monitoring system for certain crops. After that, the researchers proceeded to the development of chapters 1 and 2 that includes the necessary explanation of functionalities and contents regarding to this study.

Project Design Models

Mathematical models were taken into consideration in order to comprehend some significant features of the research's sensors monitoring system.

The moisture content of soil also referred to as water content, is an indicator of the amount of water present in soil. The moisture content of a substance is the mass of water that is present in its pore spaces to the solid mass of its particles, expressed as a percentage. Please see Appendix K for moisture content formula.

Humidity is the amount of water vapor in the air. Water vapor is the gaseous form of water and is commonly undetectable to the naked eye. Humidity indicates the likelihood for precipitation, dew, or fog to be present. Humidity is frequently explained as relative humidity.

To obtain the level of the relative humidity, calculate the saturated vapor pressure or the maximum amount of water vapor the air at that temperature can hold. Please see Appendix K for saturated vapor pressure formula.

Therefore, calculate the actual vapor pressure or the present amount of water vapor in the air. Please see Appendix K for actual vapor pressure formula.

After getting the saturated vapor pressure and the actual vapor pressure, lastly calculate the relative humidity or the expressed percentage of humidity. Please see appendix K for relative humidity.

The purpose of this monitoring system was to create a sustainable platform of sensing and irrigation automation that allows the farmer or the owner to monitor the changes or the parameters condition day by day.

Statistical Treatment

To determine the level of acceptability of the Smart Crop and Health Monitoring System for Cucumber Farming: Innovating Techno–Ecological Awareness with the variables to be used through the questionnaire, weighted mean was utilized. (Please see Appendix J for the weighted mean formula)

Chapter 3

PRESENTATION, ANALYSIS AND DESIGN RESULT

This chapter discusses the design, level of acceptability, user's manual, design result and analysis, project development and the interpretation of the results.

Design of Smart Crop and Health Monitoring System

The researchers created an innovative project which used Arduino Uno R3 as its main brain designed to assist farmers in monitoring the health and growth of their crops, also by using advanced technologies such as Internet of Things (IoT), sensors, and machine learning algorithms. This system aimed to provide farmers with real-time data on crop health and environmental conditions.

The system has three main parts namely the device structure, monitoring device and the graphical user interface (GUI) software which is accessible to the user and is connected to a certain server.

The device structure which shows the external appearance of the structure (Please see in appendix L). The device is composed of Palochina wood and plant rope. The said materials were used to build the structure seem very useful in providing the needed requirements in growing the cucumber crop.

The main function of monitoring device is to wirelessly monitor the soil moisture, temperature, and humidity conditions by the DHT22 sensor. The DHT22 sensor is connected to the Arduino Uno R3 and send the sensor value to the NodeMCU ESP8266. It allows the connectivity of the sensor to the Liquid Crystal Display (LCD). Current conditions of the parameters displayed in the LCD to allow the users to know the current values. The NodeMCU on the other hand, also serves as an open source IoT platform, it includes firmware which runs on the ESP8266 WiFi SoC that allows the transmission of data from the monitoring device to the website application. (Please see Appendix M for monitoring device)

The monitoring device and website application shall be both connected to the same network where the NodeMCU is connected in order to transmit and display the gathered values at the same time through localhost.

The Web application for monitoring served as the visual aid for the monitoring personnel through its graphical user interface. It displays the current state of the temperature, humidity and soil moisture (screenshot is shown in Appendix N). The alert message box appears if the temperature is above the threshold on the other hand, when the value of humidity and soil moisture drops on its threshold then another alert message box will appear (screenshot is shown in Appendix O). The monitoring software was written using the HTML, CSS and JavaScript programming language on Sublime Text 3.

Appendix P shows the schematic diagram of Smart Crop and Health Monitoring System for Cucumber Farming: Innovating Techno-Ecological Awareness. Wherein the Arduino is the main component of the device. The 5 volts pin and the ground pin of the Arduino is connected to the breadboard. The power pin and the ground pin of the soil moisture is connected to the breadboard, while the analog pin is connected to the A0 pin of the Arduino. The DHT22 sensor's power pin and ground pin is also connected to the breadboard while the data pin is connected to the digital pin 2 of the Arduino. The Node MCU is powered through the 3.3v and ground pin of the Arduino. The Node MCU's pin 5 and 6 serves as the Rx Tx pin for receiving the data gathered by the sensors from the Arduino. The power pin and ground pin of the Liquid Crystal Display (LCD) is connected to the breadboard while the SDA is connected to the D2 and SCL is connected to the D1 of the Node MCU. The solar panel is connected to the solar charge controller and will charge the lead acid battery that will provide the renewable energy to power the entire device. The solenoid valve is also connected to the solar charge controller. The normally closed (NC) pin of the relay is connected to the power pin of the solenoid valve while the common pin is connected to the positive load of the solar charge controller. The power pin and ground pin of the relay is connected to the breadboard and the input pin is connected to the digital pin 3 of the Arduino.

Level of Acceptability of Smart Crop and Health Monitoring System

Table 1 presented below shows the computed weighted mean, verbal interpretation and average mean of the level of acceptability of the Smart Crop and Health Monitoring System for Cucumber Farming: Innovating Techno-Ecological Awareness in terms of functional suitability.

Table 1 shows that based on the perception of respondents, item 1.1 got the highest score weighted mean of 4.78, it is followed by item 1.3 with weighted mean of 4.63, and item 1.2 got the lowest weighted mean of 4.55 where in all of the items are verbally interpreted as very much accepted.

Table 1

Computed Weighted Mean of the Smart Crop and Health Monitoring System for Cucumber Farming in Terms of Functional Suitability

Functional Suitability	Respondents	
	Weighted Mean	Verbal Interpretation
1.1 The developed device functions well	4.78	Very Much Accepted
1.2 The developed device can make expected results	4.55	Very Much Accepted
1.3 The developed device can respond to user's command	4.63	Very Much Accepted
Average Weighted Mean	4.65	Very Much Accepted

Therefore, the Smart Crop and Health Monitoring System for Cucumber Farming: Innovating Techno-Ecological Awareness got an average weighted mean of 4.65 in terms of functional suitability as evaluated by respondents respectively which is interpreted as very much accepted.

The result shows that the device provides an accurate result that satisfy the standards of the user in terms of functional suitability. Plant monitoring system can be a valuable tool for students who are interested in studying plants and agriculture. It provides a hands-on approach to learning and allows students to observe the effects of different factors on plant growth and health in real-time. On the other hand, plant monitoring system is a valuable tool for experts in the fields of agriculture, botany, horticulture, and environmental science. It provides a way to study plant growth and development in real-time, optimize plant growth in commercial settings, and develop predictive models to forecast plant growth under different conditions. This relates to the study of A. Kohli in 2020 that created smart monitoring system for plants that maintains the bionomic cycle and the proper growth of plants.

Table 2 presented below shows the computed weighted mean, verbal interpretation and average mean of the level of acceptability of the Smart Crop and Health Monitoring System for Cucumber Farming: Innovating Techno-Ecological Awareness in terms of performance efficiency.

Table 2 shows that based on the perception of respondents, item 2.3 got the highest score weighted mean of 4.58, and items 2.1 and 2.2 got the lowest weighted mean of 4.53 where in all of the items are verbally interpreted as very much accepted.

Table 2

Computed Weighted Mean of the Smart Crop and Health Monitoring System for Cucumber Farming in Terms of Performance Efficiency

Performance Efficiency	Respondents	
	Weighted Mean	Verbal Interpretation
2.1 The developed device can gather values of the parameters	4.53	Very Much Accepted
2.2 The developed device can help to produce the desired and accurate results	4.53	Very Much Accepted
2.3 The developed device can maintain certain humidity and temperature conditions	4.58	Very Much Accepted
Average Weighted Mean	4.55	Very Much Accepted

Therefore, the Smart Crop and Health Monitoring System for Cucumber Farming: Innovating Techno-Ecological Awareness got an average weighted mean of 4.55 in terms of performance efficiency as evaluated by respondents respectively which is interpreted as very much accepted.

The result shows that the device provides an accurate result that satisfy the standards of the user in terms of performance efficiency. One of the key benefits of a plant monitoring system is its ability to provide real-time data on plant growth and health. This allows students to quickly identify any issues that may be affecting plant growth, such as nutrient deficiencies or overwatering. By using the plant monitoring system, students can make adjustments to environmental conditions in real-time, optimizing plant growth and health. While for the experts, this allows to quickly identify any issues that may be affecting plant growth, such as disease outbreaks or changes in environmental conditions. By using this system, experts can make adjustments to environmental conditions in real-time, optimizing plant growth and health. This relates to the study of S. Siddagangaiah in 2016 that the system can check and gather values of different parameters such as temperature, humidity and soil moisture.

Table 3 presented below shows the computed weighted mean, verbal interpretation and average mean of the level of acceptability of the Smart Crop and Health Monitoring System for Cucumber Farming: Innovating Techno-Ecological Awareness in terms of reliability.

Table 3 shows that based on the perception of respondents, item 3.1 got the highest score weighted mean of 4.63, it is followed by item 3.3 with weighted mean of 4.58, and item 3.2 got the lowest weighted mean of 4.55 where in all of the items are verbally interpreted as very much accepted.

Table 3

Computed Weighted Mean of the Smart Crop and Health Monitoring System for Cucumber Farming in Terms of Reliability

Reliability	Respondents	
	Weighted Mean	Verbal Interpretation
3.1 The developed device can make correct and accurate information	4.63	Very Much Accepted
3.2 The developed device is ready to use and accessible anytime when it is needed	4.55	Very Much Accepted
3.3 The developed device can perform its work efficiently	4.58	Very Much Accepted
Average Weighted Mean	4.59	Very Much Accepted

Therefore, the Smart Crop and Health Monitoring System for Cucumber Farming: Innovating Techno-Ecological Awareness got an average weighted mean of 4.59 in terms of reliability as evaluated by respondents respectively which is interpreted as very much accepted.

The result shows that the device provides an accurate result that satisfy the standards of the user in terms of reliability. Another benefit of a plant monitoring system is its reliability. The sensors used in these systems are designed to be accurate and durable, ensuring that students can rely on the data they collect. In additional, a plant monitoring system is a reliable tool for experts in the fields of agriculture, botany, horticulture, and environmental science. It provides accurate and reliable data on plant growth and health, is designed to be durable and resistant to environmental factors, and can help to ensure the reliability of scientific research. This relates to the study H. Jeong in 2016 that the device was tested in greenhouse and field conditions to prove that it is accessible anytime that it is needed.

Table 4 presented below shows the computed weighted mean, verbal interpretation and average mean of the level of acceptability of the Smart Crop and Health Monitoring System for Cucumber Farming: Innovating Techno-Ecological Awareness in terms of maintainability.

Table 4 shows that based on the perception of respondents, item 4.1 got the highest score weighted mean of 4.73, it is followed by item 4.3 with weighted mean of 4.58, and item 4.2 got the lowest weighted mean of 4.50 where in all of the items are verbally interpreted as very much accepted.

Table 4

Computed Weighted Mean of the Smart Crop and Health Monitoring System for Cucumber Farming in Terms of Maintainability

Maintainability	Respondents	
	Weighted Mean	Verbal Interpretation
4.1 The developed device components are available locally	4.73	Very Much Accepted
4.2 The developed device is easy to operate and not that complicated to build	4.50	Very Much Accepted
4.3 The developed device is effective and durable	4.58	Very Much Accepted
Average Weighted Mean	4.60	Very Much Accepted

Therefore, the Smart Crop and Health Monitoring System for Cucumber Farming: Innovating Techno-Ecological Awareness got an average weighted mean of 4.60 in terms of maintainability as evaluated by respondents respectively which is interpreted as very much accepted.

The result shows that the device provides an accurate result that satisfy the standards of the user in terms of maintainability. Plant monitoring system for students is its ease of maintenance. The sensors used in these systems are typically designed to be simple to install and use, and the data collected can be easily accessed and analyzed using a computer or mobile device. However, experts felt at ease due to the sensors that were used in these systems are typically designed to be simple to install and use, and the data collected can be easily accessed and analyzed using a computer or mobile device. Additionally, many plant monitoring systems have remote monitoring capabilities, allowing experts to monitor plants from a distance, reducing the need for on-site maintenance. This relates to the study of S. Dizon in 2020 that the device can be operated without great effort and easy to access by a non-technical person like farmers.

Table 5 presented below shows the computed weighted mean, verbal interpretation and average mean of the level of acceptability of the Smart Crop and Health Monitoring System for Cucumber Farming: Innovating Techno-Ecological Awareness in terms of portability

Table 5 shows that based on the perception of respondents, item 5.3 got the highest score weighted mean of 4.60, it is followed by item 5.2 with weighted mean of 4.55, and item 5.1 got the lowest weighted mean of 4.45 where in all of the items are verbally interpreted as very much accepted.

Table 5

Computed Weighted Mean of the Smart Crop and Health Monitoring System for Cucumber Farming in Terms of Portability

Portability	Respondents	
	Weighted Mean	Verbal Interpretation
5.1 The developed device can effectively and efficiently be adapted for different hardware, software, or other operational environments	4.45	Very Much Accepted
5.2 The developed device can be effective, efficient and can be installed in a specified environment	4.55	Very Much Accepted
5.3 The developed device can be replaced by another software product for the same purpose	4.60	Very Much Accepted
Average Weighted Mean	4.53	Very Much Accepted

Therefore, the Smart Crop and Health Monitoring System for Cucumber Farming: Innovating Techno-Ecological Awareness got an average weighted mean of 4.53 in terms of portability as evaluated by respondents respectively which is interpreted as very much accepted.

The result shows that the device provides an accurate result that satisfy the standards of the user in terms of portability. The sensors used in these systems are typically designed to be lightweight and compact, making it easy for students to move them from one location to another. This allows students to monitor plants in various environments and settings, such as greenhouse, field, or laboratory. Overall, a plant monitoring system is a portable and versatile tool for experts in the fields of agriculture, botany, horticulture, and environmental science. It is lightweight and compact, easy to install and use, allows for real-time monitoring and adjustments, and can contribute to advances in research and management practices. This relates to the study of Saxby (2020) and Jeong (2016) that the device can be handheld and can operate whether it is in greenhouse conditions and field conditions.

Table 6

Composite Table of the Average Weighted Mean on the Level of Acceptability of the Smart Crop and Health Monitoring System for Cucumber Farming

Items	Respondents	
	Weighted Mean	Verbal Interpretation
1. Functional Suitability	4.65	Very Much Accepted
2. Performance Efficiency	4.55	Very Much Accepted
3. Reliability	4.59	Very Much Accepted
4. Maintainability	4.60	Very Much Accepted
5. Portability	4.53	Very Much Accepted
Average Weighted Mean	**4.58**	**Very Much Accepted**

Table 6 above presents the composite table of the average weighted mean on the level of acceptability of that Smart Crop and Health Monitoring System for Cucumber Farming: Innovating Techno-Ecological Awareness in terms of functional suitability, performance efficiency, reliability, maintainability and portability.

It can be seen from the table that based on the evaluation made by the respondents on the Smart Crop and Health Monitoring System for Cucumber Farming: Innovating Techno-Ecological Awareness, the functional suitability got the highest rank with an average weighted mean of 4.65 , followed by the maintainability of the device with an average weighted mean of 4.60, next is the reliability that resulted to a weighted mean of 4.59, then followed by the performance efficiency which has 4.55 as average weighted mean then lastly is the portability which has 4.53 average weighted mean, all of the items are verbally interpreted as vary much accepted. All of the different criteria are verbally interpreted as very much accepted.

This concludes that Smart Crop and Health Monitoring System for Cucumber Farming: Innovating Techno-Ecological Awareness is very much accepted for the respondents revealed by the average weighted mean of 4.58 verbally interpreted as very much accepted since it satisfies the user’s demands in terms of functional suitability, performance efficiency, reliability, maintainability and portability.

The implication of the Smart Crop and Health Monitoring System for Cucumber Farming, referred to as the innovation, has been evaluated by respondents based on different criteria. The average weighted mean for the Functional Suitability is 4.65. Therefore, this implies that the system is well-suited to its intended purpose, which is to monitor and manage crop health in cucumber farming. It indicates that the system's functionalities are highly effective and align well with the needs and expectations of the users. For the Maintainability, it has an average weighted mean of 4.60, this implies that the innovation is designed in a way that facilitates ease of maintenance. On the other hand, Reliability has an average weighted mean of 4.59. This indicates that the system is dependable and consistent in its performance. Cucumber farmers can rely on the Smart Crop and

Health Monitoring System to provide accurate and timely data on crop health, enabling them to make informed decisions and take appropriate actions. The weighted mean of Performance Efficiency is 4.55, therefore, it implies that the innovation is efficient in terms of its speed, responsiveness, and resource utilization. Lastly, the Portability gathered the lowest average weighted mean of 4.53. This suggests that the innovation offers a level of portability, although it may not be the primary focus. It implies that the Smart Crop and Health Monitoring System can be transported and used in different locations or settings, enhancing its versatility and adaptability for farmers who may need to monitor multiple cucumber farms.

Overall, the result indicates that the respondents highly rated the Smart Crop and Health Monitoring System for Cucumber Farming across all evaluated criteria, signifying that the innovation is considered highly suitable, maintainable, reliable, efficient, and to some extent, portable. This implies that the system is well-designed and aligned with the techno-ecological needs of cucumber farming, and it has the potential to bring significant benefits to farmers in terms of crop health management and overall farm efficiency.

User's Manual Developed on the Utilization of Smart Crop and Health Monitoring System

The User's Manual is a tool used by the researchers to help the users to operate the system accordingly. This user's manual discusses the step-by-step process for the operation of the Smart Crop and Health Monitoring System (Please see the images of User's Manual in Appendix T).

Parts and their Functions

The system was comprised of two important components necessary for its satisfactory operation namely the hardware and software. Appendix Q shows the pictorial presentation of different hardware parts and their functions while Appendix R shows the pictorial presentation of different software and programming languages and their functions used in the development of the Smart Crop and Health Monitoring System for Cucumber Farming: Innovating Techno-Ecological Awareness.

Project Development

The following materials used in the development of the device consists of quantity unit, items/description, unit price and total price. (Please see Appendix S for Materials Used)

Chapter 4

SUMMARY OF DESIGN RESULT, CONCLUSIONS AND RECOMMENDATIONS

This chapter presents the summary of design result, conclusions and recommendations of the study.

Summary of Design Result

Based on the analysis and interpretation of results, the following were hereby summarized:

1. The Smart Crop and Health Monitoring System for Cucumber Farming: Innovating Techno-Ecological Awareness that is suitable to use for cucumber farming was successfully constructed out of locally available materials and designed using Arduino IDE and Sublime Text.
2. When it comes to the acceptability of the Smart Crop and Health Monitoring System for Cucumber Farming: Innovating Techno-Ecological Awareness, it was found out that in terms of functional suitability, performance efficiency, reliability, maintainability and portability of the system, the device obtained an average weighted mean of 4.58 that was verbally interpreted as very much acceptable.
3. The User's Manual provides a step-by-step guide for operating the Smart Crop and Health Monitoring System. It begins with connecting the sensors to the Arduino and then connecting the Arduino, battery, and solar panel to the solar charge controller. Once the LCD displays the sensor values and the IP address, the user can connect their device to the same Wi-Fi network and open any browser to search for the displayed IP. The main page will display the parameters gathered by the sensors. The manual also provides instructions on how to respond to three

different warning messages that may appear on the screen, which alert the user to a crop that is getting too much sunlight/heat, low on humidity, or low on soil moisture. Finally, the manual advises the user to manually check the system by disconnecting their device from the Wi-Fi.

Conclusions

The following conclusions were drawn based on the summary of design result:

1. The Smart Crop and Health Monitoring System for Cucumber Farming was successfully developed using locally available materials and designed using Arduino IDE and Sublime Text. The system is specifically designed to monitor and optimize the growth and health of cucumber crops, promoting techno-ecological awareness in agriculture. The system includes sensors for temperature, humidity, and soil moisture, a solenoid valve for automatic watering, and alert messages for low humidity or soil moisture levels. The successful construction of this system demonstrates the potential for locally sourced materials and open-source software to support sustainable agriculture and innovation in farming practices.
2. The designed and constructed monitoring system was found very much acceptable in terms of functional suitability, performance efficiency, reliability, maintainability and portability. This indicates that the device performs well in terms of its intended functions, is efficient and reliable, and can be easily maintained and transported. The high level of acceptability suggests that the device has the potential to be widely adopted in the agricultural sector, helping to improve crop yields and reduce resource waste.

3. User's Manual provides a helpful guide for operating the Smart Crop and Health Monitoring System. The step-by-step process is easy to follow, and the manual provides valuable information on how to respond to warning messages related to crop health. Overall, the User's Manual provides a clear and user-friendly guide for operating the Smart Crop and Health Monitoring System, which can help to increase its adoption and effectiveness in promoting techno-ecological awareness and supporting sustainable agriculture.

Recommendations

Based on the results of the study, the researchers came up with the following recommendations:

1. Build a monitoring device that is made up of stronger materials that will provide fire resistant capabilities, security and durability for the device structure.

2. Create a compact and lightweight design that is easy to transport and store. Consider using materials that are durable but lightweight, such as aluminum or carbon fiber. Ensure that the system can withstand the rigors of transportation and use in various environments. Use rugged materials and incorporate shock-absorbing features, such as padding or shock mounts, to protect sensitive components.

3. Make the user’s manual brief that frequently asked questions and answers, addressing common concerns and providing solutions to common issues. In additional, provide a glossary of terms and technical jargon used in the manual and system interface, to help users better understand the system and its features. Provide a list of references and resources for users who want to learn more about

plant care and monitoring, including books, websites, and other relevant sources of information.

4. Make the parameters adjustable by using the data gathered by the different sensors of the monitoring system. Making the parameters adjustable means that the values used to control the system can be changed based on the data gathered by the different sensors of the monitoring system. The system can be programmed to adjust the amount of water released by the solenoid valve based on the soil moisture levels detected by the soil moisture sensor. This can help ensure that the crop receives the appropriate amount of water at all times, which can improve crop health and yield.