AUTOMATED PLANT WATERING SYSTEM USING MICROCONTROLLER WITH SMS NOTIFICATION

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Abstract

Automated plant watering systems have revolutionized vegetable cultivation by empowering gardeners and plant owners to efficiently manage water volume and enable automatic irrigation. This abstract provides an in-depth overview of the capabilities of these systems, focusing on their customizable water volume control and the convenience of automated plant watering. In vegetable cultivation, the ability to control the volume of water is crucial for optimizing plant health and growth. Automated plant watering systems offer gardeners and plant owners the flexibility to adjust and customize the amount of water delivered to individual plants or specific areas of their garden. By providing precise control over water volume, these systems ensure that vegetables receive the appropriate amount of moisture, reducing the risk of overwatering or underwatering. This capability promotes healthy root development, efficient nutrient absorption, and overall plant vigor.

Furthermore, the automation features of these systems is a key advantage for vegetable growers. With automated plant watering, gardeners can set desired schedules based on the specific needs of their vegetable crops. The systems are equipped with sensors and timers that monitor soil moisture levels and automatically initiate watering when necessary. This eliminates the need for constant manual monitoring and intervention, providing convenience to busy gardeners and ensuring consistent and timely irrigation for vegetables.

The abstract also emphasizes the benefits of automated plant watering systems in terms of water conservation and resource management. By allowing precise control of water volume, these systems minimize water waste and promote efficient water usage, especially in regions where water scarcity is a concern. Additionally, the automation feature optimizes resource

utilization by reducing labor requirements associated with manual watering, enabling gardeners to allocate their time and resources effectively.

In conclusion, automated plant watering systems tailored for vegetable cultivation offer gardeners and plant owners the ability to control water volume and automate irrigation processes. These systems contribute to optimized plant health, water conservation, and resource management. By providing customizable water control and automating watering tasks, they enhance the efficiency and convenience of vegetable cultivation, empowering growers to achieve healthy, thriving vegetable crops with minimal effort.

Chapter I
Introduction

Background of the Study

Over the last several decades, people have engaged in large-scale transformation of natural systems causing a net accumulation of carbon dioxide in the atmosphere. Climate change is recognized as a serious threat to ecosystem, biodiversity, and health. It is associated with alterations in the physical environment of the planet Earth and affects life around the globe (Heshmati, 2020). Subsequently, there has been an observed shift in phenology, along with the growth and distribution of plant species and permafrost degradation. It is expected that climate change will amplify these impacts going forward. Hence, plant survival is affected by climate change (Auffhamer, 2019).

We all know that plants are very beneficial to all human beings in many aspects. Plants help in keeping the environment healthy by cleaning air naturally and producing oxygen. In busy schedule of day-to-day life, many times people forget to water their plants and due to these plants suffer many disarrays and ultimately died. In addition, the world's biggest problem in modern society is the shortage of water resources; cultivation is a demanding job to consume large amounts of water. It is essential to utilize the water resources in proper way (Shivaraj & Jagadeesh, 2017). To handle this task automatically, a system is needed to help gardeners or plant owners to sustain the development of the plants. Thus, the researchers decided to conduct this study with the use of an automated system which are small programmable devices capable of executing specific tasks, to create a judicious and efficient plant care solution as well as maintaining the health and growth of plants.

Statement of the Problem

The main purpose and goal of this study is to create and design an automated plant watering system using microcontroller and sim 800l that allows the gardeners and plant owners to control the volume of the water and the ability of the system to automatically water the plants.

This study will specifically be seeking to answer the following questions:

1. How to design a device that will notify the gardeners and plant owners to __________?
2. Which software and hardware parts are appropriate for the device?
3. Will it cover more than 5 pots?
4. How does the automated plant watering system control work?

    4.1 Will the device automatically opens ______?

    4.2 Does having __________ control saves time?

    4.3 Will it alert the user to errors?

5. How to evaluate the system in terms of FRUMPS

    5.1 Functionality

    5.2 Reliability

    5.3 Usability

    5.4 Maintainability

    5.5 Performance

    5.6 Supportability

Significance of the Study

To the Municipality of Plaridel, this research will help the people to provide the optimal amount of water required by the plants, preventing both overwatering and underwatering. They will be aware of the approaches and solutions available to help with gardening. Also, they can avoid withering and damaging the plants.

To the gardeners and plant owners, this will serve as a basis to eliminate the need for manual monitoring and watering of plants, saving time and effort for gardeners, or plant owners. They will also gain insights on how to assess and manage their plants.

To the researchers, this study will bring insight into plant watering system. It will serve as a basis for enhancing the importance of teaching the value of controlling the plant watering system.

To the future researchers, this study can be used as a reference for future researchers who will conduct another study regarding the same topic in the future. Also, this study can serve as a foundation for another research.

Scope and Delimitation

This study focused on the use of a microcontroller in creating an automated plant watering system to build a more advanced control system. This study will produce a prototype miniature to demonstrate an automated plant watering system using a microcontroller. This prototype will automatically determine if the soil moisture sensor detects that the soil is dry, and in response, it will release water using a water pump that comes from stowage into the plants and send an SMS notification. It will automatically stop when it detects that the soil is wet and will also send an SMS notification.

This study does not include where to get enough electricity to operate it, and in terms of climate changes or weatherproof, the researchers cannot be sure if the flow of water from the storage to the plants will be effective due to the volume of the water produces, cracks, and the fertilization of the plant.

Chapter II
Theoretical Framework

Relevant Theories

Control Theory

A hydraulic system known as an irrigation canal's primary function is to transport water from a source (such as a dam or river) to various users. Such systems exhibit severe unknown disturbances, time delays, nonlinear dynamics, and interactions across subsystems. They can be very vast (spanning several tens or hundreds of kilometers). Its managers are given a variety of operational goals. The primary overall goal is to deliver water to the various users at the appropriate time and in the appropriate quantity while minimizing losses as much as possible to ensure the safety of the infrastructure. Preventing the canals from overflowing, as well as keeping the water levels inside the pools above the supply depths of the gravity off takes, is of utmost importance (Gil, 2018).

Control theory speaks of "tracking" when these target variables are time dependent. Some authors use the term "regulation" in a general sense for all types of targets (constant or variable), while others only in the case of a null constant target. The needs of irrigation canal users are defined mainly in terms of discharge. For example, agricultural needs are expressed in terms of discharges delivered to a plot, to a secondary canal, or to a pumping station; environmental needs are expressed as tail-end discharges or minimal discharges; urban needs are expressed as discharges delivered to a house or to a city water filtration plant; and industrial needs are expressed as discharges delivered to a factory. Control theory implies a three-step process: 1) system modeling (i.e., the definition of a model), 2) system analysis (i.e., the study of the model behavior), and 3) controller design. Heuristic mono variable methods have been developed based on hydraulics and not control theory (e.g., Zimbelman (1987), CARDD (Burt 1983). Although quoted in the literature, these methods are too site-specific and have not been implemented on operating canals (Mallatere et al., 2022).

Related Studies and Literature

Problem of lack of plant watering control

Based on the study conducted by Kassing, R. et al. (2020), the appropriate distribution of water is a challenging issue that many farmers encounter on a yearly basis, particularly during droughts. In this paper, researchers present an optimization-based feedback control to increase water productivity in irrigation and agricultural output for a plantation with several fields. An ageohydrological model employing the crop water productivity modeling program Aqua Crop-OS is used to describe the interaction between soil, water, crop (in this case sugarcane), and the atmosphere. Researchers provide a two-level optimum control strategy to distribute water throughout the fields as efficiently as possible. This method uses an approximation of the crop productivity function to determine the best water distribution over the fields for the duration of the growing season to optimize crop yield.

In addition, the daily control of soil moisture is handled by the model predictive controller, who follows the seasonal planner's decision on water distribution. Based on the Aqua Crop-OS model, a mixed-logic dynamical model is found in order to lessen the computational complexity of the daily controller. To enhance model quality, this dynamical model explicitly incorporates saturation dynamics. By considering the anticipated growth of the crop over the course of the season using remote sensing-based measurements of the canopy cover, researcher design an evapotranspiration model to further enhance performance. A closed-loop simulation of a genuine sugarcane plantation in Mozambique is run in Aqua Crop-OS to assess the performance of the two-level method. In comparison to local heuristics, our optimal management strategy increases water production by up to 30% and can take drought-related water consumption restrictions into account.

Automated Plant Watering System Using Microcontroller with SMS Notification

According to Zahari, A. et al., (2022) One of the agricultural production technical developments that must be promoted is aquaponics. The world's most critical concerns are climate change, population growth, water scarcity, soil degradation, and food security. Climate change, population growth, water shortages, soil degradation, and food security may be addressed through aquaponics, a closed-loop system that combines hydroponics and aquaculture. To develop and build an aquaponics system that combines fish farming with plant growth, that is the purpose of this article. The system monitored and controlled the water quality, plant humidity, and other variables using a range of sensors, including temperature and humidity sensors, ultrasonic sensors, and pH sensors. It also employed microcontrollers like Arduino. To guarantee a healthy growth environment for fish and plants, early warnings are supplied to the user as soon as the sensor detects any unexpected scenario. These early warnings come in the form of SMS and push notifications. Writing a program to connect the microcontroller to numerous sensors and other devices requires the use of the Arduino Development Environment (IDE) software. The system includes liquid crystal displays (LCDs), pH sensors, temperature and humidity sensors, ultrasonic sensors, and GSM circuits. When the pH, temperature, and ultrasonic sensor readings are outside of the acceptable range, a GSM notification message is delivered to a mobile phone. The values that have been taken daily are revealed by the data from this system's monitoring. The graph showed that the plant is growing more and more each day.

The article details the creation and design of an automated plant watering system for potted plants' soil humidity. The 32-Bit Arduino Uno microcontroller system was used to implement the investigation. Soil moisture sensors, humidity sensors, and temperature sensors were the three main transducers employed in this study to get the necessary data. To measure the environment and surroundings for the soil in the pot, the LM393 soil moisture sensor and the DHT11 humidity and temperature sensor were positioned half the height of the soil in the pot. The irrigation system was connected to a motor pump. When the earth dried, the motor pump began to irrigate the plants. The measured data was then presented on an LCD screen and continuously tracked by a Visual Basic GUI during this procedure. Temperature and soil humidity data were presented in degrees Celsius on a range of 0 to 1030. The earth was dryer as the scale got bigger. As a result, an automated plant watering system that can monitor data and analyze garden factors was successfully created using an Arduino Uno to control the soil moisture. (Hamzah, I. et al., 2017)

Nowadays, humans can benefit greatly from plants. In daily life, watering plants is more significant. The most significant cultural practice that lessens job effort is this one. Depending on whether it's too hot and dry or overcast and wet, researcher need to provide plants enough water.

The plants are watered using a modern pipe system as needed. Knowing when and how much to water the plants is one of this project's two most crucial components. Gardeners are exerting more effort to water the plants; thus this automatic plant watering system was developed to make their work simple and practical. This project makes use of an 8051 microcontroller. This system is built up so that it can detect the soil's moisture level. If it is below than the needed voltage, a relay will immediately turn on, supplying the necessary water. This system primarily aids in plant maintenance and plays a role in supporting both small and large gardens. (Kusuma Vani, P. et al., 2018)

Impact of Climate Change using Plant Watering Control System

In terms of man-made wetland ecosystems, farms are significant for both food production and ecosystem preservation. Climate change is currently posing a danger to rice farming in the Mekong Delta of Vietnam, yet there is a dearth of data and studies on how rice will be produced in the future. The biomod2 platform in R software is used in the current study's ensemble-modelling approach to examine the effects of climate change on rice agriculture in the MD. In order to simulate the habitat appropriateness for rice production in the current and future climate, RCP 4.5 and RCP 8.5 scenarios of the year 2050, rice cultivation occurrence sites, eco - physiological data, and bioclimatic data were used. With scores for KAPPA, ROC/AUC, and TSS of 0.880, 0.993, and 0.960, respectively, the ensemble model achieved respectable accuracy. According to simulation data, between now and 2050, there will be a mean loss of appropriate land and a mean gain of unsuitable land of 31.4% and 64.6%, respectively. The loss of suitable habitat was mostly caused by salinity intrusion, increases in precipitation during the rainy season, and decreases in precipitation during the dry season. The results of this study provide important guidance for planners and policy makers in creating effective strategies for climate change adaptation and mitigation for sustainable rice farming. (Dang, An. et al., 2020)

Planning a sustainable agricultural system requires estimating the prospective land resources suitable for irrigation and assessing the potential effects of climate change on land suitability. The suitability of land for irrigation in Ghana was assessed in this study using a GIS-based Multi-Criteria Evaluation (MCE) technique for the baseline period (1990 to 2010) and the future timescales 2050s (2041 to 2060) and 2070s (2061 to 2080). The biophysical characteristics of the land (such as the climate, land use, soil, and slope) and socioeconomic aspects are important considerations when determining whether the area is suited to drip irrigation (such as proximity to roads and population density).To calculate the country's potential for irrigation, these parameters were weighted using a pairwise comparison matrix, categorized, and then superimposed on a 30 m grid. To assess the irrigation potential and the accessibility of shallow groundwater with basic water lifting technologies, groundwater data from the British Geological Survey (BGS) were superimposed onto the land suitability map layer. The future climate horizon was represented using downscaled and bias-corrected future climate data from HadGEM2-ES under the RCP 4.5 emission scenario. Rainfall will rise by 15 mm and 20 mm, respectively, from the baseline period in the 2050s and 2070s because of climate change. Most of Ghana's average temperature is rising steadily, and a faster rate of rise is predicted for the 2070s. As a result, in the 2050s and 2070s, respectively, the potential evapotranspiration will increase by 6.0% and 7.6% because of the rising temperature. According to the suitability research, 9% of the nation is appropriate for surface irrigation during the baseline period. The southern region of the nation holds a sizable share of the potential land. The potential suitable area is well-suited for the use of low-tech water lifting techniques since it has an average groundwater access of 12 meters below the surface and an average borehole potential yield of 2.5 L/second.9.5% of the eligible area will no longer be appropriate for irrigation because of climate change in the 2050s, and 17% in the 2070s. (Worqlul, A. et al., 2019).

Research Matrix

TITLE	YEAR	PROPONENTS	METHODOLOGY	FINDINGS
Optimal Control for Precision Irrigation of a Large-Scale Plantation	**2020**	• Ruud Kassing • Bart De Schutter • Edo Abraham	researcher propose a methodology to reduce this complex problem into two separate optimal control problems, which are solved using a two-level structure consisting of a seasonal irrigation planner and a daily MPC irrigation controller.	The results indicate, for each field, how much water is required in each growth stage for maximum yield.

Automated Plant Watering System	**2018**	• P. KUSUMA VANI • N. AVINASH • M. SACHIN KUMAR • M. TIRUPATHI RAO • B. SIMHACHALAM	This set up is programmed in such a way that it will sense the moisture content of the soil, if it is less than required voltage then relay will automatically turn ON and then required water is supplied. This system is basically used for plant care, and as well as the part of helping small and large gardens.	
Effect of climate change on land suitability for surface	**2019**	• Abeyou W. Worqlul • Yihun T. Dile • Jaehak Jeong • Zenebe Adimassu • Nicole Lefore • Thomas Gerik • Raghavan Srinivasan	The land suitability study was accomplished using a multi-criteria evaluation technique for baseline period using historical climate data (1990 to 2010) and	The result indicated that the comparison matrix to be trustworthy, with a consistency ratio of 5%

irrigation and irrigation potential of the shallow groundwater in Ghana		• Neville Clarke	projected time horizons 2050s (2041 to 2060) and 2070s (2061 to 2080).	(Ceballos-Silva and Lopez-Blanco, 2003, Saaty, 1980).

Modelling the Potential Impacts of Climate Change on Rice Cultivation in Mekong Delta, Vietnam	**2020**	• An T. N. Dang • Lalit Kumar • Michael Reid	the impacts of climate change on rice cultivation in the MD using an ensemble-modelling approach, implemented by biomod2 platform in R software.	the mean loss of suitable land and mean gain of unsuitable land were 31.4% and 64.6%, respectively, for the year 2050 compared to the present. Salinity intrusion, increases in precipitation during rainy season and decreases in precipitation during dry season were key factors driving the loss of suitable habitat.

DEVELOPMENT ON AUTOMATED PLANTWATERING SYSTEM FOR SOIL HUMIDITY	**2017**	• Irni Hamiza Hamzah • Muhammad Salehan Tutor • Mohaiyedin Idris • Aida ZuliaZulhanip • Mohammad Nizam Ibrahim • Ali Othman • Alhan Farhanah Abd Rahim	The system wasconnected with motor pump for irrigation. The motor pumpstarted to water the plants when the soil dried. During this process, the measured data was then being displayed at LCDscreen and monitored in real time at GUI created by Visual Basic.	The data were displayed in degree Celsius fortemperature and for soil humidity in a scale of 0 to 1030. Thebigger the scale, the dryer the soil was. As a conclusion, anautomated plant watering system was successfullyimplemented using Arduino Uno to control the soil moistureand capable in monitoring data

				and analysis the parametersin the garden.
Smart Plant Monitoring System Using Aquaponics Production Technological with Arduino Development Environment (IDE) and SMS Alert: A Prototype.	**2022**	• Abu Bakar, Zahari • Muhammad Nor, Muhammad Zairil • Kadiran, Kamaru Adzha • Misnan, Mohamad Farid • Nooreza m,	The system used a variety of sensors, including temperature and humidity sensors, ultrasonic sensors, and pH sensors, as well as microcontrollers like Arduino, to monitor and manage the water quality, plant	The data from this system's monitoring reveals the values that have been taken on a daily basis. The graph demonstrated that the plant's growth is increasing every day.

		Maisarah	humidity, and other variables. When the sensor identifies any abnormal circumstance, early warnings in the form of SMS and push notifications are immediately given to the user to ensure a healthy growing environment	

			for fish and plants.	

Conceptual Framework

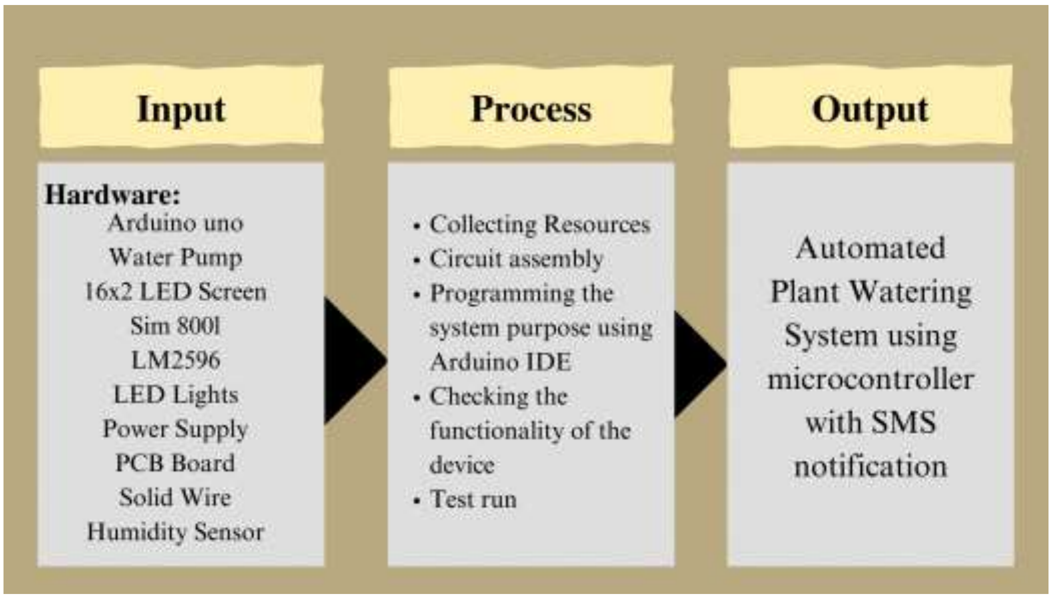

Figure 1:Conceptual Framework

The diagram illustrates the path of automated plant watering irrigation system from concept to reality, where its necessary components, the procedure, and the expected outcome are described and precisely explained. The objects, tools, and raw materials required to create the automated Plant watering control system are present in the input. Given the quality and cost, this material will most effectively carry out its important roles. The procedure consists of systematic instructions for the components and the way the materials will be assembled to form the proposed device. Each step will be simple to ensure that complexity is not an issue.

Conceptual Diagram

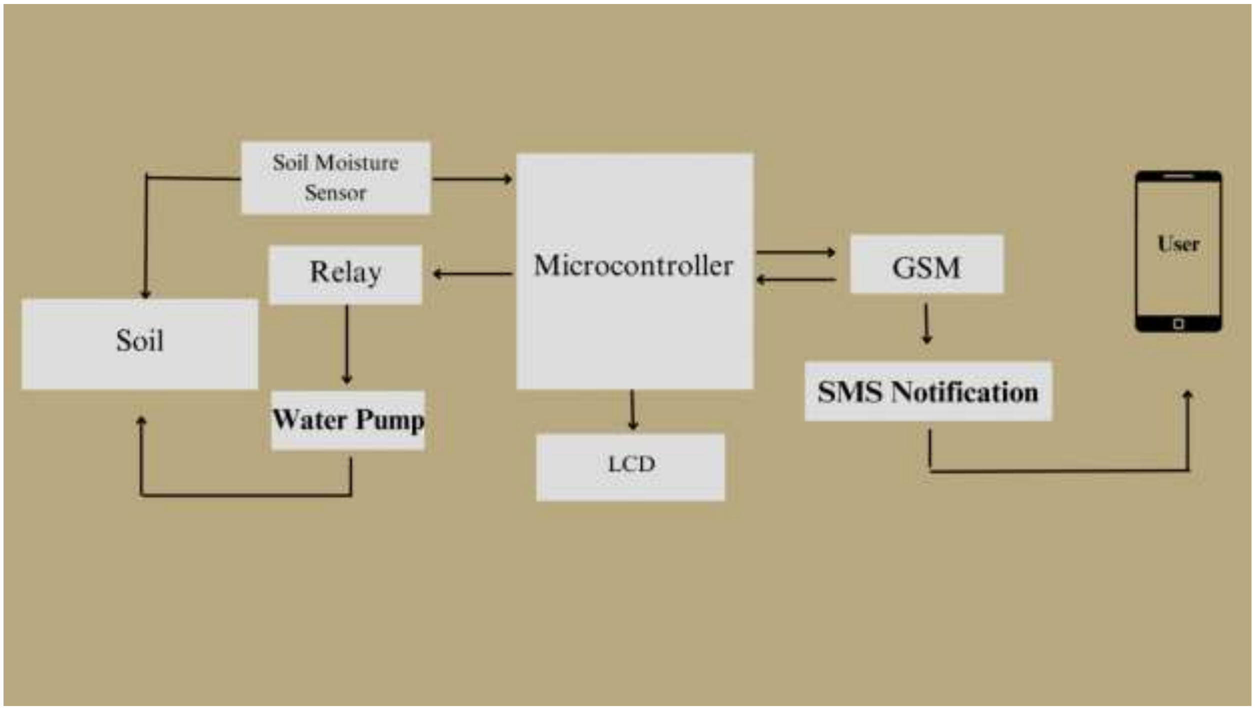

Figure 2: Conceptual Diagram

In this study, the researcher created a device that can automatically open a plant watering irrigation sprinkler and notify the user when it is about to open. Figure 2 depicts the study's concept diagram. The user must first place the sensor on the ground or manually open the gate via text. Following that, the sensor or SIM 800L will receive the data and activate the device to open the canal gate; if the device fails to open the gate, it will send an SMS notification to the user.

Definition of Terms

1. Automated Plant Watering System. Canal automation always has had the potential to save water and improve efficiency of irrigation water supply projects or of irrigation district operations (Wahlin & Zimbelman, 2016).
2. Water Pump is a machine that boosts water pressure to move it from one place to another. Water supply for municipal, industrial, agricultural, and residential uses is provided by modern water pumps all over the world. Wastewater is moved in sewage treatment plants using water pumps as well (Koth, n.d.).
3. Water Level Sensor is a device that measures the liquid level in a fixed container that is too high or too low. (Rekeer, 2021).
4. C++ is an object-oriented programming language which gives a clear structure to programs and allows code to be reused, lowering development costs.

Chapter III
Methodology

This chapter contains specific procedures essential to this study. This will provide the techniques used to identify the details and flow of the study and the methods that will be used in this study. The methodologies will include areas such as research design, sampling technique, research instrument, data gathering procedure, statistical treatment, and target client.

Methods and Techniques of the Study

The target respondents for the pre-need assessment test of the study would be the people who reside in Plaridel, Bulacan, Philippines, most especially those farmers who are growing crops, particularly green house, or those people who have their own greenhouse farming. The proponents will be using a purposive sampling method, wherein the researchers will choose these individuals according to specific traits or qualities that are directly associated with the study, which are people who are growing crops, particularly green house. The researchers would not be able to conduct an online pre-need assessment test because the policies are not strict and there is a lack of social media use by the elderly. Instead, they will use a face-to-face survey platform to obtain the data. The researchers will use a hardcopy survey questionnaire to deliver the test to the target respondents. The ideal number of respondents is set at 20 since it is hard to find relevant respondents due to the lack of greenhouse farm owners.

Population and Sample of the Study

The study's target clients, according to the researcher's proposal, would be the following: First, farmers who are working on the land will be the ones using these tools. This applies to those who are habitual or when the unexpected occurs. Second, a farm that is unable to work on irrigation land.

Research Instrument

The first research instrument that will be used will be the need analysis survey questionnaire, which will be answered face-to-face through a hardcopy survey questionnaire. The survey for the need analysis of the project is going to be a thirty (30) item questionnaire; each question will be based on this study's review of related literature to determine the gaps and set the usability objectives.

The said questionnaire would be on a Likert scale and would be answerable by "Highly Acceptable, Moderately Acceptable, Acceptable, Fairly Acceptable, Poorly Acceptable " to get a higher response rate from the participants.

Data Gathering Procedure

The participants gathered in this study were in a face-to-face setting. The participants are given time to test the product before answering. The informed consent was given face-to-face. Participants had a 15–30-minute allotment to complete answering the questionnaires. The study participants are given informed consent to learn the objective and purpose of the study. It provides sufficiently detailed information about the current study to give the participants a rational decision to partake. The participants had the privilege to withdraw without any corresponding penalty or loss of benefits. The answers were kept confidential and used for academic purposes only. After gathering the data, the researchers encoded and tabulated it.

Data Processing and Statistical Treatment

The researchers analyzed the current study through the following statistical method: The study used frequency and percentage to ascertain the product's efficiency. Statistical parameters were used to compare the float switch sensor, water pump, and water level sensor. The parameters were applied to measure the performance of the sensor and motors. The mean difference, which describes the average difference between the sensor data and the corresponding automated plant watering system using a microcontroller and text notification, was used to assess the degree of differences in the plant watering irrigation system process.

Project Development

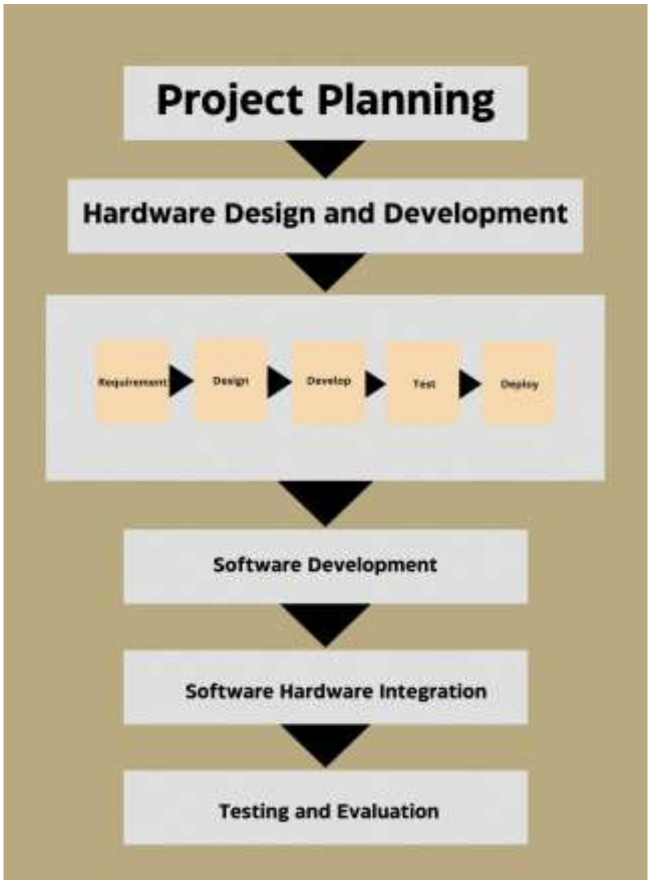

Figure 3.1: Project Development

Automated Plant Watering System using a microcontroller and SMS Notification is an innovative project aimed at revolutionizing the agricultural sector by automating the plant watering irrigation system process. This project involves the use of a microcontroller to automate the irrigation process and a GSM module to send SMS notifications to the farmer regarding the status of the plant watering irrigation system.

The system is designed to automatically turn on the plant watering irrigation system when the soil moisture level falls below a certain threshold. The microcontroller is connected to soil moisture sensors that continuously monitor the moisture level in the soil. Once the moisture level falls below the set threshold, the microcontroller sends a signal to turn on the plant watering irrigation system.

The system also includes a GSM module that sends SMS notifications to the farmer regarding the status of the plant watering irrigation system. The farmer can receive notifications regarding the start and end of irrigation, and it records the monthly report of data coming from the soil moisture sensor. This enables the farmer to remotely monitor the irrigation process, ensuring that the crops receive the optimal amount of water.

The benefits of this project are significant. Automated plant watering irrigation saves time and resources by eliminating the need for manual monitoring and control. This project also helps to conserve water resources by preventing over-irrigation and wastage of water. Moreover, SMS notifications enable the farmer to receive real-time updates, allowing them to take timely action in case of any issues with the plant watering irrigation system.

Overall, the project development of Automated Plant Watering System using a microcontroller and SMS notification is an important step towards modernizing the agriculture industry and improving crop yields.

Conceptual Design of the Device

The researchers created the device's conceptual design, which can be seen in the figure below, during the early or very preliminary stages of the design process.

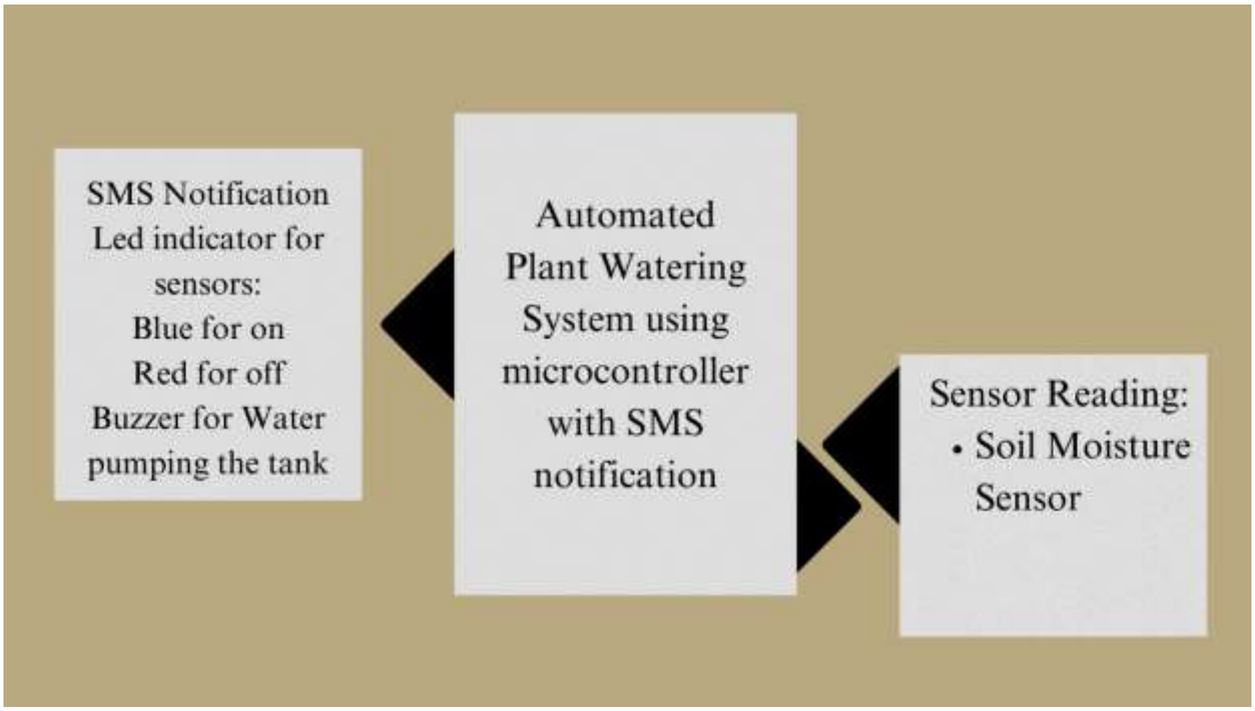

Figure 4.2: Conceptual Design of the Device

Hardware Design

When the researchers had the device conceptual design, they began to plan how the device would be designed as well as how it would function. Following the brainstorming, the researchers developed the hardware design concept blocks depicted in the figure below.

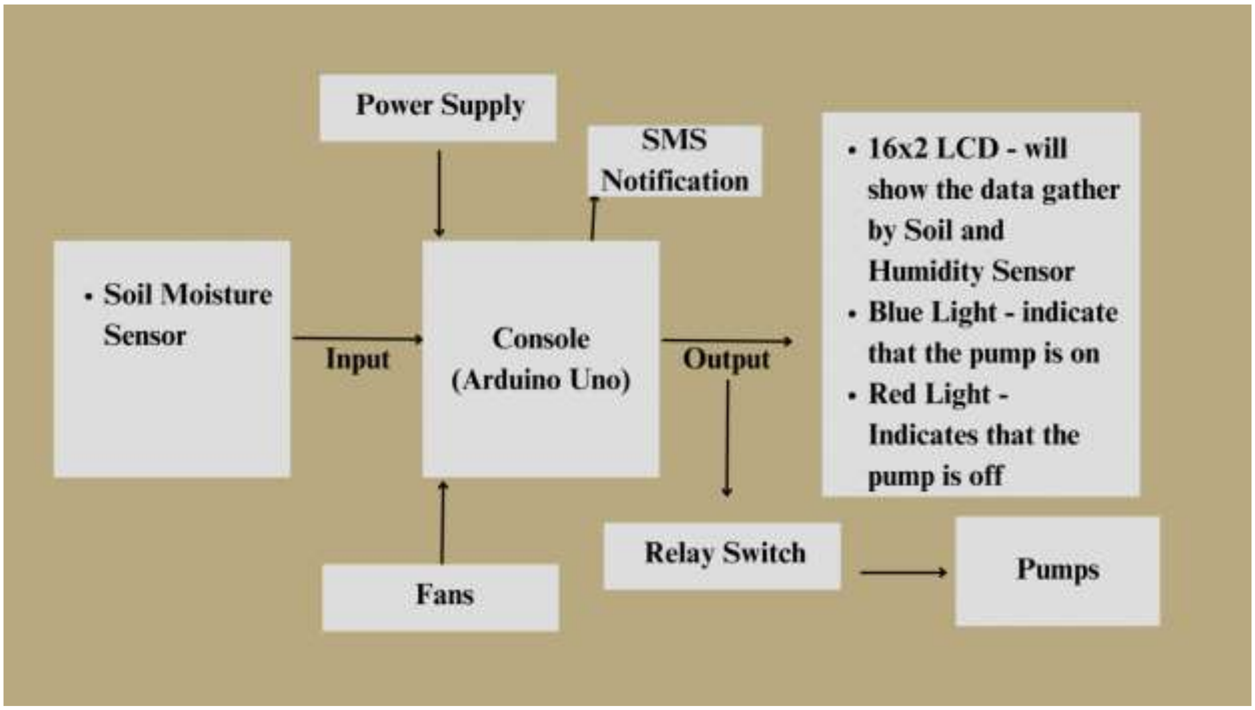

Figure 5.3: Hardware Design

Chapter IV
Presentation, Analysis, And Interpretation of Data

This chapter presented the analysis and interpretation of the study's data. It went over the various manual processes, their benefits, and drawbacks. It also includes the findings of the device observations, as well as the results of the survey and evaluation of respondents. It is an essential component because it provides readers with a detailed and objective view of the data and the conclusions drawn from it.

Design the hardware device.

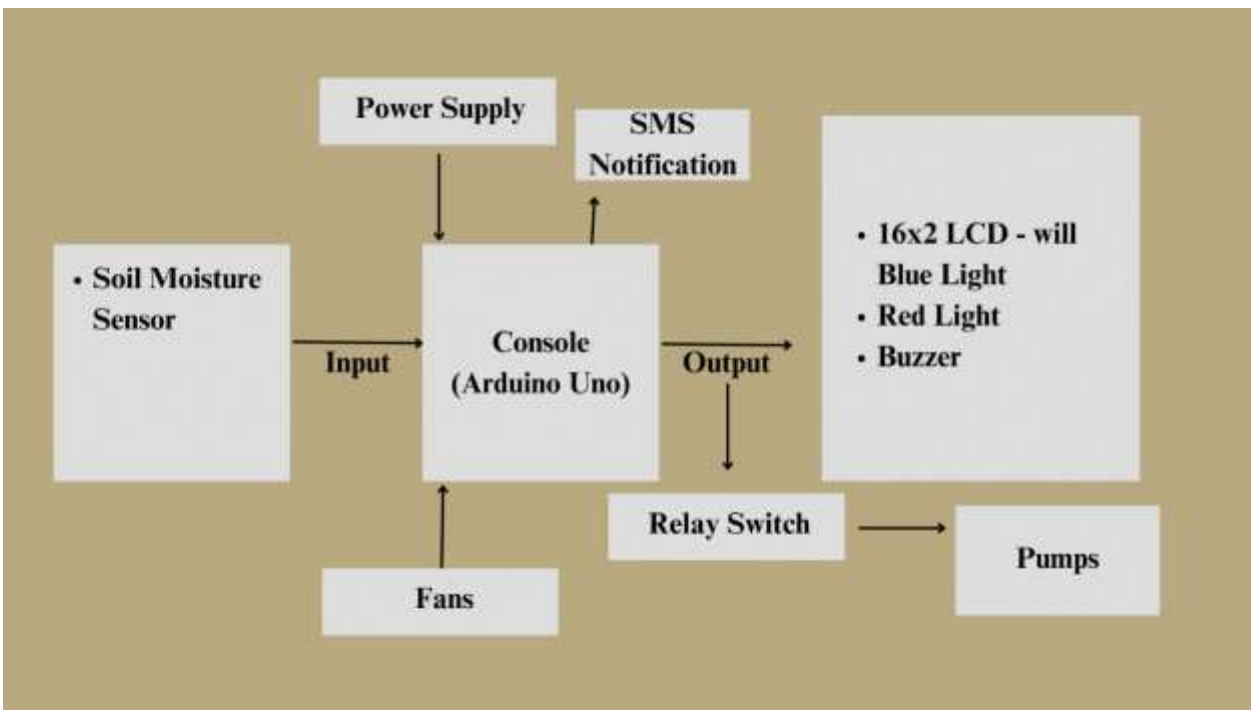

Figure 4.1: Block Diagram of Hardware Design

The researcher designs the hardware device, a block diagram and flow chart to explain the data flow of entire system to describe logically the system in detail. The researcher uses Arduino Uno to integrate the needs of the system to function according to the formulate process.

The researchers were the first to identify the device's key components. The block diagram of the device is shown in Figure 4.1. The diagram provides a high-level summary of the main system components' relationships and connections.

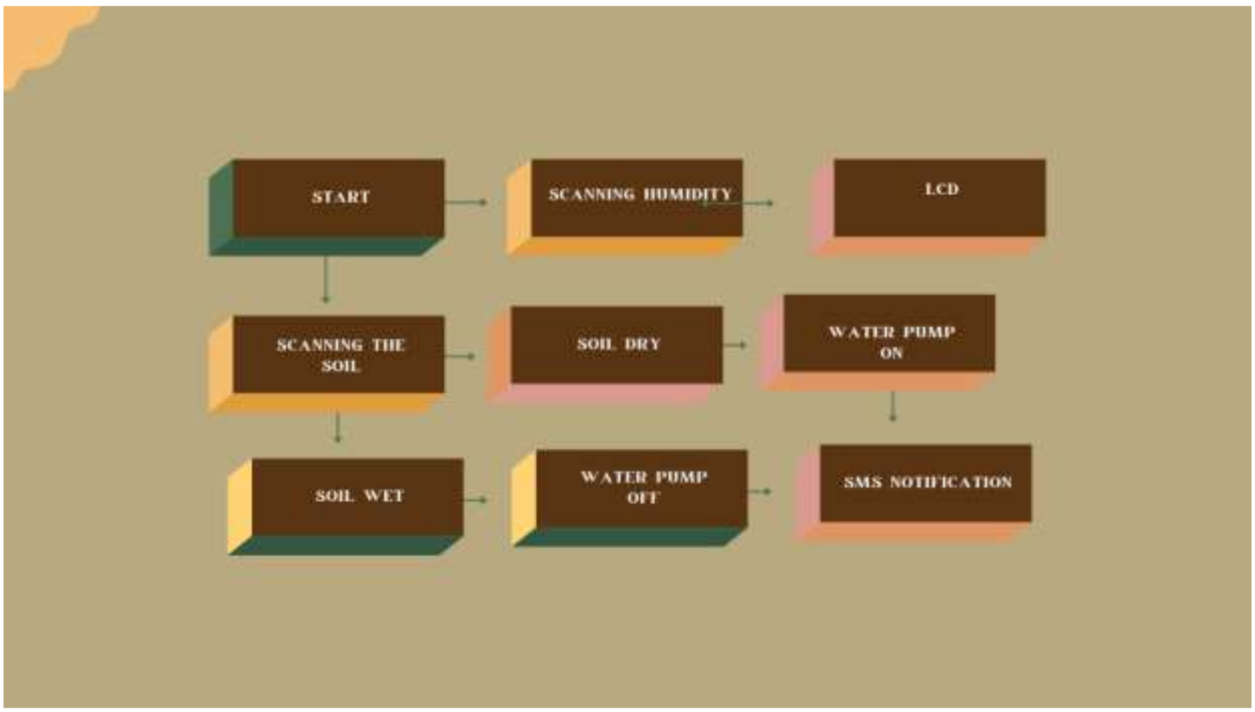

Figure 4.2: Flowchart of the Main Process of the System

1. Planning

In developing the "Automated Plant Watering System using Microcontroller with SMS Notification" Planning, Hardware Development, Hardware Specification, and Software Integration, System Testing and Project Evaluation are the methods taken to get the desired result.

Planning in watering system is the process of designing, developing, and implementing a systematic approach to managing water resources for agricultural purposes. It involves understanding the needs of the crops, soil, and climate, and determining the amount of water required to achieve optimal growth and yield.

The following are some key steps in the planning process for plant watering:

Assess water requirements: The first step in watering plant planning is to assess the water requirements of the crops being grown. This involves determining the evapotranspiration rate of the plants, which is the amount of water lost through both evaporation from the soil and transpiration from the plants.

Identify water sources: The next step is to identify potential sources of water for planting. This may include surface water from rivers or lakes, groundwater, or rainwater harvesting.

Design the plant watering system: Once the water requirements and sources have been identified, the next step is to design the watering system. This includes determining the best delivery method and designing a system that is efficient, cost-effective, and sustainable.

Implement the system: Once the plant watering system has been designed, it needs to be implemented. This involves installing the necessary equipment and infrastructure, and ensuring that the system is properly maintained and operated.

Monitor and evaluate: Finally, it is important to monitor and evaluate the plant watering irrigation system to ensure that it is meeting the needs of the crops and the environment. This includes monitoring the water supply, assessing the effectiveness of the plant watering system, and making any necessary adjustments to improve its performance.

Overall, effective planning in plant watering is essential for ensuring that water resources are used efficiently and sustainably, and that agricultural crops are able to thrive and produce optimal yields.

2. **Hardware Development**

The researchers chose iterative as the preferred hardware development paradigm because it allows the device to gradually adapt to changes in physical components based on the device's needs.

Figure 4.3: Arduino Uno

The **Arduino UNO** is the best board to get started with electronics and coding. If this is your first experience tinkering with the platform, the UNO is the most robust board you can start playing with. The UNO is the most used and documented board of the whole Arduino family.

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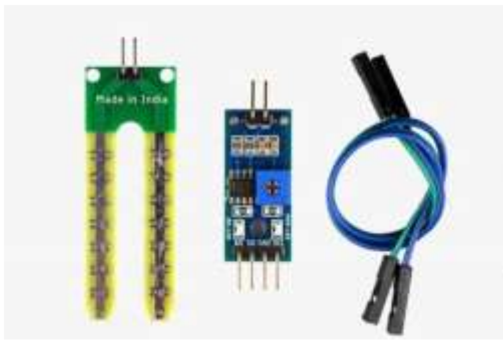

Figure 4.4: Soil Moisture Sensor

Soil moisture sensors measure or estimate the amount of water in the soil. These sensors can be stationary or portables such as handheld probes. Stationary sensors are placed at the predetermined locations and depths in the field, whereas portable soil moisture probes can measure soil moisture at several locations.

Figure 4.5: Relay Module

The 2 Channels **Relay Module** is a convenient board which can be used to control high voltage, high current load such as motor, solenoid valves, lamps, and AC load. It is designed to interface with microcontroller such as Arduino, PIC etc.

Figure 4.6: 16x2 LCD With I2C

A **16x2 LCD** means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. The 16 x 2 intelligent alphanumeric dot matrix display can display 224 different characters and symbols. This LCD has two registers, namely, Command and Data.

The **inter-integrated circuit (I2C)** API provides a set of functions to configure the device's I2C module. The driver supports operation in both master, slave mode, and provides functions to initialize the module, to send and receive data, to obtain status information, and to manage interrupts.

Figure 4.7: 5V Water Pump

5V water pumps - The main advantage of this water pumps it’s their operating current, because it is so low they can be powered directly by the Arduino 5V outputs, making a very simple set-up that will make it easier and faster for prototyping of your automated watering system.

Figure 4.8: LM2596

The **LM2596** series of regulators are **monolithic integrated circuits that provide all the active functions for a step-down (buck) switching regulator**, capable of driving a 3-A load with excellent line and load regulation.

The **LM2596** DC-DC module with voltage display is **a step-down voltage regulator, which has a wide input range (between 4V and 40V), and the output voltage is adjustable using the potentiometer between 1.25 V and 37 V**. This module has good quality and its voltage display does not require additional power.

Figure 4.9: Power Supply

This 5A power supply is a beefy enough for your high-power applications. The fact that it is a switching supply means it's a lot smaller and much lighter weight than a linear supply that uses a transformer, it can supply 12V DC up to 5 Amps, running from 110V or 220V power.

Figure 4.10: Sim 800l

SIM800L is **a miniature cellular module which allows for GPRS transmission, sending and receiving SMS and making and receiving voice calls**. Low cost and small footprint and quad band frequency support make this module perfect solution for any project that require long range connectivity.

Figure 4.11: 12V DC Fan

A DC, or direct current fan, uses a power source that is connected to a transformer. The transformer then converts the energy to direct current, or a one-way current. As a result, the quantity of power utilized is ultimately decreased.

Casing. Use to house all the electronic components.

The hardware was conceptualized by the researchers based on the needs structure design that the researchers planned on how it would be done. The researchers created circuit diagrams to help users understand the connections between the components, as well as 3D designs to help users visualize the size of the device, the covered spaces of various components, ventilation, and how the user interacts with the device.

The First iteration shows the whole design of a chassis, with 1 fan and holes in ply board

Figure 4.12: Side of the Device

4. Hardware and Software integration

Data acquisition (DAQ) is the process of collecting data from various sources such as sensors, instruments, and devices. In recent years, the popularity of Arduino microcontrollers has made it easier than ever for makers and DIY enthusiasts to integrate DAQ hardware with software.

The researchers use a low cost but friendly software to track the record of soil moist in daily basis.

5. Testing

The device was evaluated through its functionality, reliability, usability, maintainability, portability, and supportability. The device was evaluated by 20 random plant owners and gardeners. The results of the evaluation were analyzed and interpreted.

The researchers perform computation on the collected data to find the weighted mean. The weighed mean will be used to place a proper interpretation using the Five-Point Likert Scale. Table 1.1 to 1.6 will present the descriptive measures of the system.

Table 1.1: Functionality Assessment of Automated Plant Watering System Using Microcontroller with SMS Notification

FUNCTIONALITY	Responses					MEAN	INTERPRETATION
	5	4	3	2	1		
1. The device performs its intended functions effectively.	17	3	0	0	0	4.85	Highly Acceptable

2. This device can be easily turned on and off or adjusted as needed.	10	8	2	0	0	4.4	Highly Acceptable
3. The software integrates with hardware and other devices well.	11	4	5	0	0	4.3	Highly Acceptable
4. This device provide the necessary coverage and volume of water needed for the specific area being irrigated.	7	9	4	0	0	4.15	Moderately Acceptable
5. This device is adjustable to meet the changing needs of the plants or crops as they grow.	6	9	5	0	0	4.05	Moderately Acceptable
Overall Weighted Mean	**4.35**						**Highly Acceptable**

Table 1.1 shows that the weighted mean for functionality is (4.35), with "Highly Acceptable" as the descriptive interpretation. This suggests that the respondents firmly believe that the developed system is functional in terms of the following attributes: (4.85) The device performs its intended functions effectively. (4.4) This device can be easily turned on and off or adjusted as needed. (4.3) The software integrates with hardware and other devices well. (4.15) This device provides the necessary coverage and volume of water needed for the specific area being watered. (4.5) This device is adjustable to meet the changing needs of the plants or crops as they grow.

Table 1.2: Reliability Assessment of Automated Plant Watering System Using Microcontroller with SMS Notification

RELIABILITY	Responses					MEAN	INTERPRETATION
	5	**4**	**3**	**2**	**1**		
1. The device experiences no errors or malfunctions.	12	5	3	0	0	4.45	Highly Acceptable
2. The device can maintain a specified level of performance in case of faults of its interface.	12	5	3	0	0	4.45	Highly Acceptable

3. This device reduce workload.	13	6	1	0	0	4.6	Highly Acceptable
4. The device rarely has any problems.	9	8	3	0	0	4.3	Highly Acceptable
5. This device's backup water source is effective and efficient.	9	8	3	0	0	4.3	Highly Acceptable
Overall Weighted Mean	**4.42**						**Highly Acceptable**

Table 1.2 shows that the weighted mean for reliability is (4.42), with "Highly Acceptable" as the descriptive interpretation. This suggests that the respondents firmly believe that the developed system is reliable in terms of the following attributes: (4.45) The device experiences no errors or malfunctions. (4.45) The device can maintain a specified level of performance in case of faults of its interface. (4.6) This device reduce workload. (4.3) The device rarely has any problems. (4.3) This device's backup water source is effective and efficient.

Table 1.3: Usability Assessment of Automated Plant Watering System Using Microcontroller with SMS Notification

USABILITY	Responses					MEAN	INTERPRETATION
	5	**4**	**3**	**2**	**1**		

1. The device is attractive and convenient to the user.	16	3	1	0	0	4.75	Highly Acceptable
2. The device can be easily operated and controlled.	15	3	2	0	0	4.65	Highly Acceptable
3. The device can be easily learned even without training.	12	3	5	0	0	4.35	Highly Acceptable
4. This device brings positive results.	10	6	4	0	0	4.3	Highly Acceptable
5. This device does not need high maintenance.	12	5	3	0	0	4.45	Highly Acceptable
Overall Weighted Mean	**4.5**						**Highly Acceptable**

Table 1.3 shows that the weighted mean for usability is (4.5), with "Highly Acceptable" as the descriptive interpretation. This suggests that the respondents firmly believe that the developed system is usable in terms of the following attributes: (4.75) The device is attractive and convenient to the user. (4.65) The device can be easily operated and controlled. (4.35) The

device can be easily learned even without training. (4.3) This device brings positive results. (4.45) This device does not need high maintenance.

Table 1.4: Maintainability Assessment of Automated Plant Watering System Control Using Microcontroller with SMS Notification

MAINTAINABILITY	Responses					MEAN	INTERPRETATION
	5	4	3	2	1		
1. The device can be easily analyzed for deficiencies or causes of failures.	13	1	6	0	0	4.35	Highly Acceptable
2. The device is stable and has low risk of unexpected effects as result of modifications.	8	6	6	0	0	4.1	Moderately Acceptable
3. The device assesses the availability and usefulness of diagnostic tools for troubleshooting and identifying problems.	12	4	4	0	0	4.4	Highly Acceptable

4. This device has any spare parts or components on hand to quickly replace any damaged or broken parts.	16	3	1	0	0	4.75	Highly Acceptable
5. This device has a process in place to identify and address any leaks or other issues with the system.	15	4	1	0	0	4.7	Highly Acceptable
Overall Weighted Mean	**4.46**						**Highly Acceptable**

Table 1.4 shows that the weighted mean for maintainability is (4.46), with "Highly Acceptable" as the descriptive interpretation. This suggests that the respondents firmly believe that the developed system is maintainable in terms of the following attributes: (4.35) The device can be easily analyzed for deficiencies or causes of failures. (4.1) The device is stable and has low risk of unexpected effects as result of modifications. (4.4) The device assesses the availability and usefulness of diagnostic tools for troubleshooting and identifying problems. (4.75) This device has any spare parts or components on hand to quickly replace any damaged or

broken parts. (4.7) This device has a process in place to identify and address any leaks or other issues with the system.

Table 1.5: Portability Assessment of Automated Plant Watering System Control Using Microcontroller with SMS Notification

PORTABILITY	Responses					MEAN	INTERPRETATION
	5	**4**	**3**	**2**	**1**		
1. The device can be easily transported between different growing areas or fields.	14	4	2	0	0	4.6	Highly Acceptable
2. The device can work well or compatible with other operating systems, software and hardware components.	10	8	2	0	0	4.4	Highly Acceptable
3. The device can be installed easily.	11	5	4	0	0	4.35	Highly Acceptable
4. The device can adapt to different specified	6	8	6	0	0	4.0	Moderately Acceptable

environments or areas of application.							
5. This device is portable, and easy to move.	9	8	3	0	0	4.3	Highly Acceptable
Overall Weighted Mean	**4.33**						Highly Acceptable

Table 1.5 shows that the weighted mean for portability is (4.33), with "Highly Acceptable" as the descriptive interpretation. This suggests that the respondents firmly believe that the developed system is portable in terms of the following attributes: (4.6) The device can be easily transported between different growing areas or fields. (4.4) The device can work well or compatible with other operating systems, software and hardware components. (4.35) The device can be installed easily. (4.0) The device can adapt to different specified environments or areas of application. (4.3) This device is portable, and easy to move.

Table 1.6: Supportability Assessment of Automated Plant Watering System Using Microcontroller with SMS Notification

SUPPORTABILITY	**Responses**					**MEAN**	**INTERPRETATION**
	5	**4**	**3**	**2**	**1**		

1. This device has replacement parts or components be obtained if needed.	15	4	1	0	0	4.7	Highly Acceptable
2. This device has software or technology updates that need to be installed regularly.	14	3	3	0	0	4.55	Highly Acceptable
3. There is a process for reporting any issues or problems with the irrigation system.	11	7	2	0	0	4.45	Highly Acceptable
4. There are troubleshooting guides available for common issues with the device.	7	7	6	0	0	4.05	Moderately Acceptable
5. There are compliance or regulatory requirements that need to be considered in relation to the use or	9	8	3	0	0	4.3	Highly Acceptable

maintenance of the device.							
Overall Weighted Mean	**4.41**						**Highly Acceptable**

Table 1.6 shows that the weighted mean for supportability is (4.41), with “Highly Acceptable” as the descriptive interpretation. This suggests that the respondents firmly believe that the developed system is supportable in terms of the following attributes: (4.7) This device has replacement parts or components be obtained if needed. (4.55) This device has software or technology updates that need to be installed regularly. (4.45) There is a process for reporting any issues or problems with the irrigation system. (4.05) There are troubleshooting guides available for common issues with the device. (4.3) There are compliance or regulatory requirements that need to be considered in relation to the use or maintenance of the device.

Chapter 5
Summary of Findings

This chapter includes the summary of the study. It also contains conclusions drawn from the findings and recommendations offered based on the study.

Plants are very useful to all humans and animals in many aspects. Especially in helping us in keeping our environment healthy by cleaning air naturally and producing oxygen. In this, the researchers make a system to helps the gardener and or plant owners to sustain the development of the plants.

Our main purpose and goals are to create and design an automated plant watering system using microcontroller and SMS notification will control the volume of the water, to water the plants, this will automatically determine if the soil moisture sensor detects that the soils dry is dry – it will release water using a water pump that comes from the storage into plants and send an SMS notification. However, if it wet, it will automatically stop and will send SMS notification.

In addition, the daily control of soil moisture is being handled by predictive controller that fallow the seasonal planner’s decision on water distribution that are based on Aqua Crop-OS model.

The benefits of this project in automated plant watering using microcontroller with SMS notification saves time and resources and eliminating the needs for manual monitoring, control, and helps to conserve water resources. Through SMS notification, enable the gardeners to receive real-time updates.

Conclusion

The findings of the study implied that the gardeners are satisfied with the results of the automated plant watering system using microcontroller with SMS notifications. Climate change has affected gardeners due to high heat at this time of the year and gardeners are finding it difficult working due to the weather. The researchers have developed this device to improve their field of work and brings efficiency on water sources. Thus, the researchers have improvements to make via expansion of watering system to increase the number of plants being watered.

Recommendation

The researcher recommends using the following:

- 12 – 220v water pump – to have a right amount of pressure of water
- Sprinkler – for a better control on water like rainfall
- Optimize Watering Schedule - Design the system to allow for customizable watering schedules based on individual plant requirements. Different plants have varying water needs, and some may require more frequent watering than others may. By implementing a flexible scheduling feature, users can easily adjust watering intervals or durations to suit the specific needs of their plants.
- Implement Battery Backup - It is recommended to include a battery backup system to ensure continuous operation of the automated plant watering system. In case of a power outage or disruption, the backup battery will keep the system functional, ensuring that plants continue to receive water as per the scheduled or sensor-based requirements.

- Include Water Level Monitoring - In addition to soil moisture sensing, consider incorporating water level monitoring within the system. This feature will allow the microcontroller to detect when the water reservoir is running low or empty. When the water level drops below a certain threshold, the system can send an SMS notification to the user, indicating the need for refilling the reservoir. This proactive approach ensures uninterrupted watering and prevents the plants from drying out.
- Provide User-Friendly Interface - Create a user-friendly interface for configuring and managing the automated plant watering system. This interface can be a dedicated mobile application or a web-based dashboard accessible from any device. It should allow users to monitor real-time data, adjust watering settings, view historical information, and receive SMS notifications, providing a convenient and intuitive way to interact with the system.

References

Dang, An., Kumaar, L., & Reid, M. (2020). Modelling the potential impacts of climate change on rice cultivation in Mekong Delta, Vietnam. *Sustainability*, *12*(22). https://www.mdpi.com/2071-1050/12/22/9608

Hamzah, I., Tutor, M., Idris, M., Zulhanip, A., Ibrahim, M., Othman, A., & Rahim, A. (2017). Development on automated plant watering system for soil humidity. *Academia.* https://www.academia.edu/86369249/

Kassing, R., Schutter, B., & Abraham, E. (2020). Optimal control for precision irrigation of a large-scale plantation. *AGU Advancing, Earth and Space Science.* https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2019WR026989

Kusuma Vani, P., Avinash, N., Kumar, M., Rao, M., & Simhachalam, B. (2018). Automated plant watering system. *International Journal of Scientific Engineering and Technology Research*. http://ijsetr.com/uploads/263415IJSETR16651-111.pdf

Worqlul, A., Dile, Y., Jeong, J., Adimassu, Z., Lefore, N., Gerik, T., Srinivasan, C., & Clarke, N. (2019). Effect of climate change on land suitability for surface irrigation and irrigation potential of the shallow groundwater in Ghana. *Science Direct*. https://www.sciencedirect.com/science/article/pii/S0168169918311426

Zahari, A., Zairil, M., Adzha, K., Farid, M., & Maisarah, N. (2022). Smart plant monitoring system using aquaponics production technological with arduino development environment (IDE) and sms alert: A prototype. *ESBSCO*.

https://web.s.ebscohost.com/abstract?direct=true&profile=ehost&scope=site&authtype=crawler&jrnl=18657923&AN=160474436&h=WXIgwhnr6Rk%2fWKIvaB5i6w64291tzned9gNhTn%2bf7nNJ55KFeEkB0Y%2bhYU42z7h89EeJJKyGAGK7opxp3wzNSQ%3d%3d&crl=c&resultNs=AdminWebAuth&resultLoc