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Solar-powered automatic plant watering system with moisture sensor using Arduino Uno

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Abstract

This study utilized applied experimental research to develop a Solar-powered automatic plant watering system with a moisture sensor using Arduino Uno. The device aims to automatically water the plants by detecting their moisture content, encourages water conservation, and helps users water plants. To improve soil management efficiency, a solar-powered plant watering system and soil moisture sensor have been developed using materials such as Arduino Uno R3, a mini water pump with a small pipe, a mini solar pane, a soil moisture sensor, jumper wires, batteries, 5V relay module, a 16x2 LCD for the automation, while a charge controller, and a plastic container as the main base of the product. Twenty-three participants took part in the survey to assess the usefulness and effectiveness of the system, offering helpful suggestions for improvement. The results show that the system functions well at its level and that it has the potential to support sustainability by keeping the soil hydrated. Moreover, the automatic watering system can shorten the time it takes to water the plant. The researchers also discovered that the wiring and coding play the most significant role in the device's effectiveness. A minor alteration to these components can significantly affect the device, particularly the pump's code, to improve the water intake, thus lessening the time to water the plants. This study promotes technological advancement and environmental awareness since it is essential to incorporate sustainable practices.

Keywords: water conservation, soil moisture sensor, Arduino Uno R3, solar powered, convenience

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1. Introduction

For a variety of reasons, sustainable vegetable production prioritizes effective water utilization. The right amount of water application helps to maximize plant yield and quality while reducing the risk that plant nutrients will be washed away from the root zone. This reduces costs for farmers and can lead to high sediment loads that can harm public waterways through eutrophication and groundwater contamination (Brooks et al., 2016). Additionally, some producers discover that water use efficiency is crucial if water supplies are scarce or if they purchase municipal water (Schattman et al., 2023). A specific amount of moisture is needed, depending on the plant type. Since plants, among other things, rely on water, this is the case for the survival of others. All living creatures require water to survive. Even though water is relatively basic, its special qualities and capacity to take on various forms make it crucial to the numerous chemical processes that occur on Earth. The primary chemical process for physical life, photosynthesis, is one of these processes. By synthesizing compounds the soil creates when carbon is present, plants can produce the necessary energy in carbon dioxide, water, and sunlight. This suggests that photosynthesis cannot take place in this process without the presence of these chemicals. As a result, for the plant to continually create energy, the soil around it must be consistently moist. People are frequently found outside of their homes because of their busy schedules. These days, the majority of them are still occupied with their jobs. Many plants and vegetables dry out because they frequently become so concentrated on one thing that they need to remember to do simple things like watering the plants (Bhateja et al., 2023).

According to Rais & Scheoran's (2015) supply chain management study, India produced over 162.187 MT of vegetables and 81.285 MT of fruits in 2015, making up nearly 14.0% of the country's portion of the world's vegetable production. In addition, Rais (2015) stated that it was clear that the supply chain is vital in the delivery of goods and services and the marketing of products, particularly agricultural products like vegetables. If not enough vegetables are produced in a year, our economy will also be affected. If the supply of vegetables is low and the demand is high, it will cause a lot of damage to our economy. The prices of the products have a high chance of increasing, resulting in us needing help buying them due to their high cost and low supply. Many people in Mindoro are very worried because the general problem in our province is its electricity. Most of the household water supply in Mindoro is connected to electricity, which causes plant and vegetable owners to worry about its high price and sudden, unnoticed brownouts. An automatic plant watering system has benefits that go beyond utility. The technology the researchers created may help save money on electric bills while promoting electric conservation.

In this context, the researchers aimed to create a system that automatically watered plants by sensing their moisture while encouraging water and electricity savings. The automatic plant watering system is a technology powered by solar energy. It helps individuals water their plants and vegetables at an appropriate time, featuring a moisture sensor that determines whether the plants need water at that moment; if not, it will stop watering them and will only resume if the sensor determines that the plants or vegetables require moisture. With the help of this technology, the plant will begin receiving water automatically. That is why this research, the Automatic Plant Watering System (APWAS), offers a solution to this problem.

Statement of the Problem - This study aimed to create a solar-powered automatic plant watering system with a moisture sensor using Arduino Uno; it sought to answer the following questions: (1) What is the level of effectiveness of the Solar-Powered Automatic Plant Watering System with Moisture Sensor Using Arduino Uno in terms of convenience and detecting moisture levels of the plant's soil? (2) Is it effective to use the 5V relay, module, solar, and Arduino Uno to water the plant automatically? (3) Is the soil moisture sensor accurate in sensing if the soil is dry or wet? (4) Is there a significant difference between automatic watering systems and manual watering of plants in terms of the time it takes to water them and the height of the plants?

Significance of the Study - The study aims to create a solar-powered automatic plant watering system with a moisture sensor using an Arduino Uno. The system seeks to efficiently maintain an optimal moisture level for plants, ensuring consistent growth and maximum productivity. The study's results will benefit the following: This study will also be valuable for the environment. Effectively using this technology to plant many trees and plants will benefit our society because we are promoting water conservation and helping the environment become greener and healthier. For individuals, this study offers valuable assistance in maintaining the health of their plants and ensuring they get watered promptly and effectively. By implementing the findings of this research, they can ensure their plants receive the optimal care they deserve, resulting in a flourishing and vibrant garden. This study helps institutions provide a well-maintained and attractive landscape. The study ensures that the right amount of water is delivered to the plants, promoting healthy growth and reducing the amount of water wasted. Additionally, they save time and effort for maintenance staff, enabling them to allocate their resources efficiently. This study saves time for farmers and other landowners and helps conserve water. It ensures that their crops are hydrated in a timely and efficient manner. Watering your crops efficiently can maximize crop yields while lowering water bills. It can also monitor and regulate practically all aspects of irrigation using an automated irrigation system. For future researchers, to advance this work and provide more information for researchers, both current and future. Researchers may concentrate on making this work more widely known to aid anyone interested in improving the environment.

Scope and Delimitation of the Study - This study focuses on the primary goal of developing an automated solar-powered plant watering system that will assist people who plant vegetables and other plants who struggle to water them and need assistance. Because this works with solar, it applies to or is relevant to certain people, reducing their water expenses. An embedded system like this combines hardware and software to assist with a particular activity. The existence of every component can be advantageous to the system by constructing specific Arduino modules, resulting in an irrigation system that people can utilize. The scope of this study covers only the automatic plant watering system with a moisture sensor using Arduino-Uno. An automatic watering system provides more precise irrigation directly to the specific plant that needs to be planted well to reduce water loss due to evaporation or improper watering. It also intends to assist specific audiences, the public, and communities to ease gardening work. This study covers the efficient and effective watering of plants and crops using this Arduino-based watering system. The watering system was tried out using the Munggo plant. This watering system can be used for farming, household gardens, or even simple houseplants. It excludes larger farm territories like ranches and intensive agriculture from the beneficiaries of this system because it can only cover a limited area and a limited water source for it to function. Also, the device has yet to develop an alarm system to detect if the water has run out, so the user must check if the water needs to be refilled manually. This constraint makes it challenging to operate consistently, especially on the aforementioned large farms; it will need hundreds of these before it can cover larger farm territories or a larger garden than usual. This study was conducted during S.Y. 2023-2024.

2. Methodology

Research Design - This study utilized an applied experimental research design to develop a solar-powered automatic watering system and test its effectiveness. This device was designed to help researchers evaluate the moisture of the plant. The researchers analyzed selected related literature and studies with the assistance of the Arduino Uno. The experimental design would be important in obtaining accurate results for answering the research questions and developing robust conclusions and recommendations for future researchers interested in a similar topic. When constructing the plant watering system, the researchers tested and performed experiments to see how well the Arduino and solar panels worked together. This makes it possible for the researchers to categorize and contrast the results to evaluate how well the study's focal components worked.

Data Gathering Procedure - This automatic plant watering system helps people water plants and vegetables at the appropriate time. It has a moisture sensor that helps detect whether the plants require water at that moment. The user would be informed via this technology, and the plant would begin receiving water automatically as the system has detected that the plant's soil is dry. The automatic plant watering system makes it easier for people to water their plants. A soil moisture sensor would detect if the plant's soil is dry for this to work. While it works, the pump will also stop automatically when the soil's moisture reaches the correct level. The data was gathered through multiple trials using the Munggo plant, textual documentation, and the survey conducted by the researchers. The researchers asked permission from their 23 classmates to answer the evaluation checklist after testing the device. The evaluation checklist was validated using expert validity. The timeframe for the data gathering was from March 20 to March 30, 2024.

Research Process: Stage 1 Preparation and Gathering of Materials - The materials needed to create the Arduino-based solar-powered Automatic Plant Watering System with Moisture Sensor are as follows:

- For the device: Arduino Uno R3, Mini water pump with a small pipe, Mini Solar Panel, Soil Moisture Sensor, Jumper Wires, Batteries, 5v Relay Module, 16x2 LCD and Charge Controller.
- For Housing: Plastic Container, Foldable Dog Bowl and Mini Water Container.

The researchers used Arduino, an already familiar controller kit at Divine Word College of San Jose. Major components, such as the Arduino Uno, soil moisture sensor, 5V relay module, wires, a mini water pump with a small pipe, a 16x2 LCD, and a mini solar panel, were purchased online. The components were estimated to cost around ₱ 2877.

Stage 2: Building and Development of the Project - The machine comprises various components that work together to carry out the desired function of the product. The researchers utilized automatic irrigation to create the device and its intended result for the experiment, suggesting that using a soil moisture sensor was a critical component of the machine's design. The soil moisture sensor in the machine is connected to the Arduino Uno, and it senses any moisture in a plant's soil. The activation of the soil moisture sensor sends an electric signal to the Arduino Uno, and the part is the one that processes the signal and makes a decision based on what it has been programmed to do, which is to pump water into the soil in a specific time frame. Another feature of the machine is the 16x2 LCD that displays if the soil is dry and if the plant is getting watered or not. The Arduino Uno serves as the machine's brain, receiving and sending electrical signals to the device's various components. It is powered by the machine's solar panel and includes a spare 9-volt battery for emergencies like nighttime or low-light conditions. The researchers also used a charge controller to regulate the current and voltage supplied by the solar panels to batteries and electrical loads such as the machine. The 5V relay module controls the water pump with the Arduino and is programmed by the researchers to determine the right time for the machine to water the plant. After the soil moisture sensor senses that the soil in the plant is dry, the 16x2 LCDs a message that the soil is dry, after which the machine immediately pumps water into the soil.

The 16x2 LCD is positioned above the solar charge controller and is the machine's indicator. The researchers used the 16x2 LCD to indicate if the plant was being watered and to display if the plant's soil was either dry or wet. The components are programmed and connected to the Arduino Uno. The researchers programmed the part to indicate whether the plant soil is either dry or wet and to water the plant if the soil is dry, and when it is the appropriate time, the soil moisture sensor will send a signal through the Uno and the Relay Module to the water pump to water the plant. To notify the machine's next course of action. The computer code for the LCD is related to the machine's systematic operation. The researchers set the LCD to display whether or not the soil is dry, signaling the appropriate time to water the plant, followed by a message indicating that the plant is currently being watered. The computer code for the LCD is related to the machine's systematic operation. The researchers set the LCD to display whether or not the soil is dry, signaling the appropriate time to water the plant, followed by a message indicating that the plant is currently being watered. The researchers used a Mini Water Pump with Small Pipe as the product's watering mechanism, meaning that it is also a critical component of the machine, as it carries out the primary objective of the machine, which is to water the plants automatically. The small pipes would be positioned near the soil to disperse the water accurately. When the soil moisture sensor senses the soil is dry, the pump is activated, and the plants are automatically watered. The water pump, soil moisture sensor, and LCD are all connected to the Arduino Uno. The researchers constructed the machine for almost a month by connecting the soil moisture sensor, the mini water pump, the LCD, and the Arduino through the jumper wires. To test the functionality of the components, the researchers would adjust the machine's code until they get the desired results. The components are then attached to the enclosure. The researchers designed an enclosure to help prevent the device from being affected by water. The enclosure also utilizes a foldable dog bowl as a plant container and a mini water container to house the water and the pump. After the machine was assembled and its components were secured and properly positioned, the final step would be to test the final product using the Mungo plant.

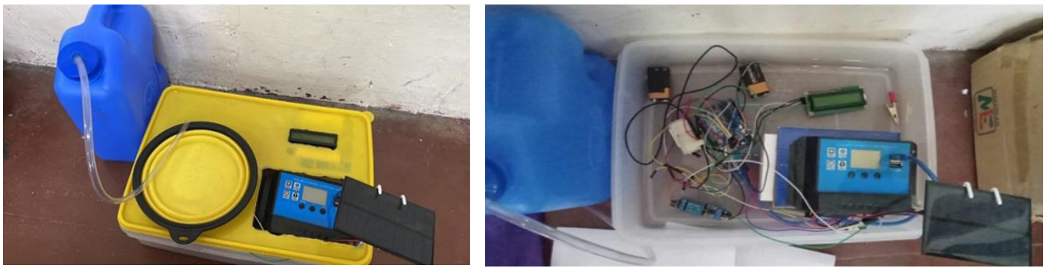

Figure 1. Actual Product of Solar-powered automatic plant watering system with a sensor using Arduino Uno

Stage 3: Experimental Stage, Observation and Data Recording - The researchers experimented and observed whether the proposed device is a beneficial and more efficient tool for helping ease gardening work and the effective utilization of water. Primarily, the device was tested using Munggo in an open area with clear access to sunlight to ensure that it operates reliably and efficiently. The researchers would set the device in a wide area for testing and observation. The researchers also used different bases and categories to determine what this device could possibly do. To determine the device's accuracy, the researchers needed two weeks to see the results as the device continuously functioned. After its availability, the researchers could finally evaluate what the product could do and its limits. This study utilized a researcher-made evaluation checklist to determine whether the device was properly functioning. The expert in Divine Word College of San Jose validated the checklist. The irrigation this device contributed to the specific area would be observed when the device stopped functioning or operating. In addition, the results and observations made during the actual testing would be documented by the researchers. The essential data for this research study was collected both before and after the device's performance was finished. The creation of the device to ensure optimal functionality would be documented by the researchers, along with every stage of the process and the preparation of necessary materials. The researchers also documented and compiled the recordings of this technology to demonstrate that they created the device. With the future completion of the device, the researchers observed its functionality to determine whether the finished product achieved the intended functionality of this technology. In addition, the researchers documented all of the information and guaranteed the integrity and accuracy of the data they collected.

Statistical Treatment of the Data - The researchers employed descriptive statistics, such as weighted mean, to determine the level of effectiveness of the Solar-powered automatic plant watering system using Arduino-Uno. Moreover, this study used T-test analysis to determine the difference between automatic and manual watering of the plant, and regression analysis was used to determine if the materials used were influential in developing the device.

3. Results and Discussions

Table 1 displays the average responses from each participant to the first part of the survey. The first part consists of questions evaluating the performance level of the solar-powered automatic plant watering system with a moisture sensor using an Arduino Uno. The overall weighted mean was 3.25, indicating that participants agreed that the device functions properly. Automated plant watering systems have emerged as efficient solutions for maintaining optimal soil moisture levels and promoting plant growth. These systems integrate Arduino microcontrollers with moisture sensors to regulate watering cycles based on soil moisture readings. Previous studies by Sheikh et al. (2024) proved the effectiveness of Arduino-Uno in their experiments in providing consistent moisture levels to various plant species, resulting in improved overall plant health. Additionally, research by Louis (2018) emphasized the ease of installation and operation of Arduino-based systems, making them accessible to hobbyists and professional gardeners alike.

Table 1

Level of effectiveness of the Solar-Powered Automatic Plant Watering System with Moisture Sensor Using Arduino Uno

Indicators	Weighted Mean	Descriptive Indicator
1. As a plant owner, solar-powered automatic plant watering is convenient.	3.25	Agree
2. The device is effective in detecting moisture levels.	3.25	Agree
Overall Mean	3.25	Agree

Legend: 3.26 - 4.00 Strongly Agree, 2.51 - 3.25 Agree, 1.76 - 2.50 Disagree, 1.00 - 1.75 Strongly Disagree

Table 2

Correlation Analysis on the Effectiveness of Using the 5V Relay Module, Solar, and Arduino Uno in automatically watering the plant

Independent Variable	Dependent Variable	R-value	R^2(Effect Size)	t-value	P value	Interpretation
5v Relay Module	Automatically Watering the plant	0.500	0.250	3.741657	0.005692	Significant
Solar	Automatically Watering the plant	0.612	0.375	2.4480	0.040061	Significant
Arduino Uno	Automatically Watering the plant	0.999	0.998	63.18230	0.000	Highly Significant

Legend: *Highly Significant at p≤0.01 *Significant at p≤0.05

Five trials were conducted to determine the effectiveness of the 5V Relay Module, Solar, and Arduino Uno. Based on the results of the experiments, the parts were not working consistently in the first three trials, indicating the need for tweaking and adjustments to the parts. After the right adjustments were made in the code and the wiring of the parts, the last two trials showed that the parts were working effectively. Integrating a 5V relay module, solar power, and an Arduino Uno microcontroller presents a promising solution for automating plant watering processes. This combination allows precise control over watering schedules based on environmental conditions and plant needs. Additionally, previous research by Johnson et al. (2023) demonstrated the effectiveness of such integrated systems in optimizing water usage while promoting healthy plant growth. Table 2 shows the correlation analysis of the effectiveness of the 5V relay module, solar, and Arduino Uno. The table demonstrates that the independent variables positively correlate with the dependent variables (automatically watering the plant). The findings show that the 5V relay module and solar are significant, with the two variables having positive correlations. In contrast, the Arduino Uno, on the other hand, is shown to be highly significant in automatically watering plants. A solar-powered automated irrigation system offers a sustainable solution to improve the efficiency of water usage in agricultural fields by using renewable energy systems to remove the labor needed for flooding irrigation. This result is supported by Kumar (2019), who affirmed that solar energy is workable in saving electricity by reducing grid power use, and by reducing water losses, it conserves water.

Table 3

Correlation Analysis on the Accurateness of Soil Moisture Sensor in Sensing if the Soil is Dry or Wet

Independent Variable	Dependent Variable	R-value	R^2(Effect Size)	t-value	P value	Interpretation
Soil Moisture Sensor	Accurate-If Soil is Dry	0.577	0.333	13.010	0.005865	Significant
Soil Moisture Sensor	Accurate-If Soil is Wet	0.999	0.998	38.6911	0.000179	Highly Significant

Legend: *Highly Significant at $p \leq 0.01$ *Significant at $p \leq 0.05$

Table 3 shows the correlation analysis on the accuracy of soil moisture sensors in determining whether the soil is dry or wet. As the table exhibits, the independent variable (the soil moisture sensor) positively correlates with the dependent variables (accurate if the soil is dry/wet). With the two variables having positive correlations, the interpretation shows that the soil moisture sensor's ability to accurately sense if the soil is dry is significant. In contrast, its ability to sense if the soil is wet accurately is shown to be highly significant. This study proved that the soil moisture sensor accurately senses if the soil is dry or wet. Once the soil level goes below a certain value, the controller sends the signal to the module, which runs a water pump, and the amount of water is dropped to the plant. Once the required amount of water is delivered, the pump automatically stops working. This result is supported by Yu et al. (2021), who confirmed that the accuracy of the soil and its moisture is done by the hardware sensor, which will send the next information and parameters regarding the soil to the controller, which controls the water pump. The soil and its moisture are measured by the hardware sensor, which will send the next information and parameters regarding the soil to the controller, which controls the water pump. According to them, a comparison and analysis were conducted on the benefits and drawbacks, and the different measuring methods' variables were determined. These investigations suggested that high-precision, low-cost, non-destructive, automated, and highly integrated systems should be the goal of future developments in soil moisture sensors. Furthermore, it was suggested that creating customized sensors for various scenarios and applications should be a focus of future research. This review study gave application departments and scientific researchers a point of reference when choosing soil moisture sensor products and taking soil moisture readings.

Table 4

The device's ability to lessen the time it takes to water the plants

Observations	Type of Plant/s	Time (the time it takes to water the plants)	Appearance of the Plant (Height)
Normal Watering			
Day 1	Munggo	1 minute	½ cm
Day 2	Munggo	1 min. and 30 seconds	½ cm
Day 3	Munggo	1 minute	1 cm
Day 4	Munggo	1 min. and 15 seconds	2 cm
Day 5	Munggo	1 min. and 17 seconds	2 ½ cm
Day 6	Munggo	45 second	3 cm
Day 7	Munggo	1 minute	3 ½ cm
Day 8	Munggo	58 seconds	4 cm

Day 9	Munggo	1 min. and 8 seconds	4 ½ cm
Day 10	Munggo	1 min. and 4 seconds	5 ½ cm
Using a Solar-powered automatic plant watering system			
Day 1	Munggo	1 minute	½ cm
Day 2	Munggo	1 minute	½ cm
Day 3	Munggo	1 minute	1 cm
Day 4	Munggo	1 minute	2 cm
Day 5	Munggo	1 minute	2 ½ cm
Day 6	Munggo	1 minute	3 cm
Day 7	Munggo	1 minute	3 ½ cm
Day 8	Munggo	1 minute	4 cm
Day 9	Munggo	1 minute	4 ½ cm
Day 10	Munggo	1 minute	5 ½ cm

Table 4 shows the device's ability to lessen the time it takes to water the plants. As the table demonstrates, the plants grew at about the same time. The data further indicates that utilizing the product provides more constant timing for watering the plants than manually watering them at a consistent 1 minute. According to the Alliance for Water Efficiency (2020), prioritizing the characteristics of water and how the plant has adapted to the water system's characteristics has been the method used. Water's characteristics, vapor, and atmosphere (including transpiration elements) are covered in six chapters, along with the water's role in plants and how it travels through the plant, soil, cells, and tissues.

Table 5

t-Test Results: Difference between an Automatic Watering System and a Manual Watering System in terms of the time it takes to water the plant and height of the plant

t-Test: Two-Sample Assuming Unequal Variances				
The time it takes to water the plant			Height of the plant	
	Variable 1	Variable 2	Variable 1	Variable 2
Mean	1.094444444	0.908888889	2.944444	2.944444444
Variance	0.167502778	0.032686111	2.652778	2.652777778
Observations	9	9	9	9
Hypothesized Mean Difference	0		0	
df	11		16	
t Stat	1.244157127		0	
P(T<=t) one-tail	0.019650207		0.5	
t Critical one-tail	1.795884819		1.745884	
P(T<=t) two-tail	0.239300414		1	
t Critical two-tail	1.20098516		2.119905	

Legend: *Highly Significant at $p \leq 0.01$ *Significant at $p \leq 0.05$

Table 5 shows the t-test results based on the variations in Automatic Watering Systems' watering time for the plants. This T-test table compares two samples, Variable 1 and 2, assuming unequal variances. The mean of Variable 1 is 1.094, while the mean of Variable 2 is 0.909. Variables 1 and 2 each have variances of 0.168 and 0.033, respectively. Each of the two samples has nine observations. These findings indicate that, at the 0.05 significance level, there is evidence to reject the null hypothesis in favor of the alternative hypothesis since the computed t statistic falls below the threshold value for a one-tail test. However, the calculated t statistic for a two-tail test does not drop below the crucial threshold, meaning there is insufficient data to reject the null hypothesis at the 0.05 significance level. According to the Alliance for Water Efficiency (2020), many new homes today come equipped with clock-driven automatic irrigation because this is a popular convenience amenity. Manual irrigation, which was much more prevalent in the past, is more time and labor-intensive, requiring regular attention and vigilance. An automatic irrigation system can be simply programmed, turned on, and left to run. Unfortunately, a completely “hands-off” approach almost always results in over-watering, but there is no denying the convenience of an automatic irrigation system.

Moreover, in terms of the height of the plant, the comparison between Variable 1 and Variable 2 samples is conducted in this T-test table under the assumption of unequal variances. There is no computed t statistic. The p-values for one-tail and two-tail tests are 0.5 and 1, respectively. At a significance level of of 0.05, the crucial t values for one-tail and two-tail tests are roughly 1.746 and 2.120, respectively. These findings imply that the means of variables 1 and 2 do not significantly differ. The p-values verify no significant difference, and the t-statistic of 0 shows that the means are the same. In addition, we cannot reject the null hypothesis in both the one-tail and two-tail tests since the computed t statistic of 0 is smaller than the crucial t values. According to Gunawan's study (2022), it is estimated that the plant with the system can maintain the optimal moisture level, whereas the other plant’s moisture measurement continues to decrease. Compared to manual watering, automatic watering also results in accelerated plant growth. Consequently, a smart agriculture system is anticipated to improve plant growth and system efficiency.

4. Conclusions

The researchers made the following conclusions based on their data: The Arduino-Based Plant Watering System with a Moisture Sensor effectively detects moisture levels and is convenient for plant owners. The 5V Relay Module, Solar, and Arduino Uno are effective at automatically watering the plants after minor modifications were made to the code and component wiring. A solar-powered, automatic plant watering system with an Arduino-Uno moisture sensor accurately determines whether the soil is moist or dry. The Arduino-Uno-based Solar Powered Automatic Plant Watering System with Moisture Sensor is more convenient to use than manual watering because of its consistency and the ability to lessen the time it takes to water the plants manually, making the task easier.

Recommendation - Based on the results and conclusions of the study, the following recommendations are offered: the researchers recommend to future researchers that they improve the solar-powered automatic plant watering system with Moisture Sensors’ convenience by enhancing the wiring, parts, coding, and enclosure, further improving the device’s effectiveness. The researchers also recommend to the users that an additional feature of this device to help detect soil moisture is to install an alarm system to notify the plant owner if the plant needs water. The researchers also discovered that the wiring and coding play the most significant role in the device's effectiveness. A minor alteration to these components can significantly affect the device, particularly the pump’s code, which improves water intake, thus lessening the time it takes to water the plants. Future researchers may consider this kind of issue and are advised by the researchers to enhance specific areas of our study. For instance, they can further research how to make a more efficient and larger-scale device version for larger areas.

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