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Intelligent Water Control System for Agriculture Monitoring with Mobile Application

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ABSTRACT

This research paper presents an intelligent watering system with a mobile application to provide an automated and efficient way of watering plants. The system was designed to be cost-effective, power-efficient, dependable, and adaptable. The system consists of a soil moisture sensor, a water pump, a water tank, and a mobile application. The water pump moves water from the water tank to the soil, and the soil moisture sensor tracks the moisture in the soil. The system comes with a mobile app that can track the temperature of a specific area, the moisture level of the soil for the vegetable crops, and the water level of the tank. Results of the study showed that the system was able to reliably detect soil moisture levels and provide an effective method of watering plants. The user survey revealed high acceptability of the system. Hence, the use of this efficient and cost-effective intelligent watering system with a mobile application can greatly benefit the agricultural sector.

Keywords: Arduino, mit app inventor, soil moisture sensor, temperature sensor, thingspeak

INTRODUCTION

Applications for day-to-day work are one of the most outstanding achievements of technology nowadays. Automation can now perform more tasks with better efficiency and more reasonable rates than what has been already available in the market. Automation using mobile applications can be used to operate various equipment. However, using the manual system to water plants is inefficient because manual watering can cause overwatering. As such, farmers should be concerned about water conservation due to the rising water demands and the high cost of water.

According to the Irrigation Water Management (Brouwer and Heiblom, 2017), all field crops require soil, water, air, and light (sunlight). Crops cannot grow in the absence of water. However, too much water is bad for many crops. Certain crops grown in a sunny and hot climate need per day more water than same crops grown in a cloudy and cool climate. One of the most crucial inputs required to grow crops is water (Water Management of Indian Agro Net, 2016). Water is required by plants in enormous amounts and continually throughout their lives. Water has a significant impact on several functions, including cell division, respiration, absorption, translocation, and use of mineral nutrients. A plant's growth and development, as well as its production and quality, are directly impacted by water excess and shortage.

Irrigation is both the most labor-intensive and crucial technique in everyday agricultural or gardening operations. Irrigation must be able to manage how much water gets to the plants regardless of the weather, whether it is so hot and dry or so overcast and damp. Plants may be adequately watered with contemporary irrigation devices. However, two crucial factors must be taken into account while using this manual watering method: when and how much to water.

The study conducted by Nugraheni and Suyoto (2021) cited that automation is starting to dominate the world today, entering a new era of computing technology, the Internet of Things (IoT), which is experiencing rapid development. IoT is a worldwide neural network in the cloud that connects a mixture of things, aiming to maximize the benefits of Internet connectivity in transferring and processing data. Using IoT, one can monitor and control a device remotely with a computer or smartphone. IoT can be applied in various fields, one of which is agriculture.

Some existing systems utilize smartphones with built-in sensors to provide agricultural solutions. The goal is to remotely control agriculture devices and provide security to the farm through online streaming. The existing system uses few technologies that allow remote control of agricultural monitoring, thereby making a farmer's work much easier and less dependent on the present conditions. However, smartphones are not utilized in agricultural applications.

Optimizing the use of this system can be very helpful because there has been a shortage of land-reserved water due to a lack of rain and an unplanned use of water, resulting in a large amount of water going to waste. Lastly, this study gives local farmers access to an intelligent plant watering system with the integration of a mobile application for monitoring that is cost-effective, power-efficient, economical, dependable, and adaptable.

RELATED LITERATURE

Mobile Application. Mobile application development is a set of processes and procedures involved in writing software for small, wireless computing devices, such as smartphones and other hand-held devices. Like web application development, mobile application development has its roots in a more traditional software development. One critical difference, however, is that mobile apps are often written specifically to take advantage of the unique features of a particular mobile device (Tech Target). Accordingly, mobile application development is the process of making a software for smartphones and digital assistants, especially for Android and iOS. A software can be preinstalled on the device, downloaded from a mobile app store, or accessed through a mobile web browser. The programming and markup languages used for this kind of software development include Java, Swift, C#, and HTML5 (IBM Cloud Education, 2020). Numerous studies in precision agriculture and smart agriculture were conducted as a result of the increased interest in the field of information and communications technology (ICT), notably the Internet of Things (IoT) and sensor technologies. With this, a system for smart/precision irrigation may be developed by incorporating and integrating various concepts and technologies. A key practice in a cropping system that allows farmers to conserve water without losing crop output is precision irrigation. The system enables farmers to predict how much water would be lost from the land (Cruz et al., 2019).

Soil Moisture Analyzer. Soil moisture content tells how much water is in the soil - usually as a percentage - representing what percentage of the total 'volume' of soil's moisture. Imagine a cubic meter of topsoil. Pull out all the soil particles and compact them to remove all gaps between them (suppose it squashes down to about 40% of the original volume). Is it the same for organic matter? This would occupy about 5% of the volume. The rest of the volume is made up of pore spaces, which can be occupied by either air or water, meaning the saturated sample of this soil; the water component would be 55% of the original cubic meter, given that the soil holds onto a layer of water that is inaccessible to plants. The value of dry soil when roots cannot get any more moisture and plants become stressed, wilt, and die will not be 0% but something slightly more (Soil Moisture Measurement). As the name implies, a soil moisture sensor is used to measure the moisture content of the soil. Temperature and the kind of soil, as well as salts like iron, manganese, calcium, phosphorus, nitrogen, and sulfur that are present in the soil, all affect how wet the soil is. Irrigation is carried out by the moisture sensor's reading (Khanna et al.).

Temperature Monitoring Systems. According to The Editors of Encyclopedia Britannica, temperature is the measure of hotness or coldness expressed in terms of any of several arbitrary scales and indicates the direction in which heat energy will spontaneously flow—i.e., from a hotter body (one at a higher temperature) to a colder body (one at a lower temperature). Hence, there are three (3) temperature scales in general use today. In the United States and a few other English-speaking nations, temperatures are measured using the Fahrenheit (°F) scale. Nearly all nations that have adopted the metric system of measurement utilize the Celsius (°C) temperature scale, which is also widely used in the sciences. As the accepted global standard for scientific temperature measurement, the Kelvin (K) scale, an absolute temperature scale (obtained by moving the Celsius scale by 273.15° such that absolute zero corresponds with 0 K), is used. The use of IOT technology in agriculture helps farmers find problems in time. For gathering and processing field data, the system includes sensors for temperature, humidity, soil moisture, and rain detection. To remotely manage and monitor sensor data, these sensors are integrated with well-known web technologies to create a wireless sensor network. Together, the Internet of Things and cloud computing create a system that effectively controls the agriculture industry. This resource enables farmers to enhance cultivation in a way that the plants require. Also, it leads to a higher crop yield, prolonged production period, better crop quality, and less use of protective chemicals (Patil and Jadhay, 2019).

Solar Powered Systems. Solar energy can be utilized mainly in heat generation and electricity production. The International Energy Agency (IEA) shows, in a comparative study on world energy consumption, that in 2050, solar array installation will provide about 45% of world energy demand. Solar energy is one of the most important renewable energy sources, playing a great role in providing energy solutions. As known, there is a wide variety of types of collectors and applications of solar energy (Herez et al., 2016). According to Johnston (2022) in Investopedia, the following are the advantages of using solar energy: Sustainability. The advantage of solar energy is that it is a sustainable alternative to fossil fuels. While fossil fuels have an expiration date that may be fast approaching, the sun is likely to be around for at least a few billion years. Low Environmental Impact. Solar energy has a substantially reduced impact on the environment compared to fossil fuels. Its greenhouse gas emissions are inconsequential as the technology does not require any fuel combustion. Also, although concentrating solar thermal plants (CSP) are comparatively inefficient in their water usage depending on the type of technology being used, the right technology significantly increases efficiency while photovoltaic (PV) solar cells do not require any water when generating electricity. Energy Independence. Since the sun shines across the globe, it makes every country a potential energy producer, thus allowing for greater energy independence and security. Solar energy does not only promise to bring security and independence at the national level, solar panels can also be installed on individual homes, providing power that does not depend on being connected to a larger electrical grid. The pros of solar energy are that it is a sustainable alternative to fossil fuels and has a low impact on the environment and the potential for any country to produce it. The cons are that it only produces energy when the sun is shining, needs a significant amount of land, and certain solar technologies require rare materials (Johnston, 2022).

Intelligent Watering System. Manual plant watering systems bring many problems to plants, especially indoor plants. Lack of knowledge of the method of watering plants and measuring soil moisture is among the reasons plants fail to grow before they can be harvested. Improper attention to the watering of plants and maintenance of soil moisture may expose plants to some diseases. Residences or agriculture institutions sometimes miss their schedule of watering activity and soil moisture maintenance for several reasons (Zahid and Wahab, 2020). An automated irrigation system refers to the operation of a system with no or just a minimum manual intervention besides surveillance. Almost every system (drip, sprinkler, surface) can be automated with the help of timers, sensors or computers, or mechanical appliances. Automation makes the irrigation process more efficient, and workers can concentrate on other important farming tasks. However, such a system can be expensive and very complex in its design and may need experts to plan and implement it (Stauffer and Spuhler, 2020).

Synthesis

The current system makes use of a few technologies that enable remote controlling of agricultural monitoring, greatly reducing the amount of effort required of farmers and their reliance on the current weather. However, due to its high cost, this system is not fully exploited in agricultural applications, especially in the local setting. The proposed system offers several advantages over the existing solutions, including improved accuracy in water control, increased efficiency in water usage, and more automated control of the water supply. The proposed system also has unique features including a mobile application with real-time monitoring and control capabilities and advanced capabilities to monitor and optimize water usage. Thus, the study used a solar-powered setup since some of the farm areas are distant from an electrical power source. The system's control unit has an automated watering mechanism that consists of a water pump, motor valve, and sprinkler used to deliver the needed amount of water to the soil. In addition, a temperature sensor detects the hotness and coldness of a specific area. The generated information from the control unit is sent via wireless communication for mobile monitoring. The mobile application does this by allowing users to choose crops for planting, view crop details, check crop monitoring status, check crop soil moisture content, check the status of the watering system, view the current temperature of the area, determine the potential harvest days, and view historical data. Thus, the intelligent system can be greatly benefitted by the local farmers.

OBJECTIVES OF THE STUDY

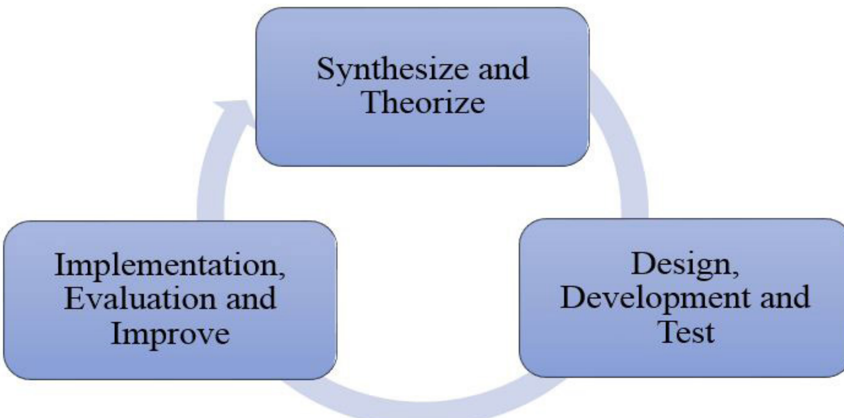
The manual system to watering and monitoring crops is far from satisfactory in terms of accuracy and throughput because crops have different water requirements needed to grow. Thus, this study aimed at developing an intelligent water control system with mobile application. Specifically, the study determined the following: (1) the current status of the following: watering system, monitoring System, soil analysis, and vegetable crops; (2) the design of the hardware setup of the intelligent water control system; (3) the user interface of the mobile application; (4) the parameters to be monitored using the mobile application; (5) the ideal threshold values of the soil moisture for okra, pechay, squash, and tomato; and (6) the level of acceptability of using the mobile application among the participants in terms of the following: functional suitability, performance efficiency, compatibility, usability, reliability, security, maintainability, and portability?

METHODOLOGY

Research Design. The study assessed the proposed study's validity and identified the main problems associated with system implementation. The researcher used the Research and Development (R&D) method. According to Kenton (2022), R&D refers to the efforts that a firm undertakes to develop and introduce new products and services to improve its existing offers to stay ahead of the competition by responding to new market desires or needs. In addition, the methodical planning and execution of actions to examine and create new goods, processes, or technologies is a component of research and development (R&D) research design. Figure 1 depicts the three (3) stages of this design.

Figure 1

Cycle of Research and Development



Synthesize and Theorize. The researcher determined and defined the requirements to create the hardware and software system for the study at this phase. In this phase, the hardware setup's components, such as microcontrollers and sensors, were chosen. The researcher decided which software program to use to create the mobile application. Theories and relevant literature were reviewed to determine gaps in the existing systems to make sure that the system would meet the set goals.

Design, Development, and Test. This phase covered the process of developing the functionalities, flow, and usability of the prototype's hardware and software systems. In designing the real prototype and the Graphical User Interface (GUI) of the mobile application for the system's development, the requirements identified in the first phase were used as input. The development of the prototype of the mobile application was also done in this phase. For the creation of the study's hardware and software systems, the researcher employed two (2) software platforms. The researcher used blocks-based programming language in MIT App Inventor, an open-source tool that enables programmers to drag and drop visual elements to construct programs that can run on Android smartphones to develop a mobile application. Additionally, it enables the usage of a private app data directory through TinyDB and cloud data using Thingspeak. Moreover, the researcher utilized Arduino IDE (Integrated Development Environment), an open-source program, to develop and upload code to the Arduino boards for the physical components to function. The IDE program is compatible with Windows, Mac OS X, and Linux, among other operating systems. The programming languages C and C++ are supported. The hardware setup consisted of microcontroller unit, sensors for soil moisture reading, and automated water pumping mechanism for the hardware system. The software setup was the mobile application used for monitoring. The mobile application was tested to determine if the sensor's reading of the desired output for monitoring is successfully sent to the mobile application. Hence, the consistency of the data from the hardware to the software was observed using serial monitoring of the hardware setup. A series of tests and trials were run until the desired outcome was achieved. A total of ten (10) trials were conducted to achieve the functionalities of the system.

Implementation and Evaluation. This phase had the system initially implemented by the target users to ensure that the implementation of the prototype had no issues related to the hardware and software systems. The deployment of the system ascertained if the system delivers its designed output. The evaluation phase ensured that the proposed system meets users' expectations. In this phase, a survey questionnaire was given to the end user of the system to determine the level of acceptability of the system. The respondents of this study were farmers because the proposed system is designed for the agricultural sector. The respondents were selected using random sampling. The respondents were 25 farmers and 25 smartphone users, hence a total of 50 respondents. Four technical experts were tapped to evaluate the level of acceptability of the system. The survey questionnaire consisted of eight areas, namely functional suitability, performance efficiency, compatibility, usability, reliability, security, maintainability, and portability. Shown below, a five-point Likert scale was used to determine the level of acceptability for each criterion.

Table 1

Likert Scale Measurement of the Study

RANGE	SCALE	DESCRIPTION
4.50 – 5.00	5	Very Highly Acceptable
3.50 – 4.49	4	Highly Acceptable
2.50 – 3.49	3	Moderately Acceptable
1.50 – 2.49	2	Acceptable
1.00 – 1.49	1	Not Acceptable

System Development

Figure 2 shows the action plan for designing the proposed system. The researcher gathered relevant data and then designed the hardware and software systems. The system implementation was done after the integration of the hardware and software systems. A series of prototype testing were done to meet the objectives and functionality of the system. Results of the prototype testing were used as basis for answering the research questions of the study.

Figure 2

System Design Procedure

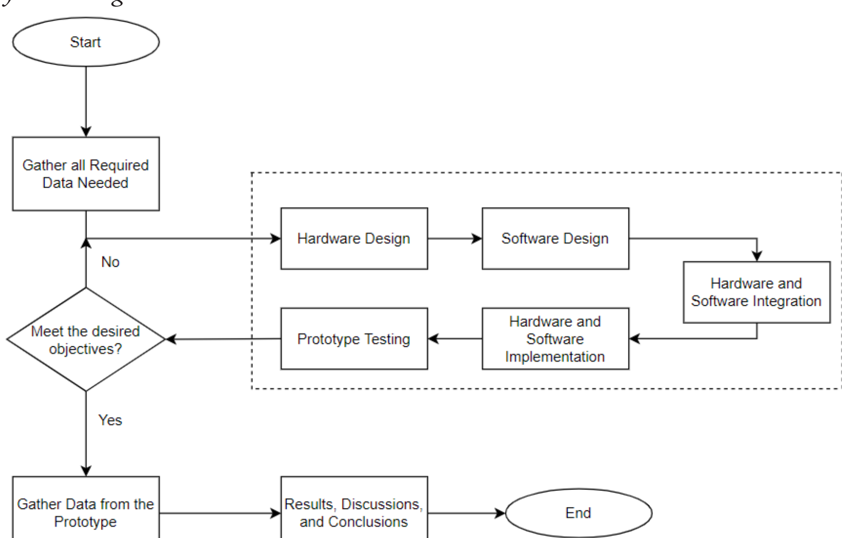


Figure 3

Activity Diagram

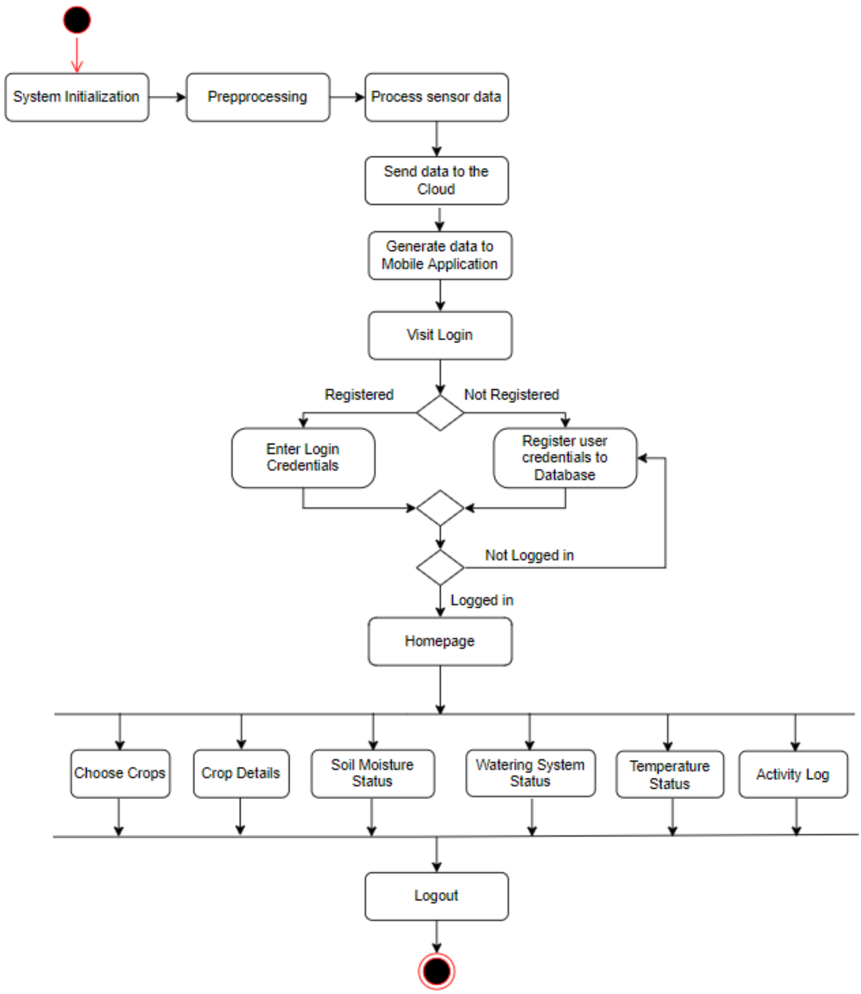


Figure 3 depicts the movement of the activities from one activity to the next in the mobile application's activity diagram. The system analyzes sensor data and sends data to the cloud for storage. The mobile application then generates the data for mobile monitoring. Upon logging in, the user enters login details, and if found that the user is non-existent, then the admin registers user credentials to the database. After successful login, the user accesses the homepage containing these user interactions: choosing crops to be planted and viewing crop details, crop monitoring status, soil moisture content of the crops, watering system status, viewing the temperature of the specific area, determining possible harvest days, and viewing previously collected and completed monitoring activity logs.

Figure 4

System Architectur

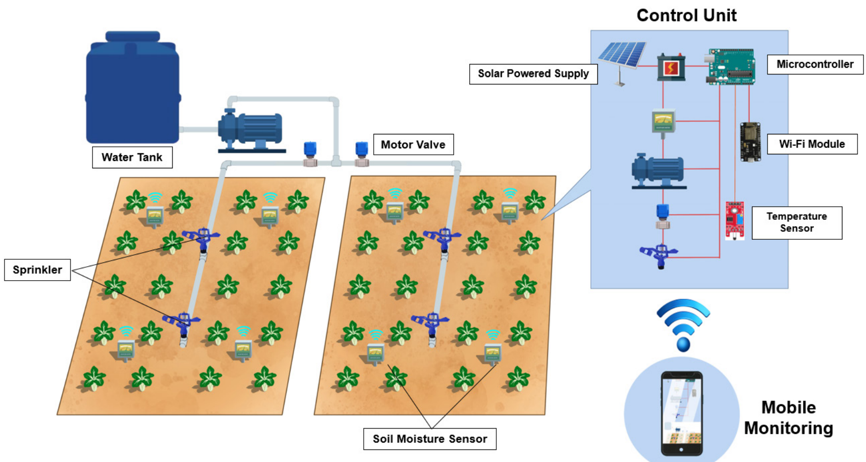


Figure 4 shows the system's architecture. It has two (2) main parts: the control unit and the mobile monitoring. Since some of the farm regions are far from an electrical power supply, the system essentially taps solar power. The sprinkler, motor valve, and water pump used to dispense the required quantity of water to the soil are all parts of the control unit's automated watering system. In detail, the system detects soil dryness and quickly activates the automatic watering setup to deliver an adequate amount of water according to the intended soil moisture content value for a vegetable crop. In addition, the temperature sensor measures the temperature of a specific area. The generated information from the control unit is sent via wireless communication for mobile monitoring. The mobile application includes login and logout functionality as well as mobile monitoring that enables users to select the different user interactions. One of the features of the mobile application is that upon selecting the vegetable crops to be planted by the user, the application sends data to the control unit to determine the appropriate level of soil moisture for each vegetable crop and determine the potential harvest date of the vegetable crops. Additionally, the monitoring section has an indicator if the soil moisture content and ambient temperature are below or above the threshold values needed per vegetable crop.

RESULT AND DISCUSSIONS

This section presents the results of the study and their discussion sequenced according to the order of the objectives.

Current Status Related to:

Watering System. Inadequate and inefficient watering system of vegetable crops is a major challenge for farmers, especially those in remote areas. Farmers often lack access to water resources and funds to invest in water systems, resulting in decreased crop yields and high costs of production. To address this issue, investing in more efficient technologies, such as watering or irrigation system, is important to ensure better water management and more efficient crop production.

Monitoring System. The monitoring of vegetable crops is an important part of ensuring sustainable agricultural practices. However, due to a lack of infrastructure and technological resources, it is difficult to monitor and track the health of vegetable crops, especially in the local setting. Climate change and erratic weather patterns have further complicated the situation, making it even more difficult to monitor and manage vegetable crops effectively. To address the challenges associated with monitoring vegetable crops, various strategies must be implemented. These strategies can include using low-cost, low-power sensors and the Internet of Things (IoT) and implementing mobile applications for agricultural monitoring.

Soil Analysis. Soil analysis of vegetable crops is a difficult and time-consuming process. In most cases, soil sample needs to be collected and sent away to a laboratory for analysis. This process can be costly and time-consuming. Additionally, there is a lack of knowledge and understanding of the soil and its requirements among farmers, leading to the planting of crops in unsuitable soil resulting in poor yields. Overall, the soil analysis of vegetable crops is an important process but can be difficult to undertake due to a lack of resources and knowledge. Efforts must be made to ensure that the soil is suitable for the crops to be grown to ensure healthy growth and good yields.

Vegetable Crops. The lack of access to resources and infrastructure, combined with poor soil and climatic conditions, results in low-yield and poor-quality vegetable crops, which is particularly true in areas that are geographically isolated and have limited access to markets and support services. In addition, limited knowledge and access to agricultural technologies, such as watering systems, have further hindered the production of vegetable crops in these areas. Overall, the current situation of vegetable crops in this area is inadequate, and lack of resources and support is a major obstacle to achieving sustainable food production. To improve this situation, it is necessary to invest in infrastructure and get access to resources and support services and agricultural technologies. Furthermore, initiatives to incentivize and support local farmers should be implemented to improve the quality and yield of vegetable crops.

In conclusion, the current agricultural setup in the local setting is poor, with limited access to resources and technology. This setup leads to low productivity and profitability among many farmers.

Design of the Hardware Setup of the Intelligent Water Control System

To develop an effective intelligent water control system, it is important to take the area's particular demands into account. For instance, certain areas encounter seasonal water shortages, necessitating the implementation of a reliable water reallocation system. Therefore, it is crucial to take into account the socioeconomic status of the populace, since those living in this area may not be able to afford to buy an expensive water control system. The system should be made user-friendly for easy system navigation.

Figure 5 shows the hardware implementation of the system. The system is designed to facilitate the automatic supply of adequate water from a reservoir. The system uses a solar-powered setup since some of the farm areas are distant from an electrical power source. To accomplish this, the control unit has an automated watering mechanism that includes a water pump, a motor valve, and a sprinkler to provide the required amount of water to the soil. To elaborate, the system detects soil dryness and promptly activates the automatic watering setup to supply enough water to the vegetable crops' ideal soil moisture content value. The temperature sensor monitors the hotness and coldness of a given location.

Figure 5

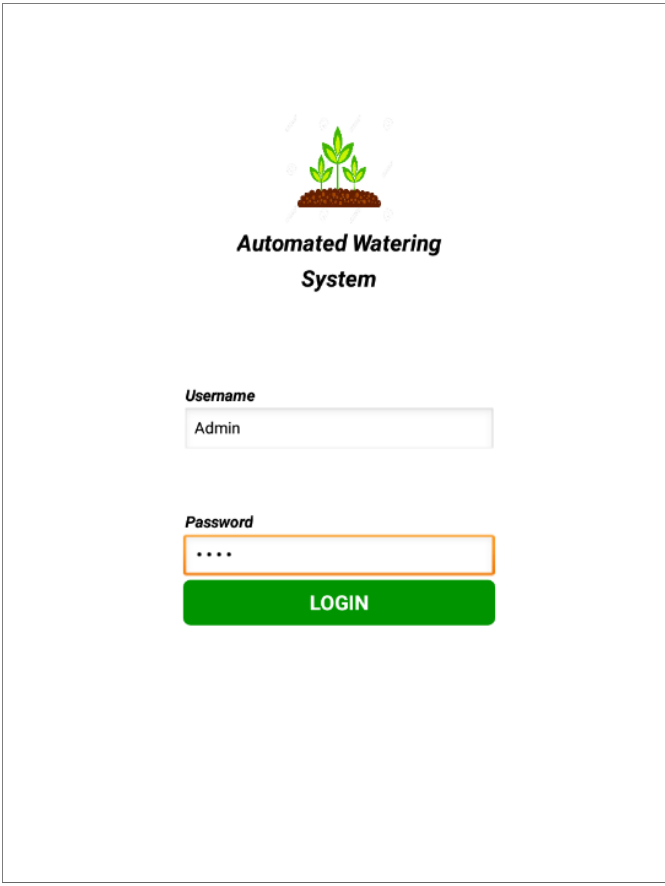
Hardware Implementation

User Interface of the Mobile Application

The mobile application is designed with an intuitive user interface that makes it easy for users to monitor the soil, temperature, and level of water in the tank. There are features in the mobile application that analyze data based on temperature and soil moisture readings. The user interface of the mobile applications is shown below.

Figure 6

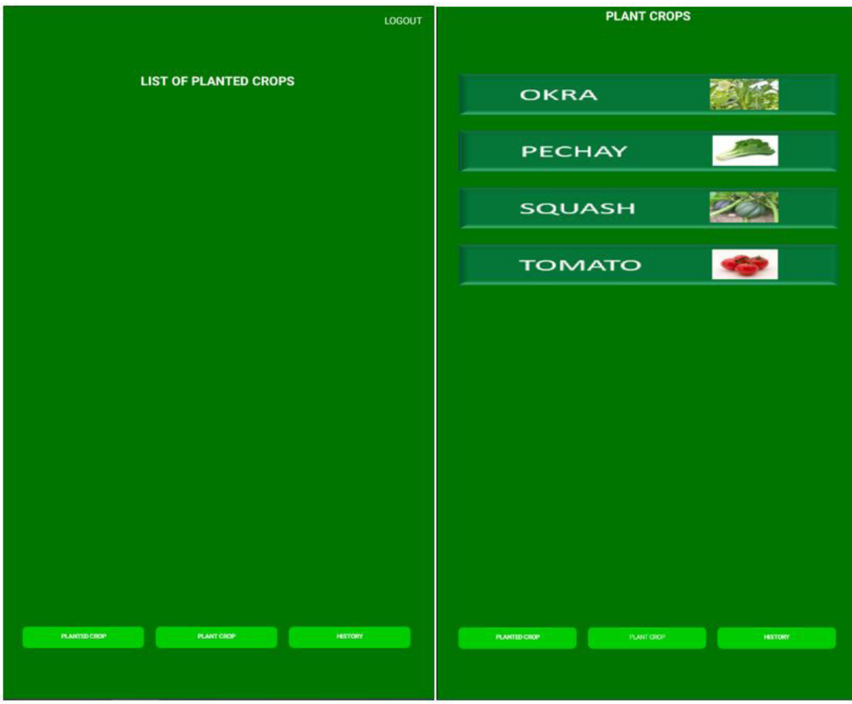
Login Form



The user can access the internal pages of the mobile application after successfully logging in using a username and a password.

Figure 7

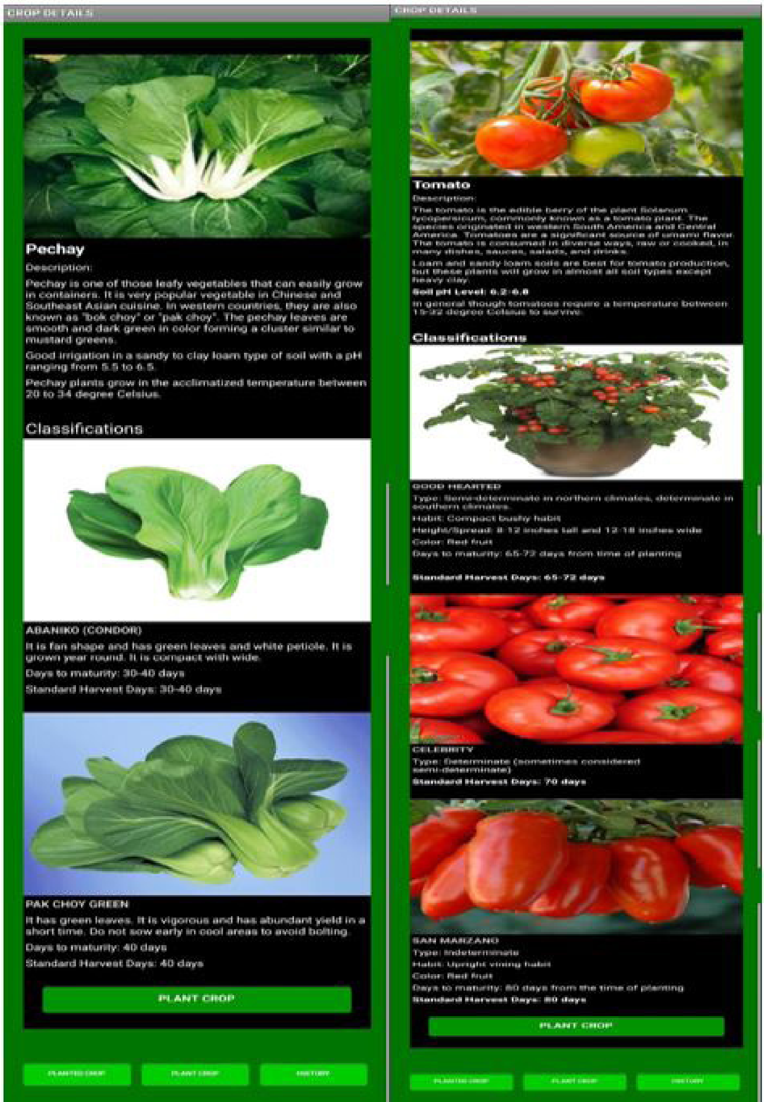
List of Planted Crops



After logging in, the user will be redirected to the mobile application's homepage, which will provide a list of planted crops. This page is currently empty since the user has not yet planted a crop. This page contains three (3) buttons: Planted Crops, which will redirect the user to the list of planted crops; Plant Now, which contains the list of crops in the mobile application; and History, which allows the user to view history data on the activity log.

Figure 8

Crop Details (Sample)



Upon clicking *Vegetable Crops*, the user will be redirected to the vegetable crop details. The crop details include a brief description of the crops, vegetable crop classification, required PH level, maturity days, and ambient temperature for okra, pechay, squash, and tomato. If the user clicks *Plant Crop*, the user selects the plot where the vegetable crop is planted. Following the selection of the plot, the user is redirected to the *Plant a Crop* page, which includes input details such as vegetable crop classification, soil type, plot number, and plant date. After clicking *Plant Crop*, the user will get an update of the list of planted crops, as shown in Figure 9.

Figure 9

Plant a Crop – 1

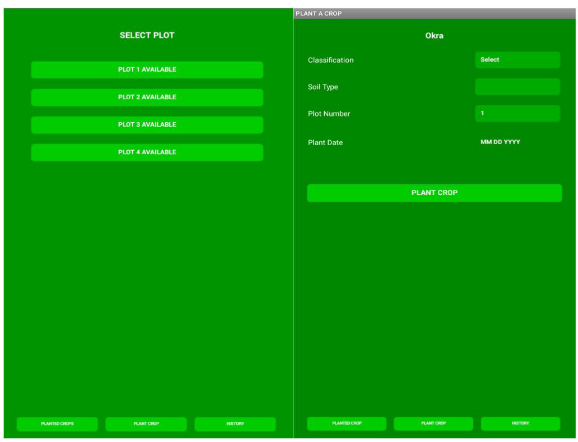
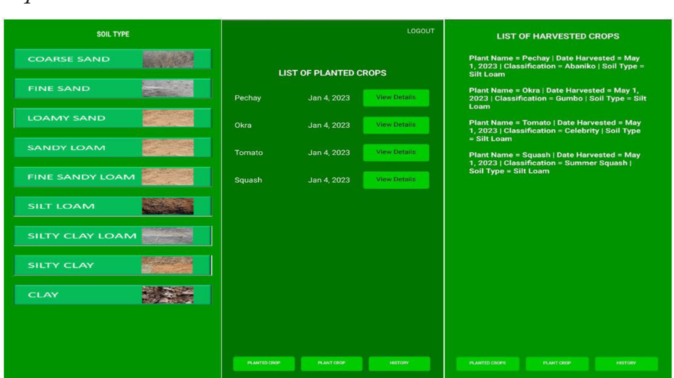


Figure 10

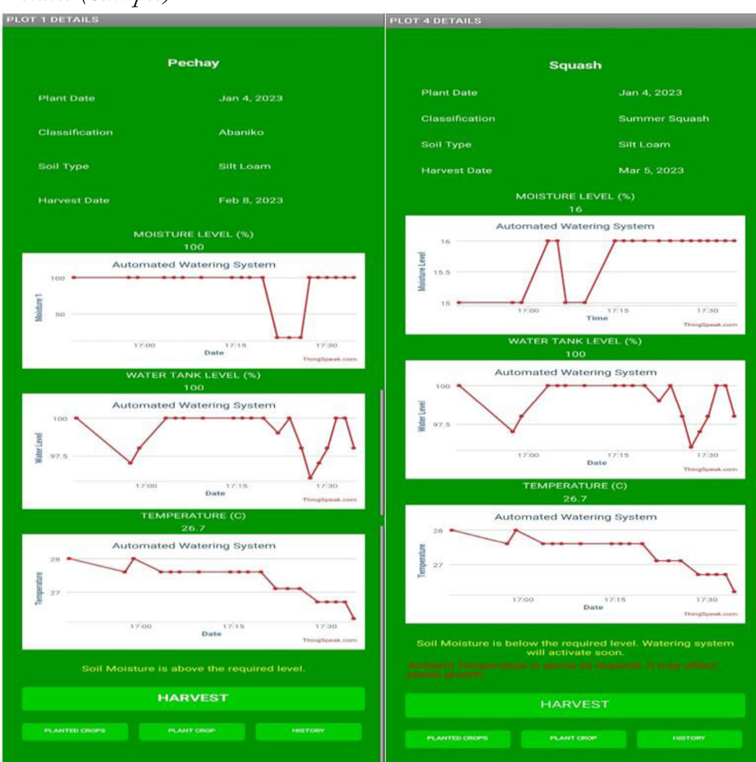
Plant a Crop – 2



Upon clicking *View Details* as shown in Figure 10, the user will be redirected to the details per plot. Plant date, vegetable crop classification, soil type, possible harvest date, and monitoring information are all included in the plot specifications. The monitoring section keeps track of soil moisture content, water tank level, and temperature in a real-time setting. Data up to twenty (20) datasets are presented in graphical form in real-time. Data come from the sensor reader and are sent to the cloud using Thingspeak, a cloud-based IoT analytics tool that allows one to gather, visualize, and analyze live data streams. Additionally, as illustrated in Figures 11 and highlighted in red and yellow, the monitoring area provides an indicator of whether the soil moisture content and ambient temperature are below or above the threshold values required for each vegetable crop.

Figure 11

Plot Details (Sample)



Parameters Monitored Using the Mobile Application

Below are the parameters covered in the monitoring system using the mobile application.

Water Usage. Monitoring the amount of water used by the watering control system is essential to ensure that the system is operating efficiently and not wasting resources. As such, the water in the tank should not be empty.

Soil Moisture. Monitoring soil moisture levels is important to ensure that the system is providing adequate water to the plants.

Temperature. Monitoring ambient temperature will allow the system to adjust water usage to account for changing temperatures and other weather-related factors.

Ideal Threshold Values of the Soil Moisture for the Crops

The intelligent water control system is created to meet the demands of the local populace in distant areas. Using this system, the soil moisture content of certain vegetable crops (e.g., pechay, okra, tomato, and squash) can be monitored. When the soil moisture sensor detects that the soil moisture content is lower than the necessary threshold values for vegetable crops, the watering system will automatically open the relay switch to activate the solenoid valve and facilitate watering through a sprinkler.

According to Acurite Support (2022), the majority of flowers, trees, and shrubs require soil moisture levels between 21% and 40%, whereas all vegetables require soil moisture levels between 41% and 80%. Soil moisture recommendations for okra, pechay, squash, and tomato range from 41%-80%. Therefore, these are the percentages of the threshold values taken into consideration during the development of the system. The varied calibrated soil moisture levels that are below, between, and beyond the threshold values on the soil's moisture content are shown in the figure below.

Figure 12 shows one of the common mistakes in watering vegetable crops. The moisture level required for vegetable crops should not exceed 80%, else, the chances of overwatering can adversely affect the growth of the plant.

Figure 12

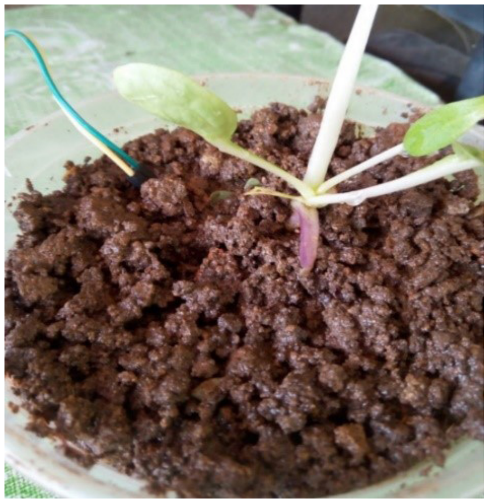
Greater than 80% Soil

Figure 13

45% - 50% Soil Moisture Level

Figure 14

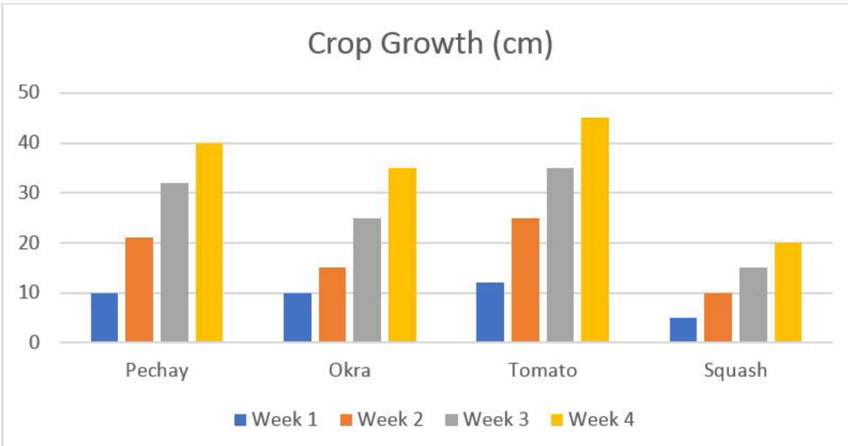
80% Soil Moisture Level



Figures 13 and 14 show the right range of the soil moisture content needed for vegetable crops. The recommended soil moisture levels for optimal growth and health of plants are between 41% and 80%. The suggested soil moisture levels are, therefore, programmed into the control unit as a starting point for the threshold values required for the system's regulated watering arrangement. If the measurement is below the necessary threshold values, the microcontroller gets data from the soil moisture sensor, which triggers the relay, turning on the valve and water pump and irrigating the crops with sprinklers. If the threshold values are met, the automated watering system automatically shuts off. The figure below shows a four-week's progress of the vegetable crops' growth.

Figure 15

Crop Growth (Pechay, Okra, Tomato, and Squash)



Acceptability Level of the Mobile Application

When evaluating a mobile application, it is essential to consider the participants' assessment of the level of acceptability of the application according to a set of criteria. Tables 2 and 3 show the participants' assessment ratings of the system's acceptability in terms of functional suitability, performance efficiency, compatibility, usability, reliability, security, maintainability, and portability.

Table 2

Results of Level of Acceptability Survey – Farmers and Smartphone Users

Characteristics		Std Dev	Mean		Indicator
Functional Suitability	fs1	0.678	4.30		
	fs2	0.688	4.34	4.37	Highly Acceptable
	fs3	0.813	4.46		
Performance Efficiency	pe1	0.587	4.32		
	pe2	0.738	4.16	4.25	Highly Acceptable
	pe3	0.573	4.28		
Compatibility	co1	0.646	4.46	4.31	Highly Acceptable
	co2	0.766	4.16		

Table 2 Continued

Characteristics		Std Dev		Mean	Indicator
Usability	us1	0.64	4.28		
	us2	0.579	4.46		
	us3	0.563	4.64		
	us4	0.825	4.18	4.4	Highly Acceptable
	us5	0.67	4.40		
	us6	0.611	4.44		
Reliability	re1	0.639	4.40		
	re2	0.688	4.34	4.27	Highly Acceptable
	re3	0.799	4.12		
	re4	0.782	4.20		
Security	se1	0.751	4.26	4.29	Highly Acceptable
	se2	0.621	4.32		
Maintainability	ma1	0.753	4.38		
	ma2	0.766	4.16	4.33	Highly Acceptable
	ma3	0.644	4.44		
Portability	po1	0.646	4.48		
	po2	0.571	4.40	4.45	Highly Acceptable
	po3	0.676	4.46		
Overall Mean				**4.33**	**Highly Acceptable**

Table 2 shows the level of acceptability of the developed system among farmers and smartphone users. As found, the system's functional suitability (mean=4.37), performance efficiency (mean=4.25), compatibility (mean=4.31), usability (mean=4.4), reliability (mean=4.27), security (mean=4.29), maintainability (mean=4.33), and portability (mean=4.45) were highly acceptable to the farmers and the smartphone users. The overall level of acceptability of the system was high as reflected by the overall mean of 4.33.

Table 3

Results of Level of Acceptability Survey – Technical Expert

Characteristics		Std Dev		Mean	Indicator
Functional Suitability	fs1	0.96	4.25		
	fs2	1.41	4.00	4.17	Highly Acceptable
	fs3	0.96	4.25		
Performance Efficiency	pe1	0.96	4.25		
	pe2	1.29	3.50	3.83	Highly Acceptable
	pe3	1.26	3.75		

Table 3 Continued

Characteristics		Std Dev		Mean	Indicator
Compatibility	co1	1.26	3.75	3.63	Highly Acceptable
	co2	1.29	3.50		
Usability	us1	1.15	4.00	4.00	Highly Acceptable
	us2	0.96	4.25		
	us3	1.15	4.25		
	us4	1.41	4.00		
	us5	1.26	3.75		
	us6	1.50	3.75		
Reliability	re1	1.50	4.25	3.69	Highly Acceptable
	re2	1.50	3.75		
	re3	1.50	3.25		
	re4	1.29	3.50		
Security	se1	1.26	3.75	3.88	Highly Acceptable
	se2	1.15	4.00		
Maintainability	ma1	1.41	4.00	3.75	Highly Acceptable
	ma2	0.96	3.25		
	ma3	1.41	4.00		
Portability	po1	1.50	3.75	3.67	Highly Acceptable
	po2	1.26	3.75		
	po3	1.29	3.50		
Overall Mean				**3.83**	**Highly Acceptable**

Table 3 shows the level of acceptability of the developed system among the four (4) technical experts that included the MIS Director of Liceo de Cagayan University, the ICT Head of USTP Jasaan, an IT expert from the industry, and a software developer. As revealed, the system's functional suitability (mean=4.17), performance efficiency (mean=3.83), compatibility (mean=3.63), usability (mean=4.00), reliability (mean=3.69), security (mean=3.88), maintainability (mean=3.75), and portability(mean=3.67) were highly acceptable to the four technical experts. The overall acceptability level of the system was high as indicated by the overall mean of 3.83.

CONCLUSION

The use of modern engineering tools has been helpful to the researcher in building and testing the prototype. The intelligent water control system for agriculture monitoring with mobile application is an advantageous system for monitoring and controlling watering in agricultural fields. The system ensures efficient and sustainable cultivation practices. With its advanced features, the system is a powerful tool for optimizing water usage in agricultural areas. The system can help reduce water wastage and improve crop yield, making it an invaluable asset to farmers.

RECOMMENDATIONS

Based on the findings and conclusion, the researcher advances the recommendations below.

1. The average size of small-scale farming is roughly 1.29 hectares (64,500 × 64,500). In this study, the approximate measurement per plot is up to 9sqms (3x3), having one soil moisture sensor installed per plot. However, to cover a 1.29-hectare lot, the approximate number of sensors required is up to 21,500 sensors, subject to various system adjustments based on the farm size. Hence, the development of similar system for large-scale farming is suggested.

2. System developers may broaden the scope of the study by developing a system for indoor setting to control all of the variables covered in the study, including humidity, PH level, and other factors considered when planting vegetable crops. Also, they may consider making a system compatible with other operating systems such as IOS.

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