International Journal of Scientific Research and Engineering Development-– Volume 7 Issue 1, Jan-Feb 2024

Available at www.ijsred.com

RESEARCH ARTICLE OPEN ACCESS

Automated Solar Powered Water Irrigation Monitoring Device: An Analysis

*Cherry Rose T. Malgapo, PhD, **Kale Andrea S. Dela Cruz, MAEd

Department of Education/Aliaga National High School, Aliaga District, SDO Nueva Ecija

--************************----------------------------------

Abstract:

The study focuses on the challenges faces in agricultural sector in the Philippines such as water scarcity and insufficient irrigation systems. The study seeks to evaluate the influence of the proposed Automated Solar Powered Water Irrigation Monitoring Device technology on increasing agricultural productivity, reducing water waste, and producing high-quality food, all while benefiting diverse stakeholders such as farmers, consumers, government, rural communities, researchers, innovators, and future researchers.The fundamental principle revolves around the integration of both hardware and software components to create a smart irrigation system. Meanwhile, they decided to implement a unique control action for various soil moisture ranges from dedicated sensors for each crop species, leading to precision in irrigation. Furthermore, the system consists of three sensor unit boxes, each housing a network of five Soil Moisture Sensors, an Arduino UNO Microcontroller (Slave Arduino), and Nrf24L01+ transceivers. These sensors measure soil moisture, providing values ranging from 420 to 1023, allowing for precise assessments of soil conditions.Therefore, the results of overall validity and implemented experiments and tests of the device can fully satisfy the quality of the study. The device is a highly effective solution for increasing agricultural vegetable production.

Keywords **—Arduino UNO**, **Automated; Irrigation Monitoring Device, Solar Power, Water**

--************************----------------------------------

I. INTRODUCTION

The agricultural sector in the Philippines faces challenges such as water scarcity and insufficient irrigation systems. A research study proposed an innovative solution, the Automated Solar Powered Monitoring and Irrigation device, to address these issues. This solar-powered device maintains ideal water levels for a variety of vegetable crops, resulting in greater yields and economic advantages for the agriculture industry. It intends to help farmers by providing a consistent water source during dry seasons, reducing crop damage, and increasing vegetable yield. The research focuses on efficiently utilizing produced energy to stabilize vegetable output and increase economic performance. Recognizing the pressing need to support farmers and the agriculture industry, the study cites research by Al-Ghobari et al. (2017) suggesting that automation can enhance conventional irrigation systems. Automated irrigation, involving sensors, timers, and minimal manual intervention, has been shown to save up to 38% of water. The device's capacity to control crop water requirements, especially during high-stress periods, helps maintain healthy crop development and long-term agricultural output. Overall, the study seeks to evaluate the influence of this technology on increasing agricultural productivity, reducing water waste, and producing high-quality food, all while benefiting diverse stakeholders such as farmers, consumers, government, rural communities, researchers, innovators, and future researchers.

The concept of the study was based on the project "Solar Powered Microcontroller-based Automated Irrigation System with Moisture Sensors", it is rooted in addressing the inefficiencies and challenges associated with traditional irrigation methods. The fundamental principle revolves around the integration of both hardware and software components to create a smart irrigation system.

Meanwhile, they decided to implement a unique control action for various soil moisture ranges from dedicated sensors for each crop species, leading to precision in irrigation. Furthermore, the system consists of three sensor unit boxes, each housing a network of five Soil Moisture Sensors, an Arduino UNO Microcontroller (Slave Arduino), and Nrf24L01+ transceivers. These sensors measure soil moisture, providing values ranging from 420 to 1023, allowing for precise assessments of soil conditions. The Nrf24L01+ modules enable low-power, long-range communication for efficient data transmission. The Master Arduino was also placed to uniquely identify each transmitting device and generate real-time control actions based on soil moisture data. This central control module includes an Arduino Mega 2560 microcontroller, an LCD – 2x16, an Nrf24L01+ transceiver, and an 8-channel relay block, essential for the system's operation. For its more effective functioning, it is powered by an 18V solar panel module and a 40AHr, 12V battery system, ensuring uninterrupted performance day and night. Additionally, a 1000-liter water reservoir, elevated for gravity-fed distribution, is employed.

The system features a meticulous piping design, utilizing main and sub-drip lines, with sensor boxes for analog soil humidity readings. These sensors calibrate values and transmit average humidity data with unique identities to the central Master control Arduino Mega. The Master Arduino, in turn, actuates solenoid valves to provide precise irrigation as determined by crop-specific algorithms. Finally, this innovative device has its focus on enhancing agricultural efficiency and sustainability. It successfully determines when each crop's soil requires water, wirelessly communicates soil moisture states, delivers controlled irrigation, and operates 24/7 using renewable solar energy.
Generally, the goal of this study is to improve the efficiency and effectiveness of water resource management for agricultural vegetable crops. It also aims to develop ways to use the energy generated during the off days could significantly improve economic performance and help stabilize, increase, and diversify production (e.g., vegetable production, including during the dry season to complement staple crops). Also, to determine the effectiveness of the device for generating sufficient water for vegetables to regulate the water that the vegetables need.

The implementation of an automatic irrigation system is indicated by a sensor that detects when the soil requires water. This system allows for the irrigation of different crops by activating a button. The moisture level of the crops is detected by the irrigation system based on the button pressed. The energy required for the water pump and control system is provided by a solar panel. These solar panels are small grids that can generate excess energy, thereby helping to alleviate the energy crisis problem (Balaji, et al., 2016).

The success of a product in agriculture depends on the collaboration between farmers, technology, and service and consulting concepts. Like other sectors, agriculture will undergo digitization in the future. To ensure the widespread adoption of digital technology in agriculture, governments should invest time and financial resources in promoting its benefits. However, challenges such as limited connectivity in rural areas, expensive service charges, and a lack of computer literacy hinder the rapid development of e-agriculture. Significant investments are needed to improve physical infrastructure, power supply, broadband connectivity, and transportation to overcome these obstacles (Padhy, et al., 2022).

According to Ajlouni et al., (2022) the system utilizes a DC water pump connected to solar panels and incorporates automated water flow control through a moisture sensor. The results showed advantages include water optimization, reduced wastage, and the potential to generate income by selling excess solar energy to the government grid. The proposed system of irrigation is environmentally friendly and sustainable, as it does not use fossil fuels thus limiting emissions of greenhouse gases. The various elements of the system are also not costly and thus affordable in the long term. It is very suitable to use in remote areas and arid zones as it is independent of national power and is water efficient.

R. Sinugo and 0. Longe (2021) South Africa is presently grappling with water and electricity shortages, stemming from an imbalance between their demand and supply. In the realm of irrigation systems, this study introduced and put into action a solar-powered smart irrigation system aimed at enhancing the efficient use of both water and electricity in irrigation procedures. This device can operate manually or automatically and utilizes Bluetooth communication for control. The conducted experiments yielded noteworthy outcomes, revealing that the device led to a remarkable 25.2% reduction in water consumption and a substantial 57.8% decrease in energy expenditure when compared to a scenario where the proposed system was not in place.

Ueeke et al., (2023) an innovative technique that has the potential to drastically reduce water consumption while increasing crop yields is the solar-based irrigation system. Moreover, the percentage change in the purchase of corn, sorghum, beans, oil, rice, and fish was significantly higher in the SMG women's groups than in other groups. At the end of the study, 57% of the women used their additional income for food, 54% for healthcare, and 25% for education. Solar Market Gardens have the potential to enhance household nutrition by increasing income and enabling economic decision-making. (Burney, et al., 2016).

According to Pokhrel et al., (2018) farmer's choice to adopt new technologies depends on various factors: education, access to the technologies, age, size of land, and proximity to an urban area. Farmers adopt a new technology to maximize utility and this utility maximization may come from increased profit, increased leisure, cost reduction, improved environment quality and being in the forefront of technology. Farmers prefer to adopt efficient irrigation technologies due to escalating energy costs and a declining water table. As a resut, farmers can utilize water more prudently by using water-efficient irrigation technologies in water deficient areas.

II. METHODOLOGY

The study was monitored soil condition and generate the right amount of water that the vegetable crops need. The variables to be discerned in the circulation of the system are generating energy from the sun through the use of solar, monitoring soil condition and water level of the water reservoir that would be describe when the vegetable crops need to be watered. Furthermore, the researcher also observed if the device can really monitor the state of the soil and if the device can really generate the right amount of water

The researchers was designed and finalized the flowchart and diagrams needed for the development of the device. Furthermore, the resources in constructing the device were also gathered and decided.

Figure 1 shows the process of the development of the device.

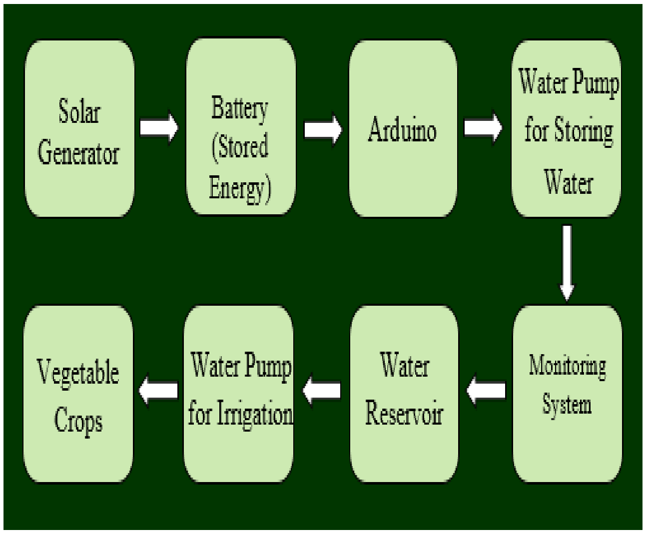

Figure 1: Proposed System Flowchart

The Automated Solar-powered monitoring and irrigation device has the potential to transform farming methods, providing farmers with a reliable and eco-friendly way to enhance crop production. This groundbreaking device offers increased efficiency and sustainability, marking a major advancement for agriculture in the Philippines. It paves the way for improved food security, economic growth, and ecological stewardship.

RESULTS AND DISCUSSION

Based on the data gathered from the respondents, they were strongly agreed with WM = 3.5 that the device had potential in monitoring the soil condition, increasing vegetable production WM=3.34 and converting energy from the sun into power WM = 3.32.

The findings meant that automated solar-power monitoring and irrigation device can manage practices soil quality, alert promptly when soil conditions require adjustment and can trigger automated irrigation based on preset soil moisture threshold.

For the increasing vegetable production, that device can be integrated with other farming technologies to further enhance vegetable crop production. It contribute to a more consistent and controlled growth environment. In addition, the automated device includes safeguards to prevent over irrigation which lead to soil erosion and root diseases and resulted to higher vegetable yields.

With regards to converting energy from sun to solar power, the automated solar device had a potential to convert sun energy into solar.

And in terms of the limitations the following are:
The solar panels on the device may not receive sufficient sunlight to generate the required amount of power for proper operation, particularly in areas with frequent cloud cover or shading from nearby structures.

The capacity and size of the device hinge on the power output, which in turn limits the extent of its irrigation capabilities.
The constant maintenance or replacement of parts likely to occur over an extended period could undermine the dependability and efficiency of the device, while the cost may be excessive for small-scale farmers with limited resources and financing.

The device may be susceptible to damage from inclement weather conditions, such as heavy rain, hail, or wind, which could interrupt or disable its functions.

The monitoring of crop health and growth may be incomplete or inaccurate, which could negatively impact irrigation strategies and hinder the device's ability to maximize crop yields.

With regards to the benefits are the following:

1. The automated irrigation process saves time and minimizes labor, reducing the likelihood of human error.

2. Growers can access real-time data on soil moisture and crop water needs, allowing them to make accurate decisions about irrigation scheduling and water management.
3. Provides growers with the ability to remotely monitor crop growth and water requirements, allowing for quick responses to crop health issues before they become significant.
4. The device generates sufficient water, resulting in improved crop yields and quality.
5. Vegetables require a precise amount of water to thrive, and the device allows for accurate control over water amounts, ensuring maximum yields.
6. Reduces growers' dependence on fossil fuels, minimizes greenhouse gas emissions, and contributes to combating global climate change.

Capacity of the device to boost vegetable production

With precise monitoring and control of water resources, these devices can provide consistent and effective irrigation to crops, leading to improved growth and yield.

Real-time data and insights into crop growth and water usage can help farmers make informed decisions about fertilization and other inputs, further contributing to increased vegetable production.

The device uses solar power, which is a clean and renewable energy source. This makes it an energy-efficient system that aligns with sustainable agricultural practices, thus, reducing the overall operational costs and the farmer earns more profits.

The optimal watering levels, less water waste, and ideal moisture levels in the soil will help to produce healthier plants, resulting in better crop yield.

A lack of proper irrigation techniques can lead to plant stress, which can negatively impact growth and crop yield. An automated irrigation device helps prevent such stress by consistently providing water to the plants.

Key Factors influencing farmers to adapt the modern device:

1. Ease of use
2. Cost savings
3. Reduce environmental impact
4. Climatic variability
5. Long-term benefits

III. CONCLUSIONS

The researcher completed the development of an "Automated Solar-Powered Monitoring and Irrigation Device" that can generate sufficient water necessary to increase agricultural veggie production. The overall validity and implemented experiments and tests of the device can fully satisfy the quality of the study. The device is a highly effective solution for increasing agricultural vegetable production.

The device was able to monitor and accurately report on soil conditions, which helps farmers make informed decisions about watering and irrigation. The ultrasonic sensor ensures that the water tank is always adequately filled and ready for use. Thanks to its solar-powered and automated features, the device operates seamlessly and consistently, without any issues affecting its functionality. Overall, this device has the potential to revolutionize the way we approach agricultural vegetable production, providing farmers with a reliable and sustainable solution to increase crop yields.

The researcher recommend further research and innovation in the field of automated solar-powered monitoring and irrigation device to increase vegetables crop production. Additionally, the researcher propose developing predictive algorithms that can help water requirements of plants based on various factors like weather conditions and plant type. Moreover, investigating the impact of automated solar-powered monitoring and irrigation devices to increase vegetables crop production will create more efficient and effective devices that contribute to a sustainable future for agriculture.

ACKNOWLEDGMENT

The proponent would like to extend her deepest gratitude and acknowledgement to all the persons behind the success of this study. To her family, friends, students and teachers. All glory to God.

REFERENCES

[1] Al-Ghobari, Hussein, et al. Automated irrigation systems for wheat and tomato crops in arid regionshttps://www.researchgate.net/publication/316348624_Automated_irrigation_systems_for_wheat_and_tomato_crops_in_arid_regions?fbclid=IwAR0FNmP4zAZgc2FDrrzATIsTHhhG2q_1bkZ2Hrik623V_NCzOEbrmqn5U_Y

[2] C. A. Bolu et al 2019 "Solar Powered Microcontroller-based Automated Irrigation System with Moisture Sensors"https://iopscience.iop.org/article/10.1088/1742-6596/1378/3/032003/pdf?fbclid=IwAR3spzMxJqLc0McmvJcTWRihuH5HaWZwBQXnoZODEVXRD61jTO8JRf2CXAQ

[3] Balaji and Sudha 2016 "Solar Powered Auto Irrigation Device" February 2016 https://www.agrisolarclearinghouse.org/wp.-content/uploads/info-library/agrisolar info/solar-irrigation/solar-powered-auto-irrigation-system.pdf. Accessed 12 October 2023

[4] Padhy, Chitrasena, et al. "(PDF) Role of Digital Technology in Agriculture." *ResearchGate*, 24 April 2022, https://www.researchgate.net/publication/360156670_Role_of_Digital_Technology_in_Agriculture. Accessed 12 October 2023.

[5] Ajlouni, Fawzi, et al. "Design and Implementation of Fully Automated Solar Powered Irrigation System" May 2022 https://www.researchgate.net/publication/360928704_Design_and_Implementation_of_Fully_Automated_Solar_Powered_Irrigation_System. Accessed 12 October 2023

[6] Sinugo, Rinae, and Omowunmi Mary Longe. April 2017 "Solar-Powered Smart Irrigation System" https://www.researchgate.net/publication/356241236_Solar-Powered_Smart_Irrigation_System?fbclid=IwAR0puUOpf6a1I6_F5k3Uypo1YYcIL9mCUUL1yFQ94WfOFRbd37tiQ_55E-I.

[7] Ueeke, Dhamgaye, et al. "An Efficient, Optimized and Solar Based Automatic Irrigation System using GSM Module" April 2023 https://www.researchgate.net/publication/370413304_An_Efficient_Optimized_and_Solar_Based_Automatic_Irrigation_System_using_GSM_Module?_tp=eyJjb250ZXh0Ijp7InBhZ2UiOiJwdWJsaWNhdGlvbiIsInByZXZpb3VzUGFnZSI6bnVsbH19. Accessed 12 October 2023

[8] Jennifer Burney, et al. "Solar-Powered Drip Irrigation Impacts on Crops Production Diversity and Dietary Diversity in Northern Benin" March 2016https://www.researchgate.net/publication/299399649_SolarPowered_Drip_Irrigation_Impacts_on_Crops_Production_Diversity_and_Dietary_Diversity_in_Northern_Benin?fbclid=IwAR2oVemDDW6wlQ9JtGyyLEwovXB8doej-WcsDUYJDhqc1jXVYWJtLe-_KsM

[9] Pokhrel, Bijay, et al. "Factors Affecting the Choice, Intensity, and Allocation of Irrigation Technologies by U.S. Cotton Farmers." *';;' - YouTube*, 9 March 2019, https://www.mdpi.com/20734441/10/6/706?fbclid=IwAR0lMxWFtxxz9kXTN_J3yJCS9vXOOLuhesuoGlrZxB3nVRYc8XbVKgcZDsE. Accessed 12 October 2023.

