Research Paper on Solar Powered Automatic Plant Irrigation System for Agriculture using IoT

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Abstract - This research paper presents a novel approach to enhance agricultural productivity and optimize water usage through the implementation of a solar-powered automatic plant irrigation system using the Internet of Things (IoT). With the increasing global population and diminishing water resources, it has become imperative to develop sustainable irrigation solutions that minimize water wastage and ensure efficient crop growth. The proposed system utilizes solar energy for powering the irrigation process, reducing reliance on conventional energy sources and minimizing carbon footprint. IoT technology is integrated to enable real-time monitoring, data collection, and intelligent decision-making, thereby optimizing water usage based on plant requirements and environmental conditions. The system's design, implementation, and performance evaluation are discussed, demonstrating its effectiveness in achieving precise and automated irrigation while conserving water resources.

The sensor nodes are equipped with soil moisture sensors, temperature sensors, and Humidity sensors to collect real-time data about the environmental conditions. The data from the sensor nodes are wirelessly transmitted to the central control unit, which processes the information and makes decisions regarding irrigation schedules. Also send data to IoT Server for Remote Monitoring.

Keywords: Solar power, Automated irrigation, IoT, agriculture, solar power, water conservation, soil Moisture Sensor.

1. INTRODUCTION

The increasing global population and the need for sustainable agriculture have led to a growing demand for efficient irrigation systems. Traditional irrigation methods are often inefficient, leading to water wastage and increased labor requirements. In this context, the integration of solar power and Internet of Things (IoT) technologies can provide a solution to optimize irrigation practices in agriculture. The design and development of a solar-powered automatic plant irrigation system for agriculture using IoT. The proposed system aims to provide a sustainable and energy-efficient solution to irrigate crops based on their specific moisture requirements. The system consists of multiple sensor nodes deployed in the field, a central control unit, and a solar power system.

The solar power system provides the necessary energy to operate the sensor nodes and the control unit. It consists of solar panels, a battery bank for energy storage, and a power management system. The solar panels harness solar energy and convert it into electrical energy, which is stored in the battery bank. The power management system ensures the efficient utilization of solar power and regulates the energy supply to the system components.
The IoT capabilities of the system enable remote monitoring and control. Farmers can access the system through a web or mobile application, allowing them to monitor the soil moisture levels, environmental conditions, and irrigation schedules. They can also adjust the irrigation settings based on their preferences or changing weather conditions. The proposed solar-powered automatic plant irrigation system offers several advantages over conventional methods. It reduces water wastage by providing irrigation only when necessary, based on real-time data. It also minimizes labor requirements as the system automates the irrigation process. Additionally, the use of solar power makes the system environmentally friendly and economically viable in remote agricultural areas with limited access to electricity.

2. PROBLEM STATEMNT & OBJECTIVES

Limitations of traditional plant irrigation methods in agriculture, such as over-watering or under-watering, which can result in water wastage, decreased crop yield, and increased operational costs for farmers. These challenges can be addressed through the implementation of an automated irrigation system that utilizes IoT technology. However, the existing IoT-based solutions often rely on grid power, making them less sustainable and cost-effective. Many parts of our country still lack in proper flow of electricity all the time and unaware of new technologies and methodologies. Uneven distribution of rainfall also leads to lack in farming and thus due to improper yielding farmers are been bound to take negative steps. Hence they are needed to be educated about the new technologies and different ways through which they can improve their yielding.

B. Objectives
1) To reduce the wastage of water in deep percolation and seepage losses.
2) To reduce the power consumption for irrigation.
3) Electricity supply not available in many farms, this technical methodology of irrigation will help in better production in those areas.
4) Due to uneven and indeterminate distribution of rainfall that cause drought and farmer suicide which can be reduced up to a certain level by this project.

PROPOSED METHODOLOGY

This System provide an innovative and sustainable solution to address the challenges of water scarcity and inefficient irrigation practices in agriculture. The integration of solar energy, IoT has the potential to significantly improve water management, enhance crop productivity, and contribute to the overall sustainability of agricultural practices. The system operated even in rural locations with little access to electricity thanks to solar power, a sustainable and renewable energy source. The system automatically activated the water pump to irrigate the plants as necessary based on the predefined threshold values and the accurate measurements of the soil moisture sensors. This automated procedure eliminated the requirement for ongoing human involvement and delivered timely irrigation. The power management system controls the energy supply to the system's components and ensures that solar power is used effectively.
The system's IoT features allow for remote monitoring and control. The system allows farmers to monitor soil moisture levels, environmental factors, and irrigation schedules through a web or mobile application. Additionally, they can modify the irrigation settings in accordance with their preferences or shifting weather patterns. The autonomous plant watering system that is being proposed for solar power has a number of benefits over traditional approaches. By supplying irrigation just when necessary, based on real-time data, it lowers water waste. Additionally, because the device automates the irrigation process, it reduces the need for labor. Additionally, the system is environmentally friendly because it uses solar electricity.

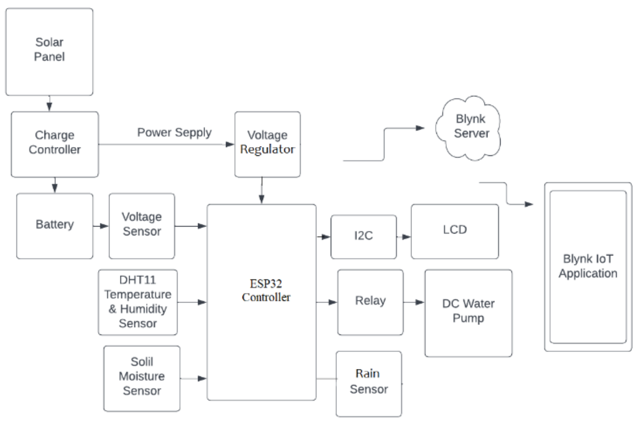

Fig -1: Block Diagram

Using the Blynk IoT application, we would concurrently receive all the information about what was happening, such as whether the engine was operating or not and how much soil moisture was there. All of this is made possible by an ESP32 wi-fi module that connects to the internet and sends data to our phone. Because everything in our project is automated online, we can assume that it was developed on IoT. Therefore, the automated system is running. If the automatic system malfunctions, the pump can also be manually turned on and off, but doing so requires going out to the field. [6].

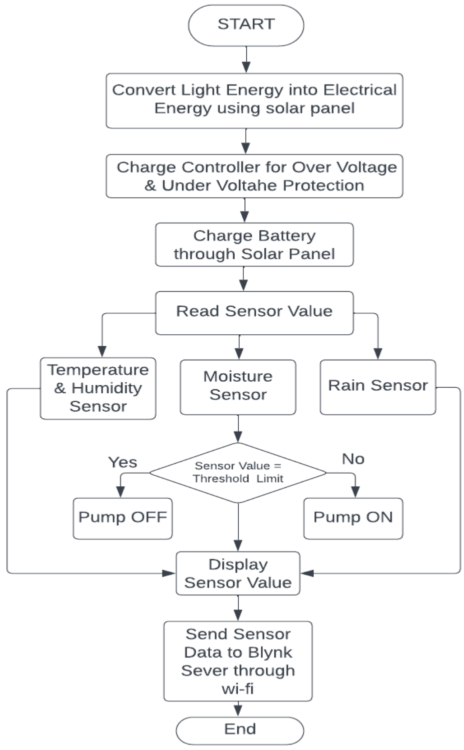

Fig -2: Flow Chart

4. COMPONENT DETAILS

ESP32 Controller

ESP32 is a low-cost System on Chip (SoC) Microcontroller from Espressif Systems, the developers of the famous ESP8266 SoC. It is a successor to ESP8266 SoC and comes in both single-core and dual-core variations of the Tensilica's 32-bit Xtensa LX6 Microprocessor with integrated Wi-Fi and Bluetooth. The good thing about ESP32, like ESP8266 is its integrated RF components like Power Amplifier, Low-Noise Receive Amplifier, Antenna Switch, Filters and RF Balun. This makes designing hardware around ESP32 very easy as you require very few external components. Another important thing to know about ESP32 is that it is manufactured using TSMC's ultra-low-power 40 nm technology. So, designing battery operated applications like wearables, audio equipment, baby monitors, smart watches, etc., using ESP32 should be very easy.

Fig -3: ESP32 Controller

Soil Moisture Sensor

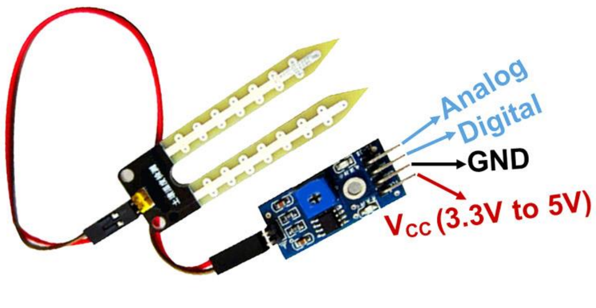

Fig -4: Soil Moisture Sensor

The soil moisture sensor is one kind of sensor used to gauge the volumetric content of water within the soil. As the straight gravimetric dimension of soil moisture needs eliminating, drying, as well as sample weighting. These sensors measure the volumetric water content not directly with the help of some other rules of soil like dielectric constant, electrical resistance, otherwise interaction with neutrons, and replacement of the moisture content. The relation among the calculated property as well as moisture of soil should be adjusted & may change based on ecological factors like temperature, type of soil, otherwise electric conductivity. The microwave emission which is reflected can be influenced by the moisture of soil as well as mainly used in agriculture and remote sensing within hydrology.

Solar Charge Controller

Fig -5: Solar Charge Controller

Charge controllers are crucial in BIPV systems to prevent batteries from being damaged by overcharging and over-discharging by controlling the current flow from and to the batteries. They can also protect the appliances that are connected to the batteries in BIPV systems. Most batteries can hardly recover after overcharging and over-discharging, so the employment of controllers in BIPV systems can prolong the service life of the batteries. There are various types of charge controllers, including shunt controls, single-stage controls, multistage controls, etc.

DHT11 Temperature & Humidity Sensor

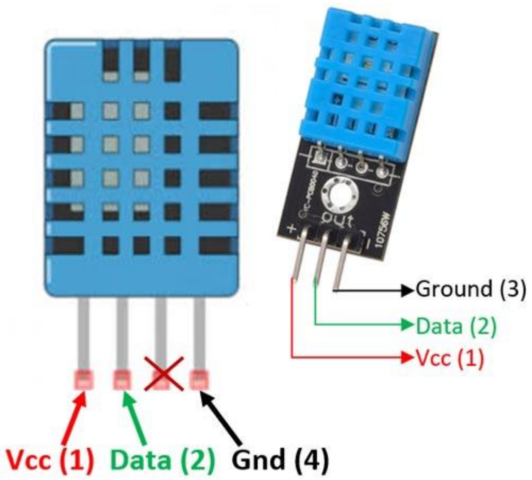

Fig -6: DHT11 Temperature & Humidity Sensor

The DHT11 is a basic, ultra low-cost digital temperature and humidity sensor. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air and spits out a digital signal on the data pin (no analog input pins needed). It's fairly simple to use but requires careful timing to grab data. The only real downside of this sensor is you can only get new data from it once every 2 seconds, so when using our library, sensor readings can be up to 2 seconds old.

Rain Sensor

Fig - 7: Rain Sensor

Rain sensor is one kind of switching device which is used to detect the rainfall. It works like a switch and the working principle of this sensor is, whenever there is rain, the switch will be normally closed. The rain sensor module/board is shown below. Basically, this board includes nickel coated lines and it works on the resistance principle. This sensor module permits to gauge moisture through analog output pins & it gives a digital output while moisture threshold surpasses.

Battery

Fig - 8: Battery

A battery can be defined as an electrochemical device (consisting of one or more electrochemical cells) which can be charged with an electric current and discharged whenever required. Batteries are usually devices that are made up of multiple electrochemical cells that are connected to external inputs and outputs. Batteries are widely employed in order to power small electric devices such as mobile phones, remotes, and flashlights. Historically, the 'term' battery has always been used in order to refer to the combination of two or more electrochemical cells.

5. RESULT

The system aims to provide an efficient and sustainable solution for watering plants by harnessing solar energy and leveraging IoT connectivity. The paper discusses the experimental setup, methodology, and results obtained from field tests conducted in a real agricultural environment. The analysis of the results demonstrates the effectiveness and reliability of the proposed system in optimizing water usage, enhancing crop yield, and reducing manual intervention in irrigation processes. To gather information about the environmental conditions in real-time, the sensor nodes are furnished with soil moisture sensors, temperature & humidity sensors, and Rain Sensor. The central control unit processes the information and decides on irrigation schedules after receiving the data wirelessly from the sensor nodes. For remote monitoring, send data to an IoT server as well.

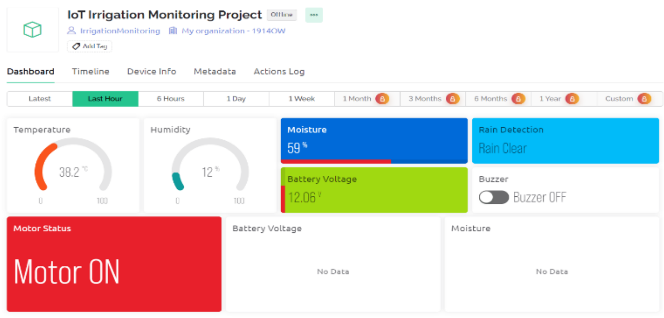

Fig.9 IoT Application Web Dashboard Result

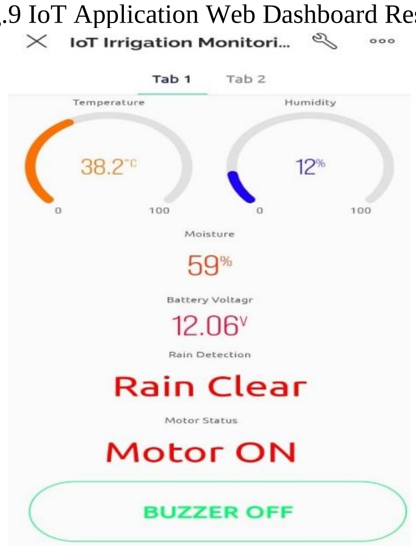

Fig. 10 Application Mobile Dashboard Result

6. CONCLUSION

In this research paper, we proposed a solar-powered automatic plant irrigation system for agriculture using IoT technology. The aim of this system was to address the challenges faced by farmers in efficiently irrigating their crops while conserving water resources and reducing manual labor. Through the implementation of IoT devices, such as soil moisture sensors, water pumps, and solar panels, we created a smart irrigation system that can monitor and control the irrigation process based on real-time data. The system utilized solar power as a sustainable and renewable energy source, ensuring its operation even in remote areas with limited access to electricity.

The soil moisture sensors accurately measured the moisture content in the soil, and based on the predefined threshold values, the system automatically triggered the water pump to irrigate the plants when necessary. This automated process reduced the need for constant human intervention and provided timely irrigation, promoting healthier plant growth and higher crop yields.

REFERENCES

1. Saraf, S.B. and Gawali, D.H., 2021, May. IoT based smart irrigation monitoring and controlling system. In 2017 2nd IEEE International Conference on Recent Trends in Electronics, Information & Communication Technology (RTEICT) (pp. 815-819). IEEE
2. Kansara, K., Zaveri, V., Shah, S., Delwadkar, S. and Jani, K., 2015. Sensor based automated irrigation system with IOT: A technical review. International Journal of Computer Science and Information Technologies, 6(6),

pp.5331-5333.
3. Xiarchos, I. M., & Vick, B. Solar energy use in US agriculture: Overview and policy issues. US Department of Agriculture, Office of the Chief Economist, Office of Energy Policy and New Uses.
4. Kruthika, K., Kumar, B.K. and Lakshminarayanan, S., 2020, October. Design and development of a robotic arm. In 2020 International Conference on Circuits, Controls, Communications and Computing (I4C) (pp. 1-4). IEEE.
5. Rachel Cardell-Oliver, Mark Kranz, Keith Smettem, Kevin Mayer, "A Reactive Soil Moisture Sensor Network: Design and Field Evaluation" , International Journal of Distributed Sensor Networks, Vol. 1, pp. 149–162.
6. Sujit Thakare, P.H.Bhagat , "Arduino-Based Smart Irrigation Using Sensors and ESP8266 WiFi Module" , Proceedings of the Second International Conference on Intelligent Computing and Control Systems, June 2018, pp.1085-1089, IEEE Xplore Compliant Part Number: CFP18K74-ART; ISBN:978-1-5386-2842-3.
7. Venkata Naga Rohit Gunturi,"Micro Controller Based Automatic Plant Irrigation System" , International Journal of Advancements in Research & Technology, Vol. 2(4), 194, 2013. ISSN 2278-7763.
8. A.R. Al-Ali , Ahmad Al Nabulsi , Shayok Mukhopadhyay ,Mohammad Shihab Awal , Sheehan Fernandes , Khalil Ailabouni,"IoT-solar energy powered smart farm irrigation system", Journal of Electronic Science and Technology", 17(4), 100017, 2021. https://doi.org/10.1016/j.jnlest.2021.10001