International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

IoT Smart Irrigation System Based on Dual Axis Solar Panels

Adaikkammai.A[1], Agalya.S[2], Keerthana Devi.S[3], Baby Srinithi.S[4]

[1,2,3,4]B.Tech Computer Science & Business Systems Department R.M.D Engineering College Chennai, India

Abstract

Water scarcity is one of the most pressing challenges in modern agriculture, directly impacting food security and sustainability. This project proposes a smart irrigation system that leverages advanced technologies such as IoT sensors, real-time data analysis, and automated control to optimize water usage. By integrating environmental data, such as soil moisture, humidity, and weather forecasts, the system delivers precise irrigation, minimizing water wastage while maximizing crop yield. This project introduces an advanced irrigation system designed to optimize water usage for agricultural applications, leveraging real-time sensor data and automation technologies. By integrating IoT devices, the system monitors soil moisture, weather conditions, and crop water requirements, dynamically adjusting water distribution to ensure precise irrigation. The project aims to minimize water wastage, enhance crop yield, and promote sustainable farming practices. Through data-driven insights, farmers can achieve better control over their resources, significantly reducing water consumption and operational costs while fostering environmental stewardship.

Keywords: Iot, Dual Axis Solar panels, Micro-controller, ESP8266, Sensors etc…

INTRODUCTION

Water—our planet's most precious resource—has been the lifeblood of agriculture for millennia. From the ancient irrigation canals of Mesopotamia to the sophisticated drip systems of modern times, mankind has always sought ways to optimize water use in farming. Yet, as global population growth accelerates, climate patterns shift unpredictably, and natural resources become strained, the quest to make agriculture more sustainable has never been more urgent. Traditional irrigation systems, while effective, are often wasteful, watering crops indiscriminately and inefficiently, and consuming vast amounts of energy. It's time for a revolution—one that blends age-old agricultural wisdom with cutting-edge technology to ensure a smarter, more responsible future for farming.

This project represents a bold leap forward, where modern innovation meets environmental stewardship to deliver an irrigation solution that is intelligent, adaptive, and eco-friendly. At its core, the project aims to solve one of the most pressing challenges in agriculture: how to provide crops with the right amount of water, at the right time, in the most efficient way possible. By leveraging the power of the Internet of Things (IoT), real-time sensor data, and automated systems, this project offers a radical reimagining of water management for farms—one that conserves resources, reduces costs, and boosts crop yield, all while promoting sustainable farming practices.

1) The New Paradigm of Precision Irrigation

Picture this: an irrigation system that "knows" exactly what your crops need, before you even do. It senses soil moisture levels, monitors upcoming weather patterns, and adjusts water delivery with laser-like precision. No more guesswork. No more overwatering or underwatering. This is the promise of precision irrigation, and at the heart of this system is a network of IoT devices that gather and analyze data in real-time.

Using smart sensors embedded in the soil, the system continuously tracks moisture levels at various depths, ensuring that crops receive just the right amount of water. It also monitors environmental factors such as temperature, humidity, and wind speed, adjusting irrigation schedules in response to changing conditions. For instance, if rain is forecasted, the system automatically reduces water flow, preventing unnecessary watering and saving both water and energy. If a sudden heatwave strikes, the system compensates by delivering additional water to prevent crop stress.

The intelligence of this system is further amplified by its ability to learn and adapt. Over time, it becomes more attuned to the specific needs of different crops, understanding which plants require more or less water, and adjusting its patterns accordingly. It's like having a 24/7 irrigation expert monitoring your fields, ensuring your crops thrive while minimizing resource waste.

2) Empowering Farmers with Data-Driven Insights

Beyond just watering crops, this project empowers farmers with invaluable data-driven insights. With a simple smartphone app or web dashboard, farmers can monitor their fields remotely, accessing real-time data on soil health, water usage, and crop conditions. Detailed reports and alerts keep them informed of any irregularities, such as leaks, blockages, or dry zones, allowing them to act swiftly and efficiently. This kind of transparency not only saves time but also cuts down on labor costs, as fewer on-site inspections are needed.

Moreover, the system’s data analytics capabilities provide long-term benefits. By analyzing patterns in water usage and crop health over time, farmers can make informed decisions about planting strategies, resource allocation, and even the types of crops that are best suited for their particular soil and climate. This turns data into actionable insights, helping farmers optimize their operations and maximize both yield and profit.

3) Sustainability at Its Core

What makes this project particularly compelling is its focus on sustainability. Water scarcity is an ever-growing global concern, and agriculture is by far the largest consumer of freshwater, accounting for approximately 70% of global use. Through intelligent water management, this irrigation system helps reduce water wastage, ensuring that every drop counts. By conserving water, farmers not only safeguard their crops but also play a critical role in protecting local ecosystems and preserving water sources for future generations.

Additionally, this project aligns with the broader goals of energy conservation and environmental protection. By reducing unnecessary irrigation, the system minimizes the energy needed to pump and distribute water, lowering the overall carbon footprint of farming operations. The result is a more sustainable approach to agriculture that balances productivity with responsible resource use.

4) A Vision for the Future of Farming

As the world faces increasingly complex environmental challenges, innovative solutions like this smart irrigation system will be critical in reshaping the future of farming. By bridging the gap between technology and agriculture, this project offers a glimpse of what's possible when we think creatively

about age-old problems. It's not just about saving water—it's about ensuring food security, empowering farmers with modern tools, and building a more sustainable future for agriculture.
This is the future of farming—intelligent, sustainable, and incredibly promising

LITERATURE REVIEW

Lately, there has been so much interest in drip irrigation systems because they enable the farmers to practice sustainable agriculture by conserving much-needed water while at the same time improving crop yield. Most traditional irrigation practices are characterized by overwatering and sometimes underwatering, which entail wastage of scarce resources besides poor growth of crops. New research centers on the use of autonomous systems with real-time information to optimize irrigation scheduling in relation to the moisture level in the soil, temperature, and other environmental factors. Preliminary work concludes that the applied systems in our work do indeed provide reliable readings for efficient application of water. The above concepts thus with DHT11 sensor measuring temperature and humidity, could be used holistically to manage irrigation. The technologies could be better presented as regards irrigation strategies by the farmers while reducing water consumption from between 50% improving crop health and productivity altogether. The upcoming benefits increase not only agricultural productivity but also the sustainability of agriculture and thus a sane remedy to tackle the challenges of global water .

Renewable energy sources, especially solar energy, have emerged as strategies, particularly in agricultural practices, to enhance sustainability. That is, the tracker solar panels which track the movement of the sun prove advantageous over the fixed panels in considerable ways. Hence, the energy supply could be significantly enhanced and therefore sufficient for irrigation systems. In fact, it has been experimentally proved that solar panels mounted in a dual-axis generate 30 to 45 percent more electricity than fixed mounted ones, thus ensuring vast amounts of energy will be supplied as provision to automatic irrigation systems. Such systems do not consume fossil fuels in the production of power; other farming practices have a relatively small carbon footprint. This solar technology usage in irrigation satisfies the worldwide call to renewable energy resources and responsible ways of managing the environment. Solar energy use in agriculture has emerged to cut operation costs and empower farmers to be independent as far as electricity is concerned. We will use solar power for our project. assist both water and agricultural productivity in achieving these.

Mobile technology in agricultural practice can hardly be underrated; however, in the case of a smart irrigation system, mobile technology has to be taken to a higher level. For instance, in this project, the example of the application is Blynk, showing the way mobile platforms might be used to monitor and control irrigation systems in real-time. Literature proves usability that is high; engagement for user decisions by farmers receiving accessible data about soil moisture, temperature, and irrigation schedules in close intervals is higher. Hence, such real-time feedback would enable the farmer to have good options, optimal utilization of water resources, and prompt response to any shift in environmental conditions. Moreover, the IoT technology in the application of mobiles enables the integration and improves connectivity among various components of the system, and then smooth communication among sensors, controllers, and users might be established. Indeed, several experiments have been proved that the achievement of such smart technologies in agriculture would lead to efficiency improvement, minimized labor costs, and better crop management. So, our project is all about filling in

this gap by connecting a farmer with his irrigation system via very easy-to-use mobile applications for revolutionizing use in sustainable and effective agriculture practice.

PROPOSED SYSTEM

We have designed a friendly mobile application to serve as an interface that exists between the farmer and the irrigation system; this will allow them to receive real-time information from the system, which may include the schedule of irrigation, the energy generated, and sensor data. These consist of monitoring soil moisture levels, temperature, and humidity: this will ensure a well-informed decision when making decisions with regard to irrigation. The application also allows for remote control of the irrigation system, so you could change the settings according to existing conditions or changes in weather that you did not predict. That simplifies irrigation practices management and powers us to support farmers to use sustainable technologies with confidence. This mobile app is not just an interface that will offer users an enjoyable experience but will also create a deeper understanding of the system's capabilities to ensure the smart irrigation solutions are widely adopted in agriculture and for a sustainable future.

This project aims to revolutionize the way people do agriculture in our day by using an automatic irrigational system powered by dual-axis solar panels. This high-tech system is going to combine both worlds-high technology and renewable resources-to offer a far better sustainable solution for irrigation of fields. Automatic irrigation technology can significantly increase crop yield with minimal loss of water. In the face of global climatic challenges and increasing water resource scarcity, this project is a much-needed breath of life for eco-friendly agriculture. This shall be carefully planned into existence, ensuring that a system addresses the urgent needs of farmers immediately while fostering long-term sustainability in agriculture. This will include dual-axis solar panels that ensure the availability of an energy source that is both cost-effective and environmental friendly.

Our automation irrigation relies on real-time data collection by a set of high-end sensors. We use capacitive soil moisture sensors, ensuring crops get just enough water without excess. For this purpose, the DHT11 sensor calculates environmental temperature and humidity that is impacting the irrigation process. It is also intended to add a Light Dependent Resistor to figure out the quantity of sun light falling on this system in order to determine suitable irrigating time with energy usage. This means the system makes decisions considering all environmental changes and irrigates crops timely. We are in a position to generate a dynamic irrigation schedule by tapping into this information. This increases efficiency, enhances crop development thus increasing agricultural productivity.

A revolutionary aspect of our proposed system is the dual-axis solar panel. It has the capability of increasing energy production massively. This is unlike other systems that only make use of fixed position solar panels. With ours, the solar panels follow the movement of the sun, thus maximizing the quantity of sun exposure they receive throughout the day. This technology will increase energy generation by 30-45% to ensure that the irrigation system continuously and efficiently operates during changing weather conditions. Harnessing solar energy means much more than a reduction in our dependence on conventional power sources, which are often increasing carbon emissions and environmental degradation. It caters to the irrigation process and aligns with the global efforts at providing energy solutions for farming. With regard to integration of solar technology, this shows commitment to innovative and sustainable farming practices that are responsive to changes in the needs of our planet.

The ESP8266 microcontroller is at the centre of our automatic irrigation system; it is powerful and versatile in so doing and aids in ensuring an easy integration of all the system elements. This particular microcontroller enables the processing of data collected from each of the sensors connected and therefore real-time decision-making concerning the activation of an irrigation schedule. It boasts Wi-Fi capabilities that make remote monitoring as well as control easier. The ESP8266 interfaces with the dual-axis solar panels to maximize energy usage and ensure proper operation in the system. In addition, it offers high compatibility with various applications, thereby ensuring a flexible system that can easily adapt to different agricultural needs. This application of microcontroller technology, therefore, not only increases operational efficiency but gives the farmer the means to make informed decisions regarding the crops.

MATERIALS USED

The ESP8266 microcontroller is a crucial component in IoT irrigation systems, providing Wi-Fi connectivity and enabling remote monitoring and control. It can interface with various sensors such as soil moisture, temperature, and humidity sensors, providing data about environmental conditions in the area where the irrigation system is deployed. The ESP8266 can make intelligent decisions about when and how much to water the plants based on the collected data, implementing algorithms for optimizing irrigation schedules to conserve water while ensuring plants receive adequate moisture.

The Capacitive Soil Moisture Sensor measures the moisture content in the soil using capacitive sensing technology, which measures the dielectric constant of the soil. The sensor provides analog or digital output representing the moisture level, which is collected by the microcontroller in the smart irrigation system. The moisture level data obtained from the sensor is used to make decisions about when and how much to water the plants. By comparing the current moisture level with a predefined threshold, the system can determine if irrigation is necessary.

The DHT11 is a digital temperature and humidity sensor commonly used in various IoT applications, including smart irrigation systems. The DHT11 measures ambient temperature, which is valuable for understanding environmental conditions that affect plant growth and water requirements. The system can adapt the irrigation schedule to match the specific needs of the plants based on current environmental conditions.

A dual-axis solar panel can increase annual energy output by approximately 40% compared to a fixed solar system. The panel is designed to track the movement of the sun in both the horizontal and vertical axes, ensuring that it always faces the sunlight. This tracking capability maximizes energy production throughout the day. The panel can be mounted on a pole and adjusted to face the sun all day, allowing for optimal solar energy levels, regardless of the sun's position in the sky irrigation system.

A 12V DC motor valve plays a critical role in an IoT-based smart irrigation system. The motor pump is responsible for drawing water from a water source (e.g., well, reservoir, rainwater harvesting system) and delivering it to the plants through a network of pipes and hoses. The motor pump can be controlled to vary the flow rate of water, allowing for precise control over the amount of water delivered to different areas or specific plants within the irrigation system. When integrated into an IoT system, the 12V DC motor pump can be controlled remotely based on real-time data from sensors.

The L293D Motor Driver Module is a popular integrated circuit used to control DC motors in various applications, including IoT-based smart irrigation systems. The primary role of the L293D Motor Driver Module is to control the operation of DC motors. The module can drive two DC motors in forward and

reverse directions, making it suitable for applications where motor direction control is needed. The module has built-in current limiting features that protect the motors from excessive current, which can occur during startup or if the motor is stalled.

Soil NPK sensors play a crucial role in monitoring and analyzing the nutrient content of the soil in an IoT irrigation system. They can be buried in the soil for an extended period and are resistant to electrolysis, corrosion, and water damage. They provide a means to systematically evaluate the fertility of the soil, enabling precise nutrient management in agricultural practices.

FUTURE SCOPE

Future work includes adding pesticide level detection and automatic sensor fault detection to the system. The system will also provide a dataset to identify plant diseases based on the given data. Advanced data analytics can identify irrigation patterns and optimize water usage, leading to improved crop yields and resource management. Maintenance alerts can prevent system failures and reduce downtime. The future of IoT Smart Irrigation systems will likely include advanced AI and automation, with sustainability trends driving the integration of renewable energy sources. Continuous innovation will lead to smarter, more efficient agricultural practices globally.

RESULT AND DISCUSSION

The project combines automated irrigation techniques with renewable energy sources to optimize crop yield, minimize water wastage, and promote eco-friendly farming practices. Real-time data from sensors monitors soil moisture, temperature, and humidity, determining the ideal irrigation schedule. Dual-axis solar panels generate electricity by tracking the sun's movement. Despite facing issues like fault connections and internal device errors, the system was designed to meet the project's objectives. The rotating solar panel captures more energy than a static panel. The smart irrigation can adjust for daily weather, plant type, soil type, and slope, reducing overwatering risk. Controllers can be adjusted remotely, identifying farm land soil moisture status, and monitoring and controlling the system according to user requirements.

CONCLUSION

In conclusion, this paper tells an automated irrigation system that has a dual-axis solar panel to ensure a sustainable energy supply. Therefore, the proposed system continuously tracks the moisture, temperature, and humidity of the soil, supplying it with water in times of need only, hence saving this natural resource from wastage and promoting efficient irrigation. It is integrated with a trained model that aids in providing personalized watering schedules according to the requirements of varied flora. Other than this, it harnesses renewable energy extracted from a dual-axis solar panel for its sustainable power and excess energy storage. This system provides a full-package solution of optimized irrigation toward the conservation of these water resources for sustainable agriculture.

REFERENCES

1. S.R. Raine The future of irrigation technologies and practices is here now, keynote address Proceedings of the Irrigation Australia 2006 Conference, Brisbane, Australia (2006)
2. 2.R.M. Michael, A. Hussain, M.H. Gillies, J. Nicholas Inflow rate and border irrigation performanceAgric. Water Manag., 155 (2015), pp. 76-86, 10.1016/J.AGWAT.2015.03.017

3. H.M. Al-Ghobari, F.S. Mohammad, M.S.A. El Marazky, A.Z. Dewidar Automated irrigation systems for wheat and tomato crops in arid regions Water SA, 43 (2017), pp. 354-364, 10.4314/wsa.v43i2.18
4. S. Millán, J. Casadesús, C. Campillo, M.J. Moñino, M.H. Prieto Using soil moisture sensors for automated irrigation scheduling in a plum crop Water, 11 (2019), p. 2061, 10.3390/w11102061
5. A.B. Mandavia Modernization of irrigation system operational management by way of canal automation in India Proceedings of the Modernization of irrigation system operations: 5th ITIS network international meeting, Aurangabad (1998)
6. J. Muangprathub, N. Boonnam, S. Kajornkasirat, N. Lekbangpong, A. Wanichsombat, P. Nillaor IoT and agriculture data analysis for smart farm Comput. Electron. Agric., 156 (2019), pp. 467-474, 10.1016/j.co mpag.2018.12.011
7. S.J. Patil, A. Patil Precision agriculture for water management using IoT Int. J. Recent Innov. Trends Comput. Commun., 5 (12) (2017), pp. 142-144
8. A. Barman, B. Neogi, S. Pal Solar-powered automated IoT-based drip irrigation system P. Pattnaik, R. Kumar, S. Pal, S. Panda (Eds.), IoT and Analytics for Agriculture. Studies in Big Data, 63, Springer, Singapore (2020), 10.1007/978-981-13-9177-4_2