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IOT Based Smart Irrigation and Soil Monitoring System for Precision Farming

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Abstract: Efficient water management is critical due to increasing global water scarcity. This paper proposes an IoT-based smart irrigation and soil monitoring system that automates irrigation using real-time sensing and cloud connectivity. Soil moisture, soil temperature, air temperature, humidity, and UV radiation are measured, while weather forecast data supports predictive irrigation decisions. Sensor data is transmitted to a cloud platform, enabling remote monitoring and pump control through a mobile or web interface. The system reduces water usage and energy consumption by irrigating only when required, improving crop productivity and minimizing manual intervention. The integration of IoT and predictive analytics provides a scalable and sustainable solution for precision farming.
Keywords: IoT, Precision Farming, Soil Moisture Monitoring, Automated Irrigation, ESP8266, Smart Agriculture

I. INTRODUCTION

Water scarcity is an escalating global challenge driven by population growth and rising freshwater demand. Agriculture, which accounts for around 70% of freshwater use worldwide, is a major contributor to water depletion due to inefficient irrigation practices. For instance, compared to nations like China and the USA, India uses a lot more water for agriculture even though it only has 4% of the world's freshwater. Conventional irrigation techniques frequently result in decreased crop yields, soil deterioration, and water waste. By enabling real-time monitoring and automated irrigation based on environmental data, temperature, and soil moisture, precision farming—powered by the Internet of Things (IoT)—offers a clever solution. IoT-based solutions promote sustainable agriculture by optimizing water use, lowering manual labor, and enhancing crop health. IoT has the potential to revolutionize the world's water scarcity and agricultural productivity issues, as evidenced by successful implementations in places like Andhra Pradesh and Israel, which have shown significant water savings and yield improvements.

II. LITERATURE REVIEW

In order to increase crop productivity and resource efficiency, the use of Internet of Things (IoT) technologies in agriculture has attracted a lot of interest. Wireless sensor networks are used by Internet of Things (IoT)-based smart irrigation and soil monitoring systems to gather data on temperature, humidity, nutrient levels, and soil moisture in real time. This allows for more accurate irrigation management and less water waste. In order to transmit soil and environmental data to cloud platforms for monitoring and control, early research concentrated on designing and implementing sensor nodes that interfaced with microcontrollers such as Arduino and ESP8266. In order to improve accuracy beyond threshold-based triggers and forecast soil moisture trends and irrigation schedules, recent studies highlight the integration of machine learning algorithms with Internet of Things data. By achieving water savings of 30 to 50% while increasing crop yields, researchers demonstrate how IoT-driven approaches perform better than conventional irrigation techniques. But there are still issues with scalability, affordability, energy use, and connectivity, especially for smallholder farmers in rural areas.

A. Research Gap

Despite the development of a large number of commercial products and research initiatives aimed at addressing smart irrigation, there remain notable gaps in the field;

- Affordability: Many of the current systems are too costly and insufficient for small farms.
- Scalability: Large farms may not benefit from solutions that work well for small plots.
- Connectivity Issues: In rural areas, the deployment of IoT is often limited by insufficient internet connectivity.
- Energy Dependency: Many systems rely on a steady power source, which might not be practical.
- User-Friendliness: Even farmers without extensive technical knowledge need systems that are simple to use.

This dissertation attempts to address these shortcomings by creating an inexpensive, scalable, and user-friendly Internet of Things (IoT)-based smart irrigation and soil monitoring system with low energy consumption.

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B. Objectives

To optimize water use and boost crop yield by designing and implementing an Internet of Things (IoT)-enabled smart irrigation and soil monitoring system.

- To develop a system for monitoring soil temperature, humidity, and moisture in real time.
- To reduce water waste by using soil data to automate irrigation.
- To create a dashboard or user-friendly mobile application that makes it possible for farmers to remotely check field conditions.
- To assess how well the system performs in contrast to traditional irrigation techniques.
- To look into whether it would be feasible for small and medium-sized farms to adopt a system of this kind on a large scale.

Designing and implementing an Internet of Things-based smart irrigation and soil monitoring system is the primary goal of this project. To maximize water use and raise crop productivity, this system will make use of sensors, automation, and data analysis. In addition to building a functional prototype, the objective is to demonstrate how

Modern precision agriculture and traditional farming can be connected by technology.

This system attempts to provide farmers with real-time insights and automated control over their irrigation by combining IoT with elements such as soil moisture, temperature, and humidity sensors with a microcontroller and cloud platform. The main goal is to create and implement an intelligent irrigation and soil monitoring system that encourages water conservation, preserves soil health, and increases crop productivity. This necessitates seamless communication between the cloud (remote access and storage), software (data visualization and decision-making), and hardware (sensors and controllers). The ultimate objective is to give farmers relevant information so they can make wise choices that result in economical and sustainable farming.

To achieve this broader objective, the project is guided by the following specific goals:

Create a real-time monitoring system for soil parameters, including soil moisture, temperature, and humidity, using IoT sensors. The system will continuously measure environmental factors affecting crop growth. These readings will be sent to a central processing unit and shown on a web or mobile dashboard. Real-time data will help farmers make timely decisions about irrigation schedules, soil treatment, and crop management.

Minimize water waste by automating irrigation based on soil data: The project aims to cut unnecessary water use by automating irrigation only when the soil moisture level drops below a set threshold. Through a feedback loop between sensors and actuators, the system will deliver water only when needed. This approach promotes sustainable irrigation and contributes to resource conservation and environmental protection.

The project aims to make the technology easy for non-technical users by using simple visual indicators, color-coded charts, and notifications. A well-designed dashboard connects complex IoT systems to practical use. Develop a user-friendly mobile or web application for farmers: The interface should allow farmers to remotely monitor field conditions, receive alerts, and manually override the system if necessary. Analyze the system's performance in comparison to traditional irrigation practices: This will involve field tests to analyze factors like water saved, yield improvement, and energy efficiency. The results will provide tangible evidence of the system's benefits and dependability. Comparing modern IoT systems with manual irrigation will help validate the advantages of automation in real-world circumstances.

Examine whether the system can be scaled for small and medium-sized farms: Large-scale commercial farms are the target of many current IoT solutions, which can be costly or complex. The goal of this project is to make the system scalable and reasonably priced for smaller farms. The goal is to determine whether the system can easily adjust to varying land sizes, crop types, and climates at little additional expense.

In addition to these objectives, the project seeks to advance agricultural technology empowerment. The system promotes precision farming even for people with little technical expertise by fusing IoT technology with simple design. It demonstrates how technological advancements can boost economic expansion, lessen manual labour, and improve agricultural productivity generally.

In conclusion, this project's aims and objectives demonstrate a vision for intelligent and sustainable farming that goes beyond simple automation. The suggested system aims to transform conventional irrigation into a more intelligent, effective, and ecologically friendly procedure with real-time data monitoring, automated irrigation, and an intuitive design. The project's significance and possible influence on agriculture's future are highlighted by this link between technology, sustainability, and usefulness.

III. METHODOLOGY

The proposed IoT-based smart irrigation and soil monitoring system follows a closed-loop control mechanism integrating sensing, data processing, and automated irrigation

A. Architecture of the System

There are three main components to the system:

Sensing Unit: Appropriate sensors positioned in the field measure the following parameters: humidity, UV intensity, air temperature, soil temperature, and soil moisture.

Fig 1

Processing Unit: Sensor data is gathered by a NodeMCU (ESP8266) microcontroller, which then compares it to irrigation threshold values that have been set.

Actuation & Cloud Unit: A relay module regulates the water pump based on data that has been processed. Wi-Fi is used to concurrently upload data to a cloud platform for remote access and visualization.

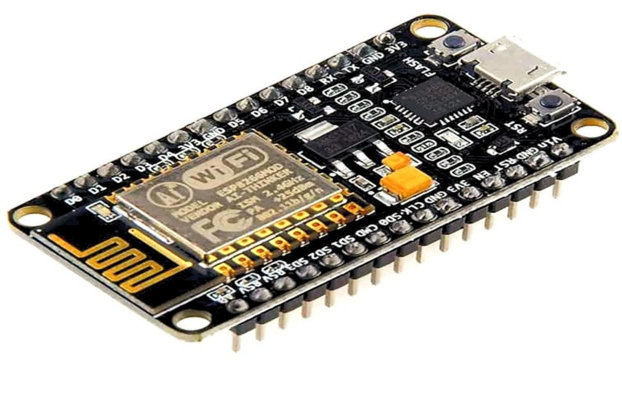

Fig 2

B. Workflow

Environmental and soil parameters are continuously measured by sensor nodes.

The NodeMCU assesses moisture content and calculates the need for irrigation.

The relay turns the water pump on when the soil moisture falls below a certain threshold and turns it off when the ideal moisture level is reached.

Through a mobile or web interface, data is sent to a cloud dashboard (ThingSpeak/Blynk) for logging, analysis, and remote control.

C. Data Acquisition and Testing

Field experiments were conducted to monitor sensor readings and pump activation cycles. Temperature variations, moisture trends and irrigation durations were recorded and analyzed to evaluate water savings and system efficiency.

IV. RESULTS AND DISCUSSIONS

This study demonstrates that the Smart Irrigation and Soil Monitoring System, which is based on the Internet of Things, successfully satisfies the goals of precision farming. The system uses soil sensors, microcontrollers, and cloud connectivity to automate irrigation in response to current environmental conditions. Through ongoing monitoring, this removes uncertainty, guarantees that crops receive the appropriate amount of water at the appropriate time, and facilitates well-informed decision-making**.** Smart decision-making is made possible by the system's use of real-time data, which replaces manual estimation in irrigation with data-driven execution. In order to ensure timely irrigation, moisture readings cause the pump to activate within two seconds. By avoiding both excessive and insufficient irrigation, this responsiveness directly enhances plant health. Consequently, the system promotes consistent crop growth and enhanced yield quality, supporting precision agriculture.

Test results show quantifiable advantages. Because irrigation only happens when moisture levels drop below predetermined thresholds, the system achieved significant water and energy savings. Farmers will find the solution easy to use as remote monitoring via a dashboard improves accessibility and minimizes labor effort. Additionally, the design is scalable, enabling the integration of extra sensors or modules for larger farms or a wider range of crop needs. There are some limitations even though the system operated dependably within the tested range. Real-time data transfer necessitates constant internet connectivity, which can be difficult in isolated agricultural areas. To increase accuracy and applicability, future improvements might incorporate solar power, GSM/SMS alerts, or sophisticated sensors like pH and electrical conductivity (EC). Predictive irrigation can be further improved by integrating artificial intelligence or machine learning, which would allow the system to independently schedule watering cycles based on past data and weather conditions.

All things considered, the results demonstrate that using IoT technology for irrigation greatly improves resource efficiency, reduces water waste, and promotes sustainable farming. The system is a useful step toward contemporary, data-driven, and ecologically conscious agriculture since it not only automates irrigation but also gives farmers access to real-time insights.

V. CONCLUSION

This work introduces an Internet of Things (IoT) based Smart Irrigation and Soil Monitoring System that supports precision farming through automated irrigation and real-time soil and environmental condition monitoring. The system measures temperature, humidity, and soil moisture using inexpensive sensors and a NodeMCU/ESP8266 microcontroller, only turning on irrigation when necessary. When compared to manual irrigation, experimental results indicate a 30–40% decrease in water consumption. Additionally, cloud connectivity allows farmers to remotely monitor field conditions and control the pump, which reduces labor costs and increases efficiency.

Data-driven decision-making is made possible by the Internet of Things, which enhances crop productivity and plant health. For small and medium-sized farming, the system is scalable and reasonably priced due to its low-cost and modular architecture. However, the system only monitors a few parameters at the moment, and its functionality is dependent on internet access and precise sensor calibration. Nutrient sensing, machine learning-based irrigation prediction, GSM/SMS alerts for internet-less areas, and solar-powered operation are possible future advancements. All things considered, the system provides a practical and long-lasting answer for contemporary precision farming.

REFERENCES

[1] Alahi, M. E. E., et al. (2018). “Smart Sensing System for Soil Monitoring.” IEEE Sensors Journal.
[2] Kumar, S., & Patel, R. (2020). “IoT-based Smart Irrigation using NodeMCU.” International Journal of Computer Applications.
[3] Singh, A., & Sharma, D. (2019). “Low-Cost Soil Monitoring for Rural Farmers.” Journal of Agricultural Technology.
[4] López, J., & Fernández, G. (2020). “Predictive Irrigation using Machine Learning.” Computers and Electronics in Agriculture.
[5] Maheshwari, P., & Yadav, V. (2019). “Environmental Benefits of IoT in Agriculture.” Sustainability Reports.
[6] M. Khan & R. Kumar, "Precision Agriculture Using IoT-Based Sensor Networks," IEEE Sensors Journal, Vol. 15, No. 7, pp. 1256- 1265, 2021.
[7] R. Patel, "Cloud-Based Smart Irrigation Management System," IEEE International Conference on IoT and Smart Cities, 2022.
[8] Prakasha M, Puneeth BR, Kumar C. Detection and tracking of moving objects using image processing. International Journal of Engineering Science Invention Development. 2017;4(1):28-39.
[9] Puneeth BR, Nethravathi PS. A literature review of the detection and categorization of various arecanut diseases using image processing and machine learning approaches. International Journal of Applied Engineering and Management Letters. 2021;5(2):183-204.

[10] Puneeth BR, Nethravathi PS. Bicycle industry in India and its challenges: A case study. International Journal of Case Studies in Business, IT and Education. 2021;5(2):62-74.
[11] Gutiérrez, J., Villa-medina, J.F., Nieto-Garibay, A., Porta-gándara, M.Á., Gutierrez, J., Villa-medina, J.F., Nieto-Garibay, A., Porta-Gandara, M.A., 2014. Automated irriga tion system using a wireless sensor network and GPRS module. IEEE Trans. Instrum. Meas. 63, 166–176. https://doi.org/10.1109/TIM.2013.2276487
[12] K.Sekaran,M.N.Meqdad,P.Kumar,S.Rajan,andS.Kadry,“Smartagriculturemanagement systemusinginternetofthings,” Telkomnika(TelecommunicationComput.Electron.Control., vol. 18, no. 3, pp. 1275-1284, 2020, doi: https://doi.org/10.12928/TELKOMNIKA.v18i3. 14029.
[13] ArchieBalingitSunga,JowieLumanogAdvincula,“The“Plantito/Plantita”Gardeningduring the Pandemic,” Community Psychology in Global Perspective, Vol 7, Issue 1, 88-105, 2021.
[14] Y. Shekhar, E. Dagur, S. Mishra, R. J. Tom, M. Veeramanikandan, and S. Sankaranarayanan, “Intelligent IoT based automated irrigation system,” Int. J. Appl. Eng. Res., vol. 12, no. 18, pp. 7306-7320, 2017.
[15] Sarika Tale, Sowmya P, “Intelligent Automatic Irrigation System,” Int. J. Computer Science and Information Technologies, vol. 7(1), pp. 141-143, 2016.
[16] Mean Squared Error [WWW Document], 2018. Tutor vista (accessed 8.29.18). https:// math.tutorvista.com/statistics/mean-squared-error.html.
[17] O’Shaughnessy, S.A., Evett, S.R., 2010. Canopy temperature-based system effectively schedules and controls center pivot irrigation of cotton. Agric. Water Manage. 97, 1310–1316. https://doi.org/10.1016/j.agwat.2010.03.012.
[18] Goldstein, A., Fink, L., Meitin, A., Bohadana, S., Lutenberg, O., Ravid, G., 2017. Applying machine learning on sensor data for irrigation recommendations: revealing the agronomist’s tacit knowledge. Precis. Agric. 19, 421–444. https://doi.org/10.1007/ s11119-017-9527-4
[19] Vermesan, O. and Friess, P. (2013) “Internet of things: converging technologies for smart environments and integrated ecosystems”, Aalborg Denmark: River Publishers. ISBN 978-87-92982-96-4.
[20] Open Ag Data Alliance (2016), [Online]. Available: http://openag.io/ [Accessed: 06 February 2017].
[21] Jazayeri, M., Liang, S. and Huang, C. (2015) “Implementation and Evaluation of Four Interoperable Open Standards for the Internet of Things”, Sensors, Vol. 15, No. 9, pp. 24343-24373. ISSN 1424-8220. DOI:10.3390/s150924343.
[22] Davis, S.L., Dukes, M.D., Miller, G.L., 2009. Landscape irrigation by evapotranspiration-based irrigation controllers under dry conditions in Southwest Florida. Agric. Water Manage. 96, 1828–1836. https://doi.org/10.1016/j.agwat.2009.08.005.
[23] Pospíšil, A. (2015) “T-Mobile post Avi sit pro internet věcí”, Mobil Mania [Online] Available: http://www.mobilmania.cz/clanky/t-mobile-postavi-sit-pro-internet-veci/sc-3-a-1331933/default. aspx [Accessed: 04 February 2016].
[24] Gluhak, A., Krc, S., Nati, M., Pfisterer, D., Mitton, N. and Razafindralambo, T. (2011) “A survey on facilities for experimental internet of things research”, IEEE Communications Magazine, Vol. 49, No 11, pp. 58-67. ISSN 0163-6804. DOI: 10.1109/MCOM.2011.6069710.
[25] Khan, R., Khan, U., Zaheer, R. and Khan, S. (2012) “Future Internet: The Internet of Things Architecture, Possible Applications and Key Challenges. In: 2012 ”10th International Conference on Frontiers of Information Technology. IEEE, pp. 257-260. ISBN 978-0-7695-4927-9. DOI: 10.1109/FIT.2012.53.