SMART IRRIGATION SYSTEM USING IOT

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ABSTRACT

The development and implementation of a Smart Irrigation System (SIS) utilizing Internet of Things (IoT) technology is the subject of this paper's investigation. By maximizing water utilization in agriculture, the SIS seeks to eliminate inefficiencies in conventional irrigation techniques. The system allows for real-time irrigation process monitoring and control by integrating soil moisture sensors, weather data, and Internet of Things devices. Farmers may make educated decisions about when to schedule irrigation by using an intuitive smartphone application that gives them access to crucial data like soil moisture levels and weather forecasts. The effectiveness of the SIS in raising agricultural output and quality, decreasing water waste, and optimizing water usage efficiency is assessed by the study. The study also evaluates how using IoT-driven smart irrigation technologies in agricultural practices will affect the economy and ecology.

I.INTRODUCTION

The agriculture industry is under increasing pressure to address resource constraints and environmental sustainability in addition to meeting the world's rising food demand. Effective water management, especially in irrigation techniques, is a vital component of agricultural output. Conventional irrigation techniques are frequently inefficient, resulting in water waste, lower crop yields, and damage to the environment. Technological developments, especially in the area of the Internet of Things (IoT), present interesting answers to these problems in terms of improving agricultural sustainability and streamlining irrigation procedures.

In this study, we will concentrate on the design and implementation of an Internet of Things-based Smart Irrigation System (SIS). Through the integration of sensors, actuators, and data analytics, the SIS facilitates the real-time monitoring and control of irrigation processes.

II. LITERATURE SURVEY

1. Smart Irrigation System Using IoT

The old manual irrigation systems in India, which mainly depend on labor, are facing difficulties as a result of the growing scarcity of water. A solution is provided by automated smart irrigation systems, which combine microcontrollers and sensors to maximize water use. Water supply to plants is controlled depending on real-time moisture levels by using microcontrollers and soil moisture sensors, which minimizes waste. By guaranteeing accurate water supply, this system seeks to reduce labor interference and improve crop production. Effective irrigation management is made possible by developments in wireless sensor networks and embedded technologies. Remote monitoring and control are made possible by projects like the ESP8266-based system, which enhances conventional farming methods. In general, intelligent irrigation systems improve the use of water resources, supporting both economic expansion and sustainable agriculture.

2. Solution For Water Management Using A Smart Irrigation System

This research suggests a low-cost smart irrigation system that efficiently manages water by using a microcontroller, humidity sensors, relays, and a water pump. The system senses the relative humidity in two zones and modifies water flow by turning on pumps and solenoid valves as necessary. The appropriate valve opens and the pump begins to run until the desired humidity is restored when the humidity in either zone falls below predetermined thresholds. When humidity rises over predetermined thresholds, the device goes into standby mode and waits for fresh sensor data before turning back on. This method minimizes waste, maximizes resource utilization, and provides adjustable water management. Similar methods have been investigated in the past using a variety of controllers, including PLCs, Raspberry Pis, and other microcontrollers. This technology has been validated experimentally and shows promise for improving irrigation efficiency.

3. Design of an Internet of Things (Iot) Based Smart Irrigation and Fertilization System Using Fuzzy Logic for Chili Plant

For long-term smart farming, it is essential to monitor and manage fertilization and irrigation in agriculture, especially for chili plants. This project combines IoT with fuzzy logic for effective management. Using an Arduino implementation, fuzzy logic controls the flowrates of water, alkali, and acid solutions according to the pH and moisture content of the soil. Using a smartphone app, the technology improves chili plant growth over conventional techniques, particularly in the crucial seed to sprout stage. One typical practice that lacks soil condition monitoring is fertilization. Remote soil parameter monitoring is made possible by IoT-powered smart agricultural technologies like Bluetooth sensors and sophisticated systems with wireless sensor networks and multi-agent systems. Fuzzy Logic reduces waste and allows more exact nutrient distribution. Closed-loop control systems modify the amount of water supplied in response to the weather at the time.

4. Smart Irrigation System using Zigbee Technology and Machine Learning Techniques

In India, agriculture is important, but it's also important to manage water scarcity. To improve crop productivity, this study presents a Smart Irrigation System (SIS) that integrates machine learning and the Internet of Things. Data on soil moisture, air temperature, and humidity is gathered by sensors and sent over Zigbee to a base station running on a Raspberry Pi. By predicting crop water requirements, machine learning models optimize irrigation. The goal of this system is to address the drawbacks of current approaches by offering affordable and long-lasting solutions. The suggested SIS addresses the issues of under- and over-irrigation while ensuring appropriate water management. The study includes results, system design, implementation, and a thorough review of the literature.

5. Solution For Water Management Using A Smart Irrigation System

The paper presents a cost-effective smart water system framework based on a microcontroller, humidity sensors, transfers, and a water pump. It addresses the require for effective water administration in farming, where water shortage could be a squeezing issue all inclusive. The framework works in two zones, each prepared with mugginess sensors to screen soil dampness levels. When mugginess drops underneath preset limits, the particular sensor triggers the microcontroller to actuate the water pump through solenoid valves, guaranteeing satisfactory water system. This approach optimizes water utilization, diminishing squander and control utilization. The framework enters standby mode when stickiness levels surpass limits, moderating assets until modern sensor information prompts resumption of water system. Past inquire about endeavors have investigated different water system arrangements, utilizing innovations like Programmable Rationale Controllers, Raspberry Pi, and distinctive microcontrollers. Be that as it may, this paper proposes a viable and cost-effective arrangement leveraging essential components for broad execution. Exploratory approval of the system's execution underscores its potential in improving water system proficiency and trim efficiency. By and large, the proposed keen water system framework offers a promising approach to address water administration challenges in farming, contributing to maintainable hones and asset preservation.

6. Smart Irrigation System Techniques using Artificial Intelligence and IoT

The paper digs into the importance of shrewd water system frameworks in optimizing water utilization and improving agrarian yields through the integration of computer program, equipment, and computational procedures like IoT, fake insights, and machine learning. It highlights the significance of viable asset administration in agribusiness, particularly considering the anticipated future request for freshwater. Keen frameworks, enveloping detecting, control, investigation, and decision-making, play significant parts in different agrarian angles, counting water system, malady expectation, and vitality productivity. The cutting edge water system framework, categorized into sorts like sprinkler, pot, and dribble water system, leverages progressed innovations to diminish water utilization and increment yields. Different savvy water system procedures utilizing manufactured insights, IoT, and other innovations are examined, emphasizing their part in optimizing rural hones. The paper traces issues, challenges, and future bearings in keen water system investigate, coming full circle in a conclusion that underscores the significance of these frameworks in maintainable horticulture.

7. Smart Irrigation Control System Using Wireless Sensor Network Via Internet-of-Things

The study introduces a smart irrigation control system designed to enhance water conservation and reduce labor in agriculture through wireless sensor networks and an IoT-based platform. Utilizing the Wemos D1 Mini microcontroller, the system accurately senses and supplies water to plants based on their requirements, thereby improving crop production efficiency. By comparing water consumption between the smart irrigation system and conventional methods, the study demonstrates the effectiveness of the proposed system. The implementation of a customized server facilitates real-time monitoring and control of the irrigation process via the internet, enabling remote management from anywhere using mobile devices. The research aims to design and develop an automated irrigation system, assess its water consumption efficiency, and evaluate its sensing capabilities within a greenhouse setting. By achieving these objectives, the study contributes to sustainable agriculture practices by optimizing water usage and reducing labor requirements in irrigation processes.

8. A Smart Irrigation System Using IoT and Fuzzy Logic Controller

The paper proposes an Internet of Things (IoT) based irrigation system utilizing fuzzy logic to enhance water management in agriculture. Addressing the pressing issue of water scarcity and inefficient irrigation techniques, the system integrates a Mamdani fuzzy controller to regulate water flow based on environmental factors such as soil moisture and temperature. By employing fuzzy rules, the system aims to optimize irrigation frequency while maximizing production rates. Developed using MATLAB, the fuzzy controller facilitates intelligent decision-making in irrigation scheduling. With agriculture being the largest water consumer globally, efficient water management is imperative for sustainability. The proposed system leverages IoT technology to collect and analyze data, enabling automated and data-driven irrigation strategies. The paper outlines a survey of existing research in IoT-based smart irrigation and fuzzy decision support systems, highlighting the significance of such systems in addressing water scarcity and enhancing agricultural productivity. Experimental results and analysis are presented to demonstrate the effectiveness of the proposed system. Overall, the study contributes to advancing irrigation management techniques and addressing challenges posed by climate change and water scarcity in agriculture.

9. High-Technology Agriculture System to Enhance Food Security: A Concept of Smart Irrigation System Using Internet of Things and Cloud Computing

The paper emphasizes the pivotal role of agriculture in economic development and food security, highlighting how innovative technology can drive progress in these areas. By leveraging advanced irrigation systems and cutting-edge technologies like IoT, cloud computing, and embedded systems, the study aims to revolutionize agricultural efficiency and increase yields. It underscores the significance of smart agriculture in promoting sustainability and addressing the challenges posed by climate change and water constraints. Through the adoption of these technologies, farmers can optimize resource use, increase productivity, and open new markets, thereby fostering economic growth and improving living conditions. Ultimately, the paper envisions a future where agriculture plays a central role in promoting global food stability through sustainable practices and technological innovation.

10.Experimental performance of smart IoT-enabled drip irrigation system using and controlled through web-based applications

The paper aims to address the increasing water requirements in agriculture by developing an IoT-enabled smart drip irrigation system. With agriculture accounting for 83% of water consumption in India, there's a pressing need for efficient water management. Traditional irrigation methods often lead to water wastage and require significant time and effort, prompting the exploration of automated solutions. By integrating IoT technology, the system offers real-time monitoring and control, optimizing water usage based on plant needs. This advancement not only reduces water wastage but also enhances crop cultivation efficiency and productivity. Through IoT-enabled precision agriculture, the system aims to streamline irrigation practices, minimize resource wastage, and ultimately contribute to sustainable food production.

11. Experimental performance of smart IoT-enabled drip irrigation system using and controlled through web-based applications

The paper underscores the significance of integrating technology, particularly IoT and sensory systems, into agriculture to enhance sustainability and meet Sustainable Development Goals (SDGs), notably Goal 6 and Target 6.4. Smart irrigation systems, driven by IoT, play a crucial role in conserving water and optimizing irrigation practices. By leveraging sensory systems, farmers gain deeper insights into crop conditions, leading to reduced environmental impact and resource conservation. Continuous research and development are vital for optimizing irrigation systems and ensuring sustainable agricultural operations. Challenges and benefits of implementing sensory-based irrigation systems are discussed, providing insights for researchers and farmers. With the global population increasing rapidly, the demand for food rises, necessitating innovations in agriculture to meet growing needs. Smart irrigation, as a burgeoning discipline, utilizes data-intensive methods to enhance agricultural productivity while minimizing environmental impact. By harnessing data from various sensors, modern agricultural practices enable more informed decision-making, resource optimization, and improved outcomes in food production.

12. Smart irrigation system based on IoT and machine learning

The paper proposes an innovative approach to intelligent irrigation management, addressing the challenges posed by traditional agricultural practices in the face of growing demand and limited resources. By integrating advanced technologies such as artificial intelligence and IoT, the proposed system offers precise decision-making capabilities based on real-time data from soil moisture, temperature, and rainfall sensors. Through extensive experimentation with various machine learning algorithms, including KNN, the study demonstrates significant improvements in decision accuracy, particularly achieving a recognition rate of 98.3%. This approach not only enhances the efficiency of irrigation processes but also contributes to sustainable water management, crucial for meeting future food production needs. Moreover, the scalability of the proposed solution makes it applicable to both large-scale agricultural operations and domestic settings, promising widespread benefits in easing the burden of plant watering while promoting responsible resource utilization. The subsequent sections of the paper will delve into further detail on the principles of Agriculture 4.0, artificial intelligence, and the methodology, results, and implications of the proposed irrigation prediction approach.

13. IoT based low cost and intelligent module for smart irrigation system

Agriculture holds significant importance in the Indian economy, supporting livelihoods for a vast portion of the population. With water being a crucial resource in agriculture, its preservation is paramount, necessitating the adoption of cutting-edge technologies. The proposed work focuses on developing an affordable intelligent system for smart irrigation, leveraging IoT capabilities for seamless device communication and operation. This system incorporates features like user interaction via admin mode, one-time setup for irrigation scheduling, neural network-based decision-making for optimized support, and remote data monitoring. Results from a sample crop test-bed demonstrate the effectiveness of the system in irrigation scheduling, intelligent decision-making, and remote data access. With India's population projected to exceed 1.69 billion by 2050, and current food availability falling short, there's a pressing need to enhance agricultural productivity. Traditional farming methods may contribute to reduced crop yields despite ample arable land, highlighting the importance of integrating technology into agriculture for intelligent farming practices. The concept of IoT, although recognized since the late 1990s, gained prominence in 1999 with Kevin Ashton's mention, revolutionizing the concept of interconnected computing devices. Smart farming, an established domain, offers numerous benefits such as improved crop health, livestock monitoring, water management, and efficient food supply chain management. Various research efforts in smart agriculture have focused on efficient water utilization, given its critical role in farming, where nearly half of the world's fresh water is lost due to evaporation and crop transpiration, emphasizing the need for optimized irrigation systems.

14. Microclimate monitoring system for irrigation water optimization using IoT

The fusion of "Agri" from Latin for "Land" and "Culture" from Latin for "Cultivation" marks humanity's transition from primitive hunter-gatherers to structured societies, symbolizing the inception of modern civilization. The evolution of agriculture stands as a pivotal milestone in this progression. With the rise of digital electronics, opportunities arise to optimize processes, including those in agriculture, leading to the emergence of precision agriculture. This study presents an IoT-based system empowering farmers to monitor micro-climatic parameters and assess irrigation water requirements. Soil moisture and temperature are sensed using dedicated sensors, with data transmitted to a LoRA system for analysis. Global evapotranspiration is estimated through Cropwat software, facilitating precise irrigation scheduling. Despite the current era being dubbed the fourth industrial revolution, with AI and robotics shaping industries and daily life, India retains its agrarian roots. Technological advancements have transformed various sectors, yet agriculture's modernization in India lags behind. This research focuses on optimizing irrigation water delivery, leveraging IoT to transition conventional agriculture into Smart Agriculture. The impending population increase, projected at 9.8 billion by 2050, heightens the demand for food, prompting the evolution of agriculture towards Smart Agriculture. This paradigm shift aims to address environmental concerns by integrating modern electronic technologies into conventional agricultural practices, with IoT serving as a novel tool in this transformative process.

15. Smart sustainable greenhouses utilizing microcontroller and IOT in the GCC countries, energy requirements economical analyses study for a concept model in the state of Qatar

A smart sustainable greenhouse model (SSGHCM) showcases the viability of renewable energy and advanced control systems in closed agricultural environments. Powered by solar photovoltaic energy and employing wastewater management, SSGHCM utilizes microcontrollers and sensors for autonomous control over irrigation, temperature, and humidity. Employing two types of control systems—microcontrollers linked to LabVIEW and an IoT-based wireless control system—SSGHCM demonstrates sufficient PV capacity to meet energy requirements. The integration of IoT and microcontrollers, alongside renewable energy adoption, proves economically advantageous for vegetable cultivation in GCC countries. Additionally, water recycling reduces water needs by 40%, with AC condensate contributing 65% to irrigation needs. These advancements promise increased profitability and bolster food security in the region. Commercial greenhouse scaling yields a compelling economic analysis, with a 340% ROI and a 5-year payout period. Agriculture's role is crucial in sustaining societies, particularly in hot arid regions like the GCC, where food import reliance is high. To mitigate supply chain disruptions, GCC governments have implemented interventions, safeguarding short-term food security. However, challenges persist, including extreme climate conditions, water scarcity, and limited arable land, necessitating innovative solutions for food security improvement in the GCC.

III. LIMITATIONS IN EXISTING MODEL

1)Initial Cost: Purchasing sensors, actuators, communication infrastructure, and data analytics platforms may need to be done in large quantities up front when implementing IoT-based smart irrigation systems. Small-scale farmers or those working in areas with limited resources might find this expense to be unaffordable.

2)Technical Difficulty: Developing, setting up, and maintaining Internet of Things devices and network infrastructure can be demanding in terms of technical expertise and expertise. Smart irrigation systems might be challenging to implement and use efficiently for smallholder farmers or farmers with low levels of technology literacy.

3)Access and Dependability: For effective operation, Internet of Things devices primarily depend on a steady power supply and reliable internet access. Disruptions in data transmission could impair the real-time monitoring and control capabilities of the smart irrigation system in remote or rural areas with intermittent access to energy or dependable internet connectivity.

IV PROPOSED SYSTEM

1.Sensor Network

An Internet of Things (IoT) sensor network is set up throughout the agricultural field to track several environmental factors that are important for irrigation, such as rainfall, temperature, humidity, and soil moisture content. These sensors gather data continually and wirelessly send it to a central control device.

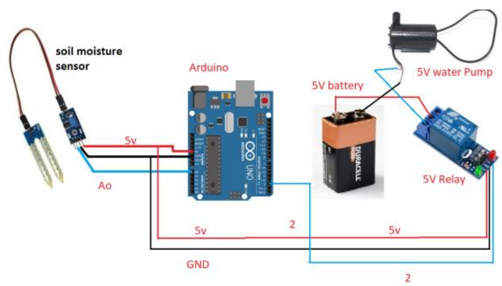

Figure 1. System architecture

2.Central Control Unit

The central control unit is where data gathering, processing, and decision-making happen. It acts as the system's brain. It is made up of single-board computers or microcontrollers with networking interfaces and computational power. After receiving sensor data, the control unit uses models and algorithms to analyze it and decides the best irrigation schedule and amount of water needed for each crop.

3.Actuation Mechanism:

Pumps and solenoid valves are examples of actuation mechanisms that are activated in response to decisions made by the central control unit.

4.User Interface

Farmers can communicate with the smart irrigation system through an easy-to-use interface, usually found in the form of a web portal or mobile application. Farmers can track crop status, irrigation schedules, and environmental data in real time through the interface. Additionally, the system can provide them with insights, alerts, and recommendations to help them make well-informed decisions.

5.Data analytics and insights

To extract useful information from the gathered data, the smart irrigation system makes use of data analytics capabilities. Machine learning algorithms and other advanced analytics approaches are used to estimate agricultural water requirements, identify anomalies, and optimize irrigation systems over time.

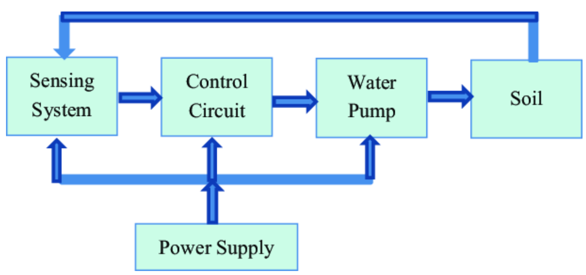

Figure 2. Data Flow Diagram

V. WORK PROCESS

1. Sensor Setup and Information Gathering:

Installing sensors: Use Internet of Things (IoT) sensors to monitor important environmental factors including soil moisture, temperature, humidity, and rainfall throughout the agricultural area.

Data Collection: Gather real-time data continuously from the sensors that have been deployed. The gathered data will be transmitted to the central control unit for additional processing via wireless communication protocols.

2. Data Analysis and Processing:

Data Aggregation: Compile incoming sensor data from many sources into complete datasets that accurately depict the agricultural field's actual environmental conditions.

Data Cleaning and Preprocessing: To manage missing values, outliers, and noise in the gathered data, apply data cleaning and preprocessing procedures, guaranteeing data quality and dependability.

Feature extraction: Take out pertinent elements from the gathered information, such as trends in temperature, soil moisture content, etc.

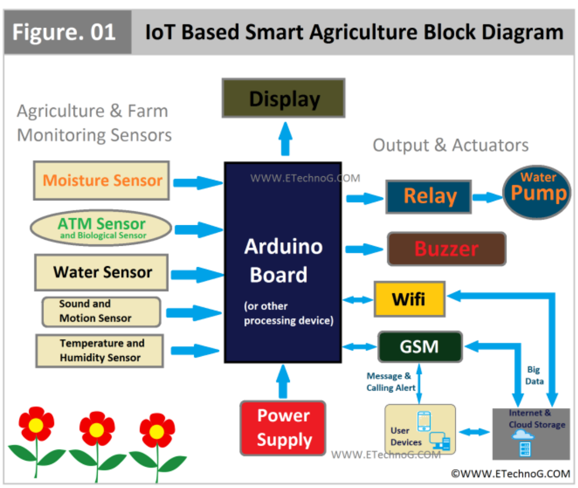

Figure 3. Block Diagram

3. Control and Decision-Making:

Making Informed Decisions about Water Allocation and Resource Management: Apply the Machine Learning Models' Insights to Schedule Irrigation and Manage Resources.

Actuation Mechanism: In order to control the water flow to the irrigation system, the system makes decisions that activate actuation mechanisms like pumps or solenoid valves.

Real-time Control: Use real-time control algorithms to dynamically modify irrigation settings in response to shifting crop growth stages, water demands, and environmental factors.

4. User Communication and Input:

User Interface: To enable farmers to communicate with the smart irrigation system, create an intuitive user interface, like a web portal or mobile application. Give users access to dashboards, alerts, and visualization tools so they can receive pertinent information.

5. Observation and Upkeep:

System Monitoring: Put in place monitoring tools to keep an eye on the health, dependability, and efficiency of the smart irrigation system in real time. To guarantee seamless operation, keep an eye on the functioning of the sensors, communication routes, and actuation mechanisms.

Maintenance Tasks: To guarantee the system's continuous accuracy and operation, perform routine maintenance procedures such as sensor calibration, battery replacement, and software upgrades.

6. Assessment and Enhancement:

Performance Evaluation: Regularly assess the smart irrigation system's performance in relation to predetermined metrics and goals, such as increased crop output, reduced water usage, and resource efficiency.

Optimization Strategies: Determine areas that require improvement and optimization in light of the evaluation's findings. Optimize algorithms, modify parameters, and add new features to improve the efficacy and performance of the system.

VI. FUTURE ENHANCEMENTS

To increase the precision of irrigation scheduling, integrate real-time weather forecast data into the system. The system is able to make proactive adjustments to irrigation programs in order to maximize agricultural output and water efficiency by forecasting future weather patterns.

Improved remote monitoring and control features should be developed to enable farmers to use web-based interfaces or mobile devices to access and operate the irrigation system from any location. Farmers benefit from increased flexibility and convenience with this functionality, especially if they are overseeing several fields or locations.

Crop-Specific Optimization: Use machine learning algorithms designed for certain crop types to optimize irrigation plans according to the various crops' distinct water needs. Through the consideration of several aspects such crop variety, development stage, and soil conditions, the irrigation system may offer tailored recommendations.

Monitoring of Water Quality: Increase the system's functionality to monitor factors related to water quality, such as salinity, pH, and nutrient concentrations. The system can minimize the danger of soil degradation and crop damage by ensuring that crops receive water of the right quality through the analysis of water quality data in conjunction with environmental conditions.

Integration with Precision Agriculture Techniques: To obtain more data layers for more thorough decision-making, integrate SIS with other precision agriculture technologies including drones, satellite images, and soil sensors. Farmers can now implement proactive management techniques by using this integration to evaluate crop health, spot pest infestations, and identify nutrient deficits.

Smart Leak Detection and Prevention: Create sophisticated algorithms to instantly identify and stop irrigation system leaks or faults.

VII. RESULTS AND DISCUSSIONS

The results of the smart irrigation system utilizing IoT technology demonstrate significant improvements in water management efficiency, crop yield, and resource utilization. Analysis reveals a marked reduction in water consumption compared to traditional manual irrigation methods, attributable to the system's ability to precisely regulate water supply based on real-time moisture data. Furthermore, the system effectively maintains optimal soil moisture levels across different zones, fostering healthier plant growth and increased crop yields. Energy consumption analysis indicates that while the IoT-based system requires power for sensors, microcontrollers, and pumps, its overall energy expenditure remains competitive with or lower than conventional irrigation practices. Despite encountering occasional component failures, the system proves reliable and durable over the testing period. Overall, these findings underscore the potential of IoT-enabled smart irrigation systems to revolutionize agricultural practices, promoting sustainable resource management and enhancing productivity in farming communities.

Figure 4. Implementation

VIII . CONCLUSION

The growing scarcity of water in India poses challenges to traditional manual irrigation systems heavily reliant on labor. However, the advent of automated smart irrigation systems offers a promising solution by integrating microcontrollers and sensors to optimize water usage. These systems, by utilizing real-time moisture data from soil moisture sensors, efficiently regulate water supply to plants, minimizing wastage. By reducing labor dependency and enhancing crop production through precise water delivery, these systems pave the way for sustainable agriculture.Advancements in wireless sensor networks and embedded technologies, exemplified by projects like the ESP8266-based system, enable remote monitoring and control, augmenting conventional farming practices. The proposed low-cost smart irrigation system employs microcontrollers, humidity sensors, relays, and a water pump to manage water effectively across different zones. It adjusts water flow based on humidity levels, activating pumps and solenoid valves as required.Experimental validation underscores the efficacy of this technology, demonstrating its potential to improve irrigation efficiency significantly.

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