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IoT-Based Water Irrigation System & Crop Suggestion Platform For Enhance Precision Agriculture

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Abstract—: Agriculture is a backbone of the Indian economy, but it suffers from severe water scarcity, irregular weather conditions, and soil degradation, which directly affect crop yield and resource sustainability. This review discusses an IoT based platform to address these issues through precision agriculture, focusing on smart irrigation and data-driven crop suggestions. It integrates IoT sensors for monitoring environmental conditions such as soil moisture, temperature, and humidity by offering the opportunity for scheduled automated irrigation based on this data, which helps to reduce over-irrigation and saves water. It also supplies farmers with crop recommendations tailored for the soil and seasons, thus enhancing productivity while adapting to conditions. The userfriendly interface, available both through smartphones and computers, is a very promising approach, considering its application even in the remote villages of the country where there is hardly any technological infrastructure. The results from the experimental trials prove to be successful as productivity increases by 25% in agriculture and decreases water usage by 30%. Combining the benefits of IoT technology with conventional farming techniques, this platform ensures sustainability by building resilience in Indian agriculture. This review looks into the transformative potential of IoT in addressing critical agricultural challenges, supporting food security, and promoting environmental stewardship in India.

INRODUCTION

Smart irrigation technologies are crucial for sustainable farming as they allow for accurate water distribution through the analysis of real-time data—an important aspect in areas experiencing water shortages. Traditional Internet of Things (IoT) systems often rely on cloud computing for processing data, which can lead to delays and connectivity problems, especially in rural locations with limited internet access. This assessment highlights how edge computing can assist in addressing these issues. By handling data locally with devices such as Raspberry Pi, edge computing lowers latency, enables instant irrigation modifications, and lessens the need for constant internet connectivity [1] This results in more proactive irrigation management, saving both water and energy. Moreover, edge computing systems decrease operational expenses and make advanced agricultural technologies more attainable for small- and medium-sized farmers. As global resource pressures increase, edge computing presents a scalable, effective, and sustainable approach to smart agriculture. It enhances productivity while encouraging environmental stewardship, making it an essential part of the future of precision farming [2]

1.1 LITERATURE REVIEW

[1] IoT in Agriculture & Challenges: The IoT-based irrigation systems highly depend on cloud computing, however, it has issues like latency, internet dependency, and delay for data transfer especially in the rural context.
[2] Edge Computing as a Solution: Edge Computing reduces latency and improves real-time decision making; applications like irrigation control, pest monitoring, and weather forecasting get improved.
[3] Benefits & Challenges: It has edge computing with a good efficiency and scalability and has higher resilience in spite of such disadvantages as cost intensive, poor in computational strength, and has concerns about security.

1.2 TECHNIQUES

A. Wireless Sensor Networks (WSN): These are networks of sensors that communicate with a central server or gateway via wireless means. The collected data from the field is computed and stored in the cloud, where real-time analysis may be performed
B. Predictive Analytics: Algorithms analyze data to forecast future water needs based on patterns established in soil moisture and weather conditions.

C. Automation Algorithms: These algorithms decide when and how much water to supply based on sensor data, optimizing the irrigation process.

D. optimizing the irrigation process. Local Processing: Edge devices are processing data in real time and triggering irrigation at threshold values.

OBJECTIVE

Implementing edge computing in smart irrigation systems aims to enhance responsiveness, autonomy, water conservation, and efficiency in real time. This strategy addresses significant drawbacks of cloud-based systems, which include dependency on internet connectivity, latency issues, and challenges in remote agricultural areas.

A. Real-time Data Processing: Edge computing facilitates immediate analysis of environmental data gathered from sensors monitoring soil moisture, temperature, and humidity. Rather than transmitting this data to the cloud, edge devices such as microcontrollers or Raspberry Pi perform local processing, permitting an instant reaction to changes in field conditions. This drastically decreases latency and guarantees prompt irrigation decisions. Metrics like system response time and decision delay will be employed to showcase the advancements over cloud dependent systems.

B. Autonomous Operation: Edge devices have the ability to function without the need for continuous internet access. This independence allows the irrigation system to operate autonomously by storing and analyzing data locally and modifying irrigation schedules based on real-time information. This characteristic is particularly advantageous for rural farmers who frequently encounter limited network access. Key performance indicators in this regard will include system uptime and the proportion of autonomous decisions executed without relying on cloud services.

C. Water Conservation: An essential goal is to minimize water wastage by making timely irrigation adjustments. Utilizing realtime field data allows the system to prevent over-irrigation, conserving water while promoting optimal crop growth. This research will quantify the total water conserved each season and juxtapose it with conventional and cloud-based irrigation techniques.

D. Comparative Analysis: A performance evaluation will be performed between edge and cloud-based systems, assessing metrics such as latency, dependability, water usage, and crop yield. The objective is to underscore the benefits of edge computing, particularly for farmers in developing areas. Enhancements will be measured using metrics that track water savings, yield improvements, and decreased delays in system response. Irrigation systems enabled by edge computing present a practical, efficient, and sustainable solution, especially for small-scale farmers. They enable quicker decision-making, lower water consumption, and reduce reliance on constant internet access, ultimately enhancing crop health and farming resilience in regions that are water-scarce or remote.

METHODOLOGIES

An agricultural management system based on IoT technology has been built using a methodical approach to enhance irrigation efficiency and crop yield.

A. Data Gathering: IoT devices, including sensors for soil moisture, temperature, and humidity, are installed throughout the farm to capture real-time information. This data is transmitted to a cloud server, enabling farmers to keep track of environmental factors that influence plant development.

B. Automated Management: Utilizing data from the sensors, the system operates actuators to manage water valves. This automation guarantees that crops receive the appropriate amount of water, minimizing waste and optimizing growth by adapting irrigation schedules in real-time.

C. User Dashboard: An intuitive mobile or web interface allows farmers to monitor soil conditions, water requirements, and crop recommendations. The straightforward design ensures that even those with limited technical experience can effectively operate the system.

D. System Architecture: A network of sensors and edge devices, such as Raspberry Pi or Arduino, collects and analyzes data locally. This arrangement diminishes delays and assures quicker responses from the system.

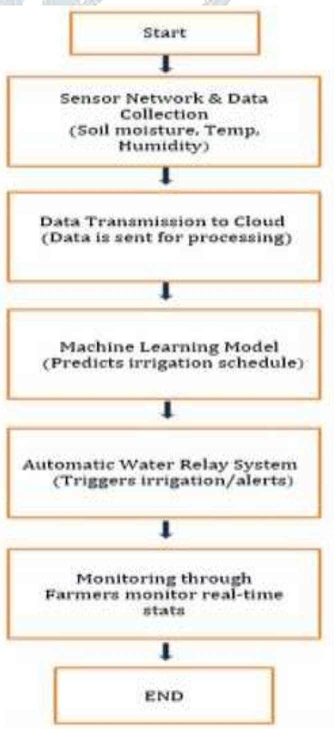
E. Data Analysis: Edge devices process data and make instantaneous irrigation choices based on established thresholds, diminishing the necessity for human involvement.

F. Evaluation and Verification: The system undergoes testing in actual farming conditions, assessing its performance against conventional techniques. Metrics like water consumption and crop yield confirm its efficiency and inform future enhancements

SCOPE

This research investigated the effectiveness of Turnaround Time (TAT) and backhaul utilization in the Indian logistics network, surveying logistics managers in differing industries. The research confirms that experienced logistics staff acknowledge and utilize backhaul and TAT mechanisms for cost savings, compared to less experienced managers who exhibit less consistent usage. Major drivers of successful implementation are correct cost estimation, efficient forecasting, reduction of waste, optimal manpower, good outbound logistics relations, and internal coordination.

FLOW CHART



CONCLUSIONS

Edge computing is revolutionizing precision irrigation by facilitating real-time, localized decision-making without the need for continuous internet access. This is particularly advantageous for rural areas where access to connectivity is limited. By utilizing edge devices such as Raspberry Pi or microcontrollers, the system can analyze data from soil moisture, temperature, and humidity sensors on-site, enabling prompt and precise control of irrigation. This localized data processing contributes to minimizing water waste, reducing energy consumption, and lowering operational expenses, making smart irrigation more feasible and economical for small and medium-sized farms. It also supports environmentally sustainable agricultural practices by supplying water only when and where it is necessary. Nonetheless, additional research is essential to enhance the scalability and energy efficiency of edge systems. Incorporating artificial intelligence at the edge can improve decision-making by forecasting irrigation demands based on environmental trends. A hybrid model—merging edge and cloud computing—might provide a balance between immediate responsiveness and sophisticated analytics along with long-term planning. In conclusion, edge computing presents a sustainable, efficient, and accessible solution for smart irrigation, assisting in tackling global issues such as water scarcity and food security, particularly in agricultural regions with limited resources. 3.2 Data and Sources of Data

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