



## **IOT AND EDGE AI-BASED PRECISION AGRICULTURE SYSTEM FOR WATER OPTIMIZATION**

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### **Abstract:**

Water scarcity and inefficient irrigation practices remain major challenges in modern agriculture, leading to reduced crop yield, resource wastage, and increased production costs. The proposed project, “IoT and Edge AI-Based Precision Agriculture System for Water Optimisation,” aims to develop an intelligent, real-time irrigation management system that optimises water usage through data-driven decision-making at the edge.

The system integrates Internet of Things (IoT) sensors such as soil moisture, temperature, humidity, and light intensity sensors to continuously monitor field conditions. The collected data is processed locally using an Edge AI module, enabling real-time analysis and predictive irrigation control without relying entirely on cloud connectivity. By deploying machine learning algorithms at the edge, the system can determine optimal watering schedules based on soil conditions, crop requirements, and environmental factors, thereby minimising water wastage and ensuring efficient irrigation.

A cloud platform is incorporated for long-term data storage, visualisation, and remote monitoring via a web or mobile dashboard. This hybrid architecture enhances scalability, reduces latency, and improves reliability in rural areas with limited internet connectivity. Automated irrigation control using smart valves or pumps ensures precise water delivery tailored to specific crop zones.

The proposed system promotes sustainable agriculture by improving water-use efficiency,



increasing crop productivity, and reducing operational costs. It supports data-driven farming practices and contributes to environmental conservation through intelligent resource management. This project demonstrates how the integration of IoT and Edge AI technologies can transform traditional irrigation systems into smart, adaptive, and sustainable precision agriculture solutions.

**Keywords:** IoT + Edge AI for precision agriculture enables real-time soil moisture monitoring and automated smart irrigation, optimizing water usage through machine learning, cloud integration, and sustainable resource management.

## 1. INTRODUCTION:

Agriculture is one of the most important sectors for economic development, food security, and employment. A major challenge faced by modern agriculture is the efficient management of water resources. Increasing water scarcity, changing climatic conditions, and growing agricultural demand make it necessary to use water carefully and effectively. Proper irrigation is essential for maintaining soil health, improving crop growth, increasing productivity, and reducing unnecessary water consumption.

Traditional irrigation methods mainly depend on fixed schedules, manual observation, or farmers' experience. These methods do not always consider the actual moisture requirements of crops or real-time environmental conditions. As a result, over-irrigation or under-irrigation may occur, leading to water wastage, soil degradation, increased costs, and reduced crop productivity. Moreover, continuous manual monitoring requires significant time and effort from farmers.

The integration of the Internet of Things (IoT) and Edge Artificial Intelligence (Edge AI) provides an effective solution to these problems. IoT technology allows sensors to continuously collect real-time information such as soil moisture, temperature, humidity, and other environmental conditions. Edge AI processes this sensor data locally and makes intelligent decisions regarding irrigation. Since the processing takes place near the source of data, the system can respond quickly without completely depending on cloud connectivity.

The proposed IoT and Edge AI-Based Precision Agriculture System for Water Optimisation uses soil and environmental sensors connected to microcontrollers to monitor agricultural field conditions. The collected data is analysed using AI-based techniques to determine the appropriate amount of water required by the crops. Based on the decision, the irrigation system can be automatically switched ON or OFF. This helps provide water at the right time and in the required quantity, thereby reducing both over-irrigation and under-irrigation.

The system can also be integrated with a cloud platform for data storage, visualisation, and remote monitoring. Farmers can access real-time field information through web or mobile dashboards, helping them make better decisions and manage their farms efficiently. Historical data can also be useful for analysing irrigation patterns and improving future resource management.

Overall, the proposed system provides a smart, cost-effective, and sustainable approach to



precision agriculture. By combining IoT, Edge AI, automated irrigation, and cloud technologies, the system aims to reduce water wastage, minimise manual intervention, improve crop productivity, and promote efficient use of agricultural resources. It demonstrates the potential of modern technology in developing intelligent and environmentally sustainable farming practices.

## 2. LITERATURE SURVEY:

- 1) Peng & Zhang (2025) proposed an advanced IoT and Machine Learning-based smart irrigation system aimed at improving water efficiency in agricultural practices. Their system integrates soil moisture and temperature sensors to continuously monitor environmental conditions in real time. The collected data is transmitted to a central processing unit, where machine learning algorithms are applied to analyse patterns and predict irrigation requirements. The system uses predictive models to determine the exact amount of water needed by crops, thereby avoiding unnecessary irrigation. This approach not only enhances crop growth but also ensures optimal utilisation of available water resources.
- 2) Amit Kumar et al. (2026) developed an IoT-based smart irrigation system integrated with edge computing and LoRa communication technology. The system utilises multiple sensors, including soil moisture, temperature, and humidity sensors, to monitor environmental parameters in agricultural fields. The use of LoRa technology enables long-range wireless communication, making the system suitable for large-scale farming areas where traditional communication methods may not be effective. The collected data is processed locally using edge computing, reducing the dependency on cloud infrastructure and enabling faster decision-making.
- 3) Hasib et al. (2026) introduced an IoT-based smart irrigation system that utilises cloud computing for monitoring and control of agricultural processes. The system employs soil moisture sensors and DHT sensors to collect real-time data related to soil condition, temperature, and humidity. This data is transmitted to a cloud platform, where it is processed and analysed to determine irrigation requirements. Based on predefined conditions, the system automatically activates or deactivates the irrigation system, ensuring efficient water usage.
- 4) Taueatsoala et al. (2026) proposed an advanced smart irrigation system based on IoT and Tiny ML, which is a form of Edge AI designed for low-power devices. The system integrates sensors such as soil moisture, temperature, and pH sensors to collect environmental data. Unlike traditional systems that rely on cloud processing, this system performs data analysis locally on edge devices. This approach reduces latency and enables real-time decision-making directly at the source of data collection.
- 5) Jiang et al. (2025) developed an innovative IoT-based agriculture system that combines Edge AI with advanced data processing techniques, including large language models (LLMs). The system collects data from multiple sensors and processes it locally to provide real-time insights and decision-making.



**Table 1 Comparative review of Smart Fertigation Controller for Sustainable Pomegranate Farming**

| SR.NO. | Author(s)          | Year | Technology Used               | Sensors/ Methods                     | Accuracy / Performance        | Notable Feature           |
|--------|--------------------|------|-------------------------------|--------------------------------------|-------------------------------|---------------------------|
| 1      | Peng & Zhang       | 2025 | IoT + Machine Learning        | Soil Moisture, Temperature Sensors   | High prediction accuracy      | ML-based smart irrigation |
| 2      | Amit Kumar et al.  | 2026 | IoT + Edge Computing (LoRa)   | Soil Moisture, Temperature, Humidity | Reliable real-time monitoring | Long-range communication  |
| 3      | Hasib et al.       | 2026 | IoT + Cloud                   | Soil Moisture, DHT Sensor            | ~92% accuracy                 | Saves up to 40% water     |
| 4      | Taueatsoala et al. | 2026 | IoT + Tiny ML (Edge AI)       | Soil Moisture, pH, Temperature       | ~99% accuracy                 | Edge AI-based prediction  |
| 5      | Jiang et al.       | 2025 | IoT + Edge AI + LLM           | Multi-sensor data                    | High efficiency               | Real-time decision making |
| 6      | Alreshidi          | 2019 | IoT + Artificial Intelligence | Multi-sensor system                  | Improved efficiency           | Improved efficiency       |

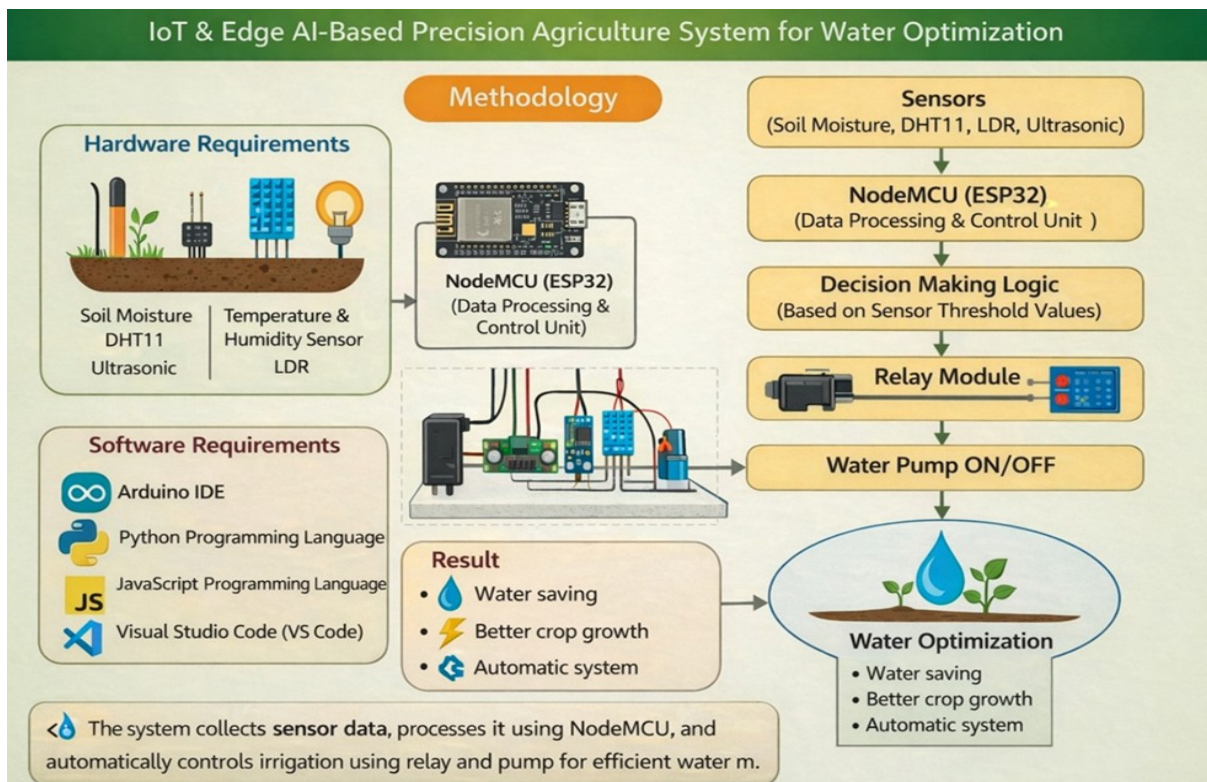
7

### Proposed Methodology:

The proposed IoT and Edge AI-Based Precision Agriculture System for Water Optimisation is designed to monitor field conditions in real time and automate irrigation to reduce water wastage.

Initially, soil moisture, temperature, humidity, and pH sensors are deployed in the agricultural field to continuously collect environmental and soil data. These sensors are interfaced with a microcontroller-based unit that gathers and transmits the readings for processing.

An edge computing device processes the collected data locally to ensure fast and reliable decision-making without continuous internet dependency. The raw sensor data is preprocessed to remove noise and normalise values. A lightweight Edge AI model, trained using historical agricultural data, analyses soil moisture levels and environmental conditions to predict the precise water requirement of crops. Based on the model's output, the system automatically controls irrigation components such as water pumps and solenoid valves. When soil moisture drops below the optimal threshold, irrigation is activated, and once the desired level is achieved, the system stops water flow to prevent over-irrigation. A flow sensor monitors water usage to ensure accurate distribution.



**Figure 1 Block Diagram of Smart Fertilization Controller for Sustainable Pomegranate Farming**

**Result:**

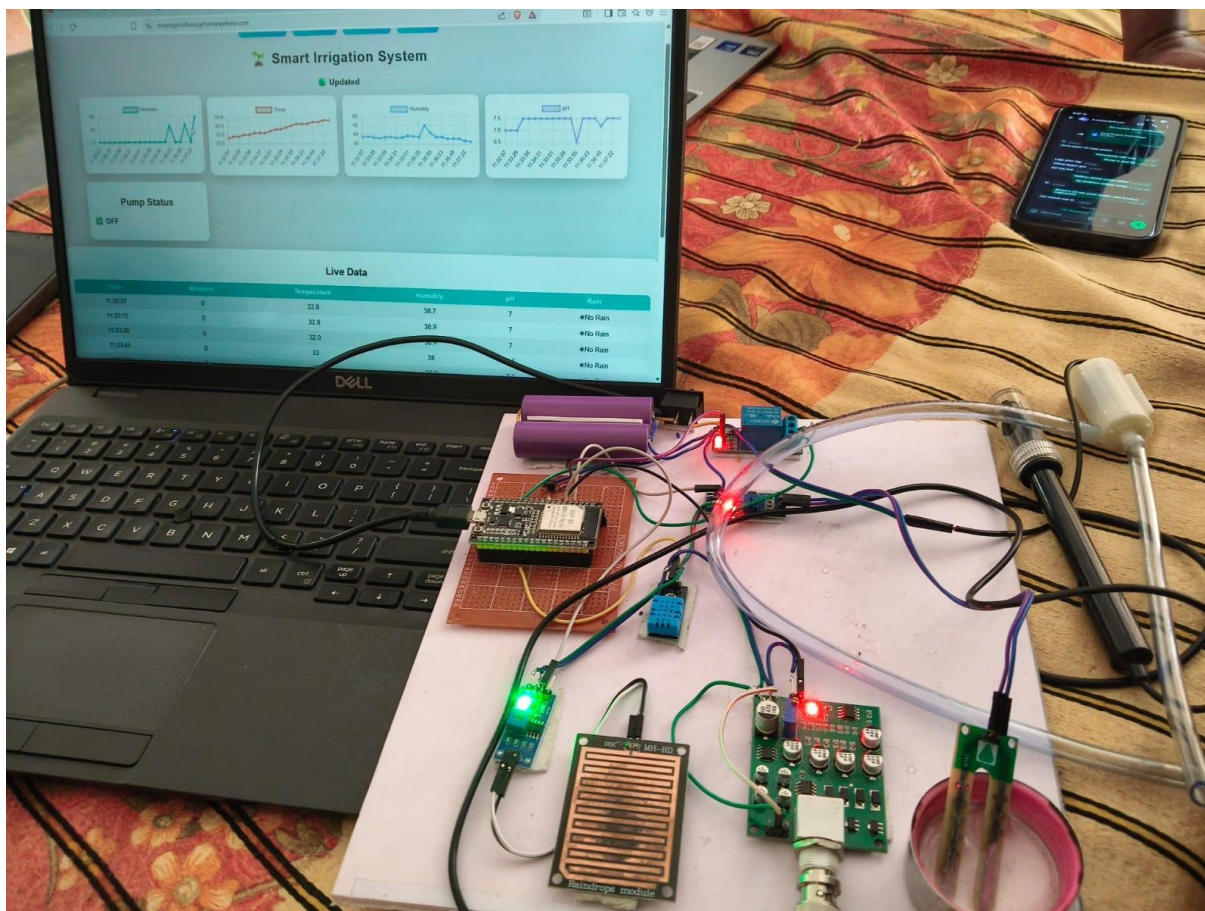


Figure 1 Project Setup



**Figure 2 Smart Irrigation Status**

The IoT and Edge AI-based precision agriculture system was designed to continuously monitor soil moisture, temperature, and environmental conditions in real time. It utilized IoT-enabled sensors along with an edge computing device to process data locally and make intelligent irrigation decisions. By applying Edge AI algorithms, the system could predict water requirements and automatically adjust irrigation without relying entirely on cloud processing. The collected data was also synchronized with a cloud platform for remote monitoring through a mobile application. This approach improved water efficiency, reduced unnecessary usage, and provided precise control over irrigation practices. Overall, it enhanced the sustainability of farming by optimizing resource utilization and enabling smarter crop management.

### 3. CONCLUSION:

The proposed IoT-based Smart Fertigation Monitoring System is designed to effectively track soil moisture, temperature, and humidity as they happen. The ESP8266 collects data from the sensors and sends it to the Blynk cloud platform, where farmers can see the live information on a dashboard. This system allows farmers to make smarter decisions about watering their crops, use less water, and grow better quality pomegranates. It offers an affordable and dependable way to support sustainable pomegranate farming.



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