

# Smart Irrigation System Using IoT for Water Conservation

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*Manuscript Received: May 25, 2026; Revised: June 10, 2026; Published: June 17, 2026*

**Abstract:** In the present world, there are many problems, but the main problem is that to save water because for drinking the water in limited quantity, but in farming the water is used in huge quantity for growing the crop even if the crop doesn't have the need of water at specific time, then also the farmer gives the water to it so, this is fully wastage of water. Flood irrigation remains one of the most widely used yet water-inefficient methods in farming, leading to avoidable large-scale water loss. So, use for the awareness and as well as solving the problem of this type. We implement IoT technology in the agricultural sector to assist farmers in improving crop productivity. Given India's fast-growing population and the rising demand for food, the need for enhanced agricultural output is becoming more critical. So, it is required to generate the high Quality & Quantity of food for this population. By deploying this technology in farming, it becomes possible to monitor soil pH, water quality and quantity, climate conditions, and soil moisture levels, allowing the system to supply water and fertilizer in the exact amount required by the crop at any given time. When climate conditions change, the system evaluates the new scenario and responds with the most suitable action. The sensor is used to monitor soil moisture levels, helping detect the amount of water in the soil. It provides valuable data that allows farmers to act when necessary. During rainfall, the system helps prevent excess water accumulation. Agriculture is a primary source of income in India, and this technology can help farmers reduce labor costs, leading to savings.

**Keywords:** Soil, Sensors, Irrigation, Water, Farm, IoT, etc.

## 1. Introduction

Agriculture serves as the economic backbone of India, generating employment for approximately 70% of the country's population. This sector not only supports livelihoods but also plays a crucial role in food production. However, agriculture consumes a significant amount of water, and with increasing global water shortages, managing this resource effectively has become more important than ever. Traditional irrigation methods are often outdated, requiring a lot of labor and resulting in inefficient water use, which can lead to wastage. Conventional irrigation methods exhibit significant water wastage, consuming around 50,000 units in the field. This highlights the inefficiency of traditional practices and the importance of adopting advanced irrigation techniques to conserve water.

In response to these challenges, smart irrigation systems have been developed that make use of modern technology to overcome the limitations of conventional methods. These systems use soil moisture sensors to automatically control irrigation, adjusting based on the soil's current moisture levels. This means that instead of manually checking and watering plants, these systems can do it automatically when needed. This study seeks to advance agriculture by incorporating automation and the Internet of Things (IoT) technologies. This technology makes easier for homeowners, farmers, and students using Android devices to monitor and manage their watering systems.

When mobile applications are integrated with IoT technology, smart irrigation systems are capable of continuously tracking essential field variables such as soil moisture and temperature. This data ensures plants get the optimal water supply, enhancing efficiency and minimizing water waste.

The paper will explore the problems with traditional irrigation methods and discuss how IoT-based smart irrigation technologies can provide solutions. The study uses sensors and data analysis to optimize water use, making them not only efficient but also cost effective. Low-cost sensors mean that even small farmers can afford to implement these smart systems, which can lead to wider adoption and promote sustainability in agriculture.

With growing global interest in smart irrigation technologies, it is evident that they carry the potential to bring about a lasting transformation in agricultural practices. This introduction lays the foundation for a deeper exploration of how technology can enhance water management in agriculture, reducing consumption to under 50,000 units, and contributing to a more sustainable future for both farmers and the environment. Water management in agriculture is

vital due to increasing global water scarcity. This study introduces a smart irrigation system utilizing IoT technology to optimize water use by monitoring soil and environmental conditions, promoting sustainable farming practices and conservation.

## 2. Literature Review

Nyakuri Jean Pierre, Bikorimana Sefu investigates the deployment of a wireless sensor network (WSN) for efficient data collection and transmission in a smart irrigation system. Bluetooth technology is used to wirelessly link sensor nodes to a base station. Conducted on a 12-hectare maize farm, the results were notably positive: water and energy usage were reduced by 50%, labor costs dropped by 80%, and crop yield grew by 20%, all achieved by sustaining ideal soil moisture conditions through automated irrigation management. [1]

Nidhi Gosavi and Deepa Chourasiya examine smart irrigation systems that make use of advanced technologies such as soil moisture sensors and automated controls to improve water usage efficiency. These systems continuously track both soil moisture and environmental conditions in order to deliver water with accuracy, thereby reducing consumption and supporting better crop health. The authors emphasize that such systems offer an effective solution to the challenges of water scarcity in agriculture. [2]

Mayuri Barange investigates an IoT-driven smart irrigation system that brings together soil moisture sensors and an Arduino board to automate the irrigation process. With WiFi capabilities for remote monitoring, the system empowers farmers to manage irrigation based on realtime soil data. The research emphasizes the system's effectiveness in enhancing water efficiency, boosting crop yields, and improving responsiveness to changes in soil moisture. [3]

Emad S. Hassan and Ayman A. Alharbi propose a novel approach for precise localization of sensor nodes in wireless sensor networks (WSNs), a critical component for the functionality of smart irrigation systems. The proposed technique, based on nonlinear least-squares estimation, improves node positioning accuracy, leading to better irrigation efficiency. The method brought about a significant decrease in water usage, cutting consumption by 28% in comparison to conventional irrigation practices, thereby promoting better water conservation in agricultural settings. [4]

Lim Clarin, Baharudin Osman, Yuhamis Yusof, Abdul Razak Rahamat examines the integration of IoT technologies with mobile applications to create an efficient smart watering system. Utilizing the Waterfall Model for system development, the paper outlines phases such as planning, system design, and testing. The system enables users to track soil moisture and environmental parameters in real time via mobile applications. Future enhancements include features for notifications and data visualization, further improving system functionality. [5]

S.L. Karthik, Prudhvi Kurella, L. Jinit Reddy explores the role of IoT in modernizing agricultural practices, particularly through the integration of sensors, wireless networks, and automated irrigation. The system, implemented using Arduino IDE, enables realtime data collection and analysis to enhance irrigation decision-making. Findings suggest that IoT-based smart agriculture can significantly increase crop output by improving water efficiency and supporting sustainable farming practices. [6]

Akash R, Akash M discusses IoT-based smart irrigation systems that are purpose-built to automate irrigation processes and improve overall resource management. By incorporating soil moisture sensors and environmental monitoring tools, these systems ensure efficient water usage while supporting sustainability goals. The research emphasizes how these systems can enhance crop yields and contribute to water conservation by automating irrigation based on real-time field data. [7]

Laura García, José M. Jiménez, Jaime Lloret provides an overview of recent developments in IoT-based smart irrigation systems, particularly within the scope of precision agriculture. The authors examine the impact of wireless sensor networks, cloud computing, and robotic systems in improving irrigation efficiency. By incorporating IoT technologies, these systems help optimize water usage, leading to better resource management and improved crop productivity, which is critical in addressing water scarcity in agriculture. [8]

## 3. Research Gap

Although numerous studies have proposed IoT-based smart irrigation systems using soil moisture sensors and automated irrigation techniques, the majority of existing systems remain focused on basic moisture detection and do

not integrate multiple environmental parameters such as weather conditions or cloud-based real-time monitoring. Furthermore, most of these systems are either costly or overly complex, making them less accessible for small-scale farmers. There is therefore a clear need to develop a cost-effective IoT-based smart irrigation system that brings together soil moisture sensing, weather monitoring, cloud computing, and remote access through a web interface – all aimed at improving water conservation and irrigation efficiency.

#### 4. Methodology

The figure 1. represents the framework of a smart irrigation system, highlighting its key components and their interactions. It demonstrates how water is managed and distributed using real-time environmental data gathered from sensors. The system integrates automation with advanced technologies such as cloud computing and wireless communication to optimize irrigation efficiency.

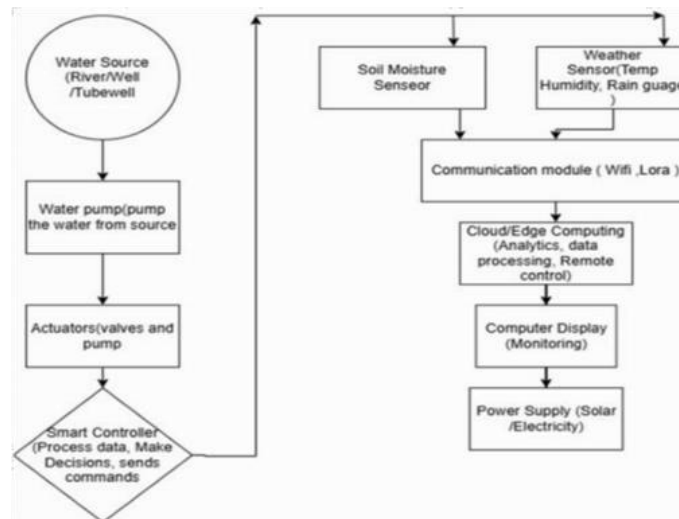


Figure 1: Smart Irrigation System Architecture

Soil Moisture Sensor - To enhance water conservation through precise irrigation, the process begins with Arduino soil moisture sensor (Figure no.2) based on soil properties and crop requirements. Sensors should be installed at multiple depths within the soil to provide accurate and representative moisture readings. Following installation, moisture thresholds are set: the system activates irrigation when readings fall below the lower threshold and automatically stops watering once the upper threshold is reached. The sensor connects directly into an automated irrigation network, ensuring that water is delivered only when the soil genuinely requires it. Incorporating weather forecast data into the system provides an additional layer of control over irrigation scheduling, helping to minimize water loss due to evaporation. Regular data analysis helps refine irrigation practices over time, ensuring optimal water use. Proper maintenance and recalibration of the sensor is essential for ongoing accuracy and effective water management. This method helps reduce water consumption while maintaining healthy plant growth.

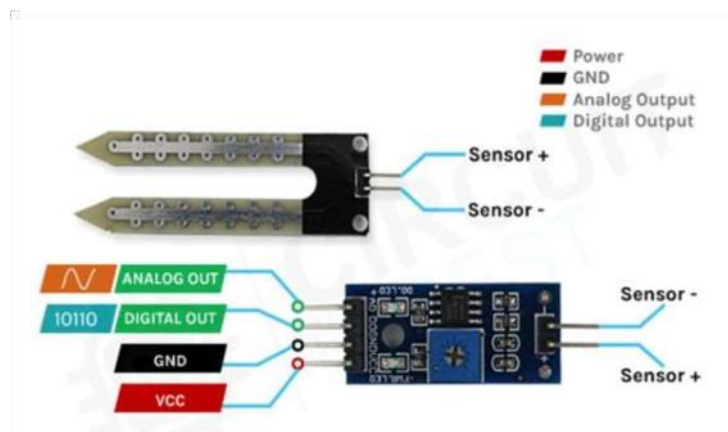


Figure 2:Arduino Soil Moisture Sensor

Weather Sensor- The use of weather sensor as shown in figure no.3 is essential for optimizing irrigation by offering real-time insights into environmental conditions. The sensor measures key environmental variables, including temperature, moisture levels, precipitation, wind velocity, and sunlight exposure. The first step involves strategically placing weather station throughout the field or targeted area to capture accurate local climate data. Monitoring temperature and humidity allows the system to update irrigation schedules in response to changing evaporation rates, making sure water is only applied when conditions genuinely call for it. Data from rainfall sensors is used to reduce or suspend irrigation following recent precipitation, preventing over-watering. Wind speed readings inform the timing of irrigation to minimize water loss due to wind. Furthermore, incorporating weather data into automated irrigation system allows for dynamic scheduling, where irrigation can be automatically modified or delayed based on forecasted weather conditions. Continuous data analysis further enhances irrigation management, leading to water conservation, improved crop health, and more efficient use of resources under different environmental conditions.



**Figure 3: Weather Sensor (courtesy: Grow Sphere, Netafim)**

Smart Controller/ Sprinkler- In figure no.4, the Rachio smart controller serves as the central unit in the automated irrigation system, generating real-time irrigation decisions by processing live inputs received from both the soil moisture sensors and the weather sensors. The controller continuously draws on soil moisture data collected across various soil depths along with environmental readings from the weather sensor, including temperature, humidity, precipitation, and wind speed. By processing this data, the controller determines the irrigation needs of the crops. Whenever soil moisture drops below the pre-configured threshold, the system triggers irrigation, ensuring water reaches the crops only when it is genuinely required. Additionally, the controller uses weather data to optimize watering schedules. For instance, if rain is forecasted, the system can skip or delay watering to avoid unnecessary water use. Additionally, temperature and humidity data help adjust the irrigation timing, minimizing water loss due to evaporation. By combining real-time inputs from both soil and weather sensor, the smart sprinkler ensures efficient water application, adapting to varying conditions. This dynamic system conserves water, reduces waste, and ensures optimal crop health by supplying the precise quantity of water exactly when and where the crop needs it.



**Figure 4: Rachio smart Sprinkler (Courtesy: Rachio)**

Actuator - Actuator, which include valves and pumps, are essential in automated irrigation systems for managing water flow based on instructions from a smart controller. These components regulate when valves open or close in order to release water into the irrigation network as and when the situation demands. After the smart controller processes data received from the soil moisture and weather sensors, it dispatches commands to the actuators to either initiate or halt water flow accordingly. For example, when the soil moisture falls below a specified threshold, the controller signals the actuator to open the valve and release water. In the case of predicted rainfall, the controller may close the valve to prevent overwatering. Pumps are controlled by the smart controller to maintain proper water pressure and flow. This system of automated water flow regulation ensures efficient water use, minimizes waste, and ensures optimized irrigation by adjusting to live environmental data and up-to-date soil moisture readings continuously collected from the field.



**Figure 5: Automated Valve (courtesy: Flow-tech enterprise)**

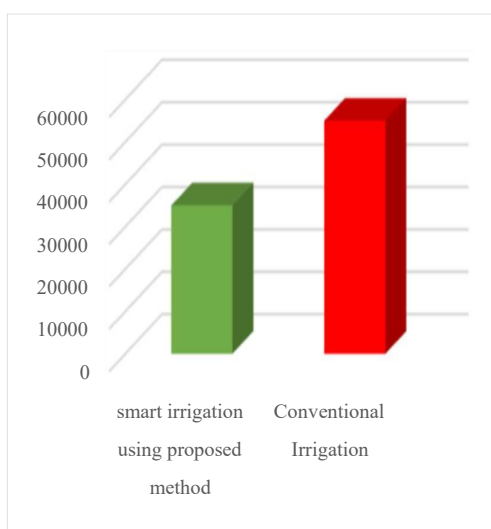
Communication System - In an automated irrigation system, a communication network facilitates seamless data exchange between critical components including the soil moisture sensors, weather sensors, smart controller, and a remote monitoring platform connected to the system. These sensors maintain a continuous watch over soil moisture and environmental variables, forwarding the collected data to the smart controller for processing. The controller analyzes the information to determine irrigation needs and then shares these decisions, along with the sensor data, with a cloud-based platform for real-time monitoring. This remote communication capability allows users to track system performance, make adjustments, and review trends via a web interface. It provides access to live data covering soil moisture levels, weather forecasts, and water usage patterns, all of which support smarter and more efficient irrigation management decisions. Additionally, the system can send alerts or recommendations for irrigation adjustments, helping optimize water usage and ensuring healthy crops while minimizing water waste.

Cloud Computing - Cloud and edge computing are essential for managing and analysing data from soil moisture sensor, weather sensor, and smart controller in an automated irrigation system that depends on sensors to collect live field data on soil moisture and environmental conditions, which is then forwarded to either a local edge device or a remote cloud server for further processing. Cloud computing handles the storage and large-scale analysis of this data in real time, while edge computing brings processing closer to the source, enabling faster local responses and reducing dependence on distant server infrastructure. These computing systems support decision-making by providing analytics to inform irrigation actions. Cloudbased platforms can collect and analyze data from various sources, utilizing predictive algorithms to adjust irrigation schedules based on weather forecasts or longterm moisture trends. Meanwhile, edge computing performs analysis on-site, supporting rapid decision-making and allowing the system to trigger immediate irrigation adjustments in direct response to live sensor readings. Both methods work together to ensure that irrigation is based on accurate, real-time information, optimizing water use, minimizing waste, and improving crop health.

Web Interface - A web interface serves as a central platform for remotely overseeing and managing an automated irrigation system. By connecting to cloud or edge computing infrastructure, the interface presents real-time data sourced from the soil moisture and weather sensors as well as from the smart controller. This allows users to monitor key information, including soil moisture levels, environmental conditions, and the operational status of the irrigation system. Through the web interface, users can adjust irrigation schedules, modify system settings, and manually activate or pause irrigation when necessary. The interface also provides alerts based on sensor inputs and analytics, allowing users to respond quickly to changing conditions, whether those are approaching rainfall events or sudden fluctuations in soil moisture levels. This convenient access to real-time data and control features promotes more efficient water usage, optimizes irrigation decisions, and helps maintain optimal crop health from any location with internet access.

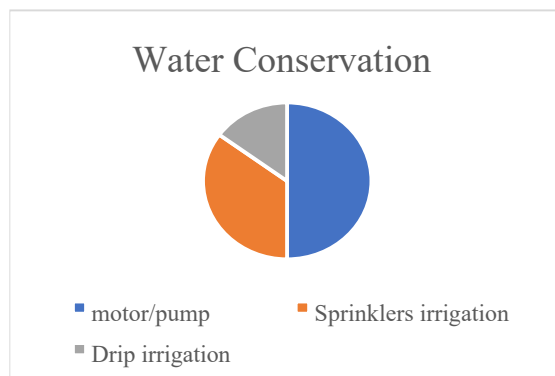
### 5. Observation

As illustrated in Figure 6, water consumption under conventional irrigation methods is exceptionally high. By implementing the proposed smart irrigation system, water that would otherwise be wasted in traditional systems is conserved. This clearly demonstrates that the proposed IoT-driven method is highly effective at minimizing water loss.



**Figure 6: The ratio of water consumption in smart irrigation and conventional irrigation**

Data compiled from various agricultural resources and illustrated in Figure 7 outlines the current distribution of widespread irrigation practices. The majority of irrigation is conducted via traditional motor/pump setups, which see higher usage than any other method. Sprinkler irrigation is less prevalent than motor/pump systems but remains more widely adopted than drip irrigation. Crucially, while drip irrigation is currently utilized less than the alternative methods, observations show that water wastage within drip systems is comparatively minimal. Consequently, it represents a highly efficient approach to agricultural water conservation.



**Figure 7: The Proportion of irrigation methods used in**

## 6. Conclusion

Smart irrigation systems are engineered to supply crops with precise amounts of water, ensuring minimal resource waste, heightened environmental conservation, and improved crop yields. This technological approach holds immense potential for addressing global water scarcity while fostering sustainable agricultural and landscaping practices. By enabling real-time data tracking and system control through smartphone applications and PCs, these setups provide a convenient, accessible solution for farmers to manage their fields remotely. This study explored an IoT-based irrigation system that empowers farmers to continuously monitor vital field parameters, such as soil moisture, temperature, water quality, and changing weather conditions. The proposed model effectively minimizes manual labor requirements, supports ecological stability, and significantly reduces water and energy consumption compared to traditional flood irrigation techniques. By deploying precision agriculture via IoT, farmers stand to save time, energy, and financial resources through reduced operational costs and enhanced crop output. Ultimately, the study highlights that by integrating the proposed localization method, the system can reduce total water consumption by up to 28%. This underscores the vital role modern technology can play in driving sustainable, highly productive, and water-efficient farming practices for the future.

## 8. References

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