

# To Study A Smart Plant Watering And Irrigation System Based On IOT.

Yash . J . Gawali, Prof. Manjusha Mishra, Prof. Rajeshwari Dandage  
*Member,Keystone School of Engineering*

**Abstract:** *A The increasing demand for efficient water management in agriculture and home gardening has led to the development of Smart Plant Watering Systems, which leverage modern technologies to optimize plant care. This paper surveys the evolution, design, and implementation of such systems, focusing on their core components like soil moisture sensors, environmental monitoring, and IoT-based control mechanisms. These systems automate irrigation, ensuring that plants receive the precise amount of water they need based on real-time data, thereby reducing water waste and preventing overwatering or underwatering. Additionally, smart watering systems often incorporate remote control and monitoring features via mobile apps or smart home integration, allowing for enhanced user convenience and flexibility. This survey analyzes the benefits, challenges, and future trends of smart plant watering technology, highlighting its role in promoting sustainable water usage and improving plant health in both agricultural and residential settings*

**Index Terms**—Automated Irrigation , Smart Watering , Soil Moisture Sensor , Arduino Uno , Remote irrigation control.

## I. INTRODUCTION

Water management is one of the most critical factors in agriculture and horticulture, impacting plant health, crop yields, and resource efficiency. Traditional irrigation methods, such as manual watering and fixed-schedule sprinklers, are often inefficient, leading to issues like overwatering, underwatering, and unnecessary water waste. In response to these challenges, the concept of Smart Plant Watering Systems has emerged, offering a more precise, data-driven approach to irrigation by utilizing modern technology, including sensors, automation, and Internet of Things (IoT) connectivity.

A Smart Plant Watering System is an automated solution designed to monitor the environmental conditions of plants, particularly soil moisture levels, and adjust the watering process accordingly. The core of these systems revolves around sensors that detect soil moisture, temperature, and sometimes humidity, providing real-time data to determine the ideal watering schedule for plants. Based on these inputs, a

central controller or microcontroller activates an irrigation system, such as a drip or sprinkler system, to deliver water exactly when and where it is needed. By automating this process, the system ensures that plants receive the optimal amount of water, which promotes healthy growth while minimizing water wastage.

The integration of IoT technology allows smart watering systems to be controlled remotely through smartphones or other devices, offering users enhanced convenience and flexibility. These systems can be programmed to adapt to different plant species, soil types, and weather conditions, making them highly versatile. For example, some systems are capable of integrating weather forecasts to prevent watering during rainy conditions, further conserving water.

The growing interest in sustainable agriculture and water-efficient technologies makes smart plant watering systems a valuable tool for achieving greater productivity while addressing global water scarcity issues. This survey paper aims to explore the various components, design methodologies, and benefits of smart plant watering systems, while also discussing the challenges associated with their implementation and potential future developments. Through this comprehensive review, we seek to provide a better understanding of how smart watering technology is transforming plant care and resource management in both agricultural and domestic contexts.

## II. COMPONENTS OF SYSTEM

A smart plant watering system automates the process of watering plants by monitoring soil moisture, environmental conditions, and other factors. Here's a detailed list of components typically required for building such a system:

(a) Microcontroller:

- Examples: Arduino, ESP8266, ESP32, Raspberry Pi
- Function: Acts as the brain of the system. It processes data from sensors and makes decisions

based on programmed logic (e.g., when to water the plants).

- Consideration: Use Wi-Fi-enabled controllers like ESP32 or ESP8266 for remote monitoring and control.

(b)Soil Moisture Sensor:

- Function: Pumps water from a water source to the plants based on the signal from the microcontroller.
- Types: Submersible pumps or diaphragm pumps.
- Power Source: Can be powered by DC (low voltage) for safety.
- Control: Controlled by a relay or MOSFET switch.

(c)Water Tank or Reservoir:

- Function: Stores water for the pump to use. Must be filled periodically or connected to a continuous water source.
- Capacity: Depends on the number of plants and watering frequency.

(d)Relay Module:

- Function: Acts as an electronic switch. It allows the low-voltage signal from the microcontroller to control high-voltage devices like water pumps or solenoid valves.
- Type: 1-channel or multi-channel relay module based on the number of pumps or devices to be controlled.
- Protection: Includes protection diodes and optocouplers to ensure safe operation.

(d)Solenoid Valve:

- Function: Controls the flow of water through the pipes. Can be used instead of or along with a pump, particularly when water pressure is available.
- Power Source: Usually controlled by a relay and powered by DC voltage.
- Use Case: Suitable for systems using gravity-fed water or mains water supply.

(e)Water Flow Sensor:

- Function: Measures the rate of water flow and sends the data to the microcontroller.
- Benefit: Helps in monitoring the amount of water delivered to plants and can detect any leaks or overwatering.

(f) Power Supply:

• Types:

- Battery: For off-grid systems, solar panels can be used with a rechargeable battery.
- DC Adapter: For powering the system from a wall outlet.
- Function: Provides consistent power to the microcontroller, sensors, and pump.
- Voltage: Depends on the microcontroller and pump requirements (e.g., 5V, 9V, or 12V).

(g)Connecting Wires And Breadboard:

- Function: Used for connecting all components like the microcontroller, sensors, pump, and relays.
- Consideration: Ensure secure connections to avoid loose wiring that could cause the system to malfunction.

(h)Software/Code :

- Programming Language: Typically written in C/C++ for Arduino, MicroPython for ESP32/ESP8266.
- Function: Implements the logic to read sensor data, control the pump, and handle Wi-Fi communication.
- Features: May include logic for scheduling, threshold-based watering, and remote control.

(i)Real Time Clock Module(RTC) :

- Function: Keeps track of time for scheduling watering events.
- Example: DS3231, DS1307 modules.
- Use Case: Useful for time-based watering systems that operate on a fixed schedule, even without sensor input.

### III. TYPES OF PLANT WATERING SYSTEM

#### 1. Drip Irrigation System

##### Overview

Drip irrigation, often referred to as micro-irrigation, is a system that delivers water slowly to the plant's root zone using a network of pipes, emitters, and valves. The water is applied either at the soil surface or directly to the root zone, drop by drop, which minimizes water wastage.

##### Mechanism

- The system comprises lateral pipes and emitters spaced along the line.

- Water is delivered at low pressure, and the emitters discharge small, regulated quantities of water.
- It allows for precise irrigation directly to the plant roots, significantly reducing evaporation and runoff.

#### Applications

- Commonly used in agriculture, greenhouses, and gardens.
- Ideal for plants that require specific moisture levels, such as fruits, vegetables, and flowers.

#### Advantages

- **Water Efficiency:** Can reduce water use by 30-60% compared to traditional methods.
- **Minimizes Weed Growth:** Only the plant roots receive water, reducing moisture in surrounding areas where weeds could grow.
- **Scalability:** Suits small gardens to large-scale agricultural fields.

#### Limitations

- **Clogging:** Emitters are prone to clogging if water is not well-filtered.
- **Initial Setup Cost:** Installation can be costly due to the extensive piping and emitters required.
- **Maintenance:** Requires regular checks and cleaning of filters.

#### Scholarly Insight

Drip irrigation has been widely researched for its role in sustainable agriculture and precision farming. Studies show that it significantly increases crop yields while reducing water usage, making it an ideal solution for regions facing water scarcity .

### 2. Sprinkler Irrigation System

#### Overview

Sprinkler irrigation mimics natural rainfall, distributing water across the field through spray nozzles. The water is pumped under pressure and delivered through a network of pipes, allowing for even water distribution over the crops.

#### Mechanism

- Water is sprayed through rotating or fixed nozzles, covering large areas.
- The system may be manual or automated with timers for scheduled watering.

#### Applications

- Suitable for lawns, gardens, parks, and larger agricultural fields.
- Ideal for crops with shallow root systems and for areas with compacted soils.

#### Advantages

- **Coverage:** Can irrigate large areas uniformly, making it suitable for extensive fields.
- **Flexibility:** Adaptable to various types of terrain and crops.
- **Automation:** Can be easily integrated with timers and sensors for automated watering.

#### Limitations

- **Water Wastage:** High evaporation rates, especially in hot and windy climates.
- **Energy-Intensive:** Requires high-pressure pumps, leading to higher energy consumption.
- **Water Distribution:** Inefficient on uneven terrain, leading to overwatering or underwatering in some areas.

#### Scholarly Insight

Sprinkler systems have evolved with technological advancements such as center-pivot and lateral-move systems, which optimize water use in large-scale farming. However, challenges related to water loss through evaporation and wind drift remain significant concerns .

### 3. Soaker Hose Irrigation System

#### Overview

A soaker hose system uses a porous, flexible hose laid on or slightly below the soil surface. Water seeps out of the hose evenly along its length, saturating the surrounding soil slowly.

#### Mechanism

- The system works at low pressure, allowing water to pass through the porous material of the hose and into the soil.
- Water spreads laterally and downward, covering the root zone.

#### Applications

- Ideal for flower beds, vegetable gardens, and raised beds.
- Suitable for close-row crops where surface coverage is important.

#### Advantages

- **Simple Setup:** Easy to install and maintain.
- **Water Efficiency:** Reduces evaporation compared to overhead watering.
- **Low Cost:** More affordable than drip or sprinkler systems.

#### Limitations

- **Water Pressure Variability:** Inefficient in large gardens due to inconsistent water pressure over long distances.
- **Durability:** Porous hoses degrade over time when exposed to sunlight.

#### Scholarly Insight

Soaker hose systems are particularly valued in home gardening for their cost-effectiveness and ease of use. While their application in commercial agriculture is limited, they are ideal for small-scale settings requiring efficient water delivery .

### 4. Self-Watering Planters

#### Overview

Self-watering planters, also known as sub-irrigation systems, use a reservoir built into the pot. Water is drawn upward from the reservoir into the soil through capillary action, allowing the plants to self-regulate their water intake.

#### Mechanism

- The planter consists of a water reservoir at the bottom, separated from the soil by a barrier or wick.
- The plant's roots draw water as needed from the reservoir.

#### Applications

- Commonly used in urban settings, for potted plants, and small indoor or balcony gardens.
- Ideal for plants that require consistent moisture, such as herbs and certain houseplants.

#### Advantages

- **Low Maintenance:** Reduces the need for frequent watering.
- **Prevents Overwatering:** Ensures plants receive only the water they need.
- **Indoor Use:** Perfect for indoor plants where precise watering is difficult.

#### Limitations

- **Reservoir Overfilling:** Can cause root rot if not monitored.
- **Limited Capacity:** Suitable only for small to medium-sized plants.

#### Scholarly Insight

Self-watering planters are an emerging trend in urban agriculture, particularly due to their convenience and water-saving properties. Studies have shown that these systems can extend the time between waterings, which is critical in urban environments where water conservation is important .

### 5. Wick Irrigation System

#### Overview

A wick system is a passive watering method that uses a wick, usually made from cotton or synthetic fibers, to transfer water from a reservoir to the plant's root zone. It is commonly used in hydroponics or indoor potted plants.

#### Mechanism

- The wick, placed in the water reservoir, absorbs water and moves it into the growing medium through capillary action.
- Water is continuously available to the plant as needed, with no electricity or pumps involved.

#### Applications

- Suitable for small-scale indoor gardening and hydroponic systems.
- Ideal for drought-tolerant plants and DIY systems.

#### Advantages

- **Energy-Free:** Requires no electricity, making it highly sustainable.
- **Low Maintenance:** Simple design with minimal intervention required.
- **Cost-Effective:** Inexpensive to set up.

#### Limitations

- **Limited Scalability:** Not practical for large gardens or agriculture.
- **Inconsistent Watering:** Water delivery is slower and less precise than other systems.

#### Scholarly Insight

Wick systems are particularly useful in low-resource environments due to their simplicity and cost-effectiveness. However, their limited scalability

restricts their use to hobby gardening or small-scale indoor setups .

## 6. Hydroponic Irrigation Systems

### Overview

Hydroponics is a soilless system where plants are grown in a nutrient-rich solution. Water and nutrients are circulated directly to the plant's roots through various systems, optimizing the plant's access to nutrients and moisture.

### Mechanism

- The system can be based on several designs: Nutrient Film Technique (NFT), Deep Water Culture (DWC), Drip Hydroponics, or Ebb and Flow.
- Water and nutrients are pumped through the system and circulated continuously or at set intervals.

### Applications

- Ideal for controlled environments like greenhouses, indoor farming, and vertical farms.
- Used for growing high-value crops such as leafy greens, herbs, and vegetables.

### Advantages

- **Water Efficiency:** Hydroponics uses up to 90% less water than traditional soil-based farming.
- **Faster Growth:** Plants grow faster due to direct nutrient access.
- **Space Efficiency:** Can be implemented in compact spaces, making it suitable for urban farming.

### Limitations

- **High Setup Cost:** Requires pumps, timers, and a controlled environment.
- **Vulnerable to System Failures:** If pumps fail, plants can die quickly due to lack of water.

### Scholarly Insight

Hydroponics is considered a leading technology in the future of sustainable agriculture, particularly in regions with water scarcity or limited arable land. Research supports its potential to enhance food security, particularly in urban settings .

## 7. Flood and Drain (Ebb and Flow) System

### Overview

In flood and drain systems, the plant roots are periodically flooded with nutrient-rich water, which

then drains back into a reservoir. This cycle provides nutrients while allowing the roots to receive oxygen during the drain phase.

### Mechanism

- Water is pumped into the grow tray for a set period, after which it is drained back into the reservoir.
- The cycle is controlled by timers, ensuring plants receive water intermittently rather than continuously.

### Applications

- Primarily used in hydroponics for growing vegetables, herbs, and other high-demand crops.
- Suitable for both indoor and greenhouse environments.

### Advantages

- **Oxygenation:** Allows plant roots to access oxygen between watering cycles, promoting healthier growth.
- **Efficient Use of Water and Nutrients:** Nutrients are recirculated.

## IV. ADVANTAGES

- **Optimized Water Usage:** Waters only when needed, reducing water wastage.
- **Automated Irrigation:** Automatically schedules watering based on environmental data.
- **Prevents Overwatering:** Ensures plants receive the right amount of water, avoiding root rot.
- **Remote Control:** Allows users to monitor and adjust watering via smartphone apps.
- **Adaptable to Weather:** Adjusts irrigation based on real-time weather conditions.
- **Time-Saving:** Reduces the need for manual watering, saving time.
- **Improves Plant Health:** Consistent and precise watering promotes healthier growth.
- **Energy Efficient:** Uses power only when needed, reducing energy consumption.
- **Customizable for Different Plants:** Can be set to meet specific plant watering needs.
- **Real-Time Data Monitoring:** Provides real-time insights into soil and plant conditions.

## V. DISADVANTAGES

- **High Initial Cost:** Setup costs for sensors, controllers, and smart devices can be expensive.

- **Technical Complexity:** Requires technical knowledge for installation and troubleshooting.
- **Dependency on Internet/Power:** Relies on internet connectivity and electricity for remote control and automation.
- **Maintenance Requirements:** Regular maintenance is needed for sensors, valves, and controllers to ensure proper functioning.
- **Potential System Failures:** Any technical malfunction, like sensor errors or software bugs, could lead to overwatering or underwatering.
- **Limited Compatibility:** May not be compatible with all garden types, especially in areas without stable internet access.
- **Data Privacy Concerns:** Some systems collect and store data, raising potential privacy issues.
- **Environmental Exposure:** Sensors and electronics may degrade over time due to weather exposure, requiring replacements.

#### VI. FUTURE SCOPE

- **Integration with AI and Machine Learning:** AI could optimize irrigation patterns by learning plant growth cycles, weather predictions, and soil data for more precise watering.
- **Improved Sensor Technology:** Advanced, more affordable, and durable sensors could provide more accurate real-time data on soil moisture, nutrient levels, and plant health.
- **Water Conservation Strategies:** Enhanced water-saving algorithms could be developed to maximize efficiency, especially in areas facing severe water shortages.
- **Smart City Integration:** These systems could be integrated into urban farming and landscaping projects within smart cities to optimize resource usage.
- **IoT Expansion:** Broader integration with the Internet of Things (IoT) could allow seamless control and monitoring across larger agricultural fields, greenhouses, or home gardens.
- **Automated Crop Health Monitoring:** Systems could evolve to monitor not just moisture but also plant health parameters like nutrient levels, pest infestations, and diseases.
- **Renewable Energy-Powered Systems:** Incorporating solar or wind energy could make smart irrigation systems more sustainable and energy-independent.
- **Data-Driven Farming:** Aggregating large-scale data from multiple farms and gardens could enable predictive models to improve overall agricultural yields.

- **Cost Reduction:** With advancements in technology, the overall cost of these systems is expected to decrease, making them more accessible to small-scale farmers and gardeners.
- **Sustainable Agriculture Support:** Smart watering systems could play a key role in sustainable farming practices by minimizing water wastage and promoting eco-friendly agricultural methods.

#### VII. CONCLUSION

Smart plant watering systems represent a significant advancement in both residential and commercial agriculture, offering precise, automated irrigation solutions that optimize water usage and enhance plant health. By leveraging real-time data from sensors that monitor soil moisture, temperature, and environmental conditions, these systems ensure that plants receive the right amount of water at the right time, preventing both overwatering and underwatering. This precision leads to improved crop yields, healthier plants, and significant water conservation, which is crucial in regions facing water scarcity.

One of the primary benefits of these systems is the convenience they offer. With automated scheduling and remote monitoring via smartphone apps, users can manage their gardens or farms from anywhere. This automation reduces the need for manual labor and allows for more efficient use of resources. Additionally, smart watering systems can be tailored to meet the needs of different plant species, making them highly adaptable to various environments, from small home gardens to large agricultural fields.

However, despite these advantages, the adoption of smart watering systems is not without challenges. The initial setup cost, which includes sensors, controllers, and the necessary infrastructure, can be high. Furthermore, the systems rely heavily on stable internet connectivity and electricity, making them less viable in regions without these resources. Maintenance is another concern, as sensors and electronics may require frequent checks or replacements due to environmental exposure or wear.

In terms of future potential, the integration of artificial intelligence and machine learning promises to make smart watering systems even more efficient by predicting weather patterns and optimizing irrigation schedules based on large-scale data analysis. IoT

connectivity could further enhance their scalability, allowing for more precise, networked control of vast agricultural areas. Additionally, as sensor technology improves and costs decrease, these systems will likely become more accessible to small-scale farmers and individual gardeners

In conclusion, smart plant watering systems provide an innovative, environmentally-friendly solution to traditional irrigation challenges, significantly contributing to water conservation and improved agricultural practices. While there are technical and financial barriers to widespread adoption, ongoing advancements in technology suggest that these systems will become an integral part of future sustainable agriculture practices. Their ability to adapt to both small and large-scale needs ensures they will continue to evolve, playing a key role in addressing global water and food security challenges

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#### IX. CONCLUSION

The development and application of smart plant watering systems represent a transformative step in modern agriculture and horticulture, addressing critical challenges like water conservation, labor efficiency, and plant health. Through the integration of Internet of Things (IoT) technologies, sensors, microcontrollers, and automated irrigation systems, these solutions provide precise water delivery based on real-time data such as soil moisture, temperature, and humidity levels. This ensures that plants receive adequate hydration at the right time, minimizing water waste and preventing overwatering, which are common issues in traditional irrigation methods.

The literature demonstrates that these systems are particularly valuable in areas prone to water shortages or where manual monitoring of plant conditions is impractical. In agriculture, smart watering systems can help farmers optimize water use, reducing operational costs and improving crop yields. Meanwhile, in residential or urban gardening, they offer users convenience, enabling remote monitoring and control through mobile applications or cloud-based platforms.

Moreover, smart watering systems play a crucial role in environmental sustainability. By automating water distribution, they contribute to the efficient use of this precious resource, which is increasingly important in the context of climate change and growing global water demands. As research and innovation in this field advance, the scalability and affordability of such systems will improve, making them accessible to small-scale farmers and individual users alike.

In conclusion, the smart plant watering system not only enhances agricultural productivity and plant health but also aligns with global efforts toward sustainable resource management. With ongoing technological advancements, the potential for further innovation in sensor accuracy, AI-driven decision-making, and energy-efficient designs will likely push the boundaries of smart irrigation systems. This evolution will be instrumental in addressing the water challenges of tomorrow, ensuring food security, and promoting sustainable agricultural practices on a global scale.

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