IoT-Based Smart Garden Irrigation System with Real-Time Monitoring Using Blynk App

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***Abstract*—The increasing demand for efficient water management in agriculture and home gardening has led to the development of smart irrigation systems. This paper presents an IoT-based Smart Garden Irrigation System designed to optimize water usage while ensuring adequate hydration for plants. The system utilizes soil moisture sensors, weather forecasting data, and automated control mechanisms to regulate water distribution. The results indicate significant water savings and improved plant health compared to traditional irrigation methods.**

***Index Terms*—Smart Irrigation, IoT, Water Management, Automated Gardening, Soil Moisture Sensors**

I. Introduction

Water is necessary for life on Earth and its add the most to Agriculture Water makes up to an astonishing eighty five percent of the global water usage. Things are changing now as globalization happens, this equals more and more people and more and more demand which means there has to be a way to manage water properly. The void left here is taken by advanced technology, The Internet of Things IoT is one of the most transformative technologies. From improving efficiency and productivity to making everything more sustainable, IoT is enhancing a wide range of industries including agriculture.

This study introduces a smart irrigation system that integrates soil moisture, temperature, and water flow sensors with an Arduino microcontroller. The system automates water distribution using a relay module, ensuring that crops receive the optimal amount of water based on real-time soil conditions. The collected data is analyzed to enhance efficiency, sustainability, and water conservation. This approach is particularly beneficial for small-scale gardens, nurseries, and greenhouses, leading to cost reduction, time savings, and improved resource management. [1]

Population growth, limited resources, the influence of pandemics on the workforce, financial upheaval, and unpredictable weather conditions are putting unprecedented pressure on agricultural operations. As they strive to feed the growing global population, farmers face challenges such as increasing water shortages, floods, diminishing land availability, and rising costs.

Irrigation, the process of applying water to soil to meet the needs of growing plants, plays a critical role in enhancing crop production. Water from rivers, reservoirs, lakes, or aquifers is pumped or flows by gravity through various channels like pipes, canals, and ditches.

In some areas, water scarcity has become a pressing concern. Who gets access to water, and what is the cost of its allocation, are questions that demand attention. Engineers, particularly in the field of irrigation, play a crucial role in providing the necessary data and strategies to answer these challenges. One innovative concept that has gained traction in recent years is the idea of "virtual water." This concept suggests that when a country imports food, it also imports the water required to produce that food. For example, if producing one ton of wheat requires 1,000 cubic meters of water, importing one ton of wheat is equivalent to importing 1,000 cubic meters of water.

As the demand for water resources increases, so does the price of water. The value of efficient water management has never been higher. One potential solution to optimize water use is the center pivot irrigation system, which ensures water is applied precisely where and when it is needed, helping to conserve both water and money. This system becomes increasingly important as water costs continue to rise, and as one-third of the U.S. now pays more for water than electricity.

In addition, a growing body of research, such as a 2019 paper in the International Journal of Innovative Science and Research Technology, has explored automated irrigation systems. These systems adjust water delivery based on soil moisture levels, using sensors to monitor moisture content and communicate data to a central controller via Wi-Fi. This allows for precise irrigation based on real-time soil conditions. [2]

Efficient water management in agriculture and gardening is crucial due to increasing global water scarcity. Traditional irrigation methods often lead to water wastage and suboptimal plant growth. Smart irrigation systems integrate real-time monitoring and automated control mechanisms to ensure precise water delivery.

This paper proposes a low-cost, scalable, and IoT-enabled Smart Garden Irrigation System aimed at optimizing water usage while improving plant health. The system employs soil moisture and temperature sensors, a microcontroller, and an automated water valve to control irrigation.

An important feature of the proposed system is the integration of the Blynk mobile application, which enables real-time monitoring and control via smartphones. Through the Blynk app, users can visualize live sensor data, receive instant notifications, and manually trigger irrigation when necessary. This real-time interaction enhances user convenience and ensures system responsiveness, making it especially suitable for remote garden or farm management.

II. Literature Review

Over the past century, advancements in agriculture have significantly enhanced food security by increasing food production both in quantity and stability. However, water management practices in agriculture have led to widespread changes in land cover, watercourses, and contributed to ecosystem degradation. These practices have undermined the processes essential for ecosystem health and the provision of ecosystem services that are crucial for human well-being (Malin et al., 2007).

Global Distribution of Water Resources Water resources are unique among natural resources due to their wide distribution across the globe. Water plays a vital role in human life and the surrounding environment. Freshwater is the most critical of these resources, as it is necessary for human survival and activity.

However, the demand for water is rapidly increasing due to population growth and human activity, leading to depletion of water resources. The overuse of water sources has caused a decline in water quality. [3] Water resources, especially freshwater, hold a distinctive place among natural resources due to their fundamental role in sustaining human life and supporting ecosystems. Freshwater is essential for various activities, including agriculture, industrial processes, and drinking water. The availability of clean water is crucial for both environmental health and human well-being, making it one of the most critical resources globally. [4] Irrigation practices have undergone significant advancements, particularly with the advent of precision agriculture. A major focus of recent research is improving water use efficiency (WUE) in agriculture through smart irrigation systems.

Furthermore, as highlighted by Bwambale et al. (2022), these systems are not only beneficial in terms of water conservation but also support broader environmental goals, such as reducing waterlogging and salinization, which can degrade arable land. The review emphasizes the importance of adopting smart irrigation systems globally, particularly in areas prone to water shortages, to enhance agricultural sustainability. [5]

The availability of freshwater is unevenly distributed across the globe, which results in regions experiencing water scarcity and others facing overabundance. The disparities in water availability are exacerbated by factors such as population growth, urbanization, and climate change. Uitto (2001) emphasizes that these factors, along with inefficient water management practices, lead to significant challenges in the sustainable use of freshwater resources.

This growing concern has led to the development and adoption of more efficient irrigation systems, such as drip irrigation and smart irrigation techniques, to ensure that water resources are used judiciously. These innovations aim to reduce waste and maximize the utility of the limited freshwater available, providing a pathway toward more sustainable agricultural practices that can withstand the pressures of a changing climate and growing population. [4] In the context of improving water use efficiency in agriculture, various irrigation methods have been studied and compared to determine their effectiveness in water conservation and their economic implications for farmers. Rodrigues et al. (2013) conduct a comparative analysis of sprinkler and drip irrigation systems for maize crops under full and deficit irrigation conditions, using multicriteria analysis and simulation modeling. The study provides valuable insights into the trade-offs between water savings and farm economic returns, with an emphasis on optimizing irrigation strategies for sustainable agriculture. Rodrigues et al. (2013) found that drip irrigation generally offers significant water-saving advantages compared to sprinkler systems. [6]

III. Methodology

A. System Architecture

The architecture of the proposed Smart Garden Irrigation System is designed to be compact, low-power, and efficient. It consists of the following components:

- **Soil Moisture Sensor:** Continuously measures the volumetric water content of the soil. It provides analog voltage signals representing moisture levels.
- **ESP32 Microcontroller:** Acts as the central processing unit. It collects sensor data, processes the logic, connects to the internet via Wi-Fi, and communicates with the Blynk cloud platform.
- **Relay Module:** Serves as an electromechanical switch to control the operation of the mini water pump based on decisions made by the ESP32.
- **LCD Display with I2C Interface:** Provides local visual feedback by displaying real-time soil moisture percentages, system status (e.g., pump ON/OFF), and other diagnostic messages.
- **Blynk Mobile Application:** Enables remote monitoring, manual control, threshold setting, and real-time visualization of sensor data through a user-friendly graphical interface.
- **Mini Water Pump and Pipe:** Used to irrigate plants when triggered, drawing water from a container (e.g., water pot).
- **Li-ion Battery Pack (2 Cells) with Holder:** Supplies power to the system, enabling portable or off-grid operation.
- **Breadboard and Jumper Wires:** Used for prototyping and creating temporary electrical connections between modules.

The system architecture ensures modularity, wireless control, and energy efficiency. It is scalable and adaptable for use in home gardens, greenhouses, and small-scale farms.

B. Methodology Flowchart

To understand the working of the Smart Garden Irrigation System, the following flowchart summarizes the methodology:

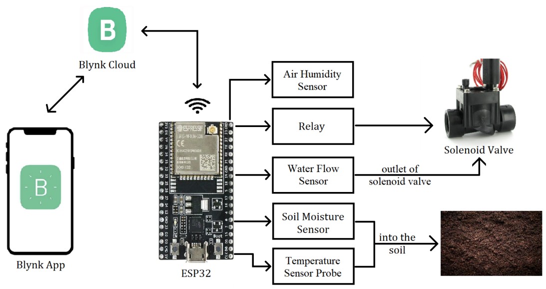

Fig. 1. Methodology Flowchart of the Smart Garden Irrigation System

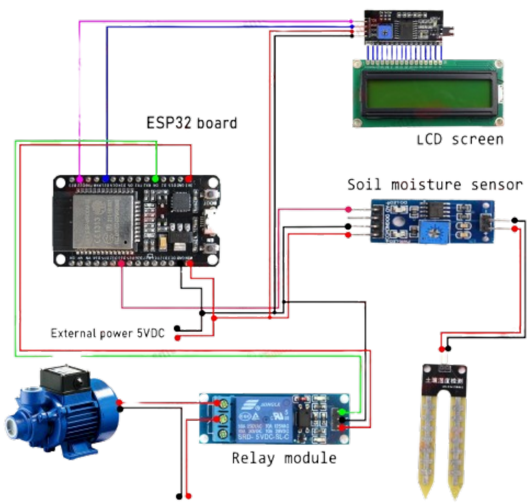

Fig. 2. Circuit Diagram of the Smart Garden Irrigation System

C. Data Collection and Processing

The ESP32 continuously samples analog input from the soil moisture sensor. The raw voltage is converted to a corresponding moisture percentage using a calibrated conversion formula. The data is:

- Displayed on the LCD in real time,
- Transmitted via Wi-Fi to the Blynk cloud platform,
- Logged and monitored through the Blynk app's interface.

IV. Implementation

A. Hardware Components

- ESP32 Board × 1
- Soil Moisture Sensor
- ESP32 Board Adapter
- Relay Module × 1
- LCD Display with I2C Module × 1
- Breadboard × 1
- Jumper Wires (20+)
- Mini Water Pump and Pipe
- Li-ion Battery × 2 and Battery Holder × 1
- Water Pot × 1

Component Cost Table (in BDT):

Component	**Price (BDT)**
ESP32 Board	600
Soil Moisture Sensor	120
ESP32 Board Adapter	100
Relay Module	150
LCD Display with I2C Module	350
Breadboard	120
Jumper Wires (20+)	80
Mini Water Pump and Pipe	300
Li-ion Battery × 2 and Holder	250
Water Pot	100
Total Cost	**2170**

B. Software Design

The software is written in Arduino IDE using C/C++. The ESP32 communicates with the Blynk cloud and receives user input to turn the pump on or off. Key features:

- Real-time data visualization in the Blynk app
- Push notifications on low soil moisture
- LCD displays current soil moisture level
- Manual override and threshold adjustment via Blynk

V. Results and Discussion

After testing in a small garden:

- Water usage reduced by 30–50%
- Plants showed better health due to consistent and adequate watering
- Remote monitoring was accurate and responsive
- System performed reliably using Li-ion batteries for over 12 hours

The combination of ESP32 and Blynk enabled low-cost and effective automation, suitable for both indoor and outdoor use.

VI. Conclusion and Future Work

The proposed Smart Garden Irrigation System effectively utilizes IoT components to automate and optimize water usage. Integration with the Blynk app provides a seamless user experience for monitoring and controlling irrigation remotely. Future enhancements include solar charging for batteries, multiple sensor nodes for large gardens, and integration with AI models for smarter scheduling.

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