IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

# IoT-Based Smart Agriculture System for Efficient Multi-Crop Cultivation in Hilly Regions

**Dipali Arun Patil[1], Aakanksha Dinesh Thakare[2], Shivani Shamkant Devare[3], Dr. H.T. Ingale[4], Maheshkumar N. Patil[5]**

*[1,2,3]UG students, [4,5] Professor, E&TC Engg dept, GF's Godavari CoE, Jalgaon, Maharashtra, India, 425001*

***Abstract –*** *Modern agriculture requires efficient water management, especially in hilly regions where uneven terrain makes irrigation difficult. Traditional irrigation methods often result in improper water distribution, increased wastage, and reduced crop productivity. To overcome these challenges, this project presents an IoT-based smart irrigation system designed for multi-crop cultivation, specifically for Wheat and Jowar crops.The system uses NodeMCU modules as wireless sensor nodes to monitor soil moisture, temperature, and humidity in real time across different crop zones. The collected data is transmitted to the Blynk cloud platform via Wi-Fi, enabling continuous monitoring through a mobile application. A Raspberry Pi acts as the central controller, processing the data and controlling irrigation components such as a water pump and solenoid valves using a relay module.The system operates in both automatic and manual modes. In automatic mode, irrigation is controlled based on soil moisture thresholds to ensure optimal water usage. In manual mode, users can monitor data and control the system remotely through the Blynk mobile application.This system improves water efficiency, reduces manual effort, and ensures proper irrigation in hilly environments. It is cost-effective, scalable, and supports real-time agricultural applications, contributing to sustainable farming and improved crop yield.*

***Keywords*** *IoT, Smart Irrigation, Raspberry Pi, NodeMCU, Soil Moisture Sensor, Blynk, Automation*

## INTRODUCTION

Agriculture is one of the most important sectors for economic development, and efficient irrigation plays a key role in improving crop productivity. In hilly regions, irrigation becomes challenging due to uneven terrain and improper water distribution. Traditional irrigation methods rely on manual operation and do not consider real-time soil and environmental conditions, leading to water wastage and reduced efficiency.With the advancement of technology, the Internet of Things (IoT) has introduced smart solutions for modern agriculture. IoT-based systems enable real-time monitoring and automation of irrigation processes using sensors and wireless communication. This project proposes a smart irrigation system for multi-crop cultivation using NodeMCU and Raspberry Pi. The system monitors soil moisture, temperature, and humidity, and provides both automatic and manual control through a mobile application. It aims to improve water management, reduce human effort, and ensure efficient irrigation in hilly regions.

## PROJECT OBJECTIVES:

1. To design and develop an IoT-based smart irrigation system for efficient water management in agriculture
2. To monitor soil moisture, temperature, and humidity in real time using wireless sensor nodes (NodeMCU)
3. To implement a multi-crop irrigation system for crops like Wheat and Jowar with separate monitoring zones
4. To develop a centralized control system using Raspberry Pi for efficient irrigation management
5. To enable automatic irrigation based on soil moisture threshold values to reduce water wastage
6. To provide manual control of the irrigation system using the Blynk mobile application
7. To ensure efficient irrigation in hilly regions with uneven terrain and water distribution challenges
8. To reduce human effort and improve crop productivity through smart and automated irrigation

**LITERATURE REVIEW**

1.IoT Based Smart Irrigation System (2024) :-This system uses Arduino and soil moisture sensors for irrigation automation. However, it is limited to single crop zones and lacks centralized control.

2.Wireless Sensor Network in Agriculture (2023) :-Wireless nodes collect environmental data and send it to a server. However, the system lacks real-time decision-making for irrigation control.

3.Cloud-Based Smart Farming System (2025):-This system provides real-time monitoring using cloud platforms. Although efficient, it is costly and complex for small-scale farmers.

**EXISTING SYSTEMS**

1. Traditional Manual Irrigation System
   Traditional irrigation systems are widely used in agriculture, where farmers manually control the water supply based on their experience and observation. In this method, irrigation is done without considering real-time soil moisture or environmental conditions. Farmers usually irrigate crops at fixed intervals or based on visual inspection of the field.
   The main drawback of this system is inefficient water usage, as it often leads to over-irrigation or under-irrigation. This not only wastes water but also affects crop health and productivity. Additionally, manual irrigation requires significant human effort and time, making it less suitable for large agricultural fields. There is no provision for automation or remote monitoring in such systems. Due to these limitations, traditional irrigation methods are not efficient for modern agriculture, which requires precise and data-driven irrigation techniques.

2. Timer-Based Irrigation System
   Timer-based irrigation systems were developed to automate the irrigation process to some extent. In this system, water is supplied to crops at predefined time intervals using timers and controllers. The system reduces the need for manual intervention and provides a basic level of automation.
   However, this system does not consider actual soil conditions or environmental factors such as temperature and humidity. As a result, water may be supplied even when it is not required, leading to wastage. Additionally, timer-based systems are not flexible and cannot adapt to different crop requirements or changing weather conditions. They also lack real-time monitoring and remote control features. These limitations make timer-based irrigation systems inefficient for smart farming applications, where precision and adaptability are essential.

3. Single-Crop IoT Based Irrigation System
   oT-based irrigation systems use sensors like soil moisture and temperature to automate watering. These systems collect real-time data and control irrigation using microcontrollers. They improve water efficiency compared to traditional methods. However, most of these systems are designed for single crop zones only. They do not support multiple crops with different water requirements. Additionally, many systems lack centralized control and do not provide both manual and automatic modes. Due to these limitations, their application in large and diverse agricultural fields is restricted, creating the need for a more flexible and scalable irrigation system.

4. Drip Irrigation System
   Drip irrigation is a widely used modern irrigation method where water is supplied directly to the root zone of plants through pipes and emitters. This system reduces water wastage by delivering water in controlled quantities and improves water efficiency compared to traditional irrigation methods. It is especially useful in areas with limited water resources.However, drip irrigation systems do not include automation or real-time monitoring. The water flow is usually controlled manually or through basic valves, which may not respond to actual soil conditions. Additionally, it requires proper maintenance to avoid clogging of pipes and emitters. The system also does not support remote monitoring or intelligent decision-making. These limitations indicate the need for integrating IoT technology to make drip irrigation smarter and more efficient.

5. Sprinkler Irrigation System
   Sprinkler irrigation systems distribute water over crops in the form of sprays, similar to rainfall. This system is useful for covering large agricultural areas and is commonly used in fields where uniform water distribution is required. It reduces manual labor and improves irrigation efficiency compared to traditional flooding methods.
   Despite its advantages, sprinkler systems suffer from water loss due to evaporation and wind drift. They also do not consider soil moisture conditions, which may lead to over-irrigation. The system lacks automation and does not provide real-time monitoring or control. Additionally, it cannot differentiate between different crop requirements in multi-crop fields. These drawbacks highlight the need for smart irrigation systems that can optimize water usage based on actual field conditions.

## PROBLEM STATEMENT

Traditional irrigation systems used in hilly regions face several challenges due to uneven land and lack of proper water distribution. Most irrigation methods are manual and depend on farmer experience, which leads to inefficient water usage. There is no real-time monitoring of soil conditions, making irrigation inaccurate. Existing systems also lack centralized control for multiple crops and do not support flexible operation modes.

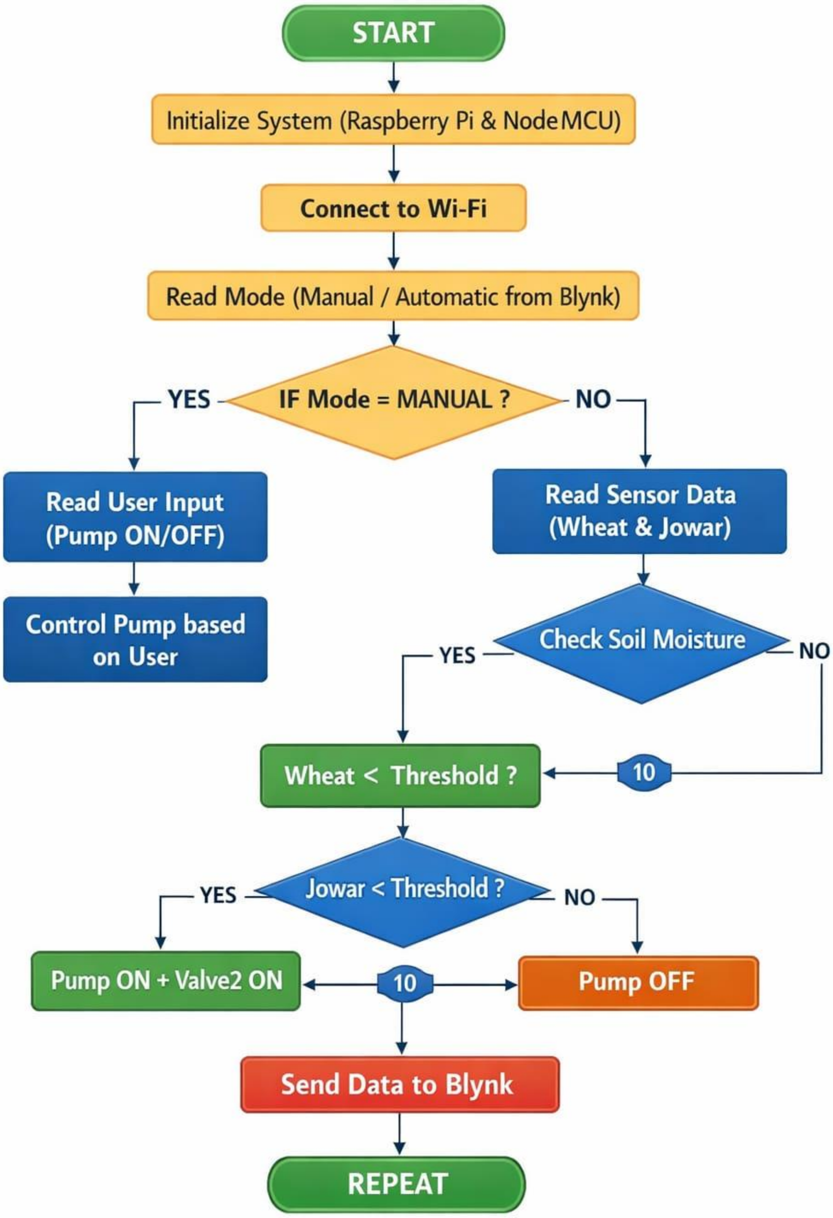
Key Problems

- Uneven terrain in hilly regions causes improper water distribution
- Lack of real-time monitoring of soil moisture and environmental conditions
- No centralized control for managing multiple crop zones
- Limited flexibility due to absence of manual and automatic combined control

## METHODOLOGY (SYSTEM DESIGN)

**Step-by-Step Flow:**

1. System Initialization
   - Raspberry Pi initializes GPIO pins and network.
   - NodeMCU modules connect to Wi-Fi
2. Sensor Data Collection
   - Soil moisture sensors detect soil condition
   - DHT22 sensors measure temperature and humidity
3. Data Transmission
   - NodeMCU sends sensor data to Blynk cloud
4. Mode Selection
   - User selects Manual or Automatic mode via Blynk
5. Decision Making
   - Automatic Mode:
     If soil moisture is below threshold → irrigation required
   - Manual Mode
     User directly controls pump via mobile app
6. Irrigation Control
   - Raspberry Pi activates pump
   - Opens specific valve (Wheat or Jowar)
7. Monitoring
   - Data displayed on Blynk app
8. Continuous Loop
   - System continuously monitors and controls irrigation




**ALGORITHM**

1. Start system.
2. Initialize Raspberry and node MCU
3. Read Mode (Manual / Automatic)
4. IF Mode == MANUAL THEN
    - Pump = User Control
5. ELSE
    - Read Wheat Soil Moisture
    - Read Jowar Soil Moisture
    - IF Wheat Soil < Threshold THEN
      Pump ON
      Valve 1 ON
      Valve 2 OFF
    - ELSE IF Jowar Soil < Threshold THEN
      Pump ON
      Valve 2 ON
      Valve 1 OFF

- ELSE

  Pump OF

  All valves OFF

6. Send data to blynk
7. repeat

**CONCLUSION**

The proposed multi-crop smart irrigation system using IoT technology provides an efficient and flexible solution for modern agriculture. By integrating NodeMCU-based sensor nodes with a Raspberry Pi controller, the system enables real-time monitoring and intelligent irrigation control. The implementation of both manual and automatic modes improves usability and adaptability in different farming conditions. The system reduces water wastage, minimizes human effort, and enhances crop productivity. Additionally, the use of wireless communication and mobile application support makes the system user-friendly and scalable. Overall, this solution contributes to sustainable agriculture and efficient resource management in multi-crop environments.

**EXPECTED RESULTS**

- The system will provide real-time monitoring of soil moisture, temperature, and humidity for different crop zones using wireless sensor nodes and IoT communication. Sensor accuracy, communication latency, coordination across many intersections needs to take care.
- Automatic irrigation will be achieved based on soil moisture threshold values, ensuring efficient water usage and reducing unnecessary water wastage.
- Manual control through a mobile application will allow users to operate the water pump anytime, improving flexibility and user convenience.
- Centralized control using Raspberry Pi will enable efficient management of multiple crops with different irrigation requirements in a single system.
- The system will reduce human effort and improve crop yield by maintaining optimal soil conditions through smart and controlled irrigation.

**DISCUSSION**

The proposed system significantly enhances irrigation efficiency by automating water supply and reducing dependency on manual labor. It ensures better water management through real-time monitoring and intelligent control. However, system performance may be affected by factors such as sensor accuracy, network delays, and varying environmental conditions. Proper calibration and stable connectivity are required for reliable operation. Future improvements can focus on enhancing system accuracy, reliability, and scalability for large-scale agricultural applications.

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