SMART IRRIGATION SYSTEM

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Abstract : This paper presents a Smart Irrigation System designed to improve water management in agriculture using automation and Internet of Things (IoT) technology. The system utilizes multi-depth soil moisture sensing to provide accurate irrigation decisions, reducing dependency on manual estimation. It also integrates weather forecasting to prevent unnecessary watering during expected rainfall. Additionally, a flow-based leakage detection mechanism is implemented to minimize water wastage.

The system is powered by solar energy with battery backup, ensuring reliable operation in rural areas with limited electricity availability. Overall, the proposed system reduces manual effort, conserves water, and improves the efficiency and reliability of agricultural practices

IndexTerms **-** Smart Irrigation, IoT, Soil Moisture Sensor, Weather Forecasting, Solar Power, Leakage Detection, Agriculture .

INTRODUCTION

Agriculture in India faces significant challenges such as water wastage, unpredictable weather conditions, and reliance on traditional manual irrigation practices. These conventional methods often depend on estimation, leading to inefficient water usage and reduced crop productivity.

The Smart Irrigation System addresses these issues by integrating sensors, IoT technology, and renewable energy. The system irrigates crops based on actual soil moisture conditions rather than assumptions. It also incorporates weather forecasting to avoid irrigation when rainfall is expected. Furthermore, leakage detection ensures that water loss is minimized, making the system efficient and reliable for modern agriculture.

NEED OF THE STUDY

With increasing demand for food production and limited water resources, efficient irrigation systems have become essential. Traditional irrigation methods result in excessive water usage and require constant manual monitoring.

The Smart Irrigation System is needed to automate irrigation, reduce water wastage, and improve agricultural productivity. It also helps farmers by minimizing labor effort and ensuring optimal water usage based on real-time data and environmental conditions.

3.1 System Implementation

The Smart Irrigation System is developed using sensors, microcontroller (ESP32), and automated pump control. The system is implemented in phases including sensor setup, solar integration, and IoT monitoring.

3.2 Data and Sources of Data

The system collects real-time data from:

- Soil moisture sensors (multi-depth levels)
- Water flow sensor (for leakage detection)
- Weather API (rain, temperature, humidity)

3.3 Theoretical framework

The system is based on IoT and automation principles. Soil moisture levels are continuously monitored and used to control irrigation. Weather forecasting is integrated to optimize water usage, and leakage detection ensures efficient water management.

RESEARCH METHODOLOGY

The Smart Irrigation System is developed using a modular approach to ensure reliability and scalability. The system consists of two main layers:

- Sensing and Control Layer
- IoT Monitoring and Prediction Layer

3.1 System Implementation

The Smart Irrigation System is implemented using a microcontroller (ESP32), soil moisture sensors, water pump, and flow sensor. The sensors are placed at different soil depths to measure moisture accurately. Based on the sensor readings, the system automatically controls the water pump. The implementation also includes solar power integration and battery backup to ensure continuous operation in rural areas.

3.2 Data and Sources of Data

The system collects real-time data from the following sources:

- Soil moisture sensors (multi-depth levels)
- Water flow sensor (for leakage detection)
- Weather API (rain probability, temperature, humidity)

The data is continuously monitored and processed by the ESP32 microcontroller.

3.3 Theoretical framework

The system is based on IoT and automation principles. Soil moisture levels are continuously monitored and used to control irrigation. Weather forecasting is integrated to avoid unnecessary watering during rainfall.

A decision-based irrigation model is used:

- 0 → No irrigation required
- 1 → Moderate irrigation required
- 2 → Immediate irrigation required

In case of abnormal water flow, the system automatically stops the pump and sends alerts through the IoT application.

3.4 System Architecture and Working

The system follows a two-layer architecture:

- Sensing and Control Layer: Includes sensors, microcontroller, and pump control
- IoT Monitoring Layer: Includes mobile application and cloud-based monitoring

The sensors collect real-time data, which is processed by the microcontroller. Based on predefined conditions, the pump is controlled automatically. The IoT platform provides real-time monitoring and alerts to the user.

IV. RESULTS AND DISCUSSION

4.1 Results of Descriptive Statics of Study Variables

The system demonstrated reliable performance during testing. Soil moisture sensors provided accurate readings, and the pump operated automatically based on real-time data. Weather integration successfully reduced unnecessary irrigation, resulting in significant water savings.

The leakage detection system effectively identified abnormal flow conditions and prevented water loss. The solar-powered setup ensured continuous operation, and the IoT application provided real-time monitoring without interruption. Overall, the system proved efficient, stable, and suitable for real-world agricultural applications.

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