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IDT Report

on

"Smart Irrigation System"

Submitted in partial fulfillment of the requirements for the
First Semester of the Bachelor of Engineering Degree, towards the completion of the **IDT Project** under the **Innovation & Design Thinking Laboratory**,
Department of Basic Sciences.

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CERTIFICATE

This is to certify that the File Structures project entitled "Smart Irrigation System" has been successfully carried out by Dakshith C (49), Deeksha P (50) and Deekshith S (51) ,bonafide students of **CMR Institute of Technology.**

The project is submitted in partial fulfillment of the requirements for the First Semester of the Bachelor of Engineering Degree, towards the completion of the IDT Project under the **Innovation & Design Thinking Laboratory, Department of Basic Sciences.**

It is further certified that all corrections and suggestions indicated during the Internal Assessment have been duly incorporated in the project report submitted to the departmental library. This File Structures project report has been reviewed and approved as it satisfies the academic requirements prescribed for the said degree.

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Abstract

The Smart Irrigation System project is designed to provide a simple, low-cost, and highly reliable solution for farmers, particularly those with limited literacy or access to digital technologies. The primary objective of the project is to automate irrigation based on soil moisture conditions without relying on displays, mobile applications, or web-based controls, thereby ensuring ease of use and inclusivity. The system operates using a soil moisture sensor interfaced with a microcontroller, which continuously monitors the moisture level of the soil. When the soil becomes dry beyond a predefined threshold, the controller activates a relay module to switch on a water pump, supplying water directly to the field. Once adequate moisture is restored, the pump is automatically turned off, preventing over-irrigation and conserving water. The entire setup is powered using a simple power source and employs minimal hardware, reducing cost and maintenance complexity. The outcome of the project demonstrates effective automation of irrigation with improved water efficiency, reduced manual intervention, and enhanced suitability for rural and traditional farming environments. The system emphasizes practicality, robustness, and scalability, making it a viable solution for small and marginal farmers seeking dependable irrigation support without technological barriers.

Keywords: Smart irrigation, soil moisture sensor, Arduino, relay module

Chapter 1

INTRODUCTION

Agriculture has historically been the foundation of rural economies and continues to play a critical role in ensuring food security and economic stability. Despite advancements in farming techniques, irrigation practices in many developing regions still rely heavily on manual judgment, visual inspection of soil conditions, and traditional watering schedules. Such approaches often result in inefficient water usage, delayed irrigation, crop stress, and inconsistent agricultural yields. Water scarcity, coupled with rising demand, has further emphasized the need for intelligent water management solutions in agriculture.

Conventional irrigation systems demand continuous human supervision and timely decision-making, which becomes challenging for farmers due to labor constraints, lack of technical knowledge, and unpredictable climatic conditions. Many modern smart irrigation solutions available in the market rely on mobile applications, internet connectivity, and digital displays. While technologically advanced, these systems remain impractical for small and marginal farmers, especially in rural areas where digital literacy, stable electricity, and internet access are limited.

The objective of the **Smart Irrigation System** project is to design and implement a **simple, automatic, and reliable irrigation solution** that operates independently without the need for displays, smartphones, or web-based interfaces. The system utilizes real-time soil moisture sensing and basic control logic to automate the water supply efficiently. By removing complex user interaction, the design prioritizes accessibility and usability for farmers who may not be able to read or operate digital systems.

This project emphasizes **cost-effectiveness, ease of maintenance, robustness, and optimal water usage**, making it highly suitable for small-scale agricultural applications. The system demonstrates that meaningful automation can be achieved through minimal hardware and straightforward logic, aligning traditional agricultural practices with modern technological efficiency.

Brief History of Irrigation Systems

Historically, irrigation methods were developed based on geographical and climatic conditions. Early irrigation systems depended on canals, rivers, wells, tanks, and manually operated pumps. These methods required extensive human labor and offered limited control over water distribution. Seasonal dependency and water wastage were common drawbacks.

With technological progress, modern irrigation techniques such as **sprinkler irrigation** and **drip irrigation** were introduced, enabling better water distribution and reduced wastage. However, these systems largely depended on manual control and fixed schedules. Automation was limited due to high implementation costs, complex operation, and lack of technical awareness among farmers.

Modern Smart Irrigation Systems

Recent advancements in agricultural automation have led to the development of smart irrigation systems incorporating sensors, microcontrollers, and communication technologies. These systems aim to optimize water usage by responding dynamically to environmental parameters such as soil moisture, temperature, and rainfall. However, many existing solutions are heavily dependent on smartphones, cloud platforms, and continuous internet connectivity, making them unsuitable for rural and resource-constrained environments. This project addresses this gap by providing a standalone, sensor-based solution.

Chapter 2

Problem Statement

2.1 Description

In conventional farming practices, irrigation decisions are often made based on farmer experience rather than actual soil moisture conditions. This subjective approach

frequently results in over-irrigation, leading to water wastage and root damage, or under-irrigation, causing crop stress and reduced productivity. Although smart irrigation technologies exist, most are expensive, complex, and dependent on digital interfaces such as mobile applications and dashboards.

These limitations make existing systems impractical for illiterate farmers or those living in remote rural areas. There is a pressing need for a solution that delivers automation without technological complexity.

2.2 Challenge Statement

To design and develop a **low-cost, fully automatic irrigation system** that functions independently without any user interface, requires minimal human intervention, and ensures efficient water utilization based on real-time soil conditions.

2.3 Objectives of the Project

The primary objectives of the Smart Irrigation System project are:

- To design and implement an automatic irrigation system based on soil moisture levels
- To reduce water wastage by supplying water only when required
- To eliminate the need for continuous human monitoring and manual operation
- To develop a low-cost and easy-to-maintain solution suitable for small farmers
- To ensure reliable and consistent irrigation using simple hardware and control logic,

Chapter 3

3.1 Design Thinking Process

Empathize:
Direct interaction with local farmers highlighted key challenges such as difficulty in accurately judging soil moisture levels, dependency on manual labor, and inability to operate digital devices or applications.

Define:
Based on field observations, the primary requirements identified were simplicity of operation, automation, affordability, reliability, and minimal maintenance.

Ideate:

Several irrigation control concepts were explored, including timer-based irrigation, manual switching, and sensor-based automation. Sensor-based irrigation was selected due to its accuracy and responsiveness.

Prototype:

A working prototype was developed using a soil moisture sensor, Arduino microcontroller, relay module, and DC water pump to automate irrigation based on soil condition.

Test:

The system was tested under different soil moisture conditions and demonstrated consistent performance, automatic operation, and reliable control of the water pump.

3.2 Methodology

The soil moisture sensor continuously monitors the water content in the soil and sends analog signals to the microcontroller. When the moisture level drops below a predefined threshold, the microcontroller processes the input and activates a relay to turn ON the water pump. Once the soil reaches sufficient moisture, the system automatically deactivates the pump, thereby preventing over-irrigation.

3.3 Prototype Description

3.3.1 Materials Used

- Arduino Uno
- Soil Moisture Sensor
- Relay Module
- DC Water Pump
- Power Supply / Battery
- Connecting Wires

3.2 Technical Methodology

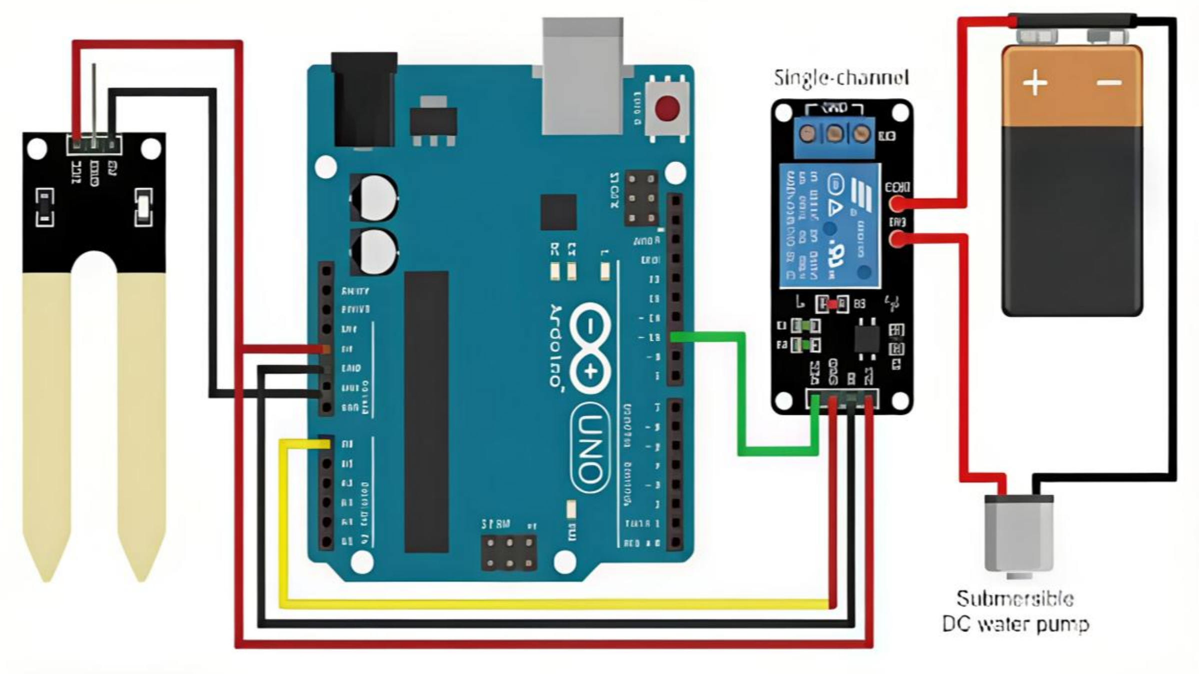
The system operates as a **closed-loop control system**, ensuring continuous feedback and automatic correction.

- **Sensing:** The soil moisture sensor continuously measures soil water content.
- **Logic:** The analog output from the sensor is read by the microcontroller.
- **Activation:** If the moisture level falls below the set threshold, a digital signal is sent to the relay module.
- **Action:** The relay switches ON the water pump.

Deactivation: Once adequate moisture is detected, the pump is automatically switched OFF

3.3.2 System Diagram

The soil moisture sensor is connected to the analog input pin of the microcontroller. The relay module is driven through a digital output pin to control the DC water pump. This configuration forms a reliable closed-loop automatic irrigation system.



Fig(1.0)

Control Strategy / Working Principle

The Smart Irrigation System follows a closed-loop control strategy based on real-time feedback from the soil moisture sensor. The sensor continuously monitors soil conditions and provides feedback to the controller. The control decision is made using a threshold-based approach.

If the sensed moisture value indicates dry soil, the controller initiates irrigation by switching ON the pump. As water is supplied, soil moisture increases, and once it crosses the predefined threshold, the controller automatically stops irrigation. This feedback-based control prevents both under-irrigation and over-irrigation, ensuring optimal water usage and healthy crop growth.

Chapter 4

Implementation

Hardware

The hardware implementation is centered around the Arduino Uno microcontroller. The soil moisture sensor acts as the primary input device, continuously monitoring soil conditions. The relay module functions as an interface between the low-voltage Arduino and the high-power DC water pump. Power is supplied using a battery or external power source, and all components are interconnected using standard jumper wires.

Software (Code)

```
int soilMoisturePin = A0; // Analog pin for soil moisture sensor
int relayPin = 7;         // Digital pin for relay module
int moistureValue = 0;
int threshold = 40;
  // Threshold value

void setup()
 {
  Serial.begin(9600);
  pinMode(relayPin, OUTPUT);
}

void loop()
{
  moistureValue = analogRead(soilMoisturePin);
  Serial.print("Moisture value: ");
  Serial.println(moistureValue);
  delay(1000);

  if (moistureValue < threshold)
 {
    digitalWrite(relayPin, HIGH);
    Serial.println("Soil is dry. Pump ON.");
  }
else
{
    digitalWrite(relayPin, LOW);
    Serial.println("Soil is moist enough. Pump OFF.");
  }
}
```

Chapter 5

Results and Analysis

Need for the Proposed System

Water is a critical but limited resource in agriculture, and inefficient irrigation practices significantly contribute to water scarcity. Traditional irrigation methods rely on fixed schedules or visual judgment, which often do not reflect the actual moisture condition of the soil. This leads to excessive watering, nutrient leaching, increased energy consumption, and reduced crop health. At the same time, delayed irrigation can cause plant stress and yield loss.

Although advanced smart irrigation systems are available, they are often expensive, complex, and dependent on smartphones, internet connectivity, and digital literacy. Such requirements make them impractical for small and marginal farmers in rural areas. Hence, there is a strong need for a **simple, low-cost, automatic irrigation system** that operates independently, conserves water, and does not require any user interaction. The proposed system directly addresses these challenges by using soil moisture–based control to ensure irrigation only when necessary.

Hardware Testing and Observations

- Automatic activation of the pump during dry soil conditions
- Immediate pump shutdown after sufficient moisture is reached
- Significant reduction in water wastage
- Stable and continuous system operation over extended periods

Photographs of the hardware setup and working prototype are included, along with a brief explanation of observed outputs. The results validate that the system fulfills all defined objectives effectively.

Scope of the Project

The scope of the proposed system defines its operational boundaries and applicability:

- The system is designed for **small-scale agricultural fields, gardens, and nurseries**

- It operates without mobile applications, displays, or internet connectivity
- Irrigation control is based solely on soil moisture sensing
- The system is suitable for rural and semi-urban environments
- The current design supports a single irrigation zone, with scope for future expansion

Applications

The Smart Irrigation System can be effectively used in:

- Small agricultural farms
- Home gardens and kitchen gardens
- Greenhouses and plant nurseries
- Plantation crops with controlled irrigation needs
- Educational institutions for learning automation concepts

Chapter 6

Conclusion and Future Work

The Smart Irrigation System successfully demonstrates an efficient, automatic irrigation mechanism using a simple hardware-based approach. It minimizes manual effort, reduces water wastage, and offers a highly practical solution for farmers with limited technical knowledge. The project proves that advanced automation does not necessarily require complex interfaces or high costs.

Advantages of the Proposed System

- Automatic operation reduces the need for manual intervention
- Significant reduction in water wastage
- Low cost and simple hardware design
- Easy installation and maintenance
- Suitable for farmers with limited technical knowledge
- Reliable and continuous operation

Limitations of the System

- The system uses only soil moisture as the control parameter
- Threshold values require manual calibration based on soil type
- Not suitable for large-scale farms without further expansion
- Does not consider weather conditions such as rainfall or temperature in the current version

Future Enhancements

- **Environmental Sensing:** Integration of a rain sensor to avoid irrigation during rainfall
- **Sustainability:** Solar-powered operation for remote and off-grid locations
- **Scalability:** Multi-zone irrigation control for diverse crop requirements
- **Communication:** GSM-based SMS alerts to inform farmers about pump status

Cost Analysis and Economic Feasibility

The proposed system is economically feasible due to its minimal hardware requirements. The approximate cost of components such as Arduino Uno, soil moisture sensor, relay module, and DC water pump is significantly lower than commercially available smart irrigation systems. Additionally, the reduction in water consumption and labor costs provides long-term savings, making the system affordable and sustainable for small and marginal farmers.

References

- Arduino Official Documentation
- Soil Moisture Sensor Datasheets
- Research Articles on Agricultural Automation

Annexures

- **Annexure A:** Hardware Photographs
- **Annexure B:** Arduino Source Code
- **Annexure C:** Testing Observations

Smart irrigation system with precision farming

Business model

1.Real-World Problem Definition

Problem Statement

Water is wasted in agricultural fields and home gardens due to manual irrigation and lack of real-time soil moisture monitoring. Farmers often irrigate crops on fixed schedules without knowing the actual water requirement of the soil, leading to over-watering, under-watering, increased electricity consumption, and reduced crop yield.

Evidence Collection

1.1. Survey Evidence

A survey conducted among local farmers and gardeners revealed:

Many farmers irrigate fields twice a day regardless of soil condition.

Over 65% of respondents do not use any soil moisture measurement tools.

Farmers reported high electricity bills due to unnecessary pump operation.

1.2. Interview Evidence

Interviews with small-scale farmers indicated:

Irrigation decisions are based on experience rather than data.

Farmers are often away from fields, causing pumps to run longer than required.

Crop damage occurs due to excess water, especially during rainy seasons.

1.3. Observation Evidence

Direct observations showed:

Water pumps running even when soil was already wet.

Overflow of water from fields leading to waterlogging.

Manual switching of motors causing human error and inefficiency.

2.Target Users and Beneficiaries

Who Faces the Problem

The problem of water and electricity wastage in irrigation is faced by:

Individual farmers practicing manual irrigation

Small and marginal farmers with limited resources

Home gardeners and greenhouse owners

Agricultural institutions managing large land areas

Rural communities dependent on groundwater for farming.

Who Will Benefit from the Solution

The Smart Irrigation System benefits:

Farmers by reducing water usage and electricity costs

Crops through optimal watering, improving yield and soil health

Communities by conserving groundwater resources

Governments by supporting sustainable agriculture initiatives

Customer Types

Individuals: Small-scale farmers, home gardeners

Institutions: Agricultural universities, research farms, government farms

Industries: Commercial farms, greenhouses, nurseries

Municipal / Government Bodies: Smart agriculture and water conservation projects.

3.unique value proposition

The Smart Irrigation System is an automated, sensor-based irrigation solution that supplies water only when crops actually need it, based on real-time soil moisture data. Unlike traditional timer-based or manual irrigation, this system eliminates guesswork and ensures precise water usage.

What Makes It Unique

Real-time soil moisture sensing instead of fixed irrigation schedules

Automatic pump control, reducing human involvement and errors

Low-cost and scalable design, suitable for small and large farms

Energy-efficient operation, minimizing unnecessary motor usage

Adaptable to different crops and soil types

Why Customers Should Choose It

Saves up to 40–60% water by avoiding over-irrigation

Reduces electricity consumption and pumping costs

Improves crop yield and soil health through optimal watering

Requires minimal maintenance and technical knowledge

Supports sustainable and smart farming practices

Innovation and Impact

Introduces data-driven irrigation to traditional farming

Promotes groundwater conservation

Helps farmers transition toward precision agriculture

Contributes to climate-resilient and eco-friendly farming

4.How the Smart Irrigation System Works

The Smart Irrigation System uses soil moisture sensors to continuously measure the water content in the soil. These sensor readings are processed by a microcontroller (such as Arduino), which compares the moisture level with a predefined threshold.

When the soil is dry, the system automatically switches ON the water pump using a relay module. Once the soil reaches the required moisture level, the pump is automatically switched OFF, preventing over-watering.

Key Features:

Automatic irrigation based on real-time soil moisture

Relay-controlled water pump

Reduces water and electricity wastage

Minimal human intervention

Technology Used :

Soil moisture sensor

Microcontroller (Arduino UNO)

Relay module

Water pump

Power supply

5. Key Activities

5.1. Product Design

Identifying user requirements (farm size, crop type, water source)

Designing system architecture (sensors, controller, relay, pump)

Developing circuit diagrams and system flowcharts

Writing and testing control algorithms for irrigation

Designing a compact, weather-resistant enclosure

5.2. Manufacturing

Sourcing electronic components (soil moisture sensors, microcontroller, relays)

PCB design and fabrication

Assembly of hardware components

Integration of sensors with control unit and pump

Packaging and quality inspection

5.3. Testing

Sensor calibration and accuracy testing

Functional testing of pump ON/OFF automation

Field testing under different soil and weather conditions

Power consumption and durability testing

Safety and reliability verification

5.4. Marketing and Sales

Identifying target customers (farmers, institutions, greenhouses)

Demonstrating product benefits through field demos

Partnering with agricultural stores and cooperatives

Digital marketing via websites and social media

Providing installation support and after-sales service

6. Critical Resources

6.1. Technical Resources

Hardware:

Soil moisture sensors

Microcontroller (e.g., Arduino UNO)

Relay module

Water pump and pipes

Power supply (battery / solar panel)

Connecting wires and protective enclosure

Software:

Embedded C / Arduino IDE for programming

Control algorithms for moisture-based decision making

Optional mobile or web interface for monitoring

Data logging and threshold configuration software

6.2. Human Resources

Electronics engineers for circuit and system design

Embedded software developers for programming and testing

Product designers for enclosure and usability

Field technicians for installation and maintenance

Agricultural experts for crop and irrigation guidance

6.3. Financial Resources

Funds for electronic components and manufacturing

Costs for prototyping, testing, and field trials

Marketing and distribution expenses

Maintenance and after-sales support costs

Support from government grants, agricultural subsidies, or startup funding

7.External Support

7.1. Suppliers

Electronic component suppliers for sensors, microcontrollers, relays, and pumps

Hardware distributors for pipes, valves, and irrigation accessories

PCB manufacturers and enclosure suppliers

These suppliers ensure quality components, cost reduction, and scalable production.

7.2. NGOs / Government Agencies

Ministry of Agriculture & Farmers Welfare for policy support and farmer outreach

NABARD for funding and rural deployment

Pradhan Mantri Krishi Sinchayee Yojana for irrigation subsidies

These bodies help in funding, awareness, and large-scale implementation.

7.3. Academic Institutions

Engineering colleges and agricultural universities for R&D support

ICAR for field trials and validation

Incubation centers in universities for mentoring and prototyping

Academic partnerships support innovation, testing, and skill development.

7.4. Industry Partners

Agri-tech companies for product integration and scaling

Irrigation equipment manufacturers for distribution networks

Renewable energy firms (solar solutions) for power integration

Industry partners enable market access, technical expertise, and commercialization.