AUTOMATED WATERING SYSTEM FOR EFFICIENT IRRIGATIONUSING ARDUINO

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ABSTRACT

In agriculture, it is very important for food production and also affects the economy of every nation in terms of its contribution toward Gross Domestic Production. Traditional methods, however, have concerns such as water waste in irrigation, dependency on non-renewable resources like fuel, coal, time, money, man labor, etc. Recently, with the increased demand for non-renewable power sources together with automation and digitalization, SMART agriculture is believed to be the most potential food production sector for the nation. SMART aims at developing the Smart Irrigation System using IoT (Internet of Things) technology. The main objective of the present endeavor is to automate the entire irrigation system in terms of water requirement of the crop by monitoring soil moisture and climatic condition, and to save water through its effective utilization. It also incorporates remote access of the irrigation system from the farmer's home using IoT technology. Hence, the farmer shall be facilitated with easy access of the irrigation system and thus be protected from the inclement weather of scorching heat and severe cold.

1. INTRODUCTION

Agriculture has been the treasure of human civilization since time immemorial. The phase of growing humanity with demand for sustainable, profitable, and environment-friendly agriculture has posed challenges to agriculture in recent years. In fact, smart farming has become one of the most influential unravelling forces, with Arduino Pro solutions opening new arenas of possibilities. With the capacity to control, analyse sensor data, and connect with the Cloud, Arduino Edge Control becomes an ideal candidate for providing agricultural applications with efficient management.

Irrigation refers to the artificial application of water to assure crop success in fields. Irrigation formed an integral part of agriculture over the last 5,000 years all over the world. In irrigation, mechanization is developing at a swift pace. The essence of efficiency in irrigation was due to modern declines in groundwater level. So, proper planning can be attributed to irrigation[1-24].

In turn, irrigation systems operate fully automated. In this case, the smart irrigation system uses an Arduino-Uno checking the moisture level of the soil. Sending alerts if the moisture level of the soil is too low, turning on the water motor for the water to flow into the soil. Agriculture is the major bone of a nation, particularly in terms of livelihood for its people and the provision of food and other raw materials for the industrial sector. Agricultural advancement is the backbone of an economy

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of a state country. Smart irrigation systems give you peace of mind in protecting your landscape investment.

2. LITERATURE SURVEY

[1] EFFECTIVE IRRIGATION SYSTEM USING IOT & ADVANCED ML (2025): This literature review analyzes 43 studies on IoT-based smart irrigation systems integrated with machine learning, published between 2017 and 2024. It highlights advancements in irrigation precision through predictive analytics, anomaly detection, and adaptive control. However, challenges such as data integration, network reliability, scalability, and the lack of standardization are identified. The review stresses the need for continued research to overcome these issues and improve the adoption and effectiveness of smart irrigation in diverse agricultural settings.

[2] LOW-COST IRRIGATION SYSTEM (2024): This research developed a low-cost smart irrigation system for tomato and melon crops in Tuscany, Italy, addressing water challenges due to climate change and population growth. Over three years (2021-2023), the system reduced water usage by 50% compared to conventional methods, demonstrating both economic viability and scalability. It enhances irrigation efficiency through advanced technologies like evapotranspiration models and wireless sensors, offering a sustainable solution for agriculture.

[3] SMART IRRIGATION SYSTEM USING IOT &MACHINE LEARNING METHODS (2023): This project introduces a smart irrigation system using IoT and machine learning to optimize water usage based on real-time data from sensors. It uses a "Crop Irrigation Scheduling" dataset for precise irrigation predictions, reducing water waste and boosting crop yield. The system features an intuitive API for easy monitoring and adjustments, proving effective in experimental results.

[4] SMART IRRIGATION SYSTEM (2022): This automatic irrigation system uses smart sensors (soil moisture, temperature, and water flow) integrated with an Arduino to control watering based on soil conditions. It automatically switches the pump on/off, with data recorded and analyzed on a computer. This system is ideal for small gardens, nurseries, and greenhouses, optimizing resource use and reducing costs.

[5] IOT BASED SMART IRRIGATION SYSTEM (2021) : The study represents a smart irrigation system that optimizes water use and boosts crop productivity, monitored through a Blynk cloud GUI. Over 7 days, 300 ml of water irrigated four sections of soil, maintaining 50% moisture, 29.89°C temperature, and 6 ppm ph. The Caixin Green Stem vegetable germinated in 7 days, which typically requires 8-12 days, outperforming traditional irrigation methods.

3. EXISTING SYSTEM

Automated irrigation systems have become essential in modern agriculture, landscaping, and greenhouse farming. These systems optimize water usage by delivering water to crops promptly, reducing waste, and improving plant health. Various technologies, including sensors, timers, controllers, and IoT-based solutions, are integrated to make irrigation more efficient and less labour-intensive. However, each system has unique features and certain limitations that affect its overall performance.

LIMITATIONS OF EXISTING SYSTEM:

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- **High Initial Cost** – Advanced automated irrigation systems require significant investment in sensors, controllers, and installation, making them expensive for small-scale farmers.
- **Sensor Accuracy Issues –** Soil moisture sensors may not always provide precise readings due to variations in soil composition, leading to overwatering or underwatering.
- **Limited Adaptability** – Some systems struggle to adapt to different soil types and weather patterns, reducing their overall efficiency.
- **Dependency on Power Supply** – Many automated irrigation systems require a continuous power source, making them less effective in areas with unreliable electricity.
- **Maintenance Challenges** – Regular maintenance is necessary to prevent clogging, sensor malfunctions, and wear-and-tear of components, which adds to operational costs.
- **Lack of Smart Integration** – Some traditional automated systems do not incorporate artificial intelligence or IoT connectivity, limiting their ability to optimize water usage dynamically.

4. PROBLEM STATEMENT

In a conventional irrigation system, saving water is usually not considered. Since the water is directly poured on the land causing a high stress level to plants due to variation in soil moisture, appearance of plants is reduced. The system has a lot of drawbacks because of the inability to control it automatically, leading to poor management systems for water. This growth is seen in countries that are deprived of water resources and are economically poor. And therefore, this is one major problem in the agriculture sector. Hence, we intend to develop a Smart Irrigation System IoT Architecture using Arduino microcontroller, which can sense the soil's moisture level and automatically switch ON/OFF the pumping motor to save water due to no interference from the farmer.

5. PROPOSED METHODOLGY

A proposed methodology for a smart irrigation system using Arduino would involve utilizing a soil moisture sensor to measure soil moisture levels, transmitting that data to an Arduino microcontroller which then analyzes the information and activates a water pump or valve to deliver water only when the soil reaches a predetermined dryness threshold, effectively optimizing water usage by only irrigating when necessary; this can be further enhanced by incorporating features like remote monitoring via a mobile app or web interface, weather data integration for more precise irrigation scheduling, and multiple sensor inputs for monitoring environmental factors like temperature and humidity.

- **Arduino Uno:**

  An open-source platform that consists of both a hardware programming circuit board (Micro controller) and a software programme (Integrated development Environment) on it.
  Arduino is an open-source electronics platform that uses simple hardware and easy software so that anyone can work with it. The Arduino Uno microcontroller is the main intelligent control unit for an automated irrigation system. It is straightforward for someone who has no experience in electronics to program and get the Arduino Uno working because it is very user-friendly. It has the capability of doing many things, so it is most appropriate when automating irrigation. It is built strongly enough to serve for a long period without being unreliable, so it is good enough to be used in agricultural applications.
- **Soil Moisture Sensor:**

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This soil moisture sensor (SMS) is a sensor connected to the irrigation system director for measuring soil moisture in the active root zone just before each planned irrigation event and skipping that event if the soil moisture is above a user-defined set point. The soil moisture sensor is an essential part of an automatic irrigation system that allows measuring soil moisture with precision. By using real-time data on soil hydration, the soil moisture sensor gives the Arduino Uno the decision-making capability for irrigation purposes. This effective device is simple to find and cheap; thus, it is available to farmers at all scales. Many factors like the kind of sensor, the material to be measured, and environmental conditions can affect the accuracy of moisture measurement.

- **Water Pump:**

  The automatic irrigation system uses a water pump as heart and soul to supply water to the plants wherever and whenever necessary. Use a battery-powered alternative or a 12V DC pump; the water pump synchronizes very well with the Arduino Uno, ensuring timely and effective irrigation. It will help to maintain the best moisture balance in the soil for better crops and yield.

- **12V Power Supply:**

  This 12V supply is the source of energy that will power the complete automated irrigation system. The power supply powers the Arduino Uno, the soil moisture sensor, and the water pump. This can be obtained from wall adapters or from batteries, as the power is supplied uninterrupted and consistently, since it ensures the optimal functionality of the system as a whole.

  The 12V power supply source of energy is that which runs the whole automatic irrigation system. It supplies power to the Arduino Uno, soil moisture sensor, and water pump; this power supply can be obtained easily from wall adapter or batteries. It therefore becomes beneficial for powering the entire system, as it keeps on functioning without interruption.

- **Relay:**

  Switches, which auto-expose and auto-close circuits mainly electro-magnetically control one electrical circuit's operations by opening and closing contacts in another circuit. Relay modules are often used on various applications to switch on or off high-power devices through a low-power microcontroller, e.g., controlling a light bulb from an Arduino using a relay module. The low-power signal species show that the relay module from an Arduino activates the high-power circuit controlling the lightbulb.

  For this reason, the relay module is also an important safety feature, maintaining isolation of the low-voltage Arduino Uno from the high voltage water pump. The relay module acts as an interface controller, controlling the water pump's switching on and off through the Arduino Uno safely. The puppetry of the relay provides protection and enhancing the microcontroller's durability alongside water pump control.

- **Temperature Sensor and Humidity Sensor**

  The DHT11 Temperature and Humidity Sensor generates a continuous digital signal carefully modulated in width for temperature and humidity sensing. This entire know-how ensures high accuracy and excellent long-term stability. A high-performance 8-bit microcontroller is interfaced with the sensor. The sensor resists the element and wet NTC temperature measuring devices. It is characterized by high performance, fast response time, interference resistance, and high-cost performance."

- **Jumper Wires:**

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Wires have great importance when connecting the different components of an automatic irrigation system. These simple, versatile, and cost-effective wires provide an extremely simple and effective way of achieving electrical connectivity between different components. This simplicity in use enables quick prototyping and modifications, making it an absolutely essential component during the development phase of the system.

- **Breadboard:**

  The breadboard provides an excellent medium for prototyping and assembling the automatic irrigation system. It has made connect-ing electronic components so easy that testing and altering can be done very rapidly. Their cheap cost and reusable nature have made them a very valuable asset for farmers and hobbyists testing and fine-tuning their irrigation systems.

ALGORITHM

```
    START
INITIALIZE soilSensorPin, waterPumpPin, alarmPin, waterLevelPin
SET moistureThreshold = 30
SET waterLevelThreshold = 20
SETUP:
  Configure waterPumpPin as OUTPUT
  Configure alarmPin as OUTPUT
  Begin serial communication
LOOP:
  Read soil moisture sensor value → sensorValue
  Convert sensorValue to percentage → soilMoisturePercent
  Print "Soil Moisture: soilMoisturePercent%"
   IF soilMoisturePercent < moistureThreshold THEN
      PRINT "Soil is dry, starting watering..."
      SET waterPumpPin HIGH (Turn ON the pump)
    ELSE
      PRINT "Soil is wet."
      SET waterPumpPin LOW (Turn OFF the pump)
    ENDIF
  Read water level sensor value → waterLevel
  Convert waterLevel to percentage → waterLevelPercent
```


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```
  Print "Water Level: waterLevelPercent%"
   IF waterLevelPercent <= waterLevelThreshold THEN
       PRINT "Tank is empty!"
       SET alarmPin HIGH (Turn ON alarm)
     ELSE
       PRINT "Tank is full."
       SET alarmPin LOW (Turn OFF alarm)
     ENDIF
WAIT 5 seconds
  REPEAT LOOP
END
```

6. FLOW DIAGRAM

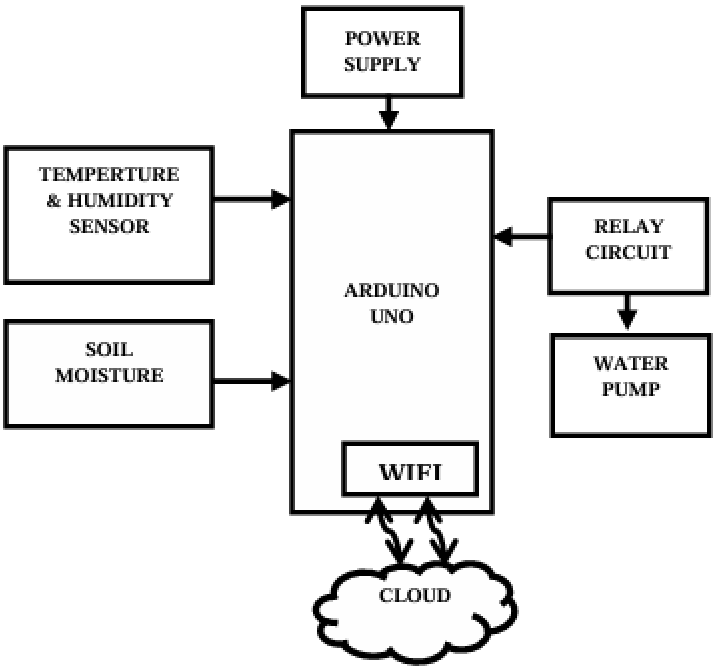

Fig 6.1: Flow diagram

7. IMPLEMENTATION

Benefits of this automatic irrigation system using Arduino Uno include the great use or advancement of precision agriculture towards better management of water and sustainability. Moisture sensor, which is at the heart of the system, continuously samples soil moisture levels and provides real-time feed to Arduino Uno, the control unit, on the level of moisture in the soil. The

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Arduino has been programmed to compare this moisture reading to the preset threshold that can be adjusted with the type of plant and environmental conditions. If the moisture level is lower than the threshold, then a relay module is activated by Arduino, and on activating water pump watering plants. When that enough amount of moisture is present in the soil, Arduino will automatically cut the pump supply to avoid watering, hence saving water resources.

This system operates in a continuous monitoring loop, optimizing water usage while minimizing irrigation costs. The automation reduces manual labor and ensures efficient irrigation, even in remote locations. The system is easy to assemble and maintain, making it a practical solution for farmers and gardeners. By integrating this Arduino-based irrigation system, agriculture moves toward a more sustainable future, improving crop yields, enhancing soil health, and promoting responsible water management. The technology empowers farmers with efficient, cost-effective irrigation control, reducing water wastage while maintaining optimal plant growth conditions.

SAMPLE CODE:

```
#include <LiquidCrystal_I2C.h>
LiquidCrystal_I2C lcd (0x27, 16, 2);
void setup() {
Serial.begin(9600);
lcd.init();
lcd.begin();
lcd.backlight();
lcd.clear();
pinMode(2, OUTPUT);
digitalWrite(2, HIGH);
delay(1000);
lcd.setCursor(0, 0);
 lcd.print("IRRIGATION");
lcd.setCursor(0, 1);
lcd.print("SYSTEM IS ON ");
lcd.print("");
delay(3000);
lcd.clear();
}
void loop() {
 int value = analogRead(A0);
Serial.println(value);
if (value >950){
digitalWrite(2, LOW);
lcd.setCursor(0, 0);
lcd.print("Water Pump is ON ");
}
 else {
digitalWrite(2, HIGH);
lcd.setCursor(0, 0);
lcd.print("Water Pump is OFF");
}
```


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```
if (value < 300) {
lcd.setCursor(0, 1);
lcd.print("Moisture : HIGH");
}
else if (value > 300 && value < 950) {
lcd.setCursor(0, 1); lcd.print("Moisture : MID ");
}
else if (value > 950) {
lcd.SetCursor(0, 1);
lcd.print("Moisture : LOW");
} }
```

8. RESULTS

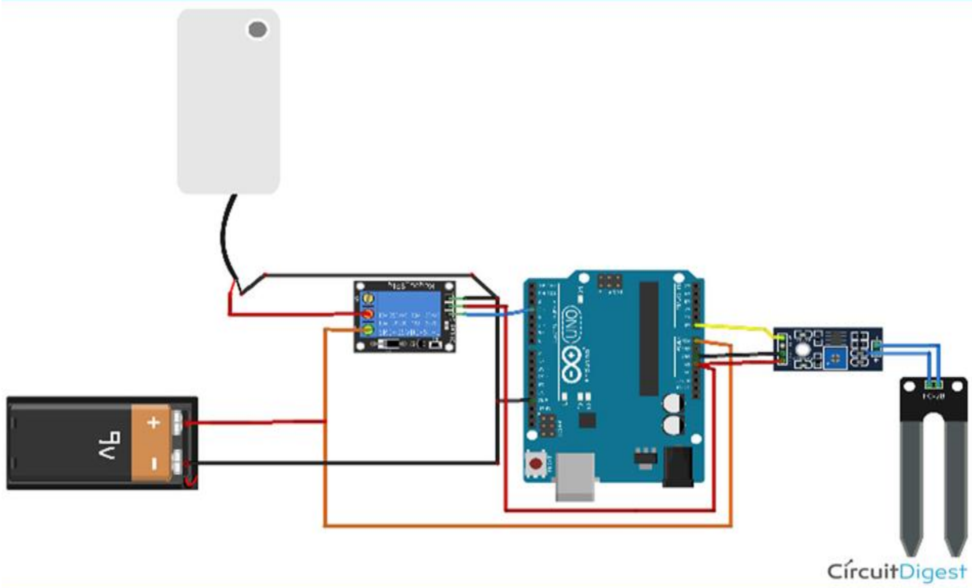

Fig 8.1

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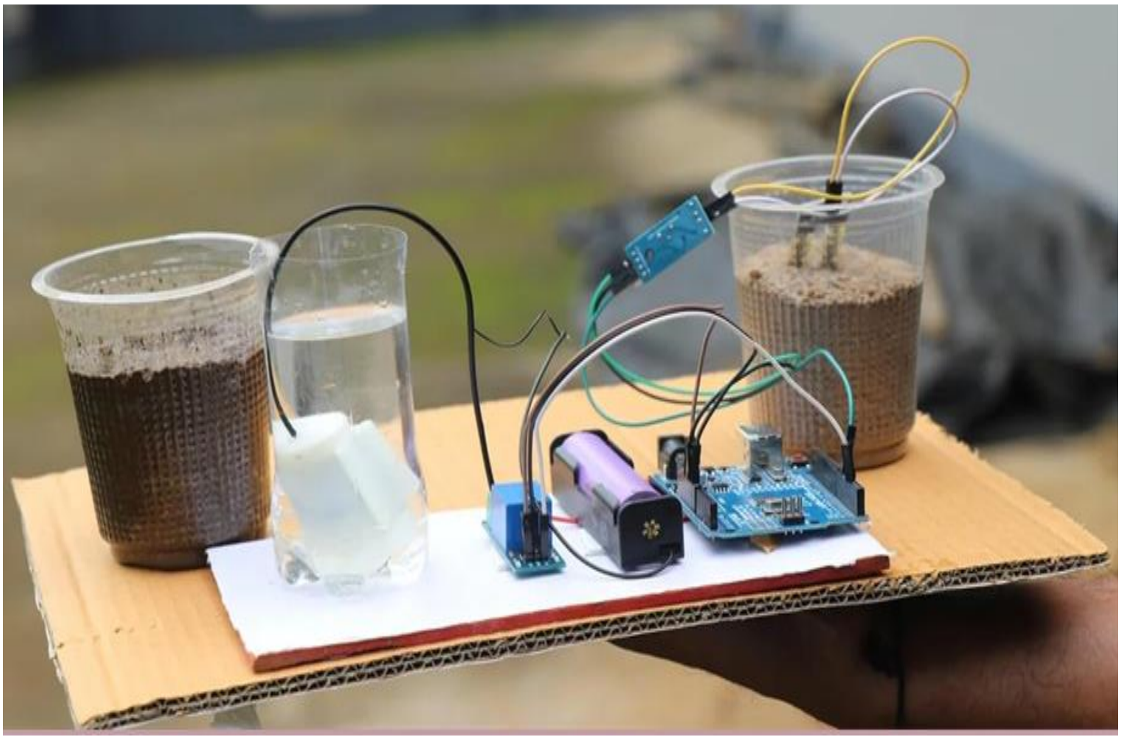

Fig 8.2

9. CONCLUSION

The key users of this project are farmers and gardeners suspended for not having enough time to attend to watering crops/plants. This also includes wasteful water usage by farmers during the process of watering their plants. Water scarcity and contamination would necessitate an increase in water-efficient irrigation in terms of the amount used during watering and, above all, minimizing the leached chemicals from the soil. Such recent technology developments in soil water sensing-now render the commercial application of the technology for automating irrigation management of vegetables possible. Studies' findings, however, show that all the sensor types provide performance under all conditions without negative effects on yield by reducing use of water from 70-100% compared with traditional practices.

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