**IoT-Based Soil Moisture and Temperature Monitoring System for Smart Irrigation**

**1. Introduction**

In modern agriculture, **water management** is one of the key factors that affect crop productivity and sustainability. Farmers often waste water by over-irrigating or suffer yield losses due to under-irrigation.  
To overcome this, **IoT-based smart irrigation systems** are developed, which monitor **soil moisture** and **temperature** in real-time and control irrigation automatically or remotely.

**2. Objective**

The main goal is to:

* **Monitor soil moisture and temperature levels** in agricultural fields using sensors.
* Use real-time data to **automate the irrigation process**.
* **Optimize water usage**, reduce manual labour, and increase crop yield through smart decision-making.

**3. Components Used**

| **Component** | **Function** |
| --- | --- |
| 🌡️ **Soil Moisture Sensor (e.g., YL-69)** | Measures the volumetric water content in the soil. |
| 🌡️ **Temperature Sensor (DHT11/DHT22)** | Measures ambient temperature and sometimes humidity. |
| 🧠 **Microcontroller (ESP8266/ESP32/Arduino Uno + Wi-Fi module)** | Collects data from sensors, processes it, and sends it to the cloud. |
| 🔌 **Relay Module** | Acts as a switch to turn ON/OFF the water pump. |
| 💧 **Water Pump / Solenoid Valve** | Controls water flow to the field. |
| 🌐 **Wi-Fi Connectivity** | Connects the microcontroller to the internet. |
| ☁️ **Cloud Platform (ThingSpeak, Blynk, Firebase)** | Displays real-time data and logs for analysis. |
| 🔋 **Power Source** | Battery or solar panel for remote operation. |

**4. Working Process**

**Step-by-step Operation:**

1. **Sensor Data Collection:**
   * The **soil moisture sensor** is placed in the field to continuously monitor moisture content.
   * The **temperature sensor** measures the environmental temperature.
2. **Data Processing by Microcontroller:**
   * The microcontroller reads the data from the sensors every few seconds.
   * It compares this data with **preset thresholds** (e.g., moisture < 30%).
3. **Automated Irrigation Decision:**
   * If the soil is dry (e.g., < 30% moisture) and the temperature is high (e.g., > 35°C), the microcontroller activates the **relay**, which powers the **water pump**.
   * Once optimal moisture is reached, the system turns the pump OFF.
4. **IoT Communication & Monitoring:**
   * The data is sent over Wi-Fi to a **cloud platform**.
   * The user can view **real-time graphs, temperature, moisture values**, and **pump status** from a smartphone or computer.
5. **Alerts and Remote Control:**
   * The system can send notifications (e.g., via Blynk app).
   * The farmer can override the system to **manually control irrigation** through an app.

**5. Block Diagram**

[Soil Moisture Sensor] ─┐

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[Temperature Sensor] ───┤

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[ESP32 / NodeMCU (Wi-Fi)]

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[Relay Module] ──> [Water Pump]

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[Cloud Server / App]

**6. Advantages**

1. **Water Conservation** – Water is used only when needed based on soil conditions.
2. **Increased Crop Yield** – Optimal watering improves plant health and growth.
3. **Remote Monitoring** – Farmers can track field conditions from anywhere.
4. **Automation** – Reduces manual labor and ensures timely irrigation even when the farmer is unavailable.
5. **Cost-Effective** – Reduces water and electricity bills by avoiding unnecessary watering.

**7. Example Scenario**

* Suppose a farmer grows tomatoes.
* He places soil moisture and temperature sensors in the field.
* The system is configured with the following thresholds:
  + **Moisture < 40%** → start irrigation
  + **Moisture ≥ 60%** → stop irrigation
* On a hot day, when the temperature reaches 38°C and the soil is dry (moisture 35%), the **system turns on the water pump** automatically.
* The pump runs for 10 minutes and then turns off once the soil reaches 60% moisture.
* The farmer gets a notification:  
  "Irrigation started at 12:15 PM, stopped at 12:25 PM. Current moisture: 62%"

**8. Possible Enhancements**

| **Feature** | **Description** |
| --- | --- |
| 📡 **Rain Sensor** | To avoid irrigation during rainfall. |
| ☁️ **Weather API Integration** | Use weather forecasts to plan irrigation in advance. |
| 📱 **Voice/AI Control** | Use Google Assistant or Alexa to control irrigation. |
| 🔁 **Machine Learning** | Predict water needs based on past trends and weather. |

**9. Conclusion**

This IoT-based system provides a **smart, sustainable solution for modern farming**. By automating irrigation using **soil moisture and temperature data**, the system ensures that crops get the right amount of water at the right time — saving resources and increasing productivity.

It is a perfect example of **precision agriculture**, combining **IoT, sensors, and automation** to meet agricultural challenges.