

IMPLEMENTATION OF IOT-BASED SMART IRRIGATION SYSTEM FOR CLIMATE RESILIENT

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Introduction:

Agriculture plays a vital role in sustaining human life, particularly in countries like India where a significant portion of the population relies on farming for their livelihood. However, with the growing impact of climate change, erratic weather patterns, and the increasing demand for food, traditional farming methods are no longer sufficient. Farmers now face the challenge of ensuring high productivity while managing resources efficiently and sustainably.

To address these challenges, the Internet of Things (IoT) has emerged as a transformative technology in the field of agriculture. The IoT-Based Smart Irrigation System project aims to revolutionize conventional farming practices by integrating advanced sensor technology, automation, and cloud computing. This system utilizes sensors to monitor key environmental parameters such as temperature, humidity, soil moisture, light intensity, and air quality. Data collected from these sensors is processed using an Arduino Uno microcontroller and analysed through platforms like the Arduino Cloud and Thing Speak.

Machine learning algorithms further enhance the system by enabling intelligent decision-making and crop recommendations based on real-time data. Additionally, an automated

irrigation feature ensures water is supplied only when the soil moisture drops below optimal levels, reducing water wastage and improving crop health.

By providing timely and accurate information to farmers, this system empowers them to take proactive measures to maintain healthy crops, increase yield, and adapt to changing climatic conditions. Ultimately, this project contributes to the vision of smart, climate-resilient, and sustainable agriculture.

Objectives:

To develop a smart irrigation system. The primary objective of this project is to develop an IoT-based smart irrigation system that enhances agricultural productivity by automating irrigation and monitoring environmental conditions. It aims to detect early-stage crop degradation using sensors that measure temperature, humidity, soil moisture, light intensity, and leaf color. The system leverages Arduino Uno and sensors such as DHT11, pH, LDR, and gas sensors for real-time data collection. This data is analyzed using machine learning algorithms to provide crop-specific recommendations. Another goal is to automate irrigation by activating water pumps based on moisture levels, ensuring efficient water use. The collected data is transmitted to the cloud via platforms like Thing Speak for visualization and monitoring. This empowers farmers to make informed decisions and adopt climate-resilient farming practices. Additionally, the system reduces dependency on manual labor and helps prevent plant diseases through early detection. The use of affordable technology ensures accessibility and scalability for broader agricultural applications. Overall, it aims to improve yield, conserve resources, and support sustainable agriculture.

Methodology:

The IoT-based Smart Irrigation System was developed to monitor plant health and optimize irrigation through real-time environmental data collection. The system architecture integrates multiple sensors, an Arduino UNO microcontroller, and cloud-based data analytics to achieve automation and decision-making.

Materials Used:

- **Arduino UNO** – central microcontroller
- **Sensors:**
 - **DHT11** for temperature and humidity
 - **Soil Moisture Sensor** for monitoring soil water levels
 - **pH Sensor** for soil health
 - **LDR** for light intensity
 - **TMP36** for leaf temperature
 - **Color Sensor** for analyzing leaf color
 - **Gas Sensor** for air quality
- **Tinker cad** – for circuit simulation
- **Thing Speak Cloud** – for real-time data collection, visualization, and analysis

Working Methodology:

- **Sensor Deployment:** All sensors were connected to the Arduino UNO. Environmental and crop health parameters were constantly monitored.
- **Data Collection:** Sensors collected temperature, humidity, light intensity, soil moisture, and leaf color data.
- **Data Transmission:** Using Wi-Fi modules, the data was sent to the ThingSpeak IoT cloud platform.
- **Analysis:** Cloud-based analytics assessed the sensor readings. If readings indicated stress or suboptimal conditions, alerts were generated.
- **Irrigation Control:** When the soil moisture sensor detected low levels, it triggered a motor to irrigate the field automatically.
- **Simulation:** A digital model using Tinkercad simulated the system's response to varying environmental inputs, ensuring feasibility before deployment.

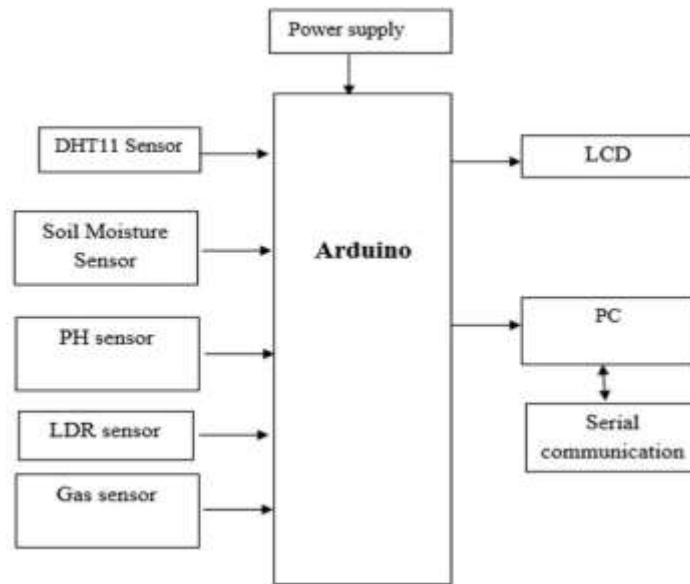


Figure.1. Block diagram of Smart Irrigation System

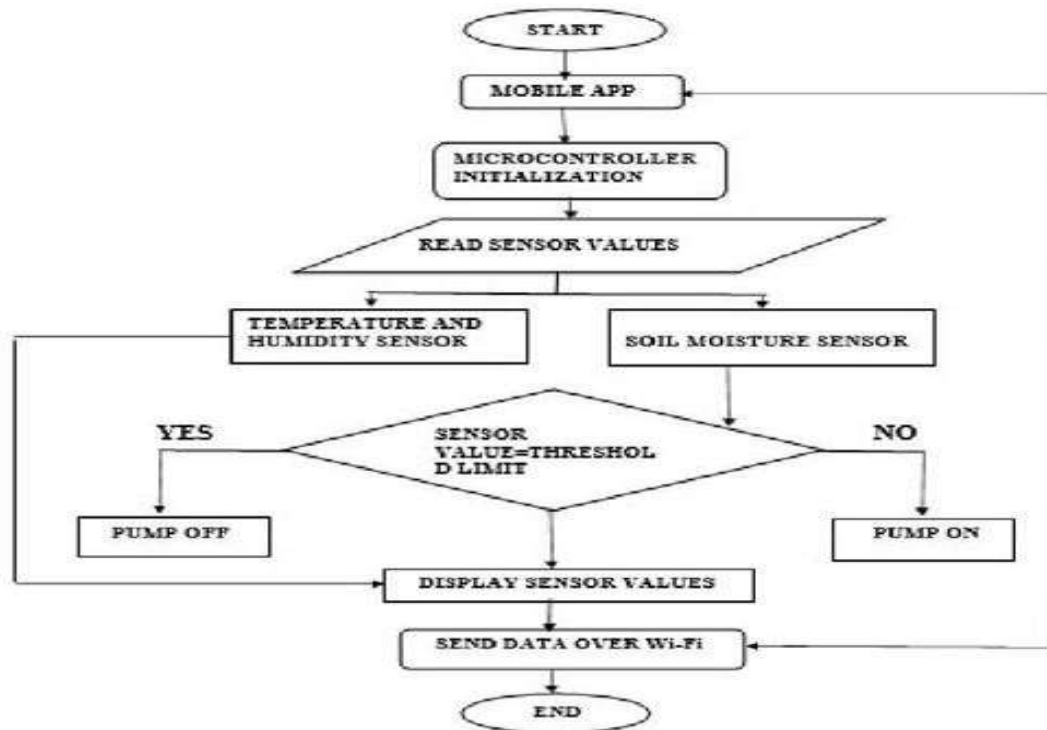


Figure.2. Flow chart of System

Results and Conclusions

The IoT-based smart irrigation system was successfully designed and implemented using Arduino Uno and multiple sensors, including soil moisture, temperature (DHT11 and TMP36), humidity, light intensity (LDR), and pH sensors. The system continuously monitored environmental conditions and sent real-time data to the ThingSpeak cloud platform. The use of Tinkercad simulation validated the accuracy and integration of sensors and ensured the reliable operation of the system before real-world deployment.

During testing, the system demonstrated effective irrigation control by automatically switching the water pump ON or OFF based on the soil moisture levels. As shown in the recorded data, the motor activation coincided with low moisture readings, and after irrigation, the moisture levels gradually increased, confirming the system's responsiveness. Graphs on the ThingSpeak platform provided a clear view of how environmental conditions varied over time and how the system reacted accordingly. The data collected also helped in identifying potential plant stress conditions. For example, fluctuations in temperature and humidity were monitored to ensure optimal crop growth conditions, while the LDR sensor provided insights into sunlight exposure. Additionally, the pH sensor indicated the acidity level of the soil, helping ensure that irrigation does not adversely affect soil quality. These features make the system suitable not just for irrigation but also for improving overall crop health.

In conclusion, the smart irrigation system presents a low-cost, energy-efficient, and automated solution that supports sustainable and climate-resilient farming. It minimizes water wastage, reduces the need for manual monitoring, and enables timely interventions. Future improvements may include real-world testing, integration of GSM modules for SMS alerts, and solar power support to make it more adaptable for rural and off-grid areas. The project lays a strong foundation for further innovations in smart agriculture.

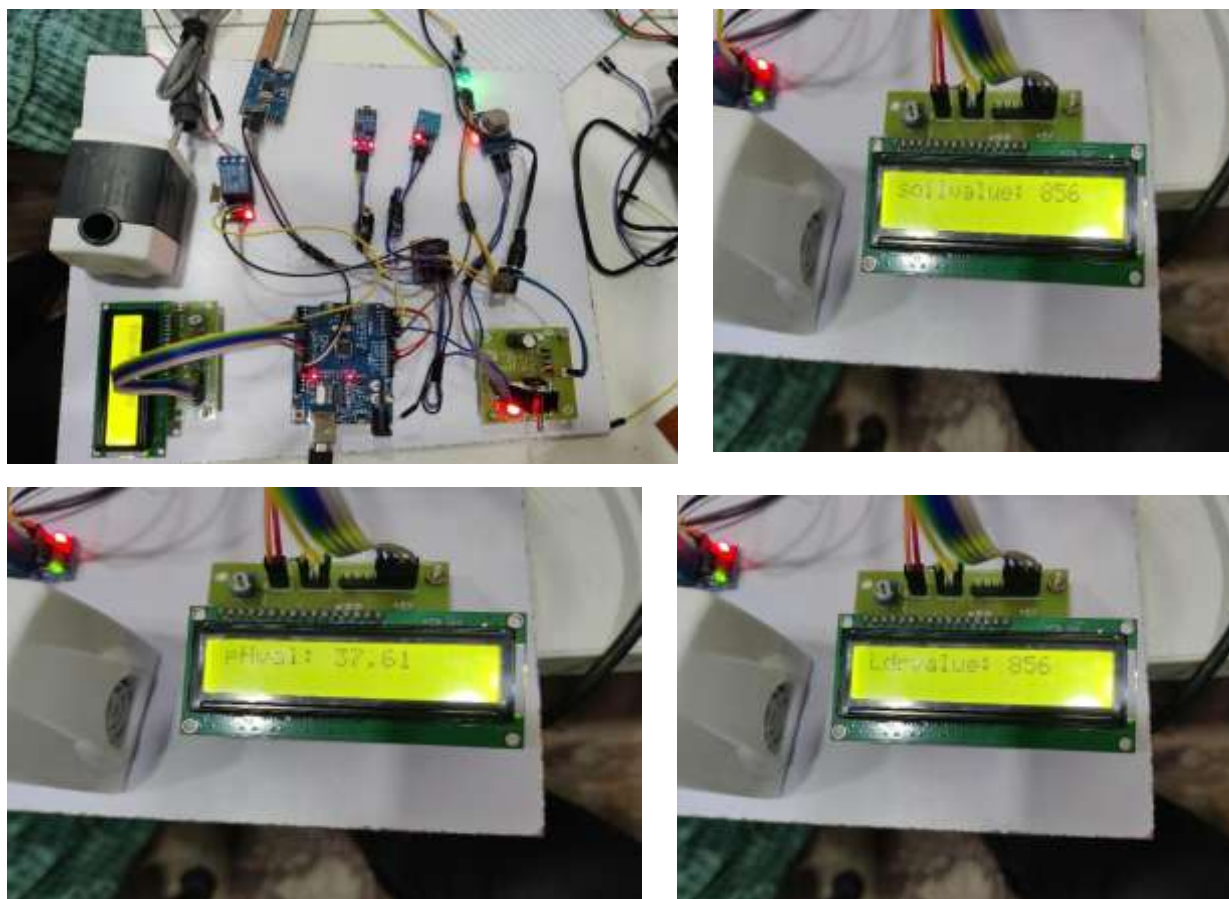


Figure 3. Outputs of Project

Scope for future work

The current system demonstrates a significant leap towards automated and climate-resilient agriculture. However, there are multiple avenues to expand and enhance its capabilities. One potential direction is the integration of image processing and AI-based disease detection using real-time leaf imagery, enabling earlier and more accurate identification of crop health issues. Incorporating GSM modules for SMS alerts would improve accessibility for farmers without constant internet access.

Future iterations could also support multi-crop systems by adapting irrigation parameters based on crop type and growth stage. Additionally, the use of drone-based aerial monitoring and remote sensing data could broaden the system's coverage to large-scale farms. Implementation of predictive analytics using historical weather and crop data can help forecast irrigation needs more accurately.

Furthermore, expanding the platform with a mobile application featuring a user-friendly interface for farmers would enhance real-time interaction and decision-making. Integration with blockchain technology could ensure transparent and secure data handling, especially useful in supply chain traceability.

Lastly, incorporating renewable energy sources such as solar panels can make the system more sustainable and feasible for deployment in remote or underdeveloped regions. With ongoing advancements in IoT and AI, the system holds immense potential to revolutionize modern farming practices and ensure food security amid changing climate conditions.