iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 13 **Issue:** IV **Month of publication:** April 2025

DOI: https://doi.org/10.22214/ijraset.2025.67949

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue IV Apr 2025- Available at www.ijraset.com

AGRI GUARD - Monitoring, Automating, and Sustaining your Crops

B. Anupama[1], Akhila .S[2], Sai Rithwik .R[3], Ruthikesh. P[4], Sejal .T[5]
Department of ECE, B.V. Raju Institute of Technology, INDIA

Abstract: Over the years, technological innovations have transformed multiple sectors, with agriculture emerging as a crucial field that demands modernization. Despite significant advancements in farming techniques, many small-scale farmers still rely on traditional methods that lack precision, leading to inefficient resource utilization and unpredictable crop health. Addressing this challenge, Agri Guard presents an intelligent, sensor-based agricultural monitoring system that enhances soil health analysis and disease detection while optimizing water usage. This project integrates a soil moisture sensor to automate irrigation, ensuring that crops receive adequate water without wastage. A DHT22 sensor monitors temperature and humidity levels, enabling farmers to assess environmental conditions that affect plant growth. Additionally, a CO_2 sensor detects changes in microbial activity, which can indicate the early onset of plant diseases, providing preemptive alerts. A GSM module acts as a bridge between the farm and the farmer, sending real-time data and alerts directly to a mobile phone, ensuring prompt action can be taken when necessary. By leveraging Arduino-based automation, Agri Guard eliminates the need for constant manual intervention, reducing labor costs while improving overall farm efficiency. The system's ability to provide real-time monitoring and automated responses makes it a valuable asset for farmers seeking to optimize productivity and safeguard crop health with minimal effort. This solution aligns with the modern vision of smart agriculture, where technology-driven farming practices ensure sustainability, efficiency, and improved yields.
Keywords: Smart Agriculture, Automated Irrigation, Soil Health Monitoring, CO_2-Based Disease Detection, GSM-Based Alerts.

I. INTRODUCTION

Agriculture faces challenges like inefficient irrigation, undetected soil issues, and high power consumption. Agri Guard addresses these by integrating automated irrigation, real-time monitoring, and solar-powered operation. A moisture sensor controls water supply, a CO_2 sensor detects plant diseases, and a humidity sensor monitors environmental conditions. A GSM module sends real-time alerts to farmers about soil health and potential crop threats. To enhance sustainability, Agri Guard incorporates a solar panel system, reducing reliance on external power and ensuring continuous operation. Controlled by an Arduino, the system is cost-effective, energy-efficient, and easy to implement. By combining smart farming with renewable energy, Agri Guard offers an innovative and eco-friendly solution for modern agriculture.

Keywords: Smart Farming, Automated Irrigation, CO_2 Sensor, GSM Alerts, Solar Power, Sustainable Agriculture

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II. LITERATURE SURVEY

The advancement of smart farming technologies has gained significant attention in recent years, with various studies highlighting the integration of automated irrigation, real-time soil monitoring, and early disease detection to enhance agricultural productivity.

A study by J. Smith et al. (2021) explored the role of sensor-based irrigation systems, emphasizing how soil moisture sensors help regulate water distribution efficiently, minimizing wastage. Similarly, Kumar & Patel (2020) examined the impact of temperature and humidity monitoring on plant health, demonstrating that continuous environmental tracking reduces the risk of crop damage caused by sudden climate variations.

Research conducted by Wang & Li (2019) investigated the use of CO_2 sensors in disease prediction, revealing that microbial activity affecting plant health can be detected through abnormal fluctuations in CO_2 levels. Furthermore, a study by Rodriguez et al. (2022) discussed the effectiveness of GSM-based communication in agriculture, enabling farmers to receive real-time alerts and take immediate action based on sensor data.

In addition, Miller & Thompson (2018) highlighted the benefits of Arduino-based automation in agriculture, showing how microcontrollers can efficiently handle multiple sensors and automate farm processes with minimal human intervention. Recent advancements in precision agriculture have also been documented by Singh & Mehta (2023), showcasing how affordable and accessible sensor technology is transforming traditional farming methods into data-driven smart agriculture solutions.

These studies collectively reinforce the importance of Agri Guard, an integrated system that combines automated irrigation, disease detection, and GSM-based alerts, providing farmers with a cost-effective, technology-driven approach to improving agricultural efficiency and sustainability.

A. *Existing System*

There Several smart farming technologies have been developed to enhance soil monitoring, irrigation automation, and disease detection. However, existing models often have limitations in terms of cost, complexity, or accessibility for small-scale farmers.

1) *Automated Irrigation Systems:* Traditional automated irrigation systems use soil moisture sensors to regulate water supply, ensuring crops receive adequate hydration. However, many existing models rely on IoT-based cloud computing, requiring internet connectivity, which is often unavailable in rural areas. Moreover, these systems can be expensive and require technical expertise for maintenance.
2) *Plant Disease Detection Using IoT:* Some advanced IoT-enabled models utilize sensors to detect plant diseases by analyzing temperature, humidity, and volatile organic compounds. While effective, these systems typically rely on machine learning algorithms and remote servers, making them less practical for farmers with limited technological knowledge.
3) *GSM-Based Farm Monitoring Systems:* Certain GSM-based systems send alerts regarding soil moisture levels and environmental conditions via SMS to farmers. However, these models often lack integration with disease detection sensors, limiting their ability to provide comprehensive farm monitoring beyond basic irrigation control.

While these existing models contribute significantly to modern agriculture, they often come with high costs, complex installation requirements, and reliance on external networks. Agri Guard addresses these gaps by providing a cost-effective, standalone solution that integrates moisture sensing, disease detection, and GSM-based alerts—ensuring an affordable, efficient, and accessible approach to smart farming.

Feature	Existing Models	Agri Guard (Our Project)
Irrigation Control	Uses soil moisture sensors, but many require internet-based IoT systems, increasing complexity.	Uses a simple moisture sensor with automatic pump activation, working without internet dependency.
Disease Detection	Some systems rely on AI-based image recognition, requiring costly hardware and high processing power.	Uses a CO_2 sensor to detect microbial activity, enabling early disease detection with minimal cost.
	Operates on grid electricity, increasing operational costs and dependency on external power sources.	Powered by a solar panel system, ensuring energy efficiency and self-sufficiency, even in remote areas

Feature	Existing Model	AgriGuard.
Communication System	IoT-based models often use cloud platforms or smartphone apps, requiring internet access.unsuitable for small-scale farmers.	Utilizes a GSM module to send real-time SMS alerts, making it functional even in low-connectivity regions.
Cost-Effectiveness	High initial and maintenance costs due to complex IoT setups and expensive components..	Low-cost solution using Arduino-based automation, making it affordable for small-scale farmers
Sustainability	Consumes high energy due to constant electricity dependency.	Solar-powered, making it an eco-friendly and cost-saving solution.

III. METHODOLOGY

A. *Soil Moisture Sensing and Automated Irrigation*

Efficient water management is a crucial aspect of modern agriculture, ensuring optimal crop growth while minimizing water wastage. The Agri Guard system integrates a soil moisture sensor to continuously monitor the moisture levels in the soil. This sensor detects the percentage of water content and transmits real-time data to the Arduino-based control unit.

When the soil moisture level falls below a predefined threshold, the system automatically activates a water pump, ensuring the crops receive adequate water. Once the moisture content reaches the required level, the pump is turned off to prevent over-irrigation. This automated process eliminates the need for manual supervision, thereby enhancing efficiency and conserving water resources.

The use of soil moisture sensors allows farmers to optimize irrigation schedules, reducing water wastage and ensuring crops receive water only when necessary.

This method not only improves agricultural productivity but also contributes to sustainable water management practices. By automating irrigation, the system significantly reduces labor costs and ensures consistent watering, leading to healthier plant growth and improved crop yields.

B. *Temperature and Humidity Monitoring*

Monitoring environmental conditions such as temperature and humidity is crucial for maintaining optimal crop health and preventing unfavorable farming conditions. The Agri Guard system incorporates a DHT22 sensor, which accurately measures both temperature and humidity levels in real time.

This sensor provides continuous updates, helping farmers make informed decisions regarding irrigation, ventilation, and overall farm management. The collected data is displayed on an LCD screen connected to the Arduino board, allowing farmers to monitor changes instantly. Additionally, if humidity levels drop too low or rise excessively, necessary alerts can be generated via the GSM module, notifying the farmer remotely. This proactive approach helps in preventing plant stress, optimizing growth conditions, and reducing the risk of disease outbreaks caused by high humidity.

By integrating automated temperature and humidity monitoring, the system enables precision farming, allowing farmers to adjust their strategies based on real-time climate data. This results in better crop resilience, enhanced productivity, and improved resource management, making farming more efficient and sustainable.

C. Soil Moisture Detection and Automated Irrigation

Water management is a critical aspect of modern agriculture, ensuring that crops receive adequate moisture without excessive wastage. The Agri Guard system integrates a soil moisture sensor to monitor the water content in the soil and automate the irrigation process accordingly.

The moisture sensor continuously measures the soil's moisture levels and sends data to the Arduino board. When the moisture level falls below a pre-set threshold, the Arduino automatically activates a water pump to irrigate the field. Once the required moisture level is reached, the pump is turned off, preventing over-irrigation and saving water.

This automated irrigation system helps in maintaining optimal soil moisture levels, reducing manual labor, and minimizing water wastage. By ensuring crops receive the right amount of water at the right time, this system promotes better plant growth, increases yield, and enhances overall farm efficiency.

Additionally, the GSM module can be used to notify farmers about the irrigation status through text alerts, allowing them to monitor and control the system remotely. This smart approach to irrigation enhances productivity while making farming more sustainable and cost-effective

D. Environmental Monitoring Using Temperature, Humidity, and CO_2 Sensors

Monitoring environmental conditions is essential for maintaining healthy crop growth and detecting potential plant diseases early. The Agri Guard system integrates a temperature and humidity sensor (DHT22) along with a CO_2 sensor to provide real-time data on the farm's environmental conditions. The DHT22 sensor continuously measures air temperature and humidity levels. This data helps farmers understand the microclimate of their fields, enabling them to make informed decisions about irrigation, ventilation, and crop protection. Sudden temperature fluctuations or excessive humidity can lead to plant stress or disease outbreaks, which can be mitigated with timely interventions.

The CO_2 sensor detects carbon dioxide levels in the soil and surrounding air, which serves as an indicator of microbial activity. An unusual rise in CO_2 levels may signal early-stage plant infections, soil degradation, or pest infestations. By continuously tracking CO_2 concentration, farmers can take proactive measures to prevent crop loss and improve soil health.

All collected data is processed by the Arduino board, which can trigger alerts via the GSM module, notifying farmers about critical environmental changes. This automated monitoring system minimizes manual efforts and enables precision farming, ensuring better yields and sustainable agricultural practices.

E. Automated Irrigation System Using Moisture Sensor

Efficient water management is crucial for sustainable agriculture. The Agri Guard system utilizes a moisture sensor to monitor soil moisture levels and automatically control water supply. The sensor detects soil dryness and sends data to the Arduino microcontroller, which then activates or deactivates the water pump accordingly.

When the soil moisture falls below a predefined threshold, the Arduino triggers the pump to irrigate the field. Once optimal moisture levels are restored, the pump automatically switches off, preventing over-irrigation and conserving water resources. This automation reduces the need for manual supervision, optimizes water usage, and ensures crops receive adequate hydration, promoting healthy growth.

By implementing precision irrigation, the Agri Guard system not only saves water but also enhances crop yield by preventing under- and over-watering. This smart irrigation approach is particularly beneficial in regions facing water scarcity, helping farmers maximize productivity while minimizing resource consumption.

F. Remote Monitoring and Alerts Using GSM Module

To ensure real-time monitoring and remote farm management, the Agri Guard system is equipped with a GSM module that allows wireless data transmission. This module enables the system to send alerts and updates to farmers via SMS or mobile notifications, providing insights into environmental conditions and irrigation status.

Whenever the system detects low soil moisture, extreme temperature fluctuations, high CO_2 levels, or irrigation activation, it sends an instant alert to the farmer's mobile device. This proactive notification system helps farmers respond quickly to changing conditions, reducing the risk of crop damage and improving overall farm management.

The GSM module eliminates the need for constant manual supervision, making it particularly useful for large farmlands and remote agricultural areas. With real-time updates, farmers can make informed decisions from anywhere, ensuring that their crops receive timely care without requiring their physical presence.

G. Sustainable Power Supply Using Solar Energy

To enhance energy efficiency and reduce dependency on conventional electricity sources, the Agri Guard system integrates a solar power supply. A solar panel unit provides electricity to the entire system, ensuring continuous operation without reliance on external power sources.

The solar panel charges a battery, which powers the Arduino, sensors, GSM module, and water pump. This setup ensures uninterrupted functionality, even in regions with frequent power outages. By utilizing renewable solar energy, the system significantly reduces electricity costs and contributes to eco-friendly, sustainable farming practices.

The adoption of solar energy aligns with the global push toward green technology in agriculture. By leveraging clean and renewable energy sources, Agri Guard helps farmers reduce their carbon footprint while maintaining efficient and automated farm management.

IV. ANALYSIS AND DESIGN

A. Hardware Design

The hardware design of Agri Guard is structured to ensure efficient soil monitoring, automated irrigation, and real-time alerts. The system consists of essential components such as the Arduino microcontroller, moisture sensor, temperature and humidity sensor (DHT22), CO_2 sensor, GSM module, water pump, and a solar panel system.

The block diagram (Fig 4.1) illustrates how different sensors interact with the Arduino microcontroller to gather data and automate irrigation based on2 soil moisture levels. The GSM module transmits alerts to farmers, while the solar panel provides a sustainable energy source to power the entire system.

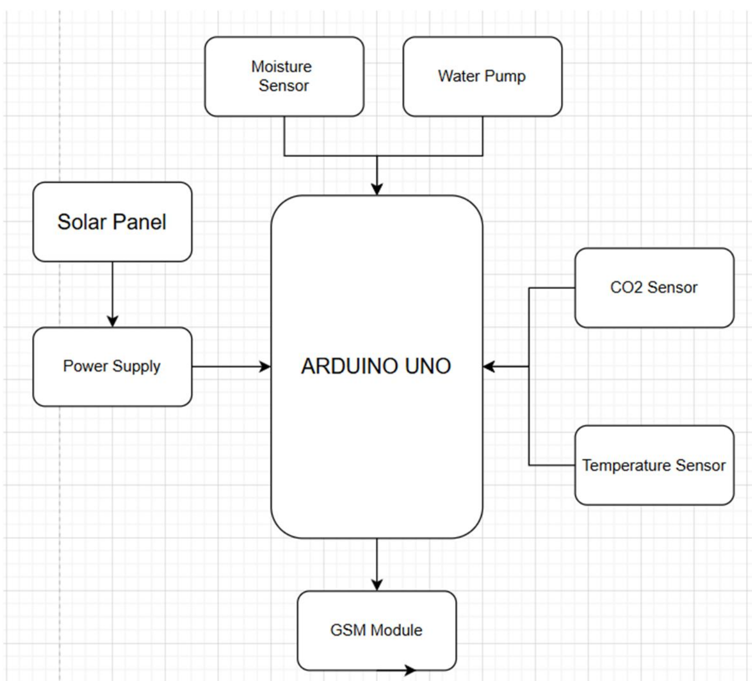

Fig 4.1 Block Diagram

B. Arduino Microcontroller

The Arduino is the central processing unit of Agri Guard. It collects data from various sensors and controls the irrigation system based on real-time soil moisture readings. The Arduino board is widely used for embedded systems due to its affordability, flexibility, and ease of programming.

- Receives input from soil moisture, temperature, and CO_2 sensors
- Processes the collected data and triggers the water pump when needed
- Communicates with the GSM module to send alerts to farmers
- Operates efficiently with a solar-powered energy system

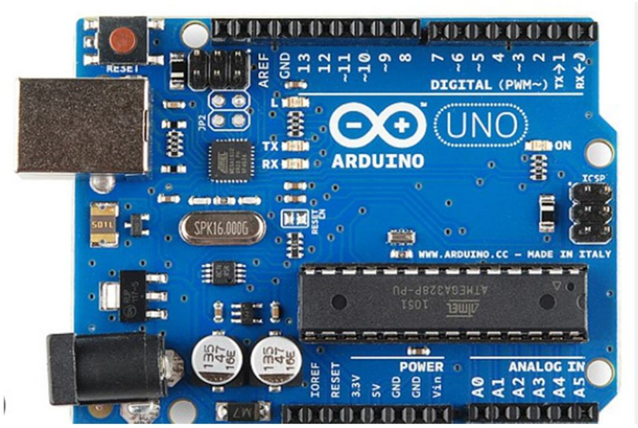

FIG 4.1 Arduino UNO

C. Soil Moisture Sensor

The soil moisture sensor continuously monitors the water content in the soil. It plays a critical role in the automated irrigation system by ensuring crops receive adequate hydration without wastage. The sensor detects moisture levels and sends signals to the Arduino, which then determines whether to activate or deactivate the water pump.

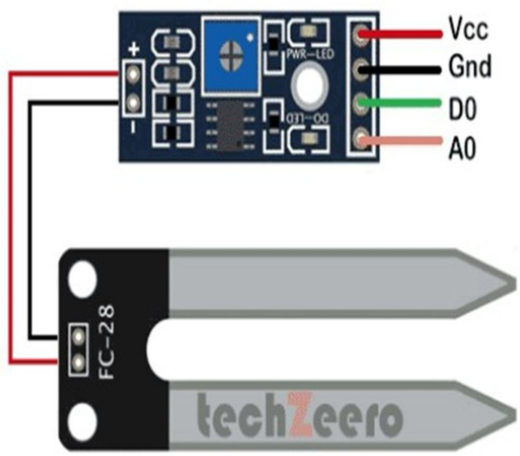

Fig 4.1.2 Soil Moisture Sensor

D. CO_2 Sensor

The CO_2 sensor detects changes in carbon dioxide levels, which can indicate microbial activity in the soil. This feature allows early detection of soil health issues, including potential diseases or imbalances in microbial ecosystems.


Fig 4.1.3 CO_2 Sensor

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
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E. Temperature and Humidity Sensor (DHT22)

The DHT22 sensor measures air temperature and humidity, providing valuable data for assessing weather conditions that affect soil moisture and crop health. This sensor helps farmers make informed decisions about irrigation and other agricultural activities.

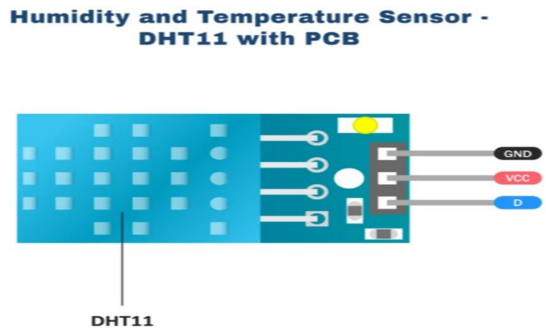

Fig 4.1.4 Temperature & Humidity Sensor

F. GSM Module for Alerts

The GSM module enables remote monitoring and real-time notifications. Whenever soil conditions change beyond predefined limits (e.g., low moisture, extreme temperatures, high CO_2 levels), the GSM module sends an SMS alert to the farmer's mobile device. This ensures quick response and proactive farm management.

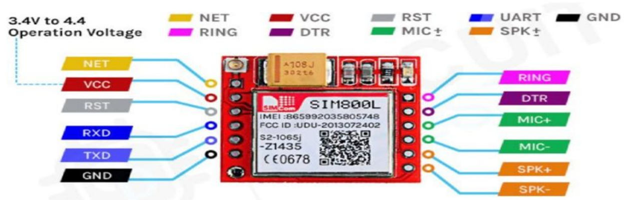

Fig 4.1.5 GSM Module

G. Solar Panel System

To make the Agri Guard system energy-efficient and environmentally friendly, a solar panel system is integrated. The solar panel:

- Powers the Arduino board, sensors, GSM module, and water pump
- Charges a battery for continuous operation, even during cloudy conditions or nighttime
- Reduces reliance on conventional power sources, lowering operational costs

By utilizing renewable energy, Agri Guard ensures sustainable farming practices while minimizing electricity consumption.

Fig 4.1.6 Solar Panel System

V. IMPLEMENTATION

A. Working Algorithm

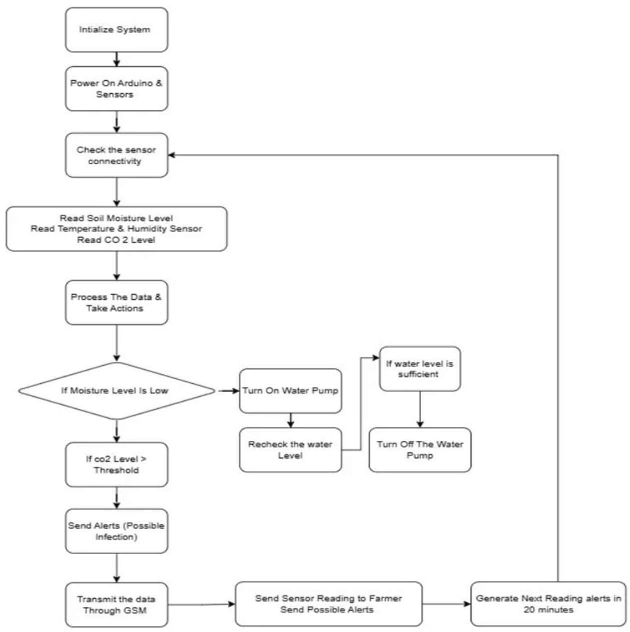

Fig 5.1.1 Working Algorithm Of Trinetra

The working algorithm of Agri Guard can be summarized as follows:

1) Initialize System: Start the Arduino-based system and ensure that all components are powered on.
2) Sensor Activation: Activate the sensors—moisture, temperature & humidity (DHT22), and CO_2 sensors—and check their connectivity.
3) Data Collection: Read soil moisture level, temperature, humidity, and CO_2 levels sequentially.
4) Process Data: Analyze the data from sensors to determine the current conditions of the farm environment.
5) Decision-Making:
   - If soil moisture is low, turn on the water pump and recheck moisture levels periodically.
   - If CO_2 levels exceed the threshold, trigger an alert for possible infections.
6) Alert Transmission: Send the sensor readings and alerts to the farmer via a GSM module.
7) Next Reading Interval: Wait for 20 minutes before repeating the cycle.

B. Installation of Required Libraries

To implement Agri Guard, you need to install specific libraries for interfacing with the sensors and the GSM module. The libraries used in this project include:

1) Arduino IDE

- Ensure that the Arduino IDE is installed on your system.
- Update the IDE to the latest version for better compatibility.

2) DHT Sensor Library

- Install the Adafruit DHT sensor library for reading temperature and humidity.
- Steps:
  - Open the Arduino IDE.
  - Navigate to Sketch > Include Library > Manage Libraries.
  - Search for "DHT Sensor Library" by Adafruit and click "Install."

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```
#include <DHT.h>
#include <SoftwareSerial.h>
```

3) *SoftwareSerial Library*
- This library is required for communication with the GSM module.
- It comes pre-installed with the Arduino IDE.

```
#ifndef SoftwareSerial_h
#define SoftwareSerial_h

#include <inttypes.h>
#include "Arduino.h"
```

4) *GSM Module Library*
- Download and install a GSM module library to send SMS alerts.
- Steps:
  - Visit the Arduino GSM library repository.
  - Download and add it to your Arduino IDE (Sketch > Include Library > Add .ZIP Library).

```
#ifndef GSMModule_h
#define GSMModule_h

#include <SoftwareSerial.h>
```

5) *Moisture Sensor Code Setup*
- Use analog pins to read moisture sensor data.
- No additional library is required for the soil moisture sensor.

C. Setting up the Hardware

1) Power the Arduino
- Connect the Arduino board to a power source using a USB cable or an external power supply.

2) Connect the Sensors
- Moisture Sensor: Attach the sensor to an analog input pin on the Arduino.
- DHT22 Sensor: Connect the data pin of the DHT22 sensor to a digital input pin.
- CO2 Sensor: Link the CO2 sensor to another analog or digital input pin.

3) Connect the GSM Module
- Use the SoftwareSerial pins to interface the GSM module with the Arduino.
- Ensure proper antenna attachment for signal reception.

4) Water Pump Setup
- Connect the water pump to a relay module, which is controlled by a digital output pin from the Arduino.

5) Test Connections
- Verify that all sensors and modules are correctly connected and powered.

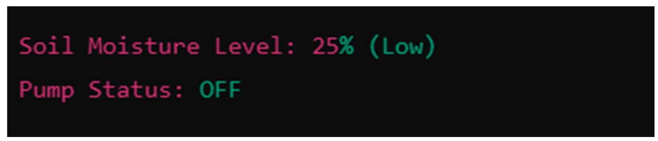
VI. RESULTS

After implementing the Agri Guard project, the results align with the expected outcomes, demonstrating successful functionality of the system.

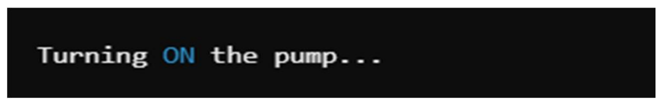
A. Sensor Readings Display

Output: Real-time values of soil moisture, temperature, humidity, and CO2 levels displayed on the serial monitor or an attached LCD screen.

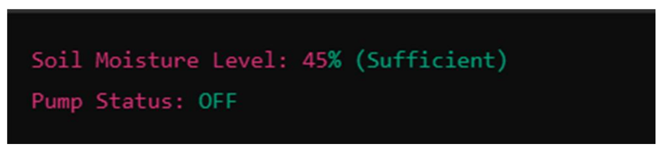
Initial State :



Action :



Final State :



- If the soil reaches the desired moisture level:
    - Pump turns off.

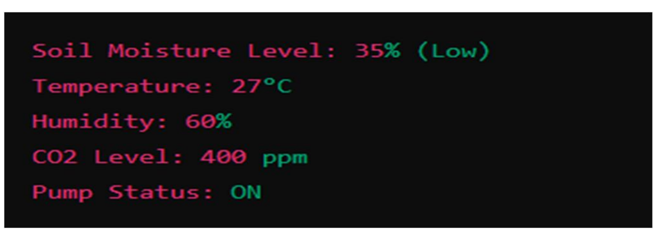
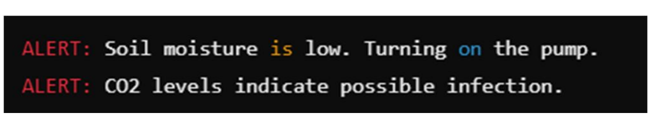


Fig 6.1 Soil Moisture and Environmental Readings Captured by Sensors

As shown in **Fig 6.1**, the sensors successfully captured real-time environmental data, including soil moisture, temperature, humidity, and CO_2levels. These readings were processed by the Arduino and analyzed to determine the appropriate actions, such as activating the water pump

- Alerts on the serial monitor or sent via GSM:



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B. Water Pump Operation

- Output: When soil moisture falls below the threshold:
  - The pump automatically turns on.

After implementation, the results must be observed so that they are in the line of the expected.

1) Alert Messages via GSM

- Output: SMS alerts to the farmer's phone for low soil moisture, high CO2 levels, and status updates

Soil Moisture Alert:

```
Soil moisture is low. Pump activated.
```

CO2 Infection Alert:

```
High CO2 levels detected. Possible infection.
```

Status Update :

```
Sensor readings:
Soil Moisture: 40% (Sufficient)
Temperature: 26°C
Humidity: 65%
CO2 Level: 390 ppm
Pump Status: OFF
```

2) Real-Time LCD Output

- **Output**: Data displayed on the LCD connected to the Arduino for easy local monitoring.

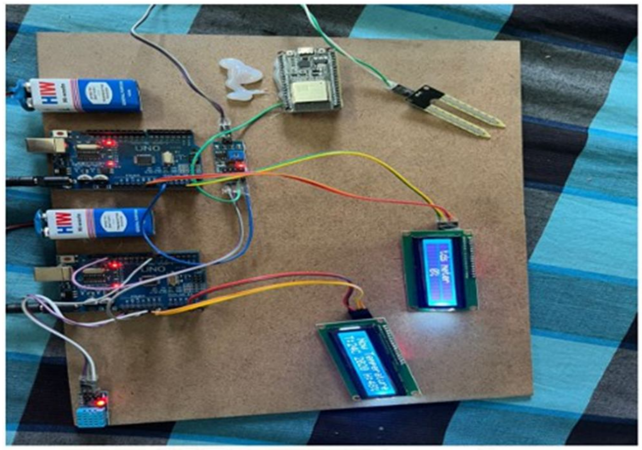
```
Agri Guard System
-----------------
Temp: 27°C  Humidity: 60%
Soil Moisture: 30%
CO2 Level: 450 ppm
Pump: ON
```

3) Power Supply Monitoring

- **Output**: If powered by a solar panel, an indicator of the solar panel's health and battery levels can be shown.

```
Solar Power Status: Normal
Battery Level: 80%
```

4) Hardware Setup Output



5) Applications

Various applications of Agri Guard can be observed as follows:

a) Precision Farming

The primary focus of Agri Guard is to assist farmers in achieving precision farming by monitoring real-time soil health and automating essential processes. For instance, when the system detects low soil moisture, it triggers the irrigation system, ensuring crops receive adequate water without wastage. Similarly, by monitoring temperature, humidity, and CO_2levels, Agri Guard ensures early detection of infections or unfavorable environmental conditions, allowing farmers to take preventive measures.

b) Sustainable Agriculture

Agri Guard promotes sustainable agricultural practices by utilizing solar energy to power the system, reducing the carbon footprint. It optimizes resource usage like water and electricity by automating irrigation and only activating it when required. This approach ensures conservation of resources while enhancing agricultural productivity.

c) Smart Alerts for Farmers

The system sends real-time alerts to farmers via GSM, keeping them updated about their farm conditions regardless of their location. For example, Agri Guard can notify the farmer about critical conditions like insufficient soil moisture or increasing CO_2 levels, enabling timely intervention. This enhances farm management efficiency and reduces crop losses.

VII. CONCLUSION

With advancements in technology, solutions like Agri Guard are paving the way for smart and sustainable agriculture.

Agri Guard is a cost-effective, user-friendly system that leverages advanced sensors and automated processes to enhance agricultural productivity. Its ability to monitor soil health, detect environmental changes, and automate irrigation ensures minimal manual intervention and maximum efficiency. By utilizing renewable solar energy, Agri Guard also contributes to environmental sustainability, making it a valuable asset for modern agriculture.

Agri Guard is designed to be highly scalable, allowing farmers to integrate additional sensors and features as needed. With its potential to improve resource management, increase yield, and minimize waste, Agri Guard demonstrates its significance as an innovative project for the agricultural sector.

A. Future Work

Agri Guard can be enhanced with further upgrades in hardware and software. Future iterations may include IoT integration to enable remote monitoring via smartphones, advanced AI-based analysis to predict weather patterns and crop diseases, and the inclusion of pest detection sensors. Additionally, integrating GPS modules can aid in mapping the entire farm and providing location-based insights. With such advancements, Agri Guard has the potential to transform traditional farming practices into a fully automated and data-driven system.

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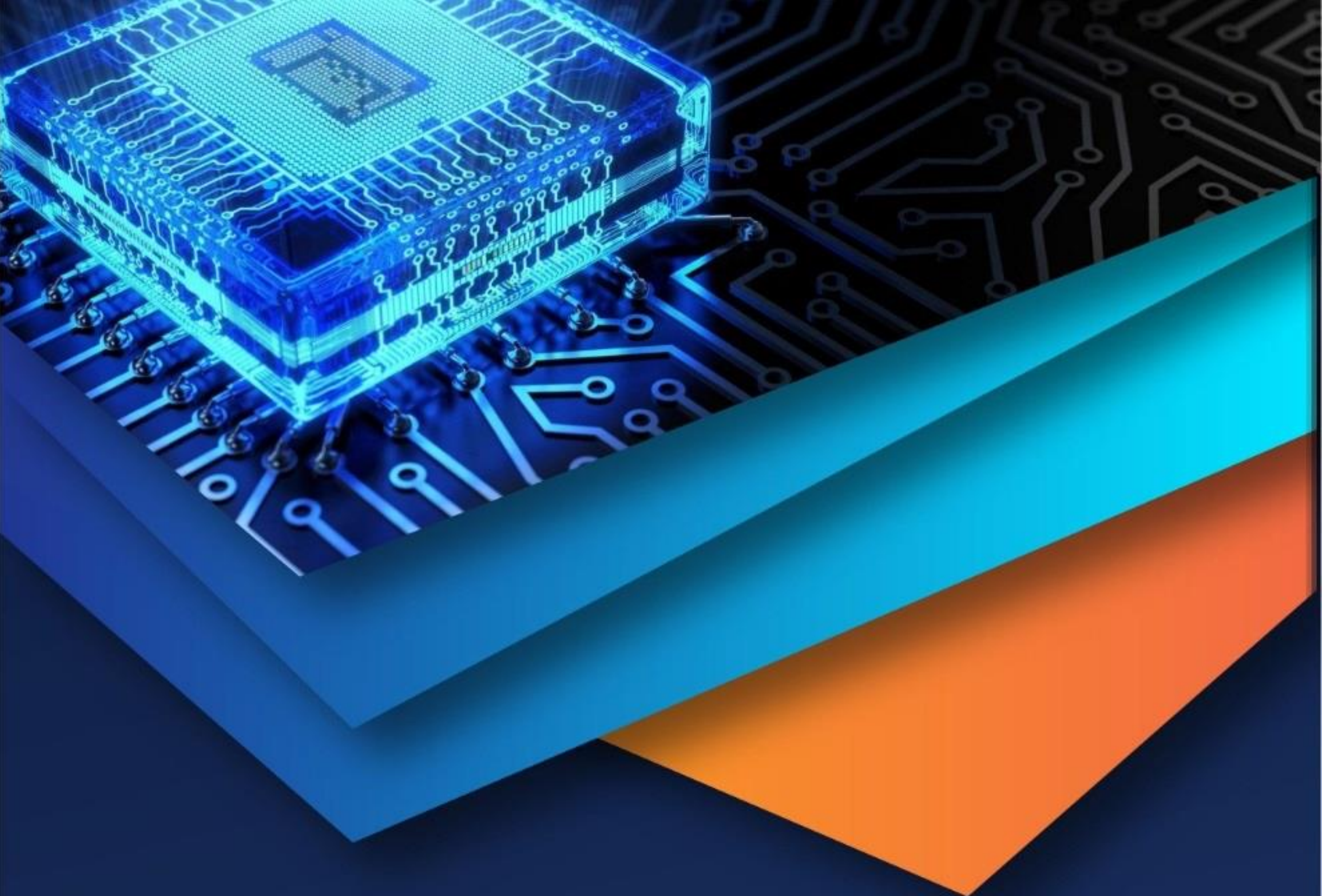

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