Sarsabz Zameen - Smart Agriculture Project Report

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1.Introduction

Sarsabz Zameen is an innovative Internet of Things (IoT)-based smart agriculture system aimed at empowering farmers with technology to improve productivity and sustainability. The project leverages affordable hardware and real-time data to automate irrigation processes and lay the groundwork for advanced farming insights, such as crop and fertilizer recommendations. Our motivation stems from the need to address water scarcity and inefficient farming practices in rural areas, making agriculture smarter and more accessible.

2.Objectives

The project focuses on achieving the following goals:

- **Automatic Watering:** Enable a pump to activate automatically based on real-time soil moisture levels, ensuring crops receive water only when needed.
- **Manual Control:** Provide farmers with remote control over the pump via a mobile application, offering flexibility alongside automation.
- **Crop Recommendations:** Develop a system to suggest suitable crops based on soil moisture, temperature, and humidity data (currently in progress).
- **Fertilizer Recommendations:** Plan to recommend fertilizers using geospatial data for optimized soil health (future scope).

3. Methodology

3.1HardwareComponents

The system uses the following hardware, selected for cost-effectiveness and reliability:

- **ESP8266 NodeMCU:** A Wi-Fi-enabled microcontroller that serves as the brain of the system, handling sensor data processing and Firebase communication.
- **Soil Moisture Sensor:** An analog sensor that measures the water content in soil, outputting values from 0 (dry) to 1024 (wet).

- **DHT11 Sensor:** A digital sensor that monitors ambient temperature (in °C) and humidity (in %), crucial for environmental data.
- **5V Relay Module:** A single-channel relay that switches the pump on or off based on signals from the ESP8266.
- **Water Pump:** A 5V submersible pump that delivers water to crops when activated by the relay.
- **Power Supply:** A 12V USB adapter powers the ESP8266 and relay, with the pump connected to the same supply via the relay.

3.2SoftwareTools

The software stack ensures seamless integration of hardware and cloud services:

- **Programming Environment:** Arduino IDE, using C++ to code the ESP8266 logic.
- **Libraries:**
  - *Firebase_ESP_Client*: Facilitates real-time data exchange with Firebase Realtime Database.
  - *DHT*: Reads temperature and humidity data from the DHT11 sensor.
- **Database:** Firebase Realtime Database, structured as:
  - /sensors/temperature: Stores temperature in °C (e.g., 25.5).
  - /sensors/humidity: Stores humidity in % (e.g., 45).
  - /pump: Stores pump state (0 = off, 1 = on).
- **Mobile App:** A Flutter-based app (in development) for manual pump control and data visualization.

3.3 Implementation Details

- **Automatic Watering:**
  - The soil moisture sensor reads analog values every 10 seconds.
  - A threshold (e.g., 30% moisture, mapped from 0-1023 to 0-100%) triggers the relay:
    - Below 30%: Pump turns on (relay HIGH).
    - Above 50%: Pump turns off (relay LOW).
  - Hysteresis prevents rapid on/off cycling.
- **Manual Control:**
  - The Flutter app writes 0 or 1 to /pump in Firebase.
  - ESP8266 listens to /pump, toggling the relay accordingly.
- **Data Logging:**
  - DHT11 sends temperature and humidity to /sensors/temperature and /sensors/humidity every 30 seconds.
  - Pump state updates in Firebase whenever changed.

4. Progress Update

4.1 Completed Work

- **Hardware Assembly:**
  - All components wired and tested on a breadboard (see Circuit.png).
  - ESP8266 powered via USB, sensors and relay functioning as expected.
- **Automatic Watering System:**
  - Fully operational—pump activates when soil moisture drops below 30%, stops at 50%.
  - Tested with a small pot; pump delivers water accurately based on sensor readings.
- **Manual Watering Control:**
  - Integrated with Firebase—app buttons (ON/OFF) update /pump, and relay responds in real-time.
  - Verified via Serial Monitor and Firebase console.
- **Firebase Integration:**
  - ESP8266 connects to Wi-Fi (e.g., "Solace tel Touseef") and Firebase (final-year-project-iot-88e97).
  - Logs sensor data and reads pump state successfully (e.g., temperature: 25.5, humidity: 45, pump: 1).

4.2 In-Progress Work

- **Crop Recommendations:**
  - Initial logic drafted:
    - If moisture < 30% && temp > 25°C, suggest "wheat".
    - If moisture > 50% && temp < 20°C, suggest "rice".
  - Requires coding in Arduino or app, plus testing with real data—currently conceptual.
- **Fertilizer Recommendations:**
  - Planned to use geospatial data (e.g., soil type from public datasets like FAO).
  - Research stage—no implementation yet; exploring APIs or static maps.

4.3 Challenges Faced

- **Real-Time App Data:**
  - Initial network issues with Flutter app—temperature/humidity didn’t update due to [firebase_auth/network-request-failed].

    - Resolved by ensuring device internet and refining data parsing (int/double handling).
- **Scalability:**
    - Current setup suits small pots—scaling to fields needs multiple sensors and geospatial integration.
- **Power Stability:**
    - USB power limits mobility—future iterations may use solar or battery.

5. Next Steps

- **Crop Recommendation Algorithm:**
    - Finalize logic in Arduino or app (e.g., if (moisture < 30 && temp > 25) Serial.println("Wheat");).
    - Test with sample soil/weather conditions.
- **Fertilizer Logic:**
    - Source geospatial data (e.g., soil pH, NPK levels) from online datasets.
    - Map data to fertilizer types (e.g., urea for low nitrogen).
- **System Testing:**
    - Deploy in varied conditions (dry/wet soil, hot/cold weather).
- **App Enhancement:**
    - Add crop/fertilizer suggestions to UI, improve interactivity (e.g., charts).

6.Conclusion

Sarsabz Zameen has achieved a functional core with automatic and manual watering, demonstrating reliable IoT integration via ESP8266 and Firebase. This foundation supports real-time monitoring and control, critical for farmers. The upcoming crop and fertilizer recommendation features will enhance its value, aligning with sustainable agriculture goals. We look forward to your feedback to refine and expand this work.

Attachments:

- Circuit.png
- Firebase_Structure.png
- SarsabzZameen.ino