Nitroasis – AI and IoT Based Smart Farming System with Aquaponics Inspired Nutrient Recycling

Problem Statement

Modern agriculture faces several challenges such as inefficient water usage, excessive dependence on chemical fertilizers, lack of real-time environmental monitoring, and limited access to expert farming advice. Many farmers rely on manual observation to determine soil conditions and irrigation needs, which can lead to poor crop selection, reduced yield, and increased production costs. Additionally, chemical fertilizers are expensive and can negatively impact soil health over time. Therefore, there is a need for a smart farming solution that can monitor environmental conditions, reuse natural nutrients, and assist farmers in making better decisions.

Objective

The main objectives of this project are:

1. **Real-Time Monitoring**
   To monitor environmental and soil conditions in real time using IoT sensors. To measure parameters such as temperature, humidity, soil moisture, NPK nutrients, rainfall, water level, and smoke detection.

2. **Automated Irrigation**
   To automate irrigation using nutrient-rich water from a fish tank.

3. **Reduce Fertilizer Usage**
   To reduce fertilizer usage by recycling nutrients naturally through fish waste.

4. **Intelligent Recommendations**
   To provide intelligent crop recommendations and farming assistance.

5. **Low-Cost & Sustainable**
   To develop a low-cost and sustainable smart farming solution.

Existing Work

Several smart agriculture systems have been developed using IoT technology to monitor soil and environmental conditions. These systems typically collect sensor data and send it to cloud platforms such as Thingspeak, Blynk, or AWS IoT for monitoring and analysis. Some systems also use machine learning models to predict crop suitability based on soil and climate conditions.

What Exists

- IoT-based soil and environmental monitoring
- Cloud platforms: Thingspeak, Blynk, AWS IoT
- Machine learning crop prediction models

Key Limitations

- Many existing systems depend heavily on internet connectivity and cloud infrastructure, which may not be practical in rural farming areas
- Most systems focus only on monitoring and do not integrate sustainable nutrient recycling methods

Gap Analysis

Although many IoT-based farming solutions exist, they still have several limitations.

Existing Systems	Limitations
Cloud-based smart farming systems	Require continuous internet connectivity
Basic IoT monitoring systems	Only display sensor data without automation
Machine learning crop prediction systems	Require high computing resources
Traditional farming methods	High fertilizer cost and inefficient water usage

There is a need for an integrated system that can monitor environmental conditions, provide intelligent recommendations, and reduce fertilizer costs while operating efficiently in rural environments.

Novelty

The novelty of this project lies in combining IoT, TinyML, and aquaponics-inspired nutrient recycling into a single smart farming system.

Aquaponics-Inspired Nutrient Recycling

The system uses fish tank water containing nitrate-rich nutrients for irrigation, which naturally fertilizes the crops. This reduces the dependence on chemical fertilizers and improves soil health.

Local AI Assistance

Additionally, the system integrates local AI assistance and real-time monitoring to help farmers make better decisions.

Unique & Sustainable

The combination of environmental sensing, automated irrigation, and nutrient recycling makes this system unique and sustainable.

Project Description

Nitroasis is an IoT-based smart farming system designed to monitor agricultural conditions and improve crop productivity. The system uses ESP32 microcontrollers connected to multiple sensors that measure parameters such as temperature, humidity, soil moisture, rainfall, NPK nutrients, water level, and smoke detection.

Data Collection & Display

The collected data is processed by the ESP32 and displayed through a dashboard and OLED display.

Automated Irrigation & Nutrient Recycling

The system also includes an automated irrigation mechanism where water pumps circulate water from a fish tank to the farming area. Fish waste contains ammonia, which is converted by beneficial bacteria into nitrate, an essential nutrient for plant growth. By circulating this nitrate-rich water to the crops, the system naturally fertilizes the soil while reducing fertilizer costs.

This integrated system improves farming efficiency, promotes sustainable agriculture, and allows farmers to monitor their farms in real time.

List of Components and Software Used

Hardware Components

Component	Purpose
ESP32 / ESP32-S3	Main microcontroller that processes sensor data
DHT11 Sensor	Measures temperature and humidity
Soil Moisture Sensor	Measures soil water content
LDR (Light Dependent Resistor)	Detects day/night light conditions
OLED Display (SH1106 1.3")	Displays live farm data locally
Touch Sensor / Touch Pin	Switch between display modes
Water Pumps (2)	Circulates nutrient-rich water for irrigation
Fish Tank	Source of nutrient-rich water from fish waste
Power Supply	Provides power to the system

9. Methodology

The system uses sensors connected to an ESP32 microcontroller to collect environmental data such as **temperature, humidity, soil moisture, and light intensity**. The collected data is processed by the ESP32 and displayed on an OLED screen for local monitoring.

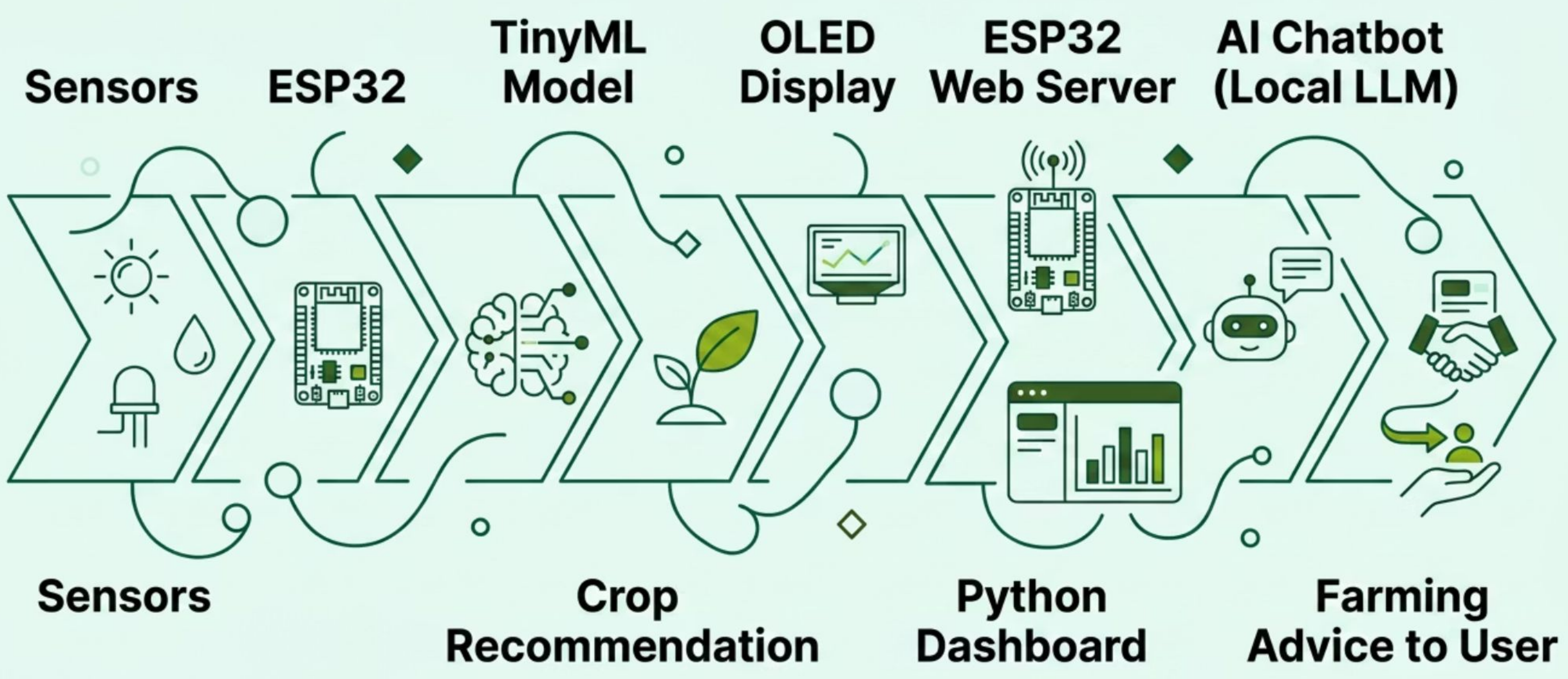
A **TinyML model deployed on the ESP32** analyzes the sensor data and predicts the most suitable crop for the current environmental conditions. The ESP32 also hosts a web server that sends sensor data to a **Streamlit dashboard**, where the values are displayed in real time.

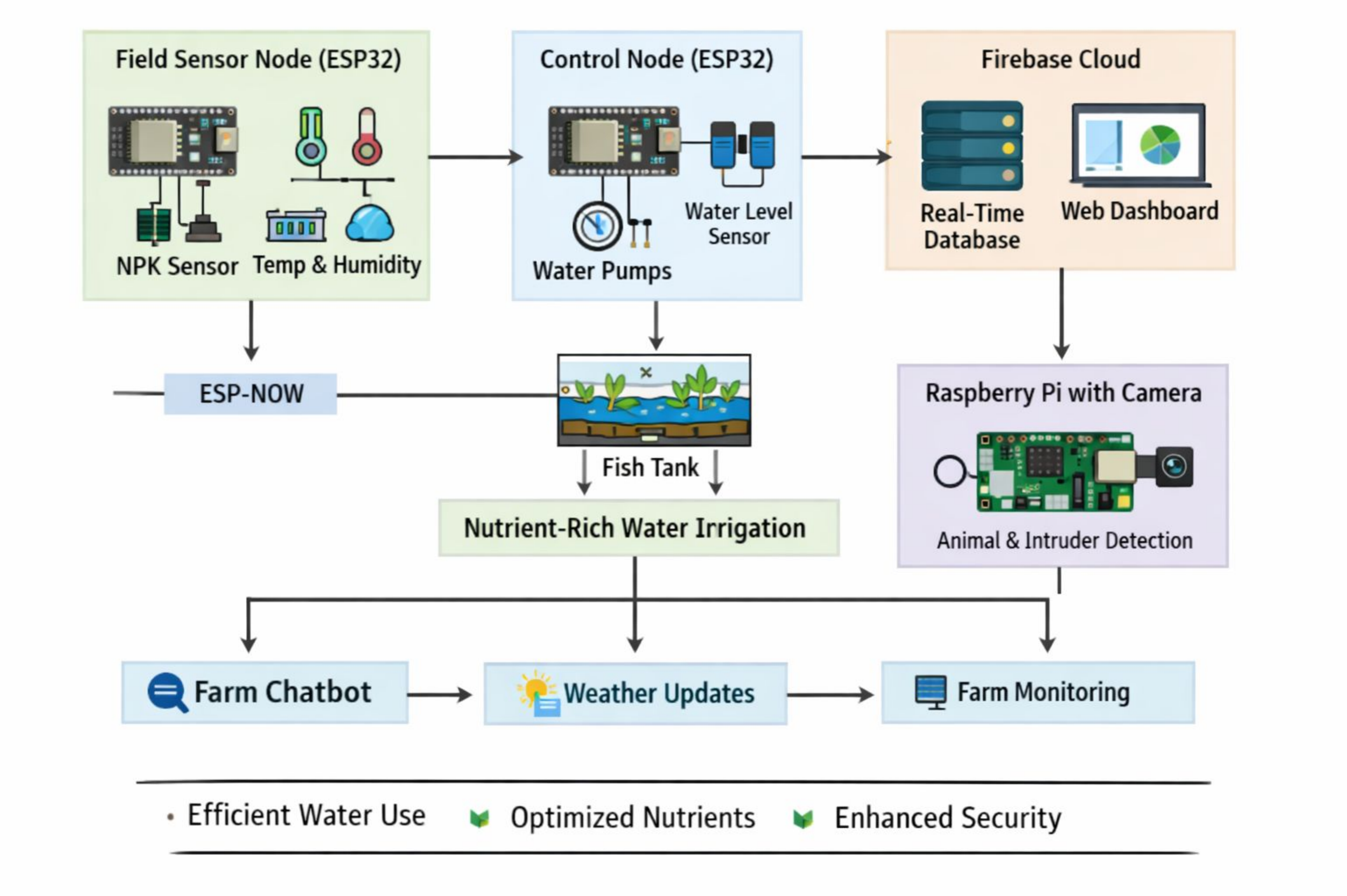
Additionally, a **local AI chatbot powered by a language model** analyzes the sensor data and provides farming advice to the user. The system also reuses **nitrate-rich water from a fish tank for irrigation**, reducing fertilizer usage and promoting sustainable farming.

Software Used

Software	Purpose
Arduino IDE	Programming the ESP32 microcontroller
Edge Impulse	Training TinyML crop prediction model
Python	Backend dashboard and AI integration
Streamlit	Web dashboard interface
Ollama	Running local AI model
Llama3	AI chatbot model
GitHub	Source code hosting
KiCad	PCB schematic and layout design

System Flow




Field Sensor Node (ESP32)
NPK Sensor
Temp & Humidity
Control Node (ESP32)
Water Pumps
Water Level Sensor
Firebase Cloud
Real-Time Database
Web Dashboard
ESP-NOW
Fish Tank
Raspberry Pi with Camera
Animal & Intruder Detection
Nutrient-Rich Water Irrigation
Farm Chatbot
Weather Updates
Farm Monitoring
Efficient Water Use
Optimized Nutrients
Enhanced Security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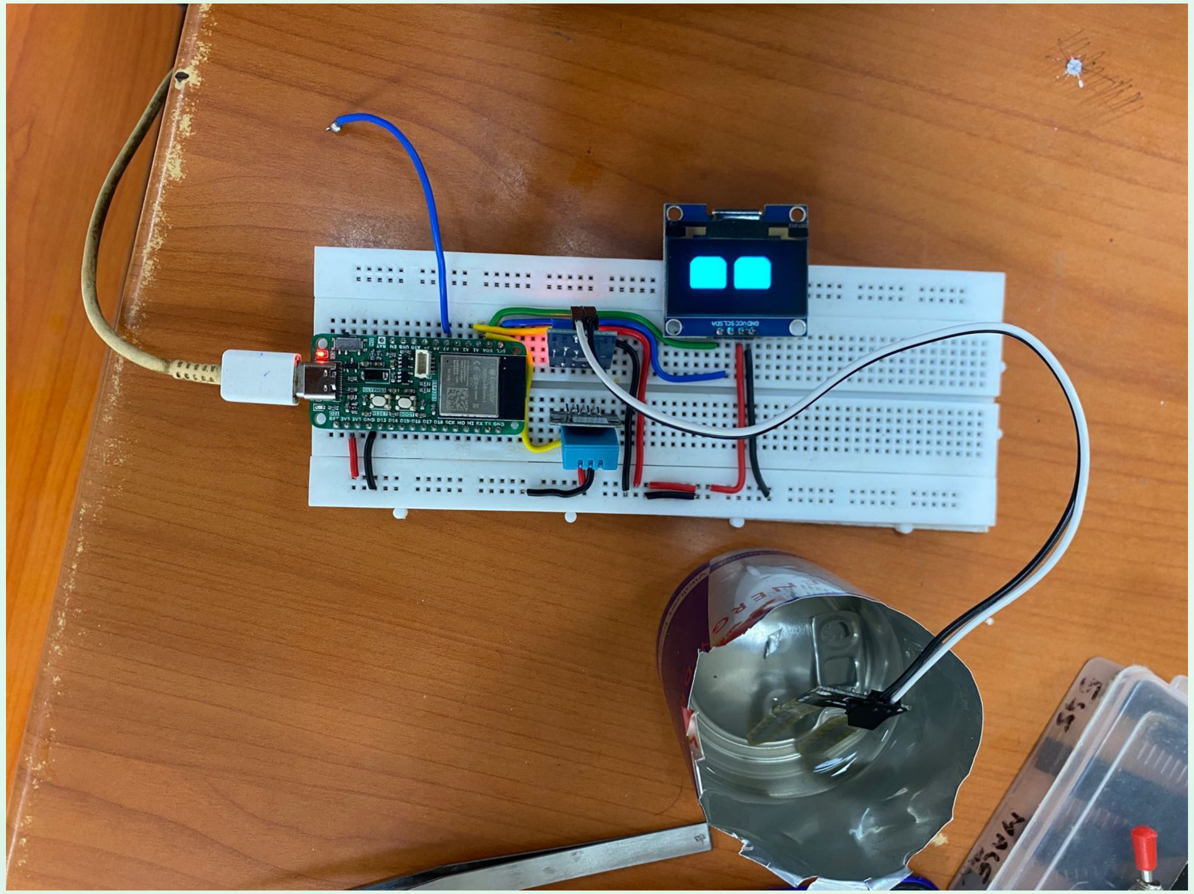
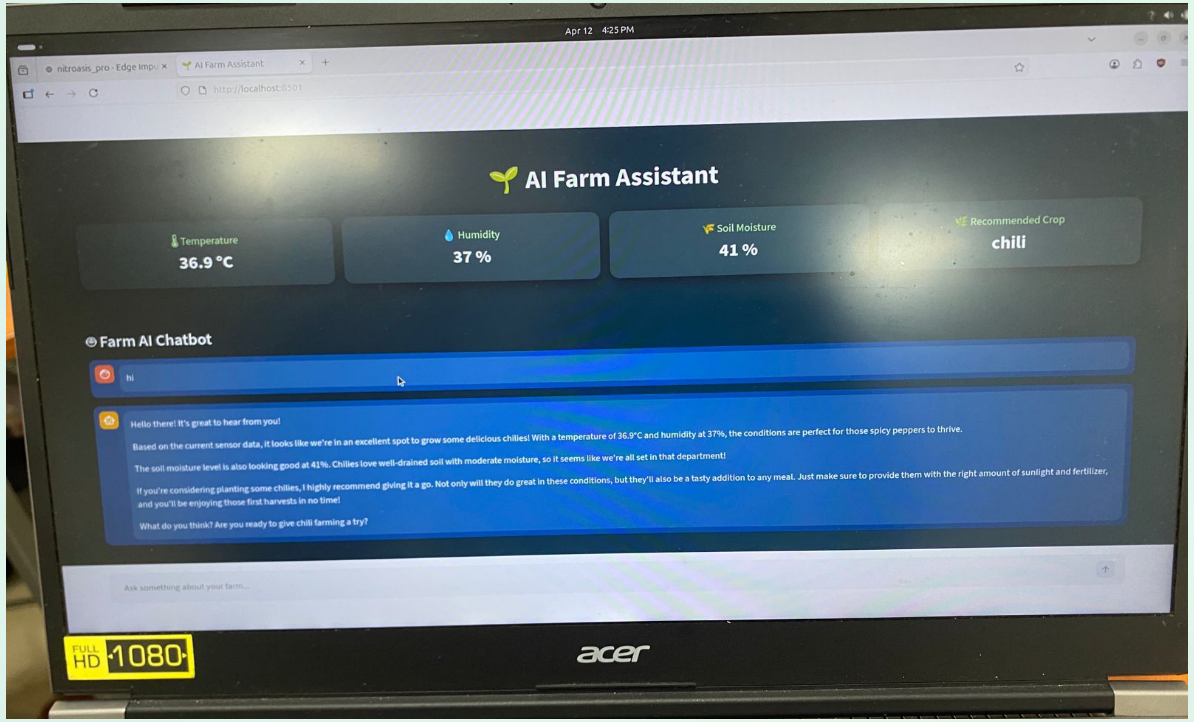
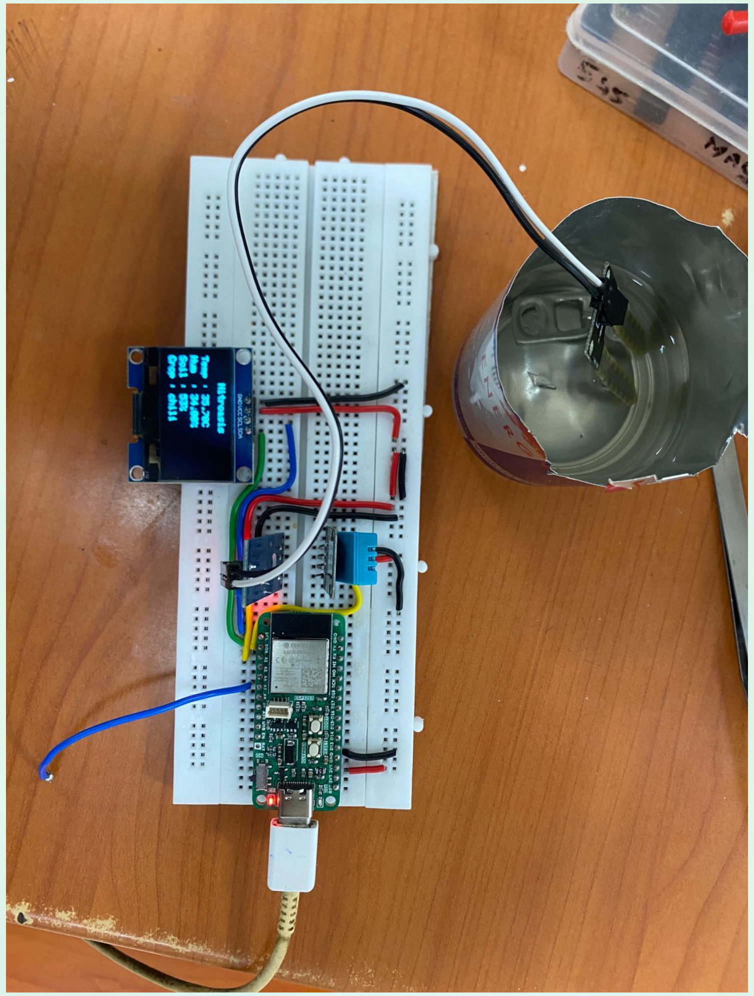



AI Farm Assistant
Temperature
36.9 °C
Humidity
37 %
Soil Moisture
41 %
Recommended Crop
chili
Farm AI Chatbot
hi
Hello there! It's great to hear from you!
Based on the current sensor data, it looks like we're in an excellent spot to grow some delicious chilies! With a temperature of 36.9°C and humidity at 37%, the conditions are perfect for those spicy peppers to thrive.
The soil moisture level is also looking good at 41%. Chilies love well-drained soil with moderate moisture, so it seems like we're all set in that department!
If you're considering planting some chilies, I highly recommend giving it a go. Not only will they do great in these conditions, but they'll also be a tasty addition to any meal. Just make sure to provide them with the right amount of sunlight and fertilizer, and you'll be enjoying those first harvests in no time!
What do you think? Are you ready to give chili farming a try?
Ask something about your farm...
FULL HD 1080
acer



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Git hub:

https://github.com/gokul2003-bot/Edge_of_intelligence_hackathon_3