First Defence : Minor Project

Project Title : AgroBuddy

“Your partner from sowing the seeds till reaping your crops”

Team Members:

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AgroBuddy

Growing Together

Problem Statement

Agriculture continues to be the backbone of India's economy, yet farmers struggle to achieve optimal productivity due to a lack of reliable, data-driven insights. Current farming practices are heavily dependent on traditional knowledge, external advisory, and unpredictable climatic conditions, which often result in low yields, financial losses, and reduced sustainability.

Key challenges include:

Inefficient data collection and monitoring: Farmers lack real-time access to critical information on soil health, nutrients, and moisture.

Difficulty in selecting appropriate crops: Without scientific recommendations, farmers often choose crops unsuited to their soil and climate, reducing yield potential.

Delayed or inaccurate disease detection: By the time crop diseases or pest infestations are identified, significant damage is already done.

Limited access to localized and continuous support: Farmers often face barriers such as language, literacy, and lack of expert availability.

Market inefficiencies: Unpredictable price fluctuations and middlemen reduce farmers' profits, making it difficult to plan and sell produce effectively.

Challenges:

50% and over marginal farmers have reported crop losses due to extreme weather events. **73%** of farmers have experienced increased pest and disease pressure, leading to an average income reduction of 1**5.7%** over two years.

Implications:

A substantial portion of India's farming community is vulnerable to environmental challenges, resulting in significant crop and income losses and these issues need to be mitigated.

OBJECTIVE

The primary objective of the project *AgroBuddy* is to design and develop an intelligent, AI-powered platform that empowers farmers to make better agricultural decisions by leveraging real-time data and predictive analytics. Agriculture in India continues to suffer from low productivity and inefficiencies, not due to lack of effort by farmers, but due to the absence of timely and accurate insights that can guide their day-to-day practices. Through this project, we aim to bridge this gap by creating a system that combines IoT, Artificial Intelligence, and Machine Learning to provide farmers with actionable knowledge in a simple and accessible manner.

One of the core objectives of the project is to provide **real-time soil and environmental insights**. Using IoT sensors deployed in the field, AgroBuddy monitors soil nutrients (N, P, K), pH level, moisture, and humidity, along with climatic parameters such as temperature and rainfall. This continuous monitoring ensures that farmers are no longer dependent on guesswork or delayed reports, but instead receive accurate, on-the-spot information about the current health of their soil and environment.

Another important objective is to **recommend suitable crops and predict yield** using advanced ML models. Farmers often face difficulties in deciding what crop to grow each season, which leads to reduced income and inefficient use of resources. AgroBuddy's machine learning algorithms analyze the soil and weather conditions to suggest the most suitable crops. Furthermore, by considering parameters such as season, area of cultivation, and soil health, the system provides an estimate of expected yield, allowing farmers to plan resources and finances in advance.

The project also seeks to **protect crops from diseases and pests** by integrating a deep learning-based image recognition module. This helps in early detection and enables farmers to take preventive measures before the damage becomes severe. In addition, AgroBuddy offers a **multilingual AI voice assistant** that breaks language and literacy barriers by providing answers to common queries in multiple regional languages, ensuring inclusivity and accessibility for all farmers.

Finally, AgroBuddy's objective extends to improving the **supply chain and market access**. By incorporating an AI-powered marketplace, the system forecasts crop prices, predicts demand and shortages, and connects farmers directly with potential buyers. This reduces dependency on middlemen and enhances profitability.

In summary, the objective of *AgroBuddy* is to provide farmers with an end-to-end, technology-driven solution that covers every aspect of farming—from soil analysis and crop recommendation to yield prediction, disease management, and market connectivity. By achieving this, the project aims to increase productivity, optimize the use of resources, minimize risks, and ultimately contribute to a more sustainable and profitable agricultural ecosystem in India.

Solution Approach

• Onboarding of farmers

The system allows farmers to easily register and create accounts using their mobile numbers, ensuring accessibility even for first-time technology users. Once onboarded, each farmer receives a personalized profile linked to their farm and region. This creates the foundation for delivering tailored insights and recommendations throughout the platform.

• Real-time weather visibility

Weather APIs integrated into the dashboard provide up-to-date information such as temperature, humidity, rainfall probability, and daily variations. Farmers can track how climate conditions will affect their crops on both a daily and seasonal basis. This helps in planning irrigation schedules, fertilizer application, and other farm activities more effectively.

• Soil analysis via IoT sensors

IoT-enabled sensors deployed across the field continuously monitor critical soil parameters like N, P, K, pH, moisture, and humidity. This real-time data is transmitted to the cloud, processed, and converted into easy-to-understand soil health reports.

• Crop recommendation using ML

Based on soil data and weather conditions, a machine learning model identifies which crops are most suitable for cultivation at a given time. The recommendation engine is trained on large datasets to improve accuracy and reliability. This ensures that farmers make informed choices, leading to better yields and efficient use of resources.

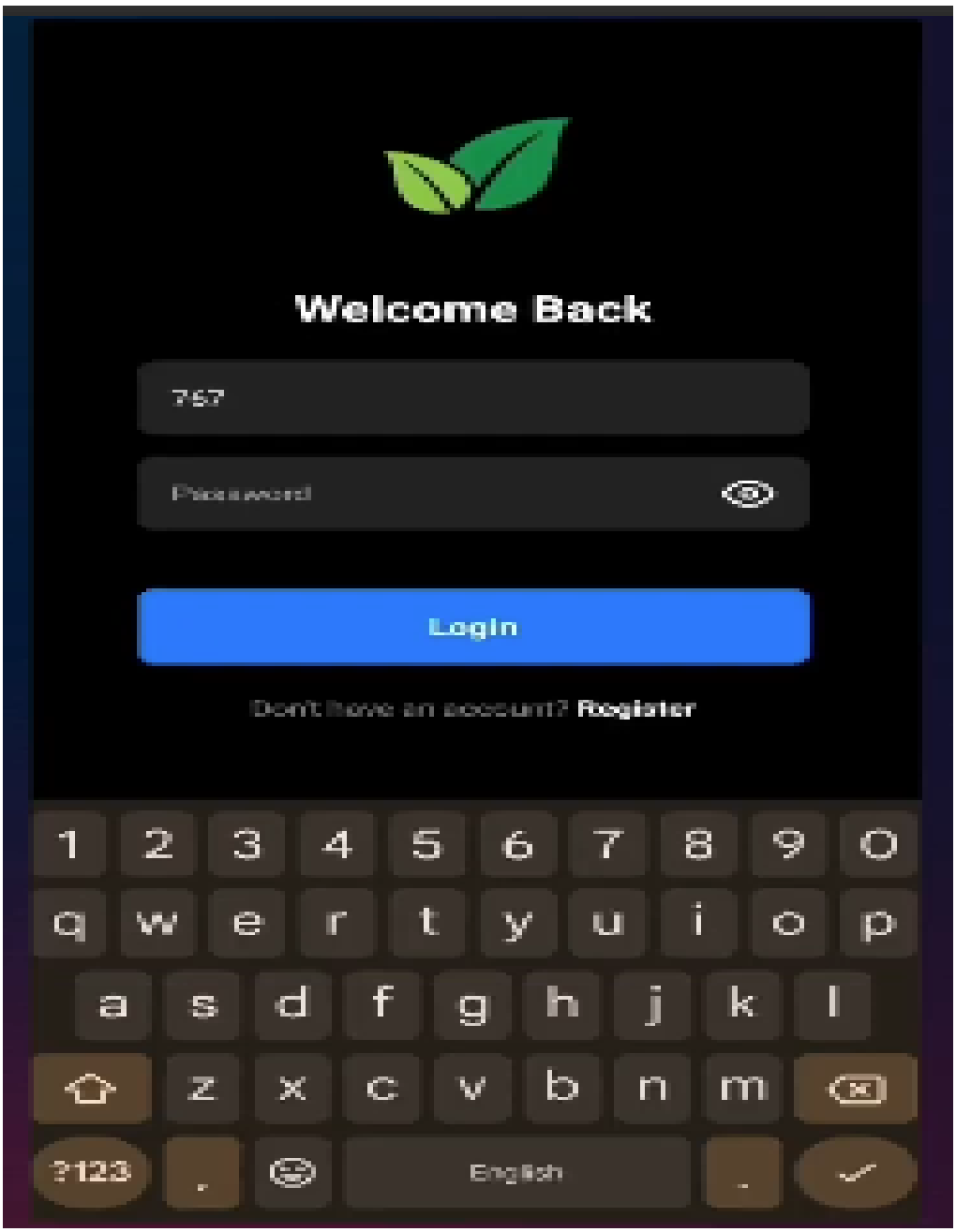
• Yield estimation using AI models

The system goes a step further by predicting the expected yield of the recommended crop using AI models trained on 1000+ datasets. Factors like soil health, climate, farm area, and seasonal variations are considered for precise forecasting. Farmers also receive improvement suggestions, such as fertilizer adjustments or irrigation practices, to optimize output.

Features Implemented so far

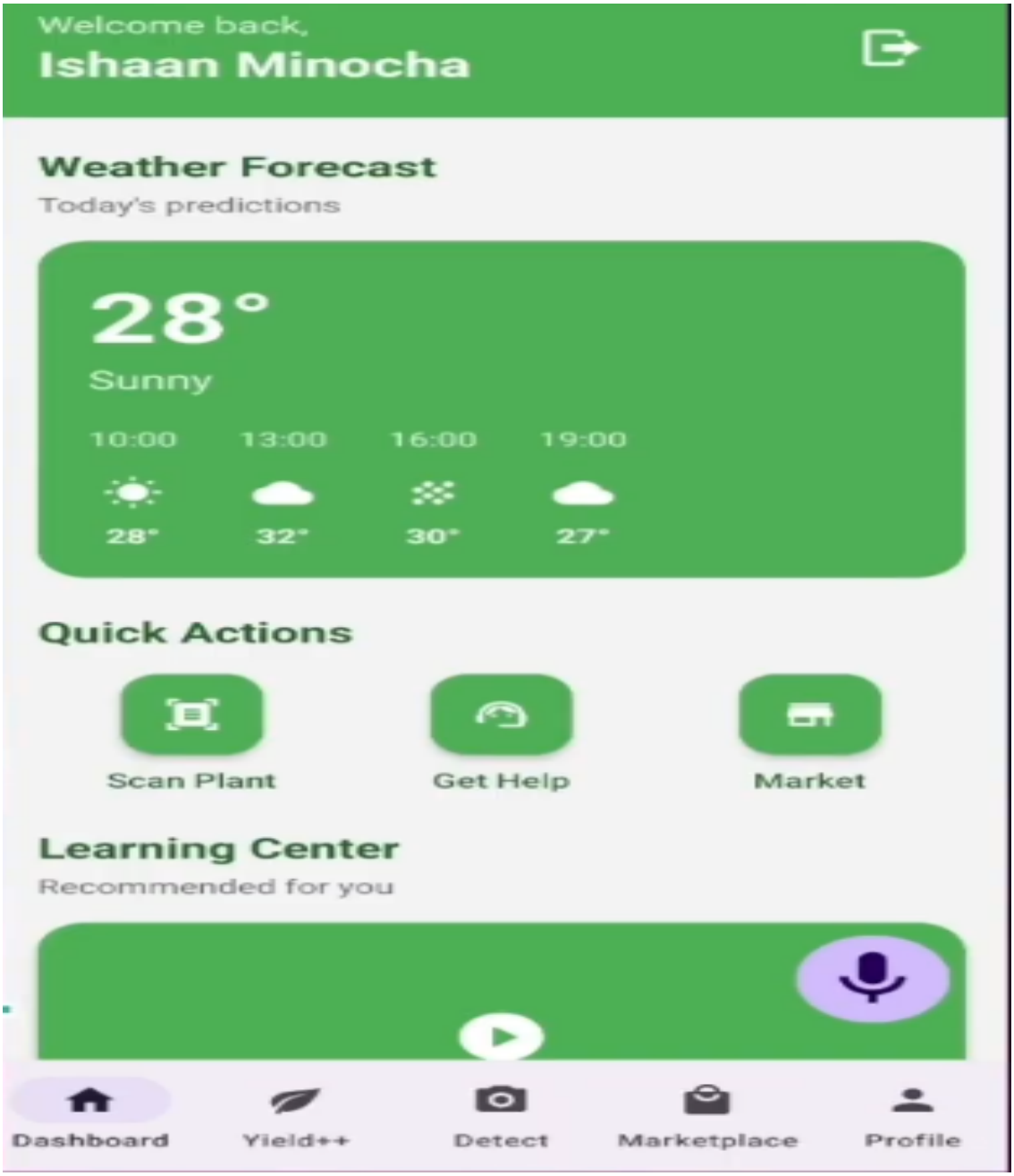
• Farmer Registration & Login

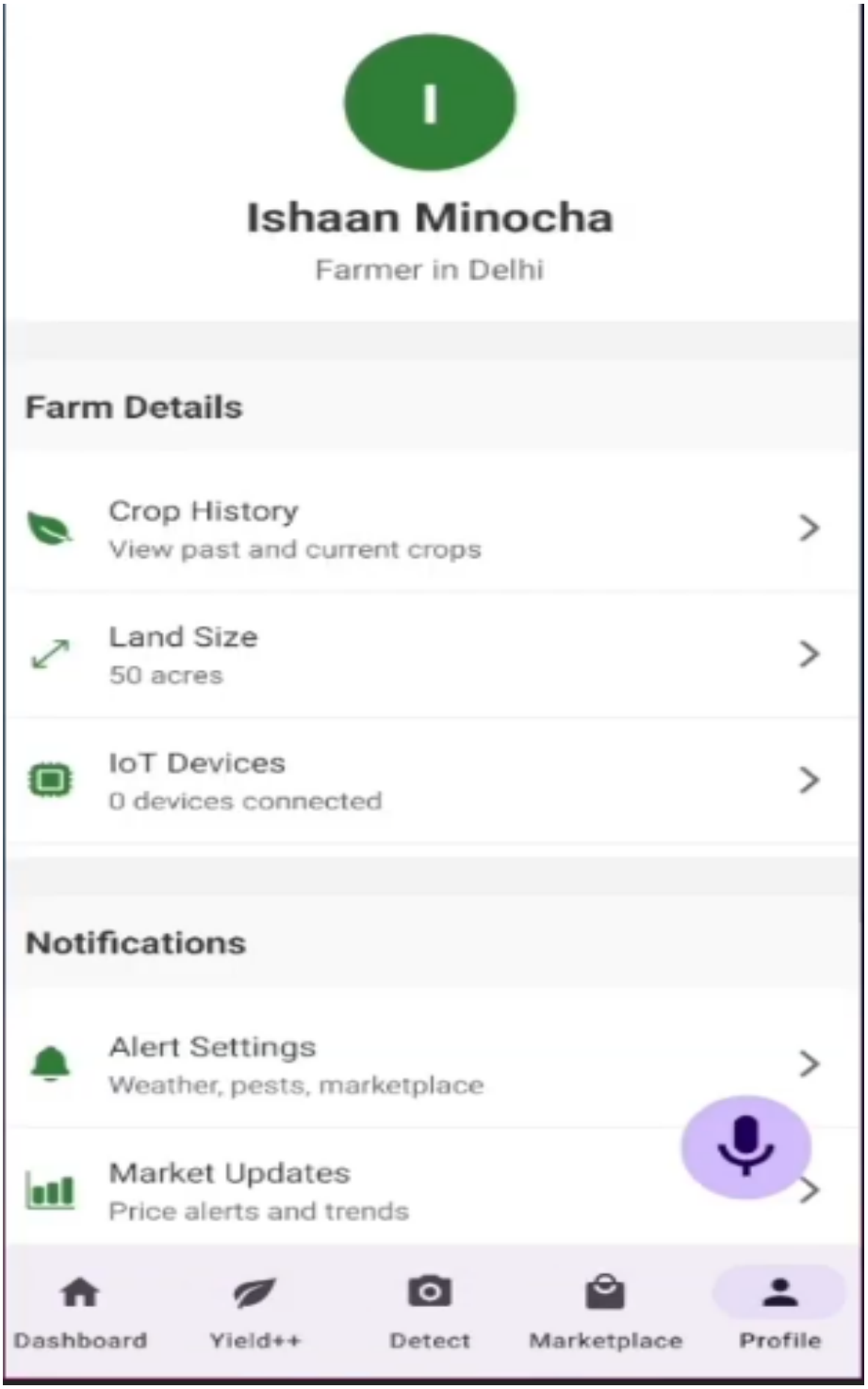
A secure onboarding system has been implemented where farmers can register using their mobile numbers and create individual accounts. This ensures that each farmer's data, preferences, and farm details are stored securely in the database. The login system provides personalized access to the platform, laying the foundation for delivering user-specific insights.



• **Dashboard**

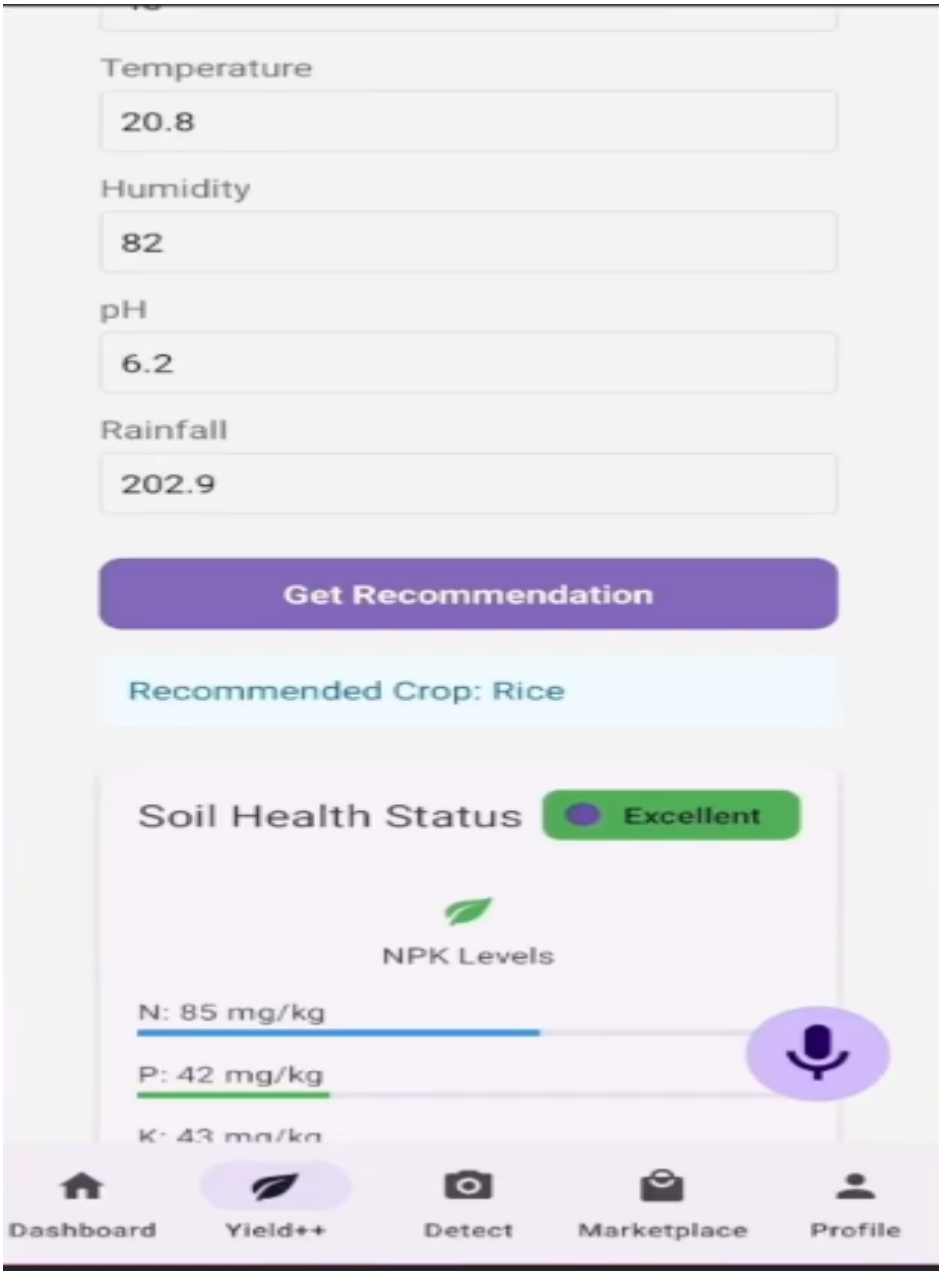
A user-friendly dashboard has been developed to greet farmers upon login, displaying key weather updates such as temperature, humidity, rainfall probability, and daily variations. This real-time climate information helps farmers make informed decisions about irrigation and crop planning. The dashboard acts as the central hub where additional features and reports are also displayed.




I
Ishaan Minocha
Farmer in Delhi
Farm Details
Crop History
View past and current crops
Land Size
50 acres
IoT Devices
0 devices connected
Notifications
Alert Settings
Weather, pests, marketplace
Market Updates
Price alerts and trends
Dashboard
Yield++
Detect
Marketplace
Profile

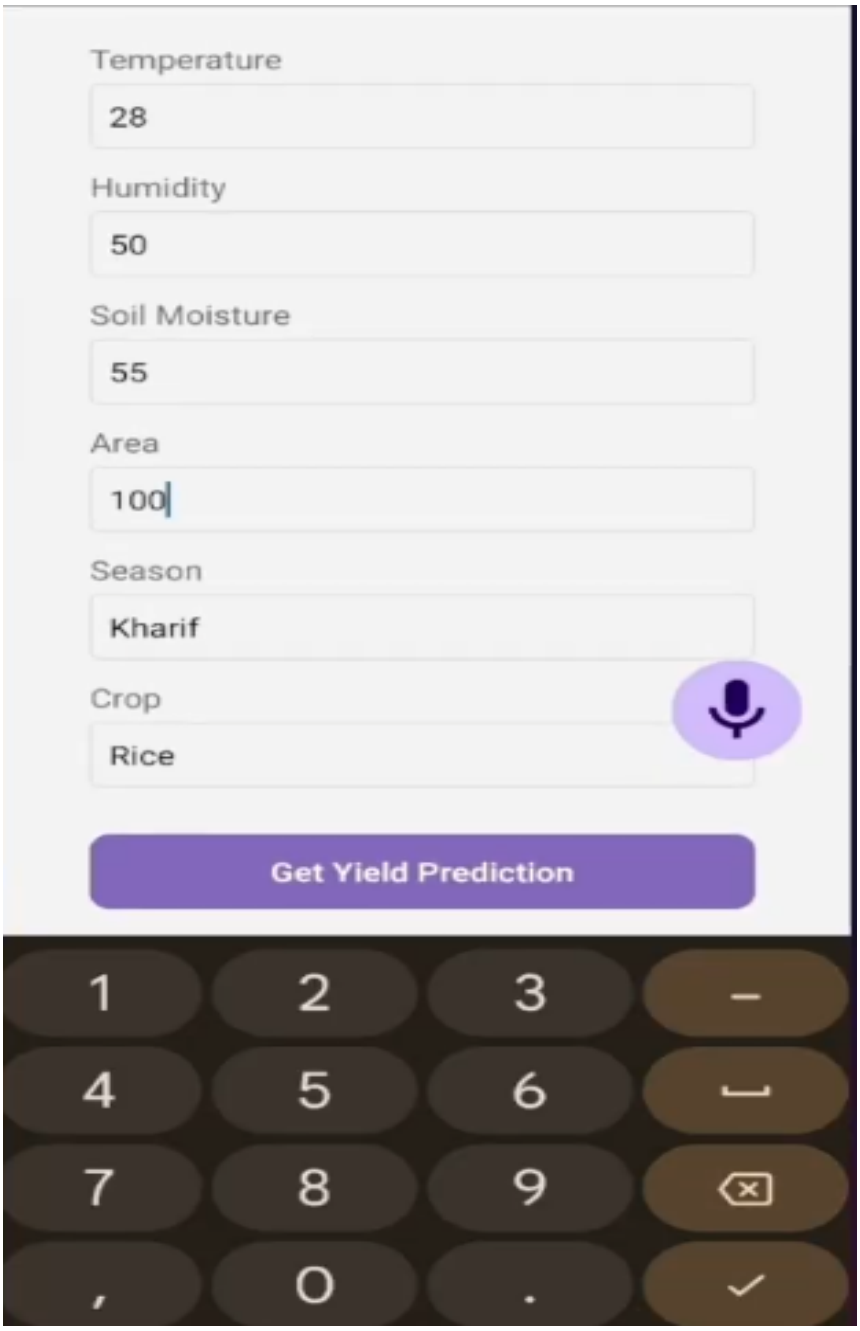
• **Soil Health Analysis**

IoT sensors deployed across the farm continuously measure soil parameters like Nitrogen (N), Phosphorus (P), Potassium (K), pH, moisture, and humidity. This data is transmitted to the backend, processed, and presented in the form of an easy-to-understand soil health report. Such real-time analysis empowers farmers to assess their soil condition instantly without relying solely on manual testing.



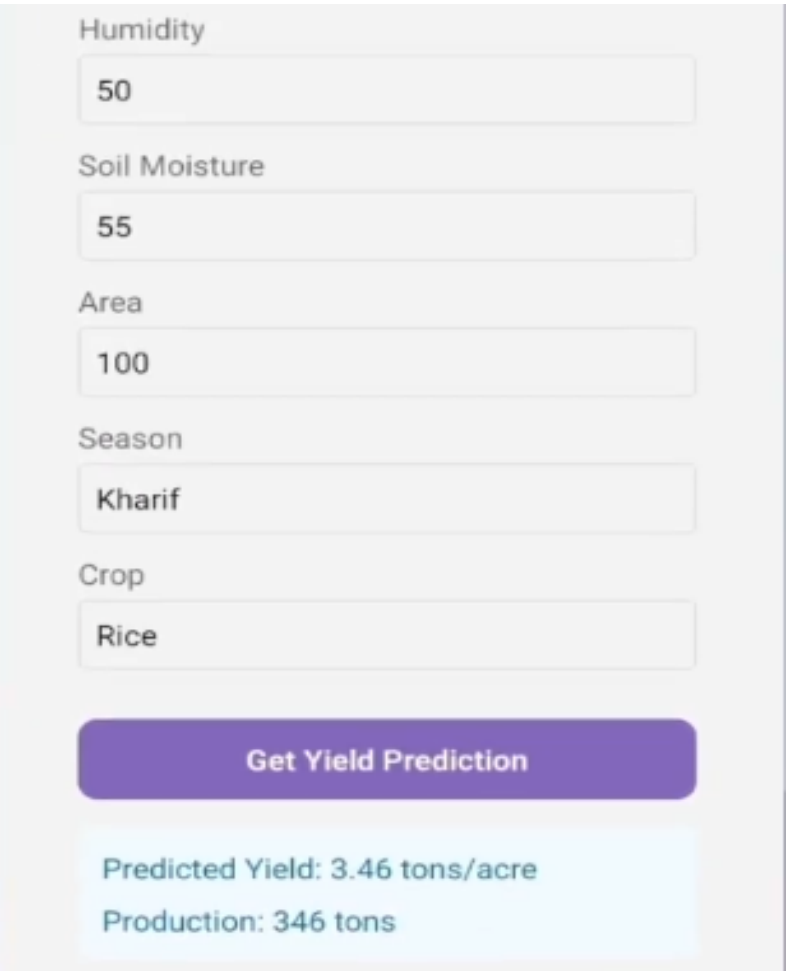
• **Crop Recommendation**

Using the soil health report and real-time weather data, a machine learning model recommends crops that are most suitable for the current conditions. The model has been trained on diverse datasets to provide accurate and region-relevant suggestions. This feature ensures that farmers can maximize yield potential while reducing the risks associated with poor crop selection.



• **Yield Estimation**

The system integrates an advanced AI model that predicts the expected yield of a chosen crop by analyzing parameters such as temperature, humidity, soil moisture, farm area, and seasonal factors. The model has been trained on more than 1000 data samples and achieves around 95% accuracy. Along with yield prediction, it also provides actionable advisories such as recommended fertilizers (e.g., Urea, Ammonium Sulphate), irrigation adjustments, and climate management practices to improve productivity.



Technology Stack

Frontend

1. **Next.js**

- React framework for building server-side rendered (SSR) and statically generated web applications.
- Used to build the **web dashboard** for farmers.
- Fetches real-time weather data, soil reports, and displays it dynamically.

2. **React Native**

- Framework for building cross-platform mobile apps (iOS and Android) using React.
- Developed the **mobile application** for farmers to access dashboards, soil reports, crop recommendations, and yield predictions.
- Integrates with backend APIs for real-time updates.

Backend

1. **Node.js**

- JavaScript runtime for executing server-side code.
- Handles farmer registration, login, dashboard data, and IoT sensor data processing.

2. Express.js

- Minimal Node.js framework for building APIs and web servers.
- Creates RESTful APIs for web and mobile frontends.
- Manages routes for soil health data, crop recommendations, and yield predictions.
- Implements authentication, session management, and middleware for security.

Database

PostgreSQL

- Relational database system for structured data storage with advanced query support.
- Stores farmer accounts, farm details, sensor readings, crop info, and AI predictions.
- Supports complex queries for real-time reports and personalized recommendations.

IoT

1. Arduino Uno

- Microcontroller board for collecting sensor data.
- Measures soil parameters: N, P, K, pH, moisture, and humidity.
- Sends data to backend via AWS IoT Core.

2. AWS IoT Core

- Cloud platform to securely connect, manage, and ingest data from IoT devices.

- Receives real-time sensor data from Arduino devices.
- Triggers backend processing pipelines for soil health analysis.

Machine Learning / AI

1. Scikit-Learn

- Python library for machine learning.
- Built the **crop recommendation model** using soil and weather data.

2. TensorFlow

- Open-source library for AI and deep learning.
- Built the **yield estimation model** predicting crop yield from soil, weather, and farm data.
- Provides actionable suggestions for fertilizer, irrigation, and climate management.

Weather Data Integration

Xweather API

- Provides real-time weather data, forecasts, and historical information.
- Integrated for:
    - **Dashboard:** Display temperature, humidity, rainfall probability, and daily variations.
    - **Crop Recommendation:** Supplies real-time weather conditions to the ML model.

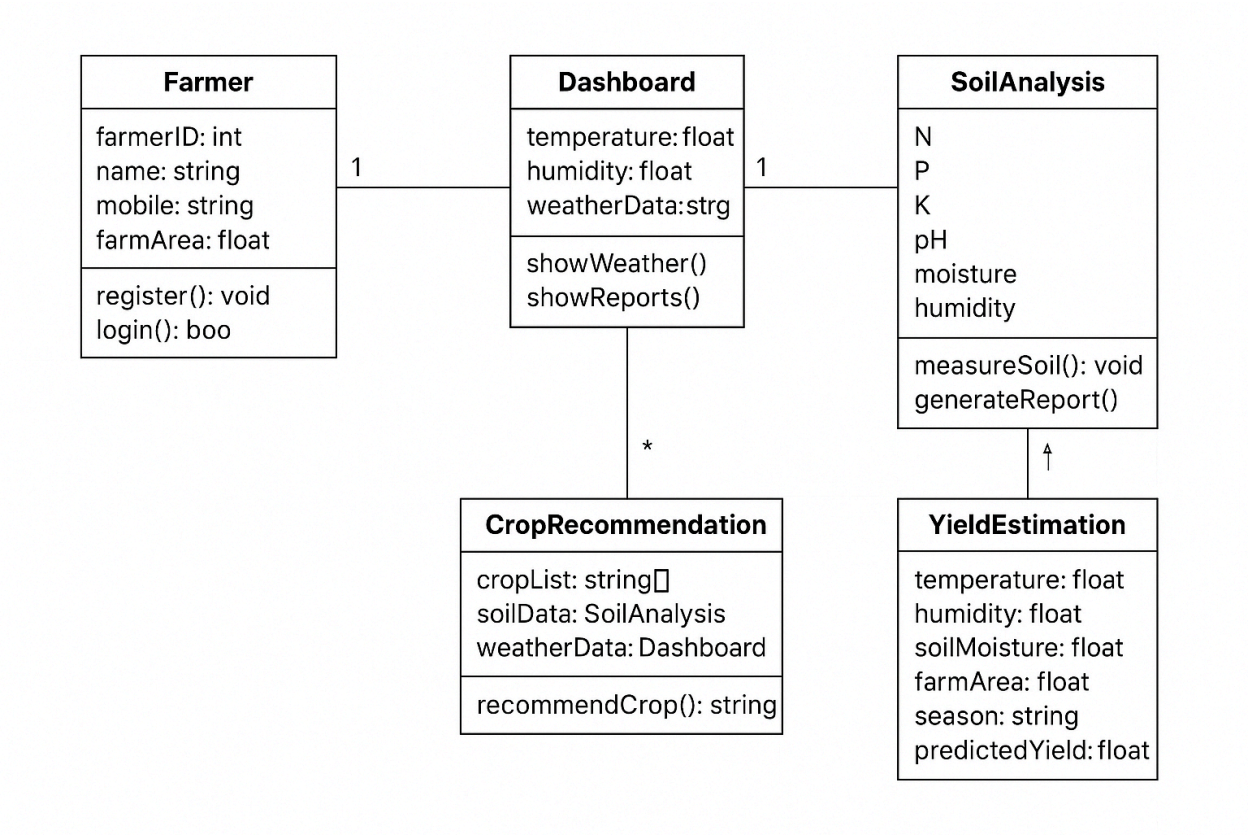
    - **Yield Estimation:** Provides weather parameters for accurate yield predictions.

- Benefits:
    - Hyperlocal forecasting tailored to specific locations.
    - AI-enhanced insights for actionable recommendations.
    - Comprehensive coverage including air quality, lightning, and maritime conditions.

Technology Stack

Frontend	Next.js, React-native
Backend	Node.js, Express
Database	PostgreSQL with Prisma
ML/AI	TensorFlow, SciKitLearn, Pytorch, OpenCV
IOT	Arduino Uno, AWS IoT Core using CoAP

UML Class Diagram for the project :



Relationships:

- **Farmer** interacts with **Dashboard**, **SoilAnalysis**, **CropRecommendation**, and **YieldEstimation**.
- **CropRecommendation** depends on **SoilAnalysis** and **Dashboard** data.
- **YieldEstimation** uses weather and soil parameters for prediction.

Progress Summary

- **Registration & Authentication System Complete**
    - A secure registration and login system has been implemented for farmers, allowing them to create accounts using mobile numbers.
    - Passwords and sensitive data are stored securely, ensuring user privacy.
    - The authentication mechanism prevents unauthorized access, providing a safe environment for all users.
    - **Impact:** Ensures only authorized farmers can access the system, safeguarding data and building user trust.

- **Dashboard with Weather API Integrated**
    - The dashboard provides real-time weather updates using the XWeather API, showing parameters like temperature, humidity, and daily variations.
    - This enables farmers to make informed decisions about irrigation, sowing, and crop protection.
    - The interface is user-friendly and visually displays key weather data for quick insights.
    - **Impact:** Helps farmers plan activities efficiently, reducing crop losses due to weather uncertainties.

• **IoT Data Pipeline Functional**

- IoT sensors collect soil parameters such as nitrogen (N), phosphorus (P), potassium (K), pH, moisture, and humidity.
- The data is transmitted to the server and processed in real-time to generate soil health reports.
- This pipeline ensures accurate and timely data for further analysis and crop recommendations.
- **Impact:** Provides precise soil health insights, enabling data-driven decisions to improve crop yield.

• **Crop Recommendation ML Model Trained & Tested**

- A machine learning model has been trained using historical soil and weather data to suggest the most suitable crops for the farmer's land.
- The model has been tested for accuracy and provides recommendations tailored to soil conditions and climate.
- This empowers farmers to optimize yield and reduce crop failure risks.
- **Impact:** Guides farmers in selecting the best crops, increasing productivity and reducing financial risks.

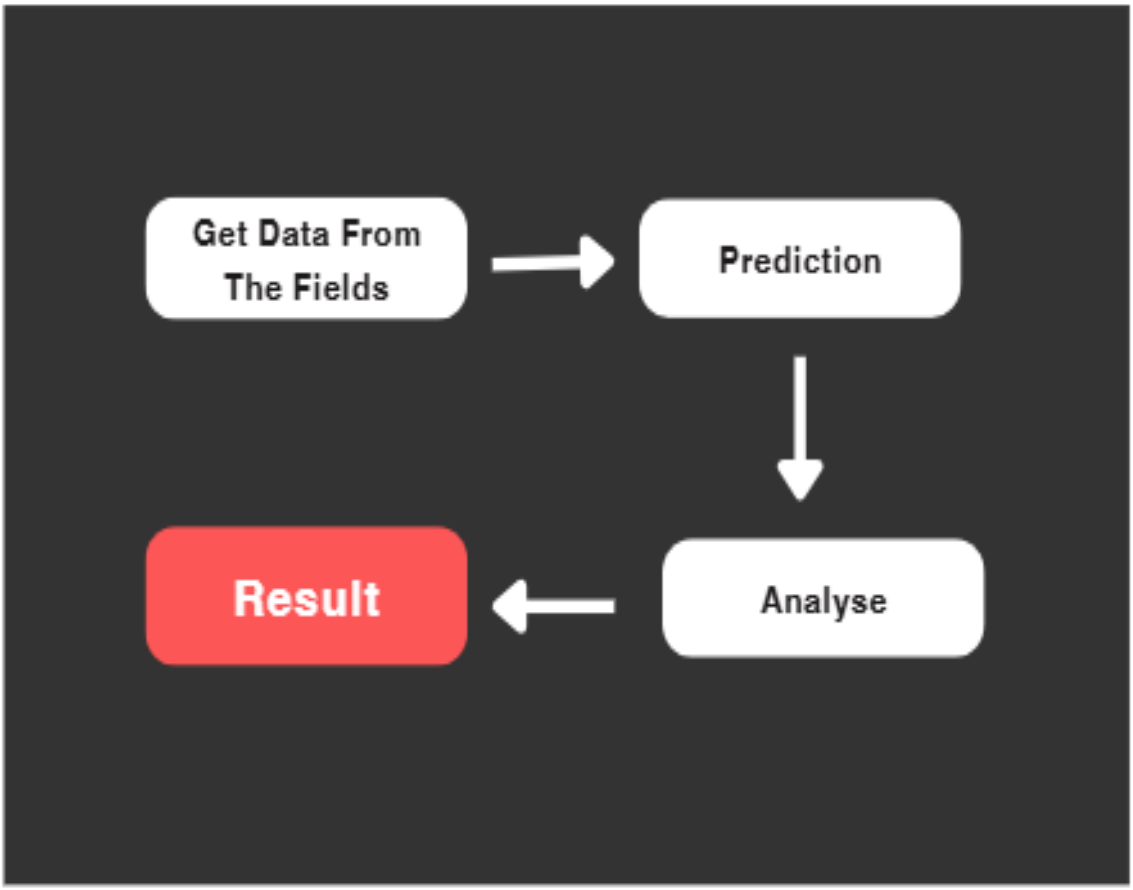
• **Yield Estimation ML Model Deployed**

- The yield estimation model predicts expected crop production based on environmental and soil data.

- It is deployed on the server, allowing farmers to access predictions directly from the dashboard.

- This feature supports planning, market decisions, and resource management for improved profitability.

- **Impact:** Assists farmers in forecasting harvests and planning resources effectively, improving revenue and sustainability.



Challenges Faced

- **Sensor Calibration with Varying Soil Conditions**
    - Soil properties like moisture, pH, and nutrient levels vary across regions and seasons, making sensor calibration difficult.
    - Ensuring consistent and accurate readings required frequent testing and adjustment of sensors.
    - Different soil types also affected the reliability of data collected, requiring customized calibration techniques.
    - **Impact:** Maintaining sensor accuracy was critical for generating reliable soil health reports and crop recommendations.

- **Collecting Enough Quality Data for Training Yield Estimation**
    - Gathering historical and real-time data for various crops was challenging due to limited availability and inconsistencies.
    - Ensuring data quality, such as removing outliers and handling missing values, required significant preprocessing.
    - The dataset needed to represent diverse soil, weather, and crop conditions for the ML model to perform accurately.
    - **Impact:** High-quality data was essential to train the yield estimation model, directly affecting prediction reliability.

• **Ensuring Low-Latency IoT–Cloud Integration**

- Real-time transmission of sensor data to the cloud posed challenges in terms of network reliability and bandwidth.
- Delays or data loss could affect soil health analysis and crop recommendation accuracy.
- Optimizing the IoT–cloud pipeline required careful design of communication protocols and data handling.
- **Impact:** Low-latency integration ensures farmers receive timely insights, enabling quick decision-making for crop management.

References

Research Paper

- **Title:** Crop yield prediction using machine learning: A systematic literature review

    - **Summary:** This paper provides a systematic review of machine learning applications in crop yield prediction, analyzing various algorithms and features utilized in the field.

Datasets

1. **Crop Yield in Indian States Dataset**

    - **Source:** Kaggle - Akshat Gupta

    - **Description:** Includes crop yield data across different Indian states, useful for analyzing regional agricultural productivity.

2. **Crop Yield Prediction Dataset**

    - **Source:** Kaggle - Patel Ris

    - **Description:** Contains data on various crops, including weather conditions and soil properties, aiding in yield prediction modeling.

3. **Crop Recommendation using Soil Properties and Weather Prediction Dataset**

    - **Source:** Mendeley Data

    - **Description:** Provides information on soil properties and weather conditions to recommend suitable crops for specific regions.

Official Documentation of Technologies Used

Frontend

- **Next.js (React Framework)**

    - **Documentation:** Next.js Docs
    - **Usage in Project:** Built the farmer dashboard and interactive UI, integrated weather API, and displayed real-time soil and crop data.

Backend

- **Node.js with Express**

    - **Documentation:** Node.js Docs, Express Docs
    - **Usage in Project:** Handles API requests, manages user authentication, and serves ML model predictions to the frontend.

Database

- **PostgreSQL**

- **Documentation:** PostgreSQL: Documentation
- **Usage in Project:** Stores farmer registration data, soil sensor readings, crop recommendations, and yield predictions.

IoT Sensors

- **Arduino IoT Sensors (Moisture, pH, NPK, etc.)**
  - **Documentation:** Arduino IoT Guide
  - **Usage in Project:** Collects soil parameters in real-time to generate soil health reports.

Machine Learning Libraries

- **Scikit-learn**
  - **Documentation:** Scikit-learn Docs
  - **Usage in Project:** Training crop recommendation and yield estimation models.
- **TensorFlow**
  - **Documentation:** TensorFlow Docs
  - **Usage in Project:** Deployed ML models for yield estimation and crop predictions.

Cloud Integration

- **AWS IoT Core**
  - **Documentation:** AWS IoT Core Docs
  - **Usage in Project:** Ensures secure and low-latency data transfer from IoT sensors to cloud for processing and storage.

Next Steps

• Work on CNN-based Disease Detection

- Implement a Convolutional Neural Network (CNN) model to detect crop diseases from leaf images.
- Train the model on labeled datasets of common crop diseases to ensure high accuracy.
- Integrate the model into the dashboard so farmers can upload images and receive instant disease diagnosis.
- **Impact:** Early detection of diseases helps prevent crop losses and improves overall yield.

• Integrate AI Voicebot in Regional Languages

- Develop a voice-enabled AI assistant to interact with farmers in their local languages.
- The voicebot will provide crop recommendations, weather updates, and answers to agricultural queries.
- Ensure natural language understanding for accurate responses and seamless communication.
- **Impact:** Makes the system accessible to farmers who may have low literacy or prefer verbal guidance.

• Develop AI-powered Marketplace Module

- Create a platform where farmers can buy and sell crops, seeds, fertilizers, and equipment.
- Use AI to suggest optimal pricing, predict demand, and connect buyers and sellers efficiently.
- Integrate it with the dashboard for a seamless user experience.
- **Impact:** Helps farmers maximize profits, reduce wastage, and access a wider market.