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AgroSphere: Smart Agriculture and Transparent Marketplace Platform for Indian Farmers

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Abstract

AgroSphere is a digital farming platform developed to support farmers with timely information and direct market access. The system brings together crop advisory services, weather insights, soil-based recommendations, and a transparent marketplace within a single application. By analyzing soil parameters, climate conditions, and past crop patterns, the platform helps farmers choose suitable crops, plan fertilizer use, and schedule irrigation more effectively. Real-time alerts on weather changes, pests, and market prices enable farmers to take preventive and informed decisions. In addition to advisory features, AgroSphere offers a secure marketplace where farmers can list their produce, receive price guidance, and connect directly with buyers. This reduces dependence on middlemen and improves income opportunities. An integrated logistics component ensures smooth delivery, while multilingual chatbot support makes the system accessible to farmers with different literacy levels. AgroSphere provides a practical and reliable solution designed to enhance agricultural productivity, improve profitability, and build a more transparent supply chain.

Keywords: Agricultural Technology,Crop Advisory, Digital Marketplace, Soil Analysis,Supply Chain, Decision
Support System.

1. INTRODUCTION

Agriculture is one of the most important sectors in India, but it still faces several challenges such as unpredictable weather conditions, inefficient resource usage, and lack of proper market access. Many farmers depend on traditional methods and do not have access to accurate or timely information, which affects productivity and income.With the advancement of technologies like Artificial Intelligence and Machine Learning, agriculture is gradually shifting towards data-driven practices. These technologies can help farmers make better decisions related to crop selection, irrigation, fertilizer usage, and selling strategies.

AgroSphere is designed as a smart farming platform that brings together agricultural advisory services and a digital marketplace into a single system. It helps farmers plan, monitor, and sell their crops more effectively.

1.1 PROBLEM DEFINITION

Farmers today face multiple problems that directly impact their income and productivity. One major issue is the lack of reliable information regarding weather, soil conditions, and crop suitability. Climate change has made farming more unpredictable, increasing the risk of crop failure.

Another significant problem is the dependency on middlemen for selling agricultural produce. This reduces profit margins and limits transparency in pricing. Additionally, existing tools are scattered and do not provide a complete solution in one place.

There is a clear need for a system that can provide accurate guidance, simplify decision-making, and offer direct market access.

1.2 EXISTING SYSTEM

Current agricultural systems mainly focus on individual features such as weather forecasting or soil testing. While these tools are useful, they are not integrated, forcing farmers to rely on multiple platforms. Most existing systems do not provide predictive analysis for yield or price forecasting. They also lack user-friendly interfaces and regional accessibility, making them difficult for farmers to use.

Due to these limitations, farmers are unable to fully benefit from available technologies.

1.3 PROPOSED SYSTEM

AgroSphere is designed as an integrated platform that combines multiple agricultural services into one system. It provides crop recommendations, yield prediction, fertilizer suggestions, and price forecasting using machine learning techniques.

The system also includes a digital marketplace where farmers can directly connect with buyers. This improves transparency and helps farmers receive better prices for their produce.

By combining intelligence and accessibility, AgroSphere aims to simplify farming and improve overall efficiency.

2.LITERATURE SURVEY

A. AI-Based Advisory and Chatbot Systems

Recent developments in agricultural advisory systems have focused on improving accessibility through AI-driven chat interfaces. Singh et al. proposed a multilingual chatbot capable of delivering crop-related guidance and weather updates using natural language processing techniques. Their system demonstrated the importance of localized and easy-to-understand communication for farmers.

Raut et al. introduced a smart assistant platform that combines predictive analytics with user interaction, enabling farmers to receive tailored suggestions based on regional conditions. Similarly, Gobinath et al. extended this concept by incorporating voice-based interaction, making the system accessible to farmers with limited literacy. These studies highlight that conversational and voice-enabled systems play a crucial role in improving the usability of digital agricultural platforms.

B. Predictive Analytics and Yield Models

Predictive analytics has become a key component in modern agriculture, particularly for crop yield estimation and market forecasting. Paudel et al. demonstrated how large-scale agricultural datasets can be used to improve decision-making through data-driven insights. Their work showed that combining soil, weather, and crop data significantly enhances prediction accuracy.

Further research has explored machine learning algorithms such as Random Forest, Support Vector Machines, and neural networks for yield prediction. These models are effective in handling complex agricultural data and identifying patterns that are difficult to detect using traditional methods.

In the context of price forecasting, Sharma et al. applied a combination of machine learning and time-series models to predict crop prices, enabling farmers to make better selling decisions. These approaches emphasize the importance of predictive modeling in improving both production and market planning.

C. Disease Detection and Computer Vision

The application of deep learning techniques in agriculture has significantly improved plant disease detection. Convolutional Neural Networks (CNNs) are widely used to analyze crop images and identify diseases at early stages. Studies have shown that these models can achieve high accuracy when trained on well-labeled datasets.

Kabala et al. introduced federated learning approaches for disease detection, allowing multiple systems to collaborate without sharing raw data. This approach ensures data privacy while improving model performance. These advancements highlight the growing role of computer vision in enhancing crop health monitoring.

D. IoT and Precision Agriculture

Precision agriculture relies heavily on real-time data collection and analysis. IoT-based systems enable continuous monitoring of soil moisture, temperature, and environmental conditions. Ibrahim et al. demonstrated that integrating sensors with machine learning models can improve farming efficiency by providing timely recommendations.

Other studies have shown that precision irrigation and nutrient management systems can significantly reduce resource wastage. Satellite-based monitoring techniques, including NDVI analysis, further enhance the ability to track crop health and optimize farming practices.

E. Research Gap

Although significant progress has been made in individual areas such as crop prediction, disease detection, and IoT-based monitoring, most existing systems operate independently and lack integration. Farmers are often required to use multiple tools to manage different aspects of agriculture, which increases complexity and reduces efficiency.

There is a clear need for a unified platform that combines advisory services, predictive analytics, and marketplace functionality into a single system. AgroSphere addresses this gap by integrating these features into an accessible and scalable solution, providing end-to-end support for farmers.

3.DESIGN AND METHODOLOGY

3.1 Introduction

The methodology used in AgroSphere focuses on developing an intelligent and data-driven platform that supports farmers throughout the entire agricultural process from planning to selling. The system integrates artificial intelligence, machine learning, and real-time data analytics to provide farmers with personalized crop schedules, weather alerts, and market insights.

The approach begins with collecting and processing key agricultural data such as soil properties, weather conditions, and crop details. This information is analyzed using AI models that generate smart recommendations for irrigation, fertilizer application, and harvesting timelines. Real-time weather monitoring ensures timely alerts and precautionary measures to reduce crop risk. In addition to the cultivation stage, AgroSphere also enables transparent trading through an AI-powered marketplace that connects farmers directly with buyers. This ensures fair pricing, eliminates intermediaries, and strengthens the overall agricultural economy. The methodology is designed to promote sustainable farming, data-driven decision-making, and digital inclusion for all farmers.

3.2 System Workflow

AgroSphere functions as a multi-module intelligent web platform that integrates both analytical and interactive components. The process begins with farmer input, where details such as soil characteristics, crop type, land size, and location are provided. The system then collects real-time weather and market data through external APIs such as OpenWeather and AGMARKNET. All collected data is preprocessed using validation, normalization, and encoding techniques to prepare it for analysis. Machine learning models analyze this data to generate personalized crop schedules, including irrigation and fertilizer planning. The system also continuously monitors weather conditions to provide alerts and precautionary guidance. After harvesting, farmers can upload their produce to the marketplace, where the system suggests fair prices and enables direct communication with buyers.

3.3 Dataset Description

AgroSphere utilizes a variety of static and real-time datasets to support its predictive, advisory, and marketplace functionalities.

Figure 3.3: Dataset Table

Type	Attributes	Purpose	Sources
Farmer Input	Soil type, pH, crop type, land size, geographic location	Crop,and fertilizer scheduling	Farmer entries
Weather Dataset	Temperature, humidity, rainfall, wind speed, seasonal index	Dynamic scheduling and weather alerts	OpenWeather API, Indian Meteorological Department

Soil & Fertilizer Dataset	NPK levels, moisture, pH	Fertilizer recommendati on models	SoilGrids, FAOSTAT, regional agricultural data
Crop Growth Dataset	Growth stages – sowing, vegetative, flowering, harvesting	Predict growth timelines and yield estimation	Agricultural repositories
Market Price Dataset	Commodity names, prices, regional demand indices	Price prediction and marketplace fairness	AGMARKNET, APEDA, local market APIs

3.4 Data Preprocessing

Before analysis, data is standardized through preprocessing to ensure highquality and consistent model inputs.

Key preprocessing steps include:

- Data Cleaning: Removal of duplicates, missing entries, and inconsistent values.
- Feature Scaling: Applying Min–Max normalization to make numerical attributes comparable.
- Label Encoding: Converting categorical attributes (e.g., soil or crop type) into numerical form.
- Time-Series Structuring: Formatting weather and price data for sequencebased forecasting models.

3.5 Machine Learning Models

AgroSphere integrates multiple AI and ML models, each optimized for specific agricultural and economic tasks.

3.5.1 Crop Recommendation and Yield Prediction

Algorithms Used: Random Forest and Gradient Boosting

Input Features: Soil parameters, crop type, temperature, humidity

Output: Recommended crop and estimated yield

Rationale: Random Forest enhances prediction accuracy by averaging the outputs of multiple decision trees.

3.5.2 Fertilizer and Irrigation Scheduling

Algorithms Used: Linear Regression and Time-Series Forecasting

Purpose: Determines optimal fertilizer quantities and irrigation timing based on nutrient availability and climatic conditions.

Formula:

$$Y=\beta_0+\beta_1x_1+\beta_2x_2+\cdots+\beta_nx_n$$

where Y represents fertilizer or irrigation quantity, and x_1, x_2, … x_n correspond to environmental and soil factors.

3.5.3 Market Price Forecasting

Algorithms Used: Long Short-Term Memory (LSTM) and Random Forest Regressor
Purpose: Predicts commodity prices and ensures marketplace fairness by suggesting AI-assisted fair prices.
Input: Historical market price trends and regional demand indices.

3.6 UML Diagrams

3.6.1 Class diagram

The class diagram shown below represents the core logical structure of the AgroSphere system. It illustrates the key classes, their responsibilities, and the relationships that define how data flows and operations are performed across different modules. The design follows object-oriented principles such as modularity, abstraction, and reusability, ensuring that the system remains scalable and easy to maintain.

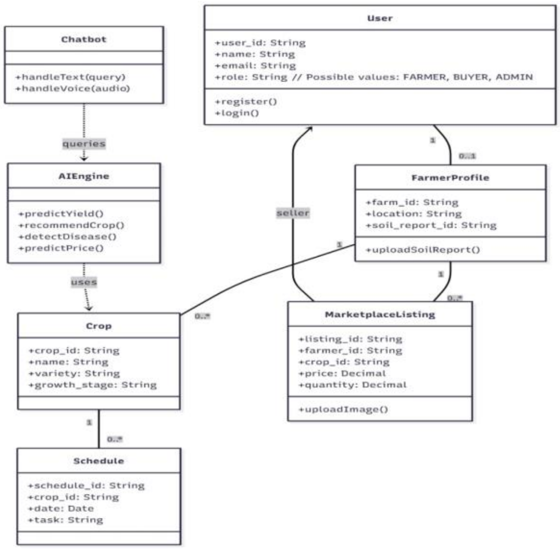

Figure 3.6.1: Class diagram

3.6.2 Architecture Diagram

Major components include:

- Farmer Portal: web & mobile UI for farmers (soil, crop input, schedules, upload produce).
- Buyer Portal : listing browsing, ordering, tracking.
- Admin Panel: user management, moderation, analytics.
- AI Engine: prediction services (crop recommendation, scheduling, disease detection, price forecasting).
- Marketplace Module: listings, orders, payment and logistics hooks.
- External APIs: OpenWeather / IMD, AGMARKNET / APEDA market feeds, satellite/NDVI providers, IoT data endpoints.
- Data Layer: primary DB (MongoDB/MySQL), object storage for images, model artifact storage.
- Message Bus / Queue: (RabbitMQ / Kafka) for asynchronous tasks: model training, email notifications, order processing. • Auth & Security: OAuth2 / JWT, role-based access control.

This figure illustrates the overall architecture of the AgroSphere platform, showing the interaction between frontend interfaces, backend services, and the AI engine. Users such as farmers, buyers, and admins access the system through web and mobile applications, which communicate via an API Gateway. The backend processes requests, integrates machine learning models for predictions, and interacts with the data layer for storage. External APIs provide real-time data, making the system intelligent, scalable, and efficient

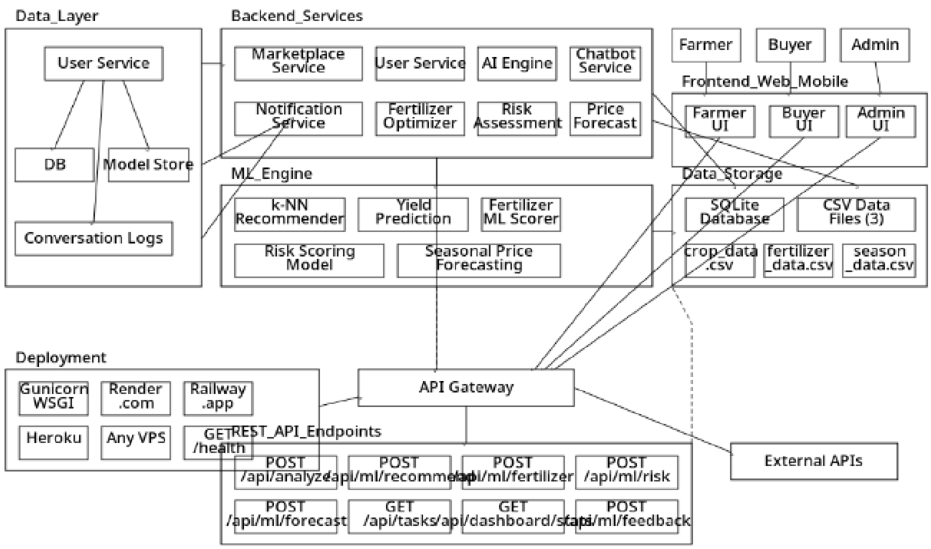

Figure 3.6.2: Architecture diagram

3.6.3 Activity Diagram Summary

Summary of the Activity Diagram

1. **Start:** The process begins with user login.
2. **User Role Decision:** The system checks if the user is a farmer or buyer and splits the activity flow accordingly.
3. **Farmer Workflow:**

The farmer enters soil and crop details into the system. The AI engine processes this data to provide crop recommendations and scheduling. The system generates weather alerts to assist with farm management. The farmer then uploads produce to the marketplace for listing.

4. **Buyer Workflow:**

The buyer browses available products on the marketplace. Buyers can view AI-driven quality grading and price predictions for listed produce. Buyers place orders and complete payments for selected products.

5. **Admin Role:**

Both farmer listing uploads and buyer orders flow to the system admin.

The admin is responsible for approving marketplace listings and monitoring system analytics.
6. **End:** The process termination is shown, concluding the business workflow.

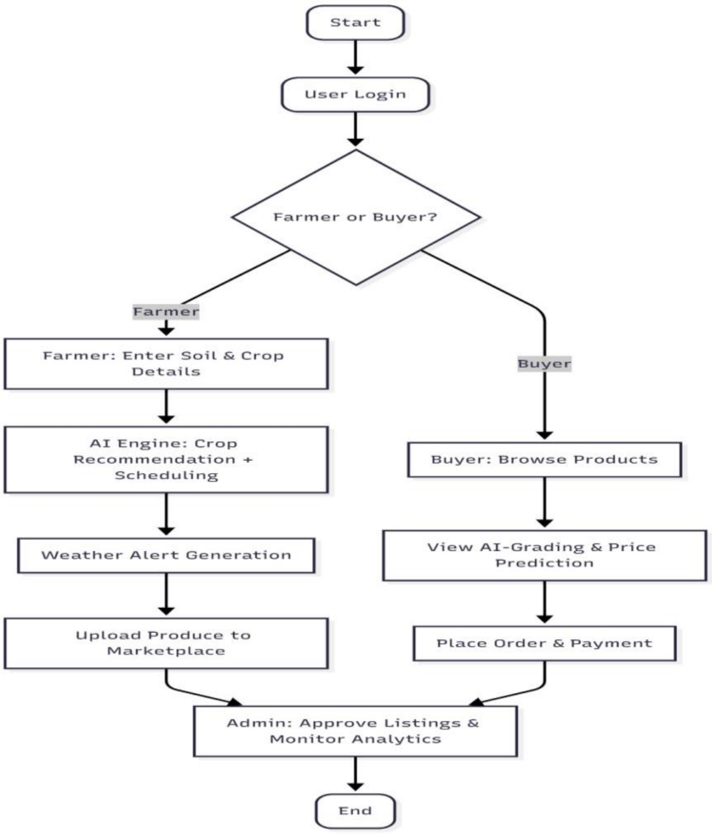

Figure 3.6.3: Activity diagram

3.7 User Interface Design

- UI principles: clean, minimal, mobile-first, multilingual, accessible (WCAG standards).
- Main screens: Farmer dashboard, Add farm/soil report, Smart schedule viewer, Marketplace, Chatbot pane, Admin dashboard.
- UX notes: Large tappable buttons, icon + text labels, voice guidance, tutorials, locale-specific formats.

3.8 Testing & Validation

- Unit and integration tests.
- Load testing for concurrency.
- User acceptance with farmers.
- Field validation against expert labels.

4.IMPLEMENTATION OF AGROSPHERE

4.1 Overview of Implementation

The implementation of AgroSphere focuses on developing a modular and user-friendly smart agriculture platform that integrates machine learning models and real-time data sources. The system is designed using a full-stack architecture to provide crop recommendations, weather insights, and market price information to farmers.

The implementation is divided into three main components: Frontend (User Interface), Backend (Server-side Logic), and Database and Machine Learning Modules. These components work together to provide an efficient decision-support system for farmers.

4.2 Frontend Implementation

The frontend is designed to provide a simple and intuitive interface for farmers to interact with the system.

Technologies Used: React.js, HTML5, CSS3, JavaScript (ES6+)

Key Features: Input forms for soil parameters (pH, NPK, etc.), crop selection interface, display of recommended crops and fertilizers, weather information dashboard, and market price display for crops. The interface is designed to be responsive and easy to use, ensuring accessibility for users with basic digital knowledge.

4.3 Backend Implementation

The backend manages data processing, API handling, and communication between the frontend and machine learning models.

Technologies Used: Flask (Python), Node.js (Express.js), RESTful APIs

Key Functionalities: Handling user input data, connecting frontend with ML models, fetching weather data from external APIs, retrieving market price data, and sending processed results back to the frontend. The backend ensures smooth and efficient data flow across all modules.

4.4 Database Implementation

The system uses databases to store agricultural data and model-related datasets.

Technologies Used: MySQL, MongoDB

Stored Data: Soil and crop datasets, weather data (historical where applicable), and market price datasets. Efficient data storage and retrieval mechanisms are implemented to support fast processing.

4.5 Machine Learning Implementation

AgroSphere integrates machine learning models to assist farmers in decision-making.

Technologies Used: Scikit-learn, Pandas, NumPy

Modules Implemented:

1. Crop Recommendation System Uses classification algorithms (e.g., Random Forest). Inputs include soil type, pH, and climatic conditions. Output: suitable crop suggestions.
2. Fertilizer Recommendation System Based on NPK values and soil conditions, it provides optimal fertilizer suggestions.
3. Yield Prediction Model Uses regression techniques to estimate expected crop yield.

4. Market Price Analysis Displays current crop prices based on available datasets/APIs and helps farmers understand market trends.

4.6 Market Price Module

The market module is designed to provide transparency by displaying crop prices to farmers.

Features: Displays current prices of different crops, uses external APIs or datasets (e.g., AGMARKNET), and helps farmers make informed selling decisions.

4.7 System Integration

The system integrates various components using APIs. Integration components include the Weather API (OpenWeather), Market Price APIs, and Machine Learning models. This integration ensures real-time data flow and accurate recommendations.

4.8 Security Implementation

Basic security measures are implemented to protect system data. These include secure API communication, input validation, and role-based access (if applicable).

4.9 Testing and Validation

The system is tested to ensure correct functionality and reliability. Testing methods include Unit Testing, Integration Testing, and output validation of ML models. The system produces consistent and reliable outputs for given inputs.

5.RESULTS AND DISCUSSION

5.1 Overview of Results

The AgroSphere platform was successfully implemented and deployed as a full-stack web application accessible at https://agrosphere-1.onrender.com. The system demonstrated effective integration of machine learning models, real-time data processing, and an intuitive user interface. The results are presented module-wise based on the actual outputs observed during system testing.

5.2 Home Page and Landing Interface

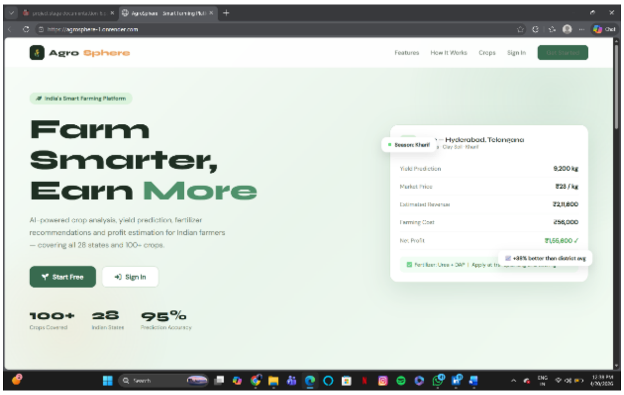

Figure 5.2: Home page

The landing page of AgroSphere (Home page) presents a clean and professional interface with the tagline "Farm Smarter, Earn More." The page clearly communicates the platform's purpose as an AI-powered crop analysis, yield prediction, fertilizer recommendation, and profit estimation system for Indian farmers. Key statistics displayed on the homepage include coverage of 100+ crops, 28 Indian states, and a 95% prediction accuracy rate. A live preview card on the homepage demonstrates a sample output for Hyderabad, Telangana, showing yield prediction, market price (₹23/kg), estimated revenue (₹2,11,600), farming cost (₹56,000), and net profit (₹1,55,600), giving new users an immediate understanding of the platform's capabilities.

5.3 User Registration and Profile Creation

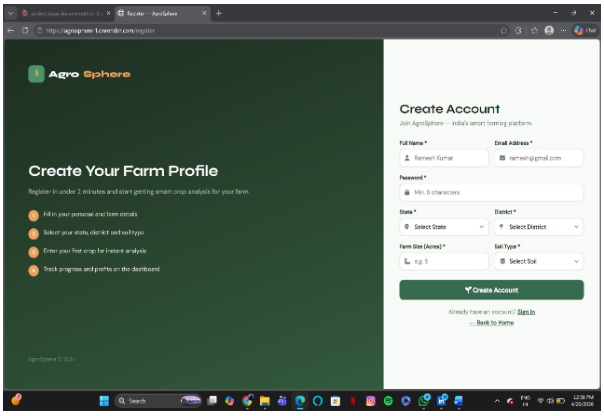

Figure 5.3: Create account

The registration module allows farmers to create an account in under 2 minutes. The registration form collects essential details including full name, email address, password, state, district, farm size (in acres), and soil type. The interface is divided into two panels the left panel guides the user through four simple steps (filling personal and farm details, selecting state/district/soil type, entering the first crop, and tracking progress), while the right panel contains the actual form. This design improves usability and reduces confusion for first-time users. Upon successful registration, users are directed to their personalized dashboard.

5.4 Farmer Dashboard

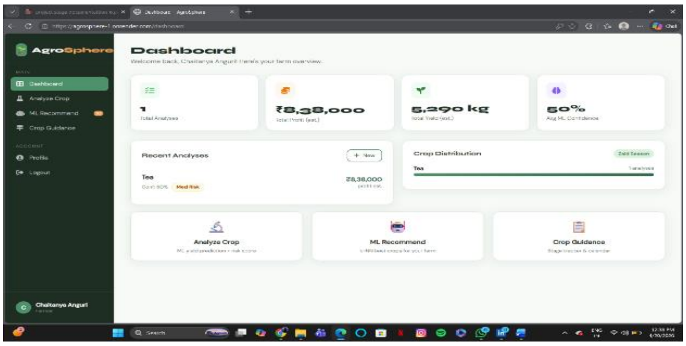

Figure 5.4: Dashboard Interface

After login, farmers are provided with a personalized dashboard that displays important farm-related insights and analysis results. The dashboard shows details such as total analyses conducted, estimated profit, predicted yield, and average machine learning confidence score. It also includes a recent analysis section displaying crop details, risk level, and estimated profit. Additional features such as crop distribution and quick-access options for crop analysis, recommendations, and guidance help users easily navigate the platform and access important tools.

5.5 Crop Analysis Module

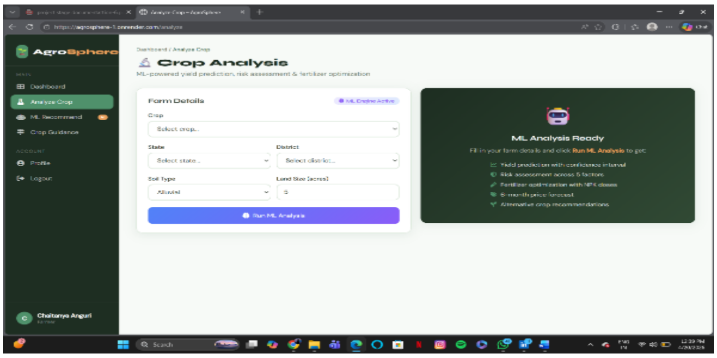

Figure 5.5: Crop analysis

The Crop Analysis page is the core feature of AgroSphere, offering ML-powered yield prediction, risk assessment, and fertilizer optimization. The input form accepts the following parameters: crop name, state, district, soil type, and land size in acres. Upon clicking "Run ML Analysis," the system processes the inputs using the trained machine learning model and returns detailed results.

During testing with Cotton crop in a Black soil, 5-acre land, the system produced the following outputs: Total Yield: 7,620 kg, Revenue: ₹4,72,418, Farming Cost: ₹88,321, and Net Profit: ₹3,84,096. The ML Prediction Confidence was recorded at 66%, with a yield range of 1109–1938 kg/acre. The system also flagged a seasonal warning "Cotton is best grown in Kharif season. Current season is Zaid. Yield may be reduced by ~15%" demonstrating the system's awareness of seasonal suitability.

5.6 Risk Assessment Results

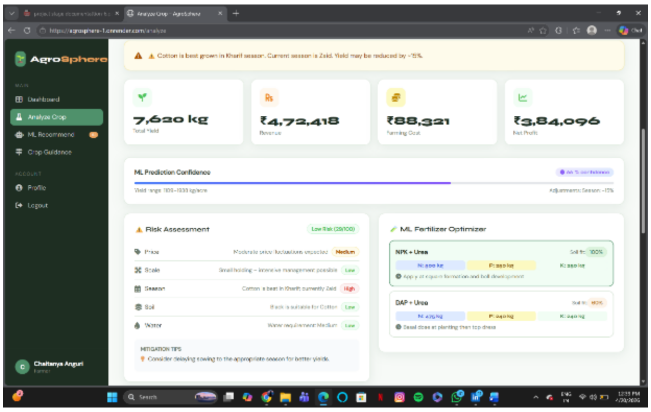

Figure 5.6: Risk Assessment

The Risk Assessment module evaluates farming risk across five key factors. For the Cotton analysis, the results were as follows: Price risk was rated Medium due to moderate price fluctuations, Scale risk was Low as the small holding allows intensive management, Season risk was High since Cotton is best suited for Kharif but the current season is Zaid, Soil risk was Low as Black soil is suitable for Cotton, and Water risk was Low given the medium water requirement of the crop. The overall risk score was 29 out of 100, classified as Low Risk. A mitigation tip was also generated: "Consider delaying sowing to the appropriate season for better yields."

5.7 ML Fertilizer Optimizer Results

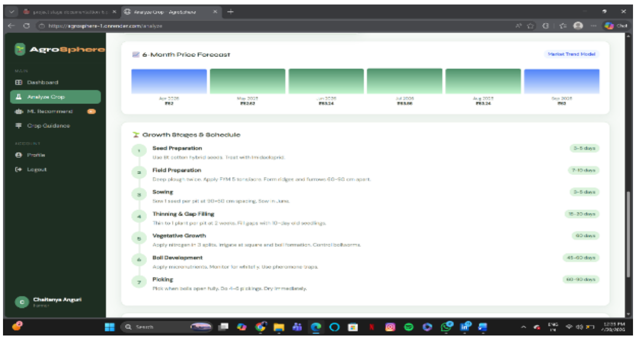

Figure 5.7 : ML results

The ML Fertilizer Optimizer provided two fertilizer recommendations based on soil compatibility. The first recommendation, NPK + Urea, achieved a 100% soil fit with dosages of N: 500 kg, P: 250 kg, and K: 250 kg, to be applied at square formation and boll development stages. The second recommendation, DAP + Urea, achieved a 60% soil fit with dosages of N: 475 kg, P: 240 kg, and K: 240 kg, suggested as a basal dose at planting followed by top dressing. These results confirm that the fertilizer optimization module provides actionable, soil-specific recommendations.

5.8 6-Month Price Forecast

The system generated a 6-month market price forecast using a Market Trend Model. For Cotton, the forecasted prices were: April 2026 - ₹62/kg, May 2026 - ₹62.62/kg, June 2026 - ₹63.24/kg, July 2026 - ₹63.86/kg, August 2026 - ₹63.24/kg, and September 2026 - ₹62/kg. This forecast helps farmers plan their harvest and selling timeline to maximize profit based on expected market trends.

5.9 Growth Stages and Schedule

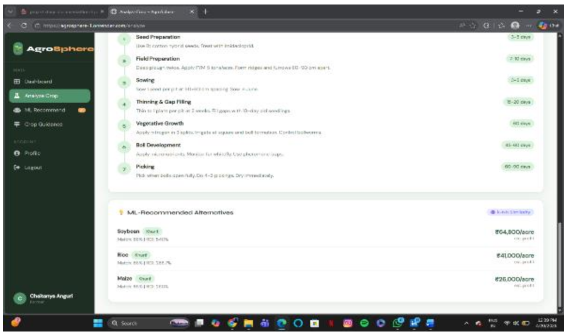

Figure 5.9: Growth Stages

The system generated a detailed crop growth schedule for Cotton, covering seven stages with estimated durations: Seed Preparation (3–5 days) use Bt cotton hybrid seeds treated with Imidacloprid; Field Preparation (7–10 days) deep plough twice, apply FYM 5 tons/acre, form ridges and furrows 60–90 cm apart; Sowing (3–5 days) sow 1 seed per pit at 90×60 cm spacing in June; Thinning and Gap Filling (15–20 days) thin to 1 plant per pit at 2 weeks and fill gaps with 10-day old seedlings; Vegetative Growth (60 days) apply nitrogen in 3 splits, irrigate at square and boll formation, control bollworms; Boll Development (45–60 days) apply micronutrients, monitor for whitefly, use pheromone traps; and Picking (60–90 days) pick when bolls open fully, do 4–6 pickings, and dry immediately. This stage-by-stage schedule provides farmers with a practical cultivation guide.

5.10 ML-Recommended Alternative Crops

Using a k-NN Similarity algorithm, the system suggested three alternative crops suitable for the farmer's conditions. Soybean (Kharif) - 86% match with an estimated profit of ₹64,800/acre and ROI of 540%; Rice (Kharif) - 86% match with an estimated profit of ₹41,000/acre and ROI of 288.7%; and Maize (Kharif) - 86% match with an estimated profit of ₹26,000/acre and ROI of 260%. These alternatives allow farmers to make informed decisions if they wish to switch or diversify their crops.

6.CONCLUSION AND FUTURE SCOPE

6.1 Conclusion

AgroSphere was developed to provide Indian farmers with a smart and easy-to-use decision support system using machine learning and real-time data. The platform successfully provides crop recommendations, fertilizer guidance, yield prediction, market price analysis, and risk assessment through an integrated web application. Testing showed reliable performance across all major modules, helping farmers make better farming and selling decisions. With support for multiple crops and Indian states, AgroSphere serves as a practical step toward improving agricultural productivity and farmer income through digital technology.

6.2 Future Scope

Future improvements include developing a mobile application, adding regional language support, integrating IoT-based soil monitoring, and improving weather forecasting accuracy. These enhancements will make the platform more accessible, accurate, and useful for farmers across different regions.

6.3 Final Remarks

AgroSphere is a practical smart farming platform that addresses important challenges faced by Indian farmers. With further development and feedback, it can evolve into a more advanced and comprehensive agricultural support system.

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