

# Agri Tech: An AI-Powered Multilingual Farmer Advisory System for Smart Agricultural Decision-Making

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**Abstract** - Agriculture forms the backbone of India's economy, supporting over 58% of the rural population and contributing approximately 17% to the national GDP. Despite its significance, the agricultural sector remains severely underserved by modern technology, leaving millions of farmers without timely access to critical crop advisory services, weather guidance, market pricing intelligence, or disease diagnostics. Agri Tech is a comprehensive, AI-powered multilingual farmer advisory system designed to bridge this gap by integrating multiple intelligent modules into a single accessible platform. The system leverages advanced Natural Language Processing (NLP), machine learning-based crop recommendation algorithms, satellite and API-sourced weather forecasting, computer vision for plant disease detection, and real-time mandi price retrieval through government agricultural data APIs. Key features include a conversational AI chatbot supporting Hindi, Marathi, and English; a crop recommendation engine utilizing soil parameter analysis with ensemble learning; a weather alert system for proactive agricultural planning; a plant leaf disease detection module using Convolutional Neural Networks (CNN); a government scheme navigator providing personalized scheme recommendations; and a smart marketplace connecting farmers directly with buyers. Experimental evaluations demonstrate strong accuracy across all modules. The crop recommendation model achieves 97.2% accuracy using a Random Forest classifier trained on NPK-soil dataset. The plant disease CNN model achieves 96.8% classification accuracy across 38 disease classes. Agri Tech is deployed as a cross-platform mobile and web application, designed for usage on low-bandwidth rural networks with multilingual voice and text interfaces. This system represents a significant step toward democratizing agricultural intelligence for the 150+ million smallholder farmers of India.

**Keywords:** Agri Tech, AI Farmer Advisory, Crop Recommendation, Plant Disease Detection, NLP Chatbot, Mandi Price API, Government Schemes, Smart Agriculture,

Multilingual Interface, CNN, Random Forest, Precision Farming.

## I. INTRODUCTION

India's agricultural sector employs over 263 million individuals, making it the world's largest employer. Yet, the average Indian farmer earns far below the national poverty line, with crop losses due to disease, weather volatility, information asymmetry, and poor market access contributing to annual losses estimated at ₹50,000 crore. The Indian government has launched numerous welfare schemes — PM-KISAN, PMFBY, soil health cards, and more — yet awareness and adoption among rural farming communities remains dismally low, largely due to communication barriers and lack of accessible interfaces.

The proliferation of affordable smartphones and expanding rural 4G/5G coverage has created an unprecedented opportunity to deliver agricultural intelligence directly to farmers. Artificial Intelligence, Machine Learning, and Natural Language Processing have matured to a stage where real-world agricultural applications can be built and deployed at scale. Agri Tech (meaning 'Farmer's Friend' in Hindi) is conceived and developed in this context — as a unified, AI-driven platform that empowers farmers with actionable intelligence across the critical dimensions of their livelihood: what to grow, how to grow it, how to protect it, when to sell it, and how to access governmental support.

The system integrates six core functional modules: (1) a multilingual AI chatbot for conversational advisory, (2) a crop recommendation engine powered by soil analysis, (3) a weather intelligence and alert system, (4) a CNN-based plant disease detection tool, (5) a government scheme navigator with eligibility filtering, and (6) a smart marketplace for direct farmer-to-buyer commerce. Together, these modules represent the most comprehensive AI-powered farmer advisory platform designed specifically for Indian agricultural conditions.

## II. LITERATURE SURVEY

Research at the intersection of AI and agriculture has grown substantially over the past decade. Mohanty et al. (2016) demonstrated that deep learning models trained on the PlantVillage dataset could achieve over 99% accuracy under controlled conditions for plant disease classification, inspiring subsequent work on real-world deployment. However, their study acknowledged significant accuracy degradation under field conditions due to lighting variation, background clutter, and image quality — challenges Agri Tech addresses through robust preprocessing pipelines.

Ferentinos (2018) further validated CNN architectures for plant disease detection, benchmarking GoogLeNet, AlexNet, and Overfeat, while highlighting the importance of diverse, field-realistic training data. Ramesh and Vydeki (2019) proposed ML-based crop recommendation systems using soil nutrient data, demonstrating that Random Forest consistently outperforms SVM and Decision Tree classifiers for multi-class crop prediction tasks.

In the domain of agricultural chatbots and NLP, Jha et al. (2020) explored conversational AI for pest management advisory in Hindi, noting that code-switching (mixing Hindi and English in speech) presents a unique NLP challenge in Indian agricultural contexts. Agri Tech's chatbot module directly addresses this through a hybrid NLP pipeline trained on multilingual agricultural corpora. Studies on government scheme adoption (Narayanan, 2019) reveal that 60% of eligible farmers are unaware of their entitlements, justifying the integration of a dedicated scheme advisory module.

Table 1: Summary of Related Works

Author(s)	Year	Contribution	Methodology
Mohanty et al.	2016	Plant disease detection on PlantVillage dataset	CNN (GoogLeNet, AlexNet)
Ferentinos	2018	Benchmarking CNN for leaf disease classification	CNN architectures
Ramesh & Vydeki	2019	ML-based crop recommendation system	Random Forest, SVM
Jha et al.	2020	Multilingual chatbot for pest advisory	NLP, Code-switching
Narayanan	2019	Govt. scheme awareness gaps in farming	Survey Analysis

## III. SYSTEM ARCHITECTURE & METHODOLOGY

### 3.1 Overall Architecture

Agri Tech follows a modular, microservices-inspired architecture where each functional module operates independently but communicates through a unified API gateway. The frontend is built with React Native (mobile) and React.js (web), enabling cross-platform deployment. The backend is powered by a Node.js / Express.js REST API layer interfacing with Python-based ML model services exposed via Flask microservices. All user data, crop profiles, and transaction records are persisted in a MongoDB cloud database, chosen for its schema flexibility and horizontal scalability.

The system is deployed on cloud infrastructure with auto-scaling capabilities to handle peak agricultural advisory demand during sowing and harvesting seasons. A content delivery network (CDN) ensures low-latency responses even in bandwidth-limited rural areas. All model inference is performed server-side, eliminating the need for high-end user devices.

### 3.2 Module 1 – Multilingual AI Chatbot

The conversational AI module is the primary interface through which farmers interact with Agri Tech. Built on a fine-tuned multilingual transformer model (mBERT / XLM-RoBERTa backbone), the chatbot understands and responds in Hindi, Marathi, and English, including mixed-language (Hinglish/Marathish) queries common in rural Maharashtra and central India.

The chatbot handles intent classification across 45+ agricultural intents — including pest control queries, fertilizer dosage questions, irrigation timing, post-harvest storage advice, and government scheme eligibility inquiries. Context management across multi-turn conversations is maintained using a session-based dialogue manager. A text-to-speech (TTS) module enables voice output in regional languages, specifically designed for low-literacy users.

### 3.3 Module 2 – Crop Recommendation Engine

The crop recommendation module analyzes soil health parameters submitted by the farmer — Nitrogen (N), Phosphorus (P), Potassium (K), soil pH, rainfall, temperature, and humidity — and recommends the top 3 most suitable crops for the given conditions. The recommendation model is an ensemble of Random Forest, Gradient Boosting, and a K-Nearest Neighbor classifier, with the Random Forest model achieving the best standalone accuracy of 97.2% on the Crop

Recommendation Dataset comprising 2,200 labeled records across 22 crop classes.

In addition to crop suitability, the module provides fertilizer composition recommendations, expected yield estimates, and crop rotation suggestions to promote soil health over successive seasons.

### 3.4 Module 3 – Weather Intelligence System

Weather is the single largest uncontrollable variable in agricultural productivity. The weather module integrates real-time forecast data from the OpenWeatherMap API and IMD (India Meteorological Department) alerts, providing farmers with 7-day weather outlooks, extreme weather warnings (hailstorm, frost, heavy rainfall), and actionable advisory tied to the forecast — such as delaying irrigation if rain is forecast within 48 hours, or covering crops before hailstorm advisories.

Farmers receive push notifications and SMS alerts for critical weather events in their local language. The system uses geo-fencing to deliver hyper-local weather intelligence at the district and taluka level, significantly more granular than generic regional forecasts.

### 3.5 Module 4 – Plant Disease Detection

The plant disease detection module enables farmers to diagnose crop infections by capturing and uploading a photograph of an affected leaf. A Convolutional Neural Network model trained on an augmented dataset derived from PlantVillage (54,306 images, 38 disease classes across 14 crop species) performs image classification. The architecture employs a MobileNetV2 backbone with custom classification head, optimized for edge-server deployment balancing accuracy with inference speed.

Preprocessing includes background removal using GrabCut segmentation, contrast enhancement, resizing to 224×224 pixels, and normalization. Data augmentation (horizontal/vertical flip, rotation ±30°, zoom, brightness variation) is applied during training. The model achieves 96.8% test accuracy and average inference time of 340ms per image on a standard cloud GPU instance.

Upon disease detection, the system delivers the disease name, severity assessment, affected crop area estimation, and a detailed treatment protocol including recommended agrochemicals with dosage, application method, and precautionary measures — sourced from the ICAR (Indian Council of Agricultural Research) advisory database.

### 3.6 Module 5 – Government Scheme Navigator

India operates over 120 active central and state-level agricultural welfare schemes including PM-KISAN, Pradhan Mantri Fasal Bima Yojana (PMFBY), Kisan Credit Card (KCC), Soil Health Card, PM Krishi Sinchai Yojana, and numerous state-specific subsidies. Agri Tech's scheme navigator maintains a structured, regularly updated database of all active schemes, their eligibility criteria, application deadlines, benefit amounts, and application procedures.

Using a rule-based expert system augmented with ML-based eligibility matching, the module analyzes the farmer's profile — land holding size, crop type, state of residence, caste category, bank account linkage — and recommends schemes for which they are likely eligible. Direct application links and document checklists are provided, substantially reducing administrative friction in scheme access.

### 3.7 Module 6 – Smart Marketplace

The marketplace module eliminates intermediaries from the agricultural supply chain by connecting farmers directly with registered buyers, retailers, and agri-businesses. Farmers can list their produce with quantity, quality grade, expected harvest date, and location. Buyers can search, filter, and place advance purchase orders. The module integrates real-time Minimum Support Price (MSP) data and live mandi rates fetched from the Government of India's Agmarknet API, ensuring farmers negotiate from an informed position.

A logistics coordination sub-module assists in arranging transportation from farm to buyer or nearest mandi, partnering with regional transport aggregators. Digital payment integration via UPI/NEFT enables seamless, cashless transactions with digital receipts for record-keeping.

## IV. SYSTEM SPECIFICATIONS

Table 2: Hardware & Software Specifications

Parameter	Specification
Server Processor	Intel Xeon E5 / AWS EC2 c5.xlarge
Server RAM	16 GB DDR4 (scalable to 64 GB)
Storage	500 GB SSD + AWS S3 cloud storage
GPU (Model Training)	NVIDIA Tesla T4 (16 GB VRAM)
Operating System	Ubuntu 20.04 LTS
Backend Language	Python 3.9 / Node.js 18

Parameter	Specification
ML Framework	TensorFlow 2.10, Scikit-learn 1.2
Frontend	React Native 0.71 / React.js 18
Database	MongoDB Atlas (Cloud)
APIs Integrated	OpenWeatherMap, Agmarknet, PM-KISAN API
NLP Framework	Hugging Face Transformers (mBERT)
Deployment	AWS EC2 + Docker + Nginx

### V. EXPERIMENTAL RESULTS & DISCUSSION

All modules of Agri Tech were evaluated independently on held-out test datasets. For the crop recommendation engine, the Random Forest model trained on the 2,200-record NPK dataset achieved 97.2% classification accuracy on a stratified 80-20 train-test split, outperforming SVM (89.4%), Decision Tree (83.7%), and Naïve Bayes (74.1%). The ensemble voting classifier combining Random Forest and Gradient Boosting reached 97.8% accuracy, further improving single-model performance.

The plant disease CNN module, based on MobileNetV2 architecture, achieved 96.8% test accuracy across 38 disease classes on the augmented PlantVillage dataset. Per-class F1 scores ranged from 0.91 to 0.99, with tomato and wheat disease classes achieving the highest precision. Average inference latency was 340ms, well within the 2-second user experience threshold.

Table 3: Performance Summary Across All Modules

Module / Model	Accuracy / Metric	Remarks
Crop Rec. Random Forest	97.2%	Best standalone model
Crop Rec. Gradient Boost	95.6%	Strong alternative
Crop Rec. Ensemble Vote	97.8%	Best overall accuracy
Disease CNN (MobileNetV2)	96.8%	38 classes, 340ms latency
NLP Chatbot Intent Acc.	94.3%	45 intents, 3 languages
Scheme Eligibility Matcher	91.7%	Rule + ML hybrid

User acceptance testing conducted with 120 smallholder farmers across Chandrapur, Yavatmal, and Wardha districts of Maharashtra yielded a System Usability Scale (SUS) score of

81.4 (Grade A, 'Excellent'). 87% of farmers reported that the disease detection module was more reliable than their previous self-diagnosis method, and 73% discovered at least one government scheme they were eligible for but previously unaware of. These results confirm the system's practical value and accessibility to its intended user base.

### VI. CONCLUSION

Agri Tech represents a holistic, production-grade AI solution purpose-built for the challenges and constraints of Indian agriculture. By unifying six critical advisory modules — multilingual conversational AI, crop recommendation, weather intelligence, plant disease detection, government scheme navigation, and smart marketplace — into a single accessible platform, the system addresses the most pressing information needs of smallholder farmers in a linguistically and technologically inclusive manner.

The experimental results demonstrate that each module achieves state-of-the-art or near-state-of-the-art performance on relevant benchmarks: 97.8% ensemble accuracy in crop recommendation, 96.8% accuracy in plant disease classification across 38 classes, and 94.3% intent accuracy in the multilingual chatbot. User acceptance testing with real farmers in Maharashtra confirms high usability and practical impact across all six modules.

Future work will focus on expanding language support to Kannada, Telugu, and Punjabi; integrating IoT sensor networks for real-time soil moisture and nutrient monitoring; developing satellite image-based crop health monitoring feature using NDVI analysis; and building a community knowledge base allowing experienced farmers to contribute advisory content, creating a virtuous cycle of peer learning and AI-assisted knowledge amplification.

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