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KrishiSahayak: Smart Crop Advisory System for Small and Marginal Farmers

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Abstract: India's economy relies heavily on agriculture, with approximately 58 percent of the rural population being employed within this sector. Despite these figures, small and marginal farmer's have difficulty obtaining timely agricultural advice regarding disease diagnosis, weather-based recommendations, market prices, and government schemes. This paper introduces a Smart Crop Advisory System called "KrishiSahayak" (Krishi Mitra) that aims to provide a comprehensive and integrated resource for small and marginal farmers. The KrishiSahayak (Krishi Mitra) Smart Crop Advisory System leverages AI, ML, Cloud Computing, and Mobile Technologies to create an integrated platform for crop disease detection, hyper-local weather-based recommendations, Mandi price updates in real-time, and government scheme information. The system also provides multiple channels of access (Flutter mobile app, SMS, IVR, AI chatbots) to allow farmers of different levels of digital literacy to access the information they need. The system was built using a cloud native architecture with the help of Django, TensorFlow/PyTorch, and Rasa to promote high levels of scalability and reliability. Based on our experimental simulations, we believe AI-based Advisory Systems have the potential to reduce crop losses due to disease by 15-25 percent, enable farmers to utilize renewable resources more effectively, and increase farmer income through access to improved market awareness

Index Terms - Smart Agriculture, Crop Disease Detection, Weather-Based Advisory, Machine Learning, Cloud Computing, Marginal Farmers, Precision Agriculture, Mobile Application, Digital Agriculture, Chatbot.

I. Introduction

The modern agricultural sector in India is undergoing a significant transformation driven by digital technologies. Agriculture contributes approximately 18% to India's GDP and supports over 58% of the rural population. Among farmers, those holding less than 2 hectares-classified as small and marginal farmers-constitute 86% of all farm holdings, yet they remain disproportionately disadvantaged in accessing modern advisory services [1].

Existing digital solutions often address isolated aspects of agricultural advisory-disease detection alone or weather data alone, without integration. Furthermore, most platforms require continuous internet connectivity, feature text-heavy interfaces unsuitable for low-literacy users, and provide generic recommendations that ignore local soil conditions, weather patterns, and crop stage. Manual disease identification through agricultural extension officers is time-consuming and frequently delayed, resulting in crop losses estimated at 15-25% of annual production [2].

The KrishiSahayak project introduces Krishi Mitra, an AI-driven Crop Advisory System that serves as a digital assistant for marginal farmers. It continuously monitors, predicts, and delivers actionable guidance to maintain a balance between disease risk, weather conditions, and market opportunities. The three functional pillars of the proposed system are:

- **DETECT:** Uses deep learning ensemble models (ResNet50, VGG16, DenseNet121) to identify crop and leaf diseases from uploaded images with confidence scoring.
- **ADVISE:** Fuses AI predictions with hyperlocal IMD weather forecasts, real-time Agmarknet market prices, and government scheme data to generate contextual recommendations.
- **DELIVER:** Executes advisory delivery through the farmer's preferred channel, Flutter mobile app, SMS, IVR, or Rasa chatbot, without requiring continuous internet access.

KrishiSahayak leverages multiple open data sources: PlantVillage dataset (54,306 images across 14 crop species and 26 diseases) for model training, IMD API for weather forecasting, Agmarknet for mandi prices, and a government schemes database for subsidy matching. These are integrated into a cloud-native Django backend with SQLite offline capability for field use.

By combining predictive analytics, personalized advisory, and multi-channel delivery, KrishiSahayak transforms reactive farming decisions into proactive, data-driven actions. It enables efficient disease management, reduction in unnecessary input costs, improved price realization, and long-term sustainability through intelligent automation.

II. LITERATURE REVIEW

The integration of AI and IoT in agricultural advisory systems has become one of the most active research areas in precision agriculture. Numerous studies have explored intelligent algorithms and real-time data to improve reliability and efficiency of crop management. The collective findings from existing literature emphasize that while smart agriculture holds great potential, significant gaps remain in integrated platforms, offline accessibility, and personalized advisory that KrishiSahayak aims to address.

A. Crop Disease Detection Using Deep Learning

Dolatabadian et al. (2025) conducted a comprehensive review of image-based crop disease detection, highlighting how deep learning coupled with imaging enables rapid and accurate identification [1]. Their work establishes the superiority of CNN-based approaches over traditional hand-engineered features. Mohanty et al. (2016) achieved 99.35% accuracy on the PlantVillage dataset using deep CNNs on 54,306 images across 14 crop species and 26 diseases, establishing smartphone-assisted diagnosis as feasible at scale [5].

Studies consistently show ResNet50 and VGG architectures achieving 96–98% accuracy on controlled datasets [2]. Wu et al. (2023) demonstrated federated learning for crop disease detection, achieving comparable results to centralized systems while preserving data privacy particularly relevant for farming cooperatives [6]. However, researchers note that real-world performance differs due to lighting conditions, background complexity, and image quality in field settings.

B. Weather-Based Agricultural Advisory Systems

Weather-based agro-advisory services (WBAAS) have emerged as critical tools for precision agriculture. Research emphasizes that agricultural production is closely linked with temperature, rainfall, wind, and humidity [11]. Mahato et al. (2024) suggest that on-time weather advisories help farmers reduce input costs and increase farm revenue by enabling timely decision-making [15]. Recent work incorporating Large Language Models achieved up to 90% accuracy in generating contextually relevant crop recommendations from weather forecasts [9].

C. Smart Agriculture and IoT Cloud Integration

A 2025 systematic review emphasizes IoT's role in enabling real-world agricultural objects to communicate through networking technologies, integrating wireless sensor networks, AI, and cloud computing [16]. India leads globally in IoT and AI agriculture research output, with significant advancements in precision irrigation, AI-based disease prediction, and cloud-integrated IoT farming networks. Edge AI is particularly promising for rural farms with poor connectivity, enabling local inference without cloud dependency [22].

D. Mobile Applications for Marginal Farmers

Mobile-based agricultural applications have proliferated in India, with over 450 agri-tech startups. Applications like BharatAgri and DeHaat provide various services but research indicates most focus on single services rather than integrated platforms, with limited support for low-connectivity scenarios [27]. Studies on technology adoption (2025) emphasize solutions that are affordable, multilingual, and designed with farmer involvement at the centre [28].

E. Identified Research Gaps

Based on the literature review, the following gaps have been identified: (i) single-point solutions dominate—most platforms focus on isolated services; (ii) few end-to-end platforms combine AI diagnosis, weather forecasting, market information, and scheme matching; (iii) limited multilingual IVR/SMS support for low-literacy users; (iv) insufficient farmer portfolio management for season-over-season optimization; and (v) absence of hybrid online/offline service delivery. KrishiSahayak directly addresses all five gaps.

III. System Architecture and Design

The KrishiSahayak system is designed as a cloud-native, microservices-based architecture to ensure scalability, reliability, and maintainability. The system consists of four primary layers (Fig. 1) that work together to deliver intelligent, multi-channel crop advisory services.

A. System Requirements

1) Hardware Requirements

- Smartphone / Feature Phone: Primary user device for mobile app, SMS, and IVR interactions. Android 6.0+ supported for full Flutter app functionality.
- IoT Gateway / Edge Device: Raspberry Pi or similar microcontroller for edge deployment in areas with intermittent connectivity, running lightweight MQTT communication.
- Cloud Server Infrastructure: AWS/Azure/GCP instances for hosting Django backend, ML inference engines, and managed databases, with auto-scaling for concurrent load.
- Weather Monitoring API Access: IMD API integration for real-time and 7-10 day forecast data (temperature, humidity, rainfall, wind speed).

2) Software Requirements

- Programming Environment: Python (backend, ML), Dart/Flutter (mobile), JavaScript, React.js (web portal).
- AI/ML Frameworks: TensorFlow and PyTorch for CNN model training and inference; Rasa for NLU and dialogue management.
- Database Management: PostgreSQL/MySQL for relational data, MongoDB for document storage, SQLite for device-side offline storage.
- Communication Protocols: MQTT for IoT device messaging; REST APIs for external service integration (IMD, Agmarknet).
- Dashboard Tools: Streamlit / React dashboard for Krishi Kendra operators; Flutter UI for farmers.

B. Four-Layer Architecture

Presentation Layer: Flutter mobile app for smartphones, SMS interface for feature phones, IVR system for voice interaction, Rasa chatbot for conversational queries, and React.js web portal for Krishi Kendra officers and admins.

Application Layer: Django framework orchestrates the Advisory Engine (contextual fusion of AI predictions with weather, crop stage, and local best practices), User Management (authentication, farmer profiles, preferences), Notification Service (multi-channel delivery), and Analytics Module (regional trend insights for extension officers).

AI/ML Processing Layer: Image preprocessing pipeline (lighting normalization, noise reduction, background segmentation) feeds an ensemble of CNN architectures (ResNet50, VGG16, DenseNet121) for disease detection with confidence scoring. Crop recommendation ML models consider soil NPK, pH, moisture, temperature, and rainfall. Yield prediction uses time-series regression on historical data and weather patterns.

Data Layer: PostgreSQL/MySQL for structured farmer profiles and transaction records; MongoDB for images and flexible API responses; AWS S3/Azure Blob for object storage; SQLite on device for offline operation; IMD API and Agmarknet for live weather and market data.

IV. Methodology

A. System Workflow

The system follows a six-step closed-loop workflow that transforms raw farmer inputs into actionable advisories and continuously improves through feedback.

1) User Input Capture

Farmers interact through their preferred channel. For disease detection, photographs of affected crops are uploaded via the Flutter app. For queries, voice (IVR), SMS, or chatbot interfaces are used. The system identifies the farmer profile and preferred language automatically.

2) Preprocessing and Validation

Uploaded images undergo quality checks (resolution, focus, lighting). Preprocessing applies color normalization, noise reduction, and background segmentation. Invalid inputs trigger guidance for re-submission. Text inputs are normalized and language-detected for routing to multilingual NLU.

3) AI/ML Inference

Preprocessed images feed the ensemble CNN model (ResNet50, VGG16, DenseNet121) on cloud compute instances. Disease predictions are returned with confidence scores. Low-confidence results are flagged for agricultural expert verification, ensuring farmer trust is maintained.

4) Context Fusion and Enrichment

The advisory engine enriches AI predictions with: hyperlocal IMD weather forecasts (7-10 day), current crop growth stage from farmer portfolio, soil health data where available, regional pest/disease outbreak alerts from extension network, and local agricultural best practices database.

5) Advisory Generation

Comprehensive actionable recommendations are generated including: disease identification and severity, organic and chemical treatment protocols, intervention timing based on weather forecast, irrigation scheduling, fertilizer guidance, real-time mandi prices from Agmarknet, and matched government schemes based on farmer profile and landholding.

6) Delivery and Feedback Loop

Advisories are delivered through in-app cards (images and step-by-step instructions), SMS summaries in local language, IVR voice messages in regional dialect, or chatbot follow-up. Farmer feedback on advisory effectiveness and outcome data (yield, disease recurrence, cost changes) drive continuous model improvement.

B. Dataset and Data Sources

Disease detection leverages the PlantVillage Dataset (54,306 images, 14 crop species, 26 disease categories) supplemented by field-captured images from agricultural universities focusing on local varieties [5]. Data augmentation includes lighting variations, blur effects, texture noise, rotation, and background variation for field robustness.

Weather data: IMD API for real-time and forecast data with 10+ years of historical data for yield prediction. Market data: Agmarknet real-time mandi prices across regions. Government schemes: Central and state scheme repository with eligibility criteria. Multilingual corpora in Hindi, Marathi, Gujarati, Punjabi, Tamil, and Telugu support IVR and chatbot systems.

C. Technical Stack

Component	Technology / Tool
Mobile Frontend	Flutter (Dart), Android & iOS
Backend Framework	Django (Python)
AI/ML Frameworks	TensorFlow, PyTorch
Chatbot Framework	Rasa NLU
Databases	PostgreSQL/MySQL, MongoDB, SQLite
Cloud Infrastructure	AWS / Azure / GCP
SMS/IVR Services	Twilio / Exotel / AWS SNS
External APIs	IMD Weather API, Agmarknet

TABLE I. Technical Stack of KrishiSahayak

V. IMPLEMENTATION AND FEATURES

The complete system is implemented using Python as the primary backend language due to its extensive ML and data-processing libraries. The LSTM (Long Short-Term Memory) neural network architecture is used for time-series demand and weather pattern analysis within the advisory engine. The ensemble CNN model (ResNet50, VGG16, DenseNet121) forms the core of disease detection. All modules are hosted on cloud infrastructure (AWS/Azure/GCP) to ensure scalability and reliability.

A. User Authentication and Farmer Profile

The application provides secure registration and login using OTP-based mobile authentication. Each farmer maintains a profile including landholding details, crop history, soil test results, irrigation methods, and preferred language. This data enables context-aware personalized recommendations rather than generic advisories. Profile data is encrypted and stored in compliance with data protection standards.

B. AI-Powered Crop Disease Detection

Farmers photograph affected crops through the mobile app. The preprocessing pipeline applies normalization, background removal, and quality enhancement before inference. The ensemble CNN returns disease name, severity level, and both chemical and organic treatment protocols. A confidence score accompanies each diagnosis; low-confidence results are flagged for expert review, maintaining farmer trust. The ensemble approach combining three architectures addresses single-model limitations, improving robustness to field image variation.

Training leverages the PlantVillage dataset augmented with field-captured images from Maharashtra and Karnataka agricultural universities, focusing on locally prevalent diseases in crops such as cotton, soybean, sugarcane, and wheat. Data augmentation (lighting variation, motion blur, background change, rotation) improves real-world robustness beyond laboratory conditions.

C. Hyperlocal Weather Advisory

The IMD API provides real-time and 7-10 day forecast data. Raw meteorological data is processed by the advisory engine to generate crop-specific guidance: irrigation scheduling, fungicide application windows, frost alerts, and harvest timing recommendations. This contextual enrichment distinguishes KrishiSahayak from weather apps that merely display data. Alerts for extreme weather events (unseasonal rainfall, heatwaves) are pushed proactively to farmers without requiring them to check the app.

D. AI Chatbot (Krishi Mitra)

The Rasa-based conversational AI, Krishi Mitra, allows farmers to ask natural-language questions about crop care, pest management, fertilizer schedules, market prices, and government schemes. Conversation context is maintained across turns, supporting follow-up questions and guided assistance for first-time users. Voice input via IVR extends accessibility to farmers with limited digital literacy. Supported languages include Hindi, Marathi, Gujarati, and Tamil, with intent-entity NLU trained on agricultural domain corpora.

E. Market Price Integration

Real-time mandi prices from Agmarknet are integrated to allow farmers to compare prices across nearby markets before making selling decisions. Price trend graphs and regional demand data help determine optimal selling timing, reducing exploitation by intermediaries and improving income realization. Historical price analytics support crop selection decisions for upcoming seasons.

F. Government Scheme Matching

The scheme recommendation engine matches farmer profiles against a comprehensive repository of central and state government agricultural schemes, subsidies, and financial assistance programs. Automated eligibility checks and application guidance reduce information asymmetry that has historically prevented marginal farmers from accessing qualifying support. Scheme deadlines and document checklists are delivered via push notification or SMS.

G. Offline-First Architecture

SQLite local storage enables core functionality without internet connectivity. Scanned results, previously downloaded advisories, and farmer profile data are accessible offline. Synchronization with cloud databases occurs automatically when connectivity is restored. This ensures continuous service in areas with intermittent network coverage a critical requirement given that 64% of India’s farming districts have unreliable data connectivity.

H. Operational Workflow Summary

- Farmer inputs (image, voice, or text) are captured through the preferred channel.
- Preprocessing ensures data quality before AI inference.
- Disease detection and advisory generation are executed in the cloud.
- Context fusion adds weather, market, and scheme data to raw AI output.
- Multi-channel delivery pushes the advisory in the farmer’s language and preferred format.
- Feedback collection drives continuous model improvement through retraining pipelines.

VI. Comparative Analysis

To validate KrishiSahayak’s design, it is compared against conventional agricultural advisory approaches and existing digital platforms.

A. Traditional Advisory Systems

Traditional advisory relies on agricultural extension officers visiting farms periodically, resulting in delayed diagnosis, generic recommendations, and inability to cover 86% small/marginal holding density. These systems lack predictive capability, cannot scale to demand, and provide no market or scheme integration. Crop losses from delayed disease identification are consistently reported at 15-25% of production [4].

B. Existing Digital Platforms

Current platforms like BharatAgri and DeHaat have introduced partial digitization through mobile apps. However, research indicates they: (i) target specific services rather than integration, (ii) require continuous connectivity, (iii) provide limited voice/IVR interfaces, (iv) lack farmer portfolio management for longitudinal optimization, and (v) do not combine disease detection, weather, market, and scheme data in a single unified workflow [27][28].

C. KrishiSahayak Advantage

- **Integrated Platform:** Unifies disease detection, weather advisory, market prices, and scheme matching—eliminating the need for multiple apps.
- **Multi-Channel Delivery:** Mobile, SMS, IVR, and chatbot interfaces serve all digital literacy levels.
- **Offline-First:** SQLite local storage ensures core functionality without connectivity.
- **Personalized Advisory:** Farmer portfolio data enables context-aware, crop-stage-specific recommendations.
- **AI Ensemble:** Three-model ensemble improves accuracy and field robustness beyond single-model approaches.

- **Continuous Learning:** Farmer feedback drives model retraining and advisory quality improvement over time.

Feature	Traditional	Existing Apps	KrishiSahayak
Disease Detection	Manual / Delayed	Partial	✓ AI Ensemble
Weather Advisory	None	Partial	✓ Hyperlocal IMD
Market Prices	None	Some	✓ Real-Time Agmarknet
Scheme Matching	None	None	✓ Automated
Offline Support	N/A	Limited	✓ SQLite Full
Voice/IVR	None	Rare	✓ Multilingual IVR
Personalization	None	Minimal	✓ Farmer Portfolio

TABLE II. Comparative Analysis: KrishiSahayak vs Existing Solutions

VII. Expected Results and Impact

A. Anticipated Technical Performance

Based on literature review and preliminary model development, the following technical performance metrics are anticipated:

- Disease Detection Accuracy: 95–98% on validation datasets, comparable to state-of-the-art (Mohanty et al. 99.35%).
- Response Time: < 5 seconds for disease detection inference; < 2 minutes for full advisory with weather and market integration.
- System Availability: 99.5%+ uptime through cloud redundancy and auto-scaling.
- Scalability: 100,000+ concurrent users through horizontal cloud scaling.
- Offline Coverage: 100% of core features functional without internet connection via SQLite.

B. Farmer-Level Impact

- Reduced crop losses through early disease detection (estimated 15-25% reduction in disease-related losses [1]).
- Improved yield and income through optimized input usage and better crop management practices.
- Better price realization through awareness of fair market prices reducing intermediary exploitation.
- Increased access to government schemes through automated eligibility matching and application guidance.
- Reduced environmental impact through precise application of water, fertilizers, and pesticides.

C. Alignment with Sustainable Development Goals

KrishiSahayak contributes to multiple UN SDGs: SDG 2 (Zero Hunger) through enhanced productivity and reduced crop losses; SDG 1 (No Poverty) through improved farmer income; SDG 13 (Climate Action) through promotion of sustainable farming practices; and SDG 9 (Industry, Innovation, Infrastructure) through digital transformation of agriculture for smallholder farmers in developing economies.

VIII. Challenges and Limitations

A. Technical Challenges

Dataset quality and diversity require continuous expansion to cover regional crop varieties and emerging diseases. Field images frequently present quality issues poor lighting, background clutter, motion blur—that degrade performance below laboratory benchmarks. Deep learning models trained on controlled datasets require continuous retraining and fine-tuning from field feedback. Integration of multiple external APIs (IMD, Agmarknet) requires robust error handling and fallback mechanisms for service continuity.

B. Operational Challenges

Farmer adoption requires extensive awareness campaigns and on-ground demonstrations, particularly to overcome initial resistance from technology-unfamiliar users. Ensuring accurate translation and cultural appropriateness across regional languages presents ongoing localization challenges. Voice recognition accuracy for diverse dialects in IVR systems remains technically demanding. Trust in AI-generated recommendations must be built through demonstrated accuracy and partnership with extension officers.

C. Sustainability Challenges

Cloud infrastructure, SMS/IVR services, and model training require ongoing investment necessitating a sustainable revenue model through government partnerships, freemium tiers, or sponsored programs. Farmer data privacy must be protected through robust security and compliance with data protection regulations. Clear consent mechanisms are essential for building and maintaining trust at scale.

IX. Future Work

Several enhancements can advance KrishiSahayak's scalability and real-world impact:

- **Edge AI:** Deploy lightweight disease detection models on low-cost edge devices (Raspberry Pi, Jetson Nano) for offline inference in zero-connectivity areas [22].
- **Drone Integration:** Incorporate drone-based crop monitoring and geospatial risk mapping for region-wide disease outbreak prediction.
- **Advanced NLP:** Multilingual voice bots fine-tuned for regional dialects using transformer-based LLMs for more natural advisory conversations [9].
- **Financial Services:** Micro-insurance products linked to crop health and weather data; crop insurance claim processing integrated with disease detection.
- **Blockchain Traceability:** Farm-to-market crop traceability for verified digital certificates supporting premium pricing for organic produce.
- **Pilot Deployment:** Real-world trials with 500+ farmers across Maharashtra and Karnataka for empirical performance validation and impact measurement.

X. Conclusion

This paper presents KrishiSahayak (Krishi Mitra), a comprehensive Smart Crop Advisory System addressing the critical information gaps faced by small and marginal farmers in India. By integrating AI-driven crop disease detection, hyperlocal weather-based recommendations, real-time market prices, and government scheme matching into a unified multi-channel platform, the system offers a holistic solution to the fragmented state of agricultural advisory services.

The literature review establishes strong foundations in deep learning for disease detection, weather-based advisory systems, IoT–cloud integration, and mobile agricultural applications. The identified research gaps particularly the lack of end-to-end platforms, limited offline support, and insufficient personalization, directly inform the KrishiSahayak architecture built on Django, Flutter, TensorFlow/PyTorch, and Rasa.

The multi-channel delivery approach ensures digital inclusivity for farmers with varying literacy and connectivity. Expected impacts include 15-25% reduction in crop losses, improved yields, better price realization, and increased scheme access. The system contributes to UN SDGs 1, 2, 9, and 13 by promoting sustainable agricultural practices and food security.

KrishiSahayak demonstrates how multiple technologies like AI/ML, cloud computing, IoT, and mobile platforms can be synergistically combined to create comprehensive agricultural decision support systems, providing a replicable blueprint for smallholder farmer empowerment in developing economies. Its success will ultimately be measured not by technical metrics alone but by empowered farmers making informed decisions, reduced crop losses, and improved livelihoods.

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