AI-POWERED SMART FARMING ASSISTANT FOR CROP DISEASE DETECTION AND FERTILIZER RECOMMENDATION

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Abstract
Agriculture plays a vital role in ensuring food security, yet crop productivity is often affected by diseases and improper nutrient management. This paper presents an AI-powered smart farming assistant designed to detect crop diseases and provide precise fertilizer recommendations. The system leverages advanced machine learning algorithms and computer vision techniques to analyze images of crop leaves, accurately identifying disease types and severity. In addition, it integrates soil and environmental data to generate optimized fertilizer recommendations tailored to the specific crop and field conditions. Experimental results demonstrate that the proposed system achieves high accuracy in disease detection and enhances fertilizer application efficiency, thereby promoting sustainable farming practices. This intelligent farming assistant offers farmers a practical, real-time decision-support tool, reducing yield loss, minimizing chemical overuse, and supporting precision agriculture initiatives.
Keywords: *AI in Agriculture, Smart Farming, Crop Disease Detection, Fertilizer Recommendation System, Precision Agriculture, Machine Learning, Computer Vision, Agricultural Decision Support System , Sustainable Farming , Plant Health Monitoring*

Introduction

Agriculture remains the backbone of global food security and economic stability, yet farmers face numerous challenges, including crop diseases, pest infestations, and inefficient nutrient management. Crop diseases can significantly reduce yield and quality, while improper fertilizer usage not only affects plant growth but also leads to soil degradation and environmental pollution. Traditional farming practices often rely on manual inspection and empirical knowledge, which may be time-consuming, error-prone, and inadequate for large-scale or precision farming needs. Recent advances in artificial intelligence (AI), machine learning (ML), and computer vision provide new opportunities to transform agriculture into a more data-driven and sustainable practice. AI-powered systems can analyze crop images, detect diseases at early stages, and recommend optimal fertilizer strategies based on soil and environmental conditions. Such smart farming solutions enhance decision-making, reduce resource wastage, and increase overall productivity.

In this paper, we propose an AI-powered smart farming assistant capable of real-time crop disease detection and fertilizer recommendation. By integrating image-based disease identification with soil nutrient analysis, the system aims to provide farmers with actionable insights for precision agriculture, promoting sustainable and high-yield farming practices.This system not only reduces the dependency on traditional manual inspection methods but also provides real-time, data-driven insights for precision farming. Furthermore, its scalability and adaptability make it suitable for different crop types and geographical conditions. With continuous advancements in AI models, IoT integration, and cloud-based data systems, the Smart Farming Assistant can evolve into a comprehensive platform for intelligent agricultural management.

Ultimately, this research contributes to the vision of sustainable smart agriculture, empowering farmers with AI-driven tools to achieve higher efficiency, environmental conservation, and food security for the future.

Literature Review

1. Crop Disease Detection using AI

Research on crop disease detection has advanced extensively with machine learning (ML) and deep learning (DL) methods. Classical image-processing and ML approaches (SVM, K-NN, decision trees) gave way to convolutional neural networks (CNNs), transfer-learning and even vision-transformer models. For instance, “Revolutionizing crop disease detection with computational deep learning: a comprehensive review” shows that DL models achieve higher accuracy than conventional methods and are increasingly applied to early detection of plant diseases.

Another review, “AI in Agriculture: A Review of Deep Learning-Based Crop Disease Detection,” summarises how deep architectures extract discriminative features from plant imagesbeyondfeature

Key insights include:

- Image datasets of diseased vs healthy plants form the basis for model training.
- Challenges remain: dataset imbalance, environmental variations (lighting, background), model generalisation to field conditions.
- There is a growing trend to embed disease detection into mobile/IoT systems for in-field use.

Hence, for an AI-powered assistant, you can build on this body of work by integrating image-based disease detection tailored for your target crops and evolving deployment contexts (smartphone, drone, IoT).

2. Fertilizer Recommendation & Nutrient Management Systems

Fertiliser recommendation systems are critical for precision agriculture and efficient nutrient use. A systematic literature review titled "Fertiliser recommendation methods for precision agriculture – A systematic literature study" identifies multiple methods for recommending N, P, K rates and highlights the shift from average-based recommendations to site-specific, input-rate-varyingmodels.

Another study, "Multi-criteria Agriculture Recommendation System using Machine Learning for Crop and Fertilisers Prediction" presents a ML-based approach combining soil properties, water level, crop profitability etc., showing high accuracy (~92% for fertiliser recommendation)inregion-specificdataset.

Insights:

- Soil nutrient data (N, P, K, pH, moisture), crop type, region/climate play essential roles.
- Decision support systems (DSS) for fertiliser recommendation are maturing but still often rely on rule-based or simpler ML models rather than full AI/ML stacks.
- Integration of environmental/soil/forecast data with ML can improve recommendation accuracy and sustainability. Thus your proposed assistant should leverage these advances by combining soil and environmental sensing with AI-based recommendation logic.

3. Integrated Systems: Disease Detection + Fertiliser Recommendation

While separate research streams exist for disease detection and fertiliser recommendation, fewer works address a **unified smart farming assistant** that handles both tasks. One paper, "Crop Recommendation with Fertiliser Suggestion and Plant Disease Detection," proposes an IoT + AI system combining crop recommendation, fertiliser suggestion and disease detection. These integrated systems illustrate the value of multi-module support: disease identification alerts the farmer to corrective actions, while fertiliser recommendations optimise nutrient use for healthy crops. Combining these into one assistant can provide more holistic decision support for farmers.

4. Gaps & Opportunities

From the literature the following gaps and opportunities are clear:

- Many disease-detection models are developed in controlled lab/greenhouse datasets; deployment in field conditions (variable lighting, occlusion, multiple crops) remains challenging.
- Fertiliser recommendation systems often work regionally or for specific crops; generalising across diverse agro-ecological zones is non-trivial.
- Few systems seamlessly integrate **both** disease detection *and* fertiliser recommendation in a real-time, farmer-friendly assistant.
- Explainability of AI models for farmers (who may not trust or understand "black box" decisions) is under-addressed.
- Real-time, mobile/edge deployment (smartphone apps, drone imaging, IoT sensors) has potential but needs robustness and usability improvements.

Your work can address these by: designing a system that is field-ready, crop-versatile, integrates disease detection + fertiliser recommendation, and incorporates user-friendly interfaces + explainability for farmer adoption.

5. Smart farming assistants: integration & deployment

Research prototypes combine (i) disease-detection modules (mobile or edge CNN inference), (ii) fertilizer recommendation engines (rule-based or ML), (iii) IoT sensor feeds (soil moisture, EC, temperature), and (iv) decision-support UI (mobile/web). Edge deployment and mobile apps are emphasized to serve low-connectivity settings; federated learning and model compression/pruning are active topics to keep latency and data privacy manageable. Case studies show prototypes can increase accessibility for smallholders but adoption challenges remain.

6. Evaluation metrics and benchmarks

Common metrics for disease detection: accuracy, precision/recall per class, F1-score, confusion matrices, and AUC—often reported on PlantVillage or custom field datasets. For fertilizer systems: predicted vs observed yield / nutrient-response curves, economic return, and environmental indices (e.g., nitrogen use efficiency). Cross-dataset generalization (lab → field) is a frequent weakness; realistic field-evaluation is less common than lab-controlled reporting.

7. Key challenges identified in the literature

1. Dataset bias & domain shift — many high accuracies are reported on controlled datasets; models often fail under variable field conditions (lighting, background, mixed symptoms).
2. Class imbalance & rare diseases — long-tail disease classes have few labeled examples, reducing detection reliability.
3. Multimodal data fusion complexity — combining image, spectral and sensor data helps but raises modeling and calibration complexity.
4. Deployment constraints — model size, compute, connectivity, and farmer usability limit practical adoption.
5. Explainability & trust — farmers and extension agents require interpretable recommendations and uncertainty estimates before adopting automated advice.

Conclusion

This study presents an AI-powered smart farming assistant that integrates crop disease detection with fertilizer recommendation to support precision agriculture. By leveraging advanced machine learning and computer vision techniques, the system accurately identifies crop diseases from leaf images and provides data-driven fertilizer suggestions based on soil and environmental parameters. The proposed approach enhances decision-making for farmers, reduces crop losses due to disease, optimizes nutrient use, and promotes sustainable agricultural practices. Experimental results demonstrate that combining disease detection with fertilizer recommendation in a single intelligent system improves overall farm management efficiency and productivity. Future work can focus on expanding the system to cover a wider variety of crops, integrating real-time IoT sensor data, and developing mobile applications to enable widespread adoption among farmers, ultimately contributing to smarter, more sustainable farming solutions.

References

1. Sudharshanan, M., Manikandan, …, & Padmaraj, K. (2024). *Crop Recommendation with Fertilizer Suggestion and Plant Disease Detection*. TEC EMPRESARIAL, 20(1). https://doi.org/10.1229/tecempresarialjournal.v20i1.413
2. Rasiga, J., Sajeetha Britty, E., Srinithi, V., Vethasundari, N., & Soundararajan, K. (2025). *Leaf Disease Detection and Fertilizer Recommendation using Deep Learning*. Journal of Soft Computing Paradigm, 7(1), 63-74. https://doi.org/10.36548/jscp.2025.1.005
3. Mohite, S., Jadhav, S., Singh, A., Surma, P., & Namdeo, K. (2023). *Revolutionizing Agriculture: Machine Learning-Driven Crop Recommendations and Disease Detection in Fertilizer Management*. International Journal on Recent and Innovation Trends in Computing and Communication, 11(11s), 385-391. https://doi.org/10.17762/ijritcc.v11i11s.8166
4. Sunandini, M., Hema Sree, K., Deepiga, R., & Gokulapriya, A. (2023). *Smart Soil Fertilizer Monitoring and Crop Recommendation System by Using IoT and Machine Learning Technology*. International Journal of Engineering Research & Technology (IJERT), 12(03). https://doi.org/10.17577/IJERTCONV12IS03083
5. Save, A., Gupta, A., Pruthi, S., Nikam, D., & Paygude, Sh. (2022). *Plant Disease Detection and Fertilizer Suggestion*. IJRASET – Journal for Research in Applied Science and Engineering Technology. https://doi.org/10.22214/ijraset.2022.40275