



POPULAR SCIENCE ARTICLE

Utilisation of Artificial Intelligence in Agricultural Science: Opportunities, Challenges and Future Directions

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Abstract

Artificial Intelligence (AI) has emerged as a transformative force across scientific domains and agriculture is no exception. From precision farming and crop disease prediction to autonomous machinery and sustainable resource use, AI-driven innovations are redefining food production and security. Current applications of AI in agricultural science are explored, with a focus on real-world implementations, the challenges of ethics, accessibility and data privacy and the future pathways that integrate AI with emerging technologies such as IoT, drones, blockchain and CRISPR.

Keywords: Agriculture, Artificial Intelligence, Sustainability, Food Security, Innovation

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Introduction

Agriculture forms the backbone of global food security, employing nearly a quarter of the world’s population and contributing significantly to GDP in many developing nations. Yet, it faces multifaceted challenges: climate change, water scarcity, soil degradation, pest outbreaks and the need to feed a growing population projected to surpass 9.7 billion by 2050. Traditional methods are proving inadequate to address these demands. Artificial Intelligence, with its capacity for learning from vast datasets, predictive analytics and automation, offers unprecedented opportunities. By integrating AI into agricultural science, farming can evolve from intuition-driven practices to data-driven precision systems.

AI Applications in Agricultural Science

Precision Farming and Decision Support harness machine learning models for yield prediction, irrigation optimization and effective fertilizer and nutrient management, enabling farmers to make data-driven choices for higher productivity. **Crop Disease and Pest Detection** leverages computer vision for early identification of diseases, sensor-based pest monitoring and farmer-friendly mobile applications to minimize losses and improve crop health. **Robotics and Automation**

integrate AI-powered drones, autonomous tractors, laser-based weed control systems and self-operating harvesters to reduce labor dependency and enhance efficiency. **Remote Sensing and Climate Adaptation** utilize satellite and drone imaging to monitor crop health, combined with AI-driven seasonal forecasting for climate-smart agriculture practices. Finally, **Supply Chain and Market Intelligence** rely on price forecasting, post-harvest monitoring systems and blockchain-enabled transparency to ensure fair trade, reduce waste and strengthen food security.

Benefits and Opportunities

Domain	AI Impact
Productivity	Higher yields via precision inputs, pest/disease prevention
Sustainability	Reduced water, fertilizer and pesticide use
Food Security	Real-time monitoring, early warnings, climate resilience
Farmer Empowerment	Mobile AI apps for diagnostics and decision support

Challenges and Risks

The adoption of AI in agriculture is accompanied by several important challenges. Data privacy

and ownership remain major concerns, particularly as vast amounts of sensitive information are collected from farms and supply chains. Bias and inequity can also arise when models are trained on region-specific datasets, limiting their broader applicability and potentially disadvantaging certain communities. Infrastructure gaps, such as limited internet connectivity in rural areas, further hinder widespread adoption. In addition, ethical and social concerns, including the risk of job displacement, must be carefully addressed to ensure inclusive growth. Also, the environmental cost of large-scale AI computation raises sustainability questions that need to be balanced against the benefits of technological advancement.

Regulatory and Policy Considerations

Global bodies like FAO emphasize responsible AI adoption. India's Digital Agriculture Mission 2021–25 promotes AI for soil health, crop mapping and market intelligence. EU's AI Act and USDA initiatives also play a role. However, stronger policies are needed around data governance, ethics and farmer education.

Future Directions

The future of AI in agriculture is likely to be defined by innovative integrations and tailored solutions. Combining AI with IoT devices, drones and digital twins of farms can enable real-time

monitoring and precision decision-making at unprecedented scales. At the same time, the

development of explainable AI will be essential for building transparency and trust among farmers, policymakers and consumers. Breakthroughs such as AI-assisted CRISPR hold promise for creating stress-resistant crops that can withstand climate challenges, while blockchain-powered AI could transform supply chains by ensuring greater traceability and fairness. Equally important is the creation of localized AI models designed specifically for smallholder farmers, enabling equitable access to these technologies across diverse agricultural contexts.

Conclusion

Artificial Intelligence in agriculture is no longer futuristic; it is an evolving reality with transformative potential. From improving crop yields to reducing environmental footprints, AI empowers farmers with knowledge, precision and foresight. However, challenges around ethics, equity and governance must be addressed to ensure technology benefits all, particularly marginalized farming communities. With international collaboration, responsible innovation and farmer-centric deployment, AI can become the cornerstone of sustainable agricultural science.