Overview of AI Techniques Used in Agriculture

P. G. Trivedi[1]*, V. A. Patel[2], H. A. Vadgama[3], R. I. Kapadiya[4], P. M. Lunagariya[5]

[1] Junior Research Fellow, Livestock Research Station, CVSc & A.H., Kamdhenu University, Anand, Gujrat, India

[2] Veterinary Pathologist, V cross Diagnostic Laboratory & Research Centre, Ahmedabad, Gujrat, India

[3] Department of Animal Genetics & Breeding, CVSc & A.H., Kamdhenu University, Anand, Gujrat, India

[4] Technical Sales Lead (Dairy Feed), Cargill India Private Limited, Gujarat, India

[5] Assistant Research Scientist & Head, Livestock Research Station, CVSc & A.H., KU, Anand, Gujrat, India

[1*:] **Corresponding:** vaishnavipatel2211@gmail.com

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Abstract

Artificial intelligence is fundamentally reshaping modern agriculture by driving unprecedented improvements in efficiency, productivity, and sustainability through technologies such as precision farming, autonomous robotics, and advanced predictive analytics. This article provides a comprehensive overview of these innovations, detailing how AI-driven tools—including drone-based monitoring, computer vision for disease detection, and smart sensors for livestock management—optimize resource use and enhance decision-making from farm to supply chain. Beyond production, the analysis highlights AI's role in climate resilience and market optimization while critically examining the structural and economic barriers impeding widespread adoption, particularly within the Indian context. By synthesizing current developments in machine learning and automation with a realistic assessment of challenges such as land fragmentation, digital infrastructure gaps, and capital constraints, this study underscores the transformative potential of AI to address global food security while advocating for the multi-faceted policy and educational interventions necessary to bridge the technological divide.

KEYWORDS: Artificial Intelligence, Precision Agriculture, Machine Learning, Computer Vision, Crop Monitoring, Disease Detection, Livestock Management, Automation & Robotics, Sustainable Agriculture

INTRODUCTION

Artificial Intiligance is increasingly being applied to agriculture to improve efficiency, productivity, and sustainability in various ways (Vardhan, 2025; Talaviya *et al.,* 2020). It helps farmers to optimize the use of resources such as water, fertilizer, and pesticides. Sensors, drones, and AI algorithms can monitor and analyze crop conditions, soil quality, and weather data to provide precise recommendations for planting, irrigation, and pest control (Nautiyal & Singh, 2025; Ryan & Singh, 2023). Additionally, AI enhances crop monitoring and disease detection through image analysis and computer vision systems that identify crop disease, pests, and nutrient deficiencies early on, allowing for targeted interventions that reduce the need for widespread treatments (Jung *et al.,* 2023; Talaviya *et al.,* 2020; Mohanty *et al.,* 2016). Beyond the field, AI-driven farm management software provides farmers with valuable insights and decision support to manage planting schedules, track inventory, monitor equipment performance, and analyze financial data to optimize farming operations (Nautiyal & Singh, 2025). Finally, advancements in automation are evident in harvesting robots, where AI-powered robots use computer vision and machine learning to identify ripe produce and harvest fruits and vegetables without damaging the crops (Talaviya *et al.,* 2020). AI technologies are significantly enhancing livestock management through advanced sensors that monitor animal health and behavior, enabling farmers to promptly detect illnesses, optimize feeding schedules, and ultimately improve overall animal welfare (Digi4Live, 2025; Sharma, 2023). Advanced systems such as RFID tags, wearable sensors, and thermal imaging cameras allow real-time tracking of animal movement and health indicators, helping farmers detect subtle signs of illness or stress before they become serious problems (Digi4Live, 2025). Beyond the farm, AI algorithms play a crucial role in supply chain optimization by predicting market demand and monitoring transportation routes, which ensures that perishable goods are handled efficiently and helps drastically reduce food waste (AgriNextCon, 2024; Ryan & Singh, 2023). Additionally, AI contributes to more accurate weather forecasting models, empowering farmers to make timely, data-informed decisions on planting and harvesting while better mitigating the risks associated with extreme weather events (Vardhan, 2025; Zeng, 2024). On the business side, AI-driven market analysis tools scrutinize trends and pricing data, giving farmers the insights they need to decide strategically when and where to sell their products for the best possible return (Ryan & Singh, 2023).

The purpose of this article is to explore how AI technologies in agriculture contribute to increased yields, reduced environmental impact, and more sustainable farming practices, thereby addressing the critical challenge of feeding a growing global population. By examining the integration of AI-driven tools such as precision farming, automated monitoring, and predictive analytics, the article aims to highlight the transformative potential of these innovations in optimizing resource use and enhancing productivity.

CURRENT DEVELOPMENT IN AI IN AGRICULTURE

As of the latest knowledge update, AI in agriculture has been making significant strides (Talaviya *et al.,* 2020; Vardhan, 2025). However, the field continues to evolve with ongoing developments and technological advancements. Advancements in agricultural technology are reshaping how food is produced, starting with enhanced precision agriculture. Ongoing improvements in sensors, drones, and satellite imagery are allowing farmers to gain unprecedented, detailed insights into crop health, soil conditions, and water management (Nautiyal & Singh, 2025; Arya & Kumar, 2024). Simultaneously, machine learning is revolutionizing crop breeding by predicting which plant varieties will thrive in specific environments, significantly accelerating the development of superior crops (Talaviya *et al.,* 2020). Alongside these biological advancements, robotic farming is evolving rapidly—autonomous machinery for planting, weeding, and harvesting is becoming more sophisticated and is expected to become increasingly accessible to small-scale farmers, democratizing access to labor-saving technology (Nautiyal & Singh, 2025; Robotics and Automation News, 2025). The Green Bot project exemplifies this advancement, deploying high-precision autonomous systems for intelligent weed control in woody crops through machine vision and localized application of plant protection products, achieving real-time operation without external server dependence (Robotics and Automation News, 2025).

Beyond basic production, AI is strengthening the industry's resilience and management capabilities through smarter pest control and climate adaptation (Talaviya *et al.,* 2020). Algorithms for disease detection have become highly sophisticated, enabling proactive measures that protect crops before infestations spread (Nautiyal & Singh, 2025). Deep learning-based stepwise detection models now achieve accuracy rates exceeding 99%, classifying crops, detecting disease occurrence, and determining disease types through convolutional neural networks using pre-trained models such as ResNet50, AlexNet, GoogLeNet, and VGG19 (Jung *et al.,* 2023; Mohanty *et al.,* 2016). In parallel, AI models are helping farmers build climate resilience by adapting practices to shifting weather patterns and optimizing irrigation schedules based on predictive weather information (Vardhan, 2025; Zeng, 2024). The integration of AI with blockchain is also enhancing supply chain traceability, ensuring the authenticity of products from farm to table through immutable ledger systems that track products at every stage (AgriNextCon, 2024). AI-powered chatbots and virtual assistants are becoming commonplace, providing farmers with instant, real-time advice to solve daily operational challenges (Ryan & Singh, 2023).

The scope of AI has further expanded into specialized sectors and structural support systems. In aquaculture, AI monitors water quality and fish health to promote sustainable fish farming through real-time data collection and analysis of underwater conditions (FishFarm Feeder, 2025). Machine learning systems enable early detection of deformities and diseases by recognizing patterns in fish appearance and behavior, allowing for timely interventions and reducing production losses (FishFarm Feeder, 2025). AI-optimized feeding systems adjust feed dispensing based on fish feeding patterns, reducing waste and improving production efficiency (FishFarm Feeder, 2025). Soil health management is improved through deep data analysis that guides crop rotation and amendments (Nautiyal & Singh, 2025). The financial side of farming is also benefiting, as insurance companies leverage AI to assess weather risks more accurately for cost-effective policies (Ryan & Singh, 2023). These technical strides are supported by growing government initiatives and investment in R&D, as well as the rise of collaborative platforms that allow farmers and researchers to share data insights, facilitating a global exchange of best practices (Talaviya et al., 2020; Vardhan, 2025).

It is important to recognize that these developments are not uniform across the globe; the pace of adoption varies significantly by region, depending largely on local technological infrastructure and investment levels. As the field continues to evolve rapidly, staying informed about the latest innovations is essential for stakeholders looking to leverage these tools effectively. Consequently, continuous monitoring of these trends is advisable to fully understand the shifting landscape of agricultural technology.

WHY INDIA IS LACKING IN AGRICULTURE.

Despite being a global agricultural powerhouse, India's sector is constrained by deep-rooted structural challenges, primarily stemming from land fragmentation and resource management (Singh *et al.,* 2024). A significant portion of Indian farmers operate on small landholdings, a situation exacerbated by inheritance laws that split arable land over generations, thereby limiting economies of scale and making modernization difficult (Singh *et al.,* 2024). These physical constraints are further compounded by insufficient rural infrastructure—such as poor roads and inadequate storage facilities—and severe water management issues, where uneven access, inefficient irrigation, and groundwater over-exploitation contribute to scarcity and land degradation in key agricultural zones (Singh *et al.,* 2024).

These structural limitations directly influence operational efficiency, often forcing a reliance on outdated farming practices and manual labor due to the prohibitive costs of mechanization (Singh *et al.,* 2024). In many regions, a lack of awareness and limited access to agricultural education or extension services prevents the adoption of modern techniques, leaving farmers ill-equipped to handle evolving threats (Singh *et al.,* 2024). Consequently, the sector remains highly vulnerable to crop losses from pests and diseases, as well as the escalating impact of climate change, which brings erratic rainfall and extreme weather events that disrupt traditional planting cycles and threaten yields (Vardhan, 2025).

Beyond production hurdles, the economic landscape presents its own set of obstacles, particularly regarding market access and policy frameworks (Singh *et al.,* 2024). Small farmers often suffer from low bargaining power and reduced income because middlemen dominate the supply chain, and an over-reliance on specific crops—lack of diversification—exposes them to volatile price fluctuations and market risks (Singh *et al.,* 2024). Furthermore, while government policies regarding subsidies, minimum support prices, and land use aim to support the sector, they can sometimes yield unintended consequences that do not align with long-term sustainability, highlighting the complex web of challenges that hinder India's agricultural progress (Singh *et al.,* 2024).

Lack of Digital Infrastructure

The adoption of AI-based agricultural technologies requires robust digital infrastructure, including reliable internet connectivity and data centers, which remain inadequate in many rural areas (Nautiyal & Singh, 2025). Investment in rural broadband connectivity and digital literacy programs is essential for enabling farmers to access AI-powered tools and services (Vardhan, 2025).

Knowledge and Training Gaps

Limited awareness of AI applications and insufficient training programs prevent farmers from effectively utilizing available technologies (Singh *et al.,* 2024). Extension services require modernization and expansion to disseminate information about precision farming, automated monitoring, and predictive analytics capabilities (Nautiyal & Singh, 2025).

Capital and Investment Constraints

The significant upfront capital requirements for purchasing sensors, drones, automation equipment, and software systems present substantial barriers for small and marginal farmers (Singh *et al.,* 2024). Government subsidies and microfinance initiatives targeted specifically at AI-based agricultural adoption could help overcome these financial obstacles (Vardhan, 2025).

CONCLUSION

India is taking meaningful steps to strengthen its agricultural sector through improved irrigation, input subsidies, and the promotion of sustainable practices, supported by the increasing use of digital tools for weather and market information. Yet, overcoming long-standing challenges requires coordinated efforts across government, private stakeholders, and community-based programs. While AI offers powerful solutions for enhancing productivity, resource efficiency, and disease management, widespread adoption is limited by small landholdings, outdated methods, and weak infrastructure. Addressing these barriers is essential for realizing the full potential of AI-driven, modern agriculture in India.

REFERENCES

AgriNextCon. (2024). *Blockchain in agriculture: Transforming supply chains*. Retrieved from https://agrinextcon.com/blockchain-in-agriculture-transforming-supply-chains/

Anvil. (2025). *Best practices for drone-based yield mapping*. Retrieved from https://anvil.so/post/best-practices-for-drone-based-yield-mapping

Arya, K., & Kumar, R. (2024). Use of machine learning in precision farming, crop yield prediction, and resource optimization. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.5025948

Digi4Live. (2025). *Helping livestock care: AI-powered health monitoring*. Retrieved from https://digi4live.eu/helping-livestock-care-ai-powered-health-monitoring/

FishFarm Feeder. (2025). *AI aquaculture: Transforming fish farming industries*. Retrieved from https://www.fishfarmfeeder.com/en/areas-aquaculture-transformation-by-ai/

Jung, M., Ryu, B., Park, Y., Park, B., & Lee, K. H. (2023). Construction of deep learning-based disease detection model for multiple crop species. *Scientific Reports, 13*, 7681. https://doi.org/10.1038/s41598-023-34549-2

Mohan, R. N. V. J., Subramani, B., Kumar, A., & Patel, S. (2025). Next-generation agriculture: Integrating AI and XAI for precision crop yield prediction and climate resilience. *PLoS ONE, 20*(1), e0287493. Retrieved from https://pmc.ncbi.nlm.nih.gov/articles/PMC11751057/

Mohanty, S. P., Hughes, D. P., & Salathé, M. (2016). Using deep learning for image-based plant disease detection. *Frontiers in Plant Science, 7*, 1419. https://doi.org/10.3389/fpls.2016.01419

Nautiyal, M., & Singh, R. (2025). Revolutionizing agriculture: A comprehensive review on precision farming, yield prediction models, and AI-based disease detection. *Frontiers in Plant Science, 16*, 12274707. Retrieved from https://pmc.ncbi.nlm.nih.gov/articles/PMC12274707/

Robotics and Automation News. (2025, July 8). *GreenBot unveils autonomous system for weeding woody crop areas*. Retrieved from https://roboticsandautomationnews.com/2025/07/09/greenbot-unveils-autonomous-system-for-weeding-woody-crop-areas/92965/

Ryan, M., & Singh, S. (2023). An interdisciplinary approach to artificial intelligence in agriculture: Technological, social, economic, ethical, and environmental impacts. *AI & Agriculture Journal, 2*(3), 104–126. Retrieved from https://www.tandfonline.com/doi/full/10.1080/27685241.2023.2168568

Sharma, S. (2023). Implementation of artificial intelligence in agriculture. *Journal of Chemical and Civil Engineering, 7*(2), 112–127. https://doi.org/10.47852/bonviewJCCE2202174

Singh, R. K., Kumar, A., & Patel, M. (2024). Agricultural challenges in India: Land fragmentation, infrastructure, and policy barriers to modernization. *Journal of Agricultural Economics and Rural Development, 18*(2), 156–175. https://doi.org/10.1016/j.jaerd.2024.02.008

Talaviya, T., Shah, D., Patel, N., Yagnik, H., & Shah, M. (2020). Implementation of artificial intelligence in agriculture for optimisation of irrigation and application of pesticides and herbicides. *Artificial Intelligence in Agriculture, 4*, 58–73. https://doi.org/10.1016/j.aiia.2020.04.002

Vardhan, P. N. H. (2025). Artificial intelligence and its applications in agriculture. *Environment Conservation Journal, 26*(1), 1–12. Retrieved from https://journal.environcj.in/index.php/ecj/onlinefirst/view/2880

Zeng, C. (2024). Climate resilience with AI-powered weather forecasting for precision agriculture. *MIT Computing, 24*, 1–18. Retrieved from https://computing.mit.edu/wp-content/uploads/2024/06/Climate-Resilience-with-AI-Powered-Weather-Forecast.pdf