



Future of Artificial Intelligence: Its Impact on the Agriculture and Nutrition Sector

ARTICLE ID: 0415

Madhur Kumar¹, Shalu Kumari², Vishal Yadav^{3*}

¹Symbiosis School of Culinary Arts and Nutritional Sciences, India

²Darbhanga College of Engineering, Darbhanga, Bihar – 846005, India

³Ph.D. Scholar, Department of Animal Husbandry and Dairying (AHD), Chandra Shekhar Azad University of Agriculture & Technology, Kanpur, Uttar Pradesh, India

Artificial Intelligence (AI) is increasingly being adopted across the agriculture and food-nutrition value chain, from the farm to the final consumer. This paper reviews the emerging role of AI technologies such as machine learning, deep learning, computer vision, and the Internet of Things (IoT) in transforming agricultural production and nutritional science. In agriculture, AI-enabled precision farming, crop and soil monitoring, pest and disease detection, smart irrigation, and yield forecasting are helping farmers improve productivity while using natural resources more efficiently. In nutrition and food science, AI is enabling personalized dietary recommendations, automated dietary assessment, food recognition, and improved food safety and quality control. Drawing on recent peer-reviewed literature, this review discusses the concept of AI, its principal applications in agriculture and nutrition, the benefits it

offers to farmers, food producers, dietitians, and consumers, and the challenges—including data quality, cost, infrastructure, and ethical concerns—that continue to limit its wider adoption. The paper concludes that while AI cannot replace human judgement in either field, it is rapidly becoming an important decision-support tool that, if adopted responsibly, can strengthen food security and contribute to improved public nutrition outcomes.

1. Introduction

Agriculture and nutrition are two of the most fundamental pillars of human survival, and both are currently under pressure from a growing global population, climate variability, shrinking arable land, and rising rates of diet-related diseases. Meeting these challenges requires tools capable of processing large amounts of environmental, biological, and behavioural



data and translating them into actionable decisions. Artificial Intelligence (AI)—broadly defined as the capability of machines to perform tasks that normally require human intelligence, such as perception, reasoning, and learning—has emerged as one such tool. Over the past decade, AI has moved beyond research laboratories into agricultural fields and food-related applications, supported by cheaper sensors, satellite imagery, mobile connectivity, and advances in machine learning and deep-learning algorithms [1], [2].

Historically, technological development in agriculture progressed from simple mechanisation to computer-aided record keeping and, more recently, to data-driven precision agriculture. In parallel, nutrition science has progressed from generalized dietary guidelines toward increasing recognition that dietary requirements vary among individuals. AI lies at the intersection of these developments. The same underlying techniques of pattern recognition and predictive modelling that enable a machine-learning model to identify a diseased crop leaf from an image can also be used to identify food items on a plate and estimate their nutritional content [3]. This article reviews the applications of AI across the agriculture–nutrition continuum, the benefits reported in the literature, and the challenges that must be addressed for wider adoption.

2. Artificial Intelligence: Concept and Relevance

Artificial Intelligence is an umbrella term encompassing several sub-fields relevant to agriculture and nutrition. Machine learning (ML) algorithms identify patterns from historical data and use them to make predictions on new datasets, such as forecasting

crop yields using weather and soil information. Deep learning, a subset of ML based on artificial neural networks, is particularly effective for image-based applications such as identifying pests, weeds, crop diseases, or fruit maturity from images captured using drones or smartphones.

The Internet of Things (IoT) refers to interconnected networks of sensors deployed in agricultural fields, storage facilities, food-processing units, or wearable devices. These sensors continuously generate data that can be analysed by AI systems for real-time monitoring and decision-making [1], [5]. Together, these technologies enable a transition from basic automation toward intelligent decision support, where systems can collect data, analyse patterns, recommend actions, and, in some cases, automatically execute operations such as adjusting irrigation or identifying potential nutritional deficiencies.

3. AI Applications in Agriculture

3.1 Precision Farming and Crop Management

Precision agriculture combines AI with satellite and drone imagery, soil sensors, and weather information to tailor agricultural operations to the specific conditions of different areas within a field. Instead of applying inputs uniformly, machine-learning models can analyse historical yield, soil, and climatic data to support decisions regarding the timing and quantity of sowing, fertilization, irrigation, and harvesting [1–3]. AI-based crop-management systems can improve resource-use efficiency and potentially reduce input costs. However, the magnitude of benefits varies

according to crop, location, data quality, technological infrastructure, and management practices.

3.2 Pest and Disease Detection

Convolutional neural networks and other deep-learning models are increasingly being used to analyse images of leaves, stems, fruits, and other plant parts captured using smartphones, drones, or other imaging systems. These technologies can assist in identifying crop diseases and pest infestations at an early stage [1], [3].

Early identification allows farmers to undertake targeted management measures, potentially reducing crop losses and unnecessary pesticide applications.

3.3 Smart Irrigation and Resource Optimization

AI-driven irrigation systems combine soil-moisture measurements, weather forecasts, and crop-growth information to determine appropriate irrigation timing and quantity [5], [6]. Such systems can help conserve water while reducing the risks associated with both water stress and excessive irrigation.

Similar decision-support systems are being developed for fertilizer application, weed management, and pest-control scheduling, contributing to more efficient and environmentally responsible agricultural practices.

3.4 Yield Prediction and Farm-to-Market Logistics

Machine-learning models integrating satellite imagery, soil characteristics, historical climate information, and crop data can assist in predicting crop yields before harvest [2–4]. Such information can support farmers, cooperatives, agribusinesses, and government agencies in planning storage, transportation, processing, and marketing.

AI is also being applied across the wider agrifood supply chain to improve logistics, reduce post-harvest losses, and match agricultural production with market demand [6].

4. AI Applications in Nutrition and Food Science

4.1 Personalized Nutrition

Personalized nutrition aims to move beyond generalized dietary recommendations by considering an individual's genetic profile, metabolic characteristics, lifestyle, dietary habits, and health objectives. AI and machine-learning models can integrate information from wearable devices, electronic health records, dietary logs, and other sources to generate individualized dietary recommendations [7–9].

Applications include dietary management, weight management, chronic-disease support, and sports nutrition. However, many applications remain in the research and early-development stages and require further validation before widespread clinical implementation [7].

4.2 Dietary Assessment and Food Recognition

Traditional dietary assessment methods often rely on food diaries, questionnaires, and dietary-recall interviews. These approaches can be time-consuming and may be affected by inaccurate reporting. AI-based image-recognition systems can identify food items from photographs and estimate portion sizes and nutritional composition, potentially simplifying dietary monitoring [8], [11].

Natural-language-processing tools can also analyse recipes and food-related information to estimate

nutritional and, increasingly, sustainability characteristics.

4.3 Food Safety and Quality Control

AI technologies, including machine learning, computer vision, and sensor-based systems, are increasingly being investigated for real-time food-quality assessment, contamination detection, and shelf-life prediction [5], [10], [12].

AI-enabled traceability systems can also support monitoring of food products across the supply chain. Such systems may help identify the source of contamination more rapidly during food-safety incidents and improve overall quality-management processes.

4.4 Nutrition Education and Public Health

AI-powered chatbots and virtual dietary assistants are being developed to provide nutrition information and behaviour-change support to consumers [7], [12]. These tools can complement, rather than replace, professional guidance from dietitians and nutritionists. At the population level, AI-based analysis of dietary and health data may assist public-health agencies in identifying patterns of malnutrition and diet-related diseases and in developing more targeted interventions.

5. Impact on Farmers, Nutritionists, and Consumers

For farmers, AI-based decision-support systems can reduce uncertainty in day-to-day farm management and provide data-driven recommendations for crop production, irrigation, pest management, and resource allocation [1], [4].

For dietitians and nutritionists, AI tools can automate time-consuming tasks such as dietary-data collection, food recognition, and nutrient estimation, potentially allowing professionals to devote more time to counselling and evidence-based decision-making [7].

For consumers, the integration of AI into agriculture and nutrition has the potential to contribute to more efficient food production, improved food quality, and personalized dietary guidance. However, access to these technologies remains uneven. Regions with stronger digital infrastructure, better connectivity, and greater financial resources generally have greater opportunities for AI adoption than resource-constrained regions [4], [6].

6. Challenges and Limitations

Despite its potential, AI adoption in agriculture and nutrition faces several challenges.

Data Quality And Availability: AI systems depend heavily on the quality and representativeness of training data. Agricultural and dietary datasets may be fragmented, inconsistent, incomplete, or unavailable for particular regions and populations [3], [4].

Cost And Infrastructure: Sensors, connectivity, computing resources, software, and technical expertise can involve substantial costs. These factors may restrict access for smallholder farmers and small food businesses [4], [6].

Data Privacy And Ethics: Personalized nutrition may involve sensitive genetic, health, and behavioural information. Ensuring privacy, informed consent, and responsible data management is therefore essential [7], [8].

Algorithmic Bias: AI systems may produce less reliable recommendations when training datasets do not adequately represent different crops, geographical regions, populations, or dietary patterns.

Interpretability: Complex deep-learning models are often described as “black boxes” because their decision-making processes can be difficult to understand. Greater transparency and explainability are important for building confidence among farmers, nutrition professionals, consumers, and regulators [5].

7. Future Directions

The integration of AI with complementary technologies such as IoT, remote sensing, robotics, and blockchain-based traceability may strengthen connectivity across the agriculture-to-nutrition value chain [5], [6], [9]. Data collected from farms could increasingly contribute to improved forecasting, food-quality assessment, supply-chain management, and downstream nutritional applications.

Federated-learning approaches, in which AI models can be trained across multiple institutions without directly sharing raw personal data, are also being explored for applications such as personalized nutrition [8]. Such approaches may help address privacy concerns while allowing researchers to work with larger and more diverse datasets.

References

1. Cabanillas-Carbonell, M., & Zapata-Paulini, J. (2025). Artificial intelligence applications in agriculture: A systematic review of literature. *IAES International Journal of Artificial Intelligence (IJ-AI)*, 14(5), 3503–3519.
2. Katharria, A., Rajwar, K., Pant, M., & Deep, K. (2024). Application of machine learning in agriculture: Recent trends and future research avenues. *arXiv*, 2405.17465.

Future progress will require investment in affordable technologies, rural digital infrastructure, capacity building, data standards, and transparent regulatory frameworks. Ensuring that AI technologies remain accessible and inclusive will be important for achieving broad societal benefits.

8. Conclusion

Artificial Intelligence is becoming increasingly important across the agriculture and nutrition sector, from precision farming and crop-health monitoring to personalized dietary recommendations and food-safety management. The available evidence indicates that AI can support improvements in productivity, resource-use efficiency, food-quality assessment, and individualized dietary guidance.

However, wider adoption requires attention to data quality, affordability, digital infrastructure, privacy, algorithmic bias, and transparency. AI should be viewed as a decision-support technology rather than a replacement for the practical knowledge of farmers or the professional judgement of dietitians and nutritionists. When developed and implemented responsibly, AI can contribute to more efficient agricultural systems, stronger food-security strategies, and improved nutrition outcomes.

3. Araújo, S. O., Peres, R. S., Ramalho, J. C., Lidon, F., & Barata, J. (2023). Machine learning applications in agriculture: Current trends, challenges, and future perspectives. *Agronomy*, 13(12), 2976.
4. Cavazza, A., Dal Mas, F., Paoloni, P., & Manzo, M. (2023). Artificial intelligence and new business models in agriculture: A structured literature review and future research agenda. *British Food Journal*, 125(13), 436–455.
5. Misra, N. N., Dixit, Y., Al-Mallahi, A., Bhullar, M. S., Upadhyay, R., & Martynenko, A. (2022). IoT, big data, and artificial intelligence in agriculture and food industry. *IEEE Internet of Things Journal*, 9(9), 6305–6324.
6. Kutyaauripo, I., Rushambwa, M., & Chiwazi, L. (2023). Artificial intelligence applications in the agrifood sectors. *Journal of Agriculture and Food Research*, 11, 100502.
7. Sosa-Holwerda, A., Park, O.-H., Albracht-Schulte, K., Niraula, S., Thompson, L., & Oldewage-Theron, W. (2024). The role of artificial intelligence in nutrition research: A scoping review. *Nutrients*, 16(13), 2066.
8. Agrawal, K., & Leung, P. (2025). Artificial intelligence in personalized nutrition and food manufacturing: A comprehensive review of methods, applications, and future directions. *Frontiers in Nutrition*, 12, 1636980.
9. Kirk, D., Kok, E., Tufano, M., Tekinerdogan, B., Feskens, E. J. M., & Camps, G. (2022). Machine learning in nutrition research. *Advances in Nutrition*, 13(6), 2573–2589.
10. Zatsu, V., et al. (2024). Revolutionizing the food industry: The transformative power of artificial intelligence—A review. *Food Chemistry: X*, 24, 101867.
11. Armand, T. P. T., Nfor, K. A., Kim, J.-I., & Kim, H.-C. (2024). Applications of artificial intelligence, machine learning, and deep learning in nutrition: A systematic review. *Nutrients*, 16(7), 1073.
12. Zhu, J., & Wang, G. (2023). Artificial intelligence technology for food nutrition. *Nutrients*, 15(21), 4562.