

## Original Research Article

# AI Driven Agriculture for Nutritional Security and Public Health Improvement

Kumari Sunita, Shalini Singh, Nidhi Singh, Omisha Kannaajiya, Firdaush Jahan, Swati

Department of Botany, Plant Physiology, Biochemistry and PGPR Lab, Deen Dayal Upadhyaya Gorakhpur University, Gorakhpur, Uttar Pradesh, India

### Corresponding Author

Kumari Sunita

Email: [ksunita78@gmail.com](mailto:ksunita78@gmail.com)

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### Abstract

Artificial Intelligence (AI) is rapidly transforming agricultural systems by enhancing productivity, efficiency, and sustainability. This review explores the role of AI-driven agriculture in improving nutritional security and public health outcomes globally. With the increasing challenges of climate change, population growth, and resource constraints, conventional agricultural practices are often insufficient to meet rising food demands. AI technologies, including machine learning, remote sensing, and precision farming, provide innovative solutions for optimizing crop production, reducing resource wastage, and improving food quality. AI-based tools enable real-time monitoring of soil health, crop growth, and pest dynamics, allowing farmers to make data-driven decisions that enhance yield and nutritional value. Additionally, AI applications in supply chain management help reduce post-harvest losses and ensure efficient food distribution, thereby improving food accessibility and affordability. These advancements contribute significantly to reducing malnutrition and enhancing dietary diversity. AI-driven agriculture supports public health by minimizing excessive use of agrochemicals, improving environmental sustainability, and reducing exposure to harmful substances. However, challenges such as limited digital literacy, high implementation costs, and data accessibility issues hinder widespread adoption, particularly in developing regions. AI-driven agriculture holds immense potential to strengthen nutritional security and public health. Strategic investments, policy support, and capacity building are essential to harness its full benefits for sustainable development.

**Keywords:** *Artificial intelligence, precision agriculture, nutritional security, smart farming, digital agriculture, food security.*

## 1. Introduction

Agriculture plays a vital role in ensuring food security, nutrition, and public health across the globe (1). However, rapid population growth, climate change, and declining natural resources have placed immense pressure on agricultural systems (2,3). Traditional farming methods often lack the efficiency and precision required to meet modern challenges, necessitating technological interventions such as Artificial Intelligence (AI) (4). AI-driven agriculture integrates technologies like machine learning, big data analytics, robotics, and remote sensing into farming systems (5,6). These innovations allow real-time monitoring of crops, prediction of weather patterns, and efficient management of resources, thereby improving productivity and sustainability (7). AI applications enable farmers to make data-driven decisions that enhance both yield and quality of produce (5,7). Nutritional security remains a major global concern, particularly in developing countries where malnutrition and micronutrient deficiencies are prevalent (8,9). AI technologies contribute to improving food quality and diversity by supporting precision farming and crop diversification (10). This ensures access to nutrient-rich foods, which is essential for improving public health outcomes (8). Precision agriculture enables efficient use of water, fertilizers, and pesticides, reducing environmental degradation and improving food safety (11). Excessive use of agrochemicals has been linked to health risks such as cancer and neurological disorders, which AI can help mitigate through targeted applications (12). Additionally, AI enhances agricultural supply chains by improving storage, transportation, and distribution systems (13). This reduces post-harvest losses and ensures that food reaches consumers in a timely and safe manner, thereby improving food accessibility and affordability (13). Despite these advantages, the adoption of AI in agriculture faces challenges such as high costs, limited digital literacy, and lack of infrastructure in rural areas (14).

### 1.1 Precision Farming and Nutritional Security

Precision farming represents one of the most transformative applications of artificial intelligence in modern agriculture, offering a data-driven approach to managing crop production systems with enhanced efficiency and sustainability (13,14). This approach integrates advanced technologies such as sensors, drones, satellite imaging, and geographic information systems to monitor real-time agricultural conditions, including soil moisture, nutrient levels, crop health, and climatic variables. (10) By collecting and analyzing these data, AI-powered systems enable farmers to make informed

decisions that optimize the use of inputs such as water, fertilizers, and pesticides (12,13). This targeted application not only improves resource efficiency but also significantly enhances crop yield and quality (9). One of the most important contributions of precision farming is its role in strengthening nutritional security (8,9). Nutritional security goes beyond mere food availability and emphasizes access to safe, diverse, and nutrient-rich foods necessary for maintaining health and well-being (16). Through precise monitoring and management of crop growth conditions, AI tools help produce crops with improved nutritional profiles. For example, optimal nutrient management ensures that plants receive the right balance of macro and micronutrients, leading to higher concentrations of essential vitamins and minerals in harvested produce (15,16). This directly contributes to improved dietary quality for consumers (15). In addition to enhancing crop quality, precision farming supports crop diversification, which is a key factor in improving dietary diversity (17). AI-based decision support systems can recommend suitable crop combinations based on soil conditions, climate patterns, and market demand (18,19). By encouraging farmers to grow a variety of crops rather than relying on monoculture systems, precision farming promotes the availability of diverse food items, including fruits, vegetables, and pulses (18,19). This diversity is essential for reducing malnutrition and addressing micronutrient deficiencies, particularly in vulnerable populations (18). Another critical aspect of precision farming is its contribution to sustainable agricultural practices (23). Efficient resource utilization reduces waste and minimizes environmental impacts (21). For instance, smart irrigation systems powered by AI ensure that water is applied only when and where it is needed, reducing water wastage and conserving this vital resource (22,23). Similarly, precise fertilizer application prevents nutrient runoff into water bodies, thereby protecting ecosystems and maintaining soil health (22,23). These practices contribute to long-term agricultural sustainability while supporting food production (21). Furthermore, precision farming enhances resilience to climate variability (22). By providing real-time data and predictive insights, AI systems enable farmers to anticipate and respond to changing weather conditions, thereby reducing the risks associated with droughts, floods, and temperature fluctuations (24,21). This resilience ensures consistent crop production, which is essential for maintaining stable food supplies, precision farming serves as a powerful tool for integrating technological innovation with agricultural practices (24). By improving crop yield, enhancing nutritional quality, promoting diversification, and ensuring sustainable resource

**Table 1.** Key Applications of Artificial Intelligence in Agriculture and Their Benefits

Application Area	AI Technologies Used	Key Functions	Benefits to Agriculture	Impact on Health and Nutrition
Precision Farming	Sensors, drones, satellite imaging	Monitoring soil, crop health, weather conditions	Improved yield, optimized resource use	Enhanced nutritional quality of crops
Pest and Disease Management	Machine learning, computer vision	Early detection of pests and diseases	Reduced crop losses, targeted pesticide use	Safer food with reduced chemical residues
Smart Irrigation	IoT sensors, predictive analytics	Real-time soil moisture monitoring and water management	Efficient water use, reduced wastage	Improved environmental health
Crop Yield Prediction	Data analytics, machine learning	Forecasting crop productivity	Better planning and resource allocation	Ensures food availability
Supply Chain Management	AI analytics, blockchain, automation	Demand forecasting, logistics optimization	Reduced food waste, efficient distribution	Improved food accessibility and affordability
Automated Farming	Robotics, AI-based decision systems	Planting, harvesting, spraying	Reduced labor cost, increased efficiency	Consistent food production

**Table 2.** Role of Artificial Intelligence in Environmental Sustainability and Public Health

Parameter/Aspect	AI-Based Intervention	Environmental Impact	Public Health Benefit	Long-Term Outcome
Water Management	Smart irrigation systems	Reduced water wastage, improved groundwater conservation	Availability of clean water	Sustainable water resource management
Soil Health	Precision nutrient management	Reduced soil degradation and nutrient runoff	Safe food production	Improved soil fertility and productivity
Air Quality	Reduced chemical input through AI monitoring	Lower greenhouse gas emissions	Reduced respiratory diseases	Climate change mitigation
Pollution Control	Targeted pesticide and fertilizer application	Decreased environmental contamination	Reduced exposure to toxic chemicals	Healthier ecosystems
Climate Change Adaptation	Predictive analytics and climate modeling	Improved resilience to extreme weather	Reduced risk of food shortages and malnutrition	Climate-resilient agricultural systems
Food Safety	Traceability and quality monitoring	Reduced contamination in supply chains	Improved food safety and nutrition	Stronger food security systems

use, it plays a vital role in achieving both food and nutritional security in an increasingly resource-constrained world (25,26).

### 1.2 AI in Pest and Disease Management

Artificial intelligence has significantly transformed pest and disease management in agriculture by introducing advanced tools for early detection, monitoring, and control (15,17). Traditional methods of identifying

plant diseases and pest infestations often rely on visual inspection and expert knowledge, which can be time-consuming, labor-intensive, and prone to human error (13). In contrast, AI technologies, particularly those based on machine learning and computer vision, enable rapid and accurate detection of plant health issues at early stages, even before visible symptoms become severe (18,19). One of the key applications of AI in this domain is image recognition, where algorithms are

trained to identify specific patterns associated with different plant diseases and pests (24). Using images captured by smartphones, drones, or field cameras, these systems can analyze leaf discoloration, lesions, or insect presence and provide immediate diagnostic results (21,22). Early detection is critical in preventing the spread of diseases and minimizing crop losses (25). By identifying problems at an initial stage, farmers can implement timely interventions that protect crop health and ensure stable yields (25,26). Predictive analytics further enhances pest and disease management by forecasting potential outbreaks based on environmental conditions, historical data, and crop growth patterns (21). AI models can analyze variables such as temperature, humidity, rainfall, and soil conditions to predict the likelihood of pest infestations or disease occurrence (20). This proactive approach allows farmers to take preventive measures rather than reacting after damage has already occurred (19,20). As a result, crop productivity is maintained, and the risk of large-scale losses is significantly reduced (18). Another major advantage of AI-driven pest management is the reduction in excessive pesticide use (18). Conventional pest control practices often involve the blanket application of chemical pesticides, which can lead to environmental pollution, soil degradation, and health risks for both farmers and consumers (25,26). AI technologies enable targeted pesticide application by identifying specific areas or plants that require treatment (22). This precision reduces the quantity of chemicals used, minimizing their negative impact on the environment and promoting safer food production systems (25,26). In addition to reducing chemical inputs, AI-based pest management supports integrated pest management strategies that combine biological, cultural, and chemical methods for sustainable control (18,19). For example, AI systems can recommend the use of natural predators or resistant crop varieties based on the identified pest species (17). This holistic approach not only controls pests effectively but also preserve ecological balance and biodiversity (12,13). The benefits of AI in pest and disease management extend beyond agriculture to public health (13,14,15). By reducing pesticide residues in food and the environment, these technologies contribute to safer food consumption and lower exposure to harmful chemicals (17,18). Moreover, preventing crop losses ensures food availability, which is essential for maintaining food security and supporting population health, AI-driven pest and disease management represents a significant advancement in agricultural practices (25,26). Through early detection, predictive analytics, and targeted interventions, it enhances crop protection while promoting environmental sustainabil-

ity and public health (25,26). As these technologies continue to evolve, they are expected to play an increasingly important role in ensuring safe and efficient food production systems (27).

### 1.3 Smart Supply Chains and Food Accessibility

Artificial intelligence is revolutionizing food supply chains by improving efficiency, transparency, and reliability in the movement of agricultural products from farm to consumer (12,13). Traditional supply chains often face challenges such as inefficiencies in storage, transportation delays, lack of real-time information, and significant post-harvest losses (17). AI-driven technologies address these challenges by integrating data analytics, automation, and predictive modeling into supply chain management, thereby ensuring that food reaches consumers in a timely and efficient manner (14,15). One of the primary applications of AI in supply chains is demand forecasting (22). By analyzing historical consumption patterns, market trends, and external factors such as weather conditions and economic indicators, AI systems can accurately predict future demand for various food products (16,17). This enables producers, distributors, and retailers to plan their operations more effectively, reducing the risk of overproduction or shortages (15). Accurate demand forecasting also helps in maintaining price stability, which is essential for ensuring food affordability (3). AI technologies also play a crucial role in reducing food wastage, which is a major global issue. Significant quantities of food are lost during storage and transportation due to poor handling, inadequate infrastructure, and lack of timely decision-making. Smart supply chain systems use sensors and real-time monitoring tools to track the condition of perishable goods, such as temperature and humidity levels (26,27). If any deviation is detected, immediate corrective actions can be taken to prevent spoilage (19). This not only reduces food waste but also improves the overall efficiency of the supply chain (12,13). Transportation and logistics are further optimized through AI-based route planning and scheduling systems (12). These systems analyze traffic conditions, fuel efficiency, and delivery timelines to determine the most efficient routes for transporting goods. By minimizing delays and reducing transportation costs, AI enhances the overall performance of the supply chain. This is particularly important for perishable agricultural products that require timely delivery to maintain their quality (26,27). Improved supply chain efficiency directly contributes to better food accessibility, especially in low-income and remote regions (19). By ensuring that food is distributed efficiently and reaches markets without significant losses, AI helps increase

the availability of food products (18,19). Additionally, reduced wastage and optimized logistics lower overall costs, making food more affordable for consumers (13). This is a critical factor in addressing hunger and improving nutritional outcomes in vulnerable populations (12). AI also enhances transparency and traceability within supply chains. Advanced tracking systems allow stakeholders to monitor the movement of food products at every stage, from production to consumption (12,13). This transparency helps in ensuring food safety and quality, as any contamination or issue can be quickly identified and addressed. Consumers also benefit from increased trust in the food system, as they have access to information about the origin and quality of the products they consume (25,26). In summary, AI-driven smart supply chains play a vital role in improving food accessibility and reducing inefficiencies in food distribution systems (19). By enhancing demand forecasting, minimizing wastage, optimizing logistics, and ensuring transparency, these technologies contribute significantly to global food security and public health (17,18).

#### **1.4 Environmental Sustainability and Public Health**

Artificial intelligence is playing an increasingly important role in promoting environmental sustainability within agricultural systems, with significant implications for public health (12). Modern agricultural practices often place considerable pressure on natural resources, leading to issues such as soil degradation, water scarcity, and greenhouse gas emissions (12,13). AI-based technologies provide innovative solutions to these challenges by enabling more efficient and sustainable resource management (19). One of the key contributions of AI to environmental sustainability is the optimization of water usage through smart irrigation systems (12,13). These systems use sensors and data analytics to monitor soil moisture levels, weather conditions, and crop water requirements in real time (17). Based on this information, AI algorithms determine the precise amount of water needed for irrigation, reducing wastage and ensuring efficient use of water resources (23,24). This is particularly important in regions facing water scarcity, where efficient water management is essential for sustaining agricultural production (25). AI also supports sustainable nutrient management by optimizing fertilizer application. Overuse of fertilizers can lead to soil degradation and water pollution due to nutrient runoff (7). AI systems analyze soil health data and crop requirements to recommend appropriate fertilizer quantities and application timings (8,9). This targeted approach not only

improves crop productivity but also minimizes environmental impacts, contributing to healthier ecosystems (18). Another important aspect of AI in sustainability is the reduction of greenhouse gas emissions (3). By optimizing farm operations, such as machinery use, irrigation, and input application, AI helps reduce energy consumption and emissions associated with agricultural activities (7,8). Additionally, AI-driven precision farming practices reduce the need for chemical inputs, further lowering the environmental footprint of agriculture (9,10). The environmental benefits of AI have direct implications for public health. Improved air and water quality resulting from reduced pollution contribute to better health outcomes for communities (6,7). For example, minimizing pesticide use reduces exposure to harmful chemicals, which can have adverse effects on human health. Similarly, preventing nutrient runoff protects water bodies from contamination, ensuring the availability of clean drinking water (23,24). AI also plays a role in mitigating the impacts of climate change, which is closely linked to public health (17). By enabling adaptive agricultural practices, AI helps farmers respond to changing climatic conditions, reducing the risk of crop failures and food shortages (12). Stable food production is essential for maintaining food security and preventing malnutrition, which is a major public health concern (8). Furthermore, sustainable agricultural practices supported by AI contribute to long-term ecosystem health (6). Healthy ecosystems provide essential services such as clean air, water, and fertile soil, all of which are critical for human well-being (11). By preserving these resources, AI-driven agriculture supports both environmental sustainability and public health, the integration of AI into agriculture offers a comprehensive approach to addressing environmental and health challenges (15). By optimizing resource use, reducing pollution, and supporting climate resilience, AI contributes to the development of sustainable agricultural systems that promote both ecological balance and human health (3).

## **2. Conclusion**

AI-driven agriculture offers significant potential to enhance food security, nutritional outcomes, and public health (1). By improving precision farming, pest management, and supply chain efficiency, AI contributes to sustainable and resilient agricultural systems (5,13). However, challenges such as high costs, lack of awareness, and limited infrastructure must be addressed to ensure widespread adoption (14). Policymakers and stakeholders must promote inclusive strategies to integrate AI into agriculture effectively (15,20). AI-driven agriculture represents a promising pathway toward

achieving global food security and improving public health outcomes. Its adoption can contribute significantly to sustainable development goals and long-term environmental sustainability (19,20).

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