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AI REVOLUTION IN AGRICULTURE: REDEFINING CROP PRODUCTION FOR RESILIENT FOOD FUTURE

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Abstract

The future of food security hinges on agriculture's resilience to sustainably produce food while navigating the dual pressure of a rapidly growing world population, projected to reach 10 billion by 2050, and adversaries of changing climate. Therefore, there is an urgent need for innovative and sustainable farming solutions to boost crop productivity, farm efficiency and build resilient agriculture system amid decreasing agricultural land, depleting natural resources, shifting climatic patterns, evolving consumer demands, and degrading agricultural land. AI is set to revolutionize agriculture by enabling both resource-efficient precision farming and climate-resilient crop production, which are crucial for building a more efficient and resilient food system.

Key words: Artificial Intelligence, AI, agriculture, climate, resilience, productivity

Introduction

Artificial Intelligence (AI) is reshaping agriculture farming by making reactive to proactive farmers through integration of advanced algorithms, real time data, IoT (Internet of Things) sensors, and machine learning (Yanamala, 2023; Benvenuti *et al*., 2023). This technology not only empowers farmers to minimize risks posed by abnormal weather conditions and climatic changes but also optimizes use of resources, and maximizing crop productivity sustainably (Rane et al., 2024; Yüksel *et al*., 2023). AI-driven precision farming reduces labour costs used for weeding and harvesting of crops by utilizing GPS and autonomous technologies (Singh *et al*., 2023; Mhamed *et al*., 2024).

By using smart sensors and site-specific pesticide applications, it also minimizes soil and water contamination, making agriculture less laborious through the consistent automation of tasks (Pachiappan *et al*., 2024). Furthermore, AI assists in developing advanced, climate-resilient crop varieties by evaluating genetic data to identify genes for drought, disease, and heat resistance (Rane et al., 2024; Patil et al., 2024). This article highlights the key applications of AI in sustainably enhancing crop productivity, potential challenges in its adoption and prospects of AI in future agricultural practices.

> AI is transforming agriculture by empowering smarter decision-making, efficien t resource use, and climate-resilient crop production.

Key Challenges in Modern Agriculture

Modern agriculture farming, often operates with inherent inefficiencies and vulnerabilities. Key challenges include:

- ❖ Unpredictable weather patterns, prolonged droughts, flash floods, harsh temperature, etc. directly impacting crop yields.

- Over-reliance on limited resources like fresh water, fertile land, and soil nutrient threatens long-term sustainability.
- Rapidly evolving pests and pathogens causes significant economic losses and food shortages.
- An aging workforce and declining interest of younger generations contribute to labour gaps.
- Overuse of fertilizers, pesticides, and water leads to wastage and environmental pollution.
- Significant portions of food are lost or wasted at post-harvest processes.

AI Revolution in Agriculture Transformation:

AI, through its various sub-fields like machine learning, computer vision, and robotics, is offering unprecedented capabilities to revolutionize agriculture:

1. AI driven Precision Farming:

Smart Sensing: IoT sensors deployed in fields to collect vast amounts of data on soil moisture, nutrient contents, crop health, pest attack, and weather by drones, and satellites.

AI-Powered Real Time Data Analysis: Farmers receive real-time recommendations for optimal irrigation, fertilization, and pest control in crop field.

2. AI driven Agriculture Operations:

Autonomous Operations: AI-powered tractors, drones, and ground robots can autonomously perform tasks like planting, spraying, weeding, and harvesting with high precision and efficiency, reducing costs and reliance on manual labour.

Targeted Activities: Robotic sprayers, weeders, and harvesters can be used for site specific applications of pesticides, to distinguish and remove weeds, significantly reducing chemical usage and pick ripe fruits gently and efficiently.

3. AI driven Crop Assessment:

Pest Detection and Control: AI systems analyse images from drone cameras to detect the presence of pests, and their initial symptoms often before visible to human, enabling timely and targeted interventions from pest outbreaks.

Plant Phenotyping for Crop Improvement: AI algorithms can rapidly analyse the plant characteristics via images, and accelerate the breeding process for high-yield climate-resilient crop varieties.

4. AI driven Yield and Weather Prediction:

Hyper-local Weather Forecasting: AI models can process complex meteorological data to provide timely and highly accurate weather information, enabling farmers to make decisions for seeding, irrigation, and harvesting of crops.

Yield Prediction: By integrating historical data with real-time environmental factors, AI can accurately predict yields, assist farmers in storage, and market distribution of products.

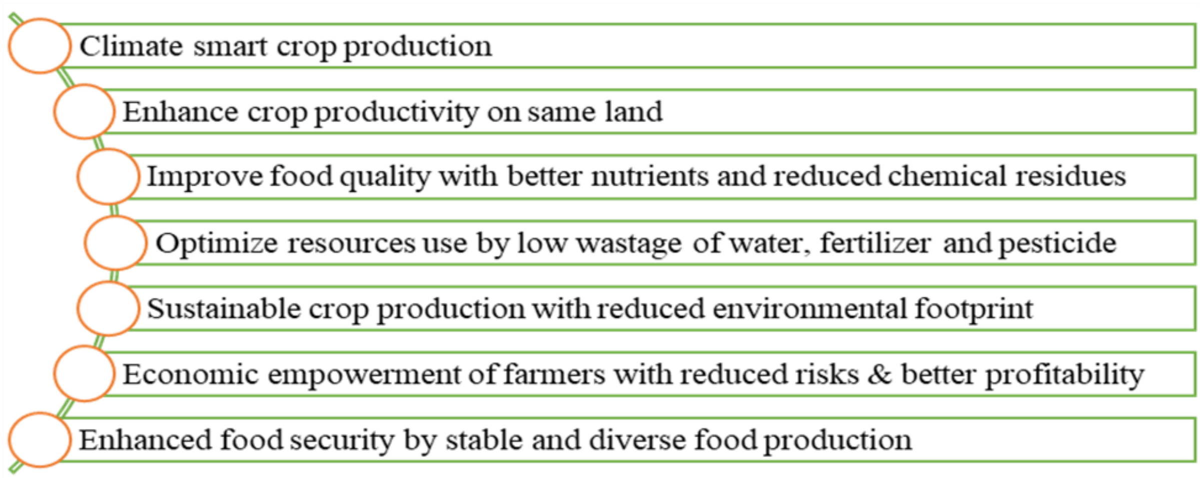
5. AI driven Intelligence in Agricultural Value Chain:

Supply Chain Efficiency: AI can optimize logistics, storage, and transportation of agricultural produce, minimizing spoilage and waste from farm to fork.

Market Intelligence: AI models can analyse market trends and consumer demand, helping farmers in selection of crop and scheduled marketing, ensuring better returns.

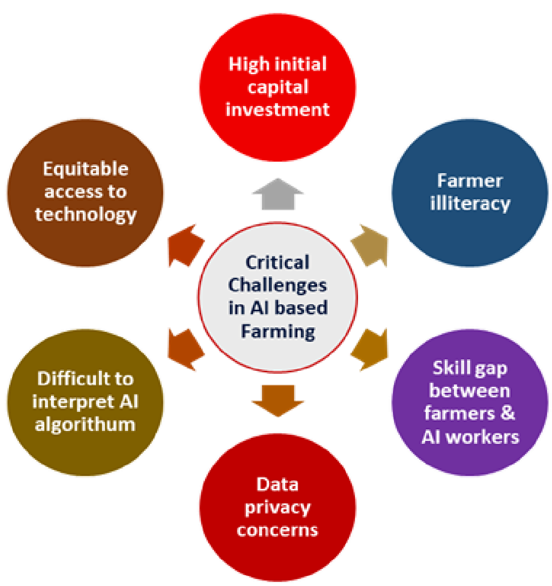
Benefits of AI integration in crop production:

The integration of AI into crop production proclaims a new era of benefits crucial for a resilient crop production. This includes:



Critical Challenges in AI based Agriculture Farming:

Despite the immense promises of AI based agriculture farming, the widespread adoption of AI in agriculture faces hurdles. Addressing these challenges requires collaborative efforts from state governments, policymakers, researchers, technology developers, and local farming communities. Investing in rural digital infrastructure, developing affordable and user-friendly AI solutions, and implementing comprehensive training programs will be crucial to democratize access to this transformative technology.



Conclusion:

The AI revolution in agriculture is not just an incremental improvement in crop production; it's a fundamental reimagining of how we produce our food. The path of tomorrow's cultivation depends on how intelligently we grow crops, securing food-safety and sustainably managing agricultural lands. By integrating artificial intelligence in agriculture, we can move towards hyper-efficient, environmentally sound, and climate resilient crop production system in the 21st century.

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