

## THE IMPACT OF AI TECHNOLOGIES ON AGRICULTURE: A REVIEW

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**Abstract.** Artificial intelligence (AI) has revolutionised the agriculture, making it more productive and efficient in addition to far less environmentally harmful. The review provides a holistic perspective on the role of AI technologies in different sectors such as precision farming, crop management, smart irrigation and logistics for agriculture. Challenges it can tackle with AI, we finally have all that is required to optimize resources and address the greatest problems humanity faces today including Climate Change, Food Security, Sustainability. It also discusses the current limitations, future directions and AI role for a sustainable agriculture. Our results highlight the significant transformative potential of AI in agriculture, yet more research and policy support is necessary to capitalize on this opportunity.

**Keywords:** *Artificial Intelligence, Agriculture, Irrigation, Crop, Sustainable.*

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### 1. Introduction

The growing population, the changing climate, and resource scarcity make it challenging for agriculture; one of the most important sectors globally. By the year 2050, it is estimated that agricultural production must increase between now and then by about 70% to fulfill global food needs [1]. Key environmental effects must be dealt with in farming at the same time as improving sustainability [2]. Introduction Artificial intelligence (AI) has recently emerged as a solution to the aforementioned challenges, providing data-driven insights for better decision-making and predictive analytics that can predict events in advance [3, 4]. This review will synthesize current applications of AI technologies dealing with benefits, limitations or disadvantages depending on implementations among others.

### 2. Methodology

These data were obtained from a review of peer-reviewed articles, industry reports, case studies published between 2000 and the early months of 2023. Information was gathered from several academic databases and trade publications. The major AI applications in agriculture, i.e. precision farming (including crop monitoring), irrigation management and logistics were identified for analysis. We also conducted a bibliometric study to understand the effect of AI on agricultural sustainability, resource efficacy and climate stability [5].

### 3. Artificial intelligence in agriculture Technologies and origins

#### 3.1 Precision Farming

One of the most important applications that AI serves in agriculture is precision farming AI can make use of machine learning (ML) algorithms for processing huge datasets obtained from satellite imagery, drones and sensors in the optimal management of crops [1, 2]. Artificial intelligence-driven tools enable farmers to keep a round-the-clock surveillance of soil fertility, forecast weather conditions and manage crop growth live. An example of that is AI systems can give personalized recommendations to apply fertilizers and pesticides which in turn increases the yields [3, 6].

#### 3.2 Smart irrigation and water management

AI is key in making agriculture water efficient. Irrigation schedules can be automatically adjusted based on soil moisture levels, weather conditions and crop water requirements with smart AI-based irrigation systems [2, 6]. It will preserve both, the water wastage and provide enough hydration for crops especially in dry areas. AI enabled irrigation systems has shown its promise as an approach to behave more sustainably, using less water [4].

### **3.3 Control of Crop Disease and Pests**

The use of AI technologies in detecting crop diseases and pest control has also increased over the past few decades. Highly sophisticated AI-powered computer vision and imaging systems are brought to bear on these sets of images, capable of recognizing the very beginnings of a disease or pest infestation just as it is taking root in its host [1]. These systems, often paired with drones or robots, analyze crops and then selectively use pesticides — cutting down on chemical usage in a way that's easy on the environment [3, 6].

### **3.4 Agricultural Robotics & Automation**

A key area in which AI has disrupted traditional agricultural automation types is by deploying robots to help with tasks such as planting, harvesting and weeding. Utilizing AI, these robots navigate fields making different decisions in real time and also perform tasks independently when deployed [7]. AI-powered robotic systems have led to a reduction in labor costs and improved operational efficiencies, especially when it comes to large farming operations [3, 8].

### **3.5 AI/Supply Chain & Logistics**

The use of AI in farming goes further: supply chain and logistics optimization. It is a system which improves the whole thing with AI based logistical routing systems improved transport and delivery of agricultural products has minimized spoilage damage to improve efficiency [6]. AI-driven IoT and blockchain have facilitated greater transparency in food supply chains, which has allayed fears relating to the safety of food & secured more market access for farmers [9].

## **4. Benefits of AI in Agriculture**

### **4.1. Improved Productivity & Efficiency Increased**

Farmers can utilize AI to determine optimal ways to both increase crop yields and resource use efficiency. As these are on-farm examples would also reduce inputs, in water, fertilizers and pesticides but provides overall higher productivity for the same. Automated systems enable farmers to take care of bigger territories with much less sources, conserving effort and time [3, 6, 7]

### **4.2 Sustainability and Environmental footprint**

Artificial Intelligence is a significant factor that contributes to the sustainability of farming by reducing pollution. Conserve valuable water with smart irrigation systems and use AI to eliminate the need for dangerous chemicals when doing pest management [4]. Its also helps in monitoring the carbon footprint of agricultural activities so contribution to climate resilient and help to mitigate it [8].

### **4.3 Enhanced Decision-Making**

AI provides farmers with improve productivity based on input parameters, hence making the decision informed in all steps of crop production. Before planting, AI systems help farmers with precise adjustments from the time of sowing to harvesting and things such as deciding when to harvest your crop in according with maturity, market demand [2, 6].

## **5. Challenges and Limitations**

### **5.1 Data Availability and Reliability**

The dearth of high caliber data is one of several hurdles facing the operationalization AI in agriculture. AI systems need tons of data on things like soil health, weather conditions and how crops have performed to work. The use of data in AI tools means that these small-scale farmers, especially those based in developing countries do not have the same services available to them [1, 8].

## 5.2 High Transaction Costs, and Access Barriers

It is expensive to launch AI technologies in agriculture, making it difficult for smallholder farmers. AI-based tools, sensors and robotics investment are capex-heavy [4, 8]. In addition to those three challenges, a digital divide exists between the developed large-scale commercial farming environments and undeveloped small scale operations where there is an infrastructure barrier [3].

## 5.3 Ethical and Social Concerns

Another worry that arises from AI is its negative effect on employment in the agricultural sector. The automation of tasks dating back to human labor could lead to job displacement in the future, especially in areas where agriculture accounts for a significant pool [2]. However, questions of ownership and data privacy are starting to arise as AI systems amass great stores of farm level information [6, 9].

## 6. Future Prospects

### 6.1 Artificial Intelligence in Climate-Smart Agriculture

With climate change becoming a rising threat for agriculture, the need of the hour is adopting AI in devising smart farming practices best suited to combat economic and environmental challenges. Models driven by AI can predict climate trends, determine which varieties are best to grow in changes and help farmers plan for extreme weather events [1, 5].

### 6.2 AI and Circular Agriculture

The transition towards circular agriculture, with the aim to minimize waste and make best use of resources, with AI support. References by combining AI with circular economy strategies, farmers can save energy wastage in inputs and utilize their resources efficiently to supplement a sustainable agricultural ecosystem [9].

### 6.3 Policy Support and Investment

Policy support and investments in infrastructure, education, and research are required not only to unleash the full potential of AI for agriculture but also strong partnerships among governments and stakeholders, if that potential is ever going to be achieved [4]. Training programs that teach farmers how to use AI tools and paying them for embracing sustainable technologies will be the driving force behind expansion of this solution [8].

## 7. Conclusion

Artificial intelligence (AI) is driving a technological revolution that reaches into many facets of agriculture, with the potential to make operations more efficient and productive while limiting negative environmental impacts. AI is revolutionizing everything from precision farming to smart irrigation and logistics, changing the way food grows as well as handled & distributed. Yet obstacles surrounding data access, expense and ethical considerations remain. Renewed efforts are needed to overcome these barriers and expand AI applications in climate resilience & circular agriculture. When done right, AI has the potential to drive a more sustainable & future-proofed global food system.

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