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Research Paper

Glimpse of artificial intelligence in the field of agriculture

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ABSTRACT

Artificial intelligence in agriculture is a developing topic with enormous potential to transform the way we produce and manage food. With the world's population growing and the need for more sustainable and effective farming practises, AI technologies have the potential to improve crop yields, reduce waste, and optimise resource allocation. The chapter will argue that incorporating AI into agriculture can lead to major improvements in output, sustainability, and security of food. The review paper intends to illustrate the relevance of embracing this transformational approach by evaluating the current issues encountered by the agriculture business and the anticipated benefits of AI technologies. As we progress through the chapter, we will look at specific uses of AI in agriculture and examine its significance for the future of farming.

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1. INTRODUCTION

Artificial intelligence in agriculture is a developing topic with enormous potential to transform the way we produce and manage food. With the world's population growing and the need for more sustainable

and effective farming practises, AI technologies have the potential to improve crop yields, reduce waste, and optimise resource allocation. The chapter will argue that incorporating AI into agriculture can lead to major improvements in output, sustainability, and security of food. The review paper intends to illustrate the relevance of embracing this transformational approach by evaluating the current issues encountered by the agriculture business and the anticipated benefits of AI technologies. As we progress through the chapter, we will look at specific uses of AI in agriculture and examine its significance for the future of farming.

1.1 Introduction to Artificial Intelligence (Ai) and its Application in Agriculture

"Artificial intelligence is a machine's ability to perform the cognitive functions we usually associate with human minds." McKinsey & Company. The ability of a computer to perform cognitive processes associated with human minds, such as sensing, thinking, learning, interacting with an environment, problem solving, and even exercising creativity, is referred to as AI. In today's society, agriculture and technology go hand in hand. Robots, temperature and moisture sensors, airborne photographs, and GPS upgrades are all used in today's agriculture industry. These push-up devices, together with the precision of agribusiness and mechanical systems, allow organisations to benefit continually, become stronger, gradually protect themselves, and even rise above ground by neighbours. Crop management systems connect to a complete crop management system that encompasses every aspect of farming. Mc Kinion and Lemmon proposed the use of AI methods in plant management in their article "Agricultural Specialist Programmes" in 1985 [1].

The world's population is expected to exceed 10 billion by 2050, putting tremendous pressure on agriculture to expand food output and maximise yields. Two potential ways to addressing projected food shortages have emerged: extending land use and adopting large-scale farming, or embracing innovative practises and utilising technological breakthroughs to increase productivity on current farmland.

1.2 Benefits and Importance of Artificial Intelligence in Agriculture

Agriculture has been the backbone of human society for millennia, supplying nutrition as well as contributing to economic progress, whereas even the most primitive AI arose only a few decades ago.

Nonetheless, creative concepts are being presented in every business, including agriculture. Rapid advances in agricultural technology have revolutionised farming practises in recent years. These technologies are becoming increasingly important as global concerns such as climate change, population increase, and resource shortages threaten the sustainability of our food system [2].

1.3 Some of the Perceived Benefits are Given Below

- **Increase in Agricultural Yields:** Crop yields can be increased by using AI-powered applications to track data on soil health, weather patterns, and plant growth. This information can then be used to make smarter choices about irrigation and fertiliser use, perhaps leading to improved agricultural yields.
- **Reduction in the use of Pesticides:** Farmers can employ AI to detect pests and illnesses in crops early on, before they do substantial damage. This information can then be used to target pesticide use, which can help to minimise the overall quantity of pesticides used on a farm.
- **Improvement in Nutritional Content in Soil:** Farmers can utilise AI-powered tools to track data on soil moisture levels, pH levels, and nutrient levels, among other things. This data can then be utilised to determine irrigation and fertilisation decisions, which can lead to enhanced soil health.
- **Reduced Water Consumption:** Farmers can employ AI-powered tools to monitor weather trends and plant growth. This data can then be used to make irrigation decisions, which can assist to minimise the overall quantity of water consumed on a farm.
- **Enhanced Efficiency:** AI-powered tools can help farmers automate operations like crop monitoring and yield analysis. Farmers' time might be freed up as a result of this automation, allowing them to focus on other activities such as marketing and sales.

- **Enhanced Sustainability:** Farmers can employ AI-powered tools to track things like energy consumption, water consumption, and chemical inputs. This data can then be utilised to implement adjustments that will result in more sustainable farming practises.
- **Decisions Based on Data:** The modern world revolves around data. Agricultural organisations employ data to acquire careful insights into every part of the farming process, from analysing each acre of a field to monitoring the entire produce supply chain to gaining deep inputs on the yield generating process. AI-powered predictive analytics is already making inroads into the farming sector. AI allows farmers to collect and process more data in less time. AI can also analyse market demand, estimate pricing, and calculate the best dates for sowing and harvesting.
- **Cost-Cutting Measures:** Farmers are constantly striving to increase farm productivity. Precision agriculture, when combined with AI, can help farmers grow more crops with fewer resources. To maximise yields while minimising expense, AI in farming combines the best soil management practises, technology, and the most effective data management practises. AI in agriculture gives farmers with real-time crop insights, assisting them in determining which regions require irrigation, fertilisation, or pesticide treatment [3].

1.4 Artificial Intelligence (Ai) and its Applications in Agriculture

- **Enhancing Autonomous Irrigation Systems:** AI algorithms provide autonomous crop management. When connected to IoT (Internet of Things) sensors that monitor soil moisture levels and weather conditions, algorithms can make real-time decisions about how much water to distribute to crops. Water conservation and the promotion of sustainable farming practises are the goals of an independent agricultural irrigation system.



Figure 1. Sprinkler Irrigation System in an Agricultural Field

- **Detection of Irrigation System Defects or Loss:** AI is essential for identifying irrigation system leaks. Algorithms can find patterns and abnormalities in data that point to potential leaks by analysing the data. Machine learning (ML) models can be trained to identify certain leak signatures, such as variations in water flow or pressure. Early detection is made possible by real-time monitoring and analysis, preventing both water waste and potential crop damage. To pinpoint regions with excessive water use, AI also takes weather information into account along with crop water requirements. AI technology improves water efficiency by automating leak detection and sending notifications, assisting farmers in resource conservation [4].
- **Observation of Crops and Soil:** The health and growth of crops can be significantly impacted by the incorrect balance of nutrients in the soil. Farmers may quickly make the necessary modifications by

identifying these nutrients and evaluating how they affect crop productivity using artificial intelligence. While the accuracy of human observation is constrained, computer vision models can monitor soil conditions to collect precise data. The health of the crop is then assessed using data from the study of plants, and yields are predicted while specific problems are noted. In actual use, AI has demonstrated a level of speed and accuracy that no human can equal in tracking the stages of wheat development and tomato maturity.



Figure 2. Smart Agriculture / AI-Enabled Precision Farming Technology

- **Disease and Pest Detection:** Computer vision can identify pests and diseases in addition to soil quality and crop growth. In order to discover insects, rot, mould, and other dangers to crop health, AI is used to scan photos. Together with alert systems, this enables farmers to take swift action to eradicate pests or quarantine crops to stop the spread of disease. Apple black rot has been successfully detected by AI with a 90% accuracy rate. It is equally accurate in identifying other insects, such as flies, bees, moths, etc. To acquire the appropriate amount of the training data set to train the algorithm with, researchers first needed to gather photos of these insects.
- **Application of Pesticides Using Intelligence:** Farmers are already aware that there is room for improvement in pesticide use. Unfortunately, there are significant drawbacks to both human and automated application processes. While manually applying pesticides might be slow and laborious, it allows greater precision in aiming at specific locations. Although automated pesticide spraying is faster and less labour-intensive, it frequently lacks accuracy, contaminating the environment. Drones driven by AI offer the best benefits of each strategy while avoiding their disadvantages. Computer vision is used by drones to calculate how much insecticide should be applied to each region. This technology is still in its infancy, but it is developing quickly [5].

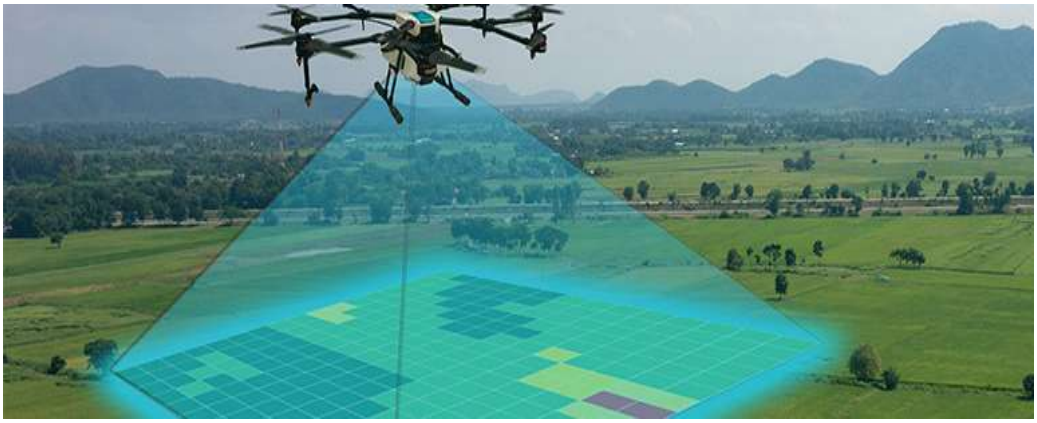


Figure 3. Drone-Based Remote Sensing and Aerial Crop Monitoring in Agriculture

- **Yield Mapping and Forecasting Techniques:** ML algorithms are used in yield mapping to instantly analyse huge datasets. Farmers can plan more effectively as a result of having a better understanding of the patterns and characteristics of their crops. Farmers may forecast soil yields for certain crops by integrating methods like 3D mapping with sensor and drone data. Data is gathered from numerous drone flights, allowing algorithms to do ever-more-accurate analysis. These techniques allow for the precise forecasting of future yields for certain crops, assisting farmers in making decisions regarding where and when to plant seeds as well as how to spend resources to get the best return on their investment.
- **Robotic Harvesting and Weeding:** Computer vision can be used to identify weeds and invasive plant species, much like it can identify pests and diseases. Computer vision examines the size, shape, and colour of leaves in conjunction with machine learning to discriminate between weeds and crops. Robots that perform robotic process automation (RPA) activities, like autonomous weeding, can be programmed using such systems. In reality, a robot of this kind has already been employed successfully. Smart bots may eventually be able to completely weed and harvest crops as these technologies become more widely available [6].
- **Sorting Harvested Produce:** AI is not only useful for identifying potential issues with crops while they're growing. It also has a role to play after produce has been harvested. Most sorting processes are traditionally carried out manually however AI can sort produce more accurately. Computer vision can detect pests as well as disease in harvested crops. What's more, it can grade produce based on its shape, size, and colour. This enables farmers to quickly separate produce into categories — for example, to sell to different customers at different prices. In comparison, traditional manual sorting methods can be painstakingly labour-intensive.



Figure 4. Automated Fruit Sorting and Processing on a Conveyor Belt System

- **The Surveillance:** A crucial component of farm management is security. Because it's challenging for farmers to keep an eye on their fields round-the-clock, farms are frequently targets for burglars. Another danger comes from animals, such as foxes that break into the chicken coop or a farmer's own livestock that tramples on fields or destroys machinery. Computer vision and machine learning (ML) can swiftly spot security breaches when used in conjunction with video surveillance systems. Some systems are even capable of telling authorised guests from staff.
- **Control Over the Quantity of Food:** Controlling the quality of food has become easier because to the development of artificial intelligence (AI) technologies, which have allowed us to employ sophisticated machine learning algorithms and other cutting-edge tools to increase agricultural output and quality. Agriculture can improve food quality control by using AI technologies to address issues like bruising, rot, and foreign items. For instance, agricultural items can be examined for symptoms of damage or spoiling using picture recognition algorithms. The utilisation of this information can then assist reduce

waste in the agricultural supply chain and guarantee consumer food safety by guaranteeing that only the best quality food is delivered to consumers.

- **AI for Predicting the Weather:** AI has the ability to aid in agricultural weather forecasting by giving farmers more precise forecasts of upcoming weather patterns. This can assist farmers in making choices about planting, irrigation, and crop protection, enabling them to maximise yields and safeguard their crops from environmental dangers. Water scarcity is one issue that many agricultural businesses deal with, and it can result in crop failure and financial losses. Farmers that use AI technologies in their operations can obtain more precise forecasts of shifting weather patterns and rainfall totals, enhancing their ability to manage water supplies and lessen the effects of drought [7].

1.5 Challenges of using Artificial Intelligence in Agriculture

- **Large Initial Expenses:** There is no getting around the fact that the initial investment in AI solutions can be highly expensive, even though they may be cost-effective in the medium- to long-term. Adopting AI may not be practical for the time being, especially for small-scale farmers and those in developing nations, as many farms and agribusinesses are experiencing financial difficulties. However, as technology advances, the cost of deploying AI might go down. Businesses can also investigate funding options including government subsidies or private investment.
- **Unwillingness to Adopt New Techniques and Technology:** Even though AI offers evident advantages, humans are frequently reluctant to adopt new technologies due to unfamiliarity. This makes it difficult for farmers to completely embrace AI. The growth of farming techniques as well as the overall profitability of the industry are held back by resistance to innovation and some unwillingness to try out new approaches. Farmers need to be aware that artificial intelligence (AI) is really a more complex version of earlier technology for analysing field data. The governmental and corporate sectors should encourage adoption of AI among agricultural workers and offer resources, training, and motivation. Additionally, governments must provide the rules required to guarantee workers that technology does not pose a threat.
- **Lacking a Comprehensive Understanding of Emerging Technologies:** Around the world, many aspects of the agricultural industry have seen different technical advancements. Even if there are some challenges in nations where next-generation agricultural technology is uncommon, some locations could profit fully from AI. Technology businesses may need to adopt a pro-active strategy if they want to conduct business in areas with developing agricultural economies. They must give training and continuous support for farmers and agribusiness owners who are prepared to adopt innovative solutions in addition to their products.
- **A Prolonged Adoption Phase for Technology:** The agriculture industry usually lacks the infrastructure required for AI to function, in addition to lacking knowledge and experience. Even farms with some technology in place may find it challenging to advance. For software suppliers and AgTech enterprises, infrastructure is a problem. One of the key strategies for resolving this is to approach farmers gradually, for example, by suggesting that they start out with a more basic technology like an agricultural trade platform. Once farmers are accustomed to a simpler solution, service providers can incorporate new tools and capabilities.
- **Technical Restrictions:** AI technology will be limited because it is still in its early stages. Accurate models require a wide range of high-quality data, which is sometimes hard to come by in agriculture. It may be challenging for robots equipped with sensors to adapt to shifting farming conditions. Continuous investigation and data analysis are needed to get around these constraints. Additionally, farmers should continue to participate in decision-making rather than delegating all authority to AI. During the early phases of adoption, manually monitoring AI judgements is probably helpful.
- **Security and Privacy Concerns:** Regulations governing the usage of AI across all businesses are still generally lacking. Implementing AI in smart farming and precision agriculture in particular creates a number of legal issues. For instance, severe issues for farmers may arise from security risks like cyberattacks and data leaks. Even the possibility of AI-based farming systems being targeted by hackers with the intention of destroying food supplies persists.

1.6 Future of Artificial Intelligence in Agriculture

Agriculture's use of artificial intelligence has a promising future with the ability to fundamentally alter how we cultivate, manage, and improve our food production systems. AI-powered solutions are positioned to address some of the most serious problems affecting the agriculture sector, such as the increasing global food demand, resource scarcity, and climate change. By incorporating AI-driven technologies like precision farming, smart sensors, and autonomous machinery, farmers may make data-driven decisions to boost crop yields, decrease resource wastage, and limit environmental impact. Machine learning algorithms can also evaluate huge databases to forecast disease outbreaks, regulate irrigation, and even monitor livestock health, which would boost agricultural productivity and sustainability overall. As the world's population continues to grow, agriculture's potential to feed it looks more promising than ever.

1.7 Case Study from Indian Company Using AI in Education

CropIn Technology Solutions is a well-known Indian business that has been utilising artificial intelligence in agriculture. Since its founding in 2010, CropIn has become a pioneer in the provision of AI- and data-driven solutions to the agricultural industry. Their platform uses artificial intelligence, machine learning, and data analytics to provide farmers and agribusinesses with up-to-the-minute information on crop health, weather forecasts, and pest control.

1.8 Maximizing Yield through Predictive Intelligence & Remote Sensing Solutions

Cropin digitally transformed farm operations and enabled plot-level predictive intelligence to increase yield, predict diseases and improve operational efficiency. One of the biggest food and beverage processing corporations in North America, their client, wanted to keep a consistent supply of excellent potatoes going. However, the processes involved in growing potatoes are complex and unpredictable, and there is a risk of contracting diseases. These factors can have an impact on crop output and quality. In order to overcome these challenges, they looked to digitise and manage their farming operations, giving them access to almost real-time reports on crop growth, production, and potential disease dangers.

1.9 How Cropin Helped the Client

The customer decided to use Cropin's Plot-level Intelligence, a technology that gives them control over the value chain of their potato crop and access to useful information on yield, crop health, and irrigation-related concerns across numerous farms and areas in Asia. The improvement of agricultural operations and profitability was made possible by plot-level intelligence, which provided specific and useful insights. It provided information on estimated yield, crop stage, crop health, anticipated harvest date, and meteorological conditions. The answers offered insights utilising tried-and-true AI/ML models:

- Canopy Greenness Index
- Canopy Water Stress
- Crop Progression Index
- Disease Early Warning System

1.10 Result of this Engagement

Cropin helped the client to achieve:

- 90% Weather prediction accuracy
- 87% Disease early warning system accuracy
- 87% Crop stage progression accuracy
- 84% Canopy greenness accuracy
- 80%Nitrogen uptake accuracy
- 80% Water stress identification accuracy

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Author Contributions Statement

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Dr. Chaya. R	✓	✓		✓	✓	✓		✓	✓	✓		✓	✓	✓
Syed Salman	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓		✓	

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

Conflict of Interest Statement

The authors declare that there are no conflicts of interest regarding the publication of this paper.

Informed Consent

All participants were informed about the purpose of the study and their voluntary consent was obtained prior to data collection.

Ethical Approval

The study was conducted in compliance with the ethical principles outlined in the Declaration of Helsinki and approved by the relevant institutional authorities.

Data Availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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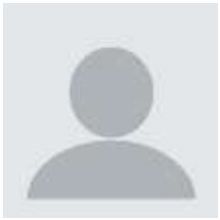
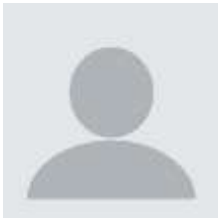
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