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Artificial Intelligence in Precision Agriculture: A Comprehensive Review

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ABSTRACT
The digitalization of data points has caused a tsunami in every industry. This has brought up a new technology named artificial intelligence among us. Artificial intelligence (AI) has revolutionized industries. AI has been in continuous demand in the farming industry for the past few years. To cultivate a healthier crop free from dis- ease and pests, forecast weather patterns, analyze data, and enhance other activities, the agriculture sector is evolving into AI. With the help of AI, farmers can increase crop production, making it economically more feasible. Many AI-equipped technologies, like AI-based chatbots, drones, and sensors, are being used in the field. Farmers are also using AI-based self-tractors and combine harvesters. Researchers are currently conducting experiments on different crops through AI, and many have been done on the crops. The future of AI farming is broad. Though AI has several advantages, it does have some limitations, like leakage or manipulation of data. This review article explores the wide-ranging applications of AI in precision agriculture. We have presented our reviews on the emergence of AI and its necessity in this progressing era of agriculture.
Keywords: *Artificial intelligence, Precision Agriculture, Global Positioning System*

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INTRODUCTION

Intelligence is defined as the capacity to think, envision, memorize, comprehend, see patterns, make decisions, adapt to change, and learn from experience. Artificial intelligence is focused on making computers behave more human-like and in a fraction of the time it takes a person to do it [1]. As a result, it is known as Artificial Intelligence. AI is growing in today's world practically in every field of industry. It is a labor-intensive, time consuming, and more resourceful method. The craze for AI-enabled technologies is rising because of its efficiency. It gives positive results in less time with the least inaccuracy. Precision agriculture is the agricultural practice of using modern technological devices or AI algorithms to enhance crop yield and productivity[2]. It is done by using technological sensors and analysis tools. The newly organized technologies require the full data of the crop which involves these as on cycle, soil conditions, climatic requirements, fertilizer requirements, irrigation, and cultural practices. Managing all these factors is a big task for the farmers. Thus, precision agriculture has come up with all the factors required by the producers. Agriculture is one of the biggest sectors of India. It is one of the major contributors to the GDP of India's economy. It has been the major center for the import and export of goods. Agriculture is a prerequisite of the country in providing food and resources for human survival and economy. It is the backbone of India economically and socially [3]. Today we are drowning in the world of artificial intelligence in agriculture because of its high efficiency. Many well-updated modern technologies are being used in agriculture. Many technologies are already being used by farmers on a high scale like drones, satellites, crop monitoring sensors, and many others. AI optimizes planting, fertilizing, harvesting, and other cultural practices.

Role of Artificial Intelligence in Precision Agriculture

Agriculture is the oldest occupation in India. Over the years it has been developing with new technologies and almost replaced conventional farming methods. Although for thousands of years, people have been practicing agriculture, it still lacks in many factors. It has remained underdeveloped for a prolonged period. Farmers worked for their landlords on low wages. They didn't have any security of job [4]. Due to losses or crop failures, farmers restrict themselves and shift towards other occupations for their livelihood. According to 2018 data, 15,000 farmers committed suicide per year. The rate of farmers decreased over the years. India's population has increased tremendously with heavy food requirements. Traditional conventional agricultural methods were unable to meet the demands of the growing over population.

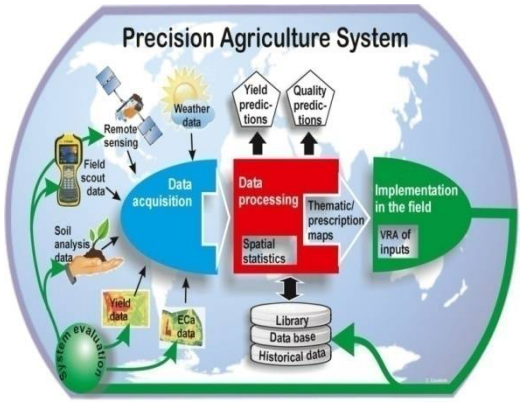


Figure1:Precision Agriculture System

Now AI has come up with solutions for producers to grow crops easily with better efficiency and more productivity [5]. Thus, the current farming methods with updated or modernized technologies have changed the agricultural sector. Farmers can take data of the crop with AI-enabled tools at different levels that link the soil and weather data, and also help in marketing and logistic conditions. It helps in checking regular updates of the crops and in maintaining soil quality and moisture levels. It enables the farmers to detect any damage before it turns into major. Detecting pests and insects has become easier with the help of drones. Forecasting helps in perceiving weather patterns and provides corrective ways to deal with them. Satellites organized in the field provide clear visuals of the crops' functioning [6]. Weeds identification helps in analyzing the growth of the plant. Manual weeding was done by the farmers when they were unaware of the technological equipment. It was labor intensive and time consuming. However, through AI, farmers can use proactive methods for its correction. It doesn't require labor and also it takes less time. AI provides the correct time of harvesting. Harvesting is also done by AI-powered robots. With the supervision of AI farmers can monitor the crops anytime. Farmers make accurate informed decisions through AI with minimum chance of error. AI has turned agriculture into a different shape. Now a new AI-based system has introduced hydroponics, where the crops are grown in favorable conditions like water, temperature, humidity, and moisture according to their requirements [7]. Crops are grown under supervision. It involves the use of highly updated technologies.

Key Principles of Precision Agriculture

Precision Agriculture is the scientific term for smart farming. The usage of robotics and the Internet of Things in agriculture made it precise and hence named precision agriculture [8]. Precision Agriculture increases the efficiency of resources and minimizes the use of manpower. Technologies such as data analytics, satellite imagery, and GPS sensors are involved in gathering real-time information about environmental conditions and crop-related information.

The primary goal of precision agriculture is to make the use of primary inputs such as water, fertilizers, nutrients, and pesticides precisely according to the genuine need of the plant and their application with proper time management [9]. It allows the targeted application of field inputs which enhances the productivity and revenue generation of the farmers. The usage of water resources is controlled by AI-operated systems along with motor sensors which allow the usage of water according to the need of the crop, not only water but the chemical application is also AI-based; what to apply, where to apply, and how much to apply everything is smartly controlled and performed by AI-based systems [10].

Data collection is one of the key components of precision agriculture. The field parameters such as soil, moisture, temperature, nutrient levels, and plant health are monitored by the sensors. The areas that require special attention are analyzed by drones and satellites which provide aerial imagery

demonstration to the farmers. The farmers then observe the problem in the particular area and immediately run for action in the area. This saves the time and resources of the farmer [11]. It helps in irrigation management, estimating crop rotation periods, and harvesting timing. With the help of precision agriculture farmers can determine the ideal time for planting and transplanting, harvesting, and other operations such as timely weeding, pruning, and thinning of crops [12]. By implementing precise and targeted practices, precision agriculture has the potential to shape the future of farming, with assurance of food security along with minimizing the environmental impact of agriculture.

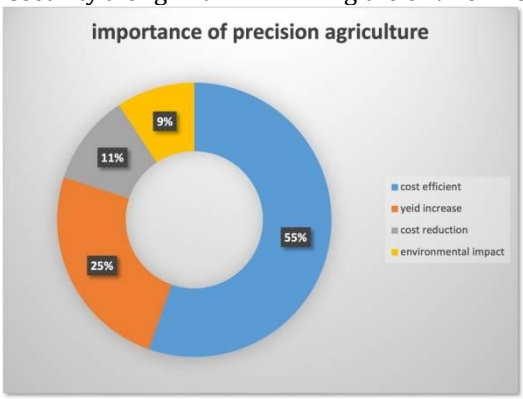


Figure2: Importance of Precision

Importance of Precision Agriculture in Modern Farming

Precision agriculture can optimize resource usage, increase yield, and promote sustainability. Farmers can achieve the improved quality of products by enabling precision agricultural techniques and contribute to the sustainable future of agriculture [13]. Additional focal points in precision agriculture include: Efficiency in resources: Precision agriculture enables the farmers to enhance the use of resources and maximize efficiency. The farmers get assistance in deciding the nutrient requirement and water requirement to the crop as it helps in computing the amount of moisture present in the soil and calculating the amount of nutrients present as well as understanding the texture and composition of the soil [14].

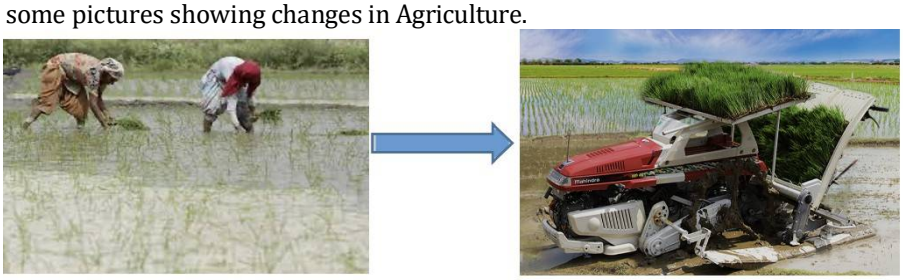
Increase in yield: As compared to the conventional methods of farming precision agriculture results in an increase in yield production.

Cost reduction: Farmers achieve good prices if they use targeted application techniques of AI.

Traditional Approaches VS Precision Agriculture

Traditional agriculture was done to complete the self-consumption needs of the farmers form any generations. It wasn't enough to produce surplus yield to sale in the market, however, some farmers still managed to produce yield to sale in the market to generate some revenue. Modern agriculture or Precision agriculture has precise bulk work and has lessened the load from the farmers. It has replaced the time and labor-consuming farm practices with machine- controlled and sensor-based systems [15].

Following are some pictures showing changes in Agriculture.



Hand transplanting to machine transplanting

Manual weeding to machine weeding

Traditional irrigation to modern irrigation

Hand threshing to machine threshing

Fig 3: Traditional Approaches VS Precision Agriculture

Some key aspects of traditional agriculture: Monoculture: Traditional agriculture focuses on cultivating a single crop with a limited number over a large area. Monoculture can lead to issues such as nutrient depletion, an increase in pest pressure, and loss of soil fertility. Uniform application of inputs: In traditional farming, the farm inputs and resources were applied uniformly across the entire field area. There was little or no consideration of soil fertility and nutrient requirements. This uniform application of the resources leads to wastage of resources and affects the soil fertility as well.

Planning season-wise: The farmers always rely on the upcoming seasons to grow different crops based on historical patterns, and techniques. Farmers use only ITK methods Indigenous Traditional Knowledge for pest control and management. Limited or no use of technology: Farmers depend on the traditional methods of farming; such as creating irrigation channels, plowing with manual plow, hand sowing or broadcasting of seeds, etc. Even when technology was discovered farmers did not believe them, they were not ready to use modern implements fearing the loss in yield.

This article tried to show that traditional agriculture was fruitful but the traditional approaches to farming have sustained agriculture for centuries, it may have limitations in terms of production, efficiency in resources and environmental impact. Precision agriculture addresses these limitations and optimizes farming practices using sensors, data analytics other AI-based systems. One of the major achievements of precision agriculture over traditional agriculture is the GPS (Global Positioning System) [8].

The Global Positioning System (GPS) has revolutionized the agriculture industry by providing accurate positioning and navigation capabilities. The GPS technology enables the farmers to precisely and smartly locate them- selves and the equipment within their work area.

Some of the key applications of GPS in modern farming are: Field mapping and boundary delineation: using this technology the farmers can map their field area on the web, not only the field area but the delineation of boundaries can be done using a GPS. It can be advantageous as it supports efficient resource planning land use planning, farm subsidies and insurance, land administration and legal boundaries, compliance, and environmental sustainability. Precision Guidance: The GPS has proved useful to farmers in navigating their equipment such as tractors and harvesters, with high precision, For example: GPS signals can be used in guiding the operator in reducing overlapping, assurance to straight rows, and consistent spacing. This reduces cost and wastage of input and stress for the operator.

Applications of Agriculture Intelligence in Precision Agriculture

AI has revolutionized traditional farming practices in this ever-evolving landscape of farming. It Empowers farmers with the newest technologies and high efficiency in their day-to-day farming. In this article we will explore various applications of AI in agriculture, highlighting its potential to boost production, optimize resource management, and promote environmental sustainability in the agricultural world. Some of the major applications of AI in precision farming are:

Crop monitoring and yield predictions

Crop monitoring and yield prediction are the two most vital components of precision agriculture [6]. It has been the most innovative technology that has synchronized farming practices in agriculture. AI-based crop monitoring harnesses smart sensing technology like drones, satellites which capture high-resolution images and collect real time data. These tools enable the farmers to monitor crop health and identify potential issues like pest infestation or nutrient deficiency in the farm so that the farmers can take corrective actions. This precision and speed of data collection have improved decision making which leads to enhanced crop yields. This also reduces the wastage of resources and also focuses on further waste management. The machine learning capabilities of AI have created such accurate yield prediction models. It analyses the vast datasets which include historical records, weather patterns, and crop growth data, and the AI algorithms can forecast crop yields with greater efficiency and remarkable accuracy.

Image Analysis and computer vision

Image analysis and computer vision are the key components that are reshaping precision agriculture by providing real-time data and actionable insights. Because these are continuously advancing technologies, they hold the potential to further enhance crop management practices, increase productivity, and promote sustainable and environmentally friendly farming methods. These advanced techniques leverage visual data to provide valuable insights and automate various farming tasks. Some of the key applications of image analysis and computer vision include crop monitoring. The aerial images of the farms are captured by drones which have high-resolution cameras in them to capture detailed information about crop health, growth patterns, and also some major potential issues like diseases or pest infestations. Similarly, ground-based cameras can be strategically placed to monitor specific areas, helping farmers identify localized problems and take swift action. The image analysis is helps the farmers to distinguish between healthy and infected plants which help the farmers to take relevant actions on time to support yield production by removing the infection before spreading.

Remote Sensing

Remote sensing allows satellites, drones, and other sensors to collect information from places at a distance which provides valuable perceptions about crop health- their growth rate and variability factors Drones having high- resolution cameras are also cost-effective which provides valuable information about the plant height, plant canopy, and other features. Drones give us a clear pictographically representation of the field. The most interesting feature of these technologies is that they have resulted in less pest activity in the field.

AI challenges and limitations

AI is growing rapidly due to its high rate of competency and output. It is full of new scientific techniques in the agricultural field which is helping farmers in many ways. Although it made farming convenient for farmers it also has several challenges and limitations. Even though AI systems are well end-to-end encrypted it is vulnerable to attack. A professional attacker can easily access the models.There are many devices of AI in agriculture such as IoT are sensitive to attack because they are placed in open places for a long time without any supervision. Location-based services are also used in the field. IoT devices are crucial for maintaining. An attacker can easily access the data after capturing the devices[16]. AI-powered robots that are used for harvesting are prone to attack.AI contains a vast amount of data including personal information and system files. It is sensitive to privacy concerns decision challenges and concern about transparency. A professional hacker can manipulate the data and can get access to those files which can cause chaos. It can create a nuisance for the world. A hacker can inject malicious data and mislead the information. No one can even imagine if a hacker got access to public data whathecando [17]. AI is very dangerous in the wrong hands. We all are well aware of cybercrime. Some people make fake content in the name of religion to create riots among the people. They also make deep fake videos of the people for fun or to black mail them just for some sort of money. They also attack social engineering aspects. AI-powered devices work on highly updated technologies. If any disturbance occurs to the devices they will stop working. Due to any natural calamity devices get nonfunctional as some of the devices remain exposed to the environment for a longer period. AI is a new method of farming for farmers. It may contain adoption barriers as farmers find it difficult to adapt to them. Farmers preferred their conventional farming practices rather than AI-powered devices. AI devices work with high efficiency and optimize crop production but on the other hand, these devices are making many farmers unemployed in the country as their primary work is agriculture. Their main source of livelihood is farming. In traditional farming, many people are required for different practices but because of AI,

only one farmer is needed for supervision of the devices in the field. So, AI should be used but not at the cost of other farmer's lives.

In this article, we explored the application of AI in agriculture and delved into the major things that comment on the traditional and modern approaches as well as the future aspects of AI in agriculture.

Disease and Pest Management

AI has unlocked many easier alternatives to the outmoded conventional farming practices. It has created a vast network across the world over a very short period. Likewise, in case of diseases and pest infestation AI had come up with easier and resourceful alternatives to manual pesticide application in the farms [17]. AI helps in the early detection and diagnosis of diseases and pest before it becomes severe. Several sources such as satellites, drones, and ground sensors are used which identify the disease at its early or development stage. As we know every disease has its cycle to develop, reproduce, and affect the crop functions; hence before the disease develops into its damaging stage the relevant actions can be taken by the farmers. AI algorithms are managed in such a way that these could capture real-time images of the diseases and pests attacking the crops. The AI systems have in built information on every recognized disease, pest, fungus, or bacteria to date; hence these can identify that particular malfunction of the crop and suggest the required treatment or formulation needed [18]. These results in good crop health leading to a higher yield production. The pesticides and insecticides are sprayed with the help of drone technology; these drones weigh up to 20 kgs of the solutions at a time. It reduces manpower and labor expenses thus maintaining the efficiency in farming.

CONCLUSION

John McCarthy, who originated the term "Artificial intelligence" in 1956, said, "It is the combination of science and engineering to make intelligent devices for human welfare. "In agriculture, engineering, medicine, the financial market, and more, AI works digitally more efficiently. It could reach more farmers. This function spreads with human help. It simulates the mind with efficient technology. It covers basic science, modern technology, philosophy, normative and idea listed science, math, sociology, etc. AI has produced crop monitoring methods, remote sensors, drones, and other video and graphic satellites that have aided farmers. AI can predict disease causes and prevent them before they become significant. Additionally, it can prevent pests from spreading. It has empowered farmers to make agricultural decisions without extension officers. It improves soil and reduces water use. Better care helps crops thrive. AI robots make harvesting easier than manual labor. This saves farmers time and money on manual work. Drones with AI make pollination easier. They mimic flower bee behavior.AI-powered brushes detect floral pollen. Shaking flowers removes pollen quickly and encourages blossoming. Slow, laborious conventional farming. Precision agriculture is new in agriculture. It gives more exact data.AI is efficient and fast, hence it should be used in the future. Well-equipped and modern AI technologies or equipment should be introduced in future ages.AI will help farmers grow high yielding, high-quality crops, which will boost their income and India's economy, which relies on agriculture. India has several revolutionized industries using agricultural raw materials. AI should be used to buy more furniture. More precision agriculture facilities should be developed through AI research. One can dig deep and create brilliant possibilities' implements. It will link agriculture and technology. It changed agriculture and the future of sustainable, efficient agriculture. It has enhanced productivity, cut expenses, and optimized crop out put, which could influence the globe. Population growth depletes resources rapidly. We must preserve resources for future generations. AI works well in most areas. Our study paper examines how AI has created new machines and methods. We can't believe a man could create such world-changing machines. Humans and machines are im- proving the planet together. Gen Z support matters too. They can help with small attempts. No one knows the AI limit, but science and engineering will make the globe peak.

REFERENCES

1. Adams, S. (2019). Agriculture and Artificial Intelligence. Cambridge University Press.
2. Brown, K.&Raj, S. (2022). AI in soil analysis and management. Soil Science Annual,93(4):375–390,
3. Chen, D.&Gupta, P. (2023). Smart farming solutions:The impact of iot and ai. In International Symposium on Smart Agriculture, ACM, p 310–322.
4. Davis, L. & Kumar, S. (2022). AI for water management in agriculture. Water Resources Management,36(6):1024–1038.
5. Foster, D. (2018). Applications of AI in Environmental Science. Mc Graw Hill.
6. Gupta, M. & Khan, I. (2023). Detecting crop diseases using artificial intelligence. Journal of Plant Pathology, 101(3): 567–582.

7. Jackson, E.& Singh, M. (2021). Ethical considerations of ai in agriculture. In Conference on Ethics in Artificial Intelligence, Ethics in Technology Association, p 150–162.
8. Johnson, E. &Clark, R. (2022). Precision Agriculture Technologies for Sustainable Food Systems. Springer.
9. Kim, J. & Das, S. (2023). The role of satellite imagery in precision agriculture. Remote Sensing Reviews, 15(3):242–256.
10. Zhou, M & Patel, J. (2021). AI and pest control: New frontiers. International Journal of Agricultural Research, 78(1):45–59.
11. Wang, F. & Singh, R. (2024). Drone technology in crop monitoring: A comprehensive review. Advances in Agriculture, 65:88–104.
12. Thompson, M. & Verma. N. (2020). Innovative ai applications in rural farming. In Workshop on Rural Development. Rural Development Association, p200–213.
13. Smith, J. & Doe, J. (2023).The role of ai in enhancing crop production. Journal of Modern Agriculture, 56(4):102–115.
14. Roberts, L. (2020). Artificial Intelligence in the Real World. Oxford University Press.
15. Nguyen, L. &Cheung, B. (2022). Advancements in hydroponics: The ai approach.In Conference on Hydroponic Innovations. Society for Urban Agriculture, p134–148.
16. Miller, T. & Li, W. (2022). Ai-based weather forecasting techniques for agriculture. Journal of Weather and Climate Technology, 12(2):190–205.
17. Newman, P. (2019). Robotics and Automation in Agriculture. CRC Press.
18. Lee, A. & Kumar, A. (2021). Integrating ai into agricultural practices. In Proceedings of the International Conference on Agricultural Innovations. IEEE.p233–245.