# ARTIFICIAL INTELLIGENCE IN AGRICULTURE

**Abstract**

Artificial intelligence (AI) is being used more and more in farming these days. AI is being used in agriculture to make crops healthier, get rid of pests, keep an eye on soil and growth conditions, help farmers analyse data, and improve management operations in the food supply chain. Farmers often finds it difficult to figure out when is the best time of year to plant seeds. Artificial intelligence aids farmers in selecting the optimal seed variety for the current growing conditions. Predictions on the weather are also included.The use of AI-driven solutions will aid farmers in increasing crop yields while decreasing input costs and accelerating the time it takes to bring their products to market. AI helps us learn about the qualities of soil. AI aids farmers by advising them on what nutrients to use to improve the soil. AI can help farmers figure out when the best time to plant seeds is. Intelligent machines can figure out how far apart seeds should be planted and at what depth. An artificial intelligence (AI)-powered system known as a health monitoring system might provide farmers with data on the state of their crops and provide recommendations on what nutrients to provide in order to maximise quality and quantity of harvest. In this chapter, significant literature on AI for agriculture are found and analysed. AI has given farmers access to state-of-the-art data and analytics tools, which will improve farming practises, boost productivity, and reduce waste in the biofuel and food production sectors while reducing negative impacts on the environment.Several sectors have been revolutionised by ML and AI, and now the agricultural sector is riding the AI wave. There are a variety of technologies in development that will make crop and soil monitoring more accessible to farmers. The two most prominent AI-based technologies

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that can assist assure crop health are hyperspectral imaging and 3D laser scanning. These AI-powered systems gather more detailed information on the condition of the crops for study. This chapter provides information on use of AI in agriculture, provides an overview of the importance of AI in Agriculture process and some of the agricultural parameters that AI monitors.

**Keywords:** Artificial intelligence, agriculture, farming, application, Machine learning

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## I. INTRODUCTION

Agriculture is the oldest and largest economic sector in the world. The population of the world is expanding quickly, which is driving up demand for both jobs and food. Since traditional farming practises are unable to achieve the requirement, new automated methods are being created to meet the world's growing demand for food while also creating employment opportunities for billions of people globally (Zhang *et al*, 2021). Increase in manpower scarcity, tough laws, an expanding global population, and a decline in farmers, farmers are compelled to look for new solutions(Sain *et al,* 2020). Nearly every industry is being affected by innovations like the Internet of Things, Big Data & Analytics, Artificial Intelligence (AI), and Machine Learning (ML). Through "smart farming," efforts are being made to make agricultural products more "connected" and "intelligent" in order to increase their quality and output (Waleed *et al*, 2020 Farming fields are treated with pesticides in a greenhouse or outdoors to boost yield. Farmers may also use ML in precision agriculture management, where agrichemicals are administered based on time, location, and impacted crops. Farmers must correctly detect and classify agricultural quality traits in order to increase product pricing and reduce wastage. Machines can utilise data to uncover fresh traits that are crucial for crop quality. The way in which water is managed in agriculture has a significant influence on the agronomic, climatological, and hydrological balance. Applications built on machine learning (ML) may calculate evapotranspiration on a daily, weekly, or monthly basis, enhancing the efficiency of irrigation systems (Mor *et al*, 2021). The estimation of evapotranspiration and evaporation, as well as the detection of impending weather events, can both benefit from accurate daily dew point temperature forecasts.The most successful farmers in the food-tech industry are those who have adopted AI and machine learning to boost productivity. Currently, crops are managed, monitored, and data is gathered using robots and sensors. There is increasing interest in applying machine learning in farming.Utilizing machine learning (ML) is a sustainable and environment friendly strategy to boost agricultural output.By collecting agricultural data, farmers may have a better understanding of crops, their DNA, and potential diseases (Shankar *et al*, 2020).

The evolution of AI is accelerating*(*Singh *et al,* 2020*)*. More sectors of the global economy are beginning to benefit from artificial intelligence as a result of advancements in computing power and rising adoption of cloud computing. One industry that has already begun to reap the benefits of artificial intelligence is agriculture.Whether it be preventing the growth of weeds, determining the optimal time to harvest crops, keeping track of the condition of both the soil and the plants, or estimating the amount of product that will be produced (Bhardwaj *et al*, 2021). Several industries have tested AI and ML as development tools over the last decade. However, it is only recently that it has become clear that the use of AI in agriculture may improve decision-making. AI technology, in particular, has the potential to assist farmers in making better decisions, thereby increasing the efficiency of agricultural and livestock output*(*Sain *et al,* 2020*)*. A variety of factors influence the agriculture sector's desire to adopt AI technology for better decision-making.. The indisputable growth in the amount of data available and the ease with which it may be accessed are the main issues (Rodzalan 2020).

Surveillance systems in the field of agriculture that are powered by artificial intelligence and machine learning offer insights to monitor crops, spot pests, and identify soil issues. These insights allow farmers to plant seeds at the optimal time for the greatest possible harvest.Agricultural operations across the board are in significant risk because of weeds.They

 

are responsible for a decrease in agricultural productivity, an encroachment on crops, the suffocation of pastures, and in a few isolated cases, harm to livestock. Sensors powered by artificial intelligence (AI) are able to detect the presence of weed infestations and choose the herbicide that will be most effective there. AI systems are able to predict weather patterns, evaluate the health of crops, and identify illnesses, pests, and inadequate plant nourishment. Using drones with AI technology, farmers can keep an eye on the health of their crops. A report on the health of the farm is compiled once experts have looked through the photographs the drone has taken. A report on the health of the farm is compiled once experts have looked through the photographs the drone has taken. This aids in pest management for farms. The most time-consuming and physically taxing farm jobs are now sometimes carried out by agricultural robots, according to some farmers. These machines may lighten the workload of workers and help farms save money on human labour. This chapter deals with the many ways in which AI is used in agriculture.

## II. ARTIFICIAL INTELLIGENCE

The goal of the multidisciplinary field of research known as artificial intelligence is to replicate human intelligence in machines by programming them to think and behave in ways that are analogous to humans, such as by solving problems and acquiring new skills. Research scientists and extension workers are increasingly turning to artificial intelligence technology in order to address problems with agricultural production.Artificial intelligence (AI) has the potential to help farmers increase yields by assisting them with tasks such as crop selection, pest and disease management, crop production estimations, and commodity price forecasting.Artificial intelligence employs state-of-the-art methods like deep learning, robotics, the IoT, image processing, artificial neural networks, wireless sensor networks (WSN), and machine learning to address issues in the agricultural sector.Now that such AI systems are becoming more widely available, they may be used to assist farmers in real-time monitoring of a wide range of elements collected from their fields, such as weather, temperature, water consumption, or soil conditions. Farmer losses can be reduced while crop yields are increased with the help of AI-enhanced smart agricultural practises. (Liu 2020; Talaviya*et al*, 2020).

Artificial intelligence (AI) is a discipline of computer science that uses machine and deep learning algorithms, among others, to learn from and interpolate data in an attempt to imitate human intellect. Predictions are generated by these networks through the dynamic linking of input and output variables. These predictions can aid in the exploration and development of many approaches to a wide variety of issues. Tools that use artificial intelligence are increasingly common in our daily lives.

From self-driving cars to mobile facial recognition software, AI is everywhere these days. It is inconceivable to envisage agriculture undergoing a digital transformation, despite the fact that other industries have benefited significantly from AI systems and machine learning capabilities. But AI is taking one of the oldest sectors of the economy into the future. Surprisingly, AI has several uses in agriculture. Artificial intelligence enables precision farming. Agricultural tasks such as watering, harvesting, selecting crops, planting, and managing pests could all benefit from ML data-driven AI. (Jung *et al* 2021).

Fundamental to artificial intelligence is the idea that information about how humans think can be expressed in a way that a computer can readily mimic human behaviour and

 

perform its tasks. Artificial intelligence (AI) aims to learn, reason, and perceive.All facets of life are being profoundly impacted by AI.Every industry is on the lookout for ways to implement AI automation.This is the result of characterising human intelligence in a way that a computer can interpret it. Additionally, the application of AI technology in agricultural settings has the potential to enhance the entire world. This technology is capable of doing tasks ranging from simple to complex. The purpose of an artificial intelligence is to acquire cognitive abilities (learning, reasoning and perceiving). It helps with the mechanisation of many different types of work. Using a smart device can make a number of different operations easier. (Sharma *et al*, 2022).

## III. AI AND ITS NEED IN AGRICULTURE

The agricultural sector is one of the most labour-intensive industries; consequently, with a growing population and a higher demand for agricultural goods, automation is becoming an increasingly important factor. In terms of components, technology, and applications, AI greatly assists farmers. Crop quality and availability are guaranteed through enhanced farm and crop management systems and predictive analytics. Businesses calculate acreage and track crop health in real time using satellite pictures and meteorological data (Subeesh and Mehta, 2020).Big data, AI, and ML technologies may be used by businesses to anticipate price, assess tomato output and yield, and identify pest and disease infestations. They may counsel farmers on demand levels, crop kinds to sow for maximum profit, pesticide use, and future pricing patterns. AI will be a powerful tool that can assist businesses in dealing with the increasing complexity of modern agriculture since it greatly decreases the scarcity of resources and labour. Large firms should invest in this field now. Many sectors are utilising AI technology to increase production and efficiency (Skvortsov, 2020).AI technology are assisting individuals in all industries in overcoming traditional barriers. Finance, transportation, healthcare, and agriculture are just a few of the industries that use AI applications (Shadrin *et al,* 2019).The rate of urbanisation is accelerating as the world's population expands. As disposable income rises, consumer behaviour changes. Since farmers are under a lot of pressure to meet the rising demand, they need a strategy to enhance output. Feeding more people will be necessary. Due to the restricted availability of fertile soil, farming will also require creativity. To help farmers reduce their risks or, at the very least, manage them, solutions must be developed. One of the most interesting potentials is the widespread application of AI in agriculture (Mohr and Kuhl, 2021).Several food producers are currently having trouble managing the hazards and threats that pests and other diseases pose to their crops. Climate change, monoculture, and extensive pesticide use all increase these hazards. These components combine to present farmers with a brand-new challenge. Due to farming's reliance on natural forces for the majority of its output, farms and farmers are under a great deal of stress. The unpredictability of the weather, the scarcity of labourers, and the yearly requirement for higher yields all contribute to this stress. This means that for us to almost fulfil our objectives, the agricultural sector will need to expand up significantly over the next several years, and farm efficiency would need to double. In order to address all of these issues, AI offers farm automation (Blessy, 2021).

Agriculture technology providers occasionally fall short in completely describing how and why their solutions are advantageous, which gives the impression that new technologies are difficult to use and excessively unaffordable.Despite the fact that AI could be beneficial to farmers, the companies that provide technology still have a lot of work to do in order to teach them how to use it effectively.The majority of the procedures and stages involved in agriculture

 

are performed manually. Through the advancement of currently available technologies, artificial intelligence may one day be able to assist with even the most routine and complicated/hard tasks.The industry of agriculture is one that relies heavily on human labour, but there is currently a severe lack of workers. The use of automation by farmers is one potential solution to this problem. Farmers may use a variety of tools, including driverless tractors, AI-based harvesting robots, intelligent irrigation and fertilisation systems, intelligent spraying, vertical farming software, and intelligent irrigation and fertilisation systems, to complete the task.Farming equipment that is powered by artificial intelligence is more productive, quick, and efficient than any human worker.The primary goals of this chapter are to investigate artificial intelligence (AI) and the necessity of it in agriculture, investigate the ways in which AI is being used in agriculture, and find specific agricultural metrics that AI is measuring as well as to outline and discuss the primary applications of AI in the agricultural sector.

## IV. AI AND ITS PROCESS IN AGRICULTURE

Combining data from remote and local sensing sources with picture recognition algorithms has the potential to completely transform how agricultural equipment is utilized and how efficiently it operates. This is especially true in the fields of agricultural harvesting and grading, early disease diagnosis, and weed management (Perea *et al*, 2019). By utilizing technology powered by AI, it is now able to keep a constant eye on these expensive items (and do so around the clock). For horticultural practices to be effective over the entirety of the plant's growth cycle, comprehensive monitoring is essential. Agriculture AI systems can make use of precision agricultural software, soil sensors, soil analysis drones, or even smartphone images to measure soil nutrient levels and compare them to clerestories that have historically provided the maximum yields on the given crop. Artificial intelligence (AI) may utilize datasets to analyze the impacts on the environment of applying different doses and types of fertilisers in order to determine the dosage that will have the least negative impact while boosting output. This may be done in order to determine the dosage that will have the most positive influence on the environment. These will be of assistance in agriculture's efforts to become more environmentally friendly (Chen and Yu, 2021). The implementation of AI in agricultural settings is depicted in Figure 1. depicts the process of AI implementation in agriculture.

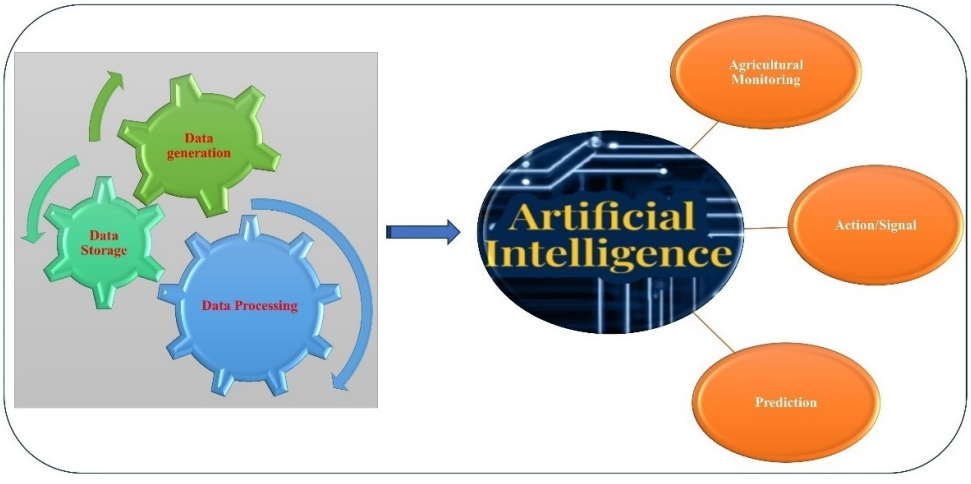


**Figure 1:** The Process of AI Implementation in Agriculture

Pollution levels have notably increased throughout time, as has the volatility of the weather. Climate change makes it difficult for farmers to determine when to plant seeds, which is where AI comes in. With artificial intelligence (AI), it is straightforward to comprehend how seasonal sunshine, wind, and rain will affect agricultural planting cycles. Weather forecasts will be useful to farmers as they study and plan when to plant seeds. The advancement of computer vision, mechatronics, AI, and ML has made it feasible to utilise remote sensing technologies to identify and manage plants, weeds, pests, and diseases. It also presents a once-in-a-lifetime opportunity to create innovative seeding strategies for precise fertilisation. AI solutions might help farmers save waste while improving product quality and hastening market access. Automated tractors are used to prepare the land for planting and harvesting. Using GPS technology, these tractors can operate without a driver. Drones collect data, remotely monitor the health of farms and crops, and then communicate the findings (Drury *et al*, 2017; Kugler, 2022). AI aids with pest control by identifying the main plant on the farm. by figuring out which pesticides can be used and in what quantities. Additionally, it uses drone technology to quickly spray herbicides over fields. Predictive analytics may be used to estimate rainfall and evapotranspiration. ML models may be taught to offer significant insights regarding soil moisture, temperature, and general condition when used in conjunction with soil samples and other data. Farmers may utilise data to water their crops more effectively, improving both their profit margins and the environment. These automated technologies can keep track of farm conditions, making agriculture less labour-intensive and more resourceful. Identifying and controlling field variability makes it possible to provide the crop exactly what it needs. Crop yields, fertiliser effectiveness, and profitability all increase with precision responsiveness to farming demands. In addition to greater production and efficiency, precision agriculture promotes sustainability and environmental preservation. A lot of corporations all around the world are adopting AI and its subset of technologies to boost the effectiveness of agriculture-based enterprises (Katiyar, 2022; Dozono*et al*, 2019). The agriculture industry has seen a workforce deficit as the globe has moved from a rural to an urban lifestyle. Workers are needed on traditional farms to do a variety of jobs, including plant seeds, water the land, harvest crops, pull weeds, and more. AI assists in the solving of such issues by offering automated solutions. Self-driving bots are being developed by several businesses to manage labour-intensive agricultural procedures. These agricultural robots are a complement to human labour and may provide work with improved quality, cheaper prices, and increased productivity. Artificial intelligence has many uses in agriculture, including disease prediction, soil retention calculations, crop development modelling, pesticide and nutrient loss assessments, and determining egg fertility. Many people think it's important to use AI to make sure that farming decisions are as smart and effective as possible. This is because AI helps farmers make better decisions about crop and livestock output.The performance of the agricultural sector and its potential to grow in the future can be judged by how well AI technologies are used and how reliable data collection is. (Vazquez *et al*, 2021).In an effort to move forward, many sectors have been conducting AI experiments over the past decade. Yet, it is only recently apparent that AI may be used to enhance agricultural decision-making.By utilising AI technology, farmers in particular may be able to make decisions that are more effective, which in turn may increase the productivity of agricultural and livestock endeavours. Data mining needs AI-based analytics. AI is used in agricultural research and industry. AI, or artificial intelligence, is a relatively new technical field that examines the growth of human intelligence through the creation of theories, techniques, algorithms, and applications.AI uses machine learning strategies to extract meaningful information from massive amounts of data because traditional data processing systems are unable to deal with the volume and complexity of big data. This helps with disease

 

prediction based on plant growth, size, or colour, as well as understanding agricultural growth patterns and possible illnesses associated with that crop. It makes use of feed sensors, weight sensors, soil sensors, temperature sensors, intensity sensors, and several types of cameras. These sensors might all be mounted on a machine. This machine might be a low-flying drone or a tiny robot moving across the field (Khan *et al*, 2022).

## V. MONITORING OF AGRICULTURE PARAMETERS USING AI

Recognising that agriculture as a labour-intensive operation, a labour shortage is unsurprising. However, automation can aid in solving of this issue. Auto-driving tractors, smart irrigation, spraying, and fertilising systems, and AI-based harvesting robots are a few examples. Software companies may find it tough to help farmers grasp the complete AI system. In agriculture, AI is utilised for field harvesting, health monitoring, pest management, and deficit identification. In the agriculture industry, machine learning and artificial intelligence are replacing outmoded forecasting and intelligence approaches (Wongchai*et al*, 2022). AI makes agriculture more adaptive by introducing cutting-edge technologies to the field. Biosensors have even enabled the monitoring of soil moisture and fertility. Instead of employing simple linear regression models, raw data and alternative ways are collected. Past weather patterns with non-linear relationships may be computed and predicted using neural networks. As a consequence, for vital commodities such as rice, wheat, and maise, AI may be used to sow the seeds at the right time because they largely require substantial rains to flourish and are often cultivated during the summer (Gambhire and Shaikh, 2020).

Few of the Agriculture parameters monitored by AI are shown using Fig. 2.Multiple variables such as temperature, soil, water usage, and weather are recorded daily by farms, adding up to hundreds of data points. Real-time analysis of this data is used by AI and ML models to draw conclusions about important agricultural decisions like when to plant seeds, which crops to harvest, which hybrid seeds to select for increased yields, and so on. Supporting precision farming, AI systems improve the accuracy, quality and consistency of the harvest.The use of AI helps farmers identify problems like pests, diseases, and nutritional deficiencies. AI sensors can identify and target weeds before deciding on the best herbicide to use in the area. As a result, herbicide use is reduced, resulting in cost savings. Robots using computer vision and artificial intelligence have been developed by a number of tech firms for the purpose of effectively detecting weeds prior to spraying. The use of AI has expanded into many fields, including business, medicine, architecture, marketing, and finance.Artificial intelligence (AI), machine learning (ML), and the internet of things (IoT) are just some of the cutting-edge technologies used to water, guard, and fertilise crops today. (Dutta *et al*, 2020).

In order to obtain the desired harvest from one's crops, it is necessary to irrigate them at the appropriate times. Due to a lack of resources, watering crops on a large scale by only a few farmers became a challenging and time-consuming task.Now on the market are intelligent irrigation system options. These systems are comprised of two components: a machine learning model that determines the amount of moisture present in the soil, and a hardware implementation that makes use of IoT devices. This application is beneficial to ML's crop and soil monitoring systems, remote sensing, satellite imagery, drones, and precision technologies, among other things. Autonomous robots are currently in the process of being developed to perform traditionally labor-intensive tasks, such as agricultural harvesting, at a higher level of efficacy and speed than is possible with traditional human labour.The early and accurate

 

detection of illnesses, allergies, chemicals, and pollutants in foods, plant and animal production systems, water, and soil is the goal of research being conducted to develop nano-based sensing mechanisms and smart sensors, which are currently undergoing testing. (Sankaranarayanan, 2022).


**Figure 2:** Agriculture Parameters Monitored by AI

Agricultural land generates millions of data points on a daily basis, which can be gathered and analysed by AI. Farmers may now make smart choices in real time, using AI to solve an age-old problem. Farmers can forecast weather conditions ahead of time, allowing them to select the optimal time to seed their crops. Another issue that AI has handled is water use. AI has made it possible to evaluate hybrid seeds and their yields before planting them in the fields. This has the dual benefit of lowering the likelihood of unsuccessful harvests while simultaneously increasing output. Due to the relatively low number of people who engage in farming, the majority of farms are contending with a shortage of skilled labour. Farms once needed a large workforce, the majority of whom harvested crops seasonally. However, a shortage of workers emerged as people made the transition from rural to urban and suburban settings. AI bots assisted in reducing the shortfall (Mokaya, 2019).

Emerging agricultural technology facilitate the data collection that farmers need to monitor and improve their crops. Additionally, it is regularly updated with changing ecological and environmental elements. Emerging agricultural technologies suggest that technical development is crucial to the agriculture industry in the present. The implementation of modern agricultural technology helps us reach our sustainability goals in agriculture. Various sectors are using AI technology to boost production and efficiency.Farmers are using AI in agriculture to improve productivity and lessen their negative environmental effects. agriculture sector has therefore firmly embraced AI to affect the overall outcome. In addition to solving a wide range of problems in the agricultural sector, this technology is also used extensively in the food,

 

agricultural, and bio-system engineering industries. (Nawaz *et al*, 2020).To aid with the cultivation of crops, data may be gathered through sensors, drones, and satellites. AI in farming may then be used to analyse the data, enabling farmers to make better decisions. Phenotyping may employ AI to examine the biomass and traits of a plant. It is possible that technology based on artificial intelligence (AI) will be developed to identify the precise causes of diseases. This will be accomplished by analysing changes in plant biomass and environmental conditions in order to identify common patterns among all crops that are afflicted.The ability of farmers to detect impurities and diseases in their crops can assist them in increasing their overall output.The use of water in agriculture has an impact on the equilibrium of hydrological, climatological, and agronomic systems.Daily, weekly, or monthly evapotranspiration estimation allows for more efficient use of irrigation systems; daily dew point temperature prediction helps identify expected weather phenomena and estimate evapotranspiration and evaporation; and these applications are among the most complex uses of ML. (Zhou *et al*, 2022).The enormous potential of AI will accelerate the pace of disruption and fundamentally alter the process by which our food is transported from farm to plate. A digital revolution is now taking place in agriculture. New agricultural regions' potential will be unlocked by AI, and these new businesses will require workers. AI is making controlled farming of both new products like insects and enduring ones like leafy greens more viable and accessible.This technology can help farmers overcome a number of problems, including pests, water scarcity, and climate change. With a wealth of data at hand, AI uses ML, Deep Learning, and other techniques to produce insightful forecasts that may help farmers make knowledgeable agricultural decisions. Humans are unable to assess vast volumes of data with such accuracy as AI can. Robots powered by AI are being used by many farmers to complete jobs that once needed human labour. Most individuals are avoiding working in agriculture as a profession due to rising urbanisation. As a result, there are now fewer people available to work in agriculture (Jha *et al* ,2021; Klyushin and Tymoshenko, 2021).

## VI. APPLICATIONS OF AI IN AGRICULTURE

Numerous advances in agricultural technology may result from the use of artificial intelligence.This includes the use of cameras and other sensors, as well as data analytics, consulting services, the internet of things, and other similar technologies. When AI is developed to a sufficient level, it will be able to examine multiple data sets, such as weather, soil, crop performance, and temperature, to provide superior predictive insights. This investigated the risks associated with applying ML models to maximise yields in agriculture, including interoperability, safety and security, data dependability, and unexpected socio-ecological effects. By promptly recognising plant diseases and effectively distributing agrochemicals, AI in agriculture may be utilised to enhance crop management and productivity. Machine learning has the potential to facilitate rapid phenotyping of plants, monitoring of agricultural practises, evaluation of soil composition, forecasting of weather and yields. More and more farmers are turning to artificial intelligence (AI), the Internet of Things (IoT), and other technological advances to increase the yields from their land. (Ramirez-Asis *et al*, 2022; Jia *et al*,2020The increased adoption of technology that is driven by artificial intelligence (AI) is causing a huge shift in the agriculture industry, and this shift will have a significant impact. The application of artificial intelligence (AI) and cognitive technologies could be beneficial to farms all over the world in improving decision-making, organizing data, automating time-consuming operations, and increasing overall production. Because of the considerable advances that have been made in technology, such as computers and software, as well as the growing faith that societies have in

 

machine learning (ML), it is now possible to use massive amounts of data to improve the productivity and sustainability of farms. The choice to implement AI technology in order to improve decision-making within the agricultural sector was brought on by a number of different considerations. It is obvious that the quantity of data that is available has grown, while at the same time the accessibility of data has improved. This is made feasible by developments in the industry, such as an increase in the use of sensors, a quicker access to satellite images, cheaper costs for data loggers, an increase in the usage of drones, and an improvement in access to government data archives. Before extending loans to farmers, financial institutions that use AI in agriculture can perform credit checks and evaluate the farmers' agricultural track records using the technology. Farmers and financial institutions are both able to benefit from the increased transparency that intelligent agricultural technology brings to the pre-disbursement process. By analyzing information about the farms' previous performance as well as current data about the predicted output for the current time, financial institutions are able to make harvest predictions for individual plots and provide loans with a lower associated risk.(Dhanabalan and Sathish, 2018; Navinkumar *et al*, 2021; Sharma *et al*, 2021).The application of AI in farming is in its infancy at this point. It will take some time before they are able to make informed decisions based on the data they receive regarding when to plant, when to irrigate, when to apply inputs, and when to harvest. There is an absence of training data, both in terms of number and quality. In order for a computer vision-based artificial intelligence program to be able to detect pests or plant diseases in user-generated photos, the program must first be trained on a large and diverse collection of pest photographs. The lighting, viewpoints, and backdrops in these photographs are frequently varied from one another. Access to existing farming expertise could make it easier to develop AI solutions that are both practically useful and scalable for use in agriculture. Utilizing a network of professionals and farmers, the artificial intelligence model is able to acquire information from a vast array of pertinent data and photos. The data might then be utilized to improve a farmer's knowledge and experience in order to enable them to choose the most effective pesticide formulation and dosage at various stages of a pest infestation. This provides decision-making and operations in agricultural production management with methodologies and analyses of multisource data with high geographic and temporal precision. The availability of sufficient, accurate, and up-to-date data for water management in agriculture is inadequate, which is a prerequisite for developing AI solutions that are efficient. Participatory and crowdsourcing techniques of data collecting may allow for the acquisition of data with a greater depth of context. Farmers are able to detect soil moisture using low-tech sensors and acquire groundwater data through participatory mapping thanks to the availability of training. (Kouadio *et al*, 2018; Streich *et al*, 2020; Javaid*et al*, 2022). The significant applications of AI in agriculture are discussed below in this chapter.

1. **Weather Prediction:** Artificial intelligence has been used to improve not only weather forecasting but also groundwater management, crop cycles, and the detection of plant diseases. Soil and plant sensors, as well as multispectral images captured by satellites or drones, make it possible to track crop health in real time. With this information, AI-powered solutions can determine if complicated unsupervised ML methods are in use. This increases output while decreasing crop failure. Security camera or drone footage could be analysed by AI to identify animals, birds, and unauthorised people that could cause crop damage. To help farmers become more productive, artificial intelligence in agriculture employs data and tools like self-driving tractors, intelligent drones, soil sensors, and other technology.Precision farming and predictive analytics are two common uses of AI in the agriculture sector. With most agricultural startups utilising AI-enabled approaches to boost agricultural production

 

efficiency, the rate of AI adoption in the agriculture industry has altered the overall results of farming operations. (Al-bayati and Ustunda, 2020).

2. **Plant Diseases Prediction:** AI is capable of identifying and removing weeds, identifying and even forecasting plant illnesses, and recommending appropriate pest control approaches. AI assists in anticipating the best agronomic product combinations, identifying the best irrigation strategies, and scheduling fertilizer applications. AI can automate harvesting and may even be able to forecast when it will be most effective. The use of predictive analytics has the potential to change entire sectors. AI allows farmers to analyse and gather more data than they could otherwise. AI can assist farmers with critical issues such as analysing market demand, projecting pricing, and selecting when to produce and harvest crops. Producers may use this to sort the fruit into stacks of varying stages of preparation before transporting it to market. Field managers may produce real-time predictions using high-quality photographs captured by devices such as arial vehicles and copters. During cultivation, forecasts are generated by developing feed and field maps and identifying places where crops need more or less water, fertilizer, or pesticides. Farmers may benefit from cognitive solutions on soil condition, weather forecasts, seed types, and insect infestation in a specific place. (Jiayu*et al*, 2015; Banthia and Chaudaki, 2022).

3. **Monitoring of Crop and Soil:** Crop and soil monitoring are common uses of AI. Drones, the Internet of Things, and satellite photos taken in the field may all be used to gather data, which can then be tracked and processed by applications using artificial intelligence to find the best solutions. Applications in artificial intelligence enable the understanding of soil problems, plant pests, and diseases. The use of ML algorithms facilitates quick and simple data analysis. Using mobile agricultural applications, farmers may be able to better manage their fields, monitor weather changes, follow their activities, and review crop data.In order to improve agricultural productivity and sustainability while ensuring food safety, herbicide and pesticide use must be optimised. Instead of performing processes in accordance with a predetermined schedule, AI systems monitor current weed and insect activity and tailor the administration of herbicides and insecticides to it. An attack by pests can be anticipated by assessing satellite or drone imagery, noticing patterns in pest activity, and monitoring fresh data to look for warning signs of an imminent attack. With this information, farmers may prevent insect attacks without jeopardising the health of their crops or applying pesticides (Qazi *et al*, 2022; Weng *et al*, 2019).

4. **Food Supply Chain Assistance:** Technology fuelled by artificial intelligence (AI) may improve agricultural output across the board, from crop production to logistics in the food supply chain. These innovations increased the demand for food in the system and provided employment for billions of people throughout the globe. The use of AI has resulted in a dramatic change in the agricultural sector. It has protected the agriculture sector from challenges associated with labour shortages, global warming, population growth, and food safety. While artificial intelligence (AI) has the potential to improve crop management and agricultural output, experts warn that there are significant hazards associated with its widespread use. New models using scale-appropriate management approaches and technology are being designed with the help of AI applications, which will be of great use to those in charge of agricultural operations, forest management, and livestock ranching. Artificial intelligence (AI) is being studied to shed light on a wide range of topics, including but not limited to: the structure and performance of agricultural markets; global trade;

 

agricultural production and resource use; consumer behaviour; food safety; food waste and loss; farm labor and immigration and policy; agricultural policy design and impacts; technological development and adoption; and science and innovation policy. (Salehin*et al*, 2020; Parasuraman *et al*, 2021).

5. **Cultivation and Harvesting of Crop:** Robots and drones designed with artificial intelligence are increasingly being used in farming. Precision in irrigation, weed management, and crop management all contribute to a more productive field. Predictive analysis is useful for finding potential problems ahead of schedule. In order to prevent significant crop loss or damage, early detection is crucial for farmers and organizations. Flood and drought forecasting might be assisted by artificial intelligence. This technique is useful for determining how much herbicide and insecticide to apply to a field. Insect infestations and other plant health issues may be detected with the use of artificial intelligence software. Soil fertility is preserved and the use of pesticides and herbicides is reduced as a result. Artificial intelligence is also useful in the field for monitoring crops and applying pesticides and weed killers. The use of chemical spraying drones can boost productivity while simultaneously lowering the demand for physical labor and the load placed on the workers. There are a variety of applications for artificial intelligence (AI) in the agricultural industry, some of which include robots, predictive analytics, unmanned aerial vehicles, and autonomous farm tractors. In the agricultural industry, AI has proven to be beneficial in a number of applications, including crop protection, weather forecasting, the automation of farm equipment, and the monitoring of animal growth. (Sparrow *et al*, 2021; Bestelmeyer*et al* 2020).

6. **Food Shortage:** As a result of food shortages and food waste caused by locust swarms, climate change, droughts, and floods, agricultural experts are looking to the field of artificial intelligence (AI) for answers. Depending on factors like soil quality, weather forecast, seed variety, and pest infestation, cognitive computing might help farmers choose the finest crops and seeds. The specifics of the farm, the climate, and the farmer's past successes all play into the recommendations given. Artificial intelligence may also considerArtificial intelligence may also factor in external factors like price changes, client preferences, and market trends. As a result of not knowing the market well enough, smallholder farmers face difficulties. Due to the lack of reliable information, many farmers have little choice but to sell their goods to intermediaries. Cybersecurity measures, and skilled workers able to put them in place, are essential in the agricultural sector, especially in international trade and data collection. The additional data in agricultural operations allows AI to work with the data required to enable better decision-making practices generally. This is made possible by the use of AI-specific procedures like machine learning. A machine learning system may automatically tweak its procedures by studying new data (Garrett *et al*, 2022; Hyunjin and Sainan).

7. **Detection of Soil Defects:** Soil sensors, drones used for soil research, and even smartphone cameras can all contribute data that can be analysed by AI systems to diagnose nutrient deficiencies and other soil problems.This knowledge could be useful for farmers in deciding how much organic matter to add to the soil to make it more manageable and compatible.The processing of vast amounts of data, both structured and unstructured, is made possible by AI and the technologies that fall under its umbrella.Several variables, including climate, soil, humidity, and crop yield, are examined in order to generate more accurate forecasts.The

 

evaluation of a massive amount of data, from farm machinery to drone footage, will improve agricultural precision and productivity by tracking and anticipating environmental effects on crop output. In addition to information gathered on the ground, IoT devices installed on drones and Unmanned aerial vehicle systems may also be accessed by AI applications.Farmers can estimate crop yields with the help of machine learning by analysing many years' worth of weather and crop records to look for patterns in the data.Monitoring the quality of the water and air can also assist in predicting farming difficulties in certain regions.Understanding the magnitude of global calamities such as wildfires, earthquakes, and hurricanes highlights the importance of resource management. (Sishodia*et al*, 2020; Widianto *et al*, 2022).

8. **Detection of Insects:** Small insects are detected using AI algorithms. When an infiltration is identified, warnings get transmitted to farmers' cellphones instantly, allowing them to take measures to prevent it. Artificial intelligence in agriculture is a more effective way to produce, harvest, and market important crops. Implementing AI-powered farming methods can help farmers respond appropriately to climate change. To increase agricultural health and productivity, AI focuses on assessing faulty crops and identifying pests. With the use of technology, crop management practises are being enhanced. Farmers may use less resources to enhance crop output while retaining quality. AI technology minimises workforce challenges and automates manual labour, accelerating food revolution.Many farmers are most concerned about the variation in crop prices. Green beans have a short shelf life, which causes inconsistencies in the manufacturing pattern. Weather and satellite photos are used by AI startups and corporations to check crop health. Big data, AI, and ML models may be used to detect pests and illnesses, increasing crop health through real-time monitoring. Based on past data, models are also created to give real-time analysis of crop yield, output, yield trend, and price projection (Patil and Kumar, 2020; Upadhyay and Gupta, 2021).

9. **Water Management:** AI in agriculture has produced applications that provide producers with precise advice on water management, crop rotation, scheduled harvesting, optimal sowing, and other issues. Using ML algorithms and images from satellites and drones, we can evaluate agricultural sustainability, manage nutrition, and predict the weather. Utilizing precise data inputs, precision agriculture maximizes agricultural production. Utilizing mobile devices and AI software, farmers can obtain a customized agricultural plan. While human input will always be necessary for design, the application of AI to lawn maintenance can significantly reduce physical labour. Through automation, robotics, and artificial intelligence, the future of horticulture is being transformed. Growers and breeders can use machine learning to identify potential diseases and parasites in plant roots. By removing diseased plants, plant generations improve in heath. Farmers play a significant role in sustaining an ever-expanding global population, despite climate change and population growth. The effects of climate change are something they deal with every day, and they have to make sure food is grown in a sustainable way. To make the best economic, environmental, and legal decisions, a number of prerequisites and factors must be considered. This is where digital agriculture could be helpful. (Zhang, 2020; Kumar *et al*, 2021; Kaur 2019).

10. **Agricultural Yield and Productivity:** Artificial intelligence in agriculture has the potential to significantly boost agricultural production and productivity. As a consequence of this, agribusinesses are beginning to apply the technology of artificial intelligence (AI) in agriculture by means of predictive analytics. The application of artificial intelligence in

 

agriculture may help farm producers with soil monitoring, the control of parasites, the improvement of crops, the management of supply chains, and data analysis. In order for farmers to safeguard their crops at this point, they remove any unwanted vegetation and get rid of any rodents. On the farm, crops are protected from pests and weeds with the use of herbicides and pesticides. It is possible for weeds to bring about a reduction in both the quality and quantity of the yields. In addition to this, it may drive up the expenses of production. Farmers may use machine learning to evaluate enormous quantities of field data in order to gain a better understanding of the performance of crops through time as well as the development of unique characteristics. The data that was retrieved makes it easier to create a probability model that can determine which genes in a plant are most likely to bestow a desirable characteristic on the plant. Comparing the color and shape of leaves is the traditional approach of determining the species of a plant. On the other hand, ML offers a classification method that is both more accurate and more time-efficient. This is accomplished by analyzing the morphology of leaf veins, which carries additional information on the features of the leaf and, in certain circumstances, aerial photographs. (Sujawat, 2021; de Abreu and Van Deventer, 2021).

11. **Funds Determination at the Farm Level:** The role of technology goes beyond locating potential recipients of the credit to also include evaluating how effectively the funds are used at the farm level. Traditionally, this entailed assigning field agents to personally inspect the operations of each region.But this wasn't a scientific way to collect data, and it took a lot of time. Smart technology could help financial institutions keep an eye on plots of land that are being farmed in real time, which would be good for them and help farmers keep a tight grip on the health of their crops throughout the whole process of farming.AI is developing into a significant source of functional automation and efficiency-improving procedures from the farm to the fork.These solutions are more crucial than ever as international trade expands and becomes more complicated.These days, AI-powered software applications are everywhere.Even though every agricultural organisation has its own unique requirements, choosing a platform that provides software as a service can give you access to the potential of AI in a way that is both secure and multi-tenant in its architecture. The Internet of Things (IoT) and artificial intelligence are becoming more accessible to the general public as they expand into new industries. This means that any knowledgeable individual can now use these technologies to develop more effective data-driven solutions. (Pallathadka*et al*, 2022; Khalifeh *et al*, 2018).

12. **Identification of Wasteful Resource Consumption Patterns:** AI systems may find patterns of excessive resource use and suggest optimisation options by crunching the data on how resources are allocated and used. Through preventative measures, such as keeping an eye on livestock health and equipment performance, the cost of veterinarian services and equipment maintenance is decreased. Since AI in agriculture increases yields without requiring farms to use more resources and lowers costs associated with various stages of agricultural operations, an increase in profitability is a logical and advantageous side consequence. Sustainable agriculture aims to find a solution that will allow us to meet our present demands for food and textiles without wasting too many resources AI assists farmers in identifying efficient resource use patterns to avoid water shortages and environmental harm.Artificial intelligence (AI), a complex technology with a number of subsets and types, has the potential to provide agriculture with algorithms and programmes of varying degrees of complexity. (Raman *et al*, 2021; Dora *et al*, 2021).

 

13. **Drive Predictive Analytics:** AI is mostly used in planting crops in the agricultural sector because it can help predict when and how to plant. It helps predict the best time to plant, apply fertilizer, harvest, bale, till, and do other farming tasks based on climate data, past events, market conditions for inputs and outputs, personal information, etc. Using AI-assisted technologies, crops can also be planted at the best levels and at the same distances from each other. With AI, IoT, connected services, and self-driving systems, farmers may be able to make decisions for each square meter, plant, or animal instead of for whole areas or all animals. This accuracy makes it possible to come up with smart solutions that help farmers grow more food with less resources and make agriculture more sustainable. Another important part of precision farming is a software program that has been taught to recognize the exact crop that will be grown in that field. Modern agricultural technology affects many farming jobs, such as planting seeds, watering crops, and using fertilizer. New innovations in agricultural engineering help crops grow better and fight pests better. Modern farming equipment has also reduced the number of people needed to till, plant, harvest, and do other tasks associated with farming. (Chukkapalli*et al*, 2020; Costa*et al*, 2021).

14. **Identification of Locations for Sowing Specific Crops:** AI assist farmers in selecting the best locations to sow crops based on the topography, the chemical composition of the soil, and other factors by analysing images taken by drones. The seed quality will be determined and the current crops will be identified using a supervised ML algorithm. Before planting, AI may examine seed photographs and compare them to images of healthy seeds. AI has effectively identified and studied potential deficiencies in nutrients and defects in soil. The AI deep learning application aids the growth of flora pattern analysis in agriculture. These AI-driven software technologies help us better understand soil flaws, plant pests, and illnesses. AI is used by farmers to manage weeds by utilising robots, ML, and computer vision. AI is used to gather data to monitor weed.Farmers are now able to spray pesticides directly on their crops. Many different scientific areas are seeing increased interest in AI. The research applies numerous concepts from the fields of agriculture, food science, and animal sciences by combining digital sensors with robots and AI technologies. The primary objective is to develop flexible and reliable models that will automate the prediction of extremely complicated processes to establish an essential objective (Sane and Sane ,2021; Bharti and Bhan, 2018; Fuentes *et al*, 2020).

15. **Improve Decision Making:** The use of AI technology in agriculture to improve decision-making is expanding. Decision-making in agriculture is being aided by the analysis and utilisation of an increasing amount of data. A few examples of industrial advancements that have made this possible for irrigation are the increased use of sensors, faster access to satellite images, cheaper pricing for data loggers, greater use of drones, and simpler access to data archives. To increase efficiency, this labour-intensive operation can be automated. Machines are able to understand past weather patterns and soil characteristics, offering important information on how to boost total output.The repetitive and labour-intensive components of agriculture are replaced by more accurate and controlled techniques used in precision farming, such as high precision positioning systems, automated steering systems, geo-mapping, sensor and remote sensing, and integrated electronic communication. Additionally, it offers guidance to farmers on crop rotation, earnings, effectiveness, and long-term sustainability. There are several steps and procedures involved in agriculture. AI can do the most complicated and common activities by completing the adopted technologies.

 

When used in conjunction with other technologies, it can compile and analyse vast volumes of data on digital platforms, choosing the optimal course of action and initiating it. To improve agricultural decisions, it is possible to assess data on soil conditions, water consumption, ambient temperature, and meteorological conditions (Hemming *et al*, 2019; Taberkit*et al*, 2021)

16. **Agricultural Efficiency Improvement:** Numerous agricultural and aggrotech companies are attempting to improve agricultural productivity by developing devices that use sensor fusion and AI models to identify the most harvestable crops. Rapid advances in video analytics, facilitated by AI and ML algorithms, contribute to the protection of remote locations such as farms and harvests. The condition of plants could be monitored using infrared camera data from drones and ground sensors. Certainly, AI has enchanted every industry, including agriculture. It affords farmers and others in the agricultural industry new opportunities for growth and prosperity. Farmers who once searched for tractor parts may soon be on the lookout for intelligent devices to assist them with agricultural tasks. Agriculture is integral to our existence because it produces sustenance. Farmers can use the results of AI to make decisions regarding planting, harvesting, and sales. Artificial intelligence evaluates vast quantities of data to generate weather forecasts. Humans are incapable of processing massive amounts of data and generating precise insights like AI. (Ghosh and Singh, 2020; Hyunjin 2020; Vincent*et al*, 2019)

## VII. AI AND ITS LIMITATIONS

The lack of straightforward solutions that can easily incorporate and subtly embed AI is one of the primary obstacles standing in the way of widespread adoption of AI in agriculture. The vast majority of farmers do not have the time or the digital skills necessary to independently investigate the various AI options. In order to smoothly accept and implement AI within agriculture, these new AI solutions will need to be integrated into the existing and legacy infrastructure and computer systems that farmers already use. Because AI cannot function outside of the parameters of its programming, agriculture cannot completely rely on it. Farmers, particularly those living in rural areas, suffer from a lack of technical understanding and are unaware of the existence of certain technologies. It is possible that agriculture will become semi-autonomous as a result of increased awareness and the increased availability of technology to the average farmer, with AI leading the way. Artificial intelligence systems require a massive amount of data in order to properly educate robots and make accurate predictions. When dealing with land that is primarily used for agriculture, obtaining spatial data is not difficult, whereas gathering temporal data can be challenging. The vast majority of data specific to individual crops can only be collected during the growing season of those crops. Because it takes some time for data infrastructure to mature, developing a powerful machine learning model is a time-consuming process.

## VIII. CONCLUSIONS

Solutions powered by AI combine data from satellites and drones with machine learning algorithms, photos captured by satellites, and wind speed in order to anticipate the weather, analyse agricultural sustainability, check farms for the presence of diseases or pests, and determine whether or not appropriate plant nourishment is being provided. Farmers that have access to Wi-Fi may utilize AI software to create a customized farm plan for their operations.

 

Farmers have the potential to meet the world's demand for an improved food supply and greater profitability by utilizing AI-driven solutions that increase both productivity and revenue without depleting irreplaceable natural resources. Farmers may be able to recognize crops that require irrigation, fertilization, or application of pesticides in real time using AI. Vertical agriculture is only one example of a forward-thinking agricultural practice that has the potential to increase food output while simultaneously reducing the number of resources required. As a result of a reduction in the usage of herbicides, an improvement in harvest quality, an increase in revenues, and significant cost savings are generated. Together with high-resolution aerial photographs, the data collected by AI tools on the necessary irrigation systems for the crops is also gathered. Problems with the soil, such as leaks and clogs, can be more easily identified with the assistance of AI. AI helps to increase farm produce and evaluates the poor state of the soil. The total output of the field can be increased through the use of techniques such as yield management, production that is enabled by artificial intelligence, as well as automated and autonomous farming activities. The production of food, as well as its packaging and sorting, can all be enhanced with the assistance of AI in picking, packing, and sorting. Farmers stand to profit from having the capability to better interpret agricultural data insights relating to temperature, precipitation, wind speed, and sun radiation. The use of AI technologies could assist farmers in addressing challenges such as climate change as well as plant and insect infestations that lower food yields. Artificial intelligence (AI) will be utilized in the agricultural sector to improve the industry as a whole.

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