**Artificial Intelligence in Agriculture**

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**Abstract**

Recently, farming has made substantial use of artificial intelligence (AI). The agricultural industry is utilising AI technology to produce healthier crops, control pests, monitor soil and growth conditions, analyse data for farmers, and improve various management tasks associated with the food supply chain. Farmers find it difficult to pick the best time of year to plant seeds because of this. AI aids farmers in selecting the best seed for a given weather circumstance. Data on weather forecasts is also provided. AI-powered solutions will assist farmers in increasing crop quality, producing more with less resources, and reducing the time it takes for products to reach the market. Understanding soil properties is aided by AI. AI aids farmers by recommending the nutrients they should use to improve the soil. AI aids farmers by recommending the nutrients they should use to improve the soil. AI can assist farmers in determining when to sow their seeds. The maximum planting depth and the distance between seeds can be calculated by intelligent machinery. Farmers may get information on the health of their crops and the nutrients they should give them to improve yield quality and quantity from an AI-powered system known as a health monitoring system. In this chapter, significant literature on AI for agriculture are found and analysed. Farmers now have access to cutting-edge data and analytics capabilities through AI, which will promote better farming, increase productivity, and decrease waste in the production of biofuel and food while minimising adverse environmental effects. ML and AI have revolutionised several industries, and the AI wave has now reached the agricultural industry. Several technologies are being developed by companies to simplify crop and soil health monitoring for farmers. The two most prominent AI-based technologies 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

1. **Introduction**

The world's oldest and most significant industry is agriculture. 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. 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). Reliable daily dew point temperature forecasts also aid in the detection of impending weather events as well as the estimation of evapotranspiration and evaporation. Farmers that use AI and machine learning to increase productivity have profited most from the food-tech sector. At the moment, robots and sensors are used to manage, monitor, and gather data on crops. The potential for using machine learning to agriculture is growing. An environmentally friendly technique to increase agricultural productivity is by using machine learning (ML). By collecting agricultural data, farmers may have a better understanding of crops, their DNA, and potential diseases (Shankar *et al*, 2020).

AI is evolving rapidly. Due to advancements in computing power and rising cloud adoption, more areas of the global economy are beginning to benefit from AI. Agriculture is one sector that has already started to benefit from AI. Whether it's controlling weeds, determining when to harvest crops, monitoring the state of the soil and crops, or predicting output (Bhardwaj *et al*, 2021). Over the last 10 years, a variety of industries have tested AI and ML as development tools. However, it has only recently been clear that using AI in agriculture may improve decision-making. AI technology, in particular, may help farmers make better decisions, increasing the efficiency of agricultural and livestock output. The agriculture sector's ambition to adopt AI technology for better decision-making is influenced by a number of reasons. The indisputable growth in the amount of data available and the ease with which it may be accessed are the main issues (Rodzalan 2020).

In the field of agriculture, surveillance systems powered by AI and ML offer insights to monitor crops, spot pests, and identify soil issues, enabling farmers to plant seeds at the perfect moment for the most harvest. Many agricultural enterprises are under danger from weeds. They reduce agricultural productivity, encroach on crops, suffocate pastures, and, in a few rare instances, harm livestock. Artificial intelligence (AI) sensors can identify weed infestations and select the optimum herbicide to use 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.

1. **Artificial Intelligence**

Artificial intelligence is an interdisciplinary field of research that tries to duplicate human intelligence in robots that resemble human cognition and actions, including problem-solving and learning. AI technology is increasingly being used by research scientists and extension workers to address issues with farm production. By supporting them in selecting appropriate crop kinds, implementing better soil and nutrient management practises, managing pests and diseases, calculating crop production, and forecasting commodity prices, AI technology may help farmers raise yields. In order to solve agricultural problems, AI makes use of deep learning, robotics, the Internet of Things, image processing, artificial neural networks, wireless sensor networks (WSN), machine learning, and other cutting-edge techniques. These AI systems may now support farmers in real-time monitoring of numerous elements collected from their fields, such as weather, temperature, water consumption, or soil conditions, in order to better inform their decisions. AI is being utilised to build smart agricultural practises that decrease farmers' losses while offering excellent yields (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. By dynamically connecting input and output variables, these networks generate predictions. These predictions can aid in the development of diverse remedies for both simple and complex problems. AI-powered gadgets are now commonplace 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. Using ML data, AI may assist farmers with irrigation, crop rotation, harvesting, crop selection, planting, and pest management (Jung *et al* 2021).

The premise at the heart of AI is that human intelligence can be expressed in a way that allows a computer to easily imitate and carry out activities of all sizes. AI's aims include learning, reasoning, and perception. AI is having a huge influence everywhere. Every sector is seeking for ways to employ intelligent technology to automate certain tasks. It happens when human intellect is characterised in such a way that a computer can understand it. Furthermore, AI technology in agriculture has the potential to improve the globe. This technology is capable of doing tasks ranging from simple to complex. The goal of a machine is to learn, reason, and perceive. It aids in the automation of labour in a variety of industries. The use of intelligent devices simplifies a variety of tasks (Sharma *et al*, 2022).

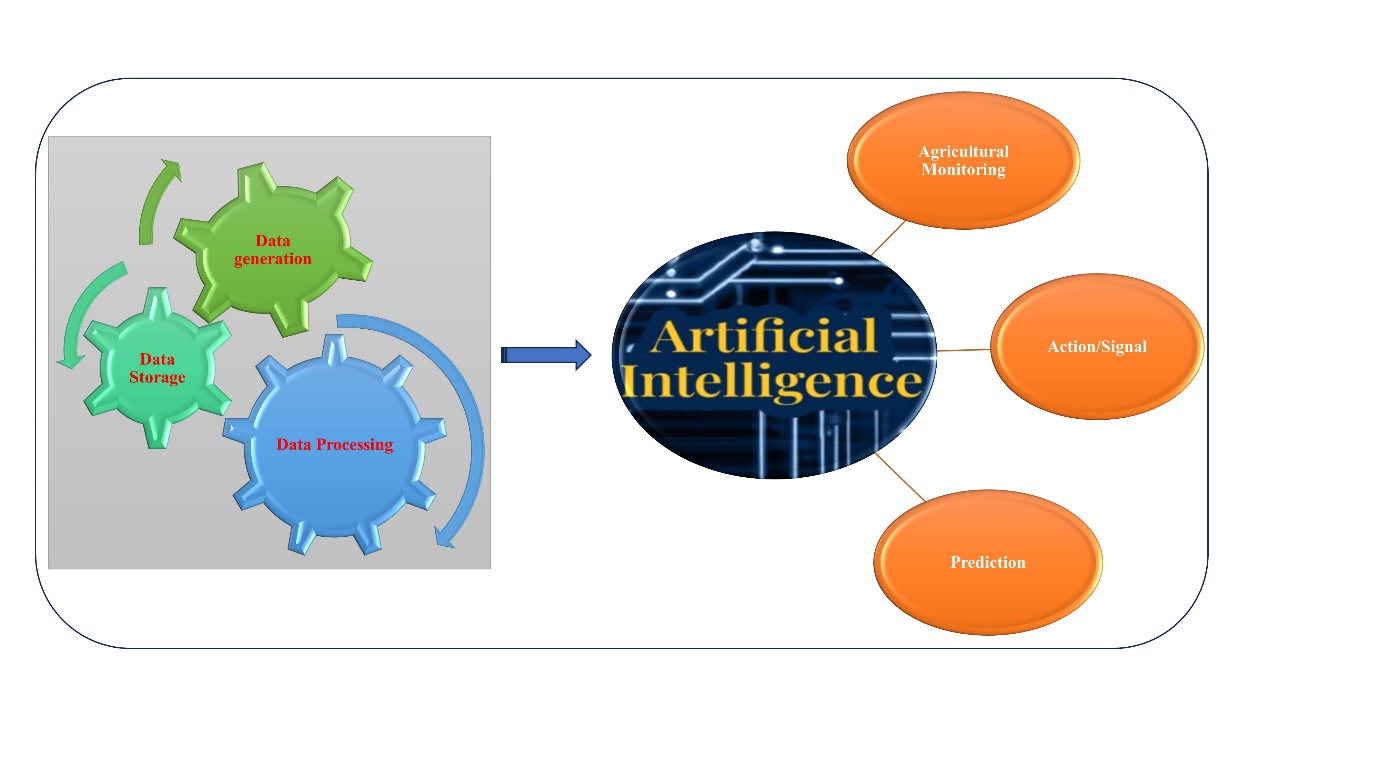
1. **AI and its need in Agriculture**

Agriculture is a labour-intensive industry, and with population growth and increased need for agricultural produce, automation is becoming more and more crucial. 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).

Vendors of agriculture technology sometimes fall short of fully describing how and why their solutions are beneficial, which makes new technologies appear complex and excessively expensive. Despite the potential benefits of AI, technology providers still need to put a lot of work into helping farmers deploy it appropriately. A large portion of agriculture's processes and phases are manual. By improving present technologies, AI may help with even the most routine and difficult tasks. Agriculture is a labour-intensive industry, and there is a severe labour shortage. In order to solve this problem, farmers can use automation. Driverless tractors, intelligent irrigation and fertilising systems, smart spraying, vertical farming software, and AI-based harvesting robots are just a few tools that farmers may use to perform the task. Farm equipment powered by AI is more productive, swift, and efficient than any human worker. This chapter's main objectives are to examine artificial intelligence (AI) and the need for it in agriculture, examine how AI is being used in agriculture, and discover specific agricultural metrics that AI is measuring. and to list and talk about the main uses of AI in agriculture.

1. **AI and its Process in agriculture**

It is well recognised that the AI system's ability to solve agricultural problems depends on the quality of the data it has access to. It is believed that AI holds the potential to provide ground-breaking agriculture solutions. This is a significant challenge, particularly when trying to find the necessary data at the farmer level. Combining image classification algorithms with data from remote and local sensing sources can revolutionise the use of farm machinery and efficiency, particularly in weed control, early disease detection, crop harvesting, and grading (Perea *et al*, 2019). The use of AI technologies makes it possible to monitor these expensive commodities constantly (around the clock). Comprehensive monitoring is required for horticultural practises during the whole plant growth cycle. Agriculture AI systems can continuously monitor the nutrient levels in the soil and compare them to the clerestories that have historically produced the highest yields on the particular crop using data from precision agricultural software, soil sensors, soil analysis drones, or even smartphone photos. To determine the dosage that will have the least negative impact while increasing output, AI may use datasets to analyse the environmental effects of using different doses and types of fertilisers. These will aid agriculture in becoming more environmentally friendly (Chen and Yu, 2021). Fig. 1 depicts the adoption process of AI in agriculture.



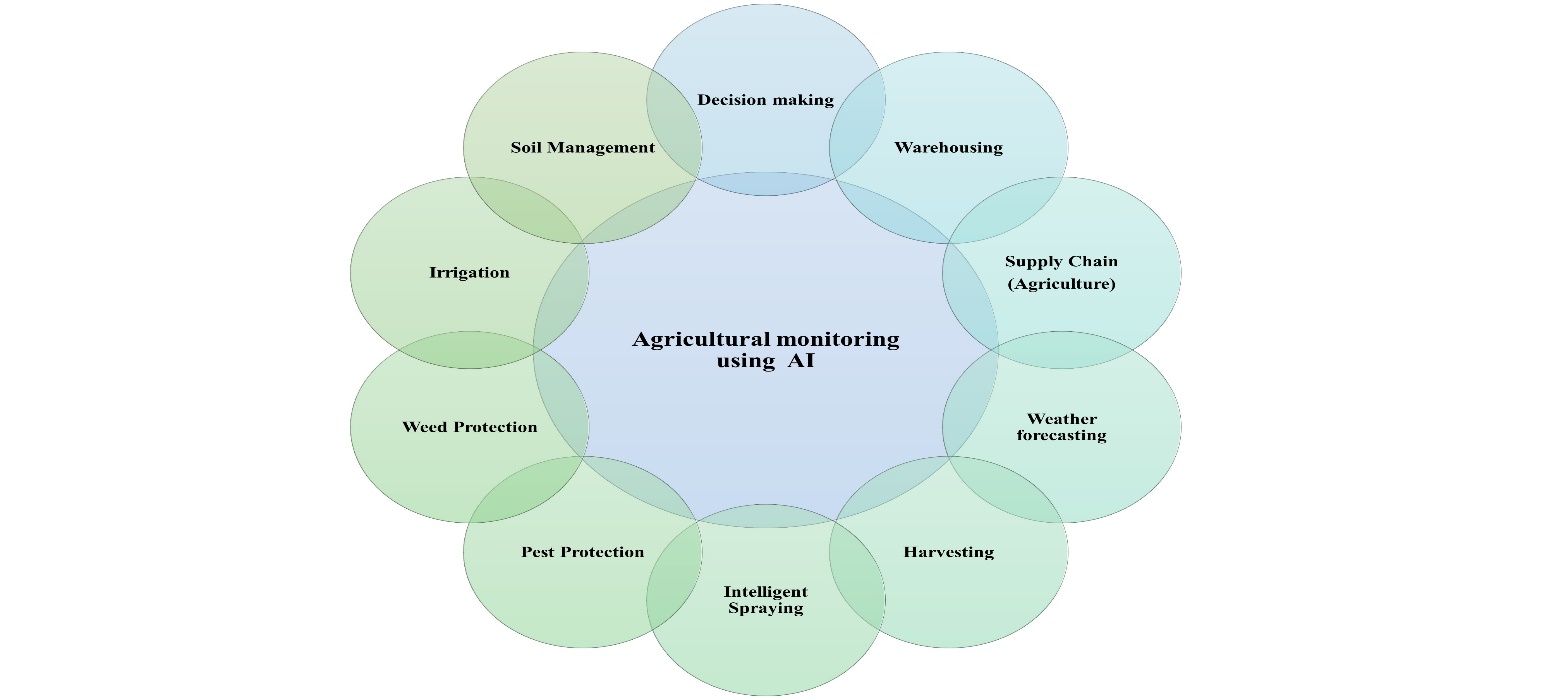
**Fig 1: The adoption process of AI in agriculture**

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. Applications of AI in agriculture include disease prediction, calculations of soil retention, crop development modelling, assessments of pesticide and nutrient loss, and fertility of hen eggs. Many people feel that adopting AI is critical to ensure that agricultural decision-making is as effective and sophisticated as possible since it allows farmers to make better informed decisions about crop and livestock output. The effective use of AI technologies and the dependability of data collection serve as indicators of the agricultural sector's performance and potential for future expansion (Vazquez *et al*, 2021). Many industries have experimented with AI over the past ten years in an effort to advance. However, it has only recently been obvious that artificial intelligence (AI) may be utilised to improve agricultural decision-making. Farmers, in particular, may be able to make more efficient decisions that increase agricultural and livestock productivity by utilising AI technology. Data mining needs AI-based analytics. AI is used in agricultural research and industry. AI is a relatively new technical field that evaluates the development of human intelligence via the development of theories, techniques, algorithms, and applications. Given the quantity and complexity of big data, which normal data-processing systems cannot handle, AI employs machine learning techniques to extract meaningful information from massive amounts of data. This aids in understanding agricultural growth patterns, potential illnesses linked with that crop, prescriptions of certain fertilisers or pesticides depending on disease pattern, and disease prediction based on plant growth, size, or colour. 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).

1. **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. Every day, farms Generates hundreds of data points about temperature, soil, water use, weather, and other factors. AI and ML models use this data in real-time to gather insightful information, such as when to plant seeds, which crops to pick, which hybrid seeds to choose for higher yields, and so on. AI systems support precision agriculture by increasing harvest accuracy and quality. AI technology assists farmers in detecting pests, sickness, and nutritional deficits. 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. Several technology companies have developed robots that utilise computer vision and artificial intelligence to correctly detect weeds and spray them. AI has made advances into a wide range of disciplines, including sales, medical, architecture, marketing, and finance. Nowadays, modern technologies like as AI, ML, and IoT are employed to irrigate, secure, and fertilise crops (Dutta *et al*, 2020).



**Fig 2: Agriculture parameters monitored by AI**

Crops must be irrigated at the correct times in order to achieve the desired yield. Watering on a wide scale by a few farmers became a complicated task due to a lack of resources. Intelligent irrigation systems are now available. These systems are made up of two parts: an ML model that calculates the amount of moisture in the soil and hardware implementation utilising IoT devices. ML's crop and soil monitoring systems, remote sensing, satellite imagery, drones, and precision technologies all benefit from this application. Autonomous robots are being developed to do traditionally labour-intensive tasks, such as agricultural harvesting, with greater efficiency and speed than traditional human labours. Nano-based sensing mechanisms and smart sensors are being developed and tested for early and precise detection of illnesses, allergies, chemicals, and pollutants in foods, plant and animal production systems, water, and soil (Sankaranarayanan, 2022). Every day, agricultural land creates millions of data points that AI can gather and analyse. 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 enabled the evaluation of hybrid seeds and their yields before to planting them in the fields, reducing the possibility of failed harvests and enhancing output. Most farms confront a skilled labour shortage due to the small number of individuals that undertake farming. Farms once needed a large workforce, the majority of whom harvested crops seasonally. However, when people moved from an agrarian to an urban and suburban lifestyle, there was a manpower shortage. 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. This technology is widely utilised to optimise the production and operation processes in the food, agricultural, and bio-system engineering industries as well as to address a variety of issues facing the farming sector (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. Artificial intelligence (AI) technology may be developed to find the precise causes of these illnesses by studying changes in plant biomass and environmental conditions to find common patterns across affected crops. Detecting impurities and diseases in crops can assist farmers in increasing overall output. Agriculture's use of water affects the hydrological, climatological, and agronomic balance. The most complex machine learning (ML)-based applications relate to daily, weekly, or monthly evapotranspiration estimation, allowing for more effective irrigation system use, and daily dew point temperature prediction, assisting in identifying expected weather phenomena and estimating evapotranspiration and evaporation (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).

1. **Applications of AI in agriculture**

The application of AI in agriculture can lead to a number of technical developments. Among other things, this involves, data analytics, consultancy services, the internet of things, and the usage of cameras and other sensors. Once AI in agriculture becomes proficient enough, it will be able to analyse a variety of data sources, including weather, soil, crop performance, and temperature, to give 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. Rapid plant phenotyping, agricultural monitoring, assessment of soil composition, weather predictions, and yield prediction may all be aided by machine learning. To improve the production of their agricultural land, more farmers are adopting AI, IoT, and other technology advancements (Ramirez-Asis *et al*, 2022; Jia *et al*,2020).  AI-powered technology is growing and will bring about a huge change in the agriculture industry. AI and cognitive technology may be used by farms all over the world to enhance decision-making, sort through data, automate tedious processes, and increase productivity. Thanks to significant improvements in technology, including computers and software, and societies' confidence in machine learning (ML), huge amounts of data may now be used to boost farm productivity and sustainability. The agricultural industry has chosen to use AI technology to improve decision-making for a number of reasons. Data accessibility has improved, and there is a clear increase in the volume of data that is available. Sector advancements including expanded sensor use, quicker access to satellite imagery, cheaper data logger costs, expanded drone use, and enhanced access to government data archives make this feasible. Before issuing loans, banks can evaluate farmers' credit and agricultural history using AI in agriculture, notably in finance. Smart agricultural technology benefits both farmers and financial institutions by increasing transparency in the pre-disbursement process. By analysing information about the farms' past performance and current data about the prospective output for the present period, banks may estimate the harvest from every plot and provide loans with lesser risk (Dhanabalan and Sathish, 2018; Navinkumar *et al*, 2021; Sharma *et al*, 2021). The use of AI in agriculture is still in its infancy. It will take some time before they can utilise the data they get to make planting, irrigation, input application, and harvesting decisions that are as efficient as possible. Training data are lacking in both quantity and quality. A computer vision-based AI programme must be trained on a sizable and varied collection of pest photographs in order to detect pests or plant diseases in user-generated photos. These pictures often feature different lighting, perspectives, and backgrounds. Development of practical and scalable AI applications for agriculture might be facilitated by access to current farming expertise. By using a network of experts and farmers, the AI model can learn from a wide range of pertinent data and photos. The results may then be used to augment a farmer's knowledge and experience so they can make better choices about the optimal pesticide composition and dosage to use at different stages of a pest infestation. For decision-making and operations in agricultural production management, this offers procedures and analyses of multisource data with high geographical and temporal resolution. There aren't enough reliable, timely, and adequate data available for water management in agriculture, which is a must for effective AI solutions. Richer contextual data might be gathered via participatory and crowdsourced data collection methods. Using low-tech instruments and training, farmers may measure soil moisture and gather groundwater data through participatory mapping (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**

The usage of AI technology helps with weather forecasting as well as other crucial agricultural aspects including groundwater, crop cycle, and the identification of plant diseases. Monitoring crop health is made feasible by sensors for the soil and plants as well as multispectral images taken by satellites or drones. Using this data, AI solutions can assess whether more complex unsupervised ML algorithms are being used. This boosts productivity while reducing crop loss. AI systems may scan footage from security cameras or drones for wild animals, birds, and unauthorised individuals who could damage crops. 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. The adoption rate of AI in the agriculture industry has changed the overall outcomes of farming operations, with the majority of agricultural startups utilising AI-enabled approaches to increase agricultural production efficiency (Al-bayati and Ustunda, 2020).

1. **Plant diseases Prediction**

AI is able to recognise and remove weeds, identify and even predict plant diseases, and suggest effective pest management methods. AI aids in predicting the ideal agronomic product combinations, determining the optimal irrigation plans, and timing the application of fertilisers. Harvesting can be automated with AI, and it may even be possible to predict when it will be most effective. The use of predictive analytics might transform whole sectors. Farmers can analyse and collect more data using AI than they can without it. AI can help farmers with important problems including analysing market demand, forecasting prices, and deciding when to grow and harvest crops. Before shipping the fruit to market, producers can use this to sort it into stacks of differing stages of readiness. Using high-quality photos from technologies like drones and copters, field managers can make forecasts in real time. By drawing up feed and field maps and identifying the regions where crops need more or less water, fertiliser, or pesticides, predictions are made during cultivation. Farmers can gain useful knowledge from cognitive solutions regarding the soil's condition, weather predictions, seed varieties, and pest infestation in a particular location (Jiayu *et al*, 2015; Banthia and Chaudaki, 2022).

1. **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).

1. **Food supply chain Assistance**

Artificial intelligence (AI)-powered technology can help the agricultural industry produce better crops and enhance a variety of agricultural-related operations across the whole food supply chain. The system's need for food rose as a result of these new techniques, which also gave billions of people worldwide job possibilities A revolution in agriculture has been brought about through the usage of AI. It has shielded agricultural production from issues with employment, climate change, population increase, and food safety. Despite the possibility that AI might enhance crop management and agricultural productivity, experts caution that there are important risks that go overlooked when applying new AI technology. The development of AI applications is assisting in the design of new models employing appropriate scale management techniques and technology to assist managers of farms, forests, and ranches. Researchers are investigating the contributions and effects of AI in order to better understand agricultural market structure and performance, global trade, agricultural production and resource use, consumer behaviour, food safety, food waste and loss, farm labour and immigration and policy, agricultural policy design and impacts, technology development and adoption, and science and innovation policy (Salehin *et al*, 2020; Parasuraman *et al*, 2021).

1. **Cultivation and harvesting of crop**

Farmers use AI-created robots and drones to help in agricultural production and harvesting. Field efficiency is increased through targeted irrigation, weed control, and crop management. Predictive analysis assists in the early discovery of issues in the field. Early identification helps farmers and groups identify the problem and avoid substantial crop loss or damage. Artificial intelligence might be used to predict floods and droughts. This technology aids in the analysis of the field's weedicide and pesticide requirements. Artificial intelligence software assists in the identification of insect infestations and plant health concerns. It also helps to maintain soil fertility and decreases the usage of pesticides and herbicides in certain fields. AI also aids with the application of pesticides and weedicides in the field, as well as crop monitoring. Drone spraying of chemicals increases effectiveness while decreasing human labour and the workload on the workforce. Some of the most common uses of AI in agriculture are predictive analytics, robotics, unmanned aerial vehicles, and autonomous farm vehicles. Agricultural applications where AI has been effectively adopted include crop protection, weather forecasting, farm machinery automation, and animal growth monitoring (Sparrow *et al*, 2021; Bestelmeyer *et al* 2020).

1. **Food shortage**

The agriculture business is looking to artificial intelligence (AI) to overcome the dual dilemma of food scarcity and food waste caused by locust swarms, climate change, droughts, and floods. Farmers may use cognitive computing to select the best crops and seeds depending on characteristics such as soil condition, weather prediction, seed type, and infestation in a given location. The advice is further tailored depending on the needs of the farm, local conditions, and prior accomplishments. External aspects such as market developments, pricing, and customer wants can also be taken into consideration by AI. Smallholder farmers encounter hurdles owing to a lack of market knowledge. Farmers are often compelled to sell their produce to middlemen who profit from the information asymmetry. Agriculture, particularly in international commerce and data collecting, demands cybersecurity measures and experienced employees capable of putting such safeguards in place. Because of the increased data in agricultural operations, AI can now work with the data needed to inform improved decision-making practises across the board. This is made feasible by AI-specific processes such as machine learning. An ML system may adjust its operations without being explicitly coded by learning from fresh data sets (Garrett *et al*, 2022; Hyunjin and Sainan).

1. **Detection of soil defects**

AI systems may identify nutrient deficiencies and detect soil problems by analysing data from sensors buried in the soil, provided by drones for soil research, or collected from smartphone cameras. Farmers may use this information to determine how much organic matter to add to the soil to increase its workability and compatibility. AI and its subset of technologies enable the processing of massive volumes of structured and unstructured data. To produce more precise forecasts, temperature, soil, humidity, weather, crop performance, and other data sources are evaluated. A large quantity of data will be evaluated, ranging from farm machinery to drone footage, in order to track and anticipate the environmental effects on crop output, hence enhancing agricultural precision and productivity. In addition to ground data, AI applications may retrieve data from IoT devices deployed on drones and unmanned aircraft systems. Farmers may use machine learning to estimate crop yields by evaluating decades of weather and crop records for trends in the data. Monitoring water and air quality can also help forecast farming difficulties in certain areas. Understanding the magnitude of global calamities like wildfires, earthquakes, and hurricanes exposes us to the need to manage resources effectively (Sishodia *et al*, 2020; Widianto *et al*, 2022).

1. **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).

1. **Water management**

AI in agriculture has resulted in applications that give farmers with accurate advice on water management, crop rotation, timely harvesting, optimal planting, pest infestations, and other problems. We can examine agricultural sustainability, manage nutrition, and predict weather conditions using ML algorithms and images from satellites and drones. Precision farming makes use of precise data inputs to optimise agricultural production. Farmers using cellphones and AI software may obtain a customised agricultural plan. While human input will always be required for design, applying AI in lawn care can substantially cut physical work. Through automation, robotics and artificial intelligence are transforming the future of gardening. Growers and breeders can use ML to discover possible illnesses and pests in plant root systems. By weeding out sick plants, plants get healthier with each generation. Farmers, from climate change to the world's population, play an important part in feeding an ever-growing global population. Every day, they are confronted with the repercussions of climate change and must guarantee that food is produced in a sustainable manner.To make the optimal economic, environmental, and legal judgements, several requirements and factors must be addressed. This is where digital agriculture might assist (Zhang, 2020; Kumar *et al*, 2021; Kaur 2019).

1. **Agricultural yield and productivity**

AI approaches in agriculture have the potential to boost agricultural production and productivity. As a result, agribusinesses are applying artificial intelligence (AI) technology into agriculture through predictive analytics. Agriculture AI technology may help farmers with soil monitoring, insect management, growing better crops, managing supply lines, and assessing agricultural data. To safeguard crops, farmers eliminate undesired plants and pests at this stage. Pesticides and weed killers are employed. It has the potential to impair yield quality as well as yield quantity. It also has the potential to boost production costs. Farmers may use machine learning to assess enormous volumes of field data in order to better understand crop performance over time and the emergence of new traits. The data extracted makes it simpler to create a probability model that predicts which genes are likely to provide a favourable characteristic to a plant. The usual way for identifying plants is to compare leaf colour and form. ML, on the other hand, presents a more accurate and faster classification approach by assessing leaf vein morphology, which contains more information about the leaf attributes and, in certain cases, aerial images (Sujawat, 2021; de Abreu and Van Deventer, 2021).

1. **Funds determination at the farm level**

The function of technology extends beyond identifying places that may benefit from the credit to analysing how successfully the funds are utilised at the farm level. Traditionally, this involved assigning field agents to personally inspect each region's operation. However, this was a time-consuming, unscientific, and wrong collection of data Smart technology may help financial institutions keep track on plots under cultivation in real time, which benefits them and helps farmers retain a stranglehold on the health of their crops throughout the cultivation cycle. From the farm to the fork, AI is becoming a strong source of functional automation and efficiency-enhancing practises. As global trade grows and gets more complex, these solutions are more important than ever. AI-powered software applications are all over the place these days. While each agricultural organisation has different needs, selecting a software as a service platform can allow you to access the potential of AI through a secure, multi-tenant architecture. IoT and AI are becoming more democratised as they extend across sectors, which means that any expert may now utilise these technologies for better data-driven solutions (Pallathadka *et al*, 2022; Khalifeh *et al*, 2018).

1. **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. AI, a complicated technology with several subsets and types, may provide agriculture algorithms and programmes of varying complexity (Raman *et al*, 2021; Dora *et al*, 2021).

1. **Drive predictive analytics**

Agricultural sowing uses AI largely because it provides predictive analytics to choose when and how to plant. Based on climate data, historical circumstances, market conditions for inputs and outputs, individual information, etc., it assists in forecasting the best time to plant, apply fertiliser, harvest, bale, till, and engage in other agricultural operations. Crops may also be sown at optimum depths and uniformly spaced intervals using AI-assisted technologies. Using AI, IoT, connected services, and autonomous systems, farmers may make choices at the square metre or individual plant or animal level rather than at the level of entire fields or all animals. This accuracy makes it possible for knowledgeable solutions that boost agricultural sustainability by assisting farmers in producing more food with less resources. A software module that has been taught to recognise the precise crop that will be grown in that field is another crucial component of precision farming. Modern agricultural technology has an impact on a variety of agricultural tasks, including seed planting, irrigation, and fertiliser use. New developments in agricultural engineering contribute to higher crop yield and improved pest resistance. Modern farming technology has also lowered manpower requirements and made tilling, planting, harvesting, and other farming activities ideal (Chukkapalli *et al*, 2020; Costa *et al*, 2021).

1. **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).

1. **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)

1. **Agricultural efficiency improvement**

Many agricultural and aggrotech businesses are trying to increase agricultural efficiency by creating devices that employ sensor fusion and AI models to identify the best harvestable crops. Rapid developments in video analytics, enabled by AI and ML algorithms, help in the security of distant sites like farms and crops. Plant health might be tracked using infrared camera data from drones and ground sensors. AI has undoubtedly enchanted all industry areas, including agriculture. It is opening up new opportunities for farmers and others in the agricultural industry to grow and flourish. Farmers who once looked for tractor components may soon be seeking for AI robots to assist them with farm chores. Agriculture is intrinsically related to our lives because it produces food. AI evaluates enormous quantities of data to provide weather forecasts, and farmers may use the AI results to make crop, harvest, and sales choices. Humans are incapable of working with enormous volumes of data and producing exact insights like AI (Ghosh and Singh, 2020; Hyunjin 2020; Vincent *et al*, 2019)

1. **AI and its Limitations**

A fundamental impediment to mainstream AI adoption in agriculture is the absence of easy solutions that seamlessly include and embed AI. The majority of farmers do not have the time or digital skills to research AI options on their own. These new AI solutions will need to be incorporated into current and legacy infrastructure and systems that farmers already utilise in order to smoothly accept and incorporate AI inside agriculture. Agriculture cannot rely entirely on AI since it cannot function outside of its programming. Farmers, particularly those in rural regions, lack technical understanding and are ignorant of such technology' existence. Agriculture may become semi-autonomous as awareness grows and technology become more available to the common farmer, with AI leading the way. To train robots and produce accurate predictions, AI systems require a tremendous amount of data. In the case of largely agricultural land, spatial data is easily available, but temporal data is difficult to collect. Most crop-specific data can only be gathered once each year when crops are being grown. Building a strong ML model takes time because data infrastructure takes time to mature.

1. **Conclusions**

In order to forecast weather, analyse crop sustainability, and assess farms for the presence of diseases or pests and inadequate plant nutrition, AI-enabled technologies combine data from satellites and drones with ML algorithms and images taken by satellites and wind speed. Farmers who have Wi-Fi access may utilise AI applications to get a personalised farm plan. Farmers can meet the world's requirement for increased food supply and profitability by utilising AI-driven solutions that increase productivity and revenue without diminishing priceless natural resources. Using AI, farmers may detect fields that require irrigation, fertilisation, or pesticide application in real-time. Vertical agriculture is one example of an innovative agricultural technique that may boost the production of food while using less resources. Herbicide use decreases, harvest quality improves, earnings rise, and considerable cost savings are generated as a consequence. AI tools gather data on the irrigation systems that are required for the crops as well as high-resolution aerial pictures. AI helps with the identification of soil problems like leaks and clogs. The bad state of the soil is evaluated and rated; AI assists in increasing farm yield. Yield management, AI-enabled production, and automated and autonomous farming activities all increase the net output from the field. Production, packaging, and sorting of food are improved by AI-assisted picking, packing, and sorting. The ability to better understand agricultural data insights relating to temperature, precipitation, wind speed, and sun radiation benefits farmers. AI technologies might help farmers deal with issues like climate change and plant and insect infestations that reduce crops yield. AI will be used in agriculture to enhance the overall farming operation.

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