

# Artificial Intelligence in Modern Agriculture: A Comprehensive Analysis

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## ABSTRACT

Crop yield forecasting is becoming more essential in the present environment, when food security must be maintained despite climate, population, and climate change concerns. Machine learning and Deep learning is a useful decision-making tools for predicting agricultural yields, as well as for deciding what crops to plant and what to do throughout the crop's growth season. To aid agricultural production prediction studies, number of artificial intelligence methods have been used. Agriculture plays a significant role in the economic sector. The automation in agriculture is the main concern and the emerging subject across the world. The population is increasing tremendously and with this increase the demand of food and employment is also increasing. The traditional methods which were used by the farmers were not sufficient and enough to fulfill these requirements. Thus, new automated methods were introduced. These new methods satisfied the food requirements and also provided employment opportunities to billions of people. In this paper, an overview of various techniques and tools based on AI is discussed.

## Keywords

Agriculture, AI

## 1. INTRODUCTION

India, being an agriculture-based country, is the largest producer of foods in the form of wheat, rice, maize, fruits, and vegetables. Many countries around the globe use smart devices and computer vision-based equipment for agriculture production [1]. The world's population is assumed to be nearly 10 billion by 2050, boosting agricultural order-in a situation of humble financial development by somewhere in the range of 50% contrasted with 2013 (FAO, 2017). At present, about 37.7% of total land surface is used for crop production. From employment generation to contribution to National Income, agriculture is important [2]. It is contributing a significant portion in the economic prosperity of the developed nations and is playing an active part in the economy of the developing countries as well. The augmentation of agriculture has resulted in a significant increase in the per-capita income of the rural community. Thus, placing a greater emphasis on agricultural sector will be rational and apposite. For countries, like India, the agricultural sector accounts for 18% of GDP and provides employment to 50% of the country's workforce. Development in the agricultural sector will boost the rural development, further leading toward rural transformation and eventually resulting in the structural transformation (Mogili and Deepak, 2018; Shah et al., 2019).

An economy's ability to sustain itself depends on the primary sector i.e. agriculture. Development of this sector is crucial for the long-term economic growth and structural transformation of the country. Historically, agriculture was only used to

produce food and plants (M.Fan, 2012). However, over the last 20 years, its horizon has expanded to include the production, distribution, marketing, and processing of agricultural goods and livestock. At present agriculture is the main driver of Gross Domestic Product development and livelihood- a source of national trade, a source of employment, source of supplying of manufacturing resources to other industries and thereby improving the global economy (T.O.Awuse et al., 2009). In the modern world, agriculture and technology go hand in hand. Due to technological advancements, in the areas of sensors-metals, machines, and development, exercise and land cultivation are carried out more dramatically than they were a few decades ago. In a country like India, nearly 60 percent of the people are engaged in agriculture and allied activities. Use of modern agricultural technology which includes robotics, sensors for temperature and moisture, aerial photography, and GPS advancements can improve our agricultural sector productivity levels and also our Gross Domestic Product to a great extent. With the help of these push-up devices and the precision of agricultural and equipment systems, organizations can gain an advantage over their neighbours and grow stronger. Numerous new data opportunities have taken place in the past as a result of the growth of e-commerce investments. Information can be gathered around the arena by satellites, unmanned aerial vehicles (UAVs), and remote sensors (J. Gupta 2019). These can evaluate crop fertility, soil quality, durability, temperature, and other factors. There is uncontrolled data that contains numerical critique, and some of the data that these sensors are capable of collecting is beyond their power. With the creation of the front line, which can expose farmers to more of their status than they can see with their own eyes, the objective is to enable farmers to develop an unmatched knowledge of the conditions on the ground. Given that farmers are embracing these new methods and will do so in the future, we can look into some of the advantages linked to the precision of agribusiness startup. Utilizing these new, enhanced techniques mostly involves two ideas: reducing risks and making efficient use of inputs like fuel, water, compost, raw materials, etc. (Kumar, 2019). The field of Artificial intelligence (AI) is expanding quickly and finding its way into the business, government, and commercial spheres. Universities that serve as resource centres may be the source of AI. (Tan and Galaski 2020; Lentner, 2007). Today's agriculture faces many new problems. In order to feed 9–10 billion people by 2050, the rate of global food production needs to rise by 60–110 percent (Rockstrom, J., and others, 2016). Thus, feeding the world's expanding population and reducing poverty depends on the agriculture sector's sustainability. Furthermore, as a result of multiple food safety scandals and accidents in the food business, such dioxin in chickens and bovine spongiform encephalopathy, a well-documented tracking system has become essential for quality control in the food chain. Significant issues in the upcoming years will also include water

scarcity and climate change, as well as sustainable water management. These factors make it imperative that a plan be developed to shift agricultural product development from its current paradigm to one that prioritizes agricultural sustainability. Anticipating practical solutions and assisting farmers and other stakeholders in making better decisions through the adoption of sustainable agriculture practices are crucial choices, particularly when it comes to the application of digital technologies like cloud computing, artificial intelligence (AI), and the Internet of Things (IoT). Furthermore, a lot of people apply AI subsets (machine and in-depth learning algorithms) combined with local intelligence technology.

In this paper we attempt to present the agricultural food industry's most important application technologies and automated learning approaches (R. Ben et al., 2013).

## **2. IMPACT OF AI ON AGRICULTURE**

Artificial Intelligence in agriculture has brought an agriculture revolution. This technology has protected the crop yield from various factors like the climate changes, population growth, employment issues and the food security problems. This main concern of this paper is to audit the various applications of Artificial intelligence in agriculture such as for irrigation, weeding, spraying with the help of sensors and other means embedded in robots and drones. These technologies save the excess use of water, pesticides, herbicides, maintains the fertility of the soil, also helps in the efficient use of man power and elevate the productivity and improve the quality. This paper surveys the work of many researchers to get a brief overview about the current implementation of automation in agriculture, the weeding systems through the robots and drones.

The technologies which are AI-based help to improve efficiency in all the fields and also manage the challenges faced by various industries including the various fields in the agricultural sector like the crop yield, irrigation, soil content sensing, crop- monitoring, weeding, crop establishment (Kim et al., 2008). Agricultural robots are built in order to deliver high valued application of AI in the mentioned sector. With the global population soaring, the agricultural sector is facing a crisis, but AI has the potential to deliver much-needed solution. AI- based technological solutions has enabled the farmers to produce more output with less input and even improved the quality of output, also ensuring faster go-to- market for the yielded crops. By 2020, farmers will be using 75 million connected devices. By 2050, the average farm is expected to generate an average of 4.1 million data points every day. The various ways in which AI has contributed in the agricultural sector are as follows [3]:

### **2.1. Image recognition and perception**

Lee et al. (2017) said that in recent years, an increasing interest has been seen in autonomous UAVs and their applications including recognition and surveillance, human body detection and geo-localization, search and rescue, forest fire detection (Bhaskaranand and Gibson, 2011; Doherty and Rudol, 2007; Tomic et al., 2012; Merino et al., 2006). Because of their versatility as well as amazing imaging technology which covers from delivery to photography, the ability to be piloted with a remote controller and the devices being dexterous in air which enables us to do a lot with these devices, drones or UAVs are becoming increasingly popular to reach great heights and distances and carrying out several applications.

### **2.2. Skills and workforce**

Panpatte (2018) said that artificial intelligence makes it possible for farmers to assemble large amount of data from government as well as public websites, analyze all of it and provide farmers with solutions to many ambiguous issues as

well as it provides us with a smarter way of irrigation which results in higher yield to the farmers. Due to artificial intelligence, farming will be found to be a mix of technological as well as biological skills in the near future which will not only serve as a better outcome in the matter of quality for all the farmers but also minimize their losses and workloads. UN states that, by 2050, 2/3rd of world's population will be living in urban areas which arises a need to lessen the burden on the farmers. AI in agriculture can be applied which would automate several processes, reduce risks and provide farmers with a comparatively easy and efficient farming.

### **2.3. Maximize the output**

Ferguson et al. (1991) said in his work that Variety selection and seed quality set the maximum performance level for all plants. The emerging technologies have helped the best selection of the crops and even have improved the selection of hybrid seed choices which are best suited for farmer's needs. It has implemented by understanding how the seeds react to various weather conditions, different soil types. By collecting this information, the chances of plant diseases are reduced. Now we are able to meet the market trends, yearly outcomes, consumer needs, thus farmers are efficiently able to maximize the return on crops.

### **2.4. Chatbots for farmers**

Chatbots are nothing but the conversational virtual assistants who automate interactions with end users. Artificial intelligence powered chatbots, along with machine learning techniques has enabled us to understand natural language and interact with users in away more personalized way. They are mainly equipped for retail, travel, media, and agriculture has used this facility by assisting the farmers to receive answers to their unanswered questions, for giving advice to them and providing various recommendations also.

## **3. DEEP LEARNING IN AGRICULTURE**

Deep learning, a subset of machine learning based on artificial neural networks with multiple layers, is increasingly being applied in various areas of agriculture. Here are several ways in which deep learning is making an impact.

**Crop Disease Detection:** Deep learning models can analyze images of crops captured by drones or smartphones to identify signs of disease, nutrient deficiencies, or pest infestations. These models can learn to distinguish between healthy and diseased plants with high accuracy, enabling early detection and intervention to prevent yield loss.

**Weed Detection and Management:** Deep learning algorithms can be trained to recognize different weed species in agricultural fields based on visual data. By analyzing images or video footage, these models can help farmers target weeds more effectively, reducing the need for chemical herbicides and minimizing environmental impact.

**Crop Yield Prediction:** Deep learning models can analyze various data inputs such as weather patterns, soil conditions, and historical yield data to predict crop yields. These models learn complex patterns and relationships within the data, providing farmers with valuable insights for crop planning, resource allocation, and decision-making.

**Precision Irrigation and Fertilization:** Deep learning algorithms can analyze soil moisture levels, nutrient concentrations, and other relevant factors to optimize irrigation and fertilization practices. By predicting crop water and nutrient needs more accurately, these models help farmers conserve resources, improve crop health, and enhance yields.

**Pest Management:** Deep learning models can assist in pest monitoring and management by analyzing data from traps, sensors, or remote monitoring systems. These models can detect patterns indicative of pest presence or activity, enabling timely intervention strategies such as targeted spraying or biological control methods.

**Plant Breeding and Genetics:** Deep learning techniques can accelerate plant breeding programs by analyzing genomic data to identify genetic markers associated with desirable traits such as yield, disease resistance, and stress tolerance. By predicting trait outcomes more accurately, these models help breeders develop new crop varieties with improved characteristics.

**Food Quality and Safety Inspection:** Deep learning algorithms can automate the inspection of agricultural products for quality and safety purposes. For example, computer vision models can analyze images of fruits, vegetables, or grains to detect defects, contaminants, or foreign objects, ensuring that only high-quality products reach the market.

**Climate Resilience and Adaptation:** Deep learning models can analyze climate data to predict future weather patterns and assess their potential impact on agricultural productivity. By providing early warnings of extreme weather events or changing climate conditions, these models help farmers adapt their practices and mitigate risks associated with climate change.

**Robotic Farming:** Deep learning algorithms are used to train autonomous robots and drones for various tasks in agriculture, such as planting, harvesting, and monitoring. These models enable robots to navigate complex environments, identify targets of interest, and perform tasks with precision and efficiency, reducing labor costs and increasing productivity.

**Market Analysis and Price Prediction:** Deep learning models can analyze market data, supply chain dynamics, and consumer preferences to forecast market trends and commodity prices. These models help farmers make informed decisions about crop selection, pricing strategies, and market timing, maximizing profitability and competitiveness in the agricultural industry. Overall, deep learning is a powerful tool for advancing agriculture by providing farmers, researchers, and policymakers with valuable insights, predictive capabilities, and automation solutions to address the challenges of food security, sustainability, and climate resilience.

## 4. MACHINE LEARNING IN AGRICULTURE

Machine learning (ML) is playing an increasingly important role in agriculture, offering a wide range of applications that help farmers optimize their practices, improve productivity, and enhance sustainability. Here are several ways in which machine learning is being utilized in agriculture:

**Crop Yield Prediction:** Machine learning models can analyze historical data on crop yields, weather patterns, soil characteristics, and management practices to predict future yields. These predictions help farmers make informed decisions about planting schedules, resource allocation, and harvest planning.

**Crop Disease Detection:** Machine learning algorithms can analyze images of crops taken with drones or cameras to identify signs of disease, nutrient deficiencies, or pest infestations. By detecting these issues early, farmers can take timely action to mitigate risks and prevent yield loss.

**Weed Management:** Machine learning models can distinguish between crops and weeds based on visual data, enabling precision spraying or mechanical weeding techniques. By targeting weeds more effectively, farmers can reduce the use of herbicides and minimize environmental impact.

**Precision Irrigation and Fertilization:** Machine learning

algorithms can analyze sensor data on soil moisture levels, nutrient concentrations, and weather forecasts to optimize irrigation and fertilization practices. By tailoring inputs to specific crop needs, farmers can conserve water and nutrients while maximizing yields.

**Pest Monitoring and Management:** Machine learning algorithms can analyze data from traps, sensors, or remote monitoring systems to detect patterns indicative of pest presence or activity. By providing early warnings and decision support, these models help farmers implement timely pest control measures.

**Livestock Monitoring and Management:** Machine learning models can analyze data from sensors, wearables, or imaging systems to monitor animal health, behavior, and performance. By detecting deviations from normal patterns, farmers can identify sick or distressed animals and provide timely care.

**Supply Chain Optimization:** Machine learning algorithms can analyze data on market demand, transportation logistics, and inventory management to optimize supply chain operations. By forecasting demand and optimizing distribution, farmers can reduce waste, improve efficiency, and enhance profitability.

**Climate Resilience and Adaptation:** Machine learning models can analyze climate data to predict future weather patterns and assess their impact on agricultural productivity. By providing early warnings of extreme weather events or changing climate conditions, these models help farmers adapt their practices and mitigate risks.

**Soil Health Monitoring:** Machine learning algorithms can analyze sensor data on soil properties, such as pH, organic matter content, and nutrient levels, to assess soil health and fertility. By identifying areas of soil degradation or nutrient deficiencies, farmers can implement targeted soil management practices to improve productivity and sustainability.

**Decision Support Systems:** Machine learning models can integrate data from multiple sources, such as satellite imagery, weather forecasts, and crop sensors, to provide farmers with actionable insights and recommendations. These decision support systems help farmers make informed decisions about crop management, resource allocation, and risk mitigation.

Overall, machine learning is revolutionizing agriculture by providing farmers with advanced tools and technologies to optimize their operations, increase productivity, and address the challenges of feeding a growing global population while promoting sustainability and environmental stewardship.

## 5. Drones in Agriculture

Drones, also known as unmanned aerial vehicles (UAVs), play a significant role in modern agriculture by providing farmers with valuable data and insights to optimize crop management practices. Here are some key roles drones fulfill in agriculture:

**Aerial Imaging:** Drones equipped with high-resolution cameras capture aerial images of farmland. These images can be used to create detailed maps of the fields, allowing farmers to monitor crop health, identify areas of stress or disease, and assess the effectiveness of irrigation and fertilization practices.

**Crop Monitoring:** Drones can perform regular flights over agricultural fields to monitor crop growth and development. By capturing multispectral or thermal images, drones can detect subtle changes in plant health, nutrient levels, and water stress, enabling early intervention to address issues and optimize yields.

**Pest and Disease Detection:** Drones equipped with specialized sensors and imaging technology can identify signs of pest infestations or disease outbreaks in crops. By detecting these issues early, farmers can take targeted actions such as precision spraying or localized treatments to minimize damage and prevent the spread of pests or diseases.

**Precision Spraying:** Drones can be outfitted with spraying systems to apply pesticides, herbicides, or fertilizers with precision. By precisely targeting areas of need based on aerial imaging data, drones reduce chemical usage, minimize environmental impact, and optimize resource efficiency.

**Crop Scouting:** Drones provide farmers with a quick and efficient way to scout large areas of farmland. By conducting aerial surveys, farmers can identify crop health issues, assess field conditions, and make informed decisions about crop management strategies without the need for extensive manual labor.

**Irrigation Management:** Drones can monitor soil moisture levels across fields using sensors or thermal imaging. By analyzing this data, farmers can optimize irrigation schedules and water usage, ensuring that crops receive the right amount of water at the right time to maximize yields and conserve resources.

**Yield Estimation:** Drones equipped with advanced imaging technology, such as LiDAR or hyperspectral sensors, can generate accurate 3D maps of fields and estimate crop yields. This information helps farmers plan harvest logistics, optimize storage capacity, and make marketing decisions based on expected yields.

**Infrastructure Inspection:** Drones can inspect agricultural infrastructure such as irrigation systems, fences, and drainage ditches. By conducting regular aerial inspections, farmers can identify maintenance needs and potential issues before they escalate, ensuring the efficient operation of farm infrastructure.

**Livestock Monitoring:** Drones can be used to monitor livestock by capturing aerial footage of grazing areas or animal herds. This information can help farmers assess herd health, locate missing animals, and identify potential security threats or predator activity.

**Environmental Monitoring:** Drones contribute to environmental monitoring efforts in agriculture by assessing soil erosion, tracking land use changes, and monitoring water quality in rivers or lakes. This data helps farmers implement sustainable land management practices and comply with environmental regulations.

Overall, drones are valuable tools in modern agriculture, providing farmers with real-time data, actionable insights, and cost-effective solutions to improve crop productivity, optimize resource management, and promote sustainability in food production.

## 6. ROBOTICS IN AGRICULTURE

Robotics in agriculture refers to the integration of robotic systems and automation technologies into various aspects of farming and related activities. Here are several key areas where robotics is playing a significant role in agriculture:

**Autonomous Tractors and Vehicles:** Autonomous tractors and vehicles equipped with GPS, sensors, and advanced navigation systems can perform tasks such as plowing, seeding, spraying, and harvesting with minimal human intervention. These machines increase efficiency, reduce labor costs, and optimize field operations.

**Precision Planting and Seeding:** Robotic planters and seeders can precisely place seeds at optimal depths and spacing, ensuring uniform germination and crop establishment. By optimizing planting practices, farmers can achieve higher yields and reduce input costs.

**Weeding and Crop Maintenance:** Robotic weeders equipped with computer vision systems can identify and remove weeds in agricultural fields with high accuracy. These robots minimize the need for chemical herbicides, reduce weed competition with crops, and improve overall crop health.

**Harvesting Robots:** Harvesting robots equipped with

specialized grippers, sensors, and vision systems can automate the picking and harvesting of fruits, vegetables, and other crops. These robots increase efficiency, reduce labor dependency, and address seasonal labor shortages.

**Crop Monitoring and Management:** Drones equipped with cameras, sensors, and imaging systems can perform aerial surveys of agricultural fields to monitor crop health, detect pests and diseases, and assess field conditions. These drones provide farmers with real-time data and insights to optimize crop management practices.

**Livestock Management:** Robotics is used in livestock farming for tasks such as feeding, milking, cleaning, and monitoring animal health. Automated systems such as robotic milkers and feeding stations improve efficiency, reduce labor costs, and enhance animal welfare.

**Post-Harvest Handling and Processing:** Robotics is employed in post-harvest handling and processing facilities to sort, grade, pack, and process agricultural products. Robotic systems can handle delicate produce with care, improve consistency, and reduce labor requirements in packing and processing operations.

**Greenhouse Automation:** Robotics and automation technologies are used in greenhouse operations to control environmental factors such as temperature, humidity, light intensity, and irrigation. Automated systems optimize growing conditions, reduce resource consumption, and increase productivity in greenhouse farming.

**Data-Driven Decision Making:** Robotics and automation technologies generate vast amounts of data on farm operations, crop performance, and environmental conditions. This data is used to inform decision-making processes, optimize resource allocation, and improve overall farm management practices.

**Research and Innovation:** Robotics and automation technologies drive innovation in agriculture by enabling research in areas such as robotics, artificial intelligence, sensor technology, and machine learning. These advancements lead to the development of more sophisticated and capable robotic systems for agricultural applications.

Overall, robotics is transforming agriculture by increasing efficiency, productivity, and sustainability throughout the entire food production process, from planting and cultivation to harvesting and post-harvest handling. As technology continues to advance, the role of robotics in agriculture is expected to expand further, driving greater innovation and efficiency in food production.

## 7. DISCUSSION

Crop management systems usually offer a connection to an all-inclusive crop management that addresses every aspect of farming. Mc Kinion and Lemmon first introduced the idea of applying AI to plant management in their 1985 work "Agricultural Specialist Programs." (J.M. McKinion et al, 1985). To comprehend the range of AI-enabled solutions inside ARS, this Special Phase underscores the application of AI approaches in numerous agricultural research domains. Management of Agricultural Production: The supply chain for agricultural production is extremely intricate.

### **Management of Agricultural Production:**

Production in agriculture involves a very intricate supply chain. AI modifies the production, distribution and consumption of our food. Throughout the food supply chain, researchers use potent AI technology to provide information and advice on a variety of agricultural-related topics, including crop rotation planning, planting seasons, water and nutrient management, pest and disease control, good harvesting, food marketing,

product distribution, and food security. (Peter and others, 2021).

The book *Using AI to Transform Agriculture and to Promote Agricultural Research* "offers a summary of the opportunities, challenges, and current developments for AI technology in Agriculture". To illustrate the capabilities of AI, four main facets of the food system have been employed—production, distribution, usage, and uncertainty. They come to the conclusion that the application of AI and other technologies depends on agribusinesses.

**Plant Observation-** The most popular techniques for keeping an eye on plant health are time-consuming and labor-intensive. AI is a useful tool for tracking and spotting possible issues with plant health or soil nutrient deficits. Applications are created to examine crop health patterns in agriculture with the use of thorough research. These AI-enabled applications are helpful for improving knowledge of plant diseases, pests, soil health, and pests (Sudduth et al. 2021).

**Information Science-**

Every day, farms generate a lot of data points. Farmers can now better inform their decisions by using AI to assess a variety of drivers in real time, such as weather, temperature, water use, and soil conditions collected on their farm. With the use of AI technology, farmers may use the data at their disposal to grow healthy plants with less natural resource consumption. (Ramos-Giraldo et al., 2020). The "AI Recommendation Program with ML for Agricultural Research" program increased the usage of data pertaining to agricultural issues, enhancing the productivity of scientific staff, and increasing the precision of food production projections by utilizing the AI recommender (RS) program with ML.

Researchers came to the conclusion that RS offers a potent method for utilizing vast volumes of data and specialized scientific knowledge in the agricultural industry to forecast the growth of agroecosystems under shifting environmental circumstances.

### **Diagnosis of Disease-**

Plant diseases pose a serious risk to the economy, the environment, and the availability of food. For plant diseases to be effectively controlled, early detection is crucial. AI-based picture identification systems have a high degree of accuracy when identifying specific plant diseases, which could pave the way for field-based diagnostics utilizing smartphones and other mobile devices (Peter et al 2021). "Enhancing agricultural research with artificial intelligence" created AI-based tools that assist land managers and farmers in making environmental decisions by utilizing big data and location-based science. These technologies direct the choice of sustainable crop management techniques and offer early warning of pest and disease outbreaks.

**Food Grade-**

The fields of food safety and quality assurance greatly benefit from the application of AI and machine vision. Artificial Intelligence (AI) enables computers to examine data from both input and output and carry out a variety of manual operations more precisely and effectively (O Baiden et al 2008). The use of ML, or "Mechanical Learning in meet quality tests," will speed up and improve the precision of carcass quality tests. They put eight machine learning algorithms to the test and discovered an astounding 81.5 percent to 99 percent accuracy rate in identifying carcass quality parameters.

### **Predictive Analytics-**

Determining how much of the crop will be gathered in a certain

situation can also be useful. Technological developments in AI-based data analysis assist farmers in conserving natural resources like soil, water, and air while lowering the quantity of inputs required for productive harvesting (Penning et al). Advanced tools using a remote sensor integrated with neural and machine learning networks are described in "Remote sensor: Improving agricultural science and agrarian applications." These tools identify dynamic areas within the fields and determine adaptive strategies to maximize the benefits of each field while minimizing environmental impact by using pesticides and nutrients efficiently. AI promises a profound shift in sophisticated methods that will reinterpret conventional agricultural patterns and constraints. AI will spearhead the revolution of agriculture at a time when global food production must increase while utilizing fewer resources. AI technology has been employed by ARS scientists in several labs to enhance agricultural research and expedite scientific discoveries.

Unfortunately, there was not enough room for all the AI-based agricultural research initiatives in ARS. Technologies that aid in the creation of intelligent agricultural forums, include IoT; Big Data Analytics (BDA); Cloud Computing (CC); Mobile Computing (MC); and Artificial Intelligence (AI). The Internet of Things (IoT) is a technology that links every intelligent thing to one main network—the internet. comprises all computer technology, including smart boards, sensors, and advanced operating systems as well as software and artificial intelligence algorithms.

Its primary goal is to create device applications that allow for domain-specific monitoring and control. In addition to being extensively utilized in agriculture for managing agricultural goods within real-time data collection,

### **Mobile Computing (MC)-**

The infrastructure that houses data processing and storage outside a cell phone is referred to as MC. When MC systems gather and provide farmers with daily data, they can tell them about weather patterns and production circumstances.

Utilizing Radio Frequency Identification (RFID) automatic tracking systems is crucial for quickly and accurately storing and retrieving data from electronic data chips. It is mostly employed in the identification and assessment of delivery procedures related to industrial items (K. Ghai et al., 2016).

### **Monitoring Crop and Soil-**

In order to process data from plant sensors and soil health—that is, the PEAT pest and soil problems—this employs computer-assisted and deep learning algorithms. These algorithms are based on an extensive analysis known as Plantix diagnostics. deficits in soil nutrients. Trace Genomics, a machine learning business that diagnoses soil degradation and offers farmers soil analysis services, is another example. This helps farmers understand the advantages and disadvantages of their land through mechanical learning, with a focus on preventing bad crops and enhancing the capacity to grow good crops. One example of utilizing drones and a computer-assisted crop analysis approach is Sky Squirrel technology (S.S Kale et al., 2019).

### **Guessing Statistics**

Based on machine learning models that can monitor and forecast a range of environmental factors, such as climate, that affect agricultural yields, this approach gathers data.

AI technology examples include:

(a)Crop stability and weather forecasting

(b) farm photos (i.e., sustainability and plant health monitoring).

Technologies for monitoring plants and soil are crucial initiatives to tackle climate change-related issues (K. sennar et al., 2019).

- 1) The proposed IOT/AI SSA forum as a solution
- 2) the smart sustainable agriculture model domains
- 3) The proposed IoT/AI architecture of the SSA platform comprise the three key components of the research methodology.

## **Smart Sustainable agricultural model domains**

**Human resources:** These are the people, rules, and practices that make up the agricultural industry. They are just as significant as any other industry, including technology and climate. Because human resources have a big influence on financial, marketing, and productivity decisions, they are getting more attention. Agricultural issues, in any event, necessitate careful planning and management of human resources, including the employment and retention of active, productive, and efficient employees. Providing the most recent information makes it possible for the agriculture industry to adopt intelligent technology (K. Lakwani et al., 2019).

### **Crops**

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### **Climate**

This is a major factor in deciding how well agricultural processes work. For water and life, a lot of field crops and livestock are completely dependent on the weather for sustaining life. Unfavorable weather conditions have the potential to reduce agricultural output, particularly in crucial growth stages.

Natural science and the development of agricultural plants and animals are influenced by climate elements, which include sunlight, temperature, rain, humidity, and wind. Storms, droughts, floods, hail, and hurricanes are examples of bad weather that can inflict significant harm to crops and cattle.

### **Soil**

This produces a crucial component of productive farming: a supply of nutrients for crop growth that are subsequently transmitted to plants and passed on to both people and animals. Rich and healthful food is produced by good soil, but as soil health deteriorates over time, farmers are forced to move to other fields. The health of the soil is dependent on regional and climatic factors. In dry climates, soil nutrients are particularly vulnerable to degradation if they are irrigated. This can result in salinity, or the production of salts and compounds that contain water, if the nutrients are not effectively handled.

IoT sensors can be used to monitor the chemical status of rich and healthy soils. By using particular sensors (such as moisture sensors), data readings from these sensors are sent to the data control and analysis layer for analysis, which helps with decisions on the amount of fertilizer needed (H Cadavid et al., 2018).

## **Insects**

These comprise any living thing that damages or intrudes onto human, animal, or plant structures. Pests harm agricultural products because they are frequently present in huge numbers. In order to prevent major diseases like sickness and malaria, as well as illnesses that affect plants and animals, it is crucial to use IoT and AI technologies to regulate and monitor these species.

## **8. CONCLUSION**

Artificial Intelligence (AI) is rapidly transforming the agricultural sector by enabling data-driven, precise, and sustainable farming practices. This comprehensive survey highlights how AI technologies—such as machine learning, computer vision, robotics, and IoT integration—are reshaping traditional agriculture into a more efficient and intelligent system. From crop monitoring and disease detection to yield prediction and smart irrigation, AI-driven solutions have demonstrated significant potential to enhance productivity, optimize resource utilization, and reduce environmental impact. The study also emphasizes that AI can play a critical role in addressing global challenges such as food security, climate change, and labour shortages. By leveraging real-time data and predictive analytics, farmers can make informed decisions that improve crop quality and resilience while minimizing costs. Furthermore, AI supports the transition toward precision agriculture, which is essential for sustainable development in both developed and developing economies. However, despite its promising advantages, the widespread adoption of AI in agriculture faces several challenges, including high implementation costs, limited digital literacy among farmers, data privacy concerns, and inadequate infrastructure in rural areas. Bridging these gaps requires collaborative efforts from governments, researchers, industry stakeholders, and policymakers to develop accessible, affordable, and scalable AI solutions.

In conclusion, AI holds immense potential to revolutionize agriculture and ensure long-term sustainability. Future research should focus on developing robust, inclusive, and region-specific AI models, improving interoperability among technologies, and promoting capacity building among farmers. By addressing existing limitations and fostering innovation, AI can become a cornerstone of smart agriculture, contributing significantly to global food security and environmental sustainability.

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