

A New Era in Agricultural Artificial Intelligence Research

Hassen Beshir¹, Berihun Mekon²

Department of Rural Development and Agricultural Extension, Debre Markos University, Debre Markos, Ethiopia

Article Info

Received: 29-12-2025 Revised: 15-01-2026 Accepted: 18-02-2026 Published: 21-03-2026

Abstract: The Food and Agriculture Organization (FAO) of the United Nations projects that by 2050, there will be an extra 2 billion people on the planet. But the FAO also projects that just 4% of Earth's surface will be used for farming. Agricultural efficiency has significantly increased thanks to technological breakthroughs and creative solutions to the sector's current problems. The widespread use of artificial intelligence (AI) and machine learning in the agriculture sector may represent a pivotal moment in its historical development. AI in agriculture offers farmers a number of advantages, such as increased output, lower costs, better crop quality, and quicker go-to-market tactics. The purpose of this project is to investigate how AI may be used in different agricultural industry subsectors. This research explores cutting-edge ideas driven by AI while simultaneously addressing potential obstacles to their use.

Keywords: Agriculture, Disease Detection, Crop Readiness, Field Management, Artificial Intelligence, Machine Learning, and Cognitive Internet of Things.

I. INTRODUCTION

Machines were used to replace or reduce the need for human labour throughout the 19th century, particularly during the industrial revolution. The development of information technology in the 20th century, especially with the introduction of computers, gave rise to the idea of AI-enabled machines [1]. It is an indisputable fact of modern civilisation that artificial intelligence (AI) will gradually replace human labour. The agriculture industry heavily relies on artificial intelligence, also known as deep learning or machine learning (ML), which often interacts with human counterparts. Artificial intelligence is already being used in a variety of applications, from personal assistants like Siri and Alexa to self-driving and parking autonomous cars to customised music suggestions, real estate ads, and job postings. The realms of learning, thinking, and perception are all included in the goals of artificial intelligence. The computer programs in this discipline are capable of producing code on their own and improving their performance by using large amounts of input data, or "Big Data." The agriculture sector is one of the oldest and most significant occupations in the world, with a \$5 trillion global economic worth. Tokede, Banjo, Ahmad, Nosiru, Ogunsola, and Oyaniyi [2] predict that by 2050, there will be more than 9 billion people on the planet, necessitating a significant 70% increase in agricultural output. Due to the complex interactions of social, environmental, and economic variables, land, water, and other resources are becoming more scarce. Implementing a supply-demand chain approach that demonstrates improved intelligence, efficiency, and production is vital. Artificial intelligence (AI) technology has the potential to benefit a number of agricultural and food supply chain disciplines. Crop production, pest control, soil and environmental monitoring, data organization, farmer productivity, and labour reduction are all included in these fields. Farmers can efficiently analyse real-time data on a variety of parameters, such as weather, temperature, moisture levels, price information, and GPS signals, by using Internet of Things (IoT) technology and sophisticated analytics. Agricultural systems that are unproductive and inefficient are a problem for developing countries. The fourth industrial revolution's (4IR) tools are making it easier to solve certain problems. The development of digital technology may be ascribed to the steady reduction in expenses and concurrent enhancement in computer processing power, data storage capacity, and network bandwidth. When combined, these technologies have the potential to accelerate innovation, lower the cost of extending solutions, improve transparency, provide consumers with more information to support decision-making, and encourage evidence-based policy choices. Additionally, these organisations are drastically altering the operational tactics used by companies and transforming the methods by which new concepts are conceived, produced, and marketed. Big data analytics, blockchain technology, unmanned aerial vehicles (UAVs), the internet of things (IoT), and artificial intelligence (AI) have the potential to improve efficiency and production across the whole agricultural value chain. This might increase farmers' profits, increase agricultural output, reduce waste, and improve supply chain efficiency, transparency, and sustainable resource use (see Fig 1).

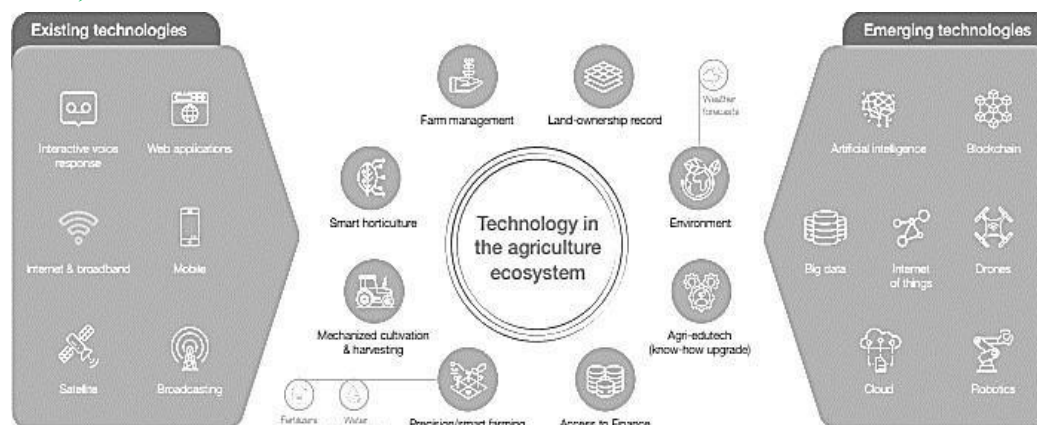


Fig 1. New Agricultural Technology

In this research, we make predictions on how the various subsectors of agriculture may be powered by artificial intelligence (AI). Along with the challenges that are anticipated to emerge soon, future ideas powered by AI are also examined. The article's structure is as follows: The study scope, which outlines the article's direction, is presented in Section II. A review of advances spurred by the internet of things is presented in Section III. Drone technology is the subject of Section IV, while precision farming is covered in Section V. The difficulties in using AI in the agriculture industry are reviewed in Section VI. Section VII concludes the work with some closing thoughts and suggestions for further research.

II. RESEARCH SCOPE

Adopting a comprehensive strategy that makes use of current technical developments and actively involves all relevant stakeholders is essential for modernising agricultural systems in an efficient manner. Every relevant stakeholder's involvement is essential. Governments have the ability to support infrastructure development and enact creative policies by putting in place suitable financial structures. Startups may be able to support new and creative solutions by using technology related to the Fourth Industrial Revolution. By exchanging knowledge and intellectual property, well-established companies may work together and explore new markets. The availability of finance for growth by investors and benefactors may be advantageous to entrepreneurs. The vital participation of civil society is necessary for these initiatives to continue.

Artificial intelligence (AI) farming approaches have been quickly used in the agriculture industry. A conceptual framework known as "cognitive computing" describes how computers are made to mimic human brains' cognitive capacities. The disruptive influence of AI technology, which can analyse, collect, and adjust to many environmental elements using learned knowledge, eventually leading to increased output, is now posing problems to the agriculture industry. Platforms like chatterbots may be able to help farmers by providing them with solutions targeted at improving their farming methods so they may take advantage of the most recent developments in the industry. Currently, Microsoft is helping 175 farmers in the Indian state of Andhra Pradesh [3]. The assistance mostly consists of helping these farmers with a variety of agricultural tasks, such as preparing the land, planting, applying fertiliser, and adding extra crop nutrients. The average agricultural output per hectare has significantly increased by 30% over prior harvests. The several subject matter areas that call for cognitive competence to manage agricultural difficulties are thoroughly examined in the following sections.

III. THE INTERNET OF THINGS (IOT) DRIVEN DEVELOPMENT

Large amounts of data in both organised and unstructured forms are produced every day. This collection includes information from a variety of sources, including weather stations, soil reports, current studies, rainfall measurements, evaluations of pest attack vulnerability, and aerial photos taken with drones and cameras. With the goal of increasing agricultural output, cognitive Internet of Things (IoT) solutions are able to observe, recognise, and provide intelligent reactions. Both proximal and distant sensing methods are often used in intelligent data fusion. When it comes to soil testing, the use of high-resolution data is crucial. Proximity sensing merely requires the deployment of sensors in close proximity to the ground, while distant sensing requires the installation of sensors in aerial or satellite systems. This makes it easier to characterise the subsurface soil in a particular area. The development of hardware solutions like Rowbot, which focuses on optimising fertiliser application for maize cultivation in order to boost crop output, has been made easier by the employment of robots and data-collecting software.

In the field of agriculture, precision farming has become a hotly contested issue. By providing precise information, the use of drone-captured photography has the potential to enable thorough crop monitoring and field surveys. The combination of computer vision technology, drone data, and the Internet of Things will enable farmers to respond quickly. The precision farming process might be accelerated by using drone imaging data to provide instant warnings. To enable real-time picture analysis, large-scale drone designers like aerialtronics have integrated IBM's Watson Visual Recognition APIs and IoT Platform. The following examples show how computer vision technology could be used:

Disease Detection

In recent years, Convolutional Neural Networks (CNNs) have shown remarkable effectiveness in the categorisation of plant diseases. Scholars have increasingly expressed a preference for the multi-layered supervised network due to its persistent better findings. Since LeNet was first published in [4], CNN architecture has seen tremendous breakthrough improvements. Complex characteristics like overlapping pooling and ReLU nonlinearity are often included into modern building design. Both the length of training and the mistake rate have decreased as a result of these technical developments. The amount and complexity of databases have increased since the turn of the twenty-first century, necessitating a rethink. More innovative components have been included into recent architectural developments, such as ResNet. This system relies heavily on both significant batch normalisation and dynamic skip connections. This might lead to a significant increase in the pace of learning during training. ResNet outperformed VGGNet, GoogLeNet, and DenseNet in the context of grape leaf disease detection, according to a research by Victor Ikechukwu, Murali, Deepu, and Shivamurthy [5]. Among the well-known modern designs that are often used as the basis for customised constructions are AlexNet, LeNet, and GoogleNet. In [6], Jadhav, Udupi, and Patil presented a system based on the LeNet architecture for the categorisation of soybean illnesses. By combining three convolutional layers—the max-pooling layer, fully connected MLP (multi-layer perception), and ReLU (Rectified Linear Unit) activation—the suggested framework was able to predict labels with a high accuracy of 99%. Using image sensing and analysis methods, plant leaf pictures are divided into three separate components: the backdrop, the sick area, and the healthy area. This allows for the extraction of pertinent information. Excising the damaged or contaminated tissue entails removing it surgically and then transferring it to a lab for further testing and analysis. This approach is useful not just for detecting vitamin deficiencies but also for locating pests. A detailed sequence is shown in Fig. 2.

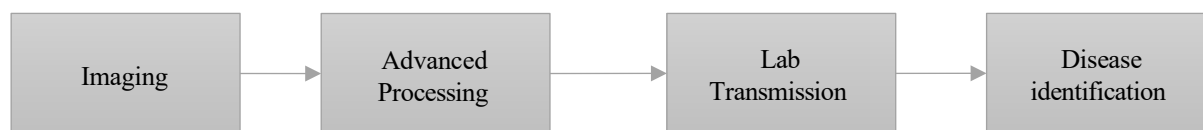


Fig 2. Disease Detection

Identify the Readiness of the Crop

Agricultural practitioners take pictures of their product in two different lighting conditions—white light and ultraviolet A (UVA) light—to determine the degree of maturity of their unripe fruits. Farmers might use this information to classify their crops according to various stages of ripeness. The products should then be carefully mixed into a variety of assortments before being distributed to the market.

Field Management

Agricultural practitioners may create accurate field maps by using aerial photography from helicopters and unmanned aerial vehicles (UAVs). Farmers may use these maps to pinpoint particular regions in their crops that need to be treated right away with pesticides, fertiliser, or water. Targeted actions to maximise crop growth and production are made possible by this real-time analysis. This makes a substantial contribution to resource optimisation.

Identification of Optimal Mix for Agronomic Products

The suggestions made by cognitive solutions for identifying the best crops and hybrid seeds to use in a certain site may be influenced by a number of aspects, including soil condition, weather forecast, seed type, and insect infestation. a tailored suggestion that takes into account the particular needs of the farm, the local climate, and past agricultural production statistics. By considering market and crop price trends, consumer tastes and expectations, and aesthetic factors, farmers may make an educated choice.

Crop Health Monitoring

The use of remote sensing (RS) methods, such as 3D laser scanning and hyperspectral photography, is necessary to produce agricultural metrics for large agricultural fields. This technology has the potential to completely change how farmers manage their land from the standpoints of labour and time. This technology will be used to track the lifetime of crops, making it possible to detect and report irregularities at their source. Dessales, Richard, Poussard, Vauzelle, and Martinsons [7] suggested creating a wireless sensor network system for field condition monitoring in order to increase

agricultural production and effectiveness. Sensors may be used to keep an eye on a number of environmental conditions, including temperature, humidity, and water level. The ZigBee protocol was used in the development of the system, which included wireless sensor nodes with wireless transceiver modules, processors such IC-S8817 BS and ATMEGA8535, and analog-to-digital conversion. A database is used in combination with a web application to retrieve and store data. In this experimental work, we take steps to maximise energy efficiency and account for the possible failure of individual sensor nodes. ZigBee-based monitoring systems for intelligent agricultural greenhouses were tested by Arunkumar, Ramaswamy, and Murugesh [8]. Data collection, analysis, transmission, and reception are all capabilities of the system. The goal of Liu, Shao, and Sun [9] is to create a greenhouse system that can efficiently control the surrounding environment, lower agricultural expenses, and save energy. The B-S architecture, which is the foundation of IoT technology, uses the cc2530 microprocessor as the processor for the wireless sensor node and coordinator. The device's powerful capabilities are enhanced by its core cortex A8 CPU and Linux operating system. Generally speaking, the idea makes it possible to monitor and control the greenhouse remotely and intelligently, doing away with the need for costly human labour and connected equipment.

Kavra, Gupta, and Kansal's experiment [10] proposed using wireless sensor networks (WSN) to automate irrigation. Wireless sensor network (WSN)-based irrigation control and rescheduling have been developed as a result of the use of automatic communication to gather data on soil moisture conditions in irrigation design. These technologies have shown promise as tools for improving water management efficiency. In order to save water, improve crop health, and minimise losses from delays in detection and load, this system uses a calculating methodology to calculate the most ideal watering frequency and time. OPNET provides services for agricultural simulation.

The irrigation system's use of a unique wireless sensor network (WSN) architecture inside the Zigbee protocol will affect how long the battery lasts. Since wireless sensor networks (WSNs) are still in their infancy, it is important to recognise that there are a number of drawbacks in this field, including slow connection speeds, vulnerability to security breaches, high power consumption, and communication failures in the agricultural industry. The irrigation system and its scheduling are automated through the use of wireless sensor networks. Because of their intrinsic low data rate and power consumption, Wireless Sensor Networks (WSNs) demonstrate energy efficiency [11]. The information gathered from strategically placed sensors in the ground controls how all systems operate. Farmers may evaluate how well the system works and decide if any corrective measures are required.

Ochepo's research [12] examined the rural agricultural community's efforts to adopt new methods rather than conventional ones. A range of additional sensors, including those that measure soil moisture, soil pH, air pressure, and the moisture content of nearby foliage, are installed on the sensor nodes. When soil moisture levels are low, the soil moisture sensor included into the mote device starts the watering system; after the proper amount of water has been applied, it deactivates the system. Water conservation results from using the Global System for Mobile Communications (GSM) architecture to broadcast the soil's pH level to the central base station and notify the farmer via SMS. This information might be used by farmers to lessen their need on fertiliser. It is suggested to create a rice crop monitoring system based on Wireless Sensor Networks (WSNs) to enable real-time monitoring of rice harvests and maximise yield for farmers. Wireless sensor networks are used to automate water sprinkler management and make information sharing easier.

Automation Techniques in Irrigation and Enabling Farmers

Irrigation is a labour-intensive and time-consuming technique in agriculture. Artificial intelligence (AI)-enabled automated irrigation systems may maximise agricultural production by using machine learning algorithms to spot trends in crop preferences, soil conditions, and weather. Irrigation uses around 70% of the world's freshwater resources. As a result, farmers are very interested in any technical developments that might improve water management for farming. Kochhar, Kumar, and Aneja [13] created the greenhouse monitoring system for smart agriculture using ZigBee technology. Data collection, processing, transmission, and receiving were among the many functions carried out by the system. In terms of efficiently managing the local ecology, cutting agricultural costs, and encouraging energy saving, the chosen strategy turned out to be a wise choice. The B-S architecture and the cc2530 processor chip were used by the wireless sensor node and coordinator. The Cortex A8 CPU and the Linux operating system make up the system's fundamental parts. Intelligent greenhouse systems may be remotely monitored and controlled thanks to the architectural design. The use of wireless technology lowers labour costs and does away with the need for costly wired infrastructure.

Additionally, [14] has looked into the security issues related to the Internet of Things (IoT). The writers emphasise the connection between the system's widespread use and the development of these problems. There are many security issues with the Internet of Things (IoT) that start with its original architecture and continue throughout all of its features. The people developed strategies to deal with these problems and put preventative measures in place to lessen their likelihood. The perceptual layers demonstrate the importance of secure routing systems, algorithm and key management, and data fusion technologies. The people put authentication and other access control mechanisms in place. [15] has proposed the deployment of a remote observation system. In order to provide real-time agricultural monitoring and enable well-informed decision-making based on the data gathered, this system makes use of ZigBee modules. A high-performance ARM microcontroller is used to improve data integration.

After data collection, GPRS modules make it easier to send collected data to a remote computer system so that it may be used to make well-informed decisions in management settings. This strategy lowers labour expenses while also increasing agricultural production.

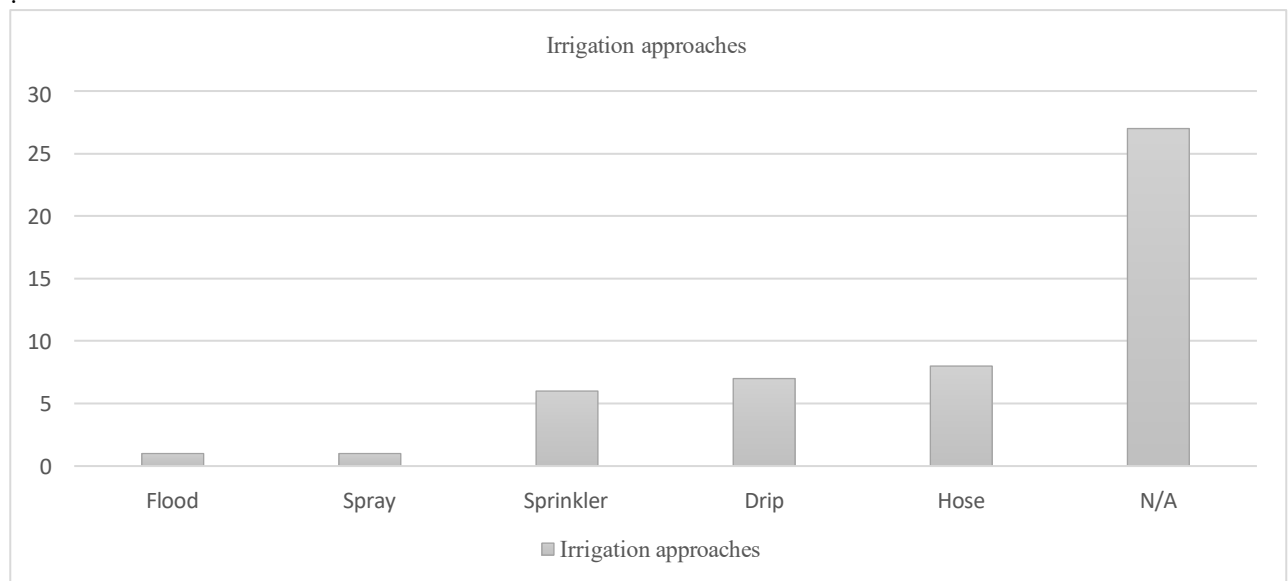


Fig 3. Different Irrigation Approaches

Publications that have analysed irrigation techniques are included in Fig. 3. When the precise irrigation technique employed cannot be identified, the acronym "N/A" is used. Publications that suggest using modelling or simulations for irrigation analysis are also included in Fig. 3. Hoses are often mentioned in academic literature when introducing minimum prototypes in the context of irrigation. Most papers mention the use of water pumps or solenoid valves, as seen in Fig. 3, but do not describe the specific irrigation technique used.

IV. DRONE TECHNOLOGY

Drone-based solutions have a \$127.3 billion worldwide market, according to recent analysis by PWC (Price Water House Coopers) [16]. The market value of the agriculture sector is \$32.4 billion. Drone-based solutions have found several uses in the agriculture sector, such as reducing the effects of unfavourable weather, increasing productivity, using more precise farming methods, and controlling crop yields. Unmanned aerial vehicles (UAVs), sometimes known as unmanned airframes (UAS), are remotely piloted aircraft that don't need a human pilot. They work together with other integrated sensors and the Global Positioning System (GPS). Drones are being used more and more in agricultural settings for a variety of purposes, including surveillance of livestock and wildlife populations, identification and management of invasive plant species, monitoring crop conditions and irrigation infrastructure, and supporting emergency response operations. The agriculture industry is being greatly impacted by the use of unmanned aerial vehicles (UAVs) in remote sensing, which includes tasks like picture gathering, processing, and analysis. The agriculture sector has shown a great propensity to absorb new ideas, especially when it comes to using propelled devices to alter conventional farming practices. The overall addressable estimate of automation-driven arrangements in different sectors surpasses USD 127 billion, according to an ongoing research by [17]. They may be compared to a traditional, user-friendly camera in order to produce high-quality photographs. However, the use of a multispectral sensor improves the process' effectiveness and enables farmers to observe phenomena that are invisible to the unaided human eye, like soil moisture levels and plant health monitoring, even though a traditional camera can provide some insights into plant growth, inclusion, and related aspects. These tactics might successfully reduce the many obstacles related to agricultural output. Wireless Sensor Networks (WSN) are included into the design and deployment of Unmanned Aerial Vehicles (UAVs). Unmanned Aerial Systems (UAS) may improve their operating efficiency by using Wireless Sensor Network (WSN) data, such as limiting the use of synthetic materials to certain areas. The regulatory body must act as quickly as possible given the unexpected and ongoing changes in the environment.

Reconciling with Wireless Sensor Networks (WSN) might be seen as a constructive and forward-thinking solution to the current issue. However, important aspects including weight, flying range, cargo capacity, configuration, and cost are the main emphasis of UAV hardware implementations. The usefulness of UAVs in precision agricultural applications, particularly in activities like field and soil analysis, crop height measurement, pesticide spraying, and crop monitoring, is limited by this concentration on these factors. The study of several facets of UAVs, such as their systems, technologies,

approaches, and constraints, is included in the topic of UAV research. More than 250 models are thoroughly compiled and examined in order to make it easier to choose the best UAVs for agricultural applications. The market for agricultural drones is expected to develop at a pace of more than 38% in the next years. The need for the adoption of sustainable farming methods is expected to increase due to predicted population growth and shifting weather patterns.

Crop spraying

Unmanned aerial vehicles (UAVs), also known as drones, rely heavily on advances in sensor technology and microcontroller systems that have been specifically designed for this application in order to enable the operation of unmanned vehicles and their autonomous functioning in the absence of a pilot. Farmers have been using unmanned aerial systems (UAS) to spray substances for a number of years. These gadgets are widely recognised as being very useful and crucial, especially in locations with cloudy weather and for reaching previously hard-to-reach portions of tall crops like corn. They are generally thought to have a substantial advantage over high-resolution image sensors installed on satellites (Cho et al., 2018). Abd El-Hamid [19] modified an air-carrier plantation sprayer with a microcomputer-based sprayer control framework. A personal computer attached to an ultrasonic range transducer-based foliage volume estimating system was used to carry out control calculations. The quantity of spray deposited served as the basis for the computations. Unmanned aerial vehicles (UAVs), sometimes referred to as drones, were used by Zou, Li, Cai, and Lin [20] to apply synthetic chemicals to crops. To create a regulated atmosphere, the drones were specifically designed to fly in unison, creating a circular pattern. To make it easier to apply synthetic pesticides to crops in the field, the drones used remote sensor networks (WSN) sensors. The drones' capacity to administer synthetic chemicals only to the designated areas was limited by the data gathered by the remote sensors. A modest volume capacity sprayer for an autonomous aircraft was built by Huang, Hoffman, Lan, Fritz, and Thomson [21]. The helicopter used in this study has a main rotor span of three meters and a maximum payload capacity of 22.7 kilos. using around one gallon of petrol over the period of about forty-five minutes. With an emphasis on increasing productivity, the approach and its systematic results provide the groundwork for the development of unmanned aerial vehicle (UAV) flight application frameworks. raising the size of the visual marker detection (VMD) droplets and raising the success rate are two examples of this.

Using an unmanned aerial vehicle as the basis, Hafeez et al. [22] created a sprayer framework with an autonomous flying system. The used system included an affordable and useful module made especially for the MSP430 single-chip microcontroller, which is distinguished by its small form factor and good power management features. The specified route was created to make it easier for UAVs to coordinate the targeted spraying of pesticides or other desired compounds to certain agricultural field regions. The spray uniformity was found to be higher than the minimal criterion for the variation coefficient of ultra-low volume spraying during the UAV testing. Using Pulse Width Modulation (PWM) technology, Zhu et al. [23] created a precision spraying controller for UAVs in 2010. This research designs a pulse width modulation (PWM) controller especially for an agricultural UAV sprayer using a TL494 fixed-recurrence modulator of the pulse width, data collecting board, and proprietary software. UAVs may be remotely controlled or automated by using pre-modified flight plans.

Prodic, Maksimovic, and Erickson's investigation [24] shows that the PWM controller experiences a major change that makes it an extremely precise system for a variety of spraying applications. Pan, Jiang, Li, and Qinu [25] evaluated the powerful swath measurement and bead rotation of aeronautical sprinkling models on M-18B and Thrush 510G aircraft. The droplet dispersion power and swath width of two agricultural aircraft models—the M-18B and the Thrush 510G—were compared in this investigation. The aircraft were assessed while in flight at 4 and 5 meters, respectively. The analysis's conclusions imply that the two agricultural aircraft's different flying styles are responsible for the difference in swath widths between them.

In order to accomplish uniform dispersion, the sprayer is the device responsible for breaking up the liquid being dispersed—such as suspensions, emulsions, or solutions—into tiny droplets and then releasing them with the least amount of force. Additionally, it is the regulatory body's responsibility to monitor and regulate the proper amount of pesticides in order to reduce the likelihood of overuse or unnecessary applications. Overuse of pesticides may have negative effects on agricultural productivity and soil quality. Additionally, dusters are used to spread information about pesticide residue. Based on the kind of energy used for atomisation and liquid shower propulsion, sprayers are divided into four different classes. Gaseous energy, hydraulic energy, kinetic energy, and centrifugal energy are some of these categories.

Crop Monitoring

There are several opportunities to increase crop production and lower yield losses via the use of sophisticated sensors and imaging technology in agriculture. The practical use of unmanned aircraft has changed significantly in recent years. The methods used in surveying, data collecting, and analysis are always being improved by ongoing developments. Additionally, new sensors are being included into UAVs to serve as the client's field-based visual apparatus. For a long time, aerial surveys have been a standard procedure in the agricultural sector. For the last decade, satellites have been used to scan vast woods and croplands, but UAVs have added a higher degree of accuracy and flexibility to this process. It is possible to conduct

UAV flights regardless of the location of the satellite or the current weather. Furthermore, there are clear benefits to operating 400–500 feet above the ground in terms of improved picture quality and exact spatial precision.

V. PRECISION FARMING

Accuracy farming is a sophisticated agricultural method that uses automation and strategic direction in place of physical labour, especially when it comes to crop rotation. It is distinguished by increased accuracy and control. Precision farming is made possible by a variety of technologies, such as variable-rate technology, high-precision positioning systems, remote sensing, geological mapping, water resource management, integrated electronic communication, estimators for figuring out the best times to plant and harvest, plant and soil nutrient management, and mitigation of pest and rodent attacks, among others. Table 1 lists the goals of precision agriculture.

Table 1. Objectives of Precision Agriculture	
Profitability	This aims to strategically analyze the selection of crops and markets, as well as estimate the Return on Investment (ROI) through the utilization of cost and gross profit projections.
Efficiency	By employing a precise algorithm, agricultural practitioners can leverage accelerated and cost-effective cultivation. Consequently, resources can be utilized in a more efficient manner universally.
Sustainability	Enhanced environmental and socioeconomic management ensures consistent and cumulative benefits for all stakeholders, year after year.

Cases of Precision Farming Management

Artificial intelligence (AI) can identify and assess a plant's stress level by using a variety of sensor data and high-resolution pictures. For AI systems to use training data, a variety of information sources must be compiled. For the goal of detecting plant stress, the combination of identifying criteria and data is made easier (see Fig. 4). To precisely identify and categorise various signs of plant stress, AI machine learning models were created utilising a wide variety of plant photos. To improve decision-making skills, this comprehensive approach should be broken down into four separate stages: identification, categorisation, quantification, and prediction (Fig 4).

AI-based yield management

To build an intelligent, effective, and sustainable agricultural environment, cutting-edge technologies including artificial intelligence (AI), cloud-based machine learning (ML), satellite imagery, and complex analytics are being created. Due to the confluence of these technologies, farmers may be able to enhance their average production per hectare and have greater influence over grain pricing. Microsoft and farmers in Andhra Pradesh, India, have teamed together to provide agricultural consulting services. The Cortana Intelligence Suite, which combines Power BI and Machine Learning capabilities to turn data into useful insights, is used in this collaboration. The average crop yield per hectare increased by a significant 30% as a consequence of this pilot project's use of an artificial intelligence (AI) based sowing program. This application provided farmers with useful advice on a number of farming-related topics, such as field preparation, sowing date, fertigation based on soil analysis, FYM application and requirements, seed selection and treatment, and sowing depth optimisation. Artificial intelligence models might be used to determine the best time to sow seeds, taking into account a number of variables including the current weather, average precipitation, and soil moisture levels. In order to provide prior notice of the likelihood of an impending pest infestation, Microsoft and United Phosphorus Limited are working together to build a Pest Risk Prediction Application Programming Interface (API) (see Fig 5). The application programming interface (API) will make use of machine learning (ML) and artificial intelligence (AI) techniques. Pest assaults are categorised as high, medium, or low based on a number of parameters, including the stage of crop development in the field and expected weather.

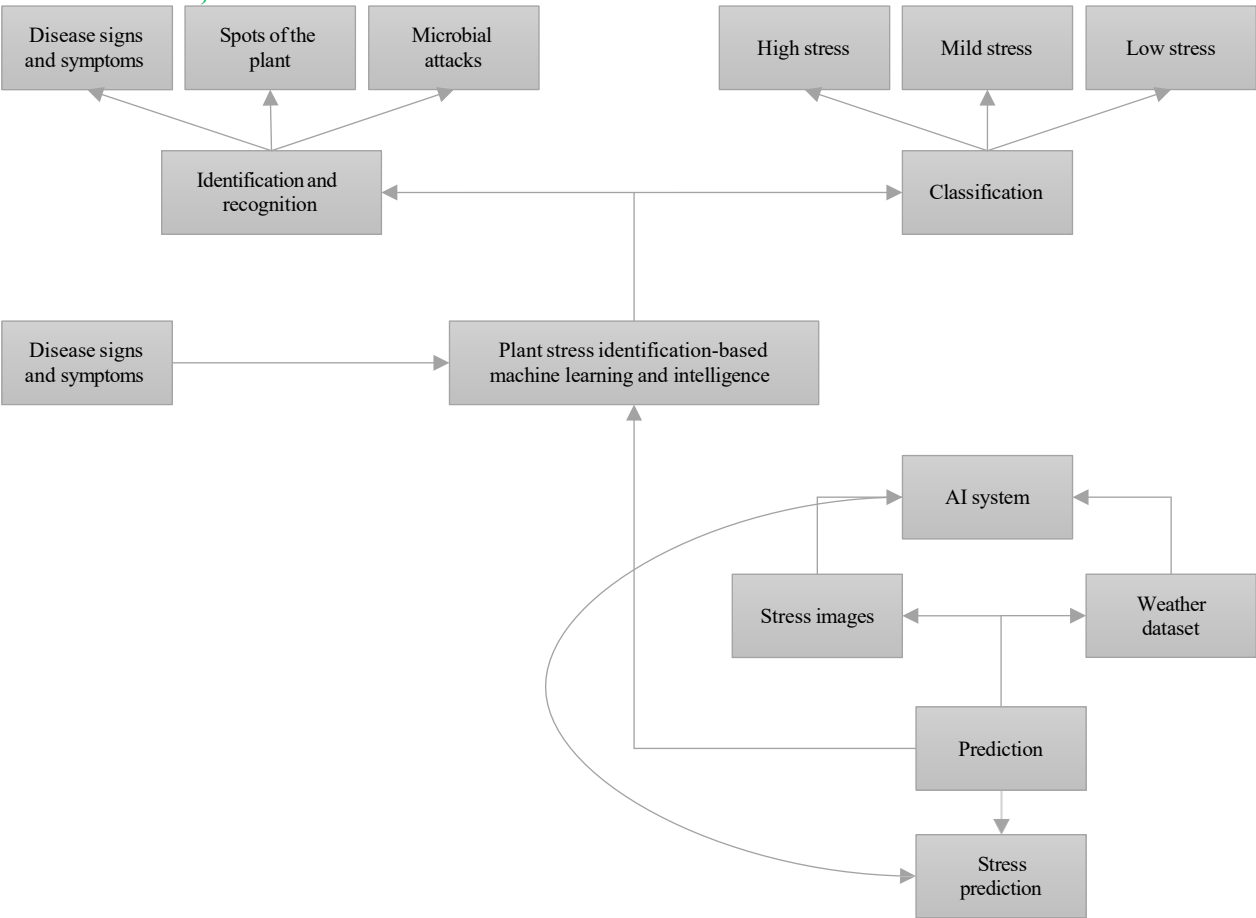


Fig 4. Plant Stress Recognition Using Machine Learning and Artificial Intelligence

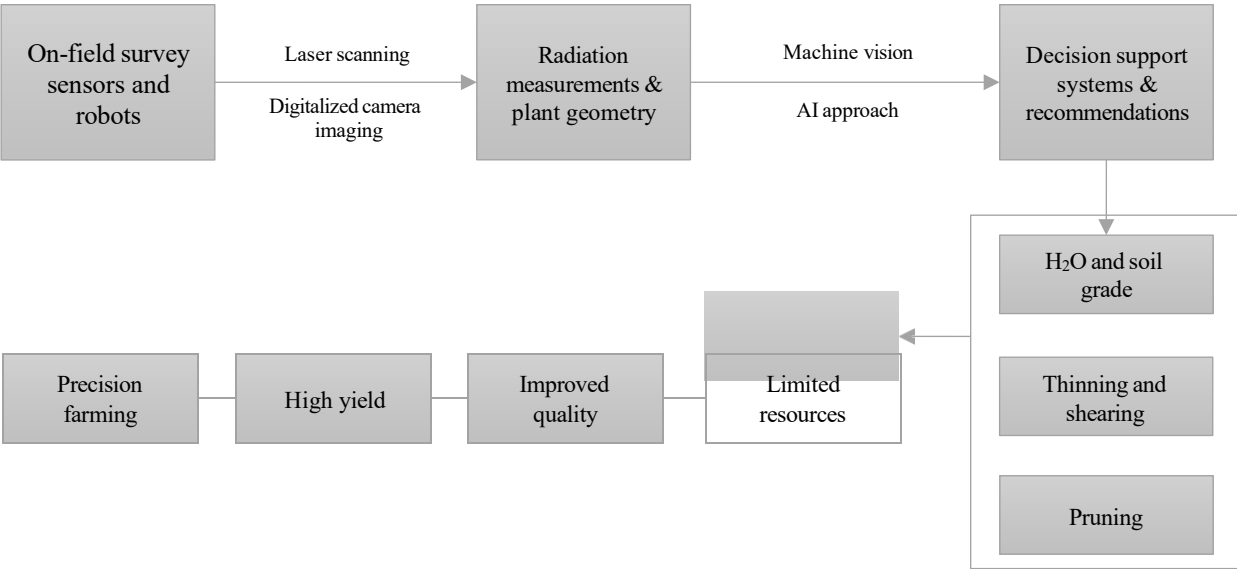


Fig 5. Robotics in Digitalized Farming

VI. CHALLENGES IN AI ADOPTION IN AGRICULTURE

International Journal of Advances in Research, Emerging Technologies and Innovations in Agriculture

Volume 1 Issue 1, 2026

Despite the enormous promise that artificial intelligence (AI) offers for a variety of agricultural applications, there is a significant lack of understanding about cutting-edge and creative machine learning solutions in the global agriculture business. The agricultural industry is particularly vulnerable to the effects of environmental variables such as insect infestations, soil quality, and climatic conditions. External influences may affect the effectiveness of a crop cultivation technique that was originally well-conceived during the harvesting phase. In a similar vein, AI systems need a large amount of data for training before they can make good predictions. Getting time data might be difficult, but getting

Geographical information is usually easier to get, especially when working with large tracts of agricultural land. Only during the growing phase was the crop-specific data available. The delayed development of databases lengthens the time needed to create a reliable AI machine learning model. For this reason, rather than on-field precision techniques, artificial intelligence (AI) is being used more and more in agronomic items including fertilisers, seeds, and insecticides. Inadequate irrigation infrastructure, rising temperatures, declining groundwater supplies, food shortages, and waste management issues are just a few of the many difficulties that farmers must deal with. Using a variety of cognitive methods has a big impact on how a cultivation project turns out. It is clear that the industry is still greatly underserved despite the continuous research efforts and the availability of several applications. The agriculture sector is only beginning to address the real-world challenges faced by farmers and use digital prediction and decision-making techniques to lessen these problems. Improving the quality of applications is essential to fully investigate the vast potential of artificial intelligence in the sector of agriculture. Only then would it be able to effectively adapt to changing external conditions, enable timely decision-making, and deploy efficient models and platforms for the retrieval of contextual data and information. One important consideration is the high expense of most of the cognitive solutions now offered in the agriculture sector. Reducing solution prices is essential to maximising technology's broad application. If the solutions were created on an open source platform, their accessibility and adoption rates may be improved. It is anticipated that this new technique would improve seasonal crop quality and raise agricultural production, offering farmers significant advantages. For agricultural production, farmers in many nations, including India, rely on the annual monsoon rains. When it comes to rain-fed agriculture, official weather predictions are quite valuable. Forecasting weather patterns and other agriculturally important aspects like groundwater levels, soil quality, crop cycles, and insect infestations will be made much easier with the use of artificial intelligence technology. By using AI technology, farmers may benefit from precise predictions and projections, which helps to allay a large number of their worries.

Sensors powered by artificial intelligence may be able to assist farmers in obtaining vital information in a number of areas. The data collected will contribute to higher output. These sensors have a lot of potential applications in the agricultural industry. To enhance the cultivation process, agricultural experts may gather data on weather, soil quality, groundwater levels, and other relevant factors. The use of AI technology on robotic harvesting equipment enables the integration of sensors for data collection. AI-based expert coaching has the potential to boost productivity by up to 30%. The damage that insect infestations and natural disasters inflict to crops is the biggest problem that farmers face. The primary cause of agricultural failures is farmers' ignorance of critical information. In the current era of digitisation, this technological advancement may assist farmers protect their crops from unauthorised access. Artificial intelligence will facilitate image identification. An rising number of companies are using unmanned aerial vehicles (UAVs), sometimes known as drones, to monitor industrial operations and identify insect infestations. The existence of several previous successes serves as motivation for the development of a comprehensive system to monitor and protect agricultural production. The robotic lens enhances the golden bloom of a tomato seedling. The computer vision system employs image analysis algorithms to identify the ideal time to pluck a tomato by examining pictures of the plant. This helps identify a ripe tomato, which is useful for packaging and placing in the fresh produce section of a store. NatureFresh Farms, a business with 20 years of expertise cultivating veggies on 185 acres in Ontario and Ohio, is looking into the concept. The IT Manager at NatureFresh Farms, Keith Bradley, claims that having accurate information about the projected quantity of tomatoes that will be available for purchase in the future simplifies the work of sales employees and rapidly boosts the company's financial performance [26]. Artificial intelligence (AI) is transforming agriculture in a number of ways, one of which is by fundamentally altering it. Despite the observed effects of climate change, such as altered growing seasons, desertification of arable land, and flooding of formerly fertile deltas by seawater, the application of artificial intelligence offers humanity a potential solution to address a major challenge: providing food for an additional 2 billion people by the year 2050. According to UN estimates, food production would need to rise by 49.9% by the middle of the twenty-first century [27]. Agricultural output rose proportionally and doubled by three while the world's population surged rapidly from 3 billion in 1960 to 7 billion in 2015. The success of agricultural development can be attributed to both technological advancements like the use of pesticides, fertilisers, and machinery, as well as the expansion of cultivated land through activities like deforestation and the redirection of freshwater resources to agricultural areas like farms, orchards, and rice paddies. In this case, we have to be imaginative. In the next years, artificial intelligence (AI) is probably going to have a significant influence on both the agricultural sector and the overall economy. Technological advancements have helped farmers understand more about hybrid crops, which might provide bigger yields in less time. Artificial intelligence (AI) in agriculture has the potential to improve crop output and provide the groundwork for future economic growth. Globally, a substantial proportion of food is lost or wasted, according to data from reliable organisations. In addition to saving time and money, using the right algorithms to solve this

problem would be beneficial for long-term economic growth. The agriculture industry's chances of attaining digital transformation are improved by the use of technical innovations like artificial intelligence. However, the success of this project is largely dependent on the large-scale data collecting, which is difficult because of the irregular annual production cycle. Conversely, farmers show that they can adapt to changing conditions by using AI to help the agriculture industry undergo a revolutionary change. The aforementioned example demonstrates how AI is revolutionising farming and is changing the agriculture industry in a number of ways. We must use our creative abilities in this situation.

VII. CONCLUSION AND FUTURE RESEARCH

In order to ensure agriculture's long-term survival in the years to come, the development of adaptive cognitive techniques will be crucial. The agriculture sector is still neglected despite the wealth of ongoing research and the wide range of applications that are already available. However, when it comes to solving the real-world challenges farmers face when putting AI-driven decision-making systems and predictive solutions into practice, agricultural AI is still in its infancy. In order to fully realise artificial intelligence's (AI) enormous potential in the agriculture industry, more sophisticated and reliable applications must be developed and implemented. It will only be able to adapt to the constantly changing external environment under such conditions. This strategy would enable improved decision-making in real-time situations and the subsequent use of the best model or application for effectively gathering contextual data. The outrageous expense of the current cognitive solutions offered for the agriculture industry is another important factor. Improving the business feasibility of AI solutions is essential to encourage the agricultural sector to use this technology. Implementing AI cognitive solutions via an open source platform may result in lower costs, more accessibility, and improved farmer understanding. AI technology is expected to provide creative and accurate answers to the current agricultural problems that farmers across the globe face in the future. AI has the ability to solve a variety of problems, including those related to agricultural automation, weather forecasting, and pest control. AI researchers are expected to make major breakthroughs in the next years that will have a direct impact on the agriculture industry. Future farmers might be equipped with scientific thinking skills via the integration of AI technology, allowing them to use data-driven strategies to maximise agricultural output on specific land plots. Currently, AI companies are working on creating robots that are easy to operate and intended for usage in agricultural settings. This machine's goal is to increase agricultural harvesting's accuracy and efficiency relative to human labour. The robots listed above have been programed to carry out activities including harvesting, packaging, and crop quality and weed inspection. The difficulties of manual agricultural labour are readily surmounted by the robots. By using pre-existing data and analysing satellite photos, artificial intelligence systems can identify insects like grasshoppers and locusts. By using mobile phone alerts to remind farmers to take appropriate action, AI-assisted pest management has the potential to help farmers.

Farmers may efficiently automate their farming operations by using AI, which advances precision cultivation methods. Farmers may increase crop quality and output while using less water and fertiliser thanks to this technology integration. There is increasing hope that the problems with the world's food supply brought on by an expanding population may be successfully resolved as technological developments continue. In particular, the creation of new technologies has the potential to assist companies looking to improve their products by using AI. This involves the use of drones, the deployment of automated technology in industrial operations, and the supply of training data for agricultural applications. In order to determine the future prospects of AI in agriculture, significant efforts must be made to ensure universal accessibility, since most advanced technological applications are currently restricted to large-scale, interconnected agricultural operations. Expanding accessibility and connectivity to small-scale farms located in rural places is necessary to ensure the future projection of ML-assisted agricultural goods and data engineering in farming internationally. AI has the potential to improve production in the agriculture sector and solve issues with scarce labour and few resources. AI has the ability to significantly improve the agriculture business sector by increasing operational efficiency and optimising resource allocation. It is impossible to overestimate the importance of this technology for horticulture research and development.

References

- [1]. G. Scoricci, M. D. Schultz, and P. Seele, "Anthropomorphization and beyond: conceptualizing humanwashing of AI-enabled machines," *AI Soc.*, 2022.
- [2]. A. M. Tokede, A. A. Banjo, A. O. Ahmad, M. O. Nosiru, A. J. Ogunsola, and T. Oyaniyi, "Impact of pastoralists-farmers' conflicts on agroforestry farmers' psychology and agricultural production in north central Nigeria," *Global J. Agric. Sci.*, vol. 20, no. 1, pp. 1–9, 2021.
- [3]. IANS, "Microsoft develop sowing app for Andhra Pradesh farmers," *The Financial Express*, FE Tech Bytes, 09-Jun-2016.
- [4]. A. Chatterjee, "Evolution of CNN architectures: LeNet, AlexNet, ZFNet, GoogleNet, VGG and ResNet," *OpenGenus IQ: Computing Expertise & Legacy*, 21-Jan-2019. [Online]. Available: <https://iq.opengenus.org/evolution-of-cnn-architectures/>. [Accessed: 16-Jul-2023].
- [5]. A. Victor Ikechukwu, S. Murali, R. Deepu, and R. C. Shivamurthy, "ResNet-50 vs VGG-19 vs training from scratch: A comparative analysis of the segmentation and classification of Pneumonia from chest X-ray images," *Global Transitions Proceedings*, vol. 2, no. 2, pp. 375–381, 2021.
- [6]. S. Jadhav, V. Udupi, and S. Patil, "Classification of soybean diseases using pre-trained deep convolutional neural networks," in *Advances in Intelligent Systems and Computing*, Cham: Springer International Publishing, 2021, pp. 746–756.
- [7]. D. Dessales, N. Richard, A.-M. Poussard, R. Vauzelle, and C. Martinsons, "Cross-layer energy analysis and proposal of a MAC protocol for wireless sensor networks dedicated to building monitoring systems," *Wirel. Sens. Netw.*, vol. 05, no. 05, pp. 91–104, 2013.
- [8]. Arunkumar, Ramaswamy, and Muruges, "Zigbee enabled iot based intelligent Lane control system for autonomous agricultural electric vehicle application," *SSRN Electron. J.*, 2022.

- [9]. J. Liu, M. Shao, and M. Sun, "The forecast of power consumption and freshwater generation in a solar-assisted seawater greenhouse system using a multi-layer perceptron neural network," *Expert Syst. Appl.*, vol. 213, no. 119289, p. 119289, 2023.
- [10]. R. Kavra, A. Gupta, and S. Kansal, "Optimization of energy and delay on interval data based graph model of wireless sensor networks," *Wirel. Netw.*, vol. 29, no. 5, pp. 2293–2311, 2023.
- [11]. C. Sureshkumar and S. Sabena, "Design of an adaptive framework with compressive sensing for spatial data in wireless sensor networks," *Wirel. Netw.*, vol. 29, no. 5, pp. 2203–2216, 2023.
- [12]. C. O. Ochebo, "Rural communities access to community and social development projects in North Central Nigeria," *J. Agric. Ext. Rural Dev.*, vol. 11, no. 9, pp. 149–155, 2019.
- [13]. A. Kochhar, N. Kumar, and S. Aneja, "Variance adaptive sporadic sampling for greenhouse monitoring," *Sustain. Comput. Inform. Syst.*, vol. 37, no. 100825, p. 100825, 2023.
- [14]. V. Kalpana, D. K. Mishra, K. Chanthirasekaran, A. Haldorai, S. Srigitha, S. Nath, and B. K. Saraswat, "On reducing energy cost consumption in heterogeneous cellular networks using optimal time constraint algorithm," *Optik*, vol. 270, p. 170008, Nov. 2022, doi: 10.1016/j.ijleo.2022.170008.
- [15]. R. Subha and A. Haldorai, "An Efficient Identification of Security Threats in Requirement Engineering Methodology," *Computational Intelligence and Neuroscience*, vol. 2022, pp. 1–14, Aug. 2022, doi: 10.1155/2022/1872079.
- [16]. S. Ayub, R. Boddu, H. Verma, S. Revathi B, B. K. Saraswat, and A. Haldorai, "Health Index Estimation of Wind Power Plant Using Neurofuzzy Modeling," *Computational and Mathematical Methods in Medicine*, vol. 2022, pp. 1–8, May 2022, doi: 10.1155/2022/9535254.
- [17]. B. Jackson, S. R. B. Balachander, A. Haldorai, V. S., and A. N. A. Sahaya, "Modified Design Structure Of A Metamaterial Microstrip Patch Array Antenna For Rf Energy Optimization," *Materiali in tehnologije*, vol. 56, no. 2, Apr. 2022, doi: 10.17222/mit.2022.384.
- [18]. S.-H. Cho et al., "High-resolution tactile-sensation diagnostic imaging system for thyroid cancer," *Sensors (Basel)*, vol. 23, no. 7, p. 3451, 2023.
- [19]. S. Abd El-Hamid, "Modification of an air - carrier sprayer for cotton picking at small holdings area," *Journal of Soil Sciences and Agricultural Engineering*, vol. 9, no. 10, pp. 513–517, 2018.
- [20]. C. Zou, L. Li, G. Cai, and R. Lin, "Fixed-point landing method for unmanned aerial vehicles using multi-sensor pattern detection," *Unmanned Syst.*, pp. 1–10, 2023.
- [21]. Y. Huang, W. C. Hoffman, Y. Lan, B. K. Fritz, and S. J. Thomson, "Development of a low-volume sprayer for an unmanned helicopter," *J. Agric. Sci.*, vol. 7, no. 1, 2014.
- [22]. A. Hafeez et al., "Implementation of drone technology for farm monitoring & pesticide spraying: A review," *Inf. Process. Agric.*, vol. 10, no. 2, pp. 192–203, 2023.
- [23]. H. Zhu et al., "Development of a PWM precision spraying controller for unmanned aerial vehicles," *J. Bionic Eng.*, vol. 7, no. 3, pp. 276–283, 2010.
- [24]. A. Prodic, D. Maksimovic, and R. W. Erickson, "Design and implementation of a digital PWM controller for a high-frequency switching DC-DC power converter," in *IECON'01. 27th Annual Conference of the IEEE Industrial Electronics Society (Cat. No.37243)*, 2002.
- [25]. X. Pan, Y. Jiang, H. Li, and L. Qin, "Experimental research on the jet-breaking characteristics and hydraulic performance of a novel automatic rotating sprinkler," *Water Sci. Technol. Water Supply*, vol. 23, no. 5, pp. 1935–1952, 2023.
- [26]. S. Briggs, "Engaging the work of Keith Bradley," *Biblic. Interpret.*, vol. 21, no. 4–5, pp. 515–523, 2013.
- [27]. V. Blazhevskaya, "UN calls for urgent action to feed the world's growing population healthily, equitably and sustainably," *United Nations Sustainable Development*, 19-Apr-2021. [Online]. Available: <https://www.un.org/sustainabledevelopment/blog/2021/04/un-calls-for-urgent-action-to-feed-the-worlds-growing-population-healthily-equitably-and-sustainably/>. [Accessed: 16-Jul-2023]