**DRONE TECHNOLOGY– THE FUTURE OF ARTIFICIAL INTELLIGENCE IN AGRICULTURE SECTOR**

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**Abstract**

Artificial Intelligence is one of the key areas of research in computer science because of its rapid technological advancement and vast area of applications. One of the main areas where the presence of AI is extremely necessary is agriculture. The need for food is rising along with the population's rapid growth. Farmers were using traditional methods, but they were insufficient to meet these demands. This led to the introduction of new automated techniques (drone technology). These innovative techniques supplied the world's food needs while simultaneously giving billions of people access to jobs. Drone technology reduces the overuse of water, pesticides, and herbicides, preserves soil fertility, aids in the effective use of labor, boosts output, and enhances quality. The use of drone technology reduces spending on chemicals while saving time, labor, and water. Additionally, it lessens chemical use and prevents human exposure to chemicals. The objective of this paper is to review the usage of Drones in agriculture applications. This paper provides an overview of drone technology's current position for agricultural applications, including crop health monitoring and farm activities. The research article concludes by recommending that more farmers invest in drone technology to better their agricultural outputs.

**Keywords:** Artificial Intelligence, Drone Technology , Agriculture, Applications.

**INTRODUCTION**

Modern technology develops quickly. Agriculture-related production equipment is in greater demand worldwide. The widespread usage of drones in commerce is very beneficial to agriculture. Drone technology was created by combining the advancements in aerial photography and aeronautical engineering. Climate change, water quality, soil quality, volatile commodity prices, economic challenges related to productivity and cost-effectiveness, strict regulation, international competition, rising labor costs, population growth, urbanization, an increasingly degraded environment, and changes in consumer tastes are just a few of the complex issues that farmers today must deal with. For solutions, they are using cutting-edge technology. Any tool that will increase production must be given significant consideration. Drones are one of these tools, and they are cheap and simple to use.

**ARTIFICIAL INTELLIGENCE IN AGRICULTURE**

The study of intelligent machines that can perform like human beings is emphasized in the field of computer application known as artificial intelligence (AI). The study of artificial intelligence requires a high level of technological expertise. Artificial intelligence will play an essential role in business and technology, and it will have a greater impact on education in the future. In the agricultural sector, artificial intelligence is now widely applied. The agricultural industry is faced with a number of dangers and difficulties, including, but not limited to, information on pest control methods, yield maximization, improper soil treatment, pest control systems, disease management information, and information on farm technology and innovation .Agriculture is one of the sectors that artificial intelligence (AI) is revolutionizing. Therefore, incorporating AI into agriculture is transforming food distribution and production. As a result, it is more effective, sustainable, and available. Additionally, AI is displacing conventional agricultural practices with technologies that aid farmers in optimizing crop yields, forecasting weather, and wise resource management. With AI, the agriculture sector is becoming more intelligent, effective, and sustainable. This is essential in a society where food consumption is always rising.

**DRONE**

DRONE (Dynamic Remotely Operated Navigation Equipment) is commonly referred as unmanned aerial vehicle (UAV). A farmer may use drones to monitor farms and assess the condition of crops because they come with all the software, sensors, and hardware they might possibly need. An average drone has GPS, sensors, infrared cameras, software, programmable controllers, propulsion and navigation systems, and other components. An aerial drone's camera functions as a security camera. Drones cannot be climbed aboard by a human body because to their size. Both directly by an operator and autonomously are options for how to control them. The drone's camera records in-depth images as it flies over the field. Using a drone to collect data on various agricultural conditions is a cost-effective strategy. A drone is a pilotless aircraft made to gather data more precisely than an airliner or a satellite. The data is given to farmers in a usable manner for management decisions once the drone captures and processes it. Agriculture drone software will be required to process the data that your drone acquires.

 **AGRICULTURE DRONES**

Agriculture drone refers to a drone that is utilized for agricultural purposes. Farmers and agriculture service providers are the two categories of professions who might be interested in owning an agriculture drone. Farmers will need to use next-generation technologies to meet new difficulties as the globe changes quickly. Drones can assist farmers in overcoming a variety of obstacles. Drone technology in agriculture has the potential to revolutionize the industry. Farmers may boost crop yields, save time, save costs, and act accurately and precisely by having access to a wide pool of data.

Drones can facilitate profitable farming, enhance yield, and enable sustainable farming. They aid farmers in making the best use possible of inputs including pesticides, water, fertilizer, and seeds. In crop scouting and monitoring, crop volume, prescription map creation, precision spraying, inspection of agricultural infrastructure (including irrigation), mapping and surveying of fields, crop damage assessment, and insurance claim forensics, drone technology is applied. Drones for agriculture can be used for spraying, monitoring, assessing droughts, and aerial photography of animal activities. Drone data is an effective tool for helping farmers see their farms. Farmers can evaluate the fertility of their crops using high-resolution drone data, which enables agricultural experts to apply fertilizer more precisely and cut down on waste.

**APPLICATIONS OF DRONES IN AGRICULTURE**

**Soil and field analysis**

Agricultural drones can analyze soil and fields for effective field planning. They can be used to mount sensors that measure soil moisture, terrain, soil conditions, soil erosion, soil nutrient concentration, and soil fertility.

**Crop monitoring**

Crop surveillance is the monitoring of a crop's development from the time the seeds are sown until the crop is ready to be harvested. This includes timing the application of fertilizers, keeping an eye out for pest infestations, and tracking the impact of weather. The only way a farmer can guarantee a timely harvest, particularly when working with seasonal crops, is through crop surveillance. At this point, any mistakes could lead to a failed crop. The upcoming farming season can be understood and planned for with the use of crop surveillance. By using infrared cameras to scan the field, drones can aid in efficient crop surveillance. Farmers can then act on the information they receive in real-time to improve the health of the plants there.

**Plantation**

Drones can assist in planting crops and trees, a task previously carried out by farmers. This technology will assist save on both labor costs and gasoline costs. Budget-friendly drones are anticipated to replace bulky tractors in the near future because they degrade the environment and release dangerous gases.

**Livestock management**

Because large cattle have high-resolution infrared cameras incorporated into their sensors, which can swiftly spot sick animals and take appropriate action, they can be monitored and handled by drones. As a result, the impact of drones on precise dairy production will quickly replace the current standard.

**Crop spraying**

Agri-drones can be used to spray chemicals since they have reservoirs that, in comparison to conventional methods, can be quickly filled with fertilizers and insecticides to spray on crops. Therefore, drone technology has the potential to bring in a new era of precision farming.

**Irrigation management**

Providing enough water to cultivate crops is a difficult undertaking in the majority of drought-prone countries. The water is currently delivered to a field uniformly using the available irrigation techniques. To make the best and most efficient use of the available water resources, it is necessary to supply the water where it is actually needed. Water is a vital component of crop growth; insufficient or excessive amounts might interfere with a plant's ability to develop properly. In a big agricultural area, farmers need to implement adequate irrigation management based on the grown crop. Using thermal cameras, the drone can help farmers make informed decisions for precise irrigation management. The soil moisture stress state and excess water at a specific location in the agricultural field can be captured by the drone. Drone-assisted fieldwork assists in improving water use efficiency and identifying irrigation leaks through regular irrigation monitoring. Drones using sensors, multispectral imaging cameras, and thermal cameras can record the effects of heat and water stress on crops in specific agricultural areas. It allows irrigation to be used on crops according to their requirements. This will ensure that irrigation water is used efficiently and prevent water from being wasted.

[**Crop Damage Assessment**](https://www.equinoxsdrones.com/agriculture#agriculture-offered-services-wrapper)

Agricultural drones equipped with multispectral and RGB sensors can also spot pests, diseases, and weeds in field regions. This information makes it possible to determine the precise quantities of chemicals required to combat these infestations, which lowers the costs incurred by the farmer.

**Verify the health of the crop**

Agriculture is a large-scale endeavor that involves acres of land. To keep track of the condition of the soil and the crop that has been planted, regular surveys are required. Manually, this could take days, and even then, human mistake is possible. The same task can be completed by drones in a few hours. Drones can use infrared mapping to collect data on the condition of the crop and the soil.

**Avoid over use of chemicals**

Drones may be particularly helpful in reducing the use of herbicides, insecticides, and other pesticides. In reality, these substances support crop protection. However, using them excessively can be dangerous. Drones are able to detect even the smallest signs of pest incursions and can provide accurate information about the severity and scope of the attack. This can be used by farmers to calculate the amount of chemical that should be used to ensure that the crops are only protected and not injured.

**Prepare for weather glitches**

The weather has the potential to be both a farmer's best friend and worst enemy. It is quite challenging to get ready for any change in patterns because they cannot be precisely foreseen. Future weather conditions can be forecast using drones. Already, better forecasts are being made using storm drones. Farmers can also make better preparations by using this knowledge. The crop to be planted that would be best suited for the season, as well as how to care for planted crops at a later stage, can be planned using advance notice of storms or lack of rain.

**Geo-fencing**

Drones with integrated thermal cameras can identify animals both during the day and at night, alerting farmers. Therefore, farmers using drones can prevent agricultural damage brought on by outside animals. The birds may flee the field after a few drone flights.

**Tracking livestock**

The drone survey enables farmers to track not only their crops but also the movements of their cattle. Thermal sensor technology aids in the recovery of missing animals and the diagnosis of illness or damage. This task is well suited for drones to perform, which significantly boosts the growth of vegetation.

**Plant establishment**

It is evident that there used to be a labor shortage during crop-sowing activities. With utmost accuracy and in a very short amount of time, drone technology can solve this problem by planting crops throughout a big field. Seeds are planted and nutrients are sprayed on the agricultural land using drone planting devices in a predetermined manner. In addition to lowering costs, it has been shown that the deployment of drone technology improves crop management consistency and effectiveness. Some inventors have created add-ons for drone systems that allow them to fire pods containing seeds and plant fertilizers into already prepared soil. Real-time meteorological conditions can be detected by drones, and farmers can analyse the data they collect to create a plan for risk reduction in preparation. Planning various agricultural activities and judicious resource allocation might be aided by advance knowledge. In disaster management, the risk is reduced by forecasting potential disaster events using real-time data collected from the ground by drones. Drone-based data collection is more flexible, timely, accurate, and less expensive than satellite-based Remote Sensing (RS).Through accurate prediction and necessary adjustments, this drone-enabled data helps to increase agricultural output and supply chain management.

**Pest management**

Locust attacks on crops are posing additional difficulties for farmers in addition to their inherent vulnerability. The cultivated crop that the army of locusts decimated caused the catastrophe and the financial loss for the farming community. Many Indian states are employing drones to spray insecticides to eradicate the locust, a process that would otherwise be very impossible to complete by hand.

**Agricultural product transportation**

In accordance with the requirements of the farmer, drones can also transport agricultural products from one place to another. The drones may park in a field and be utilized for activities like spraying, monitoring, and transferring freight. They are capable of a wide range of functions.

**BENEFITS OF DRONE TECHNOLOGY**

**1. Enhanced Production -** The farmer can raise production capacity by carefully planning irrigation, keeping track of crop health, learning more about soil health, and adapting to environmental changes.

**2. Effective and Adaptive Techniques -** Drone use provides farmers with regular crop updates and aids in the improvement of farming practices. They can allocate resources efficiently and adjust to changing weather conditions.

**3. Greater safety of farmers -** Using drones to spray pesticides in difficult-to-reach terrain, contaminated areas, taller crops, and power lines is safer and more practical for farmers. Additionally, by avoiding spraying the crops, farmers are able to reduce soil pollution and chemical contamination.

**4. Less wastage of resources -** Agri-drones enables optimum usage of all resources such as fertilizer, water, seeds, and pesticides.

**5. 99% Accuracy rate -** The drone survey helps farmers calculate the precise land size, segment the various crops, and indulge in soil mapping.

**6. Useful for Insurance claims -** Farmers use the data captured through drones to claim crop insurance in case of any damages. They even calculate risks/losses associated with the land while being insured.

**7. Evidence for insurance companies :** Agri-drones are used by the agricultural insurance industries to get reliable data quickly. For an accurate calculation of the financial compensation to be given to the farmers, they record the harms that have been done.

**CHALLENGES IN ADOPTION OF DRONES IN AGRICULTURE:**

The use of drone technology in agriculture is impeded by a number of issues. For adoption to be successful, these issues must be resolved. These challenges include:

**1. Internet connectivity issue / Internet access:**Drone operation is complicated by the poor internet access.

**2. Weather dependency:** Drones function better and more effectively than human labor under normal weather conditions. However, flying drones in bad weather is not advised because it increases the risk of falling or less precise operation.

**3. Knowledge and Skill:** Utilizing new technology is intriguing, but flying a drone frequently requires the right skill set and knowledge.

 **4. Regulatory uncertainty:** The laws governing drone use are still being created. If criteria are established for allowed chemicals, drones for spraying pesticides in agricultural fields will become more popular faster.

**5. High cost:**The cost of drone technology, training, and use in agriculture is higher. Small-scale manufacturing is done at significant fixed costs. A village businessperson cannot afford to buy or rent one and utilize it for farm applications or surveys.

**6. Limited flight time and range:** Drone flights frequently last 20 to 60 minutes because of their heavier payloads. As a result, the quantity of field coverage per charge is reduced and the cost of operating the drone is increased.

**7. Scarcity of trained pilot:** The lack of qualified pilots is a significant barrier to the expansion of the UAV business in India, in addition to technical expertise and cost. Agri-drones are available for purchase by farmers, however upkeep costs for battery technology are high.

**8. Techno-economic feasibility:**The proliferation of drone applications in India, where most farmers are small-scale and land ownership is distributed, may be constrained by their techno-economic feasibility.

**9. Safety and user-friendliness:** Drones cannot be used in public without previous government authorization due to safety issues. significant worries about crime, safety, and privacy issues.

**10. Dependency on imports:** A significant reliance on imported drone parts as a result of insufficient startup financing, insurance, and investment in drone research and development.

 **11. Privacy issue:** Many people worry that their privacy would be violated if unmanned aerial vehicles (UAVs) are used for tracking and spying. The absence of clearly defined operational and technical rules for the safe operation of UAVs is a major challenge. There is the possibility for misuse to transfer information unlawfully and to violate people's privacy.

**INITIATIVES TO APPLICATION OF DRONE TECHNOLOGY IN INDIAN AGRICULTURE**

Although drone technology in Indian agriculture is still in its infancy, the government is making an effort to encourage the use of drones by collaborating with farmers, academics, the private sector, and agri-tech start-ups in order to reap the potential benefits of this technology. In an effort to hasten the implementation of such cutting-edge digital technology in agriculture, the government is attempting to provide policy support through the NeGP-A and Union budget 2022–23. 'Kisan Drones' for the use of drone technology in agricultural tasks like crop assessment, digitalization of land data, and application of nutrients and insecticides. By increasing efficiency and accuracy, programs like Kisan Drones can completely change the agriculture industry. It would also encourage the convenience of conducting business in the farming industry and draw young, educated individuals to the field. The 'Drone Shakti' and Drone-As-A-Service (DrAAS) will be made a reality by promoting and assisting entrepreneurs that deal with the use of drones in various industries. The Indian government launched the online "Digital Sky Platform" platform for drone registration and use in India in order to encourage domestic drone development and acceptance. The two task forces were specifically created by the national government to design and manufacture aircraft and drones in the nation. This program will encourage the advancement of domestic drone technology and its use in a variety of fields, including agriculture.

The Union government has established the Production Linked Incentive (PLI) program for drone makers, and it has been suggested that any value-added drone technology be rewarded with 20% incentives. By supporting drone technology development and use in India, this program hopes to make a difference. The cost of drones is the biggest obstacle to farmers embracing this practical technology. Since 86% of Indian farmers are small or marginal farmers, new technology must be reasonably priced and accessible to them in order for it to be embraced as broadly as possible. Attempts to address this issue have been made by both the public and private sectors. The central government has authorized the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) to introduce drone technology into Indian villages and use it for agricultural research. Innovative technologies, including as remote sensing and drone technology, were employed in central government initiatives like the Pradhan Mantri Fasal Beema Yojana (PMFBY) to detect fraud, fraudulent claims, and inconsistencies.

**Conclusion :**

Drones help agriculture perform better overall, encourage farmers to use precision farming techniques, and give farmers the chance to switch from farming to a technology-intensive vocation By offering precise and trustworthy information regarding the situation on agricultural fields, it would aid in lowering human error and inefficiencies in current agricultural practices. The next agricultural revolution is brought about by the drone acting as "an eye in the sky." Software, sensors, cameras, and various analytical tools work together to automatically record data and images, translate them into usable information, and then evaluate those insights. This greatly reduces the possibility of human error. Drone technology may assist farmers in making decisions in two ways, and it can also replace human labor by doing various chores in the field more accurately and quickly. The use of drones in agriculture is being hampered by a number of issues. To effectively accept and utilize drone technology's potential for revolutionizing India's agriculture industry and millions of farmers' lives, these difficulties must be overcome.

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