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Smart Farming with Drones: A New Era in Agriculture

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Drone technology, also known as Unmanned Aerial Vehicles (UAVs), is emerging as an important tool in modern agriculture by improving precision, reducing labour dependency, and supporting efficient farm management. Farmers today face many challenges such as climate variability, rising input costs, and shortage of skilled labour. In this context, drone provides a practical solution by enabling real-time crop monitoring, accurate spraying of inputs, and better decision-making based on field data analysis. The increasing importance of this technology is reflected in its field-level adoption. Krishi Vigyan Kendras (KVKs) have conducted drone demonstrations on farmers' fields covering 41,010 hectares area, benefiting 4,52,291 farmers (PIB, 2025). This indicates increasing acceptance and awareness of drone technology among farmer community. This article highlights the major applications of drone technology in agriculture along with its benefits and challenges. Along with it can help in saving time, optimizing input use, and improving crop productivity. With continued extension efforts, training, and institutional support, drone technology has strong potential to make Indian agriculture more efficient and sustainable.

Keywords: Drone technology, Precision agriculture, UAV, Smart farming, Digital agriculture

Introduction

Agriculture is undergoing a major transformation due to the adoption of modern technologies. Precision based approaches are gradually replacing traditional farming practices. Among these innovations, drone technology has emerged as a powerful tool. Drones, or UAVs, are flying devices equipped with cameras, sensors, and GPS systems that help in farm monitoring and better management (FAO, 2017). Globally, agricultural drones are now used across many countries and a wide range of crops, reflecting their growing importance in modern agriculture. In India, the increasing focus on digital agriculture and smart farming is accelerating the adoption of drones, making agriculture more efficient and sustainable (Government of India, 2026).Studies have shown that farmers are increasingly adopting drone technology due to factors such as labour shortage, economic benefits, and influence from other farmers, indicating its growing importance in modern agriculture.

Concept of Drone Technology

Drone technology in agriculture refers to the use of UAVs for collecting field data, monitoring crop conditions, and performing farm operations. These drones are equipped with advanced tools such as multispectral sensors, thermal cameras, and GPS-enabled systems. Drones are a key component of precision agriculture, which ensures efficient use of inputs

like water, fertilizers, and pesticides. By providing accurate and real-time data, drones help farmers make informed decisions related to crop production and resource management

Applications of Drone Technology in Agriculture

The major applications of drone technology in agriculture are illustrated in Figure 1, highlighting how drones are transforming farming by improving precision, saving time, and supporting better decision-making. Drones are not limited to a single task; instead, they perform multiple functions across different stages of crop production, making them a versatile tool in modern agriculture.

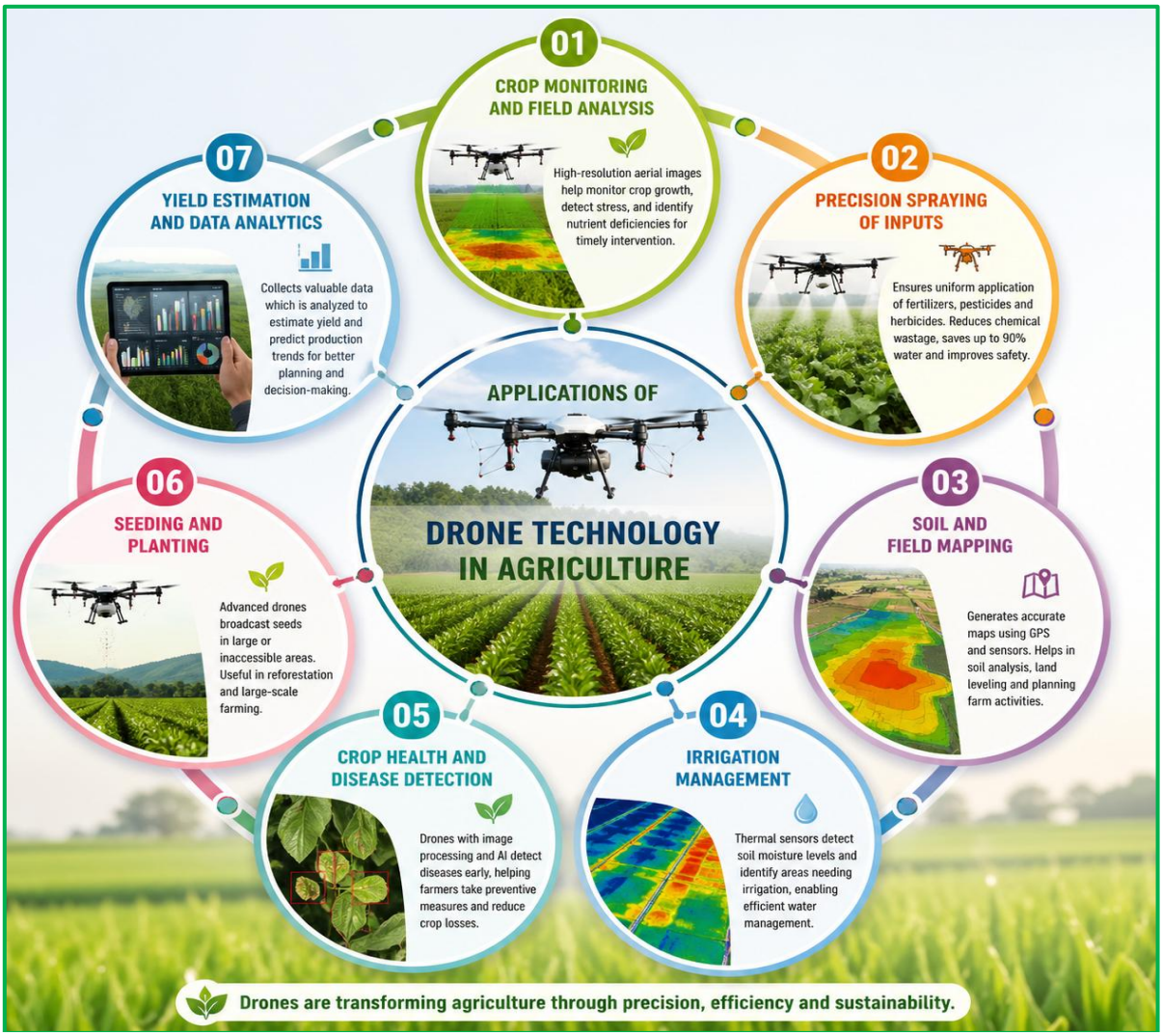

Figure 1: Major Applications of Drone Technology in Agriculture

Crop Monitoring and Field Analysis

One of the most important uses of drones is crop monitoring. Drones capture high-resolution aerial images of fields, allowing farmers to observe crop growth in detail without physically visiting every part of the field. This is especially useful for large farms. Through these images, farmers can identify crop stress, nutrient deficiencies, and uneven growth patterns at an early stage of the crop. Early detection helps in taking timely corrective measures, which ultimately improves crop health and productivity. Thus, drones make monitoring faster, more accurate.

Precision Spraying of Inputs

Drone-based spraying is emerging as a highly efficient method for applying fertilizers, pesticides, and herbicides. Unlike traditional methods, drones ensure uniform and targeted application, which reduces wastage and improves effectiveness of input. They can spray only the required areas, avoiding overuse of chemicals. Studies have shown that drone spraying can reduce water usage significantly making it highly resource-efficient. In addition, drones

minimize farmers' direct exposure to harmful chemicals, thereby improving safety and reducing health risks.

Soil and Field Mapping

Drones play a crucial role in creating accurate maps of agricultural land using GPS and advanced sensors. These maps provide valuable information about field boundaries, soil variation, and land conditions. Farmers can use this data for soil analysis, land levelling, and better planning of agricultural activities. Mapping also helps in identifying problems within the field, enabling site-specific management practices. As a result, drones support more scientific and data-driven farming (Ahmed, 2026).

Irrigation Management

Efficient water management is a major challenge in agriculture, and drones offer a practical solution. Drones equipped with thermal sensors can detect variations in soil moisture and identify areas that need irrigation. This allows farmers to apply water only where it is required, avoiding both under-irrigation and over-irrigation. Such targeted irrigation not only conserves water but also improves crop growth.

Crop Health and Disease Detection

Drone technology enables early detection of crop diseases and pest infestations through advanced imaging and artificial intelligence. By analysing images captured by drones, farmers can identify affected areas before the problem spreads across the entire field. Early identification allows timely intervention, reducing crop losses and improving yield quality. It is important in managing diseases (Guebsi *et al.*, 2024).

Seeding and Planting

Modern drones are also being used for seed broadcasting, especially in areas that are difficult to access or require quick plantation. This technology is useful in reforestation, hilly regions, and large-scale farming operations. Drone-based seeding ensures faster coverage and uniform distribution of seeds, saving both time and labour. Although still developing in many regions, this application shows strong potential for future agricultural practices (Nafar, 2025).

Yield Estimation and Data Analytics

Drones collect large amounts of data related to crop growth, plant health, and field conditions. This data can be analysed using digital tools to estimate crop yield and predict production trends. Accurate yield estimation helps farmers in planning harvesting, storage, and marketing strategies. It also supports better decision-making at both farm and policy levels. Thus, drones are not only tools for field operations but also important instruments for data-driven agriculture

Benefits and Challenges of Drone Technology

Drone technology is increasingly contributing to agricultural development by enhancing efficiency, reducing labour dependency, and supporting precise farm management. By enabling rapid crop monitoring and accurate input application, drones help improve productivity and optimize the use of resources such as water, fertilizers, and pesticides. This not only reduces operational costs over time but also promotes sustainable farming practices . In addition, real-time data generated by drones strengthens farmers' decision-making capacity, leading to more timely and informed interventions in crop management.

However, despite of these benefits, the adoption of drone technology in agriculture remains constrained by several factors. The high initial investment cost limits accessibility, particularly for small and marginal farmers. Furthermore, the lack of technical knowledge and inadequate training facilities in rural areas restrict effective utilization. Regulatory requirements and operational restrictions also pose challenges in scaling up drone usage. Additionally, the predominance of small and fragmented landholdings in India reduces the economic feasibility of individual drone ownership. Therefore, while drone technology offers significant potential to improve agricultural efficiency its widespread adoption depends on addressing these structural, economic, and institutional constraints through targeted policies, capacity building, and extension support. Research indicates that farmers' decision to adopt drones is influenced not only by their benefits but also by economic, social, and personal

factors such as labour scarcity, peer influence, and individual innovativeness (Sundar *et al.*, 2023).

Government Initiatives and Recent Developments

The Government of India has taken several important steps to promote the adoption of drone technology in agriculture. The Digital Agriculture Mission (2024) focuses on integrating advanced technologies such as drones, artificial intelligence, and big data into farming, with a financial outlay of ₹2,817 crore to support digital transformation in the agricultural sector (Government of India, 2026). In addition, the Sub-Mission on Agricultural Mechanization (SMAM) provides financial assistance to farmers and Farmer-Producer Organizations (FPOs) for purchasing agricultural drone. Government of India (2023) The government is also emphasizing capacity building through drone training and skill development programs, which aim to equip rural youth and farmers with the necessary technical skills while also creating new employment opportunities Furthermore, several state governments have initiated pilot projects for drone-based spraying and crop monitoring, demonstrating the practical benefits of this technology at the field level Together, these initiatives reflect a strong policy push towards modernizing Indian agriculture through the use of drone technology.

Future Scope of Drone Technology in Agriculture

The future of drone technology in agriculture is highly promising. The global agricultural drone market is expected to exceed USD 10 billion by 2030 (MarketsandMarkets, 2025).Integration with emerging technologies such as Artificial Intelligence, Internet of Things (IoT), and big data analytics will further enhance the effectiveness of drones in agriculture. In India, increasing awareness, government support, and technological advancements are expected to drive rapid adoption of drone technology.

Conclusion

Drone technology is revolutionizing agriculture by making it more precise, efficient, and sustainable. It enables farmers to monitor crops, apply inputs accurately, and make informed decisions based on real-time data. Although challenges such as cost and lack of awareness remain, government initiatives and technological advancements are helping overcome these barriers. With proper implementation and support, drone technology can play a significant role in improving agricultural productivity and sustainability in India. Drone technology is not just a modern tool but a powerful solution for making Indian agriculture smart, profitable, and sustainable.

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