## Chapter 1

# UAV Technology in Precision Agriculture

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### Abstract

Smart Farming leverages IoT with the use of Unmanned Aerial Vehicles (UAVs), to collect environmental data in real-time, improving crop management and precision agriculture applications. Precision agriculture employs autonomous UAVs to gather data from wireless sensor networks, particularly in places with inadequate or no established communication infrastructure. This study explores the use of unmanned aerial vehicle (UAV) technology to regulate agricultural output. It evaluates whether combining diverse sensing and control technologies—such as optical, radio frequency, near infrared, thermal, multi-spectral, hyper-spectral, LiDAR, and sonar—is practicable in smart agricultural environments. In addition to stressing the cost and small size of unmanned aerial systems (UAS), which might encourage economic growth in developing countries, the article also emphasizes the potential of drones and UAS in agriculture and the need for increasing financial investment in the farm. With the recent integration of precision agriculture sensors into UAS, operations such as field visualization, plant stress recognition, biomass calculation, weed control, stock counting, and chemical spraying may now be completed with greater effectiveness. This research attempts to give a review of the most successful techniques to have precision-based crop monitoring and pest management in agriculture fields utilizing unmanned aerial vehicles (UAVs) or unmanned aircraft.

### Keywords

UAVs, UAS, LiDAR, Precision Agriculture, Geo-ICTs, Biomass Calculation,

## 1. Introduction

Advances in Information technologies and sensor technologies, including open-source technology, smart sensors, and longer flight times, are making drones or unmanned aerial vehicles (UAVs)—once associated

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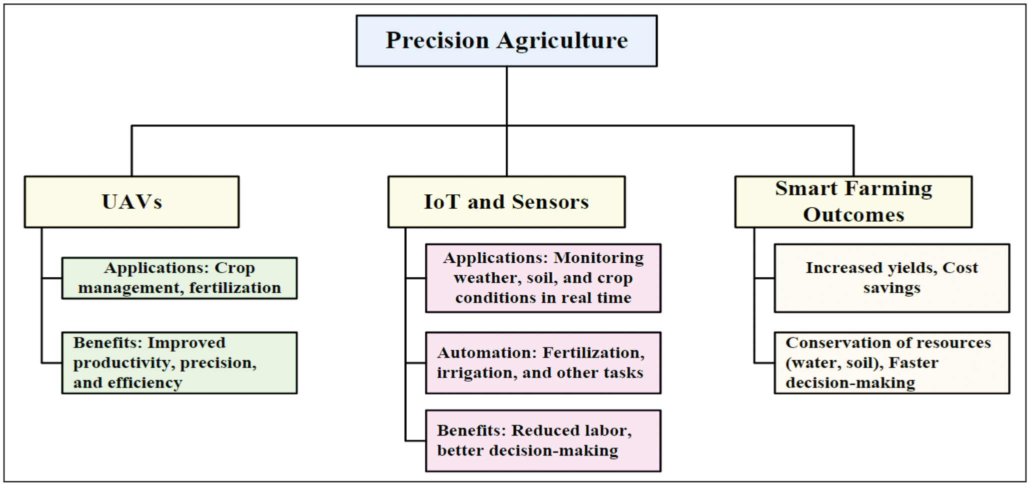


**Figure 1 Technologies in Precision Agriculture**

with military and industrial operations—more and more acceptable in agriculture [1]. With the emergence of vision-based systems, embedded electronics, and drones, precision agriculture (PA) is growing more and more popular while offering farmers with services and insights to optimize the efficiency of farming [2]. Through the use of UAVs for crop management and real-time environmental data collecting, IoT has the potential to completely transform Smart Farming. These technologies can boost yields, save costs, and accelerate decision-making, but choosing and implementing a suitable technology will be challenging to achieve widespread adoption [3]. PA has been transformed by the incorporation of cutting-edge technologies onto UAV platforms, which have reduced operating costs and increased production. However, limitations like inadequate resolution, dependency on environment, and geometrical adjustment approaches prevent widespread application [4]. In PA, the adoption of drones for fertilization, wildlife deterrence, and remote sensing functions is expanding. Additionally, they may work as mobile gateways, suggesting drone operators on the optimal conditions for airing the WiFi data successfully [5]. IoT and wireless sensors helps in monitoring weather, soil and crops in real time. They automate the tasks such as fertilization and irrigation which results into less labor intervention and also boosts the productivity. [6]. Drones are mandatory for precision management in agriculture as they can presume the degree of erosion by providing measures of conservation for both water and soil, and contribute at the stages of operational execution, planning, assessment and monitoring [7]. Figure 1 shows the precision agriculture using the technologies

## 2. Leveraging UAV Technology in Precision Farming

Industry 4.0 innovations, including IoT, AI, remote sensing, and GIS, are revolutionizing agriculture by utilizing high-resolution images, soil samples, and meteorological data to identify crop stress factors and recommend mitigation strategies [8]. Agricultural robotics-based precision agriculture has multiple advantages for increasing accuracy, optimizing productivity, and streamlining procedures. Drone integration improves dependability and accuracy in farming operations [9]. The integration of robotics, AI, big data, and IoT with information and communication technologies is expected to significantly boost the agricultural UAV industry across various agricultural sectors [10]. UAV-derived imagery enables high-accuracy ecosystem monitoring, aiding in plant identification, floral resource identification, and livestock management. It minimizes biodiversity conflicts and aids in biomass assessment, crop plant health, insect identification, soil fertility monitoring, and weed targeting [11]. UAVs enhance farm management, yields, and sustainability in agriculture, ensuring global food security through their deployment and applications [12]. UAVs can improve crop management by targeting small fields at lower altitudes, but evaluating sensing and control technologies like optical, thermal, near-infrared, and LiDAR is crucial for system range, precision, and response time [13]. UAVs and UAS are revolutionizing agriculture by reducing health risks, boosting economic development, and streamlining operations like fertilization, crop scouting, and pesticide application due to their compact design and low cost [14]. Field mapping, plant stress detection, biomass calculation, weed management, inventory counting, and chemical spraying have all been transformed by UAS technology. In addition to peripherals and sensing equipment, these systems incorporate statistical techniques, machine learning models, vegetation indices, point clouds, and additional data processing tools [15]. Identification of management zones is dependent upon satellite photography, which is cloud-free, particularly in temperate regions. An option is provided by UAVs, which generate maps of crop heterogeneity and replicate these zones by repeatedly capturing data [16]. Geographic Information and Communication Technologies (Geo-ICTs) in PA enable farmers to identify crop health concerns, using UAV-based sensing and image analysis, enabling real-time stress area identification for remedial measures like pesticides and fertilizers [17]. The detailed summary of applications and benefits of UAVs in Agriculture is provided in the table 1 below.

As agriculture grows, insufficient surveillance and uneven distribution make it more challenging to locate and diagnose insect and pest infestations. To mitigate agricultural losses and enhance crop productivity, innovative machinery—like UAVs has substituted manual labor [18]. Crop losses are caused

**Table 1 Showing the Application and Benefits of UAVs in Agriculture**

| | Applications | Benefits |
|---|---|---|
| 1 | UAVs in Agriculture | UAVs enhance farm management, yields, and sustainability in agriculture, ensuring global food security through their deployment and applications. [12] |
| 2 | Crop Management | UAVs can improve crop management by targeting small fields at lower altitudes. [13] |
| 3 | Agricultural Revolution | UAVs and UAS are revolutionizing agriculture by reducing health risks, boosting economic development, and streamlining operations. [14] |
| 4 | UAS Technology Applications | Field mapping, plant stress detection, biomass calculation, weed management, inventory counting, and chemical spraying have all been transformed by UAS technology. [15] |
| 5 | Integration of Technology | In addition to peripherals and sensing equipment, these systems incorporate statistical techniques, machine learning models, vegetation indices, point clouds, and additional data processing tools [15]. |
| 6 | Zones of Management | Identification of management zones is dependent upon satellite photography, which is cloud-free, particularly in temperate regions. [16] |
| 7 | Precision Agriculture and Geo-ICT | Enables farmers to identify crop health concerns, using UAV-based sensing and image analysis, enabling real-time stress area identification for remedial measures like pesticides and fertilizers [17]. |

by pests and insects, which additionally reduce productivity. One million negative impacts are estimated by the WHO to occur from manual pesticide spraying. In locations where labor and equipment are scarce UAVs provides a practical answer [19]. UAVs retrieve information from wireless sensor networks located on the ground, facilitating real-time monitoring and analysis in scenarios such as agricultural automation. Eliminating the need for additional infrastructure, these drones may transmit data directly to a command-and-control center [20].

## 3. Recommendations

Based on the thorough literature review on the present status of the UAV technology being used in the agricultural sector, we propose following recommendations.

- Ad hoc methods, data-intensive picture analysis, and a lack of standardized workflow are some of the drawbacks that UAVs for precision agriculture encounter. These issues can deter stakeholders and make deployment challenging.
- Collaboration between governments, research institutions, and industry is necessary for the development of UAV technology, with professional and research organizations playing a critical role in the development of human resources.
- Diverse digital standards pose a barrier to precision agriculture; they also obstruct the acceptance and growth of IoT and reduce production efficiency through the adoption of smart agriculture apps.
- Even though data security measures are more expensive, they are essential for maintaining data integrity in precision agriculture systems. Precise sensor readings allow for targeted operations, but data corruption due to infiltration poses a risk to system efficacy.
- Although unmanned aerial system (UAS) technology has the advantage of high spatial resolution, its efficacy in difficult terrain and with heavy payloads is hampered by short flight intervals and weather conditions.

## Conclusion

This study analyzes the platforms, control systems, and functions of agricultural unmanned aerial vehicles (UAVs), emphasizing how these vehicles might improve agricultural operations. In order to forecast future research in this sector, it also looks at current limitations, applications that are available, and emerging trends. UAVs can increase field management and productivity in agriculture, which is important for the world's food security. Integrated technologies can improve operations, tackling particular issues and furthering the goals of research. By employing resources like water, fertilizer, and pesticides as efficiently as possible, precision agriculture seeks to optimize productivity. Farmers can use prescription maps to identify the health needs of their crops, as research has mostly focused on vegetation indicators. This study evaluates the deployment of UAVs in agricultural operations and how widely researchers have used them. It covers technical characteristics, platforms that are available, sensors, flight planning, image registration, calibration, and correction, as well as the elements that affect precision agriculture and the derivation of data deliverables. The study intends to assist researchers and growers in choosing appropriate UAVs and techniques.

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