**Chapter 1**

# UAV Technology in Precision Agriculture

**Mansi Sahu**[1] iD **, Shailendra Thapliyal**[2] iD **and Devendra Singh**[3] iD

## 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

Biomass Calculation, Geo-Icts, Lidar, Precision Agriculture, UAS, Uavs

## 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 with military and industrial operations—more and more acceptable in agriculture [1]. With the emergence

[1]Division of Research & Innovation, Uttaranchal University, Dehradun. mansi.smile.1999@gmail.com

[2]Uttaranchal Institute of Management, Uttaranchal University, Dehradun, India. shailendra@uumail.in

[3]Uttaranchal Institute of technology, Uttaranchal University, Dehradun, Uttarakhand, India. devendrasingh0503@gmail.com

**Corresponding author:**
Email id: devendrasingh0503@gmail.com

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 function as mobile gateways, advising drone operators on the optimal conditions for transmitting WiFi data successfully [5]. By utilizing Wireless Sensor Networks and PA to collect real-time data on crop health, soil conditions, and weather patterns, IoT integration in agriculture could enhance productivity and eliminate human labor [6]. Drones are essential for precision agricultural management as they can estimate the degree of erosion, provide conservation measures for both soil and water, and contribute at the stages of planning, operational execution, monitoring, and assessment [7].

## 2. Leveraging UAV Technology in Precision Farming

Agriculture is undergoing a transformation driven by Industry 4.0 innovations like IoT, AI, remote sensing, and Geographic Information Systems (GIS). These technologies gather high-resolution images, soil samples, and meteorological data in order 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 likely to accelerate the agricultural UAV industry, which encompasses multiple agricultural fields [10]. High-accuracy ecosystem monitoring is made possible by UAV-derived imagery, which also helps identify plants, floral resources, and livestock. It minimizes the conflicts between biodiversity and pesticide input by assisting with biomass assessment, crop plant health, insect identification, soil fertility monitoring, and weed targeting [11]. UAVs offers an ecological option for farm management, boosting yields and boosting sustainability in agriculture through insights into their deployment and applications. Global food security necessitates a supply of food that is readily available [12]. Utilizing UAVs to target small crop fields at lower altitudes and manage challenging scenarios can enhance crop management. For system range, precision, and response time, evaluation of sensing and control technologies—such as optical, thermal, near-infrared, and LiDAR—is crucial [13]. The compact design and low cost of UAVs and Unmanned Aircraft Systems (UAS) are transforming agriculture. These devices lessen health hazards, boost economic development, and ease farmers' workloads by streamlining operations like fertilization, crop scouting, and pesticide application [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]. 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 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.

## ORCID iDs

Mansi Sahu [iD] https://orcid.org/0009-0003-2859-0620
Shailendra Thapliyal [iD] https://orcid.org/0009-0002-6212-2057
Devendra Singh [iD] https://orcid.org/0000-0002-4062-0576

## References

1. Puri V., Nayyar A., Raja L. (2017). Agriculture drones: A modern breakthrough in precision agriculture. *Journal of Statistics and Management Systems*, *20*(4), 507–518.
2. deOca A. M., Flores G. (2021). The AgriQ: A low-cost unmanned aerial system for precision agriculture. *Expert Systems with Applica-tions*, *182*, 115163.
3. Tsouros D. C., Bibi S., &Sarigiannidis P. G. (2019). A review on UAV-based applications for precision agriculture. *Information*, *10*(11), 349.
4. Delavarpour N., Koparan C., Nowatzki J., Bajwa S., Sun X. (2021). A technical study on UAV characteristics for precision agriculture applications and associated practical challenges. *Remote Sensing*, *13*(6), 1204.
5. García L., Parra L., Jimenez J. M., Lloret J., Mauri P. V., Lorenz P. (2020). DronAway: A proposal on the use of remote sensing drones as mobile gateway for WSN in precision agriculture. *Applied Sciences*, *10*(19), 6668.
6. Shafi U., Mumtaz R., García-Nieto J., Hassan S. A., Zaidi S. A. R., &Iqbal N. (2019). Precision agriculture techniques and practices: From con-siderations to applications. *Sensors*, *19*(17), 3796.
7. Rachman L. M., Purnomo M. B., Purwakusuma W., &Rachman R. A. (2019 December). The role of drones for supporting precision agricultural management. In Sixth International Symposium on LAPAN-IPB Satellite (Vol. 11372, p. 1137202). SPIE.
8. KIRKAYA A. (2020). Smart farming-precision agriculture technologies and practices. *Journal of Scientific Perspectives*, *4*(2), 123–136.
9. Shahrooz M., Talaeizadeh A., &Alasty A. (2020 November). Agricultural spraying drones: Advantages and disadvantages. In *2020 Virtual Sym-posium in Plant Omics Sciences (OMICAS)* (pp. 1–5). IEEE.
10. Kim J., Kim S., Ju C., Son H. I. (2019). Unmanned aerial vehicles in agriculture: A review of perspective of platform, control, and applications. *Ieee Access*, *7*, 105100–105115.
11. Librán-Embid F., Klaus F., Tscharntke T., Grass I. (2020). Unmanned aerial vehicles for biodiversity-friendly agricultural landscapes-A systematic review. *Science of the total environment*, *732*, 139204.
12. Norasma C. Y. N., Fadzilah M. A., Roslin N. A., Zanariah Z. W. N., Tarmidi Z., Candra F. S. (2019 April). Unmanned aerial vehicle applications in agriculture. In *IOP Conference Series: Materials Science and Engineering* (Vol. *506*, p. 012063). IOP Publishing.
13. Sinha J. P. (2020). Aerial robot for smart farming and enhancing farmers' net benefit. *Indian Journal of Agricultural Sciences*, *90*(2), 258–267.
14. Rahman M. F. F., Fan S., Zhang Y., Chen L. (2021). A comparative study on application of unmanned aerial vehicle systems in agricul-ture. *Agriculture*, *11*(1), 22.
15. Hassler S. C. Baysal-Gurel F. (2019). Unmanned aircraft system (UAS) technology and applications in agricul-ture. *Agronomy*, *9*(10), 618.
16. Rasmussen J., Azim S., Boldsen S. K., Nitschke T., Jensen S. M., Nielsen J., Christensen S. (2021). The challenge of reproducing remote sensing data from satellites and unmanned aerial vehicles (UAVs) in the context of management zones and precision agriculture. *Precision Agricul-ture*, *22*, 834–851.
17. Raj R., Kar S., Nandan R. Jagarlapudi A. (2020). Precision agriculture and unmanned aerial Vehicles (UAVs). *Unmanned aerial vehicle: Applications in agriculture and environment*, 7–23.

18. Velusamy P., Rajendran S., Mahendran R. K., Naseer S., Shafiq M., Choi J. G. (2021). Unmanned Aerial Vehicles (UAV) in precision agriculture: Applications and challenges. *Energies*, *15*(1), 217.
19. Mogili U. R., Deepak B. B. V. L. (2018). Review on application of drone systems in precision agriculture. *Procedia computer sci-ence*, *133*, 502–509.
20. Caruso A., Chessa S., Escolar S., Barba J. López J. C. (2021). Collection of data with drones in precision agri-culture: Analytical model and LoRa case study. *IEEE Internet of Things Journal*, *8*(22), 16692–16704.