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Role of Drones in Precision Crop Monitoring and Smart Pesticide Spraying

Sadras Bhavana[1*], D. Sheshanka[2], M.P. Bharath[3]

[1]Assistant Professor & Head, Dept. Of Crop Physiology, School of Agriculture Kaveri University
[2]Assistant Professor, Dept. of Plant Pathology, School of Agriculture, Kaveri University
[3]Assistant Professor, Dept. of Entomology, School of Agriculture, Kaveri University

*Corresponding Author
Sadras Bhavana*

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INTRODUCTION

Agriculture is one of the prime sectors where modern technologies are being integrated with the motive of enhancing productivity, improving resource-use efficiency, and ensuring long-term sustainability. Within this changing scenario, drones have emerged as one of the most powerful and versatile tools for precision farming. Equipped with high-resolution cameras, advanced sensors, and automated spraying systems, these unmanned aerial vehicles enable farmers to monitor the real-time health of their crops and detect early signs of stress caused by nutrient deficiency, pest attack, disease infection, or water imbalance. Besides enhancing farm efficiency, the adoption of drone-based solutions supports the reduction of chemical risks, minimizes farmers' exposure to pesticides, lowers labor use, and encourages the application of eco-friendly agricultural practices. Drones will, therefore, be integral components of smart agriculture, allowing farmers to make informed decisions on the management of their crops.

2. Drones in Precision Agriculture

Precision agriculture is based on the principle of applying the right input at the right place, in the right amount, and at the right time to optimize resource utilization and improve crop performance. Drones strengthen this approach immensely through a multitude of functions and capabilities.

High-resolution aerial imagery

Drones capture high-resolution aerial photographs and videos, enabling farmers to visualize complete fields from above and showing patterns of crop stress, soil issues, waterlogging, and overall field variability with great clarity.

Accurate field health insights

The drones, fitted with multispectral, hyperspectral, or thermal sensors, provide highly detailed insights into crop health indices such as NDVI to detect nutrient deficiency, pest infestation, disease symptoms, and moisture stress before they become visible to the naked eye.

Targeted spray delivery

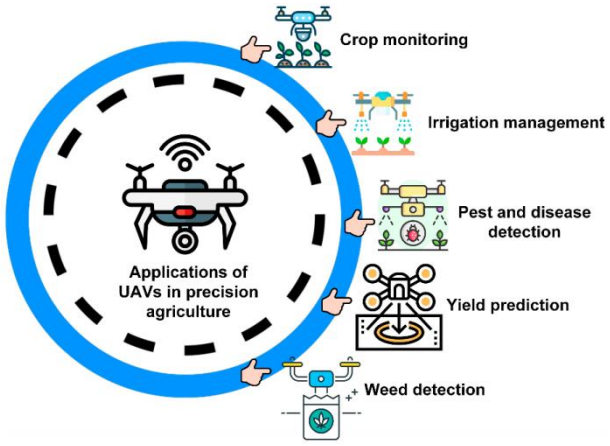
The drone-mounted spraying systems apply pesticides, herbicides, or micronutrients precisely at the affected areas, treating only that portion of the field that is actually required. This minimizes chemical usage and reduces environmental contamination.

Reduced input costs

Drones have helped farmers assess the actual need of the crop accurately and avoid excessive application of inputs like fertilizers, pesticides, and water, thus reducing the total cost of cultivation.

Automated data collection

Drones automate field data gathering, eliminating the need for manual scouting, enabling farmers to access updated information more quickly, efficiently, and with higher accuracy to support timely decision-making.



3. Drone-Based Precision Crop Monitoring

3.1 Sensors and Imaging Systems

- ✓ Drones can be fitted with various advanced sensors, which help in accumulating really essential information on the state of crops highly accurately and efficiently.
- ✓ RGB cameras capture images in the visible spectrum, allowing farmers to visually assess overall conditions of the field, plant growth, and surface anomalies.
- ✓ Multispectral sensors provide details on plant vigor and nutrient status by measuring vegetation indices such as NDVI, NDRE, and SAVI, which help in highlighting early signs of stress.
- ✓ These variations in canopy temperature detected by thermal cameras allow farmers to recognize signs of water stress, irrigation problems, or early disease development.
- ✓ LiDAR systems produce highly accurate 3D maps of crop fields that help estimate biomass, understand canopy structure, and analyze variability in plant height and density.

3.2 Applications of Crop Monitoring

- ✓ The real-time data obtained from flights of drones allows farmers to monitor various aspects of crop health and field conditions much more effectively.
- ✓ Farmers can rapidly locate pest and disease outbreaks that can help them take timely control measures before the damage spreads.
- ✓ Early detection of nutrient deficiencies by drones helps in effective corrective fertilizer application to improve plant health.
- ✓ They also help in locating weed patches for timely, selective management to minimize the use of herbicides.
- ✓ By analyzing aerial imagery, farmers can visually recognize growth patterns across various sections of the field and realize how much variation exists due to soil or management practices.
- ✓ Drones can detect soil moisture variability for better irrigation time scheduling and reduction of water wastage.
- ✓ They help in monitoring crop maturity and yield variation for better harvesting decisions and yield estimation.
- ✓ Diagnosing such conditions early and accurately reduces yield losses, improves efficiency of inputs, and supports cost-effective management of crops.

3.3 Vegetation Indices Used

- ✓ Several vegetation indices based on drone-based sensor data facilitate a more scientific assessment of plant health.

- ✓ NDVI is widely used to assess plant health, chlorophyll content, and general vigor.
- ✓ Particularly, NDRE is effective for the detection of early nutrient stress related to nitrogen deficiency during mid to late growth stages.
- ✓ Application SAVI: To monitor the states of crops in areas where vegetation is sparse, reflecting soil brightness.
- ✓ Thermal Index provides information on heat stress and irrigation needs through the analysis of canopy temperature differences across the field.

4. Smart Drone-Based Pesticide Spraying

4.1 Key Features of Spraying Drones

Modern spraying drones are fitted out with bespoke components, which ensure efficiency and accuracy in applying the chemical. They come fitted out with a chemical tank that can range in capacity from 10 to 30 liters, which enables them to cover large areas in one flight. Application is uniform due to a pressure pump and a controlled flow system that regulates the spray output. Ultra-fine atomizing nozzles produce uniform droplets that improve the effectiveness of pesticide coverage. Advanced GPS navigation and autonomous flying systems enable the flying robot to follow the predefined routes with very high precision. The built-in anti-drift mechanisms minimize chemical drift, ensuring that the spray reaches its intended target area only.

4.2 Smart Spraying - Benefits

Drone-based spraying comes with several advantages over the traditional methods. It allows for precision application, ensuring only the needed area of the field is treated with chemicals. This technology minimizes the use of chemicals by 30–60%, reducing input cost and limiting environmental pollution. Spraying from drones improves farmers' safety dramatically, as it eliminates direct exposure to dangerous pesticides. It ensures uniform coverage, delivers consistent droplet size, and proper distribution across the crop canopy. Drones can easily access some difficult terrains, like waterlogged fields, steep slopes, and tall-standing crops, which are difficult to manage manually. Drones also make the process highly time-efficient, spraying 10–30 acres per hour depending on the tank capacity and model.

4.3 Types of Spray Applications

Drones support various application modes in order to fit different field needs. Spot spraying enables the drone to target only the infected patches, thus minimizing unnecessary applications of chemicals. Variable-rate spraying works by automatically adjusting the spray volume based on crop health data to achieve optimum input use. Swarm spraying involves multiple drones flying and operating together in coordination to complete large farms quickly and efficiently. This technology works well for large-scale agriculture.

5. Benefits to Farmers

- ✓ Drone technology offers several direct and indirect benefits to farmers in improving productivity while reducing operational challenges.
- ✓ Drones enable better decision-making with real-time, high-resolution data about crop conditions and hence allow the farmer to take timely corrective measures.

- ✓ They greatly cut down on inputs since fertilizers, pesticides, and irrigation water can be applied only when and where they are required, thus avoiding wastage.
- ✓ Early identification of nutrient deficiencies, pest attacks, and moisture variability by drones helps farmers increase their productivity and improve the quality of the crops.
- ✓ The automation provided by drones also decreases reliance on manual labor, which makes field operations simpler, quicker, and more effective.
- ✓ Drone-based practices promote sustainable and environmentally friendly farming by cutting down excessive chemical use and reducing soil and water contamination.

In summary, the adoption of drones makes farming more profitable by enabling farmers to generate better yields with lower production costs.

6. Challenges in the Adoption of Drones

- ✓ Despite all those gains, farmers still face several challenges to widespread drone adoption.
- ✓ A major constraint is the high initial investment; quality agricultural drones and multispectral sensors are often expensive for small and marginal farmers.
- ✓ Another challenge lies in the fact that trained operators are needed, and DGCA-approved certification requires time, development of skills, and regulatory compliance.
- ✓ Drone operations are also considerably dependent on battery capacity, and consequently, limited flight duration restricts the area to be flown in one mission.
- ✓ These tools are sensitive to wind and weather conditions; therefore, any adverse climatic situations may delay operations or affect the accuracy of the data.
- ✓ Farmers also have to consider legal and airspace regulations, No-Fly Zones, and permissions that may be required for certain operations.

Moreover, effective use of drones also assumes some level of digital literacy, notably in the interpretation of maps, vegetation indices, and any analytic reports developed through drone software.

7. Policies and Government Support in India

- ✓ In tandem, the Indian government has introduced many policies and schemes to foster the safe and productive use of drones in agriculture.
- ✓ Licensing, operation guidelines, safety protocols, and airspace rules are clearly enlisted in the DGCA Regulations for agricultural drones from 2021 onwards.
- ✓ Farmers, FPOs, and CHCs are eligible for subsidies, sometimes up to 75%, under the Sub-Mission on Agricultural Mechanization for the purchase of drones for their agricultural requirements.

- ✓ Drone Shakti Yojana will facilitate drone-based startups through financial assistance, training programs, and incubation support to young entrepreneurs.
- ✓ KVKs are playing a crucial role in this regard by demonstrating and conducting workshops, hands-on training, and capacity-building programs for farmers to expose them to drone operations.

Moreover, the government provides subsidies toward the creation of custom hiring centers, where farmers can rent drones at a lower price than buying them.

8. Future Prospects

The future of drone technology in agriculture, therefore, looks bright, with rapid improvements expected within the next few years. AI-enabled automated disease and pest detection will soon feature on drones, enabling instant diagnosis and intervention without manual scouting. Integration with IoT-based soil moisture probes, weather sensors, and farm monitoring systems shall enable real-time data-driven decision-making. Ongoing innovation will further increase payload capacity and battery technology, enabling the spraying of larger fields with a single mission. Large-scale farming will be faster and more efficient with swarms of drones, meaning several drones coordinated to operate together. Fully autonomous spraying missions with one click will further simplify the operations for farmers.

Big data analytics and machine learning will integrate drone-generated data into advanced decision-support systems that help farmers attain optimal yields with high precision.

CONCLUSION

Drones are revolutionizing precision agriculture by granting farmers powerful tools to monitor crops with an unprecedented degree of precision, as well as applying pesticides with great accuracy. This innovation not only enhances productivity but also contributes to sustainable agriculture by reducing chemical use, improving the efficiency of inputs, and protecting both the environment and farmers. Thus, drone technology has become fairly affordable, more accessible, and widely supported through government initiatives; hence, it is expected to become a core component within the future smart farming system. Equipping farmers with modern tools and data-driven insights, drones have the potential to significantly raise agricultural productivity, ensure environmental safety, and build economic resilience in the long term.

REFERENCES

Hafeez, A., Husain, M. A., Singh, S. P., Chauhan, A., Khan, M. T., Kumar, N., ... & Soni, S. K. (2023). Implementation of drone technology for farm monitoring & pesticide spraying: A review. *Information processing in Agriculture*, *10*(2), 192-203.

Devi, G., Sowmiya, N., Yasoda, K., Muthulakshmi, K., & Balasubramanian, K. (2020). Review on application of drones for crop health monitoring and spraying pesticides and fertilizer. *J. Crit. Rev*, *7*(6), 667-672.

Borikar, G. P., Gharat, C., & Deshmukh, S. R. (2022, October). Application of drone systems for spraying pesticides in advanced agriculture: A Review. In *IOP Conference Series: Materials Science and Engineering* (Vol. 1259, No. 1, p. 012015). IOP Publishing.

Guebsi, R., Mami, S., & Chokmani, K. (2024). Drones in precision agriculture: A comprehensive review of applications, technologies, and challenges. *Drones*, *8*(11), 686.

Daniel Lawrence, I., Pavitra, A. R. R., Karu, R., & Saravanan, M. P. (2025). An Advanced Application of UAV–Drone Technologies in Precision Agriculture for Seed Dropping, Fertilizers and Pesticides Spraying and Field Monitoring. *Computer vision in smart agriculture and crop management*, 139-157.