

Drones in Pest Management

Madhurima Vinod¹ and Ishwari. G. Hiremath²

¹Assistant Professor, Department of Entomology, KLE College of Agricultural Sciences, Tenikolla (Affiliated to UAS, Dharwad)

²Assistant Professor, Department of Plant Pathology, KLE College of Agricultural Sciences, Tenikolla (Affiliated to UAS, Dharwad)

Corresponding Email: madhu19pvinod@gmail.com

Agriculture is the backbone of Indian economy providing a livelihood to nearly 55 % of the population. It remains a vital part of our country's GDP even with the rise of industrial and service sectors. The agriculture industry provides food and fibre and plays a significant role in employment, cultural practices and socio-economic development. However, Indian agriculture faces numerous challenges including scarcity of water, inadequate infrastructure and machinery, climate changes, pest management, less adoption of modern technologies, market access and pricing issues, socio-economic issues etc which hinders the sustainability and productivity. To address these challenges, a multi-faceted approach is required which includes promotion of sustainable farming practices, adoption of modern technologies, higher investment in infrastructure and machinery purchase along with government intervention in regulating interest rates and improving market access.

One of the crucial aspects of agriculture is pest management, which involves various strategies to control pest populations and minimize their impact on crops. It aims to protect the crops from harmful organisms that directly results in reduced yield and quality. However, the prevalent conventional methods of pest management such as manual scouting and blanket spraying are often inefficient, costly, and environmentally damaging. Therefore, there is a need for innovative and effective tools that can enhance pest detection and control, while minimizing negative impacts. One such tool is drone technology, which refers to the use of unmanned aerial vehicles (UAVs) or remotely piloted aircraft systems (RPAS) for various agricultural purposes.

UAVs are aircraft that operate without onboard crew or passengers. They can function as automated 'drones' or be controlled remotely as piloted vehicles (RPVs). Originally developed for military reconnaissance and combat operations since World War 1, the rapid technological advances have enabled the evolution of drones towards diverse civilian and commercial applications. Drones are now providing innovative solutions for sectors like agriculture, infrastructure, transportation and disaster response. In agriculture, are various functions of drone tools like crop supervising, crop quantity and verve considerations, crop record, production of recommendation records,

meticulousness drenching, and examination of farm infrastructure, high declaration mapping and examination of individual areas, crop scratch measurement & insurance claim forensics. This imaging technique can help with overall field organization, giving results in real-time determining where precise crops may need much water, fertilizer, soil or pesticides. Drones can be equipped with cameras, sensors, and dispensers, and can fly over crop fields and orchards, collecting and analysing data, and applying treatments in a precise and timely manner. Drones can offer several benefits for pest management such as improving accuracy, reducing time, saving costs, and increasing sustainability. Drones are becoming increasingly popular in the agriculture sector in India and offers a wide range of benefits to farmers, such as improved efficiency, enhanced crop yields, reduced costs, and improved accuracy.



The use of drone technology in agriculture has become more popular in the Indian context. That's when the question of why to adopt drone technology in agriculture arises. Farming is facing many economic challenges in terms of productivity and cost effectiveness, and increasing labour shortage. External factors like weather, soil conditions, and temperature also play a critical role in farming. Agriculture drone empowers the farmer to adapt to specific environments and make mindful choices accordingly. According to experts, the predicted world population will be 9 billion by 2050. Agricultural consumption is also said to increase simultaneously by nearly 70%. Drone technology, equipped with artificial intelligence (AI), machine learning (ML), and

remote sensing features, is rising in demand because of its advantages.

The best-known applications of drone technology in agriculture are irrigation monitoring, crop damage assessment, crop health monitoring and surveillance, soil analysis, monitoring field conditions, seeding and planting, crop spraying and spot spraying, drone pollination etc.

Monitoring irrigation:

Drones equipped with thermal and multispectral sensors provide critical insights into field moisture levels. As a result, farmers can identify dry patches, over-irrigated zones, leaks or system failures etc. Moreover, drones reduce manual labour and allow irrigation decisions to be based on data, not guesswork. The main application of drone-based irrigation is Moisture mapping. Thermal drones detect temperature variations in plants and soil, revealing where water is insufficient or excessive. This allows for zone-specific irrigation. Drones offer real-time monitoring with live feedback on crop hydration which helps farmers to adjust irrigation schedules instantly and avoid under- or over-watering. Using drone imaging, farmers can easily spot malfunctions in drip or sprinkler systems, improving system performance. Paired with smart irrigation systems, drone data helps automate watering with scientific accuracy, saving water and improving growth. With application of drone technology in irrigation monitoring, upto 40 % water can be saved, faster diagnosis of irrigation related problems is possible, crops grow healthy with consistent growth, time is saved effectively, the waste of water and energy is reduced.

Crop damage assessment:

The key advantage of using drones for damage assessment in agriculture includes rapid deployment and data collection. Drones can be deployed quickly after a pest or disease incidence, allowing for immediate data collection. This rapid response is crucial for timely decision-making and initiating recovery efforts. Drones are able to capture high-resolution images that provide detailed information about crop conditions. This level of detail is essential for accurately assessing damage and planning recovery strategies. Drones can cover large areas in a relatively short amount of time, providing comprehensive assessments of extensive agricultural fields. This is particularly useful in large-scale farming operations. Compared to traditional methods, drones offer a cost-effective solution for damage assessment. They reduce the need for extensive manual labor and minimize the time required for on-ground inspections. The data collected by drones is highly accurate and can be analyzed using advanced algorithms and software. This accuracy is critical for insurance claims and effective disaster

recovery planning. The major plus point of drone technology is that drones can assess crop damage without physically entering the fields, reducing the risk of further damage to crops and soil.

Crop health monitoring and surveillance:

Modern agricultural drones rely on a combination of hardware and software technologies to deliver actionable insights. Unlike standard cameras that capture visible light, multispectral and hyperspectral sensors on drones collect data across multiple wavelengths beyond human vision—such as near-infrared (NIR) and red-edge bands. These spectral bands are sensitive to plant physiological parameters including chlorophyll content, water stress levels and disease presence. By analyzing this data through vegetation indices like NDVI (Normalized Difference Vegetation Index), farmers can identify stressed or diseased plants early before symptoms become visible. This early detection enables timely interventions that can save crops and reduce chemical use. Thermal imaging cameras detect temperature variations across the crop canopy. Since plant transpiration regulates leaf temperature, thermal data can reveal water stress conditions not evident through visual inspection. Drones equipped with thermal sensors help optimize irrigation schedules by pinpointing areas experiencing drought stress or inefficient water distribution. LIDAR (Light Detection and Ranging) sensors emit laser pulses to measure distances from the drone to the ground or canopy surfaces. This technology helps create accurate 3D maps of field topography and crop structure. LIDAR data enables precision in planting density analysis, biomass estimation etc. Raw data collected by drones require processing to transform into useful information. AI algorithms analyze imagery to detect patterns related to pests, nutrient deficiencies, or growth irregularities. Machine learning models improve over time by learning from new datasets, enhancing prediction accuracy. Cloud-based platforms allow farmers to access processed results remotely through smartphones or computers. Integration with farm management systems streamlines decision-making and operational planning.

Soil analysis:

Drone soil analysis refers to the use of drones to monitor soil's nutrient levels, moisture content, and more. The ideal levels of nutrients, salinity, and moisture will vary depending on the crop in question, but the balance must be tracked closely. The drone survey allows farmers to obtain information about their land's soil conditions. Multispectral sensors allow seizing data useful for seed planting patterns, thorough field soil analysis, irrigation, and nitrogen level management. Digital soil mapping refers to "the creation and population of spatial soil information systems by the use of

field and laboratory observational methods, coupled with spatial and non-spatial soil inference systems. It helps farmers to predict soil classifications or properties from gathered data using an algorithm. These samples can then be used to better understand the soil landscape.

Seeding and planting:

Drone planting is a newer technology and not as widely used, but some firms are experimenting with drone planting. Planting with drones means very hard to reach areas can be replanted without endangering workers. Drone seed technology involves the use of drones equipped with specialized payloads capable of carrying seeds, fertilizers, and even soil amendments. These drones are pre-programmed with flight paths and dispersal patterns, enabling precise and targeted distribution across the intended area. The intention behind this precision is to maximize seed germination rates and minimize wastage, thus enhancing the overall effectiveness of reforestation or land restoration initiatives. The meaning of drone seeding extends beyond simply planting trees. It embodies a shift towards more efficient, scalable, and environmentally conscious methods of ecological restoration. The implication is profound, offering a tool to combat deforestation, mitigate climate change, restore biodiversity, and enhance ecosystem services on a global scale. The denotation of ‘seeding’ here is not just about placing seeds in the ground; it’s about initiating a process of ecological renewal and fostering sustainable landscapes for future generations.

Crop spraying and spot spraying:

The use of UAVs for pesticide spraying can be beneficial for reducing human contact with chemicals, improving the performance of spraying operations, and avoiding the presence of chemicals outside designated areas. Drones are able to cover large areas of farmland quickly and accurately, while minimizing the risks associated with human exposure to pesticides. Furthermore, the use of drones in pesticide spraying has been found to reduce the amount of pesticide needed, resulting in cost savings and decreased environmental impact. Drones can spray chemicals like fertilizers and pesticides based on the spatial variability of crops and fields, and the amount of chemicals can be adjusted depending on the crop conditions or the severity of the pest attack. Heavy lift UAVs are required for large-scale spraying, providing accurate, site-specific application for crop fields. By detecting pest hotspots and enabling variable rate application of pesticides, drones can potentially reduce the amount of pesticide lost to drift and minimize its impact on neighbouring ecosystems and human health.

Limitations of Drone technology in agriculture:

Drones are opening up the skies to farmers who want better ways to monitor their crops. Although flying a drone over a field is less labor-intensive than walking through one, use of drone in precision agriculture still takes too much time and effort for farmers to use. There are also some challenges that may hinder the adoption of drone technology, such as fear of job loss, lack of knowledge and training, cost, and regulatory barriers. Following are few of the disadvantages of drones:

- It requires basic knowledge and skills to operate the agriculture drones.
- Most of the drones have less flight time and covers less area. Drones having long flight time and long range are costlier.
- Drone shaving more features are also more expensive.
- Need to obtain government clearance in order to use it.
- It uses same air space as commercial aircrafts and hence may interfere with manned aircrafts if it comes in their flight path.
- It is difficult to fly them in extreme conditions.
- Flight Time and Flight Area.
- Heavy Cost for Good Feature Drones.
- Federal Laws.
- Weather Dependent etc

Conclusion:

The Indian government is actively promoting the use of drones in agriculture, especially for crop assessment, digitization of land records, and spraying of insecticides and nutrients. The government has announced the National Drone Policy and the Drone Rules 2021, which aim to make it easier for people and companies to own and operate drones in the country. The government has also launched the Kisan Drone Scheme, which provides financial assistance to institutions, individual farmers, and entrepreneurs to procure and use drones for agricultural purposes. Drone technology is a game-changer for the agriculture sector in India, as it can provide a range of benefits to farmers, such as improved efficiency, enhanced crop yields, reduced costs, and improved accuracy. However, there are many challenges in the adoption of drone technology in the Indian context. There is a need for more efforts and initiatives to overcome these challenges, and to create a favourable and enabling ecosystem for the use of drones in agriculture. Drones can be a powerful tool for transforming Indian agriculture, and ensuring the country’s food security and prosperity.

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