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# Drones - Applications in Agriculture

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**Abstract**

Agriculture sector is now facing several challenges, among which, the scarcity of labour, increasing cost of production, environmental degradation etc., are very important. Furthermore, India's population is expected to reach 1.64 billion by 2050 and it is required to produce up to 333 million tonnes of food grains in near future. In this context, information and communication technologies (ICT) driven tools and solutions can help people to make better decisions. Among many emerging technologies which can provide solutions, unmanned aerial vehicles (UAVs), often known as drones is one of the most recent innovation. It is also a non-human centric, transparent, evidence-based technology. It can save labour while also achieving social distancing norms during COVID 19 and national lockdown. In this article, an effort was made to synthesize available information on multiple uses of drones in Agriculture.

## 1. Introduction

Farmers are now facing diverse problems in Agriculture. Climate change, soil quality, prevalence of weeds, insects, population growth, urbanization and deteriorated environment have all been identified as global concerns. Climate change is now having a major impact on food security and more than 815 million people are chronically hungry and among them 64 % are situated in Asia (Pathak et al., 2020). Adoption of modern technologies in agriculture, such as the use of drones or unmanned aerial vehicles (UAVs) can significantly enhance risk and damage assessments and revolutionize the way we prepare for and respond to disasters that affects the livelihood of vulnerable farmers and the country's food security (FAO, 2018). Drone is frequently utilized in farms to help the farmers as a part of "Precision Agriculture" to modernize farming in developed countries. Within a few years, drones will become more common in both large and small farms in developing countries too. Modern farmers have already started using high-tech solutions such as UAVs for monitoring and forecasting in agriculture. Drones can collect data on crop yield, livestock health, soil quality, nutrient assessments, weather and rainfall patterns, and other aspects. This information is then utilized to produce a more accurate map of any existing problems, as well as remedies based on highly dependable data. Goldman Sachs predicts that the agriculture sector will be the

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second largest user of drones in the world with in next five years (FAO, 2017).

**Figure 1: Remotely controlled or autonomous drone**

## 2. Definition, History and Basic Components of Drone

A drone, in technological terms, is an unmanned aircraft. They are more formally known as unmanned aerial vehicles (UAVs) or unmanned aircraft systems (UASes) weighing up to 2-20 kg. Essentially, a drone is a flying robot that can be remotely controlled or fly autonomously through software-controlled flight plans in their embedded systems, working in conjunction with onboard sensors and GPS. Concept of Drones have come into existence for the first time in 1849, when Austria attacked Venice with unmanned balloons laden with explosives (www.interestingengineering.com). During World War I, the Hewitt-Sperry Automatic Airplane, also known as the "flying bomb," flew for the first time on September 12, 1917, demonstrating the concept of an unmanned aircraft. According to numerous unreferenced sources, the first known use aerial application in agriculture, was in 1906 by John Clervaux Chaytor, who used a hot air balloon with moveable tethers to scatter seeds over a drowned valley bottom in Wairau in New Zealand on the family farm "marshlands". Soon after, in 1921, the US Agriculture Department and the US Army Signal Corps research station in Ohio used a plane for crop dusting (Johnson., 2002). Drones have a wide range of applications, including photography, agriculture, and military applications, but their primary functions are flight and navigation. Drones have a power source, such as a battery or fuel, which allows them to fly. The frame of a drone is typically made of light weight, composite materials, to reduce weight and increase maneuverability during flight. Drones require a controller, which can be launched, navigated, and landed remotely by an operator. Wi-Fi and radio waves are used by controllers to communicate with the drone. Component of agricultural drones include

- Frames
- Controller Systems
- Propulsion Systems
- Camera Systems
- Navigation Systems
- Batteries (power systems)
- Other Components (Wires, connectors, carry cases, sprayers, and sprinklers)

There are different kinds of unmanned aerial vehicles available and can be categorized into the following groups:

1. Fixed wing.
2. Rotary wing.
3. Tethered vehicle.
4. Lighter-than-air (LTA).

There are some differences between drone and satellite i.e., Drones can take pictures with a resolution of a few cm per pixel, whereas commercial satellites have a resolution of 50 cm per pixel. Because drones can fly below the clouds, they can capture images with higher quality and precision in real time, but the presence of cloud affect the satellite imagery. A satellite, after all, only takes photos once a week or once a month.

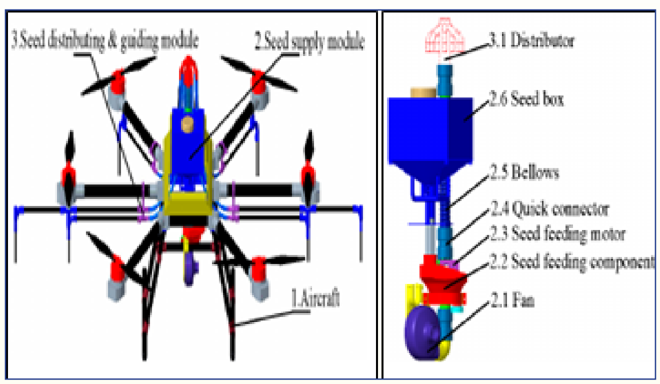



**Figure 2: Agricultural drone with their different components**

## 3. Application of Drones in Agriculture

Drones can be used to monitor any type of crop in any location. Integrating drone technology can boost up crop yields, save time, make land management more sustainable and improve long-term performance.

**A. Soil and field analysis**

Drones equipped with remote sensing cameras collect data from the ground with the help of electromagnetic spectrum to analysis the soil and field. Different elements reflect different range of wavelengths, which can be used to distinguish between them. Drones gather raw data and use algorithms to transform it into useful information. As a result, they can be used in a variety of farming applications, such as monitoring the following parameters:

- ➢ Crop health: damage made by pests, nutrient deficiencies, color change due to pest infection.
- ➢ Vegetation catalogues: leaf area, treatment effectiveness, phenology, yield.
- ➢ Plant growth: plant height, LAI and plant density.
- ➢ Plant inspection: plant size, field statistics, stand number, compromised field, planter skips
- ➢ Water requirements: water requirement according to climatic situation, water-stressed parts of the field/ orchard in need of watering
- ➢ Soil investigation: nutrition concentration in plant, nutrient availability for plant nutrient management

This information aids farmers to determine the most efficient planting, crop management and soil management practices.

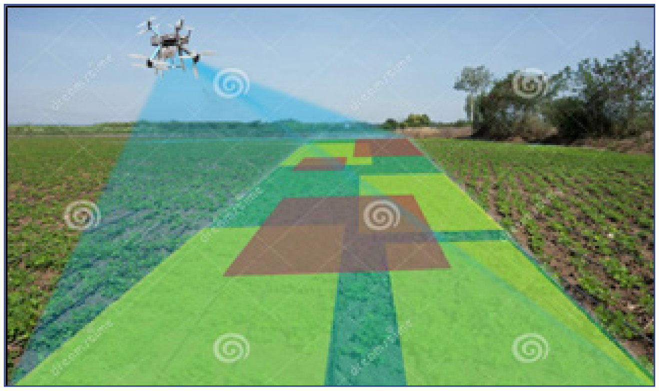


**Figure 3: Soil analysis through drone**

**B. Planting of seed from air**

Every year, about 15 billion trees are cut down for horizontal agricultural growth, mining and specially for urban sprawl (Erin stone, 2017). However, we can quickly afforest using drone-seeders. These drones use a pneumatic firing device that shoots seed pods deeper into the soil in some areas, such as in hilly terrain or mangrove forests. Two flying drones can plant up to 40,000 seeds into the ground in a day. A drone in just ten minutes can plant equal to the average human can plant. It can achieve an emergence rate of 90 % and decrease planting costs by 85%. In India, the first drone-seeding trial took place on June 5, 2017, on the banks of the Pinakini River in the Gauribidanur area of Karnataka. A group of scientists from the Indian Institute of Science (IISc Bangalore) hopes to turn a 4000-ha area in the Doddaballapur hill range north of the city green and into the forests.

**Figure 4: Sideview of a drone with its seeding mechanism**

**C. Spraying operation in agriculture**

Spraying chemicals to kill pests and unwanted plants like weeds is now critical for crop health. For quicker spraying, drones can carry appropriately sized reservoirs that can be filled with fertilizers, pesticides, herbicide, plant growth regulators (PGRs) etc. Sometimes manual spraying operations are very difficult because of the crop's height, so smart farms use drones for spraying, which reduces the contact of humans with fertilizers, pesticides and other harmful chemicals (Pathak et al., 2020). Spraying capacity is up to five times faster than traditional machinery and completes a spraying in a 1 ha field in less than 40 minutes. It saves 30% pesticide.

**Figure 5: Spraying operation done by a drone**

### D. Crop health assessment

Drones equipped with sensors that can scan crops using visible and near-infrared light can be used to track crop health over the time and monitor response to remedial measures. This can be programmed to detect details such as NDVI, water stress or lack of specific nutrients in crops (Pravin and Munde, 2019). Farmers can use data from advanced sensors represented as 2D or 3D to better understand and find new ways to increase crop yields while reducing crop damage, it serves as evidence for farmers or government agencies seeking crop insurance or obtaining an estimate in future.

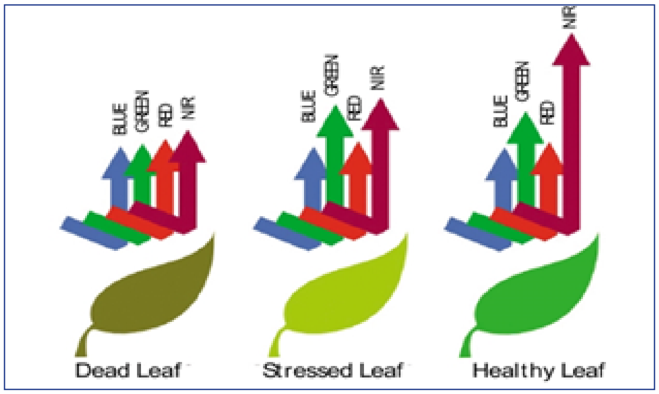



**Figure 6: Crop health assessment with the help of NDVI and drone**

### E. Crop count and plant emergence analysis

Unmanned aerial vehicles (UAVs) are a useful, faster and cost effective technology for obtaining data on crop emergence, drive replanting decisions and help predict yield using drones and high-resolution data combined with Machine Learning algorithms (MLAs). This system produces 97% accuracy in its output using data obtained with drones and Photogrammetry. Drones equipped with LiDAR sensors allows for the estimation of tree/crop biomass change based on differential height measurements, which is used to estimate timber production in forests.

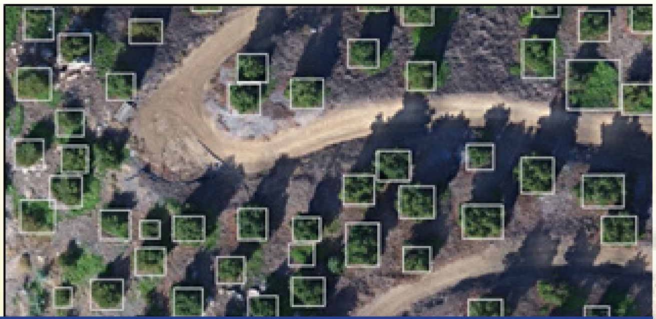


**Figure 7: Plant population analysis with the help of drone view**

### F. Irrigation monitoring and planning

With thermal cameras and remote sensing abilities, drones can help to solve irrigation related problems and can split the areas by different moisture regime. This helps in planning the irrigation precisely. The drones used by FAO in the Republic of the Philippines are equipped with photogrammetric and navigation equipment with a ground resolution of up to 3 cm (Pravin and Munde, 2019).

### G. Disaster risk reduction

FAO has partnered with national counterparts in developing systems to use drones for data collection that assist in Disaster Risk Reduction (DRR) efforts. These useful data are then loaded into modelling systems with analytics capabilities, which produce insightful results. Such data can help the government better organize disaster relief and response services while also providing high-quality, dependable recommendations to rural areas. Drones prompt immediate action on the ground, much faster than manual detection, analysis, and action. Drones can cut the time it takes to respond to a disaster by up to 44.46 %.

### H. Wildlife conservation

Drones with thermal cameras can be used to track, inspect, and monitor livestock from multiple angles. Drones have the potential to revolutionize forest and wildlife conservation research. They provide a bird's-eye view of forests and wildlife, as well as information, imagery, and data that would otherwise be difficult or prohibitively expensive to obtain. The government of Assam, the Republic of India has partnered with Tata Consulting Services (TCS) to use drones to conduct surveillance, identify unauthorized settlements and to deter poachers in Kaziranga National Park spread over 480 square km. Even if poachers are hiding in thick foliage, drones equipped with thermal cameras can detect their heat signatures and identify them. The endangered one-horned rhino has benefited from this effort.

**Figure 8: Wildlife monitoring in a jungle using drone**

## 4. Ethics and Regulations of Drone

Drones have enormous potential and countries all over the world, are investing in it in their development. However, they are having some usage guidelines. The Directorate General of Civil Aviation (DGCA) of India has issued its own set of regulations to govern the Indian skies, known as the Remotely Piloted Aircraft System (RPAS) regulations. The DGCA, GOI, regulations implicitly allow the use of RPAS (drone/UAV) for agricultural purposes with the exception of pesticide spraying, until specifically cleared. The Unmanned Aircraft System (UAS) Rules18-Part VI govern drone operations in India and other related activities. The following are the general rules for using drones.

➢ Avoiding densely populated areas of large crowds is essential.

➢ Should fly during daylight hours and in good weather conditions

➢ Use of drones or camera drones is prohibited in sensitive areas, such as government or military facilities, within 5 km of airports or in areas where aircraft are operating.

➢ Drone user must be qualified drone pilot and should have attained the age of 18 years.

➢ A license plate with the operator's information and contact information must be attached to the drone.

➢ When using RPAS, keep your visual line of sight open.

➢ A single person cannot control multiple UAVs at the same time.

➢ Drone flying is prohibited within 50 km of the country's border.

➢ Drones must not be flown more than 500 m out to sea from the coast.

➢ When flying a drone weighing more than 250 g, basic drone laws must be followed.

## 5. Additional Benefits of Drones in Agriculture

To get a large-scale view of the farm and identify potential problems, satellite or plane imagery was previously used. These images, on the other hand, were not only expensive, but they also lacked the precision that drones can deliver. It provides not only real-time footage, also get time-based animation that can show crop advancement in real-time. Some of the remarkable benefits are given bellow-

➢ Less manpower is required, and this is an outsourced solution. As a result, there is less reliance on departmental personnel.

➢ The results can be obtained in a short period of time (roughly 3-4 weeks), allowing for quick processing.

➢ A drone can fly in any type of weather. Although drones are water resistant, image quality can be harmed if photos are taken in rainy conditions.

➢ Drones can assist farmers in maximizing the use of inputs (seed, fertilizers, and water), responding more quickly to threats (weeds, pests, and fungi), reducing crop scouting time (validating treatment/actions taken), improving variable-rate prescriptions in real time, and estimating yield from a field.

➢ Drones can be used to monitor any type of crop in any location. As it is a relatively new agricultural technology, its market and application are expected to expand significantly in the upcoming years.

➢ The technology has also proven useful in gaining a comprehensive picture of plant emergence and population, which can aid in replanting decisions.

➢ Drone data's high resolution can be used to assess crop fertility, allowing agricultural professionals to apply fertilizer more precisely, reduce waste, and plan irrigation systems.

➢ Given the vast terrain that needs to be surveyed, drones are more efficient and are allowing users to capture high-resolution imagery faster than other methods.

## 6. Constraints of Drone Use in Agriculture

Agriculture Drones have the following downsides or disadvantages.

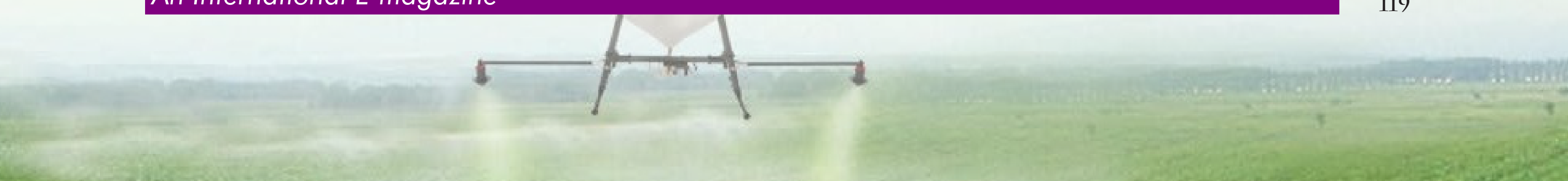
➢ High initial cost

➢ A traditional farmer is unable to perform the necessary analysis on drone images. To operate agriculture drones, you'll need some basic knowledge and skills. In these circumstances, the farmer will need to learn image software skills and knowledge.

➢ Among the many serious negative environmental consequences, the threat to wildlife, particularly birds, is a major concern

➢ Drones fly above ground and may cause an accident if they lose control for any reason; they use the same airspace as commercial aircraft and thus may interfere





with manned aircraft if they fly in their flight path

➢ Extreme weather makes flying them difficult. Extreme rain, fog, or wind can all prevent the devices from flying or recording the required space. The electronic components of a drone can be damaged by rain. A high amount of sunlight is required for image capture.

➢ Need some government clearance in order to use it.

➢ With the ever-changing laws and regulations surrounding drone flight, the growing list of restrictions surrounding air space could result in financial or legal penalties.

➢ The battery life of a drone survey is a limitation. It reduces the drone's flight time.

## 7. Cost of Drone in Agriculture

Agricultural drones generally have fixed wings and can cost up to $25,000 (Precision Hawk's Lancaster) depending on the features and sensors required to carry out their intended function. Some drones are more expensive because of imaging sensors, software, hardware, and tools are all included in the price (Pathak et al., 2020).

## 8. Conclusion

Drone technology has lot of potential for efficiently carrying out a variety of agricultural task. The Association for Unmanned Vehicle Systems International (AUVSI) predicts that by 2020, over 2900 unmanned aerial vehicles (UAVs) will be in use by over 900 companies worldwide. High initial costs and policy reforms are two of the most difficult obstacles to overcome in order to make it popular and farmer-friendly. Despite the limitations, these tools and technology are rapidly expanding their use in agriculture to provide information about farming.

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