Review Article
A Comprehensive Review of Unmanned Aerial Vehicle (UAV) Sprayers Used in Modern Agriculture

ABSTRACT

Food consumption is increasing as a result of the population's exponential growth. This will lead to an increase in demand for food, which can only be satisfied by increased crop productivity. Plant pests and diseases are causing an annual reduction of 20 to 40% in global crop production. For the farmers to meet these needs, their traditional methods were not adequate. As a result, modernizing the agriculture industry becomes imperative. Diseases brought on by pesticides and insecticides cause health issues for even farmers working in the agricultural sector. One million incidences of illness were estimated by the World Health Organization (WHO) as a result of manually applying insecticides to crop fields. As a result, new automated drone technology techniques were unveiled. These new methods not only provided food for the world's population but also created jobs for billions of people. Drone technologies help to ensure the efficient use of human labor while preserving soil fertility, reducing excessive use of water and pesticides and herbicides, improving quality, and increasing production. In order to improve their agricultural results, more farmers should invest in drone technology, the research article's conclusion suggests. In order to support productive and sustainable farming methods, it also offers information into the state and potential of sprayer technology today.

Key Words:*Crop productivity,Drone technologies, Spray technology, Unmanned Aerial Vehicle (UAV).*

1.INTRODUCTION

The Indian agricultural industry stands as a cornerstone of the nation's economy, contributing a substantial 18% to its Gross Domestic Product (GDP) and offering employment to half of the country's workforce. Globally, agriculture faces daunting challenges, with the United Nations Food and Agriculture Organization (UNFAO) projecting a daunting 70% increase in food production over the next four decades to meet burgeoning demand driven by economic and population growth. India's population anticipated to grow from an estimated 1.34 billion to 1.51 billion by 2030 and further to 1.66 billion by 2050, the countries predominantly comprised of small-scale farmers must confront these pressing issues head-on.

Despite the fact that our nation is heavily dependent on agriculture, it has not yet fully realized its potential due to inadequate crop monitoring techniques, inconsistent irrigation schedules, and the need for pesticides. Modern agriculture uses a variety of technologies, one of which is the use of drones to spray pesticides [1]. Although India's economy is heavily dependent on agriculture, it still lags behind western nations in terms of implementing innovative technologies to boost agricultural output [2]. We must minimize conventional methods and embrace new technologies in order to guarantee the profitability of agriculture [3].The application of fertilizers and pesticides is crucial for increasing crop yields, but applying them by hand can cause chronic illnesses like cancer, arthritis, and asthma, as well as eye irritation and the development of skin and neurological disorders. It can also be fatal because of the excessive ingestion of toxic chemicals found in these products. Each year, thousands of farmers, employees, and laborers are impacted by pesticides and fertilizers [4][5].

Most agricultural operations in India are conducted with the aid of traditional methods. Spraying activities using hand-operated sprayers (manual spraying) lead to an overuse of chemicals and prevent the delivery of a uniform layer of spray in dense agricultural fields, orchards, and paddy fields, hence decreasing crop yields and contributing to atmospheric pollution. Drones are being used by farmers to apply insecticides. The pesticide is able to perfectly penetrate the crop since the drones are flying at the right altitude. It is simple to spray dense crop fields, orchards, and paddy fields. Since the chemical may now enter the plant, which is not achievable with manual spraying, the pesticide's effect is also increased. In addition to lowering labor costs and times, agricultural unmanned aerial vehicles (UAVs) also facilitate efficient pesticide spraying, protecting farmers, agricultural products, and the environment while reducing the risks associated with chemical pesticide use [6][7].

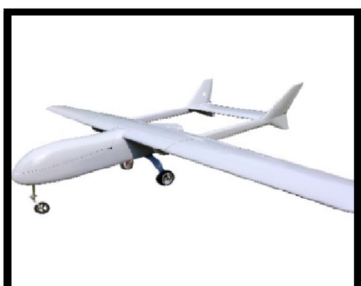
More than 35 drone start-ups are based in India, and their goal is to lower the cost of agricultural drones while also improving technology. Furthermore, eighty percent of the country's geographical area consists of parcels smaller than five acres. Thus, farmers can lessen their effort by utilizing drone technology. A wealth of research data can simplify the process of achieving sustainable agriculture in the future, requiring less time and effort.

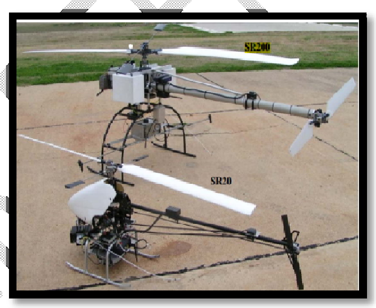
Drone spraying is one of the operational areas of activity where UAS are anticipated to keep expanding in the upcoming years. Some nations, including South Korea, use drones to spray around 30% of their agricultural land. Drone spraying in Japan was first done using unmanned helicopters, including the Yamaha R-Max [8], which dates back to the mid-1990s. Other unmanned helicopters, like the DJI Agras MG-1 [9], were just released onto the market in 2016. Drone spraying can be expanded by addressing legal and technological obstacles. In certain nations, the usage of pesticides requires the updating of laws [10].

In 2018, the Indian government released a regulation that allowed drones to be used for agricultural purposes. As a result, drones can be used to spray fertilizer and insecticides on agricultural fields, protecting people from potentially harmful exposure. In conclusion, the rapid development and application of "Drones" is critical to maintaining the country's economy, lifestyle, and health.

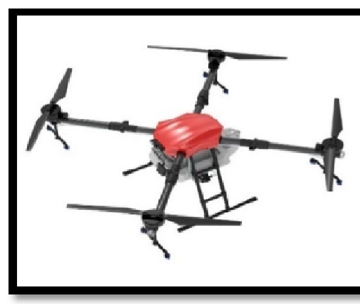
1.1 Types of UAV (Unmanned Aerial Vehicle)

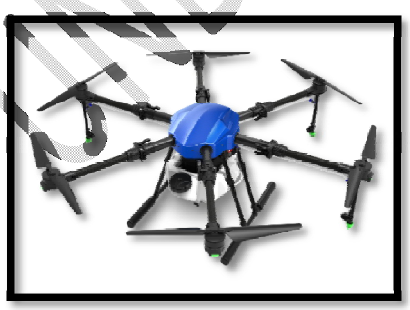
Unmanned Aerial Vehicle (UAV) is a radio-controlled aircraft that can fly without a human pilot. UAVs with multiple rotors are categorized based on the quantity of rotors on their platform. The various UAV models that have been in operating during the last two decades are shown in Fig. 1(a) Fixed wing: UAVs with two wings have an easier time gliding since their aerodynamic shape makes them far more aerodynamic than those with many rotors. Fig. 1(b) Single rotor helicopter - with one large rotor on top and one little rotor on the UAV's tail.Fig. 1(c) Quad copter, Fig. 1(d) Hexa copter, Fig. 1(e) Octa copter - are multirotor that use four, six, or eight rotors to lift and propel them.


(a) Fixed Wing aircraft



(b) Single rotor helicopter


(c) Quad Copter


(d) Hexa Copter

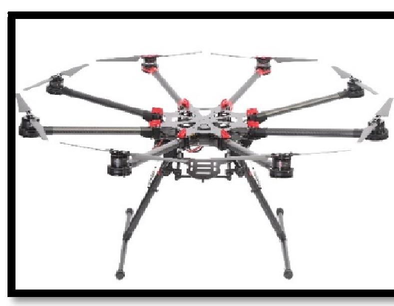

(e) Octa Copter

Fig. 1: Types of UAV

2. OBJECTIVES

1. The primary objective of this review paper is to provide a comprehensive analysis of the current state, technological advancements, and application of Unmanned Aerial

Vehicle (UAV) sprayers in modern agriculture, with a particular focus on their use in India.

2. This review aims to evaluate the efficacy, challenges, and potential of UAV sprayers in enhancing agricultural productivity, sustainability, and safety.
3. Additionally, it seeks to compare UAV sprayers with traditional methods of pesticide and fertilizer application, considering factors such as economic viability, environmental impact, and operational efficiency.
4. By synthesizing existing research and case studies, this paper intends to identify key areas for further development and policy recommendations to facilitate the widespread adoption of UAV sprayers in the agricultural sector.

3. REVIEW OF LITERATURE

The Indian economy is based primarily on agriculture. Daily advancements in agriculture are occurring that are advantageous to farmers. The main objective of raising output is safeguarding crops from diseases and pests. For plants to be protected from pests and diseases during the spraying process, plant protection equipment must be used. The three main power sources used for spraying in India are engines, batteries, and manually operated equipment.

3.1 DevelopedUnmanned Aerial Vehicle

To enhance operational efficiency, it's essential to configure UAV spraying systems for delivering high-concentration, low-volume sprays. Typically, spray rates for UAVs range around 1-2 l/ha, significantly lowerabout 25-50 timesthan conventional spray systems. However, despite the advantage of higher concentration sprays, applicators must meticulously manage spray patterns to prevent issues like phytotoxicity or inadequate coverage. Given the fine droplets used in low-volume spraying, UAVs should fly at low altitudes, ideally between 3-5 meters, to minimize spray drift. Additionally, it's crucial for UAV spraying operations to maintain stable low-altitude flight and precise control over spray swath. Advances in automatic guidance systems have significantly enhanced flight control accuracy, further optimizing UAV spraying processes[11][12].

Careful design is crucial for ensuring the precision of spray systems on UAVs. Huang *et al*. [13] pioneered the development of a UAV spraying platform and conducted simulation tests to assess its efficacy. Their innovative spray system harbors the potential to facilitate precise, site-specific crop management when integrated with a UAV system.

Table. 1 suggests that various developed Unmanned Aerial Vehicle for agriculture sector which is connect with various application *viz.,* spraying, sowing, soil report, stress analysis of crop, irrigation requirement, prediction of crop yield, need of fertilizer and health report of crop during season.

Table. 1: Developed UAVs for agriculture application

Study	Focus	Recommended Parameter	Key Finding
Huang *et al*. [13]	Developed UAV with gasoline engine	Droplet size (<50-µm), Micron-air nozzle (2,3 & 4), spray pump pressure (13 – 49 PSI)	Potential to provide accurate and site-specificcrop management, potential for vector control
Koo *et al*. [14]	Roll-balanced, unmanned	Tail rotor thrust 39.2 N during hovering, payload of 235.4 N	Altitude of a helicopter depends on dynamic variables for roll-balanced flight and physical tilt phenomena
Huang *et al*. [15]	Develop UAV and compared with aircraft	Attitude (1500 m), cargo capacity (22.7 kg), flight endurance (5 hrs.)	Routine monitoring of crop plant health, Application of fertilizers and chemicals
Ru *et al*. [16]	Developed fixed wing aircraft (Y5B)	Spray angle (80°) and discharge rate of (0.8 - 1.4 l/min)	Improves droplet deposition, pest control effectiveness, and economic efficiency compared to non-electrostatic and rotary spray methods

Kale *et al*. [17]	Developed agricultural drone with ATmega328 micro flight controller	3000 mAh, 25 C Li-Po battery, 2.4 GHz remote control with a 40-mA radio link, Ground control station software: ARDUINO, EAGLE, Multi Wii	Agricultural drone resulted in significant savings of 20%-90% in water, chemicals, and labor
Ru *et al*. [18]	Developed electrostatic spraying platform for UAV model (XY8D)	Spray Pressure (300 kPa),Nozzle Spacing (400-500 mm) and Discharge Rate (0.4 l/min)	System achieved a maximum spray width of 6.8 m.
Zhou and He [19]	Developed multicopter unmanned aerial vehicle spraying platform	Nozzlespositioned 1.5 m above the ground, working pressure of 0.2 MPa, with a flow rate of 0.45 l/min	Increased flight velocity improves droplet distribution uniformity but decreases droplet density and spray coverage percentage.
Spoorthi *et al*. [20]	Developed low-cost user-friendly UAV	Arduino Mega 2560 with GPS and Wi-Fi, and integrate magnetometer, gyro, and accelerometer for drone stability.	Cost-effective, user-friendly UAV for pesticide spraying was developed, featuring Android control, high-resolution wireless camera, and robust hardware integration for stability
Balaji *et al*. [21]	Developed novel hexacopter UAV	System integrated various sensors including DH11, LDR and water level monitoring sensors	Significantly reduce water usage (by 20% to 90%), chemical overuse, and labor requirements
Suryawanshi *et al*. [22]	Developed quadcopter for fertilizer spraying	Drone speed and spraying speed controlled using Mission Planner V1.3.49 software	Agricultural drone enhances safety and efficiency in fertilizer spraying
Susitra *et al*. [23]	Developed hexacopter	Payload capacity of approximately 1 kg.	Hexacopter autonomously returns to its initial position during low battery or signal range issues
Ukaegbu *et al*. [24]	Developed modular unmanned aerial vehicle	Use transfer learning with a CNN model and deep learning algorithms on a Raspberry Pi for accurate weed identification and removal	System achieved 99.98% test accuracy and 98.4% validation accuracy in weed detection and spraying
Deepika *et al*. [25]	Developed quadcopter	Arduino plates installed holds the motor, flight controller, electronic speed controller, battery and receiver	UAV with a connected tank for pesticide spraying covered more ground faster, reduced pesticide waste, and required less human labor

3.2 Arial Spray Application by Various UAVs

In a landscape marked by heightened productivity and the swift evolution of contemporary agriculture, the widespread adoption of novel agricultural technologies stands poised to exert a profoundly positive influence on both food production and security. With the integration of modern technologies and their judicious application, crop yields witness a notable surge, allowing for enhanced productivity even amidst resource constraints [26]. Empowering farmers with a spectrum of technological advancements facilitates the acquisition of essential skills, thereby fostering agricultural practices that are not only socially and economically beneficial but also environmentally sustainable[27].

In the field of pesticide application, unmanned aerial vehicles (UAVs) are often considered a cutting-edge technology. UAVs are aerial vehicles, which operate without the need for a human pilot on board. The literature collectively suggests that variations in application of spraying, droplet density, fan angle, liquid pressure, height and length of drone and area coverage (Table 2). These findings collectively underscore the importance of speed in the optimization of the performance of UAVs.

Table. 2: Arial Spray Application by Various UAVs

Study	Focus	Recommended Parameter	Key Finding
Ru *et al*. [28]	Helicopter for aerial spray applications with electrostatic technology	Charging voltage of 10 kV	Achieved 12 droplets per square centimeter and a 38% reduction in droplet drift
Bae and Koo [29]	Roll-balanced helicopter's performance in hovering and spraying operations	Roll-balanced design for improved spray pattern uniformity	Balanced spray patterns with coverage rates of 20% to 25% in both manual and automatic modes
Qiu *et al*. [30]	Unmanned helicopter's spray deposition properties, flight height, and flight velocity	Flight height of 0.8 m above the crop canopy	Flight height and velocity significantly affect the concentration of spray deposition
Giles and Billing[31]	RMAX unmanned helicopter for pesticide application in rice crop	Rotor diameter (3.1 m), vehicle length (3.6 m, height (1.1 m), engine power (13.6 kW)	Achieved a field capacity of 2.0 to 4.5 ha/h and application rate of 14 to 39 l/ha
Ru *et al*. [18]	Effectiveness of aerial sprayers comparing non-electrostatic and electrostatic spray systems	Flight altitude of 2 meters was identified as optimal for non-electrostatic sprays	Droplet deposition, increasing by 35.4, 26, and 9 droplets/cm² at the top, middle, and bottom of the plant canopy, with droplet sizes ranging from 80 to 200 µm
Wang *et al*. [32]	Downwash airflow using the 3WQF80-10 single-rotor diesel plant-protection UAV	Flight height of 3.0 m, velocity of 5.0 m/s, and crosswind speed of 0.8 to 1.2 m/s for optimal droplet distribution	Increasing height improves droplet distribution uniformity, with a high coefficient of variation (R^2) of 0.9178 at the lower part
Yallappa *et al*. [3]	Performance of a dronesprayer for pesticide application in groundnut and paddy fields	Forward speed of 3.6 km/h and a spray height of 1.0 m above the crop canopy	Increasing the spray height and working pressure improved spray uniformity, with an average spray droplet size of 345 µm
Yanliang *et al*. [33]	Developed and evaluated a six-rotor UAV electrostatic spraying system in comparison to a non-electrostatic sprayer	Higher droplet deposition with 16.1 droplets/cm² at the top and 28 droplets/cm² in the middle	Electrostatic sprayer demonstrated more concentrated droplet deposition and reduced drift compared to the non-electrostatic sprayer
Wang *et al*. [34]	Spraying deposition quality and dispersion characteristics of an unmanned aerial vehicle (UAV)	Wind speed of 0.9 m/s, a temperature of 31.5°C, and a relative humidity of 34.1%	Average spraying deposition distribution ratios of 4.4% (upwind), 2.3% (highest), 50.4% (downwind), and 43.7% (bottom)
Hussain *et al*. [35]	Testing the spray uniformity of a hexacopter unmanned aerial spraying system	Homogeneity and coverage with 50, 75, and 100% spray nozzle openings at an operational height of 1.5 m	Effective spray coverage at wind speeds from 1 m/s to 5.8 m/s

3.3Operational Parameters of UAV for Aerial Spraying

3.3.1 Aerial spray drift

Pesticide drift during aerial spray application was main concern due to its negative effects on human health, crop and livestock contamination and also endangerment on ecological resources. The main significant factor in regulating off-target drift application during low-flight operations was droplet size. Off target drift increased as wind speed rose, although the impact was not as great as droplet size effects. A number of trials were carried out by Bird *et al*.[36] in an effort to assess off-target deposits that occurred during aerial spray application. According to the outcome data, during low flight applications, the median values of pesticide deposition decreased from 5% of application rate at 30 m downwind to 0.5% at 150 m.

Ru *et al*. [18] examined the designed XT8D UAV electrostatic aerial sprayer. As per the drift result, there was no significant difference between electrostatic and non-electrostatic spray at heights of 1, 2, and 3 m. For flight heights, the mean drift amount was 5.88, 10.31, and 14.98 $\mu g/cm^2$, and the mean droplet drift distance was 12.1 m, 15.8 m, and 18.6 m, respectively. They found that the impact of flight height on spray drift was larger. The deposition concentration of droplets on polyester cards sprayed with electrostatic spray under three flying heights increases by 2.36, 2.91, and 1.56 $\mu g/cm^2$ in comparison to non-electrostatic spray, respectively.

Wang *et al*. [37] found that the effect of wind speed on drift was more than flight height and speed of UAV. At a height of 1.5-3 m and a velocity of 2.4-5 m/s, there was around 80% droplet drift below 2 m, compared to 8% droplet drift on the sample frame at 4 m from the ground. Only the area downwind from the spraying field saw droplet drift. They maintained a 15 mbuffer zone for safe aerial spraying because the wind speed ranged from 0.76 to 5.5 m/s and the 90% drift droplets were situated between 9.3 and 14.5 m from the target region.

3.3.2 Spray deposition measuring techniques

Moor *et al*. [38] examined the droplet dispersion using the water sensitive paper (WSP) method, and measured the droplet size, coverage, and spacing using the image analysis method.

Jain [39] measured the droplet sizes from various hydraulic nozzles using a droplet analyzer. The analyzer comprised a camera that was used to capture a sample of droplets measuring 3.2 mm by 2.4 mm. A magnifying glass was placed between the sample and the camera to facilitate data entry into the computer. The droplet size analysis program utilized was called "Image-Pro." By misting a mixture of Methylene blue MS dye and water at a rate of 5 g/l on glossy paper, the spread factor was calculated in order to translate the spot size into the real size of the droplets.

Salyani *et al*. [40] employed a water- and oil-sensitive paper to collect droplets in a citrus field, and an image processing system to determine the spray quality.

Collins [41] employed ImageJ software to assess spray quality. ImageJ, an open-source Java-based image processing software developed by the US National Institutes of Health (NIH), is compatible with multiple platforms and supports various file formats.

Qiu *et al*. [30] carried out an experiment using a glass sample dish with a 90 mm diameter. Six measuring locations were put with a 5 m interval between them, and each sample dish was positioned 0.8 m above the wheat's surface. To collect settling droplets for the spray test, 10 milliliters of distilled water were added to the sampling plate as a sample basis. The obtained samples were measured using an ultraviolet visible spectrophotometer of the UV-2102 PCS type. The wavelength of the 508 mm scan was chosen to measure the absorbance.

Qin *et al*. [42] measured the size of the water droplets using a laser particle size analyzer. The size of the droplets was used to compute the average volume median diameter, and 20 l/ha of pesticide was applied.

Tang *et al*. [43] measured factors such as droplet size, density, and covering rate using water-sensitive paper. On the citrus tree, WSPs were stapled in three separate layers. WSPs were eliminated after spraying and scanned using a digital picture with a resolution of 600 dpi × 600 dpi. Deposit Scan software was used to assess the droplet deposit dispersion on the WSPs.

3.4Economics of Sprayers for Field Crops

3.4.1 Ground agricultural sprayers

Saha *et al*. [44] investigated several spraying methods in the mango orchard. The operational costs of the aero blast sprayer were substantially higher than those of the manual rocker sprayer, at ₹42.26 per hectare, at ₹197.19 per hectare. Owing to its better performance, the former can be advised for private ownership or custom hire in medium-height orchards of varying sizes.

Shani *et al*. [45] investigated a more effective herbicide sprayer drawn by an animal that was intended for extremely low volume application. An average swath width of 5.814 m and an application rate of 4.62 l/ha were found in the field evaluation and performance test findings. Field capacity was 1.89 ha/h, while efficiency was 91.1%.

Nanda *et al*. [46] evaluated the efficacy of three distinct sprayer types: disc type low volume sprayers, manual compression sprayers, and air-assisted power sprayers. The field capacities of the power sprayer, manual compression sprayer, and low volume sprayer were 0.30, 0.11, and 0.08 ha/h, respectively. It was found that the cost per hectare for a low volume sprayer, a manual compression sprayer, and a power sprayer was ₹65, ₹114, and ₹134, respectively.

3.4.2 Aerial sprayers

Qin *et al*. [42] used a model N-3-equipped UAV to spray maize crops. Two nozzles were used in a spray test, with working heights of 5 m and 7 m. For swaths of 5 m and 9 m, the spraying deposition was 38.4% and 38.1%, respectively, under the same operating height. The largest amount of deposition on corn was seen at a flying height of 7 meters. At a flying speed of 3 m/s, the aircraft could spray 15 l/ha.

Yallappa *et al*. [3] investigated and tested a drone-mounted pesticide sprayer in rice and peanut crops. At 2, 3, and 4 m/s forward speeds, the average field capacity was found to be 1.38 ha/h, 1.43 ha/h, and 1.62 ha/h, respectively. The cost of operation for paddy and peanuts using the drone spraying technology was ₹367 and ₹345 per hectare, respectively.

Parmar *et al*. [47] tested a new drone-mounted pesticide sprayer's effectiveness in rice, cotton, and moong crops. It was discovered that the average field capacity was 1.38 ha/h and 1.08 ha/h, respectively, when forward speed was set at 3.6 km/h and height spray and operating pressure were applied. The measured spray droplet size was 345 μm.

4. ADVANTAGES AND LIMITATIONS OF DRONE SPRAYING

4.1Advantages

1. **Precision Application**: Drones can accurately apply fertilizers, pesticides, or herbicides in targeted areas, reducing wastage and minimizing environmental impact.
2. **Time Efficiency**: Drones can cover large areas quickly compared to traditional methods, saving time, especially in hard-to-reach places or uneven terrains.
3. **Reduced Labor Costs**: Automation reduces the need for manual labor, especially in remote or difficult areas, lowering the overall cost of operations.
4. **Less Water Consumption**: Drone sprayers often require less water for chemical applications, making them more suitable for regions with limited water resources.
5. **Reduced Soil Compaction**: Since drones operate from the air, there is no risk of soil compaction, which is a concern with ground-based machinery.
6. **Access to Difficult Terrains**: Drones can easily reach areas that are inaccessible to traditional machinery, such as hilly regions or fields with dense crops.
7. **Real-Time Data Collection**: Modern agricultural drones can be equipped with sensors and cameras to collect data on crop health, helping farmers make informed decisions on treatments.

4.2Limitations

1. **High Initial Investment**: Drones, especially those equipped with advanced sensors and GPS technology, can be expensive to purchase and maintain.
2. **Limited Payload Capacity**: Most drones have a limited capacity for carrying pesticides or fertilizers, meaning they may need to make multiple trips or cover only small areas per flight.
3. **Battery Life Constraints**: Drones typically rely on batteries, which limit their flight time. Frequent recharging or battery replacements can slow down operations in larger fields.
4. **Regulatory Restrictions**: Depending on the country, there may be strict regulations regarding the use of drones for agricultural purposes, including restrictions on altitude, proximity to populated areas, and operator certifications.
5. **Weather Dependency**: Drones are sensitive to weather conditions like wind, rain, or fog, which can limit their usability on certain days.
6. **Skill Requirement**: Operators need to be trained in drone piloting, software handling, and maintenance, which may require additional investment in training.
7. **Potential for Malfunctions**: Like any technology, drones are susceptible to technical failures or crashes, which could result in crop damage or additional repair costs.

5. CONCLUSION

Over the last ten years, precision agriculture has seen significant integration of cutting-edge technologies aimed at enhancing crop productivity. Unmanned aerial vehicles (UAVs) have emerged as a crucial component in this endeavour, yet they encounter several key challenges. These include considerations such as payload capacity, the types of sensors utilized onboard the UAV, overall cost, duration of flight, effectiveness of data analytics, environmental factors, and specific operational requirements. Chief among these challenges is the financial aspect, as the expenses associated with UAV implementation encompass not only the vehicle itself but also a range of sensors, mounting hardware, technology-driven applications, and the requisite software for data analysis.This article examines the advancements in UAV sprayer technology tailored for agricultural purposes. It explores a specific innovation approach closely tied to precision spraying, wherein the spray quantities and locations are determined through image analysis of land characteristics. Various factors such as wind direction and intensity, flight altitude and speed, propeller dynamics, pesticide viscosity, and spraying rate are meticulously considered in this method. The selection of nozzles and their opening settings are based on the parameters gathered, thereby ensuring an optimal spraying process. The article also evaluates and outlines the most relevant spraying systems and algorithmic methodologies for agricultural UAV sprayers, emphasizing their role in monitoring spray quality with WSP recording.

6. FUTURE SCOPE

To improve agricultural drone sprayers, increasing payload capacity and using more efficient batteries will allow coverage of larger areas per trip. Implementing an obstacle alert system enhances safety, while features like automatic spray height adjustment and autonomous flight with waypoints are essential. Developing yield prediction models using NDVI for different Indian states and studying crop damage from natural disasters can support insurance claims. It's important to compare drone sprayers with ground sprayers to assess drift potential and evaluate various techniques for drift and deposition. Additional data is needed for small UAVs under different conditions, and performance should be tested across various crops and local agro climatic conditions to determine the best UAV model for specific areas.

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