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Aerial farming: Revolutionizing M-drone in sustainable agriculture

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Abstract

Unmanned Aerial Vehicles (UAVs) commonly known as drones are Aerial robots operated without a human pilot on board. Drones come under various types, of which multirotor are popular in agriculture. As compared to traditional knapsack sprayers drone sprays are much more economical and efficient in doing the same work. By knowing its advantage central government has taken an interest in fearing different schemes for popularizing its services along with encouraging women's empowerment and promoting Nano fertilizer. In this regard, the service of M-Drone has taken extensively to meet the target of the massive scheme of popular nano fertilizer. Agricultural drones are gaining popularity day by day as it is user-friendly, efficient, and economical. Therefore, the use of agricultural drones is encouraged, and its demand in Indian Agriculture.

Keywords: Unmanned aerial vehicles, nano fertilizer, and women empowerment

Introduction

India has varied agroclimatic conditions which makes it fit for growing various agricultural, and horticultural crops across the country. In India, agriculture is the main occupation and farmers are the country's backbone (Behera, U.K. and France, J., 2016) [1]. Agriculture contributes about seventeen percent (17%) of total GDP. Over 60 % of India's land area is arable making it the second-largest country in terms of total arable land (Singh, 2017) [10]. Still, Agriculture continues to play a dominant part in the overall economic scenario of India. Because of the increasing population and lack of labor availability day by day, scientists are involved in building new technologies that can reduce the labor load and increase productivity thereby lifting the economy and better lives of people. One of the roaming sciences nowadays is the use of Agriculture drones in effective crop production.

If we think of a drone, it is common to get an image of the military and a war Because there was a misconception that drone is used only for military purposes (Grishin *et al*., 2023) [4]. Yes, it's obvious because the first drone evolved somewhere in 1849 when Austrians attacked Venice with unmanned inflatables stacked with explosives not only this but unmanned aerial vehicles (UAV) also are used in many wars like World War1 (WW1), World War2 (WW2), Korean War, Cold war, Vietnam war and later in inlet war (Pathak *et al*., 2019) [11]. Therefore, the importance of drones was limited earlier because of their usage only in military and political pioneers. Of late in the last few decades there has been tremendous improvement in drone technology and its remarkable progress in the applications where human reach is difficult.

DRONE (Dynamic Remotely Operated Navigation Equipment), also known as UAV -unmanned aerial vehicle, is a device that can fly either with the help of autopilot and GPS coordinates on the pre-set course or can be operated manually with radio signals using the remote control or smartphone app. We know that drones are multifarious in terms of applications in various fields ranging from military surveillance, cinematography, wedding videos, railway track monitoring, wildlife monitoring, delivery of small packages, security purposes, law enforcement operations, aerial photography, healthcare, disaster relief management, agriculture and even drone racing, search, and rescue operations and disaster management (Rani *et al*., 2019) [9].

When we specify the agricultural importance of drones, drones are used in soil and water sensing, seed dispersal, Crop monitoring for pest and disease, weed identification, heat and water stress detection, Drone pollination, Geofencing, wildlife conservation, livestock management, use of artificial intelligence, Drone irrigation and most popularly in taking spray schedules for fertigation and pesticides (Dutta, G. and Goswami, P., 2020) [3]. In Indian conditions, drones are majorly used to take spray but because of the incident of the Kasargod endosulfan tragedy, many of the farmers stood one step behind in the aerial application of pesticides to their farmland thinking that it may harm themselves and their pets. Therefore, the earlier aerial application was not that much supported by everyone reminded of the Kasargod endosulfan tragedy which is altogether a different concept as compared to the application by agricultural drones but later by knowing drones and their wide application in the agriculture stream it became the mass hit concerning customer priority.

UAVs vary in design from fixed-wing to rotary-wing types each suited to specific tasks. Their capabilities are enhanced by technologies like GPS, and advanced sensors. UAVs are playing an increasingly vital role across various commercial and research domains like surveillance, delivery services, and agriculture (Kim, J *et al.*, 2019) [2].

Different Types of Drones Used in Agriculture are as follows:

1. Fixed Wing Drones

These drones are like miniature airplanes, which generate lift under the wing due to forward speed which is produced by either an IC engine or BLDC motor. These types of drones stay in the air for longer periods and cover more ground. They are typically launched by hand and flown using a remote control or pre-programmed flight plan. These types are used in agriculture for mapping fields, monitoring crops, and identifying potential issues such as pests or irrigation problems. They are also used for surveying, mapping, and aerial photography.

2. Single-Rotor Drones

These are generally known as helicopter drones used in agriculture to capture high-quality images and data for crop mapping and analysis. They feature a single rotor blade and can take off and land vertically, allowing them to hover in place and fly more precisely than fixed-wing drones. Single-rotor drones are typically larger and more expensive than multi-rotor drones, but they offer longer flight times and the ability to carry heavier payloads, making them ideal for more advanced applications like precision agriculture. These are used in crop monitoring and scouting, Irrigation management, Soil analysis and mapping, and Plant counting and health assessment.

3. Multi-Rotors Drones

Multi-rotor drones are a popular type of drone used in agriculture, consisting of multiple rotors mounted on the body of the drone. These drones are highly maneuverable and can fly in any direction, making them ideal for close-range operations such as crop monitoring and analysis. These are used in mapping and surveying large agricultural areas, providing high-resolution aerial imagery that can be used to identify crop health, detect irrigation issues, and monitor pest and disease outbreaks. They can also be equipped with advanced sensors such as thermal cameras to detect temperature variations in crops, helping farmers to detect stress in plants and adjust irrigation and fertilization accordingly.

4. Hybrid VTOL Drones

Hybrid drones in agriculture combine the advantages of both multirotor and fixed-wing drones. These drones have both vertical take-off and landing (VTOL) capabilities, like multirotor drones, and the extended range and endurance of fixed-wing drones. The hybrid design allows these drones to take off and land vertically, making them easy to launch and land in confined spaces or uneven terrain, while also allowing them to fly horizontally for extended periods, covering larger areas of farmland. Hybrid drones are used in agriculture for a variety of purposes, including crop mapping, and crop scouting. The ability to take off and land vertically, combined with the range and speed of a fixed-wing drone, makes hybrid drones ideal for large-scale agricultural operations. For crop fertilization, drones such as quadcopters prove to be the most favorable owing to their multi-rotors.

How drones work

Take-off: This is the initial phase where the drone transitions from a stationary position to flight. The process typically involves increasing the thrust of the propellers to lift the drone off the ground. During take-off, the drone's systems are calibrated for stability and balance. The pilot ensures that the drone is responsive to controls and ready for the next phase.

Mission Execution: This phase is the core of the drone's flight and varies depending on the intended purpose. It could involve aerial photography, surveying, delivery, or other specific tasks. During this phase, the drone navigates to designated waypoints or follows a pre-programmed route with adjustments made for speed, altitude, and direction as necessary. In this phase, real-time data is often collected and transmitted back to the operator for analysis or decision-making.

Landing: The final phase is bringing the drone safely back to the ground. This requires reducing the thrust of the propellers gradually to descend. The operator must carefully control the descent to avoid sudden drops or collisions. In automated systems, drones can use sensors and GPS to return to a predefined landing spot. Landing is a delicate process, especially in varying weather conditions, and demands precise control to ensure the drone does not get damaged.

How drone works better than traditional spray equipment

- They are approximately 40 times faster than manual labor, thereby the outbreak of any serious pest or disease can be managed easily with the aid of drones before giving the time for perpetuation of insects and pathogens.
- There is an inconsistency when any sprays are undertaken in large areas because of human error whereas this inconsistency is almost nil when spray is undertaken by a well-fed programmed agricultural drone.
- Drones can reach inaccessible areas with ease, enabling comprehensive coverage of vast or difficult-to-reach locations. This situation can be successfully met for plantation crop management where height is the major limitation for undertaking manual spray. It saves 85% of work time.
- Additionally, drone-based spraying eliminates harmful side effects on manual labor, as operators are not exposed to potentially hazardous chemicals. Moreover, human exposure to hazardous chemicals is reduced by up to 90%.
- Agricultural drones can be flown in autonomous, semi-autonomous, and manual mode.
- 90% of water can be saved when we take a spray from

the drone as compared to a knapsack sprayer.
- 30 to 40% of agricultural inputs can be saved as compared to the knapsack spray.

With their ability to operate efficiently, cover larger areas in less time, and minimize human risk, drones have become a valuable tool in agricultural pest control and environmental management practices.

Drone Dynamics

The development and understanding of drones are rooted in a diverse array of subjects. Designing a drone for a specific purpose involves considering several key factors. These include.

- The aerodynamic design of the propellers impacts flight efficiency and stability.
- The strength and weight of the drone's components are crucial for durability and maneuverability.
- The electric motor's performance dictates the drone's power and speed, while the electric speed controller regulates the motor's speed.
- Communication with the drone is managed through a radio transmitter or receiver.
- Software interfaces on mobile devices or computers are essential for real-time monitoring and data analysis. These elements together define the drone's capabilities and suitability for various applications from photography to surveillance and beyond.

Multi-copters are a type of drone characterized by four or more propellers and are particularly favoured for their compact size, low weight, and exceptional manoeuvrability. It achieves movement and stability by varying the speed of several vertically oriented motor-propeller combinations. Nowadays multi-copters are increasingly becoming indispensable in various sectors, ranging from recreational use to professional applications in monitoring, logistics, and farming. These devices are chosen for their compact design, reduced mass, and superior agility. The most basic form of a multicopper is the quadcopter which has four propellers each situated at the corners of its frame. These propellers are individually controlled in terms of speed and rotation direction a key aspect of the drone's balance and manoeuvrability. In a standard multicopper setup, the rotors are equidistant from each other. To ensure stability, two rotors spin clockwise while the other two rotate counter clockwise. For vertical ascent or hovering all rotors operate at a higher speed. Adjustments in rotor speeds enable the drone to move in various directions, including forward, backward, and laterally. This precise control mechanism is integral to the multicopper functionality, allowing for agile and controlled flight.

Pitch, yaw, and roll are the three dimensions along which a drone can manoeuvre while in flight.

- Pitch refers to the upward or downward movement of the drone's nose, rotating around a horizontal axis. This controls the drone's climb or descent.
- Yaw is the term used for the left or right rotation of the drone around its vertical axis, akin to turning a vehicle.
- Roll describes the drone's rotation along its longitudinal axis, the axis that runs from the front to the back of the drone.

These movements are fundamental to a drone's flight dynamics, enabling it to perform a variety of movements and maintain stability in the air. A multicopper manoeuvres by varying the speeds of its four motors which control its roll, pitch, yaw, horizontal motion, and altitude. To roll left, it increases the speed of the right-side motors while decelerating the left-side ones. For pitching forward, it accelerates the rear motors and reduces the speed of the front ones. Yawing, or turning left or right, is achieved by speeding up two diagonally opposite motors and slowing down the other two. This creates a rotational motion around the vertical axis. Horizontal movement is attained by tilting the multicopter in the desired direction. This is done by temporarily adjusting the motor speeds to lean the vehicle, while simultaneously increasing overall thrust for forward propulsion. The degree of tilt correlates with the speed of travel, a steeper angle results in faster movement. Altitude control is straightforward, increasing the speed of all motors equally makes the Multicopter ascend, while decreasing them causes it to descend. This precise control of motor speeds is key to the multicopter's versatile and agile flight capabilities. Additionally, modern quadcopters often incorporate advanced technologies such as GPS for stable hovering and accurate positioning, and gyroscopic sensors to maintain balance and orientation.

General drone components and setup

Figure 1 represents the pictorial representation of the whole setup of drone components.

Radio Transmitter: RC Transmitter facilitates the communication between the pilot and the drone's systems. It sends radio signals to the Electronic Speed Controller (ESC) which is a critical component in regulating motor speed. The ESC interprets these signals and adjusts the power supplied to the drone's motors, accordingly, allowing the pilot to control the speed and direction of the drone. This process is essential for maneuvers such as ascending, descending, and changing direction. The precision of this system is crucial for smooth flight and responsive control, and it also includes safety features to protect the drone's motors from potential damage due to sudden changes in speed or direction.

Radio Receiver: An essential component mounted on the drone, responsible for receiving signals from the pilot's remote control. It acts as the communication bridge between the pilot and the drone. Once it receives a signal, the receiver processes and relays this information to the drone's flight controller, which then executes the corresponding actions, such as adjusting speed, changing direction, or altering altitude. This device is integral to the responsiveness and control of the quadcopter, ensuring that pilot inputs are accurately and promptly translated into movements.

GPS: The GPS module in a drone provides precise location data, enabling stable flight and accurate navigation. It's crucial for automated flight paths, return-to-home functions, and geofencing. This module enhances safety and functionality allowing drones to perform complex tasks like aerial mapping and tracking with remarkable accuracy.

Flight Controller: The central processing unit of a drone responsible for managing its balance and handling telecommunication through various transmitters. Embedded within this unit are several sensors crucial for flight dynamics and navigation. These include an accelerometer for measuring acceleration forces, a barometer for altitude determination, a magnetometer for orientation relative to the Earth's magnetic field, a gyroscope for tracking rotational motion, and a GPS for precise location tracking. Additionally, some flight controllers are equipped with an ultrasound sensor, used for measuring distance particularly useful in avoiding obstacles and facilitating smooth landings. This ensemble of sensors and processing capabilities makes the Flight Controller a pivotal component in ensuring stable and responsive drone flight.

Ground Control Station (GCS): The central hub for piloting and monitoring a drone during its flight. It typically consists of hardware and software components, including a computer or a portable device, a transmitter for controlling the drone, and a display for real-time video feed and flight data. The GCS is used to plan missions, set waypoints, monitor drone health, and control its movements. It provides vital information such as altitude, speed, battery status, and GPS location. This station is essential for complex operations, ensuring safe and efficient control over the drone.

M-Drone in Agriculture

Agricultural drones have an incredible role in future innovations of sustainable agriculture programs. We have a huge demand for the use of these drones, but we have a very limited that is the sum of 26 manufacturers. Out of which Multiplex group of companies also top among them as one of the manufacturers. Different companies provide drone services like Aerial survey and mapping by Skylark drone company, Crop monitoring, and data collection by Fly base company, crop multispectral image capture with artificial intelligence by Idea forge drone company, and Fertilization, Pesticide spraying, and Fumigation by Multiplex M Drone company, Granular fertilizer application, and seed dispersal by Multiplex M Drone company.

Even though drones provide various services in the Agricultural field, the most popular services provided by drones among farmers are foliar application (Nutrients, Insecticides, and fungicides), Seed dispersal, Granular fertilizer application, and fumigation. For the above-mentioned services most popular drones available in the market are Multiplex Drone, Garuda drones, and DUMS.

For the mentioned services Different types of Multirotor Drones are used but widely accepted types are as follows:

a) **Quadcopter:** A quadcopter (Figure 2) is a multirotor drone with four arms or booms, each with a rotor (hence "quadcopter"). The working principle is that one pair of rotors turns clockwise and the other anti-clockwise and by varying the speeds it is possible to generate thrust as well as turning motions.

b) **Hexacopter:** The hexacopter has six propellers (Figure that are placed in a circle around the hexacopter's main body. The machine's bottom has a pair of leg-like appendages that allow it to land safely on the ground. Because of its six propellers, the quadcopter is a more powerful flyer than the quadcopter and can carry bigger loads. The hexacopter has a substantial advantage in that even if one of the propellers fails, the craft can still fly because of the other five propellers. This implies that if one of the propellers fails, the drone will not crash to the ground, causing damage to the equipment attached to it. The contraption will not be able to fly if two propellers fail, but it will stay stable enough to land safely.

A hexacopter can go quicker and reach higher altitudes than a quadcopter. Because hexacopters are more expensive, these are typically employed to transport more valuable cargo that cannot be destroyed in the event of a crash. They are also larger and more complex to assemble and store than quadcopters.

Introducing Multiplex MD-10H: MD-10H series agricultural drone is a Hexacopter drone manufactured with high-strength carbon fibers, impact-resistant molded materials, and aerospace-grade aluminum materials. MD-10H is an 8 kg payload drone for spraying agricultural inputs on farming land.

Features

- Flying Speed – 6 m/s
- Max. Range - 500 m
- Spray Rate – 5 L/min
- Max. Take Off Weight - 24.9 kg
- Max. Operating Altitude – 50 m
- High Efficiency – Upto 5-6 acre/hr

Highlights of Drone

- MD-10H has hardware tamper-proof and software tamper-proof technology and the drone has been developed in accordance with CSUAS of DGCA.
- MD-10H has been tested from -15° C to +55° C for the operational requirements.
- MD-10H has been tested on 50+ different crops over different Indian agricultural fields.
- MD-10H can be flown in Autonomous and Manual mode.
- MD-10H uses an ultra-low volume technology nozzle for crop spaying with 40 – 60 microns.
- 30-35% of pesticides can be saved.

Parts of the MD-10H Agricultural Drone are as follows

1. **Centre Body:** The Centre body is made up of Nylon fiber plastic with a single mold It houses all the electronics, and power distribution board and is enclosed with the canopy over it (Figure 4). All the arms and landing gear are mounted on the center body Figure 5. shows the center body.
2. **Landing Gear:** The landing Gear set is a sub-assembly consisting of an Aluminum 7075 Tube of 20 mm outer diameter including 2 x vertical landing gear tubes and 1

x horizontal landing gear tube. Two vertical landing gears are joined to the horizontal landing gear using T-Clamps. Landing gear clamps are used to join the vertical landing gear to the center body (Figure 4). Tank clamps are used to hold the tank in between landing gear. All clamps are made of Nylon-grade plastic material. Horizontal landing gear has two hollow sponges which help in the landing and take-off. Figure 6 shows the landing gear image.

3. **Arm Set:** The Arm Set is a sub-assembly consisting of one CFRP Arm Tube (Dia. of 30 mm OD), and one Aluminum 7075 material hexagonal Arm tube Arm clamp is used to join and fold the two arms, and an arm locker is used to lock the CFRP arm tube during flying (Figure 4). Arm clamps are made of Nylon-grade plastic material. The front side of the CFRP arm holds the BLDC Motors and the Back hexagonal arm mounts inside the center body. Figure 7 shows the Arm Set image.
4. **BLDC Motors:** The RPA is integrated with FOC (Field Oriented Control) based PMSM (Permanent Magnet Synchronous Motors) motors (Figure 4). In this type of motor, ESC is integrated below the motor and it will make compact, low noise, high power density, and high control precision. Figure 8 shows the BLDC Motor image.
5. **BLDC Pump:** The brushless DC pump is used to pump the water from the agricultural input tank to the nozzles, effectively without obstructing the flow (Figure 4). The pump is integrated with both temperature and current protection. If the pump is working abnormally, with a sudden surge in current or temperature of more than 110 °C, the ESC will disconnect and restart. These protection functions effectively reduce the loss of overheating the water pump due to sudden failure. Figure 9 shows the BLDC Pump image.
6. **Nozzles:** The nozzles used for agricultural spraying drones are Teejet, which are flat spray nozzle tips that create a 110-degree cone angle at the time of spray (Figure 4). The water particles enter the tank through pneumatic pipes and go through nozzles and due to the orifice in the nozzle pressure will be exerted and spray will be uniform. The orifice and nozzle head are made of plastic material. This Teejet nozzle is driftproof and windproof, and to make it unbreakable nozzle head will be mounted with rubber nozzle holders which are flexible and rigid to hold the nozzle stiffly. Figure 10 shows the T-Jet Nozzle image.
7. **Agricultural Tank:** The tank is made up of PPP Plastic to hold the agricultural input solution (Figure 4). The tank has one inlet and one outlet. The tank inlet has an open lid with a filter where agricultural input solution is poured into the tank and filtered during filling. The tank outlet also has a filter that filters the agricultural input solution further before going to the BLDC Pump. Figure 11 shows the Agricultural Tank image.

MD-10H Agricultural drone has flown over 56 different crops in different regions of the country majorly in Karnataka, Andhra Pradesh, Madhya Pradesh, Uttar Pradesh, Bihar, Kerala, West Bengal, Maharashtra, and Telangana. It has covered almost 40,000 Acres so far. The Table given below indicates the different crops and the use of agriculture drones to provide Agri inputs.

Central government schemes

Nowadays central government introduced many favourable schemes to promote the use of agricultural drones.

A total of 129.19 crores is sanctioned for kisan drone promotion activities out of which 52.50 crores is released to ICAR for purchase of drones and field demonstration.

The central government-initiated sub-mission on agriculture mechanization (SMAM) program issued on April 2022 states that

- For FPO (Farmer producer organization) a 75% (7.50 Lakhs) subsidy will be granted with the purchase of a Kisan Drone
- State and central agriculture educational and research institutes are granted with 100% (10 Lacks) subsidy on the purchase of Kisan drone
- For SC, ST, Small and marginal, women, and north east farmers 50% (5.00Lakh) subsidy is granted, and other than these category farmers 40% (4.00 Lakh) subsidy will be granted on the purchase of Kisan drone
- To Popularize the drone services to farmers on a rental basis, financial assistance @ 40% up to a maximum of Rs. 4.00 lakhs are provided for the purchase of drones by CHCs under Cooperative Society of Farmers, FPOs, and Rural entrepreneurs.
- Agriculture graduates establishing CHCs are eligible to receive financial assistance @ 50% of the cost of drones up to a maximum of Rs.5.00 lakhs per drone.

Our prime minister declared the Namo drone Didi programme under Vikasith Bharath Sankalp yatra schemes which aims to provide drones to 15,000 women Self Help Groups (SHGs) during the period 2024-25 to 2025-2026 for providing rental services to farmers for agriculture purposes and also central government has hired MD-10H drone service to make success of nano fertilizer application throughout Uttar Pradesh.

Under this Namo drone Didi scheme M-Drone is taking part in training the women pilot in Begusarai, Bihar.

Central Financial Assistance @ 80% of the cost of drone and accessories/ancillary charges up to a maximum of Rs. Eight Lakh will be provided to the women SHGs for the purchase of drones. The Cluster Level Federation (CLFs) of SHGs may raise the balance amount (total cost of procurement minus subsidy) as a loan under the National Agriculture Infra Financing Facility (AIF). Interest subvention @ 3% on the AIF loan will be provided.

Table 1: The different crops and the use of agriculture drones to provide Agri inputs.

Sl. No	Crops	Disease/Problem	Type of Input sprayed
1.	Areca	Leaf Spot/Yellow Leaf/Mites	Fungicide/Micronutrient/Insecticide
2.	Banana	Sigatoka	Insecticide/Micronutrient
3.	Chilli	Leaf curl virus/Powdery mildew/Aphids/Black thrips	Fungicide/Micronutrient/Insecticide/Pesticides
4.	Coconut	Leaf spot/Rust/Thrips/ Mili Bug	Fungicide/Micronutrient/Insecticide/Pesticides
5.	Cotton	Rust/Pink ball worm/Thrips/Mili Bug	Fungicide/Micronutrient/Insecticide/Pesticides
6.	Maize	Fall armyworm/pre-emergent herbicide	Fungicide/Micronutrient/Insecticide/Pesticides/Herbicide
7.	Mango	Powdery mildew/ Anthracnose/ blight/Sulphur	Fungicide/Micronutrient/Insecticide/Pesticides
8.	Paddy	Stem borer/BPH/Zinc/Blast	Fungicide/Micronutrient/Insecticide/Pesticides/
9.	Papaya	Leaf blight/powdery mildew/nutrient deficiency/Fungus	Fungicide/Micronutrient/Insecticide/Pesticides
10.	Red Gram	Gram Pod borer/Nutrient deficiency	Fungicide/Micronutrient/Insecticide/Pesticides
11.	Safflower	White rust/Club root/Black rot	Fungicide/Micronutrient/Insecticide/Pesticides
12.	Sugarcane	Mili bug/rust/thrips/nutrient deficiency	Fungicide/Micronutrient/Insecticide/Pesticides
13.	Sunflower	Fal armyworm	Insecticide/Micro Nutrient
14.	Soyabean	Spot/spodochra/Nutrient deficiency	Insecticide/Micro Nutrient
15.	Watermelon	Nutrient deficiency	Micro Nutrient
16.	Wheat	Black rust	Fungicide/Micronutrient/Insecticide
17.	Bengal Gram	Pod borer/Blight	Fungicide/Micronutrient/Insecticide
18.	Nutmeg	Blight	Fungicide/Micronutrient/Insecticide
19.	Cucumber	Aphids/Nutrient deficiency	Fungicide/Micronutrient/Insecticide
20.	Ginger	Leaf spot/Yellow disease	Fungicide/Micronutrient/Insecticide/Pesticides
21.	Beet Root	Nutrient deficiency	Micro Nutrient
22.	Brinjal	Fruit rot	Fungicide/Micronutrient/Insecticide/Pesticides
23.	Onion	Nutrient deficiency	Micro Nutrient
24.	Tomato	Powdery Mildew/Nutrient deficiency	Fungicide/Micronutrient/Insecticide/Pesticides
25.	Herbicides		
26.	Ridge Gourd	Powdery mildew/Flies	Fungicide/Micronutrient/Insecticide/Pesticides
27.	Green Gram	Whiteflies/ pod borer	Fungicide/Micronutrient/Insecticide/Pesticides
28.	Ground Nut	Leaf spot	Fungicide/Micronutrient/Insecticide/Pesticides
29.	Calendula Flower	Powdery Mildew/Micro Nutrient/warm	Fungicide/Micronutrient/Insecticide/Pesticides
30.	Chrysanthemum	Wilt/Powdery Mildew	Fungicide/Micronutrient/Insecticide/Pesticides
31.	Black Gram	Yellow disease/Pod borer	Fungicide/Micronutrient/Insecticide/Pesticides
32.	Teak Wood	Pink disease/Powdery Mildew	Fungicide/Micronutrient/Insecticide/Pesticides
33.	Mulberry	Leaf spot/Nutrient	Micro Nutrient
34.	Hyacinth Beans	Nutrient	Micro Nutrient
35.	Potato	Black dot/Blight/Nutrient	Fungicide/Micronutrient/Insecticide/Pesticides
36.	Drumstick	Fruit rot/Nutrient	Micronutrient/Insecticide
37.	Pumpkin	Aphids	Micronutrient/Insecticide
38.	Cabbage	Diamond Black Moth/Nutrient	Micronutrient/Insecticide
39.	Guava	Fungus/Fruit rot	Fungicide/Micronutrient/Insecticide/Pesticides
40.	Beans	Blight/Micronutrient	Micronutrient/Insecticide
41.	Pineapple	Micronutrient	Micronutrient
42.	Tea	Red leaf spot/Rust	Micronutrients/Insecticide/Pesticides
43.	Chickpea	Blight/Micronutrient	Micronutrient/Insecticide
44.	Palm	Leaf related	Micronutrient/Insecticide
45.	Rubber	Colletotrichum Leaf Disease	Fungicide/Micronutrient/Insecticide/Copper Sulphate/Petroleum oil
46.	Sapota	Leaf spot/Fungus	Micronutrient/Insecticide
47.	Coffee	Coffee Leaf Rust/Leaf-related disease	Micronutrient/Insecticide
48.	Lychee	Leaf related	Micronutrient
49.	Butter Fruit	Micronutrient	Micronutrient
50.	Tobacco	Leaf blight/Nutrient deficiency	Micronutrient/Insecticide
51.	Long Grain	Leaf related	Micronutrient
52.	Ladies Finger	Powdery Mildew/Micro Nutrient	Micronutrient/Insecticide
53.	Lemon	Micronutrient	Micronutrient
54.	Pearl Millet	Micronutrient	Micronutrient
55.	Jowar	Micronutrient	Micronutrient
56.	Tuberose	Micronutrient	Micronutrient

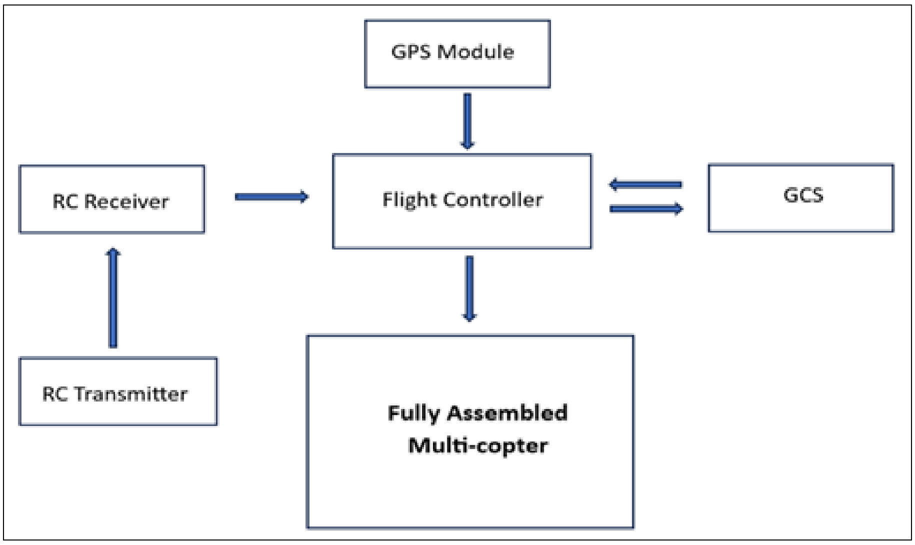

Fig 1: General component of drone

Fig 2: Quadcopter Drone (M- Drone)

Fig 3: Hexacopter Drone (M-Drone)

Fig 4: MD-10H Agri Drone, 1. Centre body; 2. Landing gear; 3. Arm set; 4. BLDC Motor with propeller; 5. T-Jet nozzle; 6. Agricultural tank

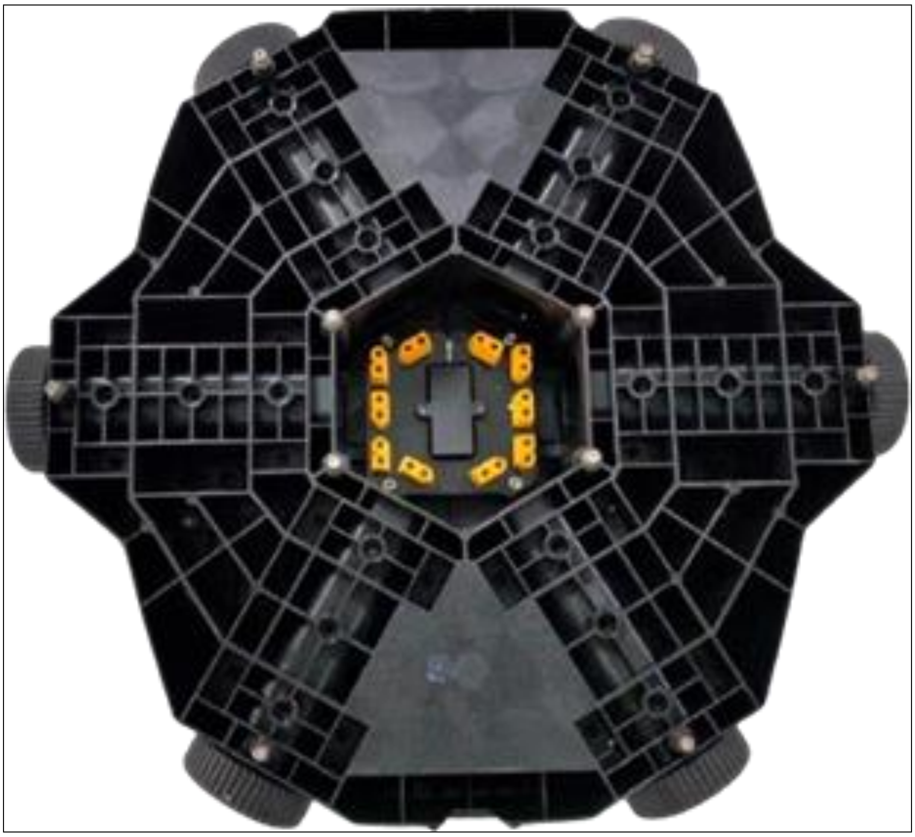

Fig 5: Centre Body

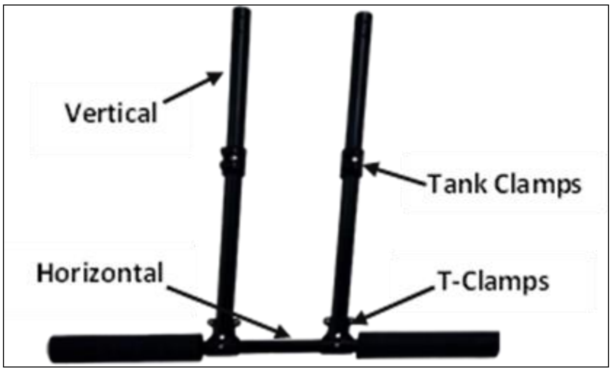

Fig 6: Landing Gear

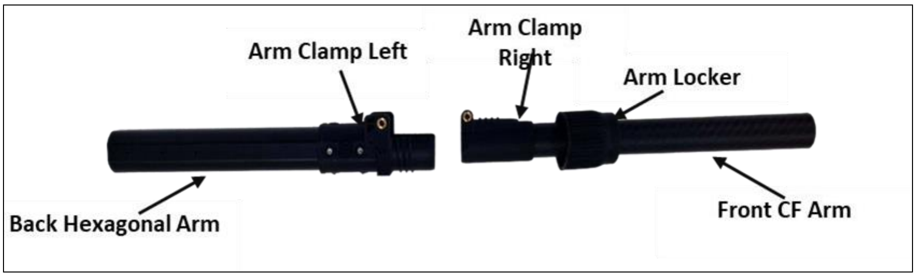

Fig 7: Arm Set

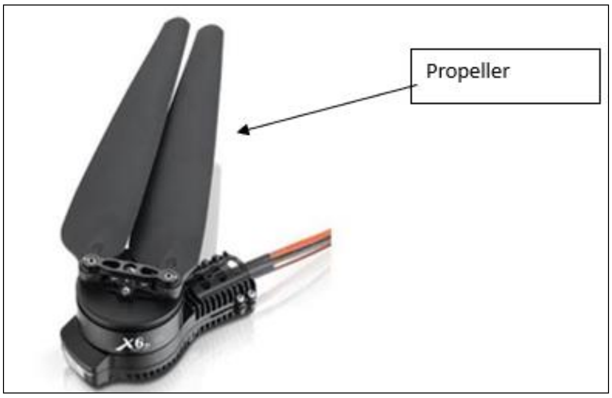

Fig 8: BLDC Motor with propeller

Fig 9: BLDC Pump

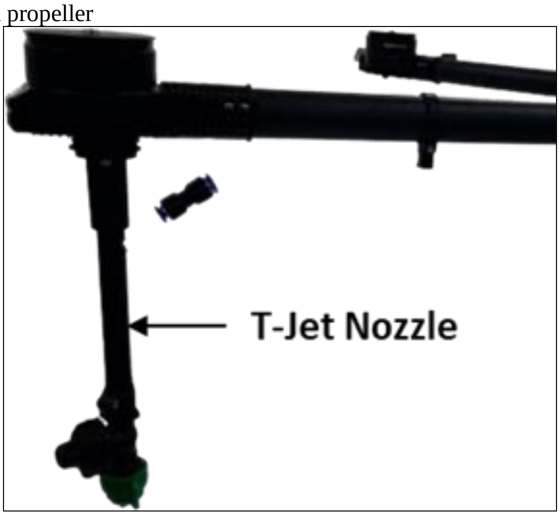

Figure 10: T-Jet Nozzle

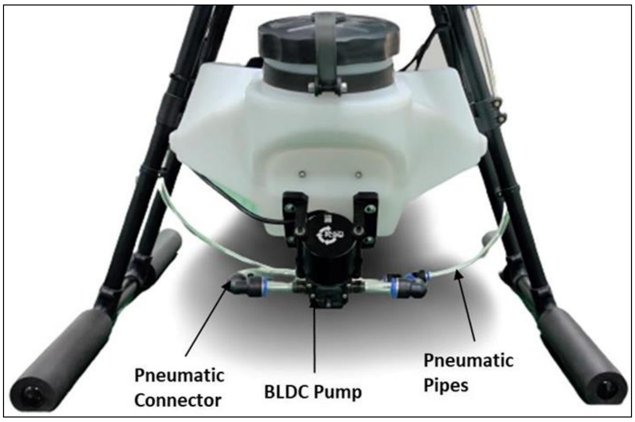

Fig 11: Agricultural tank

Conclusion

India is in a fast-developing phase concerning many sectors of which agriculture is at the forefront to meet the food requirement teaming billions. We are on the right track to utilize the service of drones in the most suitable situations. The purpose of introducing drones in agriculture is to solve the critical problem of the lack of availability of labor for agricultural operations. Recently India has introduced nano fertilizer which has to be fed as foliar spray in place of conventional bulk fertilizer through soil and requires large-scale service of drone in place of traditional knapsack sprayer. The central government has realized the intensity of the problem and proposed a lot of schemes to reduce the labor load, increase women's empowerment, and popularize the utility of nano fertilizer in Indian agriculture with this background M-Drone (MD-10H) is introduced and effectively serving the nation by joining hands with govt schemes aiming in building the India as a drone before 2030.

Future Scope

The future of aerial farming using drones in agriculture is marked by advancements in precision agriculture and sustainable practices. Upcoming developments include sophisticated crop monitoring, where drones equipped with advanced sensors assess crop health, optimizing water and nutrient use. Breakthroughs in planting and seeding technologies are anticipated, with drones performing these tasks more efficiently. Integration with AI and machine learning promises autonomous farm management, enhancing decision-making based on real-time data. Additionally, drones will play a pivotal role in disaster management and crop insurance assessment. This evolution in drone technology is set to revolutionize agriculture, making it more efficient, sustainable, and data driven.

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Authors Contribution

All authors mentioned have made a substantial direct and intellectual contribution to the work and approved it for publication.

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