Drone Application in Agriculture

TRAINING MANUAL

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INTRODUCTION: Northeastern India, comprising with eight states namely Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura is a region known for its rich cultural diversity, unique biodiversity, and challenging topography. The landscape includes rugged hills, dense forests, and fertile valleys, which contribute to its distinct agro-climatic conditions. This region is home to various ethnic communities, each with their own languages, traditions, and lifestyles. Despite its natural beauty and ecological wealth, Northeastern India faces challenges such as limited infrastructure, fragmented landholdings, and difficult terrain, which impact agricultural productivity and development. However, the region is also a frontier for innovation, with technology and sustainable practices playing an increasing role in addressing these challenges. Vastness in natural resources and cultural richness, Northeastern India holds immense potential for growth in agriculture, tourism, and eco-friendly development. With the ever-increasing demand in agricultural practices and production interventions in the field of agricultural mechanization has become immanent and vital.

Government of India under the Ministry of Agriculture and Farmers Welfare (Mechanization and Technology Division) launched Sub Mission on Agricultural Mechanization (SMAM) in the year 2014 as a part of the National Mission on Agricultural Extension and Technology (NMAET) to promote farm mechanization and ensure equitable access to agricultural machinery for farmers, particularly small and marginal farmers across the country with Mission Objective as

1. Increasing the reach of farm mechanization to small and marginal farmers and to the regions where availability of farm power is low
2. Promoting 'Custom Hiring Centres' to offset the adverse economies of scale arising due to small landholding and high cost of individual ownership
3. Creating hubs for hi-tech & high value farm equipments
4. Creating awareness among stakeholders through demonstration and capacity building activities
5. Ensuring performance testing and certification at designated testing centers located all over the country

SMAM is a key initiative launched by the Government of India to promote the adoption of mechanized farming practices across the country. Recognizing the critical role of agricultural mechanization in enhancing productivity, reducing labor dependence, and improving overall farm efficiency, SMAM aims to provide farmers, particularly small and marginal ones, with access to modern machinery and equipment. By focusing on inclusive growth, the mission supports the establishment of Custom Hiring Centers (CHCs), Farm Machinery Banks, and capacity-building programs for farmers, ensuring that advanced technology reaches even the remotest areas. SMAM is instrumental in transforming traditional farming practices into more efficient and sustainable systems, contributing to the long-term goal of doubling farmers' income and promoting sustainable agricultural development in India. Under SMAM, applications of Agricultural Drone technology is one of the breakthrough initiative that can be adopted for the enhancing the agricultural scenarios in North eastern states of India. The application of agricultural drone technology represents a significant breakthrough in modern farming, especially in regions with challenging landscapes like Northeastern India. Comprising eight states, this region is characterized by its rich biodiversity and complex topography. However, these very features, including sloping terrains, fragmented landholdings, and limited infrastructure, pose significant challenges to traditional farming methods. The region also struggles with pest infestations, plant diseases, and nutrient deficiencies, further complicating agricultural productivity.

WHY WE NEED AGRICULTURAL DRONE: Climate change and environmental pollution represent critical global challenges that are increasingly threatening agricultural productivity. To address these issues, sustainable agricultural practices have emerged as a viable solution, mitigating environmental pollution and reducing greenhouse gas emissions, thereby helping to counteract the adverse effects of climate change. In this context, there is a pressing need for the development and deployment of clean and green technologies to ensure that agricultural activities are conducted in a sustainable manner. Unmanned Aerial Vehicles (UAVs), commonly known as drones, offer a promising technological advancement to achieve these goals. The integration of modern technologies in agriculture, such as drones or Unmanned Aerial Vehicles (UAVs), has the potential to significantly improve risk and damage assessments, transforming our approach to disaster preparedness and response in agricultural and allied sectors. Drones, also referred to as Dynamic Remotely Operated Navigation Equipment (DRONE), are devices capable of flight either through autonomous operation using autopilot and GPS coordinates along a predefined route, or via manual control through radio signals, a remote control, or a Smartphone application. Equipped with a diverse array of sensors, drones can perform a wide range of detection and monitoring tasks, offering valuable data for enhancing agricultural resilience and supporting the livelihoods of vulnerable farming communities. In the trends to substitute the adoption of Chemical fertilizers with organic/ bio fertilizers that are environment friendly utilization of Agricultural drones for precise application of the organic base fertilizers and nutrient can be a game changing steps towards the implementation of Natural Farming in the region.

APPLICATION OF DRONE IN AGRICULTURE: An ever-increasing global labour force does not match plant growth proportionately; thus, there is widespread concern about food production sustainability. In such an effort to address this task, growers all over the world have to acclimate for the advanced and computerized solutions to maintain the world's human population farming needs, which are in constant state of flux. At present drones are used in agricultural fields to determine crop biomass, growth and production pattern in determining precision application of input resources, and in harvesting the produce and optimization of logistics. Various applications of drones in agriculture can be outlined as

1. Field and soil assessment
2. Plant establishment
3. Precision crop spraying
4. Crop monitoring

5. Irrigation management
6. Crop health assessment
7. Livestock monitoring
8. Crop surveillance
9. Controlling weed, insect, pest and diseases

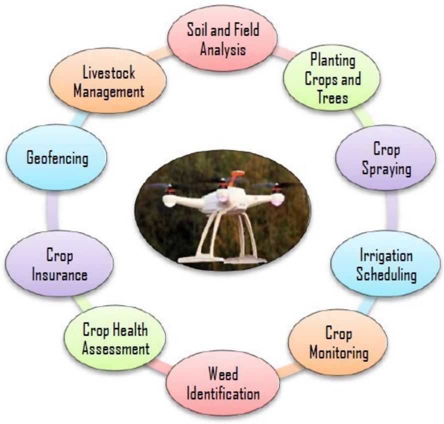


Figure: Drone application in agriculture.

Field and soil assessment: Data collected by drones on soil analysis, both before the start of the season and after crop planting, plays a crucial role in planning crop species selection, planting patterns, and determining the timing and amount of irrigation and nutrient applications. These farm-level management decisions can significantly enhance overall productivity. This approach enables the adoption of site-specific management practices, commonly known as precision farming.

Plant establishment: Labor scarcity has made crop sowing an increasingly costly and challenging task, traditionally dependent on significant human effort. Drones have streamlined large-scale planting, achieving high levels of precision and accuracy in a short period. This drone-based planting method has reduced planting costs by up to 85% and alleviated the intensive labor associated with manual planting.

Precision crop spraying: Drones equipped with sensors can perform site-specific crop spraying by scanning the cultivated area in real-time, ensuring that the precise amount of liquid, such as pesticides and nutrients, is applied to targeted locations. Experts estimate that drones can carry out aerial spraying up to five times faster than conventional methods. This approach improves spraying accuracy, saves time, and reduces input costs for farmers, while also indirectly minimizing pesticide pollution in groundwater.

Crop monitoring: Unpredictable weather extremes pose significant challenges to crop production, making it difficult to monitor crops effectively at the field level. Unmanned drones offer substantial benefits due to their simplicity and efficiency in conducting large-scale surveillance of crops and agricultural land. Currently, time-series animations generated by drones provide detailed insights into crop development and highlight production inefficiencies, enabling improved crop management strategies.

Irrigation management: Agricultural drones equipped with thermal sensing cameras provide exceptional insights into specific problem areas of a farm, particularly for irrigation management. These thermal cameras can detect a range of conditions from low moisture stress to waterlogged areas, enabling farmers to make informed irrigation decisions based on the soil's water status. This capability supports precise water application in fields, enhancing overall irrigation efficiency.

Crop health assessment: Monitoring crop health is crucial for detecting diseases caused by pathogens such as bacteria and fungi. Drones equipped with green visible light and near-infrared sensors can scan crops to assess disease incidence, analyzing spatial and temporal variations in crop reflectance. This early detection capability allows for timely interventions to protect the crops from potential damage.

Livestock monitoring: Drones offer numerous potential applications in animal husbandry. Livestock can be tagged with sensors or radio frequency identification (RFID) tags, allowing drones to monitor their feeding activity and movements. This method enables more frequent tracking of animals, with reduced time and personnel investment. Additionally, remote sensing techniques can be used to create virtual fences or boundaries, effectively establishing spatial security measures for free-range grazing practices.

Crop surveillance: In huge fields, estimating the general condition of the crops is very impossible. Using infrared cameras, drones scan the area and calculate light absorption rates to assess the condition of the crops. Farmers can take action to enhance the condition of plants in any area of the field based on accurate and up-to date information.

Controlling weed, insect, pest and diseases: Drones are able to identify and notify farmers about field regions affected by disease, weeds, and insect pests in addition to soil conditions. With the application of this knowledge, farmers can minimize the amount of insecticides used to combat infestations, saving costs and improving the health of their fields.

Comparative Analysis of Drones on Best Practices

Application	Types of Drones			
	Multi-Rotor	**Fixed-Wing**	**Single-Rotor**	**Fixed Wing Hybrid**
Estimating soil condition	Good	Moderate	Good	Poor
Planting crops	Good	Moderate	Good	Good
Fighting infections and pest	Good	Good	Moderate	Poor
Agricultural spraying	Bad	Moderate	Poor	Good
Crop surveillance	Good	Bad	Good	Poor
Livestock Monitoring	Moderate	Moderate	Moderate	Good

WORKING CONCEPT OF AGRICULTURAL DRONES: Drones utilized in agriculture, function by collecting data from geographical positioning systems (GPS) and sensor-equipped farm machinery, transmitting this data to a Ground Control Station (GCS) via satellite. Subsequently, the data is relayed over the internet to end-users for analysis and the regulation of agricultural equipment. The GCS plays a crucial role in coordinating drone operations, gathering essential information such as geographic data, and managing drone fleet missions. A fleet, composed of multiple drones, receives mission directives from the GCS and collaborates to execute tasks efficiently. Ensuring seamless connectivity between drones and the GCS is vital for enabling drone-assisted wireless communication and for transmitting instructions to field implements. In addition to their use in fleet operations, drones can also serve as standalone applicators for site-specific management, enhancing precision in agricultural practices. Various sensors are used in the drones based upon the purpose.

Agricultural drones are specifically designed to improve production and productivity through site-specific crop management. In recent years, their adoption within agricultural production systems has expanded rapidly. Advances in multispectral imaging techniques and electronic sensors have empowered farmers to obtain precise, detailed information on soil conditions and crop health. Furthermore, the use of these technologies has increased per capita income by reducing the need for labor and agricultural inputs. Mostly the sensors sensitive to the following bands of electromagnetic waves are used in agriculture:

- Red, Green, and Blue (RGB) bands: These bands are used for counting the number of plants, for modeling elevation, and visual inspection of the crop field.
- Near Infra-Red (NIR) band: This band is used for water management, erosion analysis, plant counting, soil moisture analysis, and assessment of crop health.
- Red Edge band (RE): It is used for plant counting, water management, and crop health assessment.
- Thermal Infra-Red band: This band has applicability in irrigation scheduling, analyzing plant physiology, and yield forecasting.

CLASSIFICATION OF DRONE: Drone can be classified as in terms of Payloads, Number of Rotors & Category. The drones can be classified in terms of Payloads as follows

Classification	**Maximum all up weight including payload**
Nano Drone	$\leq$ 250 g
Micro Drone	$>$250 g $\leq$2 kg
Small Drone	$>$ 2 kg $\leq$ 25 kg
Medium Drone	$>$25 kg $\leq$ 150 kg
Large Drone	$>$ 150 kg $\leq$ 500kg
Aircraft	$>$ 500 kg

In terms of Number of Rotors, the Drone can be classified as

1. Tricopters (3 rotors)
2. Quadcopters (4 rotors)
3. Hexacopters (6 rotors)
4. Octocopters (8 rotors)
5. Y6 (6 rotors)
6. X8 (8 rotors)

In terms of category the drone can be classified under as

1. Fixed wing
2. Rotary Craft
3. Hybrid Craft

DRONE ANATOMY-DIFFERENT PARTS OF DRONES: For an better understanding and visualization in respect to agricultural drones an insight of the anatomy in different part are shown below

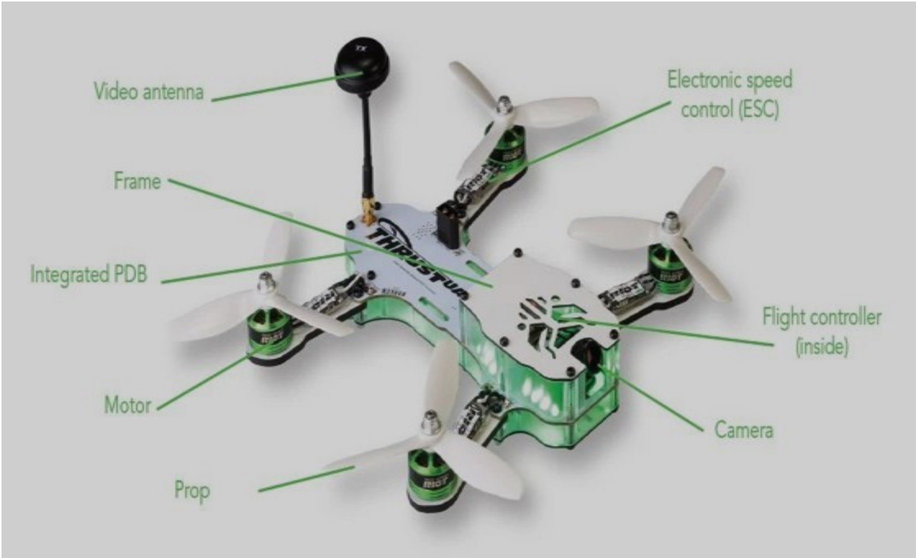


Figure: Example of Agricultural Drone (Micro)

Figure: Example of Agricultural Drone (Small)

Power Module: Power module or Power Management Unit (PMU) is an electronic component that decreases the voltage to 5V. Once voltage is 5V, it is then transferred to Flight Controller (FC).

Figure: Power Module (Power Management Unit)

Transmitter: Transmitter is an electronic device that uses radio signals to transmit commands wirelessly via a set radio frequency over to the Radio Receiver, which is connected to the drone being remotely controlled. In other words, it is the device that translates the pilot's commands into the movement of the multirotor. The General frequencies used in agricultural drones can be categorized as

1. 900 MHz (for long range drone: 10-30 km)
2. 2.4 GHz (Most Drone, Medium range: < 10 km)
3. 5.8 GHz (Short range drones, High quality video)

Figure: Drone Transmitter and receiver

Receiver: The receiver on a drone is an electronic device that uses built-in antennas to receiver radio signals from the drone controller, but the receiver doesn't just receive signals from the drone controller. It also interprets the signals and converts them into alternating current pulses. This information is then sent to the flight control board, or flight controller, which puts the information into action by controlling the drone as indicated by the original radio signals.

Motors: Motors play a critical role in agricultural drones, directly impacting their performance, efficiency, and ability to complete tasks like spraying, mapping, and crop monitoring. Typically, agricultural drones use brushless motors due to their durability, efficiency, and precision. These motors are generally Brushless DC Motors (BLDC). These motors are designed to operate with minimal friction and wear, making them ideal for the extended flight times and challenging environments often encountered in agricultural operations. In a brushless DC motor, the permanent magnets are fitted to the rotor, with the electromagnets on the stator. An electronic speed controller (ESC) regulates or communicates the charge to the electromagnetic in the stator to enable the rotor to travel through 360 degrees.

Electronic Speed Controller (ESC): An Electronic Speed Controller (ESC) is a vital component in agricultural drones, responsible for controlling and regulating the speed of the drone’s motors. The ESC functions as an interface between the drone's flight control system and its brushless motors, allowing for precise adjustments to motor speed based on input from the flight controller. In agricultural drones, ESCs are crucial for ensuring stable flight, particularly when carrying out tasks like spraying fertilizers or pesticides. By modulating the speed of each motor, the ESC helps in maintaining balance and maneuverability, even when the drone is flying over uneven terrain or dealing with variable payloads. This stability is essential for ensuring the accurate and uniform application of agro-chemicals, minimizing waste and maximizing efficiency. Additionally, ESCs play a key role in optimizing the drone’s power consumption by efficiently managing the energy supplied to the motors. This helps extend the flight time, enabling the drone to cover larger areas before needing to recharge, which is critical for large-scale agricultural operations.

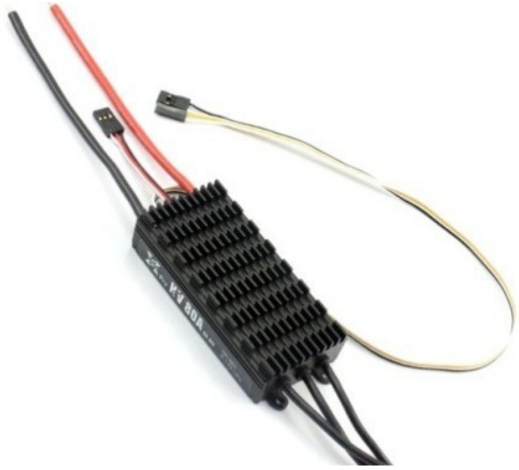


Figure: Electronic Speed Controller (ESC)

Power Distribution Board (PDB): A Power Distribution Board (PDB) ensures an efficient distribution of electrical power from the battery to various essential parts of the drone, such as the motors, Electronic Speed Controllers (ESCs), flight controller, cameras, and sensors. It acts as a central hub, managing and distributing the power supply to ensure each component receives the appropriate voltage and current for optimal operation. In agricultural drones, which often carry heavy loads and operate in demanding environments, the PDB plays an important role in maintaining power stability. It ensures that the drone's motors and other critical systems receive consistent power, which is necessary for stable flight, precise spraying, and accurate data collection. A reliable PDB helps prevent power surges or fluctuations that could otherwise lead to system failures or inefficiencies during operations. Moreover, the PDB contributes to the drone's overall efficiency by optimizing power management, allowing for longer flight times and enabling the drone to handle large-scale agricultural tasks more effectively.

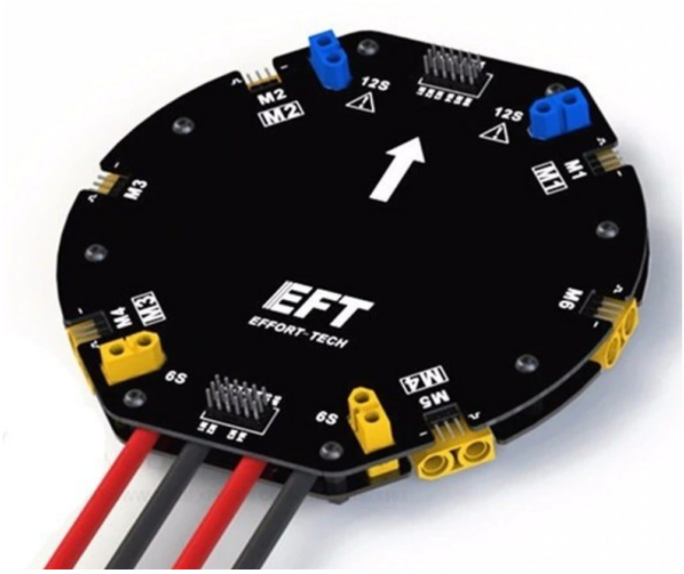
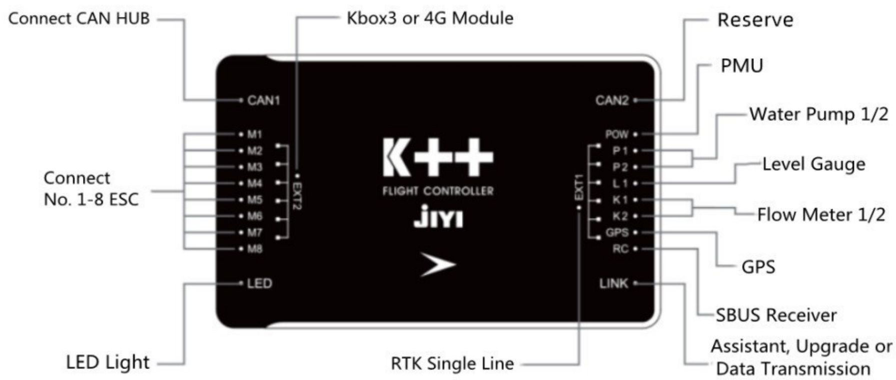


Figure: Power Distribution Board (PDB) in agricultural drone

Flight Controller (FC): The flight controller of an agricultural drone is the central processing unit that manages and controls the drone's flight operations (Shown in figure below).



It acts as the brain of the drone, receiving inputs from various sensors, the transmitter, and GPS systems, and translating them into the necessary actions to maintain stable flight, perform maneuvers, and execute agricultural tasks. The main key functions of the Flight Controller (FC) can be listed as below:

Stabilization and Navigation

- The flight controller ensures that the drone maintains stable flight even in challenging conditions such as wind or uneven terrain. It uses sensors like gyroscopes and accelerometers to detect changes in orientation and speed, automatically adjusting the drone's motor speeds to keep it balanced.
- For navigation, the flight controller often integrates with GPS and compass modules, enabling precise positioning, path-following, and autonomous operations, which are essential in large-scale agricultural tasks like field mapping or spraying.

Autonomous Flight

- Many agricultural drones are equipped with flight controllers that allow for pre-programmed, autonomous flights. This feature lets the drone follow a predetermined flight path, covering specific sections of a field for tasks such as spraying pesticides or gathering multispectral imagery for crop analysis.

- Using software, the farmer or drone operator can set the route, altitude, and spray intervals, and the flight controller executes these commands automatically.

Sensor Integration

- The flight controller processes data from a variety of sensors used in precision agriculture. For instance, if the drone is equipped with multispectral cameras, thermal sensors, or LiDAR, the flight controller synchronizes the data collection with the drone's flight path, ensuring the drone captures the correct data at the right locations.
- It also communicates with sensors responsible for collision avoidance, ensuring the drone can navigate safely around obstacles, like trees or uneven ground.

Control of Payload Systems

- The flight controller regulates the operation of payload systems, such as sprayers for pesticides or fertilizers. It can control the spray timing, flow rate, and coverage area based on flight speed and GPS location, ensuring that chemicals are applied precisely where needed.
- In drones used for seeding or granular distribution, the flight controller coordinates the release of seeds or fertilizers with the drone's speed and position for optimal coverage.

Telemetry and Communication

- The flight controller continuously sends telemetry data (like battery levels, altitude, speed, and position) to the operator through the transmitter. This real-time feedback is crucial for monitoring the drone's status and ensuring safe, efficient operation during long flights across agricultural fields.
- It also ensures communication between the drone and ground stations, enabling real-time decision-making or adjustments to flight plans.

Failsafe Features

- Flight controllers in agricultural drones are typically equipped with failsafe mechanisms, such as Return-to-Home (RTH), which automatically guides the drone back to its takeoff point in case of signal loss, low battery, or other issues.
- These safety features are particularly important in agriculture, where the drone may need to operate over vast and remote areas without constant supervision.

Main components of a Flight Controller comprises of the following:

- Inertial Measurement Unit (IMU): Includes the gyroscope and accelerometer for stabilization and orientation.
- GPS Module: Ensures accurate positioning for autonomous navigation.
- Barometer: Measures air pressure to help maintain a stable altitude.
- Compass: Ensures directional accuracy.
- Processor: The main computing unit that processes sensor inputs and controls the drone's motors and other systems.

The flight controller's ability to manage precise operations, from maintaining stability to controlling payloads, makes it the most critical component in agricultural drones. It enables:

- Efficient crop spraying and seeding, ensuring accurate distribution and minimizing waste.
- Precision data collection, crucial for tasks like crop monitoring, soil analysis, and field mapping.
- Safety and reliability during operations in expansive and sometimes harsh agricultural environments.

Battery: The battery in an agricultural drone is a critical component that powers all the drone's systems, including motors, Electronic Speed Controllers (ESCs), flight controller, sensors, and payloads such as sprayers. Most agricultural drones use lithium-polymer (LiPo) batteries due to their high energy density, lightweight design, and ability to deliver substantial power over extended flight durations. Lithium batteries have two most commonly used batteries namely Lithium ion battery (eg. Mobile batteries) and Lithium polymer battery (eg. Quadcopter, helicopter). Each cell of lithium polymer battery has a minimum of 3.7 V and maximum of 4.2 V capacities. Therefore as to say, a 6 cell battery contains 22.3 V whereas a 12 cell battery contains 44.4 V. A view of the generally used lithium polymer battery is shown as below

Figure: Example of lithium polymer battery (16000mAh)

Propeller: Propellers are a crucial component of an agricultural drone, as they generate the lift and thrust needed for flight by transforming rotary motion into linear thrust. Drone propellers provide lift for the aircraft by spinning and creating an airflow, which results in a pressure difference between the top and bottom surfaces of the propeller. This accelerates a mass of air in one direction, providing lift which counteracts the force of gravity. Drone propellers can be constructed with 2, 3 or 4 blades. Propellers with more blades provide greater lift due to more surface area moving through the air per rotation, but are more inefficient due to increased drag. Smaller drones with limited battery life are best suited to propellers with fewer blades. A view of the propeller is shown below

Figure: Example of reinforced plastic propeller.

The propellers of agricultural drones are typically made from lightweight and durable materials that provide strength while ensuring efficient flight performance. The most common materials used for agricultural drone propellers includes

- Carbon Fiber: This is the preferred material for high-end agricultural drones due to its strength, rigidity, and light weight. Carbon fiber propellers are highly durable, resistant to wear and tear, and provide superior flight stability, making them ideal for drones carrying heavy loads like agro-chemicals.
- Reinforced Plastic: Many agricultural drone propellers are made from reinforced plastic, which offers a balance between cost-effectiveness and durability. These propellers are generally lighter but less durable than carbon fiber, making them suitable for smaller or less demanding agricultural drones.
- Nylon with Glass Fiber Reinforcement: Some propellers are made from nylon reinforced with glass fibers to enhance their durability and strength while keeping them lightweight. This material offers good resilience and is cost-effective for drones operating in moderate conditions.

Landing Gear: Landing gears are not required for small drones. However, bigger drones need a landing gear to avoid damage while landing. The requirement of landing gears varies with functionality of the drone. Landing gears are designed to support the drone during takeoff, landing, and while on the ground. It helps protect the drone's body, payload, and sensitive equipment such as cameras & sensors from impact and damage. Agricultural drones typically operate in rough, uneven terrains like fields, so the landing gear needs to be durable, stable, and well-suited for these environments. Key features and materials used in designing landing gear of agricultural drones are as

- **Material**: Landing gear is commonly made from lightweight yet strong materials such as carbon fiber or aluminum alloy. These materials offer durability without adding significant weight to the drone, allowing it to carry heavier payloads such as fertilizers, pesticides, or cameras.
- **Design**: The landing gear is often designed with wide stances or extended legs to provide stability during landings on uneven surfaces. Some models feature retractable landing gear to improve aerodynamics during flight or to avoid obstructing cameras and sensors when the drone is airborne.
- **Shock Absorption**: Many agricultural drones have landing gear equipped with shock-absorbing features, such as rubber padding or suspension systems. This helps reduce impact forces when landing, protecting delicate onboard equipment and minimizing damage during hard landings on rough fields.
- **Height**: The landing gear is usually designed to provide enough clearance between the ground and the drone's components, particularly its spray systems, cameras, and sensors. This ensures that these parts don't get damaged or contaminated by dirt, dust, or debris during landing and takeoff.

A view of the landing gear in agricultural drone is shown below

Figure: Landing Gear parts and setup in Agricultural Drone

Transmitter Controls: The transmitter controls in an agricultural drone are the primary interface through which the operator pilots the drone and manages its various functions. These controls allow for precise navigation, operation of payloads (such as sprayers or cameras), and adjustments to flight settings. Typically, the transmitter is a handheld device that communicates with the drone via radio signals or wireless protocols, providing real-time control and feedback.

The main aspects of the transmitter controls in an agricultural drone can be as:

Joystick Controls: Most transmitters have dual joysticks that control the drone's basic movements. Left Joystick controls throttle (altitude) and yaw (rotation around the vertical axis). Right Joystick: Manages pitch (forward and backward movement) and roll (left and right movement).

Switches and Buttons: Transmitters typically include additional switches and buttons for various functions like Mode Selection, allowing the operator to switch between manual flight, autonomous flight, or GPS-assisted modes. Sprayer Activation: A dedicated button or switch for controlling the drone's spraying system, enabling or disabling the release of fertilizers during flight.

Return-to-Home (RTH): A safety feature that automatically brings the drone back to its starting point in case of signal loss or low battery.

Flight Modes: Agricultural drones often have multiple flight modes that can be selected via the transmitter. These modes can be in form of Manual Mode: Full control by the operator for precision tasks; GPS Mode: The drone maintains stability and position using GPS, ideal for spraying or mapping tasks over large fields and finally the Autonomous Mode: Pre-programmed flight paths and tasks, such as spraying a defined area, can be initiated through the transmitter or paired app.

Telemetry and Feedback: Modern transmitters provide real-time telemetry data on battery status, GPS coordinates, altitude, and more. This information allows the operator to monitor the drone's performance and ensure efficient operation.

Payload Control: In addition to flight control, agricultural drone transmitters can operate payload functions like adjusting camera angles, controlling sprayer flow rates, or switching between sensors.

Range and Frequency: Agricultural drone transmitters typically operate on frequencies like 2.4 GHz or 5.8 GHz, offering a long-range signal that is essential for covering large areas of farmland.

The figure below shows the view of the transmitter with depiction of the operations.

Figure: View of basic controls in transmitter of Agricultural Drone

Payloads: The payload in an agricultural drone refers to the equipment or materials the drone carries and utilizes during its operations. Agricultural drones are designed to perform a variety of tasks, and their payload can include sprayers, cameras, sensors, or other tools depending on the specific application. The payload capacity is a critical aspect, as it determines the drone's ability to carry out tasks efficiently over large agricultural areas. Technically a payload is the weight a drone or UAV can carry or the load carried by a vehicle exclusive of what is necessary for its operation. It is usually counted outside of the weight of the drone itself and includes anything additional to the drone such as extra cameras, sensors, packages for delivery etc. An average drone can carries upto 0.5 to 2 kg of weight. A professional drone can lift upto 200 kg. The payload capacity is dependent on the power to weight ratio of the drone.

Types of payloads

1. Dispensable payloads
2. Non-dispensable payloads

3. Active payloads
4. Passive payloads.

Dispensable payloads: All the deliverable payloads to the consumer end are considered dispensable payloads. The dispensable payloads can able to release from the aerial vehicle during the flight based on the received signal from the radio controller (RC) or ground control station (GCS). Examples are food delivery, medicine delivery during natural calamity period.

Non-dispensable payloads: This type physically remains on the UAV throughout the mission but their part plays a vital role in mission completion. The most widely applications are mapping, surveillance, wildlife monitoring.

Active payloads: These payloads entirely or partially throughout the mission are used for the purpose of mapping, data collection surveillance etc.

Passive payloads: Passive payloads are inactive during the mission and are deliverable at some point predefined destination. Any removable and/or interchangeable equipment from the UAVs that is used for photographs/filming, thermal scanning or other types of survey. Such equipment is and counted outside of the weight of the UAVs itself.

PRE FLIGHT CHECK: Before exercising an operation using the Agricultural Drone, one needs to follow certain precise pre flight check as to ensure safety/ precaution and smooth operation of the drone in the desired field. The pre flight check can be listed as below:

1. Documentation check
2. Area Check
3. Drone Check

DOCUMENT CHECK: One has to ensure that, the pilot has the Remote Pilot Certificate (RPC) and is in well within the validity with proper Unique Identification Number (UIN) as shown in the figure below


GARUDA AEROSPACE PRIVATE LIMITED
Remote Pilot Training Organization
Under the Rule 39 of the Drone Rules 2021,
Approved By : DGCA - 31036/41/2022-DRONE-Dte RPTO:Authorisation no: RA1222000000P 23/2022
24/46, KB Dasan Road, Alwarpet, Chennai - 600018.

This is To Certify That :
JOTISH NONGTHOMBAM
~~ID~~ / Passport No: Y9461620 Gender: Male / ~~Female~~ DOB : 23-12-1983
UIN : UA007KJSOTC
Has successfully completed the DGCA approved
THE REMOTE PILOT TRAINING COURSE

RePL Cat - 1 [VLOS] Category | Rotorcraft Sub Caterogy : RPAS Class: Small / ~~Medium~~
Ground Class: 22.03.2024 To 23.03.2024
Flying Training: 26.03.2024 To 30.03.2024
Oral Examination: 30.03.2024

Certificate No: GA/S/RC/B43/950 Date of Issue: 30.03.

(ACCOUNTABLE MANAGER) (RPAS TRAINER)

Figure: RPC with UIN of certified Drone Pilot

It’s also wise to check whether, the Drone make manual is there along with the operator along with the Remote Pilot Log Book as shown in the following section below in Figure

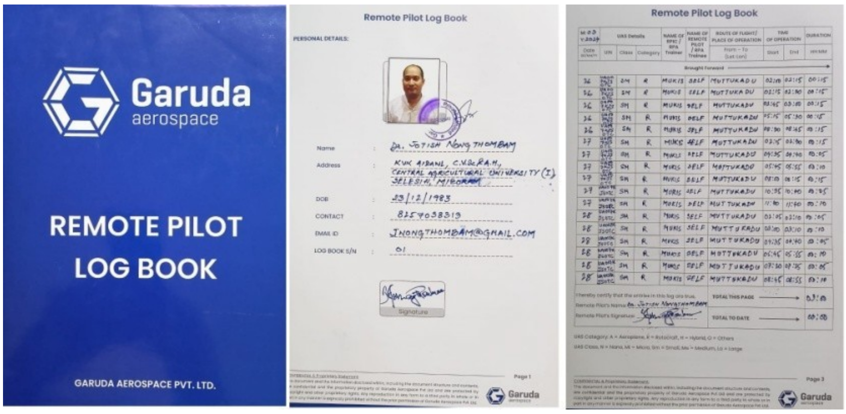


Figure: Example of Remote Pilot Log Book

AREA CHECK: When operating an Agricultural Drone or any UAVs it is utmost important that one has to execute the Area Check procedure. In perception of safety, Air Traffic Control (ATC) regulatory compliances, flight & terrain efficacy and avoidance of No-Fly Zone one needs to conduct an Area Check in agricultural drone operations to ensure safety, regulatory compliance, and operational efficiency. It helps identify potential obstacles like power lines or trees, avoid no-fly zones, and comply with local airspace regulations. By assessing the terrain and environmental conditions, operators can optimize flight paths, ensuring precise and efficient application of agro-chemicals while minimizing waste and environmental impact. Area checks also account for terrain variations, enabling the drone to adjust for altitude changes, ensuring uniform coverage and enhancing the overall effectiveness of the operation. In an area check one of the foremost steps that need to be taken care is the checking of No Fly Zone. The Airspace is classified as Airspace Classification as shown in Figure below:

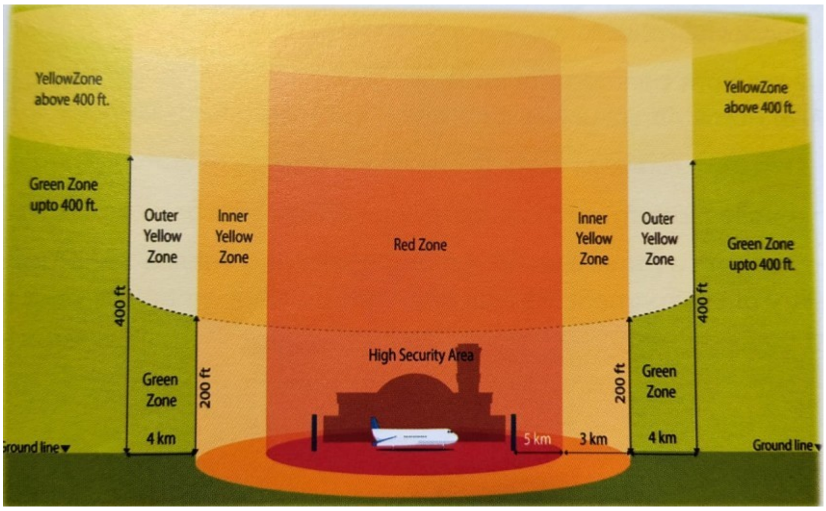


Figure: Airspace Classification diagram

The airspace is classified as Red, Yellow & Green Zones. The Red Zone, starts as from a classified point of high security area/ Airport/ Government restricted are to a span of 5 km radius. Then The Inner Yellow Zone in a radius of 5km to 8 km followed by outer Yellow Zone in a radius of 8 km to 12 km and finally the Green Zone beyond 12 km. And in terms of elevation, inner yellow zone ranges up to 200 ft, out yellow zone ranges upto 400 ft and green zone 400 ft and above.

One can check the Zones from digital sky portal available under Directorate General of Civil Aviation, Govt. of India, and the Airspace map as given below (Link & Snap clip of Site)

(https://digitalsky.dgca.gov.in/home ; https://digitalsky.dgca.gov.in/airspace-map/#/app)

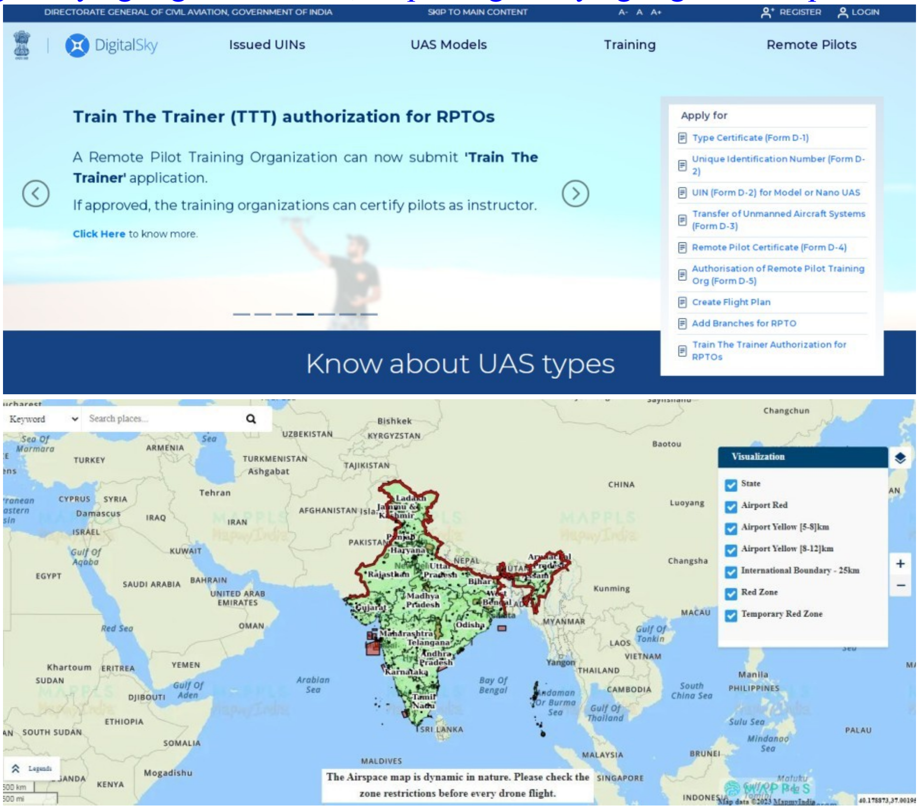


Figure: Digital Sky & Airspace map, Directorate General of Civil Aviation, Govt. of India

Once entered in the Digital sky webpage one needs to go to Airspace Map and enter the coordinates of the site one needs to operate the Agricultural Drone. When the coordinates is entered in the search space the location will be shown in the Airspace map. An example for the same is shown below for better perspective

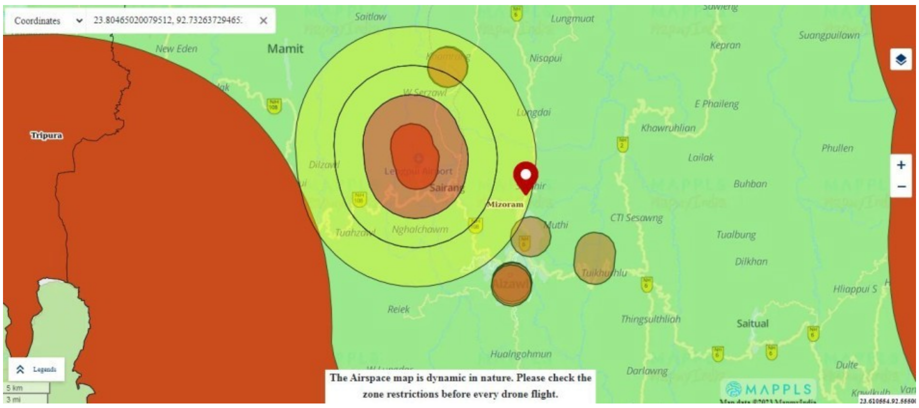


Figure: Example of Red, Yellow & Green Zone available in Airspace Map

If, the selected area of interest is under Green zone one can operate the agricultural drone, otherwise needs to take permission from the aviation department with proper clarification. Thereafter, Weather check is terms of rainfall and wind speed is essential. A maximum of wind speed 9 m/second is a limit in terms of Agricultural Drone as above this speed, the drone operation is not safe in any specific area of operation.

DRONE CHECK: Drone check or physical check is essential to ensure the drone operates safely, efficiently, and effectively. This process involves thoroughly inspecting the drone and its systems before flight to minimize the risk of malfunctions or accidents during operation. For a better understanding and reference the check list may be grouped as follows

Physical Inspection

- Frame and Body: Check the drone's body and frame for any visible damage, cracks, or loose parts. Ensure all components, including arms, landing gear, and mounts, are secure.
- Propellers: Inspect each propeller for any signs of wear, cracks, or damage. Ensure that the propellers are firmly attached and properly balanced.
- Motors: Check the motors for any debris or obstructions. Manually spin them to ensure they rotate smoothly without resistance or noise.

Battery Check

- Battery Charge: Ensure that the battery is fully charged and suitable for the expected flight duration. Inspect the battery for any signs of swelling, leakage, or damage.
- Battery Connection: Verify that the battery is securely connected to the drone's power system and properly seated to prevent disconnection during flight.

Electronic Systems Check

- Flight Controller: Ensure the flight controller is working properly. Confirm that all software and firmware are up-to-date.
- Electronic Speed Controllers (ESCs): Verify that the ESCs are functioning correctly and check for any signs of overheating or physical damage.
- Power Distribution Board (PDB): Check the connections on the PDB, ensuring that it properly distributes power to all components.
- Payload Systems: Inspect payload equipment, such as sprayers, cameras, or sensors, for proper attachment and functionality.

Transmitter and Communication

- Transmitter Battery: Ensure the transmitter or remote control device is fully charged.
- Signal Range: Check for a strong signal connection between the transmitter and the drone, ensuring the range is appropriate for the planned flight area.
- Failsafe Features: Test failsafe mechanisms such as the Return-to-Home (RTH) function, ensuring they are configured correctly.

Sensor Calibration

- GPS Module: Verify that the GPS module is functioning and locked onto sufficient satellites for precise navigation.

- Compass Calibration: Calibrate the compass to ensure accurate directional control, especially important when flying over large areas.
- Inertial Measurement Unit (IMU): Calibrate the IMU to ensure the drone can maintain stability and correct orientation during flight.

Software and Firmware

- Flight Plan: If using autonomous flight modes, ensure the flight plan is properly set and reviewed, including altitude, waypoints, and spray zones (if applicable).
- Firmware Updates: Check that all software and firmware on the drone and the ground station are up to date and functioning properly.

AGRICULTURAL DRONE FOR ORGANIC & NATURAL FARMING: Agriculture has undergone significant transformations over time, both globally and in India, leading to the present-day farming practices. The introduction of Green Revolution technologies in India played a key role in transforming the country from food scarcity to food surplus. However, this intensification of agriculture also brought adverse effects, such as soil degradation, loss of biodiversity, rising cultivation costs, and stagnant or declining crop productivity. These challenges, coupled with climate change and uncertain market conditions, have made farming less profitable, driving many farmers into debt and distress. In response, organic farming has gained importance as a sustainable alternative that not only improves soil health and reduces chemical dependency but also offers a debt-free and profitable livelihood. Similarly, there is a trend to explore natural farming for its potentials to enhance sustainability and preserve soil health. Natural farming, rooted in ancient Indian science and the principles of Vrikshayurveda, is an ecological farming approach introduced by Japanese farmer and philosopher Masanobu Fukuoka in his 1975 book *The One-Straw Revolution*. Known as the "Fukuoka Method" or "Do-Nothing Farming," this philosophy emphasizes working with nature to produce healthy food while avoiding manufactured inputs and machinery. A notable branch of natural farming is Zero-Budget Natural Farming (ZBNF), introduced by Subhash Palekar in the mid-1990s, which promotes the use of locally available natural inputs like cow dung, urine, jaggery, and neem to improve soil health and reduce input costs. Natural farming seeks to make farmers self-reliant, eliminating dependency on costly chemical fertilizers, pesticides, and market-driven inputs. By restoring soil fertility, reducing water usage, and promoting sustainable, eco-friendly farming practices, natural farming aims to produce chemical-free agricultural products in harmony with nature, ensuring long-term soil health and sustainable food production.

The adoption of agricultural drones in organic and natural farming presents promising opportunities for enhancing productivity and sustainability while adhering to eco-friendly practices. Drones can be used to monitor crop health, assess soil conditions, and manage water resources through precision technology, reducing the need for chemical inputs and minimizing environmental impact. In organic and natural farming, synthetic pesticides and fertilizers are avoided; drones can support the targeted application of natural inputs like organic fertilizers, biopesticides, and plant-based nutrients, ensuring efficient and precise usage. Additionally, drones equipped with multispectral sensors can help in early detection of pest infestations, nutrient deficiencies, and other stress factors, enabling timely interventions with natural remedies. The technology also allows farmers to survey large areas quickly, optimizing land management and promoting biodiversity. By coupling drones, organic and natural farming techniques significant improvement in crop yields can be achieve with reduce labor costs, and maintain sustainable farming practices, making them a valuable tool in the eco-friendly agricultural landscape.

CONCLUSION: The application of agricultural drones has revolutionized modern farming by enhancing efficiency, precision, and sustainability. These drones offer significant benefits, from optimizing crop spraying and seeding to providing detailed field data through imaging and sensors. By reducing the need for labour, minimizing chemical waste, and enabling precise monitoring, agricultural drones can help improve productivity and crop health, especially in challenging terrains. As technology continues to evolve, drones will play an increasingly vital role in addressing global food demands, promoting precision agriculture, and supporting environmentally friendly farming practices.

Krishi Vigyan Kendra – Aizawl, Central Agricultural University, Imphal at Mizoram Station is equip with Agricultural Drone and has already started initiating awareness and training programs under Agricultural Engineering Division. The View of the purchased agricultural Drone is shown below

Figure: View of the Agricultural Drone at KVK Aizawl.

In custom hiring program initiated under SMAM, now the Agricultural Drone is available to farmers of the region @ Rs.500/ acre. The team of KVK Aizawl, its Scientist and co-coordinating institutions such as ICAR-IIHR Bengaluru, ICAR-IARI New Delhi, CBBO (Agrico pvt. Ltd.), Mizoram University have been promoting and demonstrating the applications of drone in agriculture through awareness, trainings and demonstration. The activities of promotion of Agricultural Drone have also been highlighted by the local news channels in no of occasions. Some of the insight of the demonstration is shown below.

Figure: Clip of telecast in local channel & demonstration of Agricultural Drone

Agricultural Drone applications in promoting and demonstrating Organic and Natural Farming techniques can bring a humble cause to sustainable farming that is eco-friendly and healthy to mankind as a whole.

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