Drone for Agriculture: Challenges and Opportunities

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***Abstract*—Agriculture, the backbone of India, has seen a massive rise in the use of technology in the past decade. The Indian Agriculture Sector needs to use the capabilities of applications of Robotic Process Automation (RPA) with image processing, pattern recognition, and machine learning to apply technology for maximum effect. Machines can do automated tasks better, cheaper and faster. One can use the camera from the sky and measure things on the earth, especially on cropland, from drones and satellites. Over time, drones have increased in capabilities and fallen in cost, and their use has dramatically expanded, especially in complex terrain. High-quality remote sensing with drones' spectral imaging makes them interesting for regular use in Precision Agriculture (PA). Drones are often used in agriculture in highly controversial ways only a short time ago, even though there is no unified legislation on drone usage in agriculture. The paper proposes that farmers use an Unmanned aerial vehicle (UAV) or a drone to monitor the agricultural field and have a smooth and profitable yield of the crops. The components, design, and working of agricultural drones have been discussed in detail. The drone's control system uses sensors that help keep away the pests in the agricultural field, monitor the water level in the field, and check the health of the crops using optical crop sensors. Drones in agriculture, however, face many challenges due to technical issues, unawareness, weather dependencies, and government policies. This paper discusses the various rules and regulations of drone laws in different countries and the future implementation plan and outlook. Drones have the potential to revolutionize the agriculture sector, and current technology is creating things easy and more effective for future generations. The agricultural drone market is impressive and is rising year by year.**

Keywords - ***Robotic Process Automation, Image Processing, Pattern Recognition, Machine Learning, Drones, Remote Sensing, Precision Agriculture, Unmanned Aerial Vehicle***

INTRODUCTION

Drone technology is a phenomenal invention in today's time which has transformed various human activities spreading its roots towards agriculture as well. Drones are transforming agriculture in various ways such as carrying cameras, spraying systems, sensors that can provide real-time information about the crop status or livestock movement, etc. Drones have found several applications in agriculture, however is limited by the country policies on its use context.

DRONE MECHANISM

A Drone, commonly known as Unmanned Aerial Vehicle (UAV) is essentially a flying ROBOT (An air vehicle that does not carry a human operator). The aircraft may be remotely controlled or can fly autonomously through software-controlled flight plans in their embedded system working in conjunction with onboard SENSORS and Global Positioning System (GPS).

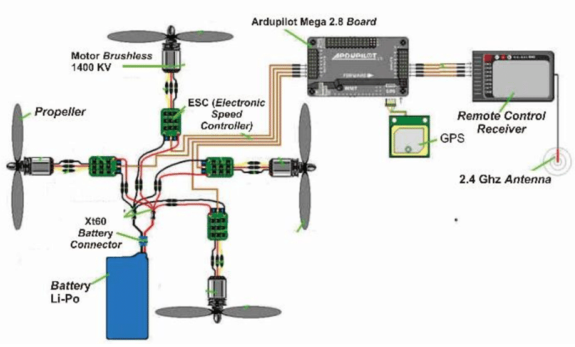
Components of Drone:

- **Frame:** It is a structure that holds all the components together. Frame should be strong as well as light-weight.
- **Electronic Speed Controller:** These devices allow drone flight controllers to control and adjust the speed of the motors of aircraft. A signal from the flight changes ESC to increase or decrease the voltage to the motors as required. They are also used to change the speed of the propellers.
- **Brushless DC Electric Motors:** Also called BLDC motors, these are synchronous motors that uses direct current. If these motors stop spinning, the propellers attached to them stop rotating and as a result the drone won't fly.
- **Propellers:** These are the wings of the drone. They transform rotatory motion into linear thrust by spinning and providing airlift to the drone. They create an airflow that forms a pressure difference between the top and bottom surfaces of the propeller.
- **Fly Sky Transmitter and Receiver CT6B:** Fly sky CT6B is a 2.4 GHz channel Transmitter and the Receiver is used to control the drone by a remote.
- **Camera:** A multispectral camera is installed in the drone to capture images of the field to determine where to spray pesticides and fertilizers.

All these parts are assembled, and a drone is formed, controlled by a transmitter and receiver CT6B. Also, an infrared camera can be installed to capture infrared images of the field. It is used to predict water stress levels and detect diseases and pathogens in crops.

CONTROL DESIGN

The most crucial component of the entire drone system is the control system. All of the drones use the same control system. The microcontroller, which uses a chip, serves as the drone's central control component. The microprocessor is coupled to various sensors, including an optical crop sensor, an ultrasonic level sensor, a transceiver for swarm communication between the drones, a GPS module, a WIFI module, and a motion tracking device.



Micro-controller

The microcontroller is the brain of the drone's control system. It performs well while using very little electricity. There are 100 pins on the microcontroller. The microcontroller and sensors may be readily incorporated. Additionally attached to the microcontroller is an SD card that serves as the memory storage unit for the complete control system. All the values the sensors acquired in monitoring the agricultural fields are stored in this memory storage. When the drone operates in an agricultural area, this SD card serves as a backup or redundancy in case the values are not accessible during live monitoring.

Battery

The battery is crucial since it powers the drone's motors, propellers, and control system. The drone uses LiPo (Lithium Polymer) batteries. LiPo batteries are selected to suit the demands of the drone for monitoring reasons while keeping in mind the power requirements. The drones use AHTech Infinity 4s LiPo batteries, which have a voltage rating of 14.8V and a

current capacity of up to 1500mAh.The battery can deliver a maximum continuous current of 127.5A due to its 85C discharge rate. The drone's propellers use 60A of electricity, and the remaining current—more than enough to operate the control system and the sensors attached to the microcontroller—is utilized to power the control system. The GPS module is incorporated into the battery, which only weighs 180g. As soon as the drone is in operation, this is done to power the GPS.

Inertia Measurement Unit

A gyroscope, an accelerometer, and a compass are necessary for the drone. The MPU 9150 IMU (Inertia Measuring Unit) is utilized to increase the modularity of the drone control architecture. This aids in lightening the drone's overall weight. A system in a package called the MPU 9150 combines two different chips. One is the MPU-6050, which has a 3-axis gyroscope and an accelerometer. The AK8975, which has a 3-axis digital compass, ranks number two. This unit of inertia measurement is essential to how the drone operates. The drone benefits from the MPU 9150's integrated Digital Motion Processor hardware acceleration engine as one additional feature.

Optical Crop Sensor

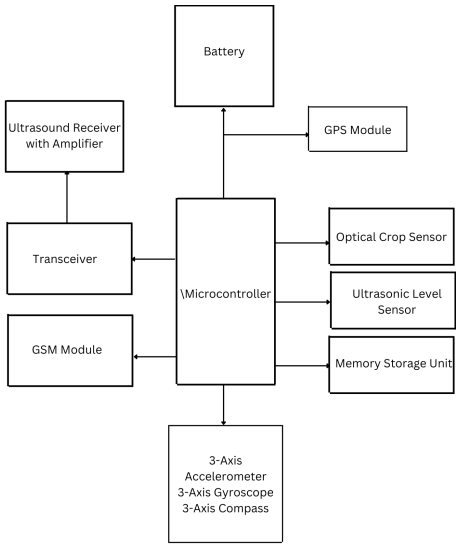
Optical crop sensors operate by shining a light with a certain wavelength on the crops, then analyzing the light reflected back from the crops to determine the crop's state. Plants reflect back green light waves while greatly increasing the absorption of red and blue light waves. This explains why the majority of plants seem green to the unaided eye. The optical crop sensors' main application in operation is this. Compared to lighter green leaves, dark green plants reflect more near infrared light and absorb more red light. The crop sensor uses the reflected red and NIR light wavelengths to determine the Normalized Difference Vegetation Index (NDVI). The NDVI measurements vary from 0.3 to 0.8. Crops that were healthy and green produced NDIV scores between 0.6 and 0.7. Crops with a lower level of health produced NDVI scores between 0.2.

Ultrasonic Level Sensor

The ultrasonic short body sensor uses high frequency sound waves to both receive and send information on the water level in the fields. They employ piezoelectric components that vibrate to create soundwaves; these soundwaves move and are reflected back once they come into touch with the water level existing in the soil. A transducer picks up these reflected soundwaves. The time it takes for the sound wave to return to the sensor is now used to determine the water level.

Transceiver

In the field, the swarm communication between two drones depends heavily on the transceiver.Due to the CC2520 RF Transceiver's good line-of-sight range, two drones can easily communicate with one another. This is connected to a microcontroller and an amplifier that aids in signal reception.



WORKING OF AGRICULTURAL DRONES

At first, the field in which drone should operate is marked on PC or mobile. Then drone starts its work in the field and captures images of the target areas with the help of multispectral camera sensors. The images obtained are then analyzed using software to get precise information.

Technology used in agricultural drones:

Low altitude remote sensing technology (LARS): It is a relatively new concept of acquiring earth surface

images at a low altitude using unmanned aerial systems (UAS) which is a promoted platform to monitor crop growth, crop stress, and to predict crop yield.

Multispectral camera remote sensing imaging technology: This technology uses green, red, red-edge and near infrared wavebands to capture both visible and invisible images of crops and vegetation. This technology enables farmers to see further than the naked eye.

USES OF DRONES IN AGRICULTURE

Agriculture industries globally have increased the use of drone technology in order to modernize farming. Drones are designed to carry sensors that can provide real-time information about the crop status or livestock movement so that decision on cultural operations and management is made efficiently and precisely. Cameras are mounted on drones to extract data captured by them and calculate land sizes, classify crop types and varieties, etc., to adequately plan the harvest of the crops. The use of drones can be advantageous in the case of pesticide spraying and replacing labour-intensive and hazardous conventional methods. The agricultural labour shortage in exceptional times of the COVID-19 pandemic that has necessitated the adoption of physical distancing measures has opened up several opportunities for using drones in agriculture. However, it is limited by the country's policies on its use context.

Soil and Field analysis

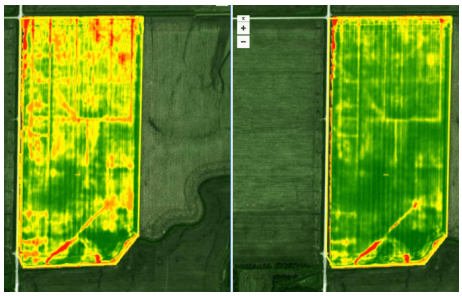
Drones can help in soil and field analysis for irrigation, planting planning, and detecting nitrogen levels in the soil. Moreover, drones are also used to produce accurate 3-D maps that can be used to analyse soil properties, moisture content, and soil erosion.

Seed pod planting

Some drone companies have come up with an additional attachment below the drone systems to shoot pods containing seed and plant nutrients into the already prepared soil. This helps to reduce planting costs to a reasonable extent, along with better efficiency.

Crop Monitoring

Crop monitoring is a crucial and tiresome step for all farmers, further worsening due to unpredictable weather patterns leading to more significant crop loss risks and maintenance costs. Here, drones can set monitoring routes by gathering multispectral geospatial and temporal datasets at pre-defined scales related to crop development and health. Further, data analytics help get insights on crop health much before being visible by manual field scouting.



Crop Spraying

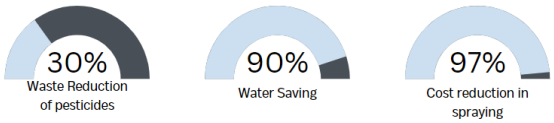
Agricultural drones can carry suitably sized reservoirs to spray fertilizers, herbicides, or pesticides for crop spraying. Drones thus help in making crop spraying a safer and cost-effective process. This also helps in reducing the contact of humans with these harmful chemicals.

Irrigation

Drones are loaded with various types of sensors which help schedule timely irrigation to the specified zones with preciseness.

Crop health assessment

The light reflected by plants has varying intensity with health status and stress levels. Drones are fitted with sensors which scan crops using visible and near-infrared light to track crop health and monitor response to remedied measures.



CHALLENGES FACED BY AGRICULTURAL DRONES

Technical issues:

Battery Problems: The cost of batteries used in drones can be dispiriting. The number of spray flights can be high. The current chemical concentration is 12-15 flights.This leads to the main problem of increased battery usage and subsequent reduced efficiency, making drone applications more costly compared to manual spraying.

Issues with aerial spraying: Though drone help to save much water but its small size can many problems. It can pollute water bodies and affect small waterways. Proper altitude, speed, wind and ground tactics are required for safety and security.

Connectivity Issues: To operate drones efficiently, it requires good internet connections. In rural areas online coverage is very difficult.In such situations, farmers need to invest in internet connectivity, which can become a recurring expense.

Unawareness

Though agricultural drones have numerous benefits but the majority of farmers are not aware of the recent technological advancements. Farmers lack the knowledge and awareness to adopt drones and IoT-based data-driven solutions and do not understand the benefits of such approaches.

High cost

The use of drones in Indian agriculture has its own strengths and weaknesses. Drone prices range from INR 4 to 10 Lakh e.g, Phoenix 4 AG - 16L Agriculture Quadcopter Drone costs about INR 4.5 lakh. Ordinary farmers don't have that luxury. However, some companies, such as Unnati, an agricultural tech startup platform, are deploying drone services. The company plans to have him spray 20,000 acres of land by the end of 2022.

Weather Dependency

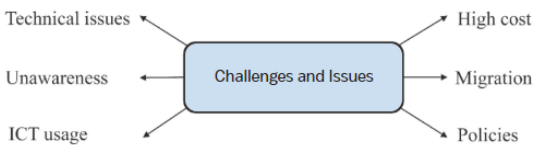
Drones are reliable as long as the weather is clear and bright. Since weather cannot be accurately predicted, it becomes extremely difficult to prepare for any shift in patterns. UAVs are not a good option for delivering products in stormy or windy weather. Lithium polymer batteries are very sensitive to moisture, making it impossible to fly the drone in the rain. This issue is a major stumbling block for e-commerce operators and they should consider using delivery trucks.

Fog also obscures vision, making it difficult for drones to fly. Fog obstructs visibility and has small enough droplets to drain the drone's battery during flight.

Policies

As a key driver for promoting precision agriculture in India, the Federal Ministry of Agriculture and Farmer Welfare has issued guidelines to make drone technology affordable for stakeholders in this sector. Submission on Agricultural Mechanization (SMAM) policy has been amended to provide up to 100 percent of the cost of agricultural drones or Rs. , Testing Institute, ICAR Institute, Krisi Vigyan Kendras, State Agricultural University. Agriculture graduates establishing Custom Hiring Centers would be eligible to receive 50 per cent of the basic cost of drone and its attachments or up to Rs.5 lakhs in grant support for drone purchases. Rural entrepreneurs should have passed class tenth examination or its equivalent from a recognized Board; and have remote pilot license from Institute specified by the Director General of Civil Aviation(DGCA) or from any authorized remote pilot training organization.

The subsidized purchase of agriculture drones for CHCs/Hi-tech Hubs will make the technology affordable, resulting in their widespread adoption. This would make drones more accessible to the common man in India and will also significantly encourage domestic drone production.



IMPLEMENTATION PLAN

Drone manufacturing
Drone manufacturing needs to increase in India. Startups can support this by facilitating local drone manufacturing and assembling.

Drone service providers
More startup providers should come up to promote drones for agricultural purposes. Recently, 50 such providers have come up through incubation centres.

Legal and policy instruments
Practical and pragmatic implementation of the legal and policy frameworks like CAR 3.0 and the Digital sky platform is essential to promote the usage of drones in agriculture.

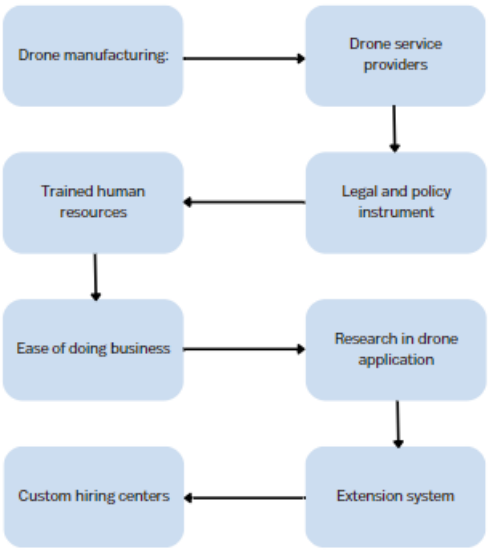
Trained human resource
Flying a drone is a skill-based operation requiring proper technical knowledge. Opening training centres in collaboration with drone industry organizations can help train people for the same.

Ease of doing business
Developing enabling ecosystem is crucial with a single-window concept for entrepreneurs. It is a business prospect for young entrepreneurs to operate drones used in agriculture. This technology can engage the new generation in agriculture and hopefully reverse the trend of deflection from farms.

Research in drone application
There is a requirement for further research on drone applications as it is vital for the future. There are not enough studies available on drone usage in the agricultural sector. More research in this sector can help in discovering new opportunities.

Extension system
There is a need for orienting field extension functionaries towards popularising drone usage with field demos of various applications in agriculture.

Custom hiring centres
Custom hiring centres should develop a mechanism to provide a single window solution for drone application services by tie-up with startups offering drone services. It will effectively utilize the farmer-custom hiring network to bridge the demand and supply chains of drone applications in agriculture.



RULES AND REGULATIONS OF DRONE USAGE IN DIFFERENT COUNTRIES

To fly a drone, a series of rules and regulations must be abided by, which are different in each country.

U.S.A.
Part 107 has been the main focal news in the drone world/industry which changed the laws in the U.S.A.

- The drone must weigh no more than 55 lbs.
- The pilot must be within Visual Line of Sight (VLOS): Operations must occur during daylight.
- To fly a drone for recreational purposes, one must take The Recreational U.A.S. Safety Test (TRUST) required by the F.A.A
- One should keep the drone below 400 feet above ground level when flying in uncontrolled airspace to ensure that one does not conflict with crewed aircraft.

France
According to French law, commercial and recreational drone users differ. Both groups of people are subjected to various restrictions and codes of conduct.

- The drones must be within the pilot's Visual Line of Sight (VLOS) and stay within 500ft of the ground.
- Unmanned aircraft activities must comply with data protection and privacy regulations.
- Camera shots are allowed, provided the shots are not commercially exploited.
- Night flights are permissible, provided one's drone adheres to all aerial visual and lighting requirements. A special 30-day permit is required.

Germany
In Germany, the European Aviation Safety Agency (EASA) regulations apply to drone regulation.

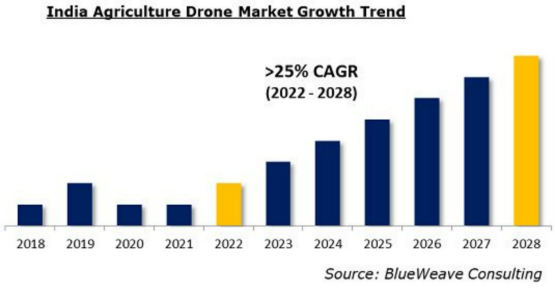
- The regional States' (Länder) authorities are allowed to authorize flights beyond the VLOS, depending on the safety and circumstances of the operation.
- Operators must pass a test demonstrating their aeronautical skills and knowledge of aviation law.
- One must have special authorization to fly a drone with a maximum takeoff weight (MTOM) above 5 kg to operate drones for purposes other than sports and leisure.
- Drones that weigh more than 250 grams are required to be labeled with a fireproof badge containing the following information:
  - Owner's name
  - Address

India
On August 26, 2021, India's Ministry of Civil Aviation (MoCA) issued a new drone policy that formalized a draft regulation released earlier this summer. The government has chosen to remove the U.A.S. Rules, 2021, and replace them with the liberalized Drone Rules, 2021:

- The new maximum penalty for drone-related nonconformity stands at 1,00,000 in India.
- For non-commercial use, no pilot license is required if one is operating nano and micro drones.
- As per The Indian Directorate General of Civil Aviation (DGCA), all drone training will be provided only by authorized drone schools.
- Before every flight, all drone pilots must request permission to fly via a mobile app, which will automatically process the request and grant or reject it. India calls their system "No Permission, No Takeoff" (NPNT). If a drone pilot tries to fly without receiving permission from the Digital Sky Platform, he or she will simply be unable to take off.

FUTURE OUTLOOK

Agriculture stands as a primary livelihood source for more than 50% of India's population. The government of India(GOI) is playing an active role in upgrading technology usage in agriculture. GOI updated rules and regulations on using farming drones. A credential scheme for drones was released to boost agriculture spraying via drones. It offered a 100% subsidy or INR 1 million to Farm Machinery Training Institutes, Krishi Vigyan Kendra, Central Island Agricultural Research Institute, and agriculture universities.



Growth Drivers
Improvise the yield rates and rescue the farm worker from the unfavorable effects of manual spraying of pesticides. Startup India, a GOI program, can provide funding support to manufacture indigenous drones, which can fulfill the local farms' necessities and reduce the cost of drone usage compared to those developed abroad. The application of drones in agriculture will provide employment prospects, especially in small towns and rural areas.

Growth Restraints

Lack of technology understanding among the farms about the usage of drones in farming; Most agriculturalists in India hold a limited size of land, which leads to an increase in the price of drone operations. Many farmers in India are not earning enough to buy agricultural drones.

Agriculture Drones Usage by Application in India, 2021-2030

Application	2022-24	2025-27	2028-30
Spraying	High	High	High
Sensing/Imaging	Medium	Medium	Medium
Sowing/Planting	Low	Low	Low
Transport Crops	NA	NA	Low

source : Frost and sullivan

Spraying functions have more than 50% of the total market share. It will further improvise as pesticide constraints developed by DGCA (Directorate General of Civil Aviation) get upgraded. Sensing and imaging have improved productivity and crop yield, particularly in crops and fruit farms. Large agricultural enterprises and plantations will adopt sensing operations earlier than average farmers of India. Sowing applications will stay down due to tough competition for cheaper availability of labor. Sowing application only has narrow usage in one crop, such as paddy, whereas seeding is complex and risky. By 2028, with the upgrade in technology and government rules and regulations, post-harvest transport of heavy crops such as cabbage and cauliflower, along with similar applications in hilly regions, is expected to be seen. Drones that weigh less than 5 kg are more likely to be adopted as they are best suited for imaging operations. With BVLOS (Beyond Visual Line of Sight) permission, subsidies and incentives will drive heavier drones weighing 5-25 kg (with 10L payload) for spraying processes in the next three to five years.

CONCLUSION

Drones have the potential to revolutionize the agriculture sector. Current technology is creating things easy and more effective for future generations. The agricultural drone market is impressive and is rising

Agriculture Drones Usage by Weight in India, 2021-2030

Application	2022-24	2025-27	2028-30
Less than 5 kg	High	High	High
5-25 kg	Medium	High	High
25-150 kg	Low	Low	Low
Above 150 kg	NA	NA	Low

source : Frost and Sullivan

year by year. Peeking at the country's size and the government's push, start-ups within the drone ecosystem have mushroomed. The technological progress and manufacturing of low-cost indigenous agriculture drones are expected to disrupt the farming market. India is a low-cost powerhouse globally; manufacturing indigenous drones can enhance the life of Indian farmers.

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