© July 2022 | IJIRT | Volume 9 Issue 2 | ISSN: 2349-6002

Use of Drone Technology in Agriculture

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***Abstract*— Agriculture sector is the most promising sector and also dealing with the lot of problems such as extreme weather events, inefficient application of agrochemicals and shortage of labours. These difficulties should be eradicated by adopting new innovative advance technologies. The agriculture growth in India is impressive in many dimensions and they brought considerable changes in basic type of agriculture. Agriculture drone is one among of those sequences. Drone technology in agriculture has the potential to address a number of large and minor concerns. India, as a predominantly agrarian culture, stands to benefit a lot if it realises the full potential of agri-drones. The main objective is to describe about some vital approaches of drone's applications in agriculture, which includes soil and field analysis, crop monitoring, crop spraying, health assessment, wild life monitoring and more. The application of these approaches has great potential in enhancing agriculture in the future and their quick implementation is desirable for the sustainability of agriculture especially in developing countries.**

Index Terms: **Agriculture, Drone, Unmanned aerial vehicle, Advance agriculture, Sustainable agriculture.**

INTRODUCTION

Agriculture is the primary source of livelihood for about **58%** of India's population (Kushvaha *et al.*, 2021). The world population has increases day by day and expecting for **9 billion** people by 2050 (Joshi *et al.*, 2020). In order to feed this larger population, food production must increase by **70%** (Ahiwar *et al.*, 2019; Oluwagbayide and Adenigba, 2020). Also, climate change will be an additional challenge for the human food supply in the near future (Esposito *et al.*, 2021).Drones in agriculture are a feasible alternative to meet the demand for rising population and food production and will improve this industry greatly through accurate measurements, real-time data gathering, and efficient crop management (Saha *et al.*, 2018). Drones offer advanced advantages above anything else, such as ease of usage, accurate monitoring of locations difficult to access by man, tracing criminal activities, forest fire observations, and crop yield surveillance on vast agriculture farms (Puri *et al.*, 2017). Since the previous two decades, the market for drones has been steadily growing, and they have ushered in important changes in the fields of industry, military, agriculture, and many others (Puri *et al.*, 2017). The Indian government has launched an online platform called Digital Sky Platform for the registration of drones and their operators and on the other, there are 35 drone startups in the country that are working to raise the technological capabilities and reduce the prices of agriculture drones (Joshi *et al.*, 2020). Drones, as a significant tool that will boost profitability and healthy crop production (Mahajan and Bundel, 2016), have a bright future in the agriculture industry.

DRONE OR UAV

Unmanned Aerial Vehicles (UAV) / Unmanned Aircraft Systems(UAS) is commonly known as Drone(Oluwagbayide and Adenigba, 2020). Drone stands for Dynamic Remotely Operated Navigation Equipment (Rani *et al.*, 2019)**.**UAV is a flying device that can fly a pre-set course with the help of an autopilot and GPS coordinates(Ahiwar *et al.*, 2019). UAV is refered as the complete system, including ground stations and video systems(Ahiwar *et al.*, 2019). Small or medium-sized aircraft that are remotely controlled by telemetry (Sujit Hensh, 2018) to fly autonomously through software-controlled flight plans (Oluwagbayide and Adenigba, 2020).

HISTORY OF DRONES

In 1849 Australians used unmanned air balloons. French engineer, Etienne Omnichen invented the first quadcopter "Omnichen 2" in 1922. The first use of drones were primarily for military applications in 1960s Vietnam war about 3,400 UAVs (Steve and

LSU, 2017). In 1980s (Iost Filho *et al.*, 2020), remote control aerial spraying system was used to spray agro chemicals in Japan (Aydoğan, 2018; Saha *et al.*,2018). Yamaha RMAX first UAV agriculture model (Mogili and Deepak, 2018) introduced for agricultural Pest control in rice fields of Asia and for crop monitoring (Giles and Billing, 2015).

CLASSIFICATION OF DRONES

Fixed wing drone- Aerodynamic shape of two wings are gives an easy glide of UAV, single rotor helicopter- model has just one big sized rotor on top and one small sized on the tail of the UAV, quadcopter- Propelled by four rotors, hexacopter- Propelled by six rotors, octocopter- Propelled by eight rotors (Mogili and Deepak, 2018).

COMPONENTS OF DRONE

Frame/Chassis

Skeleton of the drone where all the components are fixed (Sujit Hensh, 2018; Ahirwar et al., 2019).

Motors

Provided to spin propellers. Based on the drone type, number of propellers and motors will be attached. The higher the kV, the faster the motor can spin (Sujit Hensh, 2018). More rpms and faster motor spin requires much more power from the battery, causing the flight times to decrease (Sujit Hensh, 2018; Ahiwar *et al.*, 2019).

Propellers

Propellers are made of plastic / carbon fiber. Longer propellers take more time to speed up or slow down and more lift at lower rpm but Short propellers can change speeds faster and require same amount of power as longer blades to provide higher rotational speed(Ahiwar *et al.*, 2019). In Four propeller drones, Front propellers- Spins anti-clockwise (Tractor propellers), Back propellers- Spins clockwise (Pusher propellers) (Sujit Hensh, 2018).

Electronic Speed controller (ESC)

Controls each motor to provide the correct spin speed(Mogili and Deepak, 2018; Sujit Hensh, 2018) and direction (Ahiwar *et al.*, 2019).

Flight controller

Brain of copter. Interprets incoming signals from pilot (receiver, GPS module, battery monitor, Inertial Measurement Unit (IMU) and other onboard sensors) and sends corresponding inputs to ESC to control drone (Sujit Hensh, 2018; Ahiwar *et al.*, 2019). It controls autopilot, waypoints, fail safe and many other autonomous functions (Sujit Hensh, 2018).

Radio transmitter and receiver

Receives the control signals from the pilot. A minimum of 4 channels is required in the remote control to get the drone to move. The 4 channels are: Tilt up / down, left / right, forward / backward, and left / right also known as aileron (Sujit Hensh, 2018; Ahiwar *et al.*, 2019).

Battery

Generally Lithium ion Power batteries (LiPo) (Shrikrishna *et al.*, 2017) are use due to high power density, lifetime and ability to recharge (Ahiwar *et al.*, 2019). For getting the longer duration operation, a high-capacity battery is required, but it causes the increase of weight in drone. So, optimum selection of battery capacity is very important (Sujit Hensh, 2018).

Camera

For recording video (Mogili and Deepak, 2018) and taking hyperspectral and multispectral images, a good quality camera is provided. The latest drones are all-in-one, with a built-in gimbal and camera. These cameras and lenses were created specifically for aerial photography and videography (Sujit Hensh, 2018).

Sensors

Mounted onto drones and being used in a wide variety of sectors (Sujit Hensh, 2018). Sensors using in agricultural drones- Visible light sensors, Broad band color-infrared sensors, Thermal sensor, LiDAR sensor, Multi spectral sensor, Hyper spectral sensor, Flow meter sensor, Terrain following sensor, Obstacle avoid sensor (Petkovic *et al.*, 2017; Mogili and Deepak, 2018).

GPS modules

GPS is an important requirement for waypoint navigation and many other autonomous flight modes like Return to Home (Sujit Hensh, 2018) and provides geo location of an object (Mogili and Deepak, 2018).

Accelerometers
To measure the acceleration (Mogili and Deepak, 2018).

Gyroscopes
For rotational motion(Mogili and Deepak, 2018). And some other components are Scanners, Spraying Systems, Remote Control.

APPLICATIONS OF DRONE

Military
Used to send parcel to military forces, supervisions, target decoying in combat missions, research and development (Ahiwar *et al.*, 2019).

Security & Law enforcement
Helps in the surveillance of large crowds and ensure public safety. They assist in monitoring criminal and illegal activities, smugglers and to monitor border patrol (Ahiwar *et al.*, 2019).

Delivery services
Drones have the potential to save a lot of time and manpower by rerouting traffic. Besides, they can be used over smaller distances to deliver small packages, letters, beverages (Ahiwar *et al.*, 2019) and medicines and food during pandemic conditions to the people in highly man restricted areas. Helps in transportation of organs for transplantation (Bhavana, 2021).

Rescue & Disaster management
Presence of thermal sensors gives drones night vision for surveillance. Drones helps to locate the lost persons and victims, especially in unfavourable conditions. A drone can deliver supplies to unreachable spots in war torn or disaster-stricken areas (Ahiwar *et al.*, 2019) in addition to locating victims.

Films & cine industry
Fast paced action and sci-fi scenes are filmed by aerial drones and journalists use of drones for collecting footage and information in live broadcasts(Ahiwar *et al.*, 2019).

Wildlife Monitoring
Drones have served as a deterrent to poachers (Ren *et al.*, 2020). With its thermal cameras and sensors, they provide unprecedented protection to animals in night time. Drones enables monitor and research on wildlife without causing any disturbance and provides insight on their patterns, behaviour and habitat (Ahiwar *et al.*, 2019). Drones equipped with motion tracking and thermal imaging have already identified and mitigated possible threats to endangered wildlife (Michal, 2016).

USE OF DRONES IN AGRICULTURE

Farmers and agriculturists are always looking for low-cost, effective ways to check their crops on a regular basis. Drones improves management and effectuates better yield of the crops. Nearly 80% of the agriculture sector will dominated by drones in the next few years (Ahiwar *et al.*, 2019). Drone technology has offered the agriculture industry a high-technology makeover, with planning and strategy based on real-time data gathering and processing (Sujit Hensh, 2018). Camera and sensors of drone can provide information about plant growth, plant coverage, moisture content in the soil, plant health, stress levels, and fruits (Oluwagbayide and Adenigba, 2020). Becaue the drone can fly up to 400 feet in the air, the drone camera can capture high-resolution images that are superior than satellite images (Sujit Hensh, 2018; Rani *et al.*, 2019). Drones are utilized at various stages throughout the crop growing cycle (Oluwagbayide and Adenigba, 2020).

PRECISION FARMING

In precision agriculture drones are used for soil health scanning, weather analysis, monitoring crop health, planning irrigation schedule, estimate yield (Petkovics *et al.*, 2017; Joshi *et al.*, 2020). Applications of cameras: Multispectral cameras-chlorophyll content, ground cover, LAI, NDVI. RGB camera & LiDAR- Digital Terrain Model/Digital Surface Model (Daponte et al., 2019). UAVs are primary choice for precise in-situ remote sensing or survey operations (Esposito *et al.*, 2021).

SOIL & FIELD ANALYSIS

Instrumental at the start of the crop cycle(Michal, 2016). Produce 3-D maps for early soil analysis (Puri *et al.*, 2017). Useful in planning seed planting patterns (Ahirwar *et al*., 2019). Integrated with ground geophysical data to obtain a proper soil characterization (Sona et al., 2016). Drone-assisted soil analysis gives information for irrigation (Rani *et al.*, 2019) and nitrogen-level management (Puri *et al.*, 2017; Oluwagbayide and Adenigba, 2020) after planting.

PLANTING

Startups have created drone-planting systems. It reducing the planting costs by 85 %(Aydoğan, 2018). These systems release seeds and plant nutrients into the soil to sustain life (Ahiwar *et al.*, 2019). Drones are being utilized for rice seeding (Workuldumrongdej *et al*., 2019; Dampage *et al.*, 2020)and sowing seeds in China (Ibrahim, 2020). Drone is capable of delivering up payloads in the form of tree seeds, herbicides, fertilizer and water per aircraft per flight to assist reforestation (Fortes, 2017; Andrio, 2019; Yamunathanagam *et al.,* 2020). Seeds are precisely released at the desired location (Fortes,2017). Sowing in uneven land also done easily.

CROP MONITORING

Drones can create detailed GPS maps of the crop field area(Chika and Olasupo, 2019) and the data is analyzed by the Geographic indicator Normalized Difference Vegetation Index (Mogili and Deepak, 2018). With the time-series animations, accurate development of a crop can be shown & production inefficiencies can be revealed(Oluwagbayide and Adenigba, 2020). The camera takes 1 picture per second and stores it into memory and sends to the ground station through telemetry. For this wireless communication it uses MAVLINK protocol(Mogili and Deepak, 2018). Blue wavelength 440-510nm, green wavelength 520-590nm, red wavelength 630-685nm, red edge wavelength 690-730nm, near infrared wavelength 760-850nm are the wave length of bands using in picture capturing (Mogili and Deepak, 2018)

IRRIGATION

Drones with hyper-spectral, multispectral, or thermal sensors can identify which parts of a field are dry (Ren *et al.,* 2020). And shows the heat signature, the amount of energy or heat the crop emits through heat sensors (Ahirwar *et al.,* 2019).

HEALTH ASSESSMENT

By scanning a crop using both visible and near-infrared light, drone carried devices can identify which plants reflect different amounts of green light and NIR light (Oluwagbayide and Adenigba, 2020). This information can produce multispectral images that track changes in plants and indicate their health (Ahirwar *et al.*, 2019). Immediately a sickness is noticed, farmers can apply and monitor remedies more accurately (Oluwagbayide and Adenigba, 2020). In agricultural mapping tools use of NDVI data, CropWater Stress Index (CWSI) and the Canopy-Chlorophyll Content Index (CCCI) provides valuable insight into crop health (Joshi *et al.*, 2020).

HYPERSPECTRAL & MULTISPECTRAL IMAGING

Multispectral and hyperspectral imagery captures image data at specific frequencies across the electromagnetic spectrum (RGB, infrared, ultraviolet) (Sujit Hensh, 2018). These images were used to map crop diseases (Panday *et al.*, 2020). Infrared rays influence the photosynthetic activities of plants. Additional information that human eye misses can also be extracted via spectral imaging (Sujit Hensh, 2018).

NORMALIZED DIFFERENCE VEGETATION INDEX

The majority of red light is absorbed by photosynthetically active vegetation, which reflects much of the near infrared light. Dead or stressed vegetation reflects more red light and less near-infrared light. The difference between near-infrared (NIR), which plant strongly reflects and vegetation absorbs red light, is measured by NDVI. NDVI ranges from -1 to +1. Higher NDVI indicates healthier vegetation, while lower NDVI indicates dead or stressed or no vegetation.This makes it quite easy to identify and measure any weaker areas in the orchard (Sujit Hensh, 2018). NDVI = $(R_{NIR} - R_{RED}) / (R_{NIR} + R_{RED})$ (Mogili and Deepak, 2018; Sujit Hensh, 2018).

THERMAL IMAGING

Everything gives off thermal energy / heat signature. The video output from most thermal cameras shows white areas indicating greatest radiated energy and dark areas indicating lower radiation. It is used in water resource detection - red coloured portion indicates the dry soil & blue coloured portion indicates the wet soil (Saha *et al.,* 2018), greenhouse monitoring, irrigation scheduling, plant disease and livestock heat sign detection (Sujit Hensh, 2018).

UAV PHOTOGRAMMETRY & 3-D MAPPING

The camera is installed on the drone and is normally aimed vertically towards the ground to build 3D maps from aerial photogrammetry. Multiple overlapping images of the ground or model (80 to 90% overlap) are taken. Lidar is a laser scanner on a UAV to measure the height of points in the landscape below the UAV. By measuring 10-80 points per square meter, a very detailed digital 3D model of a landscape can be created, which is used in planning, design, and decision-making processes across many sectors. It assesses crop growth status, biomass estimation, plant height, plant shape, nutrient supply & health status. For automated harvesting of crops, 3D mapping is compulsory (Sujit Hensh, 2018).

FORESTRY

Monitoring health of tree crops or forests needs massive human labour (Drone Major, 2019). More time and money consuming process. Drones are used for collecting data of trees- counting (Norasma *et al.*, 2019). Drones can monitor tree health (Hassan *et al*., 2016), track animal locations, and migration patterns. Drones helps in early detection of forest disease (Drone major, 2019).

WEED MANAGEMENT

UAVs can be highly valuable since they allow for Site Specific Weed Management. For mapping weeds in a crop field, multispectral imaging is usually the best option. Following the capture of aerial data, the analyst must process the image and use density slicing or image classification algorithms in GIS softwares to classify crop cover, weed cover and soil cover. UAVs are ideal to identify weed patches and help in precisely monitoring large areas in a few minutes (Esposito *et al.*, 2021).

CROP SPRAYING

The UAVs could scan the ground and spray the right amount of liquid by adjusting their distance from the ground and spraying in real time for moderate coverage (Ahiwar *et al.*, 2019; Oluwagbayide and Adenigba, 2020).Five times faster than old traditional machinery (Michal,2019).When compared to the upper layers of paddy and wheat fields, the droplet deposition in the lower layers is nearly identical (Mogili and Deepak, 2018). Distance measuring equipment, ultrasonic echoing and lasers such as LiDAR method enables a drone to adjust altitude as the topography and geography vary, thus avoid collisions and flies in constant height with rises &drops (Michal,2019).

AGRICULTURAL INSURANCE INVESTIGATION

Drones can be used for precisely estimating and monitoring of the crop failure. So, it can be helpful for the insurance companies in providing insurance claims based on the degree of damage (Rani *et al.*, 2019).To measure the actual disaster area, agricultural insurance companies apply drones to conduct agricultural insurance disaster loss surveys and agricultural insurance claims (Ren *et al.*, 2020).

ADVANTAGES

Time saving, meets the labour shortage, pinpoint accuracy data, advanced imaging capabilities, allows the operators to collect data even with unfavorable weather conditions which satellite detection systems fail to produce very altered databases, less amount of chemicals & less environmental damage, less amount of water, cost effective, even spraying, less damage to crops, spray in uneven land and continues from the exact last sprayed location.

LEGAL ISSUES

To use a drone you have to get permissions from Directorate General of Civil Aviation, Directorate General of Foreign Trade, Ministry of Home Affairs, Ministry of Defense, Indian Air Force, Wireless Planning & Co-ordination wing, Department of Telecommunication, Bureau of Civil Aviation Security, Airport Authority of India and Local Police office

GENERAL INDIAN DRONE LAWS

When operating a drone that weighs more than 250 grams in India, operators must adhere to the following drone laws:Flying your drone over extremely populated areas or huge groups is not recommended, respect others privacy when flying your drone, you must not fly your drone within 5km of airports or in areas where aircraft are operating, you must fly during daylight hours & onlyin excellent weather circumstances, you must be at least 18 years old and have completed a training course, you must not fly your drone in sensitive areas such as government or military sites, all drones must be equipped with aliability insurance and license plate identifying the operator, and how to contact them, you must only fly your drone within visual line of sight, you can’t fly more than one UAV at a time, you can’t fly it within 50 kilometres of a border, you must not fly your drone more 500 meters into the sea, from the coastline and not over national parks or wildlife sanctuaries (Ahiwar *et al.*, 2019).

CHALLENGES

Not suits for small area- major Indian farmers are marginal and small farmers and it is not affordable to them due to high initial cost, mostly big farmers are benefited, less flight time, federal laws- a farmer must have a complete understanding of the drone’s rules and regulations, need of knowledge & skill to farmers, necessary training is required to operate the drones in proper manner, privacy- farmers believe that drones expose their lands to the public space. The main reason is the drone’s connection to the internet, safety measures- drones can end up creating safety hazards if not flown properly, service lackage and lack of research and experimental results.

CONCLUSION

In agriculture, the only thing that remains constant is change. The agriculture growth in India is impressive in many dimensions and they have brought considerable changes in basic types of agriculture. Drone technology is one among of those sequence. It reduces the inputs like water & pesticides but maintaining the same output. Better to buy a drone in village panchayat office or FPO or government agricultural implements rental office, to make available to small and marginal farmers. Due to increasing demand of agricultural Labors, need for increase in food production & food security, drones can be employed to bring the next revolution in agriculture.

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