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Application of drone technology for

sustainable agriculture in western India

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The most advanced aspect of automation of agriculture is precision agriculture. Precision agriculture has become essential due to its potential and applications. Smart agriculture encompasses various technologies and practices, including smart irrigation, drones, remote sensing, and mapping. These tools can greatly enhance farming operations and address the challenges faced by farmers. Agricultural drones have come to the aid of farmers and have made farming easier and more efficient. Using drones in smart farming not only makes farming more accurate but also can help become people farm smart. Among agricultural drones, the performance of spraying drones is very impressive and reliable. This article includes information on the potential utilization of drones in agricultural practices (spraying, crop monitoring and crop surveillance), adoption of drone technology by various implementing centres under ICAR-ATARI Pune Zone, information on drone pilot training, and progress of demonstration. Drone technology has a prominent position in assisting farmers with more efficient decision-making and automating agricultural processes. This could help overcome some of the adoption barriers faced by farmers in less economically advantaged regions.

Keywords: Agri-drone, Unmanned aerial vehicles (UAVs), Custom hiring centres (CHCs), KVKs

THE majority of rural households continue to rely on agriculture as their main source of income. India's economy is also mostly dependent on agricultural produce which includes a major portion of its exports as well. Nearly 56% of the population depends upon the agriculture sector for their livelihood. In India, about 44% of the cultivated land is taken care of by small and marginal farmers, who contribute to almost 60% of the total food grain production. It has consistently stood as the pivotal economic sector in India, assuming a strategic role in the nation's economic development. Crop failure due to adverse weather conditions and uncontrolled pest issues have been the key contributors to this scenario. Moreover, Indian farmers are even now dependent on monsoon rains for irrigation and use of old methods for other farming practices. As a result, despite farmers' tireless efforts, the quality and quantity of agricultural produce are sometimes compromised. To address the food demands of a rising human population, agricultural practices have integrated a growing number of technologies to increase crop yield and reduce operative expenditure. As a result, the increasing use of 'smart technologies,' such as artificial intelligence and automated machinery, has been incorporated into various stages of food production, from crop planting and livestock guarding to food processing and transport. At present time, when the farming sector is facing several challenges, including labour shortage and falling incomes, the use of Unmanned Aerial Vehicles (UAVs), popularly known as drones, has come to the rescue of farmers to aid them in various activities including spraying of pesticides, and nutrients management.

Drone improves efficiency by reducing workload and time required in numerous industries. The progressive automation of agricultural processes has significantly improved the productivity of agricultural labour, shifting masses of workers into other productive industrial areas.

With the advancement of technology, the research on drones has become more and more in-depth, and the practical application fields have become more extensive. The unparalleled advantages of these 'smart technologies' also play an important role in their incorporation into various stages of food production. At present, drone technology has also gradually matured.

The application of drones in agriculture is already widespread across Asia and other parts of the world. Their usages are limited and specific for commercial

operations in horticulture, agriculture, and forestry. Spraying for weeds, insect-pests, and disease management, spreading fertilizers as well as planting new forests are the diverse uses now being found for drones.

Potential application of drone technology in agriculture

Crop spraying: The technology was first implemented in Japan in the 1980s when unmanned helicopters equipped with spraying equipment and pesticide tanks were used to spray crop fields. Typical modern-day spraying drones have a tank capacity of over 10 litres of liquid pesticide with a discharge rate of over a litre a minute, allowing them to cover a ha in 10 minutes. Drones can carry reservoirs of suitable size, which can be filled with fertilizers, herbicides, or pesticides for spraying on crops in large areas in a relatively shorter time. Crop spraying is much safer and cost-effective because of its autonomous and pre-programmed run on specific schedules and routes. Drones are also programmed to self-adjust their altitude and speed using ultrasonic echoing, time-of-flight (TOF) lasers and Global Navigation Satellite System (GNSS) signals to achieve uniform and optimum spraying results across varying topography. Smart farms are using drones for agriculture spraying, which reduces human contact with harmful chemicals such as fertilizers and pesticides. Drones are also unparalleled when it comes to spot treatment automated with stress detection technology, which uses sensors and cameras to treat affected areas while leaving the healthy parts intact. Drones enhance spraying capacity up to five times faster than traditional machinery.

Crop monitoring: Crop monitoring is the biggest headache not only for farmers but also for various other stakeholders associated with agriculture operations. This challenge has also gotten worse with the rise of unpredictable weather patterns, which lead to rising crop loss risks and maintenance costs. Drones can be used to set monitoring routes by gathering multispectral geospatial and temporal datasets at pre-defined scales that relate to crop development. Data analytics help in getting insights on crop health much before being visible by manual field scouting.

Crop surveillance: It is nearly impossible to estimate the overall state of crops in large fields. Agricultural mapping using drones can help farmers stay updated on the status of their plants and identify the areas of the fields that require attention. Drones equipped with infrared cameras can inspect the fields and estimate the state of crops based on their light absorption rates. With accurate real-time information, farmers can take necessary measures to improve the health of crops in any spot of the field. This crop surveillance and health assessment feature of drones also forms the basis of using them to enhance agricultural insurance tools for cross-verifying farmers' insurance claims. However, financial implications *vis-a-vis* the insurance model adopted and practical possibilities will decide the future potential use.

In the crop insurance scheme, *Pradhan Mantri Fasal Bima Yojana* (PMFBY) of the Government of India, crop yield estimation at the lowest specified administrative level is considered the most important indicator for deciding insurance claims. For crop yield estimation, the well-established methodology of crop cutting experiments (CCE) has been in use so far, to evaluate and validate a large number of pilot studies carried out in different parts of the country.

Financial assistance

The Union Ministry of Agriculture and Farmers Welfare has issued guidelines to make drone technology affordable to the stakeholders in a major boost to promote precision farming in India. The ICAR, New Delhi had approved various State Agricultural Universities (SAUs), Krishi Vigyan Kendras (KVKs) and ICAR Institutions for allocation of funds for the purchase of drones and demonstrations during 2022-23.

To provide agricultural services through drone application, financial assistance @ 40% of the basic cost of the drone and its attachments or ₹ 4 lakhs, whichever is less is also provided for drone purchase by existing and new Custom Hiring Centers (CHCs) under Cooperative Society of Farmers, Farmers Producer Organizations (FPOs) and rural entrepreneurs. The agriculture graduates establishing CHCs are eligible to receive financial assistance @ 50% of the cost of a drone up to a maximum of ₹ 5.00 lakhs. In addition to the already identified institutions for drone demonstration, other agricultural institutions of the state and central government, and central public sector undertakings engaged in agricultural activities have also been brought to the eligibility list for financial assistance for farmers' drone demonstration.

Agri-Drone project in ATARI Pune

ATARI Pune Zone-VIII covers the states of Maharashtra, Gujarat and Goa comprising 82 KVKs; of which 50, 30 and 2 exist in the respective states. Ministry of Agriculture under the Agri Drone Project of Sub Mission on Agricultural Mechanization has sanctioned 40 drones in the year 2022-23, 7 to State Agricultural Universities, 23 to ICAR Institutes and 10 to Krishi Vigyan Kendras.

Drone pilot training in ATARI Pune

Directorate General of Civil Aviation (DGCA) has authorised 63 Remote Pilot Training Organizations (RPTO) in the country. RPTO centres have been approved by DGCA for providing drone pilot training and skilling across the country. ATARI Pune organised pilot training for the implementing centres at 3 RPTOs viz. MPKV, Rahuri, Maharashtra; Rashtriya Raksha University, Gandhinagar, Gujarat and Centre for Aerospace, Chennai, Tamil Nadu. In RPTO MPKV, Rahuri, Maharashtra, 35 remote pilots trained from 3 agricultural universities, 9 ICAR institutes, and 6 KVKs. In RPTO RRU, Gandhinagar, Gujarat, 22 drone pilots were trained from 4 agricultural universities, 1 ICAR

institute and 5 KVKs. Two drone pilots from ICAR-NIASM, Baramati were trained at Centre for Aerospace Chennai, Tamil Nadu.

Table 1. RPTO centre-wise distribution of implementing centre

Name of RPTO	Name of implementing center	No. of drone pilot trained
MPKV Rahuri, Maharashtra	MPKV Rahuri, PDKV Akola, VNMKV Parbhani, ICAR-CICR Nagpur, ICAR-CCRI Nagpur, ICAR-CIFE Mumbai, ICAR-DOGR Pune, ICAR-NRCG Pune, ICAR-NRCP Solapur, ICAR-NBSS&LUP Nagpur, ICAR-DFR Pune, ICAR-CCARI Goa, KVK North Goa, KVK Jalna-I, KVK Dhule, KVK Yavatmal-I, KVK Pune-II and KVK Kolhapur-II	35
RRU Gandhinagar, Gujarat	AAU Anand, JAU Junagadh, SDAU Dantiwada, NAU Navsari, ICAR-DGR Junagadh, KVK Ahmedabad, KVK Navsari, KVK Kheda, KVK Panchamahal and KVK Junagadh	22
RPTO, MIT, Tamil Nadu University Chennai, Tamil Nadu	ICAR-NIASM, Baramati	2
Total	29	59

Demonstrations conducted in ATARI Pune

Implementing centres (29) conducted 1,149 drone demonstrations on 569.25 ha area on different crops by KVKs, ICAR research institute, and Agricultural Universities field for benefiting 6,638 farmers. Demonstrations were conducted on various fruit crops, vegetables, pulses and other field crops.

Table 2. Demonstrations under Agri-Drone project

Category of implementing centre	No. of kisan drones sanctioned	No. of kisan drone demonstration organized	Area covered (ha)	Number of farmers who participated
Agriculture Universities	07	34	27.45	632
ICAR Institutes	23	118	120	1324
KVKs	10	997	421.80	4682
Total	40	1149	569.25	6638

Constraints/Problems encountered during drone demonstration

- Under windy or rainy conditions, flying drones is not easy, unlike traditional aircraft. Drones are weather-dependent.
- Maximum time lost for identifying four corners of the field while operating the drone in autonomous mode.
- The drone requires two people for their operation,

Drone demonstration on nano-urea foliar application, farmer's sensitization and enhancing productivity in sugarcane

Demonstration on spraying of gram

Demonstration on spraying of PGR for fruit crop

Demonstration on spraying of pesticides on onion

therefore, requires a dedicated team to be available for the planning and execution of drone demonstrations.

SUMMARY

Drone technology has a lot of potential for efficiently carrying out a variety of agricultural tasks. The modern youth are not attracted towards farming due to the hard work and drudgery involved in it. The implications of drones may fascinate and encourage the youth towards agriculture, as drones enable farmers to have a better understanding of their fields. With the help of drones, farmers can produce more food while using fewer chemicals. Almost all farmers who have made use of drones have achieved some form of benefit. They can make more efficient use of their land, exterminate pests before they destroy entire crops, adjust the soil quality to improve growth in problem areas, improve irrigation for plants suffering from heat stress and track fires before they get out of control. Therefore, drones may become a major part of agriculture in the future by helping farmers manage their fields and resources in a better and sustainable way. But high initial costs and policy reforms are two difficult obstacles to overcome, to make it popular and farmer-friendly. Despite the limitations, these tools and technology are expanding rapidly with their use in agriculture by providing information about farming.

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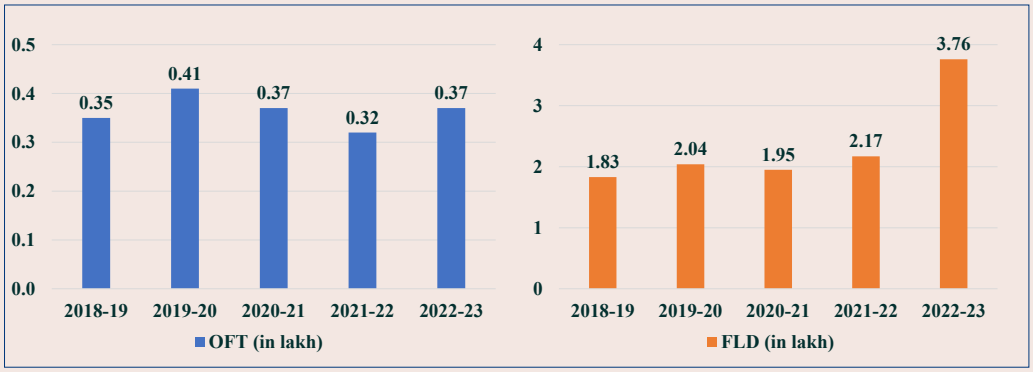
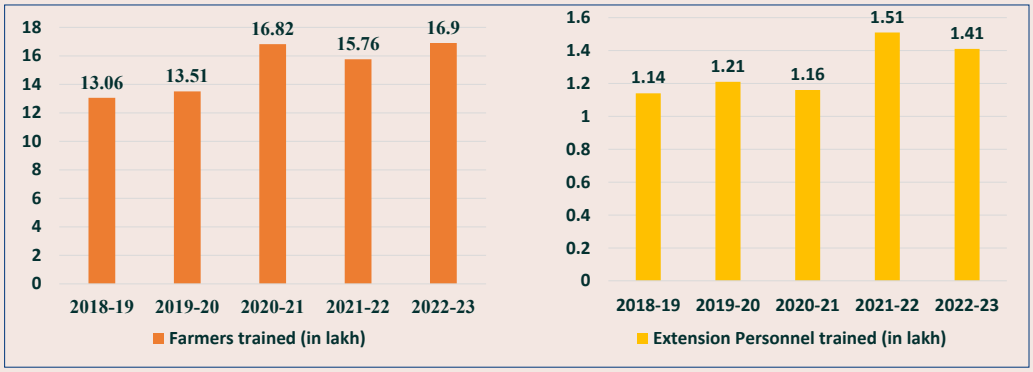
Outreach Programmes of KVKs (2018-19 to 2022-23)



Training Activities of KVKs (2018-19 to 2022-23)



Seed and Planting Materials by KVKs (2018-19 to 2022-23)