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Harvesting Benefits of Drone Technology in Agriculture

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Drones, the unmanned aerial vehicles equipped with advanced sensors and imaging technologies, have significant potential for the efficient, equitable and sustainable transformation of agri-food systems. By offering high-resolution aerial insights, they can efficiently monitor the health of crops and natural resources, thus facilitating informed decisions about the quantity and timing of inputs, such as fertilizers, pesticides, and irrigation. This precision in input application minimizes negative externalities to the environment and human health, reduces production costs, and enhances crop yield and quality. Drones also play a crucial role in surveying and mapping large tracts of land and generating data on land use for crop planning.

Recognizing these potential benefits of using drones in agriculture, the Government of India has launched several programs to encourage the adoption of their services. Announced in 2022, the Drone Kisan Yatra Scheme aims to encourage chemical-free farming. Through the Sub-Mission on Agricultural Mechanization (SMAM), financial assistance is provided to farmers, Farmer Producer Organizations (FPOs), and Custom Hiring Centres (CHCs) for purchasing drones. Moreover, other initiatives, such as the Production Linked Incentive Scheme and Drone Shakti Scheme promote domestic drone manufacturing whereas the Namo Drone Didi Scheme (NDDS) mainly aims at empowering specific groups, such as women-led Self-Help Groups (SHGs), to engage in this technological revolution.

This policy brief evaluates the economic and environmental benefits of employing drones in agriculture, identifies key challenges, and suggests measures to enhance the adoption of drone services. This assessment is based on data collected through a telephonic survey of drone service providers, adopters and non-adopters (i.e., farmers) between December 2024 and January 2025 under the NDDS in Uttar Pradesh.

Namo Drone Didi Scheme (NDDS)

The NDDS seeks to empower women-led SHGs by supplying drones for the delivery of agricultural services (Table 1). Under this scheme, a female representative from the SHG is required to undergo a mandatory 15-day training program, which includes certification as a drone pilot and specialized training in agricultural services, such as spraying of nutrients and pesticides. In addition, a male individual, preferably a family member with an inclination towards electrical and mechanical tasks, is trained as a drone assistant to manage minor maintenance and repair activities.

Table 1. Overview of Namo Drone Didi Scheme

Activity	Description
Target group	15,000 women-led SHGs during 2024-25 to 2025-26
Financial outlay	Rs.1,261 crores
Drone package	Includes a basic drone, carrying box, battery sets, camera, fast chargers, anemometer, pH meter, spare propellers, nozzles, and a one-year onsite warranty with a two-year annual maintenance contract
Financial assistance	80% of drone cost excluding accessories i.e., up to Rs.8 lakh
Training	15-day drone pilot training and additional 2 days training for nutrient application
Implementing agencies	IFFCO, CIL, KRIBHCO, and others
Ownership	SHG or Cluster Level Federations of SHGs
Monitoring & support	Drone portal for service delivery tracking, fund disbursement, and live drone usage monitoring

Source: GoI, 2025[1]

NDDS is implemented by fertilizer companies such as the Indian Farmers Fertiliser Cooperative Limited (IFFCO), Coromandel International Limited (CIL), and Krishak Bharti Cooperative Limited (KRIBHCO), among others.

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[1] https://www.india.gov.in/spotlight/namo-drone-didi.

IFFCO and CIL also contribute financially to this scheme. IFFCO covered the expenses by spending more than Rs.250 crores towards drone kit and training of drone didis, while CIL has pledged Rs.200 crores to further expand this initiative[2]. The estimated cost for each drone was approximately Rs.14 lakh, which includes the cost of the drone and its associated accessories. IFFCO also offers a subsidy of Rs.100 per acre for the application of nano-urea, nano-DAP, and Sagarika (a biostimulant) to make these products more affordable for farmers.

Economics of drone services

The economic performance of drone services and their determining factors was evaluated using data gathered through a telephonic survey involving 22 drone didis and 120 farmers, both beneficiaries and non-beneficiaries, across 17 districts of Uttar Pradesh from December 2024 to January 2025. The data pertain to the Kharif season, which runs from July to September.

Table 2. Key characteristics of drone didis

Particulars	Mean	Range
Average age of drone didi (years)	32.8	22-45
Years of schooling (years)	15.0	10-19
Experience in drone services (months)	7.7	2-13
Area covered by a drone (acres)	158.2	3-500
Area covered per month (acres)	31.5	0.5-250
Average working hours/day	7	0.5 - 12
Average Income in *Kharif* season (Rs.)	47,647	900-1,50,000

Source: Personal and telephonic survey from drone didis

The drone didis are well educated, with the majority holding a bachelor's degree (Table 2). On average, a drone didi covered 158 acres of cropped area, ranging from as little as three acres to as much as 500 acres. Low drone usage may be attributed to multiple factors, such as low demand for drone in particular area, lack of entrepreneurship among drone didis or due to some technical issues in drone or its Electric Vehicle (EV). Further analysis of the determinants of low coverage by some Drone Didis is presented in Table 3. Drone didis typically worked an average of seven hours per day and earned an average of Rs.47,647 in *Kharif* season.

Crops and activities covered by drones

Currently, the use of drones is mainly confined to spraying liquid fertilizers, pesticides, and weedicides (Figure 1). Land mapping was used sparingly by only a few Drone Didis, primarily for identifying obstructions and assessing land suitability for spraying. During the *Kharif* season, drones are most frequently used in paddy fields, as reported by over 95% of drone didis, followed by sugarcane at 59.09% (Figure 2). In these crops, manual application of fertilizers and pesticides is challenging. Expanding drone applications to include crop health monitoring and land mapping could significantly broaden their use across a more diverse range of crops.

Figure 1. Application of drones in agricultural operations (% drone didis)

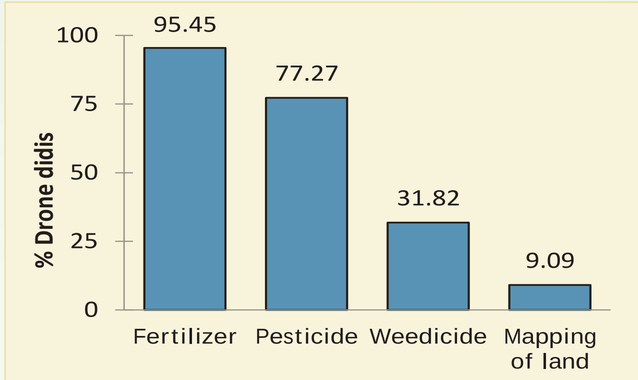
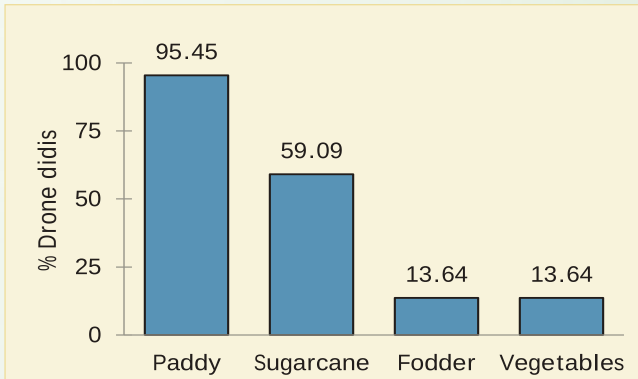


Figure 2. Application of drones across crops (% drone didis)



Factors influencing performance of drone didis

To assess the factors influencing the delivery of drone services, operators were categorized based on the area covered and their key characteristics were compared. Those covering more than the seasonal average of 158 acres were deemed strong performers, whereas those covering less were classified as weak performers (Table 3). As anticipated, strong performers had larger geographical coverage in terms of the number of villages and farmers served. In contrast, weak performers provided drone services to fewer farmers and villages, reaching only about half the number served by strong performers.

The efficiency of drone service delivery is influenced by factors such as the distance from the implementing centre (IFFCO), the number of crops covered, and the involvement of a family member as a drone assistant. Weak performers were located approximately 11 km from the nearest implementation centre and

[2] https://namodronedidi.php-staging.com/about-scheme.

encountered significant challenges in accessing timely support, training, and resources. For strong performers, this distance was nearly four times shorter.

Family support is another significant distinguishing factor. A smaller percentage of underperforming drone didis received as much assistance from their families as the strong performers did, with the help of drone assistants. Finally, performance appears to be negatively associated with alternative income sources- possibly because reduced financial pressure leads to decreased work intensity.

These findings suggest revisiting the selection criteria of beneficiaries and strengthening their logistical support and extension services.

Resource-use efficiency and crop yield

The use of drones to spray chemicals offers significant advantages, particularly in terms of soil health, time, and water savings (Table 4). For instance, drone-based pesticide or herbicide application in crops such as sugarcane and paddy require only 11 minutes per acre on average, whereas conventional spraying takes almost ten times more. Additionally, drone spraying utilizes only 10 litres of water per acre, which is almost 20 times less than what traditional spraying requires. Drone-based spraying costs Rs.300 per acre, whereas the average labour cost for conventional spraying is almost 1.5 times higher.

Furthermore, drone-based spraying ensures precise chemical application, targeting only the affected crops, and minimizing contact with the soil. This precision is likely to contribute to yield improvements. Based on our survey, the difference in yield was not significant but 4.1% higher in paddy and 1.6% higher in sugarcane. However, some articles claim up to a 35% increase in yield and 70% savings in fertilizers and water due to drone-based precision applications[3]. Due to foliar spray by drones, soil contact decreases and pesticide utilization increases by 45% which is expected to improve soil health in long run[3]. Additionally, the increased effectiveness of drone-based sprays can reduce the frequency of application, thereby contributing to environmental and human health benefits.

Table 3. Effectiveness of drone services based on area coverage

Particulars	Strong performers (≥ 158 acres)	Weak performers (< 158 acres)	Difference
Number of operators	7	15	
Area covered (acres)	236.00	45.78	190.22***
Age (years)	33.54	31.78	1.76
Education (years)	14.62	15.44	-0.82
Drone experience (months)	7.58	7.78	-0.2
Family member as drone assistant (% respondents)	92	67	25***
Distance from IFFCO centre (km)	2.75	10.66	-7.91***
Number of crops covered	4.31	3.33	0.98***
Other sources of income	2	6	-4***

Source: Estimated by authors

**** Significant at 1%*

Table 4. Improvement in resource-use efficiency and crop yield

Particulars	Drone sprays	Other sprays	% Difference
Average time for spraying (minute/acre)	11[4]	120	90.8
Water use (litres/acre)	10	200	95.0
Labour cost of spraying (Rs./acre)	300	437	31.4
Paddy yield (quintal/acre)	20.43	19.63	4.1
Sugarcane yield (quintal/acre)	320	315	1.6
Pesticide utilization[5]	85%	30%	45%

Source: Personal and telephonic survey from the farmers

Challenges in delivery of drone services

One of the key challenges is short battery life and its overheating which restrict the area coverage per flight. A fully charged pair of batteries (requiring about two hours to charge) can serve only 2–3 acres of land per cycle, necessitating frequent interruptions for battery replacement or cooling periods. Moreover, each battery pair is currently designed to serve only around 500 acres over its lifetime. This limitation is further compounded by the lack of reliable network connectivity in rural areas, which compromises the accuracy of land mapping for drone spraying and increases the risk of drone accidents.

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3 https://india.mongabay.com/2024/04/farming-with-ai-and-drones-to-increase-yields-manage-resources-and-reduce-pests/

4 Based on the spraying time after take-off. Does not include transport time and pre-take-off preparations such as mixing of pesticides with water, loading, mapping of plot before spraying, battery charging etc.

5 Gaadhe, S., Mehta, T.D., Chavda, S. K. (2025). A comparative study of drone spraying and conventional spraying for precision agriculture, *Plant Archives* 25 (Special issue), ISSN:0972-5210.

The operational challenges faced by agricultural drones are multifaceted and significantly affect their effectiveness in large-scale farming (Table 5). The weak complaint redressal system of drone manufacturers-particularly during peak agricultural seasons and lack of knowledge about crop-specific packages of practices among drone didis, undermine farmers' confidence in the drone technology.

Table 5. Challenges in drone operations

Technical challenges	• Limited area coverage due to EV issues • Poor battery backup • Drone overheating • Difficulties in land mapping due to network issues
Operational challenges	• Weak complaint system • Lack of training in spraying of crop-specific fertilizers and pesticides
Weather-related challenges	• Non-functional in adverse weather conditions
Farm level challenges	• Lack of affordability by smallholders • Lack of trust in drone applications as existing inputs are not specifically designed for drone applications, although they support existing formulations. • Fragmented landholdings

Source: Personal and telephonic survey from the drone didis and the farmers

These technical limitations are exacerbated by external factors such as adverse weather conditions and economic considerations. Strong winds and heavy rainfall not only disrupt drone flights but also reduce the precision of spraying activities, potentially leading to uneven distribution of treatments across fields.

In regions where labour is readily available and inexpensive, the economic viability of drone services is called into question, especially when considering the initial investment and operational costs.

Furthermore, the lack of standardized guidelines for fertilizer and pesticide application via drones introduces variability in treatment effectiveness, potentially resulting in over-application or under-application of agrochemicals. At the farm level, this contributes to trust issues among farmers (Table 5).

Policy implications

The benefits of using drones in agriculture, such as enhancing resource-use efficiency, ensuring timely input applications (especially for nano fertilizers, pesticides, herbicides, and growth promoters), reducing production costs, and minimizing environmental impacts- are evident. However, their immediate impact on crop yields remains uncertain. To expand the use of drones in agriculture, the following measures are recommended.

Expanding drone applications: Expanding crop coverage beyond paddy and sugarcane is crucial for the greater uptake of drone services. This requires a comprehensive approach for land mapping and crop monitoring using advanced technologies and methodologies.

Collaboration among stakeholders: Currently, drones are promoted by a few fertilizer companies. Greater collaboration with Krishi Vigyan Kendras (KVKs) and Farmer Producer Organizations (FPOs) could significantly accelerate the adoption of drone technology. KVKs, as agricultural extension centers, can play a pivotal role by organizing demonstrations, training sessions, and workshops to educate farmers about drone benefits and usage. Meanwhile, FPOs can facilitate collective ownership or rental models, making the technology more accessible and cost-effective for smallholders.

Developing women-friendly drones: Considering that a significant number of drone service providers are women, it is essential to design drones with enhanced ergonomic features. Furthermore, training female pilots to operate EVs can reduce their dependence on drivers and potentially increase their income.

Standardizing chemical dosages: Farmers often hesitate to adopt drone spraying due to the absence of standardized guidelines for optimal application rates and spray patterns of agrochemicals. Research is needed to develop evidence-based recommendations tailored to different crops and environmental conditions.

Capacity building and technical support: Raising farmers' awareness and conducting field demonstrations are essential for promoting drone adoption. These initiatives help to educate farmers, dispel misconceptions, and demonstrate real-world applications. In addition, partnerships between government agencies, agricultural extension systems, and drone manufacturers can create a robust support ecosystem for farmers. Furthermore, ensuring timely and localized technical support for drone operators is critical.

Financial support for manufacturers and operators: Substantial funding is needed for manufacturers and operators to establish efficient complaint redressal systems and supply high-quality drones to drone entrepreneurs. The capital-intensive nature of drone technology presents significant challenges for domestic manufacturers and service providers seeking to enter and sustain operations in this market.

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