

# Drone Technology in Indian Agriculture: Revolutionizing Farm Operations and Crop Management

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Manuscript No: KN-V3-08/001

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## ABSTRACT

Drone technology, or Unmanned Aerial Vehicles (UAVs), is reshaping modern Indian agriculture by enhancing operational efficiency, reducing input costs, and enabling precision interventions. Their applications include real-time crop health monitoring, precision spraying of fertilizers and pesticides, soil and terrain mapping, yield estimation, and disaster impact assessment. By offering a bird's eye view of farm operations and supporting data-driven decisions, drones are transforming how Indian farmers interact with their land and resources. Despite these advantages, adoption remains limited due to high capital costs, low digital literacy, complex regulatory frameworks, and limited access to services in rural areas. However, the government is taking active steps to promote this technology through initiatives like Drone Rules 2021, the Kisan Drone campaign, Production-Linked Incentives (PLI), and subsidy schemes under the Sub-Mission on Agricultural Mechanization (SMAM). This article evaluates the promise, limitations, policy framework, and future roadmap for integrating drone technology in Indian agriculture. It also suggests actionable strategies for bridging adoption barriers through farmer-centric models, indigenous innovation, and ecosystem partnerships.

**Keywords:** Agriculture, Drones, UAVs, Precision Farming, Rural Development, Technology Adoption, Kisan Drones

## 1. Introduction

India is home to over 145 million farmers, a majority of whom are small and marginal landholders. While the agricultural sector supports nearly 60% of India's population, it contributes only about 18% to the country's GDP, reflecting deep inefficiencies. Challenges such as low productivity, fragmented landholding, irregular monsoons, excessive use of chemicals, and limited access to mechanization have kept India's agricultural output below its potential.

In this context, the adoption of advanced technologies like drones can prove revolutionary. Globally, countries like the USA, Japan, and China have embraced UAVs to facilitate sustainable farming. Japan has been using drones since the 1980s, with over 40% of rice farms using drone-based spraying. In the USA, drones are integrated with artificial intelligence (AI) to offer real-time analytics for large monoculture farms. China, under its rural modernization program, has made UAV ownership and training part of agri-cooperative operations, rapidly scaling usage.

In India, drones are still an emerging phenomenon. However, they are gaining traction due to government support and a rising number of domestic drone startups. According to a NITI Aayog report (2023), India's agri-drone market is projected to grow at a CAGR of over 38% from 2022 to 2030, potentially creating 5 lakh jobs in rural India.

This article delves deep into how drone technology can address critical issues in Indian agriculture and what needs to be done to ensure their equitable adoption and impact.

## 2. Scope and Applications of Drones in Agriculture

Agricultural drones are not just flying cameras. They are data collection platforms with advanced sensors

that enable farmers to act with precision. Drones can be categorized based on their use-case: fixed-wing for long-range mapping, multi-rotor for spraying, and hybrid drones for dual tasks. Let's explore their practical applications:

### **2.1 Crop Health Monitoring and Disease Detection**

Using multispectral and thermal imaging, drones can capture minute details about plant health not visible to the naked eye. These images are processed into NDVI (Normalized Difference Vegetation Index) maps to assess chlorophyll content, water stress, fungal infections, or nitrogen deficiency.

### **2.2 Precision Spraying of Agrochemicals**

Conventional spraying methods waste large amounts of pesticides and expose laborers to harmful chemicals. Drone-based precision spraying ensures uniform coverage and controlled droplet size, reducing chemical use by 20–30% and labor costs by over 50%.

### **2.3 Soil and Terrain Mapping**

Before planting, drones can conduct topographical surveys of the field using photogrammetry. These images help generate digital elevation models (DEM) and soil variability maps, aiding farmers in planning sowing direction, irrigation layout, and drainage systems.

### **2.4 Seeding and Crop Sowing**

Automated seed-dispersal drones have been piloted in tribal areas of Jharkhand and Chhattisgarh under forest regeneration programs. In agriculture, this technique is being tested in inaccessible terrains and during post-flood rehabilitation of farmlands.

### **2.5 Disaster Assessment and Insurance Claims**

Under schemes like the Pradhan Mantri Fasal Bima Yojana (PMFBY), drones help assess flood or hailstorm damage to expedite insurance processing. Drones have reduced claim processing time from 3 months to just 3 weeks in certain pilot districts.

## **3. Barriers to Drone Adoption in Rural India**

Despite its potential, drone technology faces numerous bottlenecks in rural India. These challenges stem from structural inequalities, digital and financial exclusion, and policy ambiguities. The following are key hurdles:

### **3.1 High Capital and Operating Costs**

Agricultural drones in India typically cost between ₹5 lakh to ₹12 lakh depending on features like payload, GPS-guidance, battery capacity, and sensor types. Beyond hardware, costs add up through annual maintenance, battery replacements, pilot training, software licenses, and insurance.

### **3.2 Digital and Technical Illiteracy**

As per the 2021 National Sample Survey, less than 20% of rural households have regular access to computers or the internet. Farmers are often unable to interpret technical outputs like NDVI maps or geospatial charts, which limits the actionable insights drones can provide.

### **3.3 Complex Regulations and Zoning Restrictions**

The DGCA Drone Rules 2021 have eased operations, but challenges remain. Zones near airports, military bases, or international borders are marked “red zones” where drone operations are restricted or require multi-layered permissions.

### **3.4 Limited Ecosystem and After-Sales Support**

Drone repair centers are concentrated in Tier-1 cities. In the event of technical failure, rural users face 1–2 weeks of downtime and high logistics costs.

### **3.5 Land Fragmentation and Field Constraints**

With over 60% of farms in India being less than 1 hectare in size, drone navigation becomes difficult due to irregular field shapes and close proximity to trees or structures.

## **4. Government Initiatives and Policy Support**

Recognizing the transformative potential of drones in agriculture, both central and state governments have introduced progressive policies, funding mechanisms, and awareness campaigns.

### **4.1 Drone Rules 2021 (DGCA)**

The new rules eliminated many bureaucratic hurdles, including licensing and import permissions, expanding green zones to enable flying without prior approval in over 90% of India's airspace.

### **4.2 Kisan Drone Yatra (2022)**

This nationwide campaign conducted over 1,000 demonstrations via KVKs, FPOs, and agri universities to showcase the potential of drones, especially in underserved regions.

### **4.3 Sub-Mission on Agricultural Mechanization (SMAM)**

SMAM provides a 40–50% subsidy for agri-drones for FPOs and CHCs, and promotes rural youth employment as trained drone operators.

### **4.4 State-Level Drone Missions**

Telangana, Maharashtra, Punjab, and Haryana have launched specific state missions to subsidize and promote drones for spraying, mapping, and disaster relief.

### **4.5 Production Linked Incentive (PLI) Scheme**

This ₹120 crore scheme supports Indian drone and component manufacturers, lowering the cost barrier and promoting local R&D.

## **5. Case Studies and Field Examples**

### **5.1 Punjab: Cotton Spray Optimization**

The Punjab Agricultural University showed 25% reduction in pesticide usage and 12% yield improvement using drone-based spraying in cotton fields.

### **5.2 Odisha: Post-Flood Crop Assessment**

Drones mapped over 60,000 hectares of submerged farmland post-Cyclone Yaas, enabling ₹85 crore of insurance disbursement in under a month.

### **5.3 Madhya Pradesh: Drone-as-a-Service (DaaS) Pilot**

An FPO in Sehore offered spraying services at ₹200 per acre using subsidized drones and generated sustainable income for local drone pilots.

## **6. Indigenous Innovation and Startup Ecosystem**

India has seen the emergence of over 200 agri-drone startups in the last five years. Companies like Garuda Aerospace, IoTechWorld, and Marut Drones are developing cost-effective UAVs tailored to Indian farm

conditions. These startups offer solutions like multi-language flight apps, rental drones for FPOs, and AI-based analytics platforms. Collaborations with IITs, ICAR, and T-Hub have accelerated R&D and pilot deployments. Government funding through the Technology Development Board and incubation through Agri-Innovation Hubs have provided early-stage support, but scale-up capital and rural penetration remain challenging.

## 7. International Comparisons and Lessons for India

### 7.1 China

China's strategy focused on collectivized drone ownership through cooperatives, strong training infrastructure, and integration with state subsidy schemes. It has over 50,000 registered agri-drones as of 2023.

### 7.2 USA

The U.S. approach revolves around precision agriculture startups and partnerships with large agri-businesses. Regulations are tech-friendly, but rural broadband remains a barrier.

### 7.3 Japan

Japan's early adoption was driven by aging farmers and labour shortages. It integrated drone spraying into public extension services and agricultural co-ops.

India can draw from these models by promoting cooperatives, supporting digital literacy, and building rural tech ecosystems.

## 8. Environmental and Social Impact

Drone use reduces the over-application of agrochemicals, improving soil health and lowering greenhouse gas emissions. Precision farming also optimizes water and fertilizer use. Socially, it can create employment for rural youth, particularly those trained as drone pilots, data analysts, and repair technicians.

## 9. Conclusion and Recommendations

Drones present a timely and transformative opportunity for Indian agriculture. To mainstream their use, it is vital to:

- Promote Drone-as-a-Service models via FPOs and CHCs
- Expand regional training and repair centers
- Support local manufacturing through PLI and R&D grants
- Integrate drones into schemes like PMFBY, eNAM, and Atmanirbhar Bharat

A targeted, inclusive strategy can ensure that even small and marginal farmers benefit from this innovation, enabling a more resilient and productive agricultural sector.

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