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Why Indian Agriculture Needs Drones: A Market Research Perspective on Precision Farming, Productivity, and Sustainability

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Abstract

Indian agriculture is at a pivotal juncture, confronting intensifying structural pressures despite sustaining nearly 58% of the country's population and supporting one of the world's largest agricultural workforces. Rapid declines in per-capita arable land—from 0.52 hectares in 1950 to approximately 0.21 hectares in 2021—combined with highly fragmented landholdings, where over 70% of farmers operate plots smaller than one hectare, have progressively undermined the effectiveness of conventional mechanisation. These challenges are further exacerbated by climate variability, labour shortages, rising input costs, and growing sustainability mandates. Within this context, agricultural drones are increasingly transitioning from experimental tools to operational necessities. This study investigates why drone-based solutions are gaining strategic importance in Indian agriculture, adopting a market-oriented research perspective that integrates structural demand drivers, adoption barriers, policy enablers, and emerging business models. A descriptive and analytical methodology is employed, drawing on secondary data from government agencies, regulatory authorities, market intelligence reports, and industry publications spanning 2022–2025. The analysis synthesises evidence on landholding structures, technological readiness, regulatory frameworks, cost dynamics, and global trade disruptions to assess the economic and operational rationale for drone adoption. The findings indicate that small and nano agricultural drones are uniquely aligned with India's fragmented farming systems, enabling precision spraying, crop monitoring, soil assessment, and time-critical operations at scale. India has recorded over 29,500 registered drones and 65 DGCA-certified agricultural drone models, signalling rapid institutionalisation. Large-scale deployments—such as drone-based spraying across 30 lakh acres in 12 states—demonstrate substantial efficiency gains, with drones covering six acres within two to three hours compared to several days via manual labour, alongside reported yield improvements of 30–35%. Policy initiatives, including the Digital Agriculture Mission (2021–2025) and the *NaMo Drone Didi* programme, have further accelerated adoption through skill development and service-based deployment. However, affordability remains a critical constraint, intensified by recent trade disruptions that imposed tariffs exceeding 100–170% on imported drone components. The study positions agricultural drones as essential instruments of productivity enhancement, sustainability, and resilience, underscoring the importance of service-based models, capacity building, and domestic manufacturing for inclusive and scalable adoption in Indian agriculture.

Keywords

Agricultural drones, Precision farming, Indian agriculture, Market research, Sustainability, Drone-as-a-Service

1. Introduction

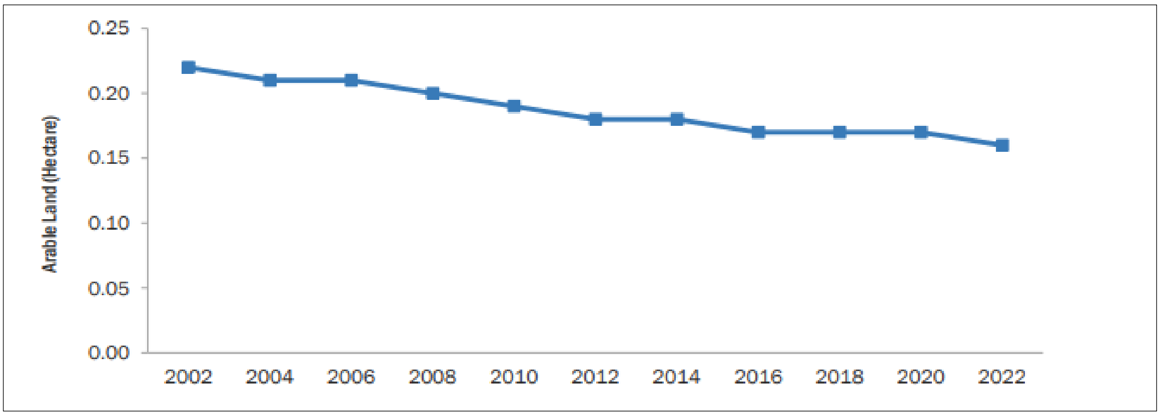
Indian agriculture is undergoing a phase of unprecedented structural stress, driven by declining natural resources, fragmented landholdings, labour shortages, and intensifying sustainability expectations. Although agriculture continues to provide livelihoods for nearly 58% of India's population, its ability to meet future food demand is increasingly constrained by systemic inefficiencies. Rapid population growth, climate variability, soil degradation, and shrinking cultivable land have collectively eroded the viability of conventional farming practices. In this context, precision agriculture technologies—particularly agricultural drones—have transitioned from optional innovations to market-driven necessities.

Agricultural drones offer targeted input application, operational efficiency, and adaptability to fragmented farm structures, positioning them as critical enablers of productivity enhancement and resource optimisation. Their relevance is especially pronounced in smallholder-dominated agrarian systems such as India, where structural constraints limit the effectiveness of traditional mechanisation.

1.1 Declining Arable Land and Rising Productivity Pressure

One of the most pressing challenges confronting both Indian and global agriculture is the persistent decline in arable land availability. World Bank data indicate that global per-capita arable land decreased from 0.52 hectares in 1950 to below 0.24 hectares in 2010, further declining to approximately 0.21 hectares by 2021. Simultaneously, nearly 33% of the world's high-quality agricultural land has been lost over the past four decades due to erosion, pollution, and unsustainable land-use practices. Soil erosion alone is occurring at rates up to 100 times faster than natural soil formation, with nearly 500 years required to regenerate just 2.5 cm of topsoil.

Figure 1: Global Decline in Per-Capita Arable Land (2002–2021)



Source: FAO; Federation of Indian Chambers of Commerce & Industry (FICCI)

These trends are illustrated in Figure 1, which highlights the widening gap between land availability and rising food demand. For India—where rapid urbanisation and industrial expansion continue to encroach upon cultivable land—future agricultural growth must rely predominantly on yield intensification, precision input use, and technological efficiency rather than horizontal land expansion.

1.2 Fragmented Landholdings and the Limits of Conventional Mechanisation

The challenge of shrinking arable land is compounded by the highly fragmented structure of landholdings in India. According to FAO estimates, over 95% of farms globally are smaller than five hectares. In India, data from the National Sample Survey Organization (NSSO) indicate that the average farm size is only 1.08 hectares, with nearly 70% of farmers operating holdings smaller than one hectare.

Such fragmentation severely restricts the applicability of conventional mechanisation. Large tractors, boom sprayers, and heavy equipment are designed to exploit scale economies and contiguous land parcels, rendering them economically inefficient and operationally impractical for smallholders. In contrast, small and nano agricultural drones are inherently compatible with fragmented plots, offering flexible deployment, lower operational footprints, and higher precision.

This structural mismatch between traditional machinery and smallholder realities is summarised in Table 1, which underscores the suitability of small and nano drones within India's agrarian context.

Table 1: Fragmented Landholdings in India and Implications for Technology Adoption

Indicator	India
Average farm size	1.08 hectares
Farmers operating below 1 hectare	~70%
Farms below 5 hectares	>80%
Suitability of small & nano drones	High

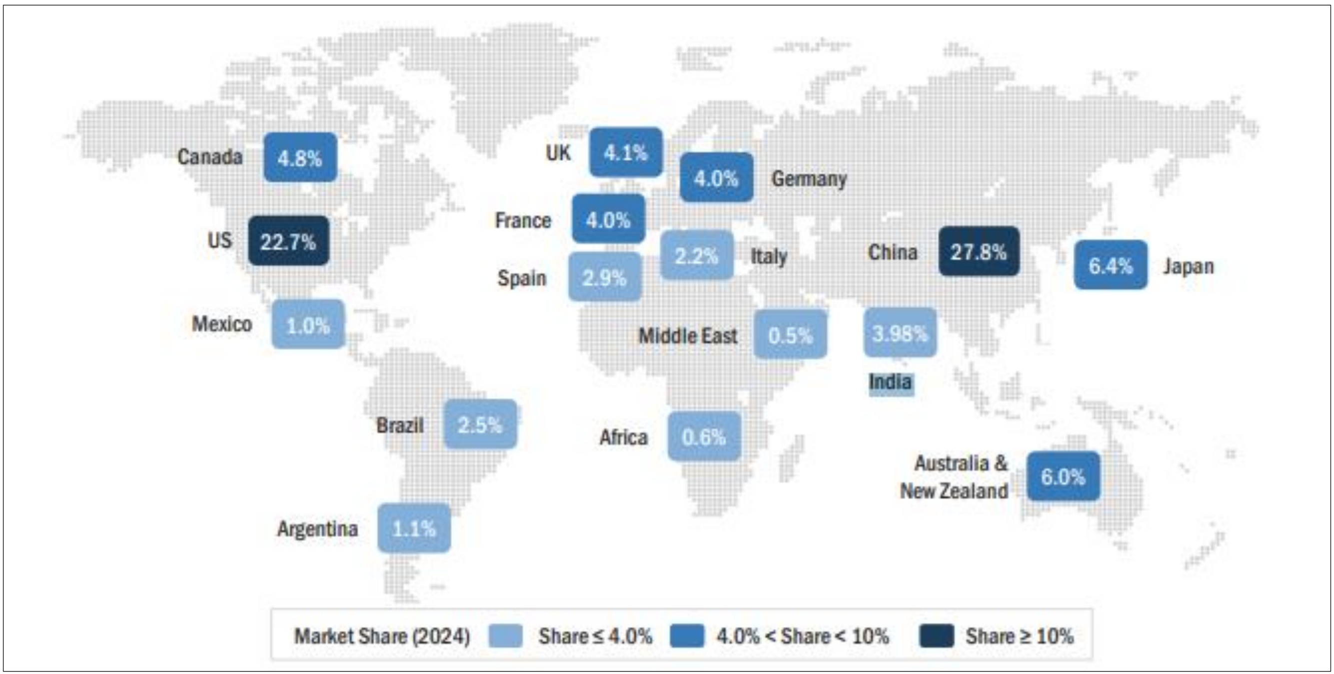
Source: FAO; NSSO

1.3 Labour Constraints and the Need for Precision Operations

Labour scarcity has emerged as a critical driver accelerating the adoption of agricultural drones. Increasing shortages have resulted from rural–urban migration, ageing farmer populations, and rising agricultural wage costs. Time-sensitive farm operations—particularly pesticide spraying and fertiliser application—are disproportionately affected, leading to yield losses and suboptimal input usage.

Drone-enabled spraying significantly enhances operational efficiency, allowing approximately six acres to be covered within two to three hours, compared to several days using manual labour. This efficiency advantage has facilitated rapid scale-up, with drone-based spraying implemented across nearly 30 lakh acres in 12 Indian states.

Figure 2: Demand for Large-Scale Crop Spraying Using Agricultural Drones Across Countries



Source: MarketsandMarkets; Times of India; Industry Reports

The growing demand for large-scale, time-critical crop spraying is illustrated in **Figure 2**, which presents cross-country comparisons of agricultural drone deployment.

1.4 Institutionalisation, Regulation, and Policy Support

India's agricultural drone ecosystem has advanced rapidly through institutional consolidation and regulatory formalisation. As of 2025, the country hosts over 29,500 registered drones and more than 65 DGCA-certified agricultural drone models, reflecting growing regulatory acceptance and infrastructural readiness.

The technological composition of the agricultural drone ecosystem is presented in Table 2, highlighting the functional role of key hardware components.

Table 2: India – Agricultural Drones Hardware Market by Offering

Hardware Component	Primary Application
Frames & motors	Structural stability and propulsion
Sensors & cameras	Crop health monitoring, NDVI analysis
Batteries	Power supply (predominantly Li-ion)
Navigation systems	GPS and GIS integration

Hardware Component	Primary Application
Spraying systems	Precision pesticide and fertiliser application

Source: MarketsandMarkets; Industry Reports

These developments are reinforced by policy initiatives such as the Digital Agriculture Mission (2021–2025) and the National e-Governance Plan in Agriculture (NeGPA), which integrate drones with AI, GIS, IoT, and remote sensing platforms.

The regulatory and institutional architecture governing agricultural drones in India is summarised in Table 3.

Table 3: Regulatory Bodies Governing Agricultural Drones in India

Country	Organisation	Type	Description
India	Bureau of Indian Standards (BIS)	Regulatory Body	Develops national standards for agricultural machinery and drone testing
India	Directorate General of Civil Aviation (DGCA)	Regulatory Body	Oversees registration, licensing, certification, and drone operations
India	Department of Agriculture & Farmers Welfare	Government Agency	Promotes AI, IoT, robotics, and drone adoption under NeGPA

Source: MarketsandMarkets; Industry Reports

1.5 Market Disruptions and Emerging Business Models

Despite strong structural demand, adoption remains uneven due to high upfront capital costs and global supply-chain disruptions. Recent trade tensions have led to tariffs exceeding 100–170% on imported drones and critical components, significantly raising equipment costs and lengthening investment payback periods.

These disruptions have accelerated the emergence of Drone-as-a-Service (DAAS) business models, which reduce capital barriers, distribute risk, and enable smallholders to access drone services without ownership. DAAS has thus become a critical market mechanism for inclusive technology diffusion.

1.6 Study Gap and Research Contribution

While existing reports and industry analyses provide rich evidence on land degradation, fragmented farm structures, labour shortages, regulatory frameworks, and evolving business models, academic research remains fragmented. Most studies focus either on drone technology performance or isolated pilot projects, offering limited insight into how structural constraints, policy instruments, pricing dynamics, service-based models, and global trade disruptions interact to shape adoption outcomes in smallholder-dominated systems.

Notably, the differentiated role of small and nano drones, the growing reliance on DAAS models, and the impact of trade-induced price shocks remain underexplored within Indian agricultural scholarship.

This study addresses these gaps by adopting an integrated market research perspective that synthesises structural, institutional, and economic dimensions of agricultural drone adoption. By grounding the analysis in India's agrarian realities and policy environment, the study advances a holistic understanding of why Indian agriculture needs drones and under what market conditions they can be scaled sustainably and inclusively.

2. Literature Review

The application of drone technology in agriculture has received growing scholarly attention in India, particularly in response to declining land productivity, labour shortages, and the need for technology-driven sustainability. Existing literature broadly recognises agricultural drones as enablers of precision farming, offering capabilities such as crop monitoring, precision spraying, yield estimation, and integration with digital agriculture ecosystems.

Several studies provide comprehensive overviews of drone technologies and their applications in Indian agriculture. Dileep et al. (2020) classify agricultural drones based on payload capacity, flight control, and application type, highlighting their suitability for spraying, surveillance, and crop assessment. Their analysis underscores the efficiency of UAVs in reducing operational time and labour dependency, while also noting limitations related to battery life, payload constraints, and regulatory compliance. Similarly, Joshi and Pandey (2024) emphasise the convergence of UAVs with Internet of Things (IoT) platforms, arguing that IoT-enabled drones significantly enhance real-time data acquisition, decision-making accuracy, and farm-level automation in Indian farming systems.

Policy-oriented literature has critically examined the institutional and regulatory environment shaping drone adoption. Pathak et al. (2020) provide one of the earliest systematic assessments of the potential, problems, and policy needs associated with agricultural drones in India. Their work identifies fragmented landholdings, lack of skilled operators, and high capital costs as major barriers, while strongly advocating government intervention through training programmes, subsidies, and regulatory clarity. More recent reviews echo these concerns, noting that while policy momentum has increased, adoption remains uneven across regions and farm sizes (Singh & Singh, 2025).

A growing body of literature focuses on India's readiness for technological transformation in agriculture. Jain et al. (2023) examine the rural–urban divide in drone adoption, arguing that technological diffusion remains concentrated in commercially advanced regions. They highlight the importance of institutional support, service-based deployment, and digital infrastructure in enabling rural adoption. Thakur (2025) similarly frames drones as a transformative technology within India's agricultural sector, emphasising their role in modernising farm operations while cautioning against unequal access and skill disparities.

From a data and analytics perspective, Masih and Rajasekaran (2019) highlight the integration of big data and IoT analytics in agriculture, establishing a conceptual foundation for drone-enabled data ecosystems. Their work demonstrates how data-driven agriculture enhances decision-making, productivity, and resource efficiency—an argument further extended by Dutta and Mitra (2021), who examine the role of drones and IoT in strengthening food supply chains during the post-COVID-19 period. These studies reinforce the idea that drones function not as standalone tools, but as integral components of digital agricultural systems.

Emerging empirical and cross-cultural research has begun to explore adoption behaviour and technology acceptance. Masih et al. (2024) examine nano-drone adoption in India and the Netherlands, revealing how land fragmentation, policy incentives, and service availability shape adoption differently across contexts. Complementing this perspective, Arthur et al. (2023) discuss smart agricultural technologies more broadly, positioning drones as central to sustainable and climate-resilient farming systems. Although Saini et al. (2025) focus primarily on AI in recruitment, their discussion of AI diffusion into agribusiness contexts underscores the broader trend of digital transformation affecting agriculture and allied sectors.

Despite these contributions, the literature remains largely segmented, with studies addressing technological capabilities, policy frameworks, analytics integration, or adoption behaviour in isolation. Comprehensive market-oriented research that integrates structural land constraints, regulatory evolution, service-based business models, and cross-sector digital transformation remains limited. This study responds to that gap by synthesising insights from technology, policy, and market perspectives to assess why agricultural drones are increasingly essential for Indian agriculture, particularly within smallholder-dominated and resource-constrained farming systems.

3. Methodology

This study employs a market intelligence–based exploratory research methodology to examine the growing need for agricultural drones in Indian agriculture. The methodological approach is designed to capture market dynamics, policy evolution, technological readiness, and adoption constraints, rather than to synthesise academic literature alone. Such an approach is particularly appropriate for emerging technologies operating at the intersection of agriculture, regulation, and digital innovation.

Research Design

The research follows an exploratory and analytical design, integrating market intelligence, policy analysis, and industry evidence to assess the role of agricultural drones in enhancing precision farming, productivity, and sustainability. The study is positioned as applied market research, aimed at understanding demand-side drivers and supply-side enablers within India's smallholder-dominated agricultural system.

Data Sources

Secondary data were drawn from multiple non-academic and academic sources to ensure triangulation and robustness. These included:

- Market intelligence reports on agricultural drones and precision farming
- Government and institutional documents related to agriculture, digital transformation, and drone regulation
- Industry reports, white papers, and technology adoption studies
- Peer-reviewed studies used selectively to contextualise technological and policy developments

These sources provided quantitative and qualitative evidence on landholding structures, labour dynamics, adoption patterns, regulatory frameworks, pricing trends, and business models.

Analytical Approach

The analysis was conducted using a thematic market analysis framework, wherein data were organised into five key dimensions:
(i) structural demand drivers (declining arable land, fragmented farms, labour shortages),
(ii) technological capabilities and limitations of agricultural drones,
(iii) policy and regulatory environment,
(iv) market and deployment models, particularly Drone-as-a-Service (DAAS), and
(v) external risks, including supply-chain disruptions and cost pressures.

A comparative assessment was used to evaluate the relative suitability of small and nano drones versus conventional mechanisation in fragmented farming systems. Emphasis was placed on identifying convergence between market demand, policy intent, and technological feasibility.

4. Results and Discussion

This section presents an integrated Results–Discussion analysis of the agricultural drones market in India. Instead of separating empirical findings from interpretation, results are discussed in conjunction with evidence from figures and tables to explain how structural agrarian conditions, technological capabilities, regulatory frameworks, market deployment models, and external risks jointly shape the adoption trajectory of agricultural drones—particularly small and nano drones—in India's smallholder-dominated agricultural system.

4.1 Structural Demand Drivers: Declining Arable Land, Fragmented Farms, and Labour Shortages

The results clearly indicate that demand for agricultural drones in India is **structural in nature**, emerging from long-term agrarian constraints rather than short-term technological enthusiasm.

Evidence from **Figure 1: Per Capita Arable Land, 2002–2022** demonstrates a sustained decline in global per-capita arable land, falling from approximately 0.52 hectares in 1950 to around 0.21 hectares by 2021. The figure further highlights that nearly 33% of high-quality agricultural land has been lost globally over the past four decades due to erosion and pollution, with soil erosion occurring at rates nearly 100 times faster than natural soil formation. Given that approximately 500 years are required to regenerate just 2.5 cm of topsoil, these results confirm declining land availability as a fundamental productivity constraint, necessitating technologies that increase output per unit of land while minimising environmental degradation.

This land pressure is compounded by the fragmented structure of Indian agriculture. Evidence summarised in **Table 1: Fragmented Landholdings in India and Implications for Technology Adoption** shows that India's average farm size is approximately 1.08 hectares, with nearly 70% of farmers operating on holdings below one hectare. Such fragmentation significantly reduces the feasibility of conventional mechanisation, which relies on scale economies and contiguous land parcels. Consistent with Pathak et al. (2020) and Singh and Singh (2025), these results highlight a structural mismatch between traditional machinery and India's agrarian realities. In contrast, the findings demonstrate that small and nano agricultural drones are inherently compatible with fragmented farms due to their operational flexibility, minimal land dependency, and precision capabilities.

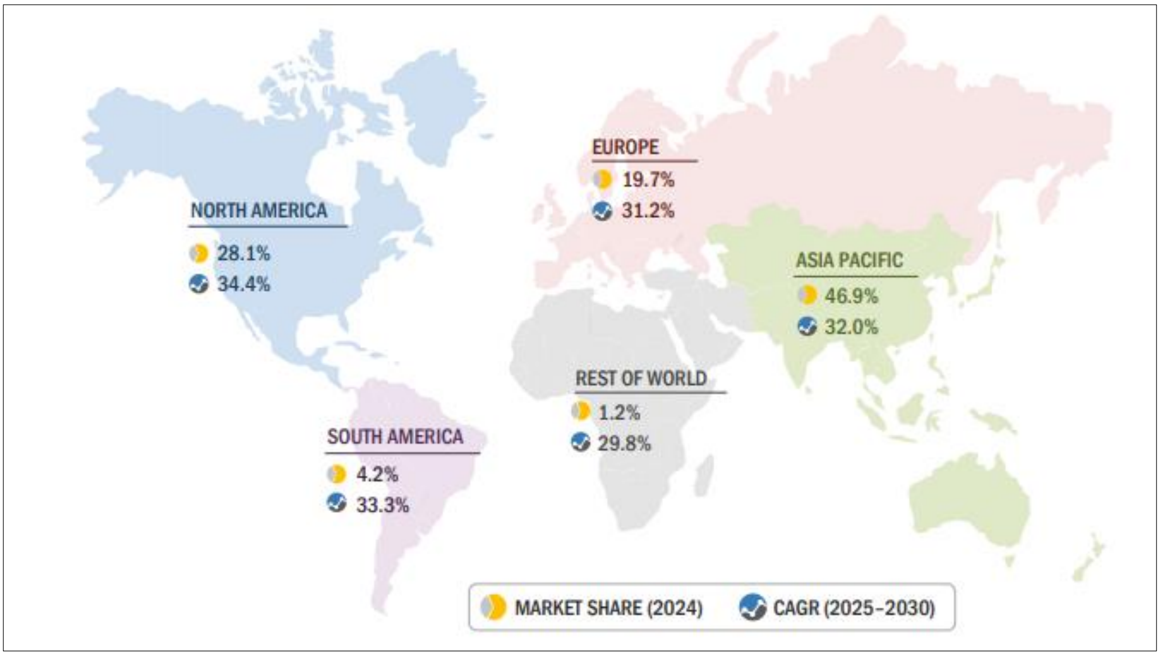
Labour shortages represent a third reinforcing driver. Evidence from **Figure 2: Demand for Large-Scale Crop Spraying Using Agricultural Drones Across Countries** shows that drone-based spraying enables coverage of approximately six acres within two to three hours, compared to two to three days using manual labour. Large-scale deployments across multiple Indian states illustrate how drones substitute scarce labour while improving timeliness, operator safety, and uniformity of application. These findings align with Jain et al. (2023), who identify labour scarcity as a critical trigger for drone adoption during peak agricultural seasons.

Collectively, evidence from **Figure 1**, **Table 1**, and **Figure 2** demonstrates that declining arable land, fragmented holdings, and labour shortages form a self-reinforcing demand structure, positioning agricultural drones as operational necessities rather than discretionary technologies.

4.2 Technological Capabilities and Operational Constraints

The results confirm that agricultural drones possess strong technological capabilities across spraying, crop monitoring, soil analysis, yield estimation, and real-time data acquisition.

Figure 3: Agriculture Drones Market Share & Growth Rate, By Region 2024 (By Value)



Source: MarketsandMarkets Analysis

Regional market momentum is illustrated in **Figure 3: Agriculture Drones Market Share and Growth Rate by Region, 2024 (By Value)**, which shows Asia-Pacific as both the dominant and fastest-growing market. Evidence associated with this figure indicates the dominance of rotary-wing drones, particularly in agricultural applications. These platforms are well suited to Indian farming conditions due to their vertical take-off and landing capability, manoeuvrability, and precision, enabling effective operations in small, irregular, and fragmented plots. This observation is consistent with Dileep et al. (2020), who emphasise the suitability of rotary-wing platforms for heterogeneous agricultural landscapes.

Beyond physical operations, the results reveal that drones function as data-generation platforms. Empirical evidence supported by Masih and Rajasekaran (2019) and Dutta and Mitra (2021) demonstrates that drone-generated data—when integrated with AI, IoT, and analytics—enhances decision-making accuracy, yield optimisation, and resource efficiency. This positions drones as enablers of data-driven and predictive agriculture, extending their value beyond mechanical tasks.

However, the results also identify important constraints. Operational limitations related to battery endurance, weather sensitivity, limited training infrastructure, and skill shortages remain significant. Singh and Singh (2025) observe that many operational inefficiencies arise not from hardware limitations but from deficits in human capital and ecosystem readiness. These findings suggest that while technological capability exists, effective utilisation depends on training, digital infrastructure, and institutional support.

4.3 Policy and Regulatory Environment

The results demonstrate that the policy and regulatory environment plays a critical enabling role in agricultural drone adoption.

Institutional governance is outlined in **Table 3: Regulatory Bodies Governing Agricultural Drones in India**, which identifies the roles of the Bureau of Indian Standards (BIS), the Directorate General of Civil Aviation (DGCA), and the Department of Agriculture and Farmers Welfare. These institutions collectively regulate standards, certification, licensing, and integration of drones into national digital agriculture initiatives such as the National e-Governance Plan in Agriculture (NeGPA).

Further regulatory clarity is provided through DGCA's drone classification framework, which categorises drones into nano, micro, small, medium, and large classes with clearly defined operational norms. Consistent with Pathak et al. (2020), the results confirm that regulatory clarity reduces uncertainty and facilitates scaling. Singh and Singh (2025) further note that formal regulatory recognition has stimulated domestic innovation and private-sector participation.

Despite these advances, the results also reveal persistent challenges. Multi-agency oversight, pilot certification requirements, and airspace restrictions can delay deployment, particularly for small service providers. In addition, the absence of comprehensive governance frameworks for AI-enabled agricultural data raises concerns regarding data ownership, privacy, and accountability. These findings indicate that while regulation is broadly supportive, greater simplification and coordination are required for inclusive scaling.

4.4 Market Deployment Models: Drone-as-a-Service (DAAS)

One of the most significant findings is the shift from ownership-based adoption to service-based deployment models, particularly Drone-as-a-Service (DAAS).

Evidence from adoption patterns shows that DAAS models allow farmers to access drone services without high upfront capital investment, making adoption viable for small and marginal farmers. This is particularly relevant in the context of rising equipment costs. As discussed by Pathak et al. (2020) and Singh and Singh (2025), cost remains the primary adoption barrier, and the results demonstrate that DAAS directly addresses this constraint by transferring capital, maintenance, and operational risks to service providers.

The emergence of a service-provider ecosystem has generated broader socio-economic benefits, including rural entrepreneurship, skill development, and women-led participation, exemplified by initiatives such as *NaMo Drone Didi*. Supporting this interpretation, Masih et al. (22024) report significantly higher adoption willingness when drones are offered as services rather than products. However, the results also highlight risks related to service availability, pricing transparency, and quality assurance, indicating the need for regulatory oversight of service markets.

4.5 External Risks: Supply-Chain Disruptions and Cost Pressures

Despite strong structural demand and supportive policy frameworks, the results identify external risks as major constraints on sustained market growth.

Table 4: India – US Adjusted Reciprocal Tariff Rates (2024–2025)

Country of Origin	Effective Tariff Rate	Impact
China	100–170%	Sharp rise in landed costs
India	~25–50%	Reduced export competitiveness
EU	10–25%	Increased drone component prices

Source: MarketsandMarkets Analysis

Evidence from **Table 4: India–US Adjusted Reciprocal Tariff Rates (2024–2025)** shows that import duties ranging from 100% to 170% have sharply increased landed costs, extended payback periods, and reduced export competitiveness. These cost pressures disproportionately affect small service providers and delay market expansion.

Table 5: India – Enhancing Tea Plantation Productivity & Sustainability Using Drones

Function	Impact
Crop Monitoring	Early disease & pest detection
Precision Spraying	Reduced chemical usage
Yield Assessment	Improved harvest planning
Labour Reduction	Lower manual intervention

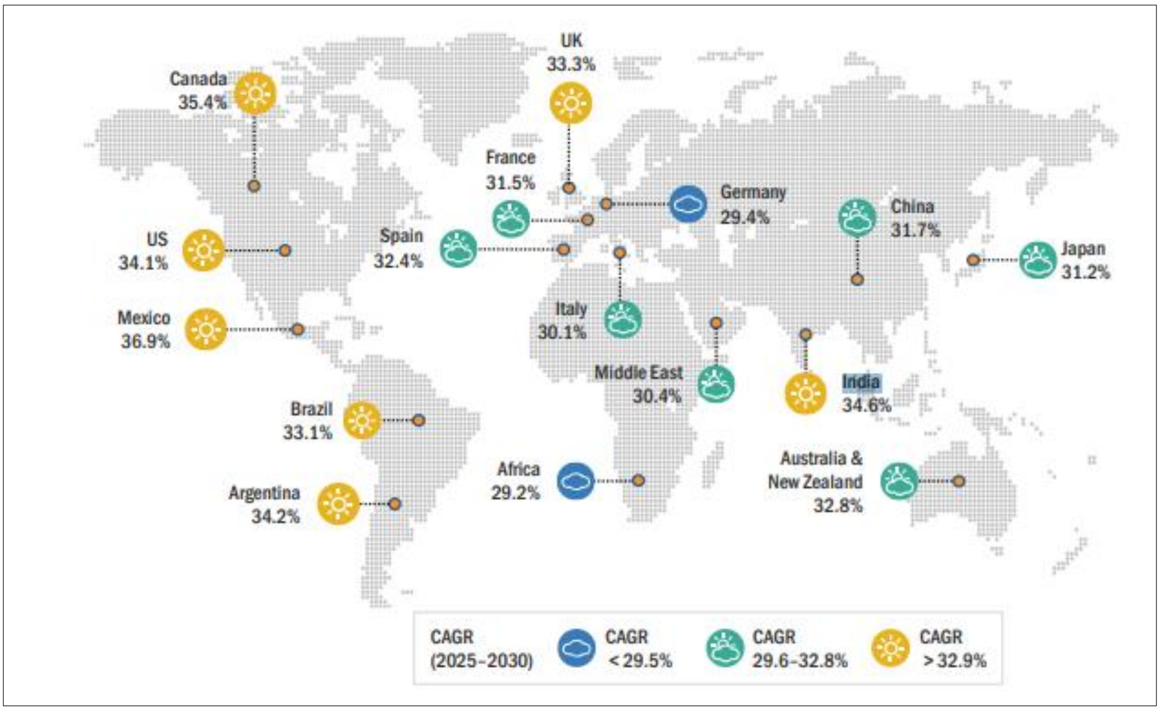
Source: MarketsandMarkets Analysis

Complementary insights are provided by **Table 5: Enhancing Tea Plantation Productivity and Sustainability Using Drones**, which demonstrates that although drones deliver measurable gains in crop monitoring, precision spraying, yield assessment, and labour reduction, cost escalation remains a significant adoption bottleneck.

Additional vulnerabilities arise from semiconductor shortages, lithium-ion battery constraints, and geopolitical trade disruptions. Singh and Singh (2025) caution that reliance on imported components exposes the sector to volatility, while Joshi and Pandey (2024) argue that supply-chain resilience has become as critical as technological capability. These findings underscore the importance of domestic manufacturing, component localisation, and diversified sourcing strategies.

4.6 Integrated Interpretation

Figure 4: Fastest-Growing Drone Markets



Source: MarketsandMarkets Analysis

Table 6: Global Agricultural Drones Market by Region

Region	***Market Status***
Asia Pacific	*Largest & fastest growing*
North America	*Technology-driven adoption*
Europe	*Regulation-intensive growth*
Latin America	*Emerging adoption*
Middle East & Africa	*Early-stage market*

Source: MarketsandMarkets Analysis

The global context is illustrated in **Figure 4: Fastest-Growing Drone Markets** and **Table 6: Global Agricultural Drones Market by Region**, which identify Asia-Pacific as the largest and fastest-growing agricultural drone market worldwide.

Synthesising evidence across figures and tables, the results confirm that agricultural drone adoption in India is driven by structural necessity rather than technological novelty. Declining arable land (**Figure 1**), fragmented landholdings (**Table 1**), and labour shortages (**Figure 2**) create persistent demand for precision agriculture solutions. Technological capabilities deliver value when supported by skills and digital infrastructure (**Figure 3**), while enabling policy frameworks (**Table 3**) and service-based deployment models expand affordability and access. Simultaneously, external risks related to tariffs and supply chains (**Table 4**) highlight the need for resilience-oriented strategies.

Consistent with Pathak et al. (2020), Singh and Singh (2025), and Jain et al. (2023), the findings position small and nano agricultural drones as essential components of India's evolving digital agriculture ecosystem, rather than supplementary or experimental technologies.

5. Conclusion and Policy Implications

This study investigated the adoption of agricultural drones in India through an integrated market-oriented framework, demonstrating that drone diffusion is driven primarily by structural necessity rather than technological novelty. Persistent challenges related to declining arable land, fragmented landholdings, and acute labour shortages create strong demand for precision and efficiency-enhancing solutions, particularly within smallholder-dominated agricultural systems.

The findings show that agricultural drones—especially small and nano variants—deliver significant operational benefits by improving input efficiency, reducing labour dependence, and enabling timely farm interventions. Beyond physical operations, drones increasingly function as data-generating platforms that support AI-enabled, predictive, and resource-efficient decision-making, strengthening India's digital agriculture ecosystem.

Policy and regulatory frameworks have played a critical enabling role by providing institutional legitimacy and operational clarity. However, further simplification, coordination, and governance mechanisms—particularly for AI-driven agricultural data—are required to ensure inclusive scaling. The study also identifies Drone-as-a-Service (DAAS) models as a pivotal mechanism for expanding access, reducing capital barriers, and enhancing adoption among small and marginal farmers.

Despite strong demand fundamentals, external risks such as supply-chain disruptions and trade-induced cost pressures remain significant constraints. Addressing these risks through domestic manufacturing and localisation strategies will be essential for long-term resilience. The study positions agricultural drones as economic, resilience-enhancing instruments central to sustainable and inclusive agricultural transformation in India.

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