



THE ROLE OF DRONE TECHNOLOGY IN ENHANCING COST-EFFECTIVENESS AND STABILITY IN THE SUGAR INDUSTRY

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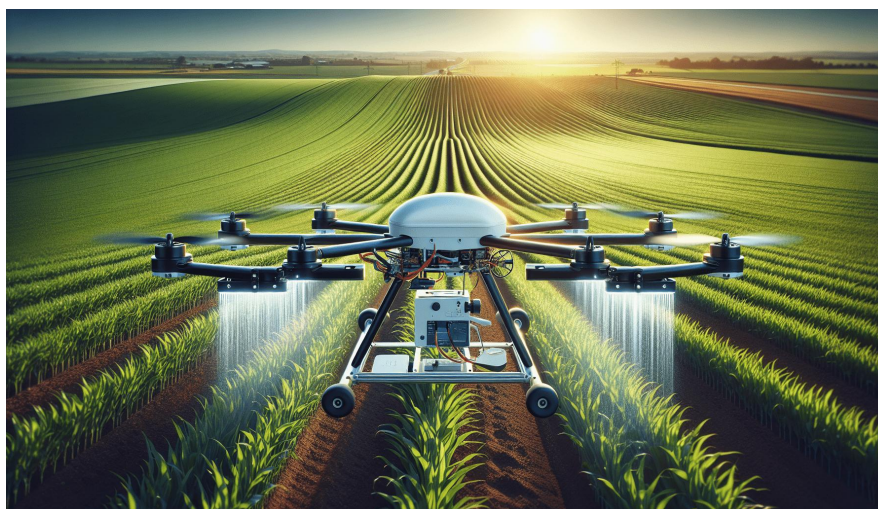
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Abstract:

This paper investigates the contribution of drone technology in sugarcane cultivation in India, and examines the government's role in promoting agricultural drone use. Drawing on the recent case studies, government schemes and pilot programmes, we found that drone-based interventions (input spraying, crop monitoring, pest/disease management) enhance efficiency by reducing labour and chemical inputs, improving yield, and lowering environmental impacts. For example, under SMAM and the Kisan Drone Scheme, over 240 subsidised drones have been deployed, and individual farmers (including SC/ST, women and north-eastern states) receive up to 50% subsidy (₹ 4-5 lakh). However, obstacles persist for smallholders: high upfront cost, lack of technical skills, regulatory complexity, limited connectivity and infrastructure. The paper recommends scaling through training, inclusive subsidy frameworks, community service models and regulatory clarity.

Key Words: Drone Technology, Sugarcane Cultivation, Government Policy, Subsidy, Crop Monitoring and Pest Management

Introduction:



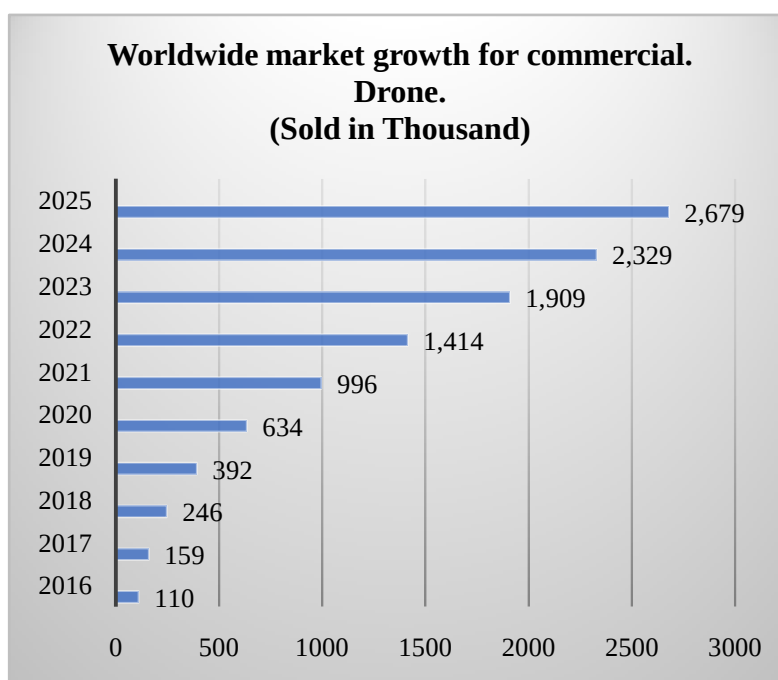
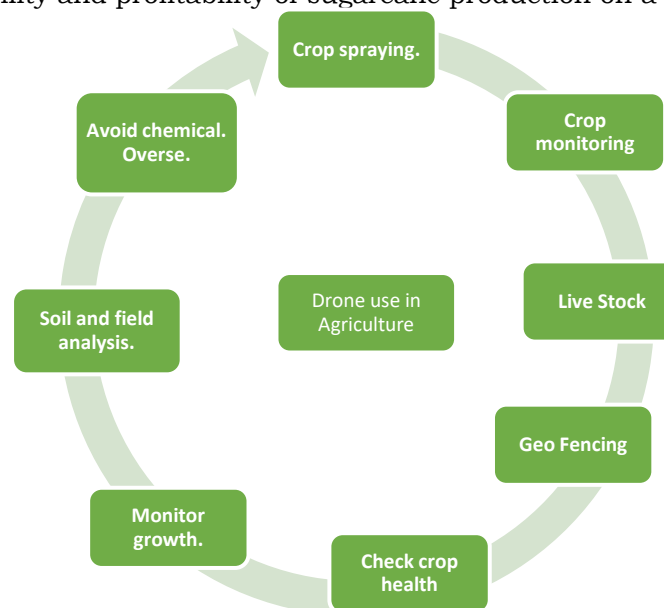
India is one of the largest producers of sugarcane, a crop that holds strategic importance in the agricultural economy. Sugarcane farming, however is a labour intensive and heavily dependent on timely irrigation, fertilization, and pest control. With the growing shortage of farm labor and increasing input costs, farmers are compelled to look for smarter solutions. This is where drone technology or Unmanned Aerial Vehicles (UAVs) emerges as a promising innovation. Drone technology enables real-time data collection, crop health monitoring through Normalized Difference Vegetation Index (NDVI), aerial spraying of pesticides and fertilizers, and mapping of large areas of farmland with great precision. These devices are equipped with advanced cameras, thermal sensors, and software interfaces that allow farmers to manage their crops proactively. In India, where small and marginal farmers constitute a major portion of agricultural stakeholders, drone usage can potentially bridge the technological gap. Initiatives such as "Kisan Drones" under the Government of India's digital agriculture mission are further encouraging adoption. In sugarcane farming, drones are already being tested and used across various states including Maharashtra, Uttar Pradesh, and Tamil Nadu. Their integration is seen as a timely response to challenges like declining yields, pest outbreaks, and inefficient water usage.

The contribution of drone technology in sugarcane cultivation is rapidly increasing outside India. In countries like Brazil, Thailand, Australia, and South Africa, drones have now become an integral part of the sugarcane production system. Brazil, the world's largest sugar-producing country, reported in a survey conducted by AgEagle Aerial Systems in July 2025 that the use of drone technology resulted

in approximately a 5% increase in sugarcane yield and a 20% reduction in pesticide usage. Drones survey fields through high-resolution imaging, allowing for quick assessment of soil moisture, crop health, and disease infestation. This helps farmers make data-driven decisions.

In Thailand, the use of agricultural drones like the DJI Agras T50 has also increased during 2024. These drones can spray approximately 16 hectares per flight at a rate of 30 Liters per hectare. According to a report by Thailand's Ministry of Agriculture (2024), drone spraying has resulted in a 25-30% saving on labor costs and improvements in spraying accuracy. Similarly, in Australia, drone-based remote sensing is being used to perform pest control and fertilizer management in sugarcane fields more precisely, reducing environmental impact and improving production quality. A recent study (3laws.io, 2025) found that farms using drone-assisted sugarcane cultivation saw an average yield increase of up to 15% and a 20-30% reduction in costs. Additionally, CO₂ emissions were reduced by up to 12% since drones use less fuel compared to traditional tractors or spray machines.

Overall, drone technology has brought a smart agricultural revolution to sugarcane farming. It allows farmers to monitor crop, Avoid chemical. Overse, Crop spraying, Prepare for. Whether. Glitches, Soil and field analysis, Monitor growth, Check crop health, Geo Fencing conditions in real-time, apply fertilizers and pesticides precisely, and also provides relief from labour shortages. These technological advancements have made the sugar industry more sustainable, environmentally friendly, and profitable. In the future, AI and IoT-based drones have the potential to bring even greater changes in this sector, increasing both sustainability and profitability of sugarcane production on a global scale



Source: Tractica (February 2023)

The growth of the commercial drone market from 2016 to 2025 demonstrates a significant upward trajectory in both revenue and the number of drones sold. In 2016, revenue was only \$0.6 billion, with 110,000 drones sold. By 2025, revenue is expected to reach \$12.6 billion, and the number of drones sold is forecasted to reach 2.7 million. This growth trend is particularly notable from 2020 on, with revenue increasing sharply from \$2.4 billion in 2019 to \$3.6 billion in 2020, and drone sales jumping from 634,000 to over 2 million units by 2025. The steady rise in sales and revenue reflects a growing adoption of commercial drones across various industries, including agriculture, logistics, surveillance, and mapping. Technological advancements and reduced manufacture prices are likely contributing factors to this expansion. Additionally, the increasing demand for drones for tasks like delivery services and eco-friendly monitoring indicates that drones are becoming an essential instrument in modern commercial operations. With a projected 12.6 billion in revenue and 2.7 million drones sold by 2025, the market is poised for continued growth, creating numerous opportunities for businesses involved in drone manufacturing, facilities, and connected technology.

“Glad to have witnessed Kisan Drones in action at 100 places across the country. This is a commendable initiative by a vibrant start-up@garuda_india. Innovative technology will empower our farmers and make agriculture more profitable.”

- Kisan Drones, (PIB, 2022)

While highlighting the use of new technology, the finance minister said that the use of ‘Kisan Drones’ will be promoted for crop assessment, digitization of land records, spraying of insecticides and nutrients.

- Prime Minister Narendra Modi, PIB, 2

Review of Literature:

- Dutta and Goswami (2020) reviewed the role of drone technology in modern agriculture, highlighting its efficiency in resource management and crop monitoring. They concluded that drones enhance productivity, reduce labour, and should be widely adopted to improve agricultural outcomes.
- Natarajan et al. (2023) highlights the transformative role of drone technology in agriculture, emphasizing its applications in crop monitoring, precision spraying, and resource optimization. The works also note challenges such as high costs, limited farmer responsiveness, and regulatory barriers affecting widespread adoption.
- Khan et al. (2021) explores the role of emerging technologies such as IoT, precision farming and smart systems in promoting supportable agriculture. They highlight both the benefits like better-quality efficiency and climate resilience and challenges, including high costs and limited farmer alertness.
- Hossain (2022) provides a concise overview of drone technology, emphasizing its rapid advancements and wide-ranging applications across manufacturing. The paper highlights drone's growing role in sectors like agriculture, surveillance and delivery, while noting challenges such as regulatory issues and limited battery-operated life.
- Chakraborty (2023) mentioned the growing impact of drone technology in agriculture, focusing on its use in crop monitoring, pesticide spraying and yield estimation. The paper emphasizes how drones improve precision, reduce labour, and enhance overall farm efficiency, especially in large-scale agricultural operations.
- Shah et al. (2024) examines the current challenges and opportunities associated with drone technology, with a focus on cyber security concerns. The paper highlights vulnerabilities in drone systems and emphasizes the need for stronger regulatory frameworks and technological safeguards.

Objectives:

- To know the Contribution of drone technology in Sugarcane cultivation in India.
- To know the government Role in Promoting drone uses in agriculture sector.

The study is based on secondary data. To study the trends in area, production and yield of sugarcane at India level study period taken as 1990-91 to 2018-19. But for value of output of sugarcane, sugar and Jaggery the study period is 2014-15 to 2024-25. The secondary sources of data collected from Government bodies of India.

Due to rising inflation, today there is a labour problem everywhere. In India, the sugar industry, which plays a major role is on the verge of shutting down its factories. Today, if we do not adopt technology, farming is becoming difficult and sugarcane farmers are starting to switch to other crops, which is directly affecting sugar factories. Currently, sugar factories are shutting down at an alarming rate.

In February 15, 2025, 77 sugar mills across India had stopped cane crushing operations in the 2024-25 season. Of them, 34 mills from Karnataka shut, 30 in Maharashtra, 4 in Tamil Nadu, 2 each in Uttar Pradesh, Telangana, Uttarakhand, and one each in Haryana and Gujarat. In Andhra Pradesh, sugarcane cultivation area fell from 1.25 lakh hectares in 2014 to 40,000 hectares by 2024, largely

because many sugar mills shut down (from 29 mills in 2014 to just 5 in 2024). We can see this decline in the table below-

State report of Cane area, production and Crushing details of all sugar factories in residuary Andhra Pradesh (after AP state bifurcation i.e., from 2014-15 to present crushing season 2024-25 season)							
S.No	Year-wise (Crushing Season)	No. of factories commenced crushing in that season	Cane area in Hectares (In lakh Ha)	Cane production (In lakh MTs)	Yield (Ton/Ha.)	Cane crushed (In lakh MTs)	Sugar production (In lakh Qtls)
1	2	3	4	5	6	7	8
1	2014-15	20	1.11	77.70	70	60.14	56.43
2	2015-16	19	0.96	68.41	71	58.94	55.11
3	2016-17	18	0.89	60.52	65	41.16	38.55
4	2017-18	18	0.83	56.44	66	48.39	46.26
5	2018-19	18	0.82	58.04	70	54.07	50.24
6	2019-20	12	0.63	45.05	71	31.82	28.31
7	2020-21	8	0.42	28.91	69	22.46	20.16
8	2021-22	5	0.41	28.70	72	22.85	20.76
9	2022-23	5	0.40	28.80	70	22.42	18.96
10	2023-24	5	0.31	23.64	75	18.91	15.89
11	2024-25	5	0.27	19.44	72	13.06	9.21
SD/-V.VENKATA RAO DIRECTOR OF SUGAR & CANE COMMISSIONER							

Reasons Behind Sugar Factory Closures in India:

- **Sugarcane Shortfall:** Several regions (Andhra Pradesh, Maharashtra, Karnataka) are experiencing lower availability of sugarcane crops due to adverse climate, disease, delayed plantings, or farmers shifting to other, more profitable or less labour intensive sugarcane crops. When factories don't get enough cane, they closed early.
- **Lower Recovery Rates:** The sugar percentage of sugar extracted from cane has declined in many states; for example, Maharashtra's average recovery dropped to 9.45 percentage in the 2024-25 period from 10.16 percentage in previous period. When recovery is low, profitability drops for sugar mills, leading to early closures.
- **Labour Shortages and High Costs:** Harvesting sugarcane is labour intensive. Where labour is scarce or expensive, prices rise, making it harder for factories to run profitably, especially in regions with less mechanisation. This increases the each unit cost of production. Regions where harvesting labour migrates, or where young person's avoid field work, tend to suffer.
- **Delayed Payments / Financial Stress:** Farmers and mills suffer when sugarcane dues are delayed or when input costs rise. In Andhra Pradesh, factories owe large sums to farmers and many mills have become non functional. This discourages sugarcane cultivation and results in area decline, further reducing supply to mills.
- **Opportunity Cost and Crop Shift:** When sugarcane becomes less profitable due to all above factors, farmers shift to other crops (paddy, maize, pulses) that are less labour intensive or offer faster returns. That reduces available field labour demand in sugarcane but also reduces cane supply to mills.

If we want to save and sustain sugar factories, we must adopt drone technology because if healthy sugarcane reaches the factory, regular spraying of medicines is necessary. If this work is done manually by labourers, it will take more time and money, which is not feasible for farmers. Therefore, we need to adopt drone technology so that farmers can continue cultivating sugarcane effectively and sugar mills can run smoothly. Drones offer a revolutionary solution to monitor crop health, detect diseases early, and ensure timely intervention, all of which are crucial for delivering high-quality sugarcane to factories. By using drones equipped with advanced imaging systems, farmers can identify stressed or infected areas in large fields with precision, allowing for targeted action instead of blanket pesticide application. This not only reduces chemical usage and environmental harm but also cuts costs and improves efficiency. Moreover, drones can be programmed to spray pesticides regularly and uniformly across plantations, even

in difficult terrains, reducing the dependence on manual labour and minimizing human exposure to harmful chemicals. Healthy sugarcane crops result in better yield and sugar content, directly benefiting the factories by providing a consistent and quality raw material supply. In a time where sugar industries face challenges due to poor crop health, inconsistent supply, and rising production costs, drone technology becomes a vital tool for sustainability. Its integration into the sugarcane value chain can improve productivity, profitability and long-term viability. Therefore, embracing drones is not a luxury but a necessity to ensure the survival and growth of sugar factories in the future.

Drone Technology in Sugarcane Cultivation:

Drone skill has established significant benefits in sugarcane farming across India. In terms of efficiency and price savings, drone spray drastically reduces labour and period requirements. For instance, in October 2021, a pilot project in Sangli, Maharashtra, showed that what previously took 4-5 hours of manual labour each acre was completed in just 5-10 minutes using drones (The Daily Guardian, 2021). Water usage also declined sharply from approximately 200 litres to just 10 litres per acre. Due to uniform application, pesticide and fertiliser usage dropped by 25-50%, resulting in lower input prices.

In April 2024, the Uttar Pradesh government deployed 329 drones to spray agrochemicals completed 24,218 hectares of sugarcane grounds affected by disease outbreaks and water logging (The Times of India, 2024). These drones allowed for timely interventions, improving pest and disease control outcomes. Precision application not only safeguarded crops but also improved yield. The Sangli case reported a 20-30% improvement in crop quality, primarily due to uniform treatment and reduced crop stress (The Daily Guardian, 2021).

Environmental sustainability is additional advantage, as drone practice minimises chemical runoff and avoids over-application of involvements. Additionally, the “Drone Didi” initiative, launched in 2023, empowers rural women to become expert drone operators. In Uttar Pradesh and other states, women are using drones in sugarcane, rice, and vegetable cultivation, increasing their service opportunities. Global, drones enhance productivity, sustainability and inclusivity in sugarcane farming.

Government Role in Promoting Drone Uses in Agriculture:

The Government of India has played essential role in encouraging the implementation of drone technology in agriculture through supervisory reforms, economic support and institutional initiatives. A major step came with the introduction of the Drone Rules (2021), which significantly eased the regulatory framework by dropping the number of endorsement forms from 25 to 5 and cutting the fee categories from 72 to just 4, making drone usage more accessible for agricultural purposes (Ministry of Civil Aviation, 2021; Vaimanika Aerospace, 2022). Additionally, Standard Operating Procedures (SOPs) were issued in 2022 for the safe application of pesticides via drones over specific crops, improving compliance and safety (India Business Trade, 2022).

On the financial front, schemes such as the Sub-Mission on Agricultural Mechanization (SMAM), operational since 2014 and extended to drone support in recent years, offer grants and subsidies up to 100% for ICAR institutions and 40-50% for FPOs and cooperatives to facilitate drone buying (Vikaspedia, 2023). The NAMO Drone Didi Scheme, launched in the 2023-24 Union Budget, provides subsidies of up to 80% for women-led Self-Help Groups (SHGs) to buy drones and receive pilot training (Vaimanika Aerospace, 2023). Meanwhile, the Kisan Drone Scheme, launched in February 2022, promotes drones for crop assessment, spray, and digitization of land annals with central financial support (Bharat Sky Tech, 2022).

To build capacity, training and awareness programs are conducted by ICAR, Krishi Vigyan Kendras (KVKs), and state agricultural universities, supported by practical demonstrations and pilot projects in areas like Sangli (2021) and Uttar Pradesh (2024) (ET Government, 2023; The Daily Guardian, 2021). Further, the government is promoting indigenous drone manufacturing through the Production-Linked Incentive (PLI) scheme, launched in September 2021, to boost home grown production and reduce import dependence (Vaimanika Aerospace, 2022). Agriculturalists without direct access to drones can avail services through Custom Hiring Centres (CHCs) and community-level representations, making drone technology more inclusive and scalable across rural India.

Conclusion:

Drone technology offers tangible benefits for sugarcane cultivation in India: reducing labour and input costs, improving efficiency, better pest/disease control, enhancing yield and quality, and reducing environmental footprint. The government has taken multiple steps (policy, regulation, subsidies, training) to encourage adoption. To fully realize the potential, focus is needed on building capacity at grass root level, ensuring affordability, and scaling pilot successes. With that, drone technology can become a mainstream tool in Indian sugarcane agriculture, contributing to sustainable production and farmer welfare.

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