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Farmers Awareness and Perception of Drone Technology

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The agricultural sector is increasingly leveraging technological advancements to enhance productivity and sustainability. Among these innovations, drone technology, a crucial component of precision agriculture, is gaining global recognition. This study explores the current awareness and perception of drone technology among farmers in Coimbatore district, Tamil Nadu, where agriculture continues to be a critical livelihood source. Using an ex-post facto research design, the study sampled 60 farmers from various regions within Coimbatore district, selected through a simple random sampling technique to assess their awareness and perception of drone technology. Data were collected through structured interviews and questionnaires, analyzed using statistical

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tools like frequency, percentage analysis and mean score is to understand response patterns. The findings reveal that awareness of drone technology is highest for its use in spraying agrochemicals (75 per cent), followed by pest and disease control (68 per cent) and irrigation management (66 per cent). Farmers expressed positive perceptions of the efficiency and precision that drones bring to farming operations, particularly in reducing labor and time spent on manual tasks. Drones were recognized for their potential to improve crop health monitoring, optimize resource use, and promote sustainability by minimizing chemical overuse. Nonetheless, logistical challenges such as the durability of drones in extreme weather conditions, connectivity issues in rural areas, and maintenance costs pose significant obstacles to widespread adoption. While government initiatives, including subsidies have begun to alleviate some financial burdens, there is a clear need for further support in terms of training, infrastructure, and policy enhancements. The study underscores the importance of integrating drones into the agricultural sector to ensure more sustainable and productive farming practices that can meet the growing global food demand.

Keywords: Drone technology; awareness; perception and farmers.

1. INTRODUCTION

Agriculture, a crucial sector for global food security, is increasingly relying on technological innovations to enhance productivity and sustainability. According to the Food and Agriculture Organization (FAO), the global population is expected to reach 9.7 billion by 2050, necessitating a significant increase in food production [1]. To meet this demand, agricultural practices must evolve, with precision agriculture emerging as a key solution [2]. Drone technology, a vital component of precision agriculture, is gaining traction worldwide [3]. In 2023, the global agricultural drone market was valued at approximately USD 1.2 billion, and it is projected to grow at a compound annual growth rate (CAGR) of 29.4% from 2024 to 2030 [4].

Drones, also known as Unmanned Aerial Vehicles (UAVs), are being adopted for various agricultural applications, including crop monitoring, soil and field analysis, irrigation management, and pesticide spraying [5]. These technologies are transforming traditional farming by offering real-time data, enhancing efficiency, and reducing input costs. In countries like India, where over 60% of the population depends on agriculture for livelihood, awareness and adoption of drone technology are critical for addressing challenges like labor shortages, climate change, and resource optimization [6].

The awareness on drone technology is on the rise, actual adoption rates vary widely across regions and farming systems [7]. In developed nations like the United States, Australia, and parts of Europe, drone adoption is relatively high, driven by technological infrastructure, government support, and a focus on high-tech, large-scale farming [8]. A study conducted in 2022 revealed that around 25% of U.S. farmers had integrated drone technology into their operations, with adoption expected to rise as costs decrease and functionalities improve. In countries like India and China, where agriculture plays a significant socio-economic role, government initiatives are critical to promoting drone technology. As part of its broader Atmanirbhar Bharat mission, India is focusing on local manufacturing of agricultural drones and encouraging startups to innovate in this space [9]. Awareness campaigns, government initiatives, and policy support are playing a crucial role in fostering adoption, with the government of India offering subsidies for agricultural drones under initiatives like the Sub-Mission on Agricultural Mechanization (SMAM). Similarly, China, a global leader in drone manufacturing, has seen rapid growth in the use of drones for tasks like pesticide spraying and field analysis, particularly in its more industrialized farming sectors [10].

The government of Tamil Nadu has played a pivotal role in promoting drone adoption through initiatives such as the *Sub-Mission on Agricultural Mechanization (SMAM),* which offers financial incentives like subsidies (up to 40-50%) to farmers and custom hiring centers for purchasing agricultural drones [11]. The state government has also partnered with Tamil Nadu Agricultural University (TNAU) to educate farmers about the benefits of drones and to provide hands-on training on drone usage for precision agriculture.

Despite the growing availability of drones for tasks like spraying fertilizers and monitoring crop health, many farmers, especially in rural and

developing regions, remain unaware or hesitant to adopt this advanced technology. Factors such as lack of technical knowledge, perceived complexity, costs, and accessibility of the technology create barriers. This study seeks to fill the gap by assessing the current level of awareness, perception of drone technology among farmers. The objective of this study is to explore the current state of awareness and perception of drone technology among farmers.

2. METHODOLOGY

This study adopts an ex-post facto research design, a non-experimental method that investigates existing conditions or outcomes without any manipulation of variables by the researcher. In this case, the study aims to assess the awareness and adoption of drone technology among farmers in Coimbatore district. The Coimbatore district was chosen for this study due to its strategic importance in agriculture and technological advancement. Coimbatore is known for its diverse agricultural practices, ranging from the cultivation of cash crops to food grains, making it an ideal location to assess the integration of modern technologies like drones. Additionally, the district has a growing interest in precision farming techniques, and its proximity to research institutions and agricultural universities makes it a prime area for testing and implementing innovations in farming. To ensure the findings represent the broader farmer population in Coimbatore district, the study employed a simple random sampling technique. To ensure an unbiased and representative sample, a simple random sampling technique was employed. A comprehensive sampling frame was developed, listing all eligible farmers from various blocks in the Coimbatore district. This method enhances the generalizability of the results and ensures that farmers with varying levels of exposure to drone technology are included in the analysis. Each farmer was assigned a unique identifier, and a random number generator was used to select 60 farmers from this list. This approach guaranteed that each farmer had an equal probability of being chosen, ensuring diversity across farm size, crop type, and geographical location. The use of simple random sampling strengthens the reliability of the study's findings and their applicability to the broader farmer population. The data were collected using structured interviews and a well-designed questionnaire tailored to gather information on drone technology awareness and perception in agriculture. The type of questionnaire described here is a structured questionnaire, which is commonly used in surveys to collect quantitative data. This type of questionnaire is characterized by a standardized set of questions that are administered to all respondents in the same way, ensuring consistency in data collection. Structured questionnaires often include a mix of closed-ended questions and occasionally some open-ended questions for qualitative insights. The data were analyzed using frequency analysis to summarize response patterns and percentage analysis to represent the proportion of farmers aware of or using drone technology. Statistical tools such as MS Excel were used for accurate data analysis and interpretation.

3. RESULTS AND DISCUSSION

3.1 Farmer's Awareness on Application of Drone Technology

Drone technology is revolutionizing agriculture by providing innovative solutions for various farming practices. From monitoring crop health to managing irrigation, drones help improve efficiency and precision. However, the extent of awareness among farmers about the various applications of drones plays a critical role in determining the adoption of these technologies. The Fig. 1. presented highlights farmers' awareness of the different applications of drone technology in agriculture, offering insights into where awareness is higher and where more knowledge dissemination might be needed.

3.1.1 Spraying of agro chemicals

The highest awareness (75 per cent) among farmers is in the use of drones for spraying agrochemicals. This indicates a strong recognition of drones as a valuable tool for improving the efficiency and precision of pesticide and fertilizer application, potentially reducing labor costs and chemical waste. Drones can spray pesticides, herbicides, and fertilizers with greater precision than manual methods, reducing wastage and environmental impact while enhancing coverage in large fields [12]. With GPS technology, drones can accurately target areas that require treatment, making them more appealing to farmers looking to reduce labor costs [13].

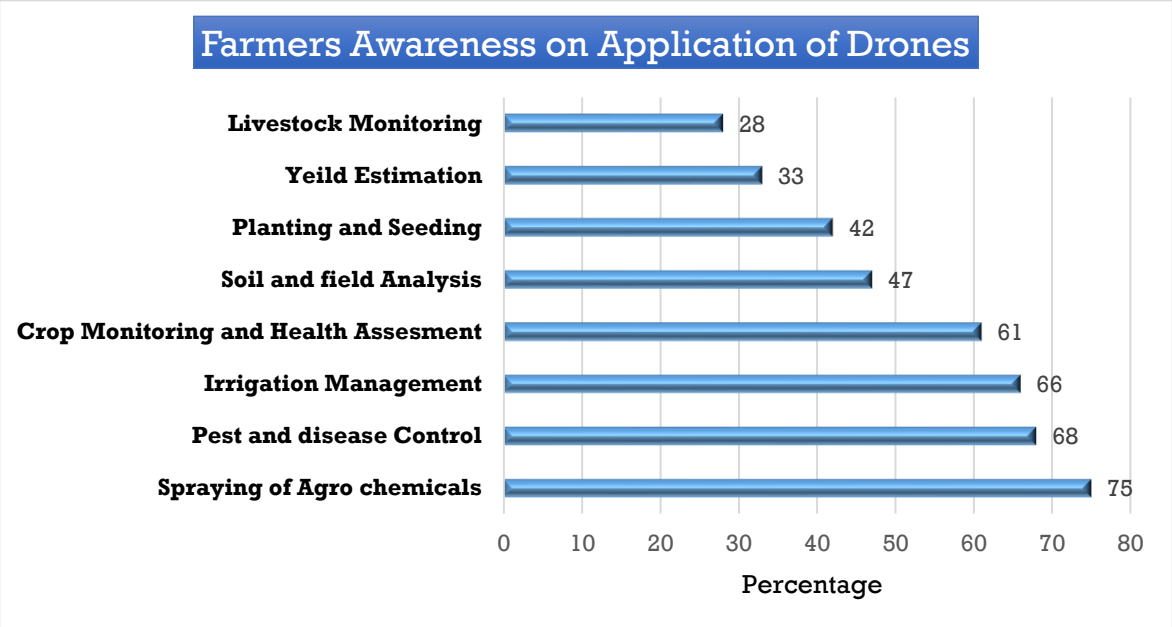

Fig. 1. Farmers Awareness on Application of Drone Technology

3.1.2 Pest and disease control

Farmers are also highly aware of drone's role with 68 per cent in identifying and managing pests and diseases, reflecting the growing use of drones for crop protection. The ability of drones to identify, monitor, and manage pests and diseases is well understood by farmers, particularly those involved in high-value crops. The study results are similar to previous findings by Abbas et al. [14], which highlighted the efficacy of drones equipped with sensors for early detection of pest infestation or disease stress. In both studies, the use of drones proved advantageous in identifying crop health issues before they were visible to the human eye, facilitating timely interventions. The alignment of these findings underscores the potential of drone technology in enhancing agricultural monitoring and promoting smarter farming practices [14]. The increasing unpredictability of pest outbreaks due to climate change has heightened the demand for more advanced monitoring systems, further boosting farmers' interest in drone technology for pest and disease management [15].

3.1.3 Irrigation management

Awareness is also high for irrigation management (66 per cent), showing that farmers recognize drones' ability to optimize water use by providing detailed insights into field conditions and irrigation needs. The findings of this study regarding the optimization of irrigation schedules through drone technology align with previous research by Zhang and Kovacs [16], which emphasized the economic benefits of drone use in precision agriculture. Their study demonstrated that drones can enhance irrigation efficiency, thus reducing water wastage and maximizing crop yields, particularly in areas susceptible to drought. Moreover, Saikanth *et al*., [17] further support these results by discussing the role of drones in promoting sustainable agricultural practices. They highlighted that drones contribute significantly to water conservation efforts, which is increasingly vital in the context of global water scarcity concerns.

3.1.4 Crop monitoring and health assessment

More than half of the farmers (61 per cent) are aware of the benefits of using drones for crop monitoring and health assessments, which can significantly improve decision-making regarding crop management and yield optimization. Drones equipped with multispectral or hyperspectral cameras can capture data beyond the visible spectrum, allowing for more accurate assessments of plant health. The findings of this study, which highlight the advantages of drone technology for crop monitoring in large farms, are consistent with Barbedo's [18] review. Barbedo emphasized that unmanned aerial vehicles (UAVs) equipped with imaging sensors provide

an efficient alternative to manual monitoring, significantly reducing both time and costs associated with crop assessment on expansive agricultural lands. Moreover, the ability of drones to quickly gather and analyze data enables farmers to detect plant stresses more efficiently than traditional methods.

3.1.5 Soil and field analysis

Nearly half of the farmers (47 per cent) understand the potential of drones in soil and field analysis, emphasizing the importance of data-driven insights for enhancing soil management practices and improving crop outcomes. Drones can map soil variations, enabling farmers to make informed decisions on planting patterns, irrigation, and fertilizer use. This promotes precision agriculture, where inputs are tailored to specific field conditions [19].

3.1.6 Planting and seeding

Awareness is moderate (42 per cent) regarding planting and seeding, suggesting an opportunity to educate farmers about how drones can automate and enhance the efficiency of these labor-intensive tasks. Drones can drop seeds directly into the soil, especially in hard-to-reach areas or for reforestation projects. While this is an emerging technology, it has not yet gained widespread use in conventional agriculture.

3.1.7 Yield estimation

Yield estimation is lower for farmers (33 per cent), there is a potential to introduce farmers to how drones can accurately predict yields and assist in planning harvest and sales strategies. Drones equipped with sensors can assess crop conditions and make yield predictions based on growth patterns, soil moisture, and plant health data. This is particularly useful for large-scale farms looking to optimize market timing and financial forecasting.

3.1.8 Livestock monitoring

Drone use for livestock monitoring has the lowest awareness (28 per cent), likely due to its niche application or the fact that many farmers in the region focus on crop farming rather than livestock. Drones can track livestock in large or difficult terrain, monitor their health, and even assist in herding. This is especially useful for large ranches or remote areas, but smaller farmers may not see the immediate benefit.

3.2 Farmer's Perception towards Drone Technology

From the Table 1. Farmers perceptions of Ease of Use and Accessibility for drone technology show a mix of ease and challenges. While drones are considered relatively easy to learn and operate for most farming tasks (3.62), the high upfront cost is a significant barrier to adoption (4.57). This suggests that although farmers recognize the potential benefits of using drones, the financial burden associated with purchasing the technology limits widespread adoption. Additionally, the limited access to drone suppliers or rental services (4.35) worsens this issue, making it difficult for farmers to acquire or experiment with drone technology [20].

Farmers perceive drones as highly efficient and effective tools in agriculture. They find drones valuable for quickly and efficiently monitoring large fields (4.01), improving pest control and fertilization (4.32) and enhancing precision in field management, which helps reduce waste (4.22). This shows that drones contribute significantly to optimizing farming practices, making operations more streamlined and accurate.

Farmers view drones as a major time and labor-saving technology. The use of drones significantly reduces the time spent on manual farm inspections (4.25) and greatly minimizes labor-intensive tasks like spraying (4.78). Additionally, drones help automate repetitive tasks, enabling farmers to focus on other critical aspects of farming (4.36). This indicates that drones not only improve operational efficiency but also reduce the physical workload, leading to more streamlined and productive farm management [21].

Farmers perceive drones as having a positive impact on environmental sustainability. They appreciate that drones help reduce environmental harm by applying chemicals only where needed (4.48), minimizing unnecessary exposure. Drones also assist in monitoring water usage, effectively reducing wastage (4.52), contributing to more efficient resource management. Additionally, the precise use of drones reduces reliance on fertilizers and pesticides (4.11), which supports sustainable farming practices.

Table 1. Farmer's Perception on Drone Technology

S.No	Statements related to Farmer's Perception on Drone Technology	Mean Score
1.	**Ease of Use and Accessibility**	
	Drones are simple to learn and operate for most farming tasks	3.62
	The high upfront cost of drones prevents many farmers from adopting them	4.57
	I have limited access to drone suppliers or rental services in my area	4.35
2.	**Efficiency and Effectiveness**	
	Drones make it easier to monitor large fields quickly and efficiently	4.01
	Drone technology has improved the effectiveness of my pest control and fertilization efforts	4.32
	Using drones allows for better precision in field management, reducing waste	4.22
3.	**Time and Labor Savings**	
	Drones significantly reduce the time spent on manual farm inspections	4.25
	The use of drones minimizes the need for labor-intensive tasks, such as spraying	4.78
	Drones help automate repetitive tasks, allowing me to focus on other important aspects of farming	4.36
4.	**Precision and Data Accuracy**	
	Drones provide accurate and detailed information about crop health	3.91
	Using drones allows for more precise application of fertilizers, pesticides, and water	4.36
	Drones give me better insights into soil conditions, leading to more informed decisions.	3.54
5.	**Environmental and Sustainability Impact**	
	Drones reduce the environmental impact by applying chemicals only where needed.	4.48
	Using drones helps me monitor water usage and reduce wastage	4.52
	The precise use of drones reduces over-reliance on fertilizers and pesticides, promoting sustainability	4.11
6.	**Costs and Economic Impact**	
	Drones help me save money by reducing the use of costly inputs like pesticides and water	4.27
	The cost of drone repairs and maintenance is a challenge for long-term use	4.04
	Drones provide economic benefits by enhancing yield quality and quantity through precise applications	3.92
7.	**Training and Skill Development**	
	I have received enough training to use drones effectively in my farm operations	3.87
	The technical knowledge required for operating drones is a barrier for most farmers	4.23
	More training programs are needed to help farmers understand how to integrate drones into their farming practices	4.52
8.	**Awareness and Knowledge**	
	I have access to sufficient information about the benefits of drones in agriculture	3.67
	Farmers need more knowledge and exposure to the potential applications of drones	4.12
9.	**Government Support and Policies**	
	Government subsidies have helped make drone technology more affordable for farmers	4.09
	More government support is needed to encourage the widespread use of drones in farming	4.25
	I am aware of government initiatives promoting the adoption of drones in agriculture	4.14

S.No	Statements related to Farmer's Perception on Drone Technology	Mean Score
10.	**Perception of Risks and Challenges**	
	I am concerned about the durability of drones in extreme weather conditions	3.97
	The reliability of drones in rural areas with limited connectivity is a concern	4.01
	Using drones in large and remote farms presents significant logistical challenges	3.89

Farmers acknowledge both the cost-saving and economic benefits of drones, though challenges remain. Drones help reduce expenses by minimizing the use of costly inputs such as pesticides and water (4.27), making them economically advantageous. However, the cost of repairs and maintenance poses a challenge for the long-term use of drones (4.04), limiting their sustained affordability. Additionally, while drones enhance yield quality and quantity through precise applications (3.92), the perceived economic benefits in this area are moderate. The findings of this study regarding the economic benefits and challenges of drone use in agriculture are in alignment with the conclusions drawn by Zhang and Kovacs [16]. Farmers in this study recognize that drones can significantly reduce operational costs by minimizing the application of expensive inputs such as pesticides and water, supporting their economic viability. Zhang and Kovacs also emphasized that drones contribute to more efficient resource management and can lead to overall cost savings in precision agriculture.

Farmers express a moderate level of confidence in the training they have received for using drones in their farm operations (3.87), but they also acknowledge that technical knowledge required for operating drones remains a significant barrier for many (4.23). The majority believe that more training programs are essential to help farmers effectively integrate drones into their farming practices (4.52).

Farmers' awareness and knowledge regarding drone technology in agriculture appear to be limited. While they acknowledge having access to some information about the benefits of drones (3.67), it is clear that many feel this information is insufficient. There is a strong consensus that farmers need more knowledge and exposure to the potential applications of drones (4.12). This indicates a significant opportunity for educational initiatives and outreach programs aimed at increasing awareness and understanding of how drones can be effectively utilized in farming, which could ultimately enhance adoption rates and maximize the technology's benefits.

Farmers express moderate concerns regarding the risks and challenges of using drones in agriculture. They are particularly worried about the durability of drones in extreme weather conditions (3.97), which could limit their long-term usability and effectiveness. Additionally, the reliability of drones in rural areas with limited connectivity is a significant concern (4.01), as it could impact their operational efficiency. Logistical challenges related to using drones on large and remote farms (3.89) further complicate their adoption [22-23].

3.3 Results Implication

The study highlights that while farmers show strong awareness of drone applications in agrochemical spraying, pest control, and irrigation management, there remains a notable knowledge gap in areas like yield estimation and livestock monitoring. Economic concerns, particularly high upfront costs and ongoing maintenance, hinder adoption, suggesting a need for financial support and accessible training programs to enhance farmers' skills and confidence in using drones. Farmers recognize the environmental benefits of precision agriculture, yet they express concerns about the durability of drones in extreme weather and logistical challenges in remote areas.

The findings of this study on farmers' awareness and perceptions of drone technology in agriculture hold significant implications for addressing Sustainable Development Goal 2 (SDG 2): Zero Hunger. By improving efficiency, sustainability, and productivity, drone technology can enhance food security and nutritional quality while promoting sustainable agricultural practices. The high levels of awareness among farmers regarding drones for spraying agrochemicals (75%) and pest and disease control (68%) highlight the technology's potential to optimize crop health and yield. Furthermore, the recognition of drones' capabilities in irrigation management (66%) and soil analysis (47%) points to opportunities for data-driven insights that can increase agricultural productivity and economic viability. As drones reduce labor

intensity and improve efficiency, they can alleviate pressure on the agricultural workforce, allowing for better resource allocation and enhanced management of agricultural activities. However, the expressed need for more training and knowledge dissemination emphasizes the importance of targeted educational initiatives to empower farmers to fully leverage these technologies. Additionally, addressing concerns about durability, logistical challenges, and accessibility to suppliers will be crucial for the widespread adoption of drone technology. Ultimately, by facilitating these advancements, the agricultural sector can contribute significantly to achieving SDG 2 by ensuring sustainable food production, reducing hunger, and promoting economic stability for farmers.

4. CONCLUSION AND RECOMMENDATION

In conclusion, while drone technology holds significant potential for revolutionizing agriculture through enhanced precision, efficiency, and sustainability, its adoption is still hindered by several factors. High initial costs, limited technical expertise, and logistical challenges, especially in rural areas, present notable barriers for farmers. Additionally, although government initiatives and subsidies have helped make drones more accessible, there is a need for further support and training programs to promote widespread use. Farmers recognize the time, labor, and cost-saving benefits of drones, particularly in tasks such as spraying, crop monitoring, and irrigation management. However, concerns about durability in extreme weather conditions, reliability in areas with limited connectivity, and maintenance costs highlight the need for advancements in technology and infrastructure to address these issues.

In recommendation, to enhance farmers' adoption of drone technology in agriculture, targeted educational initiatives and training programs should be implemented to address the gaps in knowledge and technical skills related to drone operation and applications. These programs should focus on demonstrating the cost-saving benefits, efficiency, and precision that drones offer, particularly in pest control, irrigation management, and crop monitoring. Furthermore, increased access to affordable drone suppliers and rental services would alleviate financial barriers and encourage experimentation with the technology. Government support through subsidies and initiatives promoting drone use can also facilitate wider adoption, while addressing concerns about durability and connectivity in rural areas. Overall, fostering a supportive ecosystem that combines education, access, and financial incentives will empower farmers to leverage drone technology effectively, ultimately enhancing productivity and sustainability in agriculture.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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