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Adoption of Drones in Agriculture: Social, Economic and Personal Factors

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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

Aims: The acceptance of drone technology is gradually rising up owing to its potential being understood by businesses. It is in this aspect that an outlook on the various factors that are responsible pertaining to the drone technology in the recent times has been carried out.
Study Design: Ex-post Facto.
Place and Duration of Study: Dindigul, Tiruppur, Erode and Namakkal districts of Tamil Nadu.
Methodology: Simple Random Sampling was used to select the respondents and to find out the association between the different factors, chi-square test was used.
Results: There was a highly significant association between all the factors such as economic, social and personal with that of the utilization of drones in agriculture since the calculated chi–square values are more than the table values.
Conclusion: The perceived factors which has been discussed in this article are a positive sign and can be used as an eye-opener to develop more farmer-friendly drones at a reasonable cost for owning them by the farmers.

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1. INTRODUCTION

The sector of agriculture, although it contributes to 20.2 per cent of the Gross Domestic Product (GDP) of India [1], it gambles with various constraints such as abnormal monsoons, production related issue, low productivity, labor shortage, price fluctuations, etc. Agriculture is the prime work source for man of the rural households. The FAO report on India at a Glance, 2022 in its report have insisted that 70 per cent of the rural households still depend on agriculture and about 82 per cent of the farm households are small and marginal. It is the dire need of all the stakeholders who are involved around agriculture to look into this situation seriously and find out path breaking ways to achieve sustainability for our younger generation. Automation in agriculture is an emerging subject across the world. In the current trend, the concept of Artificial Intelligence has found many applications in building solutions for agriculture related problems, which not only empower the farmers to continue farming amidst eradicating natural resources and also would improve the quality and ensure quick market penetration of various crops. Of all these, a pivotal role is being played by the technology of Unmanned Aerial Vehicles (UAVs), commonly referred to as Drones for agricultural purposes. Although it is in the latent stage and as a much longer road ahead, its presence can be felt in many patches of our country.

Drones, which are technically referred to as 'Unmanned Aerial Vehicles (UAVs)' are useful for carrying out tasks that are sometimes considered impossible for humans to do. These were originally developed for military purposes when the first types of drones were used in First World War. But now it has found its way into the mainstream because of the enhanced levels of safety and efficiency they bring. These vehicles do not need a pilot on board and it can either be controlled manually or by relying on a system of sensors (like LIDAR detectors) (Built In, 2022). Drones in general refer to multirotors. A multirotor is fixed with three or more propellers which are used for hovering or flying in any direction. However, the most commonly used type of drone is the quadcopter having four propellers [2].

Use of Drones for the Crop-protection in India is new and the country is gaining experience. Indian Council of Agricultural Research (ICAR) initiated a network program during September, 2021 where in Research on use of Drones and Artificial Intelligence (AI) for timely monitoring of crop growth, health and managing it with enhanced input use efficiency were taken up. Drone and AI technology are used to monitor near real-time crop health. Drone is also used for variable rate technology for pesticide and liquid fertilizer applications, mapping of water spread area, water sampling, mapping macrophyte infestation and aquaculture management practices, etc. Drone and AI technology are also used for precision livestock farming, particularly its health monitoring.

For enhancing farmers' income, the emphasis is on adopting a multi-dimensional strategy, which includes increase in production through creation of resources for improving irrigation; effective use of inputs; reduction of post-harvest losses; value addition; reforms in agriculture marketing; minimizing risk and providing security and assistance, and promotion of allied activities. The Government has adopted several developmental programmes, schemes, reforms and policies that focus on higher incomes for the farmers. All these policies & programmes are being supported by higher budgetary allocations, non-budgetary financial resources such as creating Corpus Funds like Micro Irrigation Fund etc. There have been several reforms to unleash the potential, e.g. Formation and Promotion of 10,000 FPOs along with necessary financial support under AtmaNirbhar Package (Agriculture). Under AtmaNirbhar Bharat special attention is being paid for creation of infrastructure for which "Agri Infrastructure Fund (AIF) has been created with a size of Rs.100,000 crore. Other special initiatives include Supplementary Income transfers under PM-KISAN; Pradhan Mantri Fasal Bima Yojna (PMFBY); Pradhan Mantri Krishi Sinchai Yojana (PMKSY); Increase in Minimum Support Price (MSPs) for all Kharif & Rabi Crops ensuring a minimum of 50 percent of profit margin on the cost of production, Bee-Keeping; Rashtriya Gokul Mission; Blue Revolution; Interest Subvention Scheme; Kisan Credit Card (KCC) that now offers production loan to even dairy & fishery farmers besides agricultural crops etc. The adoption of Drone technologies in agriculture has a potential to revolutionize the Indian agriculture. In order to make Drone technology affordable to the farmers and other

stakeholders of this sector, financial assistance @ 100% cost of drone together with the contingent expenditure is extended to ICAR/SAU/State Governments/State Government Institutions under Sub-Mission on Agricultural Mechanization (SMAM) for its demonstration on the farmer's field. Apart from this, farmers are getting timely information and advisory services through online and telecom mediums such as Kisan Call Centre and Kisan Suvidha App so that farmers can make decision for increasing crop productivity. During last three years (2019-2021) a total of 946 field crop varieties have been released comprising of 379 of cereals, 146 of Oilseeds, 168 of Pulses, 55 of Forage Crops, 158 of Fibre Crops, 26 of Sugarcane and 14 of other crops (potential/minor crops). In addition, 288 varieties of Horticultural crops were also released. These improved varieties are helping farmers to increase their income.

In the recent trend, drones have become essential for various tasks in different organizations and have also helped a lending hand in uplifting industries that were about to perish. From delivery services of food orders to scanning an unreachable military base, drones are very smart enough than humans to act in a more effective and in efficient way. Moving the work-related graph upwards, decrease in work pressure and production costs, excellent accuracy, refining service and customer relations and solving security issues on a large scale are some of the areas where drones find a place.

2. MATERIALS AND METHODS

Based on the data obtained by a pilot survey of the units offering drones on a rental basis to the farmers for spraying chemicals to the crops in all the districts of Tamil Nadu, four districts that are having the highest number of drone users for agriculture viz., Dindigul, Tiruppur, Namakkal and Erode were selected as the study area. Respondents for the study was selected by following the method of Simple Random Sampling Technique wherein from each district, 25.00 percent of respondents comprising from all the blocks of a particular district was selected randomly owing to the minimal population of drone-using farmers.

A pre–tested and well-structured interview schedule was used for the study and the factors were divided into three categories namely social, economic and personal factors. The response was recorded on a three – point continuum of greater extent, somewhat extent and not an influencing factor assigning scores of 3, 2, and 1 respectively and the responses were obtained. The responses were subjected to percentage analysis and the results were tabulated and explained.

3. RESULTS AND DISCUSSION

3.1 Economic Factors

Any new agricultural technology comes into adoption mainly because the farmers think that it may have economic benefits when compared with that of the presently undergoing technology. Economic benefits increase the adoption of a particular technology and create more diffusion among other farmers. Hence the factors that were perceived to be the influential economic factors for adopting drones in agriculture and their results are presented below.

From Table 2, it can be seen that the top most prioritized factor which was responsible to take up drones in agriculture economically was due to high wages of labor that were felt to a great extent by nearly 97.00 percent of the respondents and the rest felt that it was extended up to a level. This may be due to the reason that the labor force in agriculture is in much grave situation that the availability of labors for performing various agricultural tasks is challenging amidst the growing scenario of the technology sector. The other factors which made up the farmers adopt drones in their fields owing to economic reasons were for obtaining more profit given by about 89.00 percent to a great extent and to increase savings a factor to a greater extent to use drones in agriculture nearly 87.00 percent of the respondents. This shows that the farmers may be more oriented towards economic benefits and to cater to this need, drones are used as a helping hand.

The economic factors that were given the least importance were demand-driving and marketing aspects which were influential only to some extent by 40.85 and 37.02 per cent respectively. This would have arrived due to the reason that farmers may have felt that demand and marketing area continuous activity in agricultural scenarios and the involvement of drones in such activity might not show any major difference between conventional farming and precision farming.

Table 1. Number of respondents chosen for the study from the selected districts

S. No.	District	Total number of farmers using drones	A selected number of respondents
1.	Dindigul	298	75
2.	Tiruppur	227	57
3.	Erode	228	57
4.	Namakkal	171	43

Table 2. Economic factors influencing the adoption of drones in agriculture (n=235)

S. No	Factors	Extent of influence					
		Great extent		Somewhat extent		Not an influence factor	
		f	%	f	%	f	%
1.	To obtain more profit	209	88.94	26	11.06	-	-
2.	To increase savings	204	86.81	31	13.19	-	-
3.	High wages of labour	227	96.60	8	3.40	-	-
4.	Large scaled farm	195	82.98	39	16.60	01	04.26
5.	To get subsidy	149	63.40	86	36.60	-	-
6.	Demand driven	96	40.85	139	59.15	-	-
7.	Marketing	87	37.02	148	62.98	-	-
8.	Involvement in other economic activity	160	68.09	75	31.91	-	-

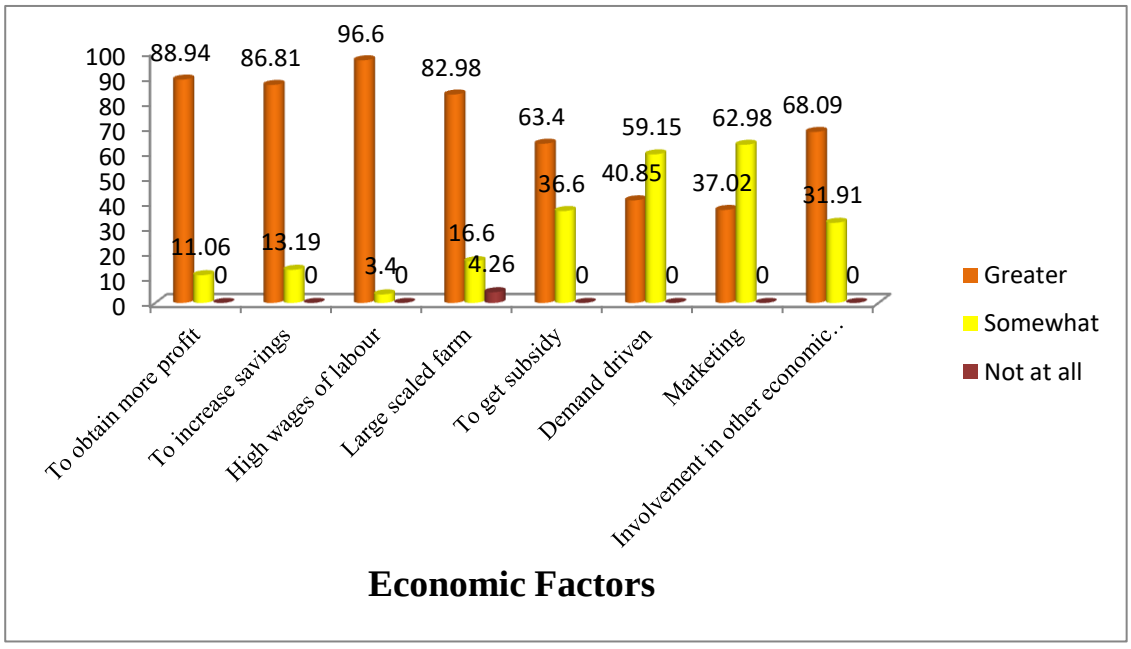

Fig. 1. Economic factors influencing adoption of drones in agriculture

3.2 Social Factors

Social factors are the factors that have a direct influence on the society and its culture. India being a diverse country is fond of various societal backgrounds and hence it has a lot of dimensions to be taken into consideration while developing any new technology. It was therefore out of many factors, the most important shortlisted social factors were perceived and after conducting the survey, the below results were obtained.

Table 3. Social factors influencing adoption of drone applications in Agriculture (n=235)

S. No	Factors	Extent of influence					
		Great extent		Somewhat extent		Not an influence factor	
		f	%	f	%	f	%
1.	Family background	148	62.98	87	37.02	-	-
2.	Compulsion from family members	163	69.36	72	30.64	-	-
3.	Encouragement from friends	178	75.74	57	24.26	-	-
4.	After looking at the peers	197	83.83	38	16.17	-	-
5.	Influence from the society	193	82.13	42	17.87	-	-
6.	Labour scarcity	198	84.26	37	15.74	-	-

From the above Table 3, it can be observed that the most influential social factor influencing farmers to adopt drones in agriculture was labor scarcity which was a greater extent for nearly 84.00 percent and to some extent the rest 16.00 percent of respondents. This would have been because the farmers may still face the problem of labor shortage in the agriculture sector due to the still prevailing societal differences among the people and which would have affected the normal productivity of crops in the field. The introduction of drones wherein the efficiency when compared with that of humans is more might have combated this problem and so the first priority was given to this factor. The other two top factors contributing to the adoption of drones include looking at peers and influence from society by 83.83 percent and 82.13 percent of respondents respectively up to a great extent for which the reason may be as determined by Rogers and Shoemaker (1971) the different categories of adopters in a society. The farmer who is more innovative and always has a search for new technology might have first used the technology and this might have influenced others also to do the same in their fields.

The least prioritized social factors include family background (62.98%) and compulsion from family members (69.36%) since the adoption of new technology involves a major contribution of taking the decision to whether to do or not by an individual at the final and hence these factors may have a less effect on the decision to adopt drones in the field.

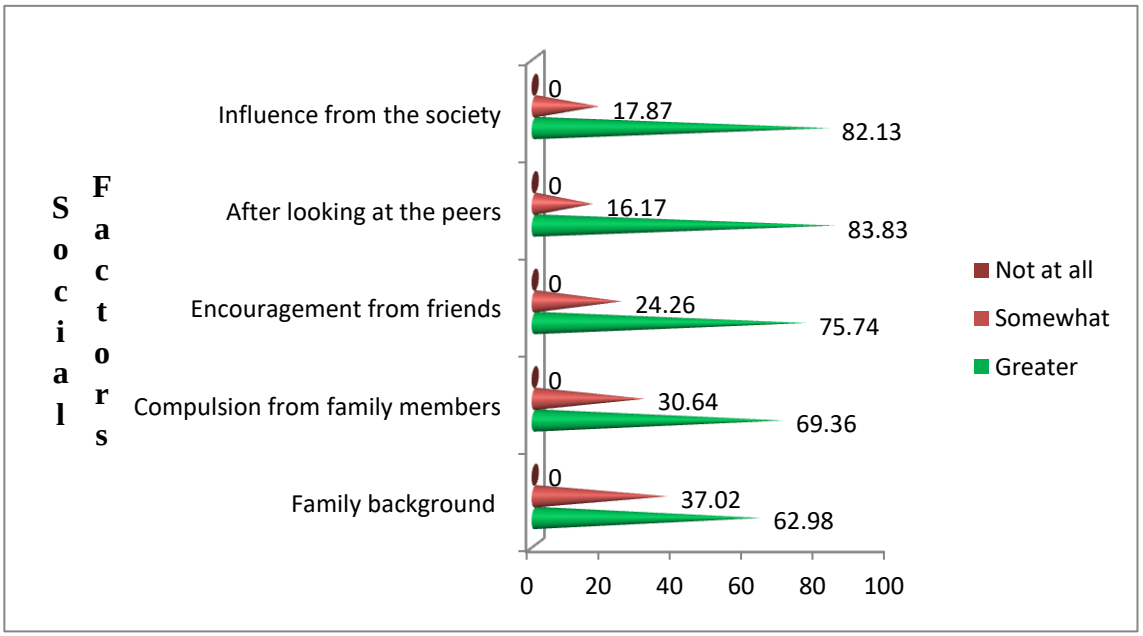

Fig. 2. Social factors influencing adoption of drone applications in agriculture

3.3 Personal Factors

Factors that are dependent on the attempt of an individual to adopt a particular technology in his / her own field are considered in the personal factors. In this context, the various personal factors that would influence an individual to take up drone technology in the field was perceived after a knowledge gained from the initial pilot survey of the farmers using drones and the results obtained after the original survey is tabulated below.

Table 4 shows that more than 95.00 per cent of the respondents expressed the amount of time consumed for agricultural activities was reduced to a greater extent when drones were applied in the field. Conventional farming used to have time constraints for conducting agricultural activities in the field owing to the dependency on various aspects such as labor availability, implement availability, pesticide availability, climate dependency etc. which ultimately results in loss of time concentrated on agriculture. But when drones are employed for activities, such as spraying and their efficiency is high, it definitely saves time for the farmers to focus on other farm activities which may be the reason for such a result. The other two personal factors that contribute to the adoption of drones include scientific orientation by more than 92.00 percent of farmers and risk orientation by 85.53 percent of farmers to a greater extent because the farmers who were under the study area may be innovative in their ideas and hence their personal interest in utilizing the drone facilities in their fields may have influenced the farmers to adopt drones.

The least influential factors to adopt drones by personal factors include self – reliance and avoiding migration which are 64.26 and 58.72 percent respectively to some extent since the farmers are mostly self–reliant even when they use conventional farming and the migration aspect nowadays is not influential among farmers because the government is focusing equally on all the villages by allocating different schemes and concentrating more on agriculture which might have caused such a result to occur.

3.4 Association of Different factors Responsible for Using Drone Applications in Agriculture

To find out the association of the factors such as social, economic and personal factors with that of the utilization of the drones in agriculture, chi – square was used.

$$\chi_c^2 = \frac{\sum(O_i - E_i)^2}{E_i}$$

where,

c - Degrees of freedom
O - Observed value
E - Expected value

Table 4. Personal factors influencing the adoption of drones in agriculture (n=235)

S. No	Factors	Extent of influence					
		Great extent		Somewhat extent		Not an influence factor	
		f	%	f	%	f	%
1.	Self –reliance or independence	84	35.74	151	64.26	-	-
2.	To avoid migration	96	40.85	138	58.72	1	04.26
3.	Saves energy	181	77.02	54	22.98	-	-
4.	Educational status	123	52.34	111	47.23	1	04.26
5.	Scientific orientation	217	92.34	18	7.66	-	-
6.	Risk orientation	201	85.53	33	14.04	1	04.26
7.	Reduces time consumption	225	95.74	10	4.26	-	-

Table 5. Association of different factors responsible for using drone applications in agriculture

S. No.	Factors	χ_c^2 value
1.	Economic factors	34.55**
2.	Social factors	30.74**
3.	Personal factors	29.24**

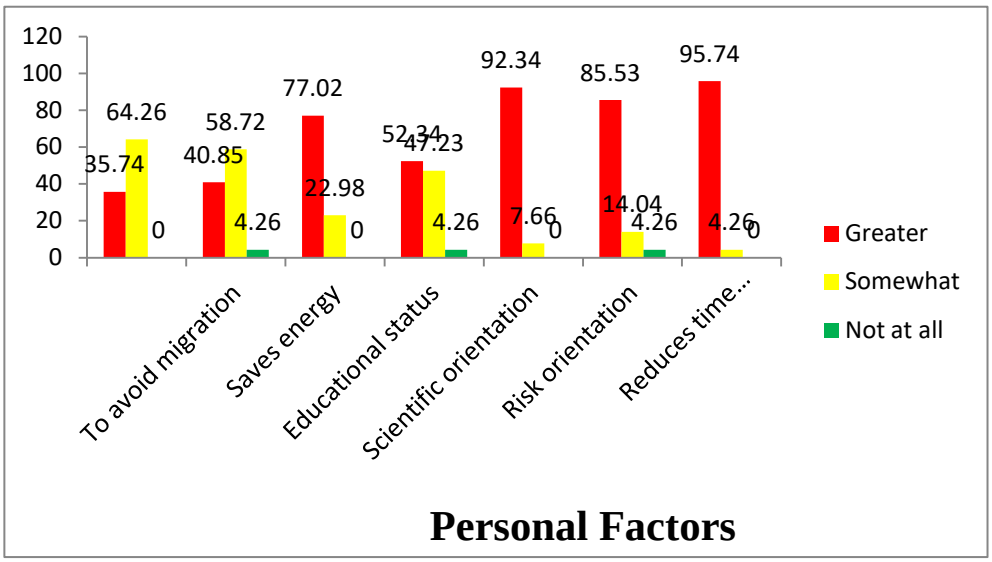

Fig. 3. Personal factors influencing the adoption of drones in agriculture

Data presented in Table 5 point out that there was a highly significant association between all the factors such as economic, social and personal with the of utilization of drones in agriculture since the calculated chi–square values are more than the table values. This indicates that the usage of drones is dependent on all the above-mentioned factors and hence these factors play a significant role in determining the adoption of drones in agriculture.

The findings highlight the urgent need to address the social, economic, and personal factors influencing the adoption of drones in tropical rural agricultural territories. Policymakers, agricultural extension services, and technology providers should collaborate to overcome the challenges identified, by offering financial incentives, tailored training programs, and simplified regulatory frameworks. Moreover, the preservation and integration of traditional farming practices within the context of drone technology should be emphasized to ensure the cultural sustainability of these territories.

4. ECONOMIC FACTORS

a. Cost-effectiveness: Economic considera-tions play a crucial role in the adoption of drones in agriculture. Farmers in tropical rural and indigenous agricultural territories of Latin America assess the cost-effectiveness of drone technologies compared to traditional farming practices [3,4]. Factors such as the initial investment cost, operational expenses, and potential return on investment influence their decision-making process.

b. Farm size and productivity: The size of agricultural landholdings and the productivity levels of farms impact the adoption of drone technologies. Large-scale farms in these territories may find drones more economically viable due to the potential for increased efficiency and productivity gains [5-7]. Conversely, smaller farms may face financial constraints that hinder their ability to invest in drone technology.

c. Access to capital and financial resources: Limited access to capital and financial resources can be a significant barrier to the adoption of drones in agriculture. In rural and indigenous agricultural territories, where traditional banking services may be limited, alternative financing mechanisms, such as microcredit and cooperative schemes, can facilitate the acquisition of drones and enabling technologies [8,9].

5. CULTURAL FACTORS

a. Traditional agricultural practices: In many tropical rural and indigenous agricultural territories, traditional farming practices are deeply ingrained in local culture and heritage [10,11]. The adoption of drones may be met with resistance due to concerns about disrupting long-standing practices, cultural values, and a preference for manual labor. Cultural sensitivity and education programs can help bridge the

gap between traditional knowledge and the benefits of drone technology [12,13].

b. Knowledge and skills transfer: Successful adoption of drones in agriculture requires a certain level of technical knowledge and skills. In rural and indigenous communities, the availability of training programs and capacity-building initiatives becomes crucial [14]. Empowering local farmers with the necessary skills and knowledge to operate and maintain drone technologies fosters a sense of ownership and encourages adoption.

c. Perception of technology: Attitudes and perceptions towards technology vary across cultures. Some communities may embrace technological advancements, while others may exhibit skepticism or fear. Overcoming cultural barriers involves engaging local communities, addressing misconceptions, and highlighting the potential benefits of drones in agriculture, such as increased efficiency, reduced labor, and improved crop yields [15,16].

6. SOCIAL FACTORS

a. Farmer networks and knowledge sharing: Social networks and community structures play a vital role in the adoption of new agricultural practices. In tropical rural and indigenous agricultural territories, close-knit communities and farmer networks can influence the spread of information and knowledge regarding drone technology [17,18]. Establishing platforms for knowledge sharing, demonstrations, and peer-to-peer learning can accelerate adoption rates.

b. Institutional support and policy framework: Strong institutional support and a favorable policy framework are essential for the widespread adoption of drones in agriculture. Governments and relevant organizations should develop policies that promote the use of drone technology while considering the specific needs and circumstances of tropical rural and indigenous agricultural territories [19,20]. This includes addressing regulatory barriers, ensuring privacy and data protection, and fostering collaborations between research institutions, industry stakeholders, and local communities.

c. Environmental and social impact considerations: Tropical rural and indigenous agricultural territories are often characterized by fragile ecosystems and cultural landscapes [18,21]. The adoption of drones should be accompanied by careful consideration of their potential environmental and social impacts [22,23]. Integrating sustainable agricultural practices, respecting land rights, and involving local communities in decision-making processes can ensure responsible and inclusive adoption [24,25].

The adoption of drones in agriculture and enabling technologies in tropical rural and indigenous agricultural territories of Latin America and India is influenced by a complex interplay of economic, cultural, and social factors. Understanding and addressing these factors are critical for successful integration and maximizing the benefits of drone technology. A comprehensive approach that combines economic incentives, cultural sensitivity, community engagement, and supportive policies can pave the way for sustainable and inclusive agricultural practices in these regions [26-31].

7. CONCLUSION

In order to provide agricultural services through drone application, financial assistance at 40.00 percent of the basic cost of drone and its attachments or Rs.4 lakhs, whichever less is also provided for drone purchase by existing and new Custom Hiring Centers (CHCs) under Cooperative Society of Farmers, Farmers Producer Organizations (FPOs) and Rural entrepreneurs. The agriculture graduates establishing CHCs are eligible to receive financial assistance at 50.00 percent of the cost of drone up to a maximum Rs.5.00 lakhs. In addition to the already identified institutions for drone demonstration, other agricultural institutions of the state and central government, central public sector undertakings engaged in agricultural activities have also been brought in the eligibility list for financial assistance for farmers' drone demonstration. The Union Ministry of Agriculture and Farmers Welfare is providing assistance to the State Governments through several schemes to promote agriculture across the country and to increase the production and productivity, besides reducing the human labor associated with various agricultural activities. The Government is also helping farmers access modern technology to improve the use efficiency of inputs such as seeds, fertilizers and irrigation.

Drone technology is definitely a game changer in the field of agriculture. Many Indian start-ups are investing more in low–cost drones that can help farmers and create simultaneously employment opportunities for the rural youth and enhance the knowledge of farmers too. However, the drone industry needs more path-breaking reforms by taking into account the rapid increase in population, dire needs of the farmers, operational policies and shrinking farm fields which is a matter to be worried.

This new technology is aimed to reach more and more farmers, which will facilitate them, reduce the cost and increase their income. During the attack of locust, the government had also promptly used drones and helicopters for rescue. The conditions are favorable to take drones to the farmers and the government is also committed in this regard. ICAR is contributing through research and training. With this, more and more farmers will be ready to use drones.

8. FUTURE RESEARCH SUGGESTIONS

This research has been made on adoption of drones. This can be extended to other aspects such as constraints and modifications required for farmers.

Also with the study conducted, the factors that are less impactful using drones can be considered by the government and focus on rectifying them at a fast pace.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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