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Factors influencing knowledge and attitude of the drone users in agriculture in *Karnataka*

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ABSTRACT

Drone technology had emerged as a promising tool in agriculture, offering opportunities to improve operational efficiency, reduce input costs and enhance precision in crop protection. The present study was undertaken to identify factors influencing knowledge and attitude of drone users in agriculture in *Karnataka*. The study comprised 90 drone-user farmers selected from major drone-utilising districts of *Karnataka*, namely Chikkaballapur, Chitradurga and Shivamogga, representing maize, red gram and paddy cultivation, respectively. Hierarchical Multiple Regression Analysis was employed by classifying predictors into sequential models to know factors influencing knowledge and attitude of the drone users in agriculture. The results revealed that Personal characteristics made the strongest contribution, explaining 70.60 per cent of the variance ($R^2 = 0.706$), with education being the strongest predictor ($\beta = 0.828$; $p < 0.001$). The final model explained 80.80 per cent of the variance in farmers' knowledge ($R^2 = 0.808$; Adjusted $R^2 = 0.775$), whereas among factors influencing attitude of drone users in agriculture, The results revealed that among the individual predictors, personal characteristics made the highest unique contribution in explaining farmers attitude, accounting for 75.10 per cent of the variance, significant at five per cent level of significance ($\Delta R^2 = 0.751$; $F = 64.254$; $p < 0.05$), while production orientation showed the least contribution and insignificant ($\Delta R^2 = 0.003$; $p > 0.05$). When predictors were grouped into four conceptual models, personal variables established the strongest baseline ($R^2 = 0.751$), followed by information sources ($\Delta R^2 = 0.080$), psychological motivators ($\Delta R^2 = 0.053$) and management orientations as the final significant differentiator ($\Delta R^2 = 0.017$; $F = 4.303$; $p < 0.05$). The cumulative model explained 90.10 per cent of the variance ($R^2 = 0.901$; Adjusted $R^2 = 0.884$). The study concluded that a combination of personal, informational, motivational and managerial factors plays a crucial role in shaping farmers knowledge and attitude towards drone technology, emphasizing the need for a holistic approach to promote its adoption towards sustainable agriculture.

Keywords: Attitude, Drone, Factors, Hierarchical multiple regression, Knowledge, Personal characteristics

Introduction

Agriculture remains a major sector of the Indian economy, where timely and efficient crop protection is essential for sustaining crop productivity. Conventional pesticide application is often associated with high labour requirements, greater water consumption and human exposure to hazardous chemicals. Drone technology has emerged as a promising alternative, offering advantages such as improved spraying efficiency, reduced pesticide wastage, water savings through ultra-low-volume spraying and reduced human exposure to hazardous chemicals (Ministry of Agriculture & Farmers Welfare, 2023) [1].

The adoption of agricultural drones in India is being promoted through government initiatives such as the Sub-Mission on Agricultural Mechanization (SMAM), which supports drone demonstrations, individual ownership and Custom Hiring Centres for providing drone services to farmers on a rental basis (Ministry of Agriculture & Farmers Welfare, 2024). As of July 2024, 16,000 Remote Pilot Certificates had been issued by the Directorate General of Civil Aviation (DGCA), along with 116 approved Remote Pilot Training Organisations and 70 type-certified Unmanned Aircraft System models, indicating the growing ecosystem for drone-based operations in India (Ministry of Civil Aviation, 2024).

Drone-based pesticide spraying has the potential to address some of the major challenges associated with conventional spraying by reducing the quantity of water required, minimizing direct exposure of farm workers to pesticides and enabling timely application over larger areas. The technology also offers an opportunity to provide spraying as a service, allowing farmers to access drone technology without bearing the high initial investment involved in purchasing and maintaining a drone. This service-based model is particularly relevant for small and marginal farmers, who may find individual ownership of drones economically unviable. However, the effective delivery and wider adoption of drone-based spraying services depend on the interac

tion between two important stakeholders: farmers, who are the users of the service and drone operators, who provide the spraying service. In this context, knowledge plays an important role in determining how farmers understand and utilize drone technology. Farmers need to possess adequate knowledge regarding the functioning of drones, suitable crops and crop stages, pesticide dosage, spray volume, weather conditions, safety precautions, flight operations and the advantages and limitations of drone spraying. Adequate knowledge may help farmers make appropriate decisions regarding when and where drone spraying can be effectively used. Conversely, insufficient knowledge may lead to inappropriate expectations, incorrect use of the technology or hesitation in utilizing drone-based services. Therefore, examining the level of knowledge among drone users provides an understanding of their capacity to use the technology effectively under prevailing farm conditions.

Along with knowledge, attitude is another important factor influencing the utilization of agricultural innovations. A farmer's attitude towards drone spraying may be reflected in perceptions regarding its effectiveness, timeliness, cost, labour saving, chemical saving, safety, accessibility and suitability for different crops and field conditions. A favourable attitude may encourage continued use and greater willingness to integrate drone spraying into crop protection practices, whereas unfavourable perceptions regarding cost, reliability, technical difficulties or service availability may restrict its utilization. Attitude is therefore closely associated with how farmers interpret their experiences with the technology and the benefits or limitations observed under actual field conditions.

The knowledge and attitude of drone users, however, are unlikely to be uniform across farming situations. They may be influenced by a combination of personal, socio-economic, psychological, communication and technological factors. Variables such as age, education, farming experience, landholding, economic motivation, scientific orientation, extension participation and access to different sources of agricultural information may influence the way farmers understand and respond to drone technology. Exposure to demonstrations, interaction with extension personnel, fellow farmers and drone operators, access to digital and mass media, and actual experience of using drone spraying services may also contribute to differences in farmers' knowledge and attitudes. Similarly, the cost of drone services, availability of service providers, crop characteristics and local farming conditions can shape farmers' perceptions of the technology.

Understanding these factors is particularly important because the successful expansion of agricultural drone technology depends not only on the availability of drones and supporting infrastructure but also on the ability and willingness of farmers to use the technology appropriately. Identifying the factors associated with farmers' knowledge and attitude can help extension agencies, policymakers, drone service providers and other stakeholders design more appropriate training programmes, demonstrations, advisory services and support mechanisms. Such an understanding can also contribute to strengthening the delivery of drone-based spraying services at the village level and facilitate the effective integration of drone technology into existing crop protection practices.

Therefore, studying the factors influencing the knowledge and attitude of drone users towards drone-based spraying in agriculture is im-

portant for understanding the human and socio-economic dimensions of this emerging technology. The findings can provide useful insights into the factors that facilitate or constrain effective utilization of agricultural drones and can support the development of need-based extension strategies for promoting safe, efficient and appropriate use of drone technology among farmers.

Material and Methods

The present study was based entirely on primary data collected from drone user farmers. Data were collected through personal interviews using a structured and pre-tested interview schedule. Information was collected on dependent variables such as knowledge, attitude and independent variable ie. personal characteristics such as age, education. Land holding, farming size, psychological variables such as extension participation, economic motivation, scientific orientation, planning orientation, production orientation, marketing orientation and information characteristics variables. The factors influencing knowledge and attitude assessed using Hierarchical multiple regression analysis. Those variables are expressed in frequency and percentage.

Results and Discussion

Results

Personal, psychological and information characteristics of drone users in agriculture

Personal characteristics of drone users in agriculture

Age

The result in Table 15 revealed that, majority of the drone users belonged to the middle age group (72.22%) followed by young age (21.11%). Only few farmers belonged to old age (6.66%) group.

Education

The data in Table 15 depicted that, majority of the drone users had education up to the level of high school (35.55 %) followed by 30.00 per cent of drone users who had education up to middle school. Primary school education was completed by 10.00 per cent of drone users, while 16.66 per cent had education up to graduation and 5.55 per cent had completed PUC. Only few drone users were illiterate and none of them had completed post-graduation (2.22 %).

Farming experience

Result on farming experience of drone users indicated that majority of the drone users were experienced medium level of farming experience (64.44 %) and equal number of drone users had low and high farming experience (17.78 %) as shown in Table 15.

Land holding

A look at the data in Table 15 clearly showed that majority of drone users were marginal farmers with land holding of less than 2.50 acres (54.44 %) followed by small farmers (22.22 %) with land holding of 2.51 to 5.00 acres. Medium farmers with land holding of 5.01 to 10.00 acres accounted for 21.11 per cent, while only few drone users were large farmers with more than 10.00 acres of land (2.22 %).

n = 90

Psychological characteristics of drone users in agriculture

Extension participation

Table 1. Personal characteristics of drone users in agriculture

Characteristic	Category	Drone user	
		f	%
Age	Young	19	21.11
	Middle	65	72.22
	Old	6	6.66

(continued on next page)

Characteristic	Category	Drone user	
		f	%
Education	Illiterate	2	2.22
	Primary school	9	10.00
	Middle school	27	30.00
	Highschool	32	35.55
	P.U.C.	5	5.55
	Graduation	15	16.66
	Post-graduation	0	0
Farming experience	Low	16	17.78
	Medium	58	64.44
	High	16	17.78
$\bar{X} = 29.46 \ s = 10.25$			
Land holding	Marginal farmers	49	54.44
	Small farmers	20	22.22
	Medium farmers	19	21.11
	Large farmers	2	2.22

The data in Table 16 revealed that, more than two-thirds of the drone users (67.78%) had medium level of extension participation followed by low level of extension participation (17.78%). Only a small proportion of the drone users had high level of extension participation (14.44 %).

Scientific orientation

The result in Table 16 indicated that, majority of the drone users possessed medium level of scientific orientation (66.67%) followed by low level of scientific orientation (18.89%) and high level of scientific orientation (14.44%).

Economic motivation

The data in Table 16 revealed that, majority of the drone users exhibited medium level of economic motivation (66.67%) followed by low level of economic motivation (22.22%), while only few had high level of economic motivation (11.11%).

Planning orientation

A look at the data in Table 16 showed that, nearly half of the drone users had medium level of planning orientation (58.89%) and high level of planning orientation (23.33%), whereas more than one fourth of the drone users had low level of planning orientation (17.78%).

Production orientation

Majority of the drone users had medium level of production orientation (92.22%) followed by high level of production orientation (7.78%). It was astonishing to know that none of the drone users had low level of production orientation (Table 16).

Marketing orientation

The data in Table 16 revealed that, three fourth of the drone users had medium level of marketing orientation (88.89%) followed by low level of marketing orientation (7.78%). It was interesting to note that only a meagre number of the drone users had high level of marketing orientation (3.33%)

Table 2. Psychological characteristics of drone users in agriculture

Characteristic	Category	f	%
Extension participation	Low	16	17.78
	Medium	61	67.78
	High	13	14.44
$\bar{X} = 13.54 \ s = 2.49$			
Scientific orientation	Low	17	18.89
	Medium	60	66.67
	High	13	14.44
$\bar{X} = 20.82 \ s = 2.34$			
Economic motivation	Low	20	22.22
	Medium	60	66.67
	High	10	11.11
$\bar{X} = 25.34 \ s = 1.74$			
Planning orientation	Low	16	17.78
	Medium	53	58.89
	High	21	23.33
$\bar{X} = 18.20 \ s = 1.77$			
Production orientation	Low	0	0
	Medium	83	92.22
	High	7	7.78
$\bar{X} = 19.36 \ s = 0.73$			

(continued on next page)

Characteristic	Category	f	%
Marketing orientation	Low	7	7.78
	Medium	80	88.89
	High	3	3.33
$\bar{X}=17.16$ $s = 4.97$			

$n = 90$

$\bar{X}$ =Mean, s =Standard deviation

Information accessibility characteristics of drone users in agriculture

Information characteristics was assessed by how a drone users access to different sources of information like formal source of information, informal source of information and mass media source of information.

Access to formal source of information by drone users in agriculture

From formal sources as showed in Table 17, the large and equal number of drone user farmers obtained information from officials of the Horticulture department and Panchayat officials (66.66%) followed by veterinary hospitals (65.55%) and input dealers (64.44%). More than half of the farmers accessed information from extension personnel (61.11%), private consultants (54.44%), banks (52.22%), NGOs (51.11%) and officials of the agriculture department (51.11%). Exactly half of the farmers obtained information from university extension personnel/KVK (50.00%) and corporate extension functionaries (50.00%)

Access to informal source of information by drone users in agriculture

It was observed from the Table 17 that, among drone users, from informal sources, a large majority obtained information from family

members (71.11%) followed by equal number of drone users obtained information from neighbours/fellow farmers and progressive/experienced farmers (68.88%). More than half of the farmers obtained information from friends (66.66%) and relatives (57.77%).

Access to mass media source of information by drone users in agriculture

From mass media as presented in Table 17,, nearly two-thirds of the drone-user farmers obtained information through television (64.44 %) followed by social media (45.55 %), mobile apps (43.33 %) and newspapers (42.22 %). Less than one-fourth of the farmers accessed farm magazines (24.44 %), while only a negligible number obtained information through radio (11.11 %).

Overall ccess to source of information by drone users in agriculture

The overall access to sources of information was observed, a majority (68.15 %) of the drone-user farmers had medium access to information sources followed by 20.74 per cent with high access, whereas only 11.11 per cent had low access to sources of information as showed in Table 17

$n = 90$

Table 3. Information accessibility characteristics of drone users in agriculture

Criteria	f	%
A. Information Sources		
I. Informal sources		
Family members	64	71.11
Friends	60	66.66
Relatives	52	57.77
Neighbors/Fellow farmers	62	68.88
Progressive/experienced farmers	62	68.88
II. Formal sources		
Extension officials of Agriculture department	46	51.11
Extension officials of Horticulture department	60	66.66
University extension personnel/KVK	45	50.00
Input Dealers	58	64.44
NGOs	46	51.11
Panchayat officials	60	66.66
Private consultant	49	54.44
Extension personnel	55	61.11
Banks	47	52.22
Corporate extension functionaries	45	50.00
Veterinary hospital	59	65.55
III. Mass media		
News paper	38	42.22
TV	58	64.44
Radio	10	11.11
Farm magazines	22	24.44
Mobile Apps	39	43.33
Social media	41	45.55
IV. Overall information seeking behaviour		

(continued on next page)

Criteria	f	%
Low ($< \bar{X} - s$)	10	11.11
Medium ($\bar{X} \pm s$)	61	68.15
High ($> \bar{X} + s$)	19	20.74

$$\bar{X} = 18.27 \quad s = 1.51$$

$\bar{X}$ =Mean, s =Standard deviation

Influence of profile characteristics on the knowledge and attitude of drone users towards drone technology

Factors influencing Knowledge of drone users towards Drone usage, Hierarchical multiple regression analysis was carried out to determine the contribution of different sets of independent variables to the knowledge of farmers towards drone usage as showed in Table 18. The variables were entered into the regression model in four successive blocks. Model 1 included personal characteristics, namely age, education, land holding and farming experience. Model 2 included information-seeking variables, namely extension participation, informal sources, formal sources and mass media, in addition to the variables entered in Model 1 and 2, Model 3 incorporated psychological variables, namely economic motivation and scientific orientation. Finally, Model 4 included management orientation variables, namely planning, production and marketing orientation.

The results revealed that, in model 1 the variables, The adjusted coefficient of determination (Adjusted R^2) was 0.74, education had a positive effect on knowledge and was statistically significant at the one per cent level. whereas age ($\beta = 0.171$), land holding ($\beta = 0.072$) and farming experience ($\beta = -0.125$) were non-significant.

With the addition of information-seeking variables in model 2, The adjusted coefficient of determination (Adjusted R^2) was 0.76. Among the newly added variables, mass media had a positive effect on knowledge ($\beta = 0.248$) and was statistically significant at the one per cent level. The addition of this block resulted in an F-change value of 7.122. while extension participation ($\beta = 0.083$) and informal sources ($\beta = 0.072$) were non-significant. Formal sources had a positive but non-significant effect ($\beta = 0.125$). In Model 3, by inclusion of psychological variables, The adjusted coefficient of determination (Adjusted R^2) was 0.78. Among the newly added variables scientific orientation had a positive effect on knowledge ($\beta = 0.212$) and was statistically significant at the one per cent level and education had positive and highly significant influence on knowledge ($\beta = 0.460$). whereas, economic motivation showed a negative and non-significant relationship ($\beta = -0.013$).

Finally, in model 4, The adjusted coefficient of determination (Adjusted R^2) was 0.775. The F-change value for the final block was 0.443, after incorporating planning, production and marketing orientation, indicated that the addition of management orientation variables resulted in only a marginal increase in the explained variance. Among the management orientation variables, planning orientation ($\beta = -0.013$), production orientation ($\beta = -0.038$) and marketing orientation ($\beta = -0.054$) were found to be non-significant. Overall, the findings indicated that education emerged as the most consistent and important predictor of farmers knowledge towards drone usage, while mass media and scientific orientation also made significant contributions at successive stages of the hierarchical regression analysis. However, the non-significant F-change in Model 4 indicated that the addition of management orientation variables did not make a statistically significant incremental contribution to the prediction of farmers knowledge.

Factors influencing attitude of drone users towards Drone usage

Hierarchical multiple regression analysis was carried out to determine the contribution of different set of independent variables to the attitude of farmers towards drone usage. The variables were entered into the regression model in four successive blocks as presented in Table 19. Model 1 included personal characteristics, namely age, education, land holding and farming experience. Model 2 included information-seeking variables, namely extension participation, informal sources, formal sources and mass media, in addition to the variables entered in Model 1 and 2, Model 3 incorporated psychological variables, namely economic motivation and scientific orientation. Finally, Model 4 included management orientation variables, namely planning, production and marketing orientation.

The results revealed that, in model 1, The adjusted coefficient of determination (Adjusted R^2) was 0.740, education had a positive effect on attitude and was statistically significant at the one per cent level ($\beta = 0.829$) of significance, whereas age ($\beta = 0.053$), land holding ($\beta = 0.011$) and farming experience ($\beta = 0.252$) were non-significant at one per cent level of significance. In addition to model 1, the information-seeking variables in model 2, the adjusted coefficient of determination (Adjusted R^2) increased to 0.815. Among the newly added variables, extension participation had a positive effect on attitude ($\beta = 0.263$) and was statistically significant at the one per cent level. mass media also had a positive effect on attitude ($\beta = 0.127$) and was statistically significant at the five per cent level. The addition of this block resulted in an F-change value of 9.619. Further, informal sources ($\beta = 0.038$) and formal sources ($\beta = 0.101$) had positive but non-significant effects on attitude.

In model 3, by the inclusion of psychological variables along with model 1 and 2, The adjusted coefficient of determination (Adjusted R^2) increased to 0.870, among the newly added variables, scientific orientation had a positive effect on attitude ($\beta = 0.196$) and was statistically significant at the one per cent level and the F-change value was 17.990. Education continued to have a positive and highly significant influence on attitude ($\beta = 0.326$). Further, economic motivation had a negative and non-significant relationship with attitude ($\beta = -0.229$).

Finally, in model 4 along with model 1,2 and 3, after incorporating planning, production and marketing orientation, the adjusted coefficient of determination (Adjusted R^2) increased to 0.884. The F-change value for the final block was 4.303, indicated that the addition of management orientation variables resulted in a further improvement in the explained variance. Among the management orientation variables, marketing orientation had a negative and significant effect on attitude at the five per cent level ($\beta = -0.102$), whereas planning orientation ($\beta = -0.115$) and production orientation ($\beta = -0.085$) were non-significant. Overall, the findings indicated that education emerged as the most consistent and important predictor of farmers attitude towards drone usage, while extension participation, mass media and scientific orientation also made significant contributions at successive stages of the hierarchical regression analysis.

n = 90

Table 4. Hierarchical Multiple Regression Analysis of Factors Influencing Knowledge of farmers towards Drone usage

Variable	Model 1		Model 2		Model 3		Model 4	
	β	Sig.	β	Sig.	β	Sig.	β	Sig.
Age	.171	.233	.105	.420	.095	.451	.098	.443
Education	.828	.000	.558	.000	.460	.000	.471	.000
Land	.072	.245	.085	.125	.091	.104	.120	.073
Farming Experience	-.125	.378	-.072	.575	-.092	.457	-.090	.473
Extension Participation	—	—	.083	.226	.060	.365	.069	.308
Informal sources	—	—	.072	.238	.059	.311	.071	.244
Formal sources	—	—	.125	.088	.115	.103	.123	.086
Mass media	—	—	.248	.000	.219	.001	.226	.001
Economic motivation	—	—	—	—	-.013	.847	-.004	.958
Scientific orientation	—	—	—	—	.212	.003	.200	.007
Planning orientation	—	—	—	—	—	—	-.013	.853
Production orientation	—	—	—	—	—	—	-.038	.515
Marketing orientation	—	—	—	—	—	—	-.054	.368
R ²	0.706		0.782		0.805		0.808	
Adj.R ²	0.692		0.761		0.780		0.775	
F Change	50.929		7.122		4.544		0.443	

 β = Standardized regression coefficient (Beta)

n = 90

Table 5. Hierarchical Multiple Regression Analysis of Factors Influencing Attitude of farmers towards Drone usage

Variable	Model 1		Model 2		Model 3		Model 4	
	β	Sig.	β	Sig.	β	Sig.	β	Sig.
Age	.053	.689	-.032	.781	.013	.895	-.001	.987
Education	.829	.000	.546	.000	.326	.000	.256	.000
Land	.011	.840	.032	.504	-.020	.635	-.017	.720
Farming Experience	.252	.054	.302	.009	.250	.010	.265	.004
Extension Participation	—	—	.263	.000	.241	.000	.223	.000
Informal sources	—	—	.038	.481	.017	.708	.017	.687
Formal sources	—	—	.101	.118	.094	.083	.092	.074
Mass media	—	—	.127	.023	.101	.035	.054	.258
Economic motivation	—	—	—	—	.229	.000	.201	.000
Scientific orientation	—	—	—	—	.196	.001	.220	.000
Planning orientation	—	—	—	—	—	—	.115	.026
Production orientation	—	—	—	—	—	—	-.085	.056
Marketing orientation	—	—	—	—	—	—	.102	.021
R ²	0.751		0.832		0.884		0.901	
Adj.R ²	0.740		0.815		0.870		0.884	
F Change	64.254		9.619		17.990		4.303	

 β = Standardized regression coefficient (Beta)

Discussion

Personal, psychological and information characteristics of drone users in agriculture

Personal characteristics of drone users in agriculture

Age

The findings presented in Table 15 revealed that a majority of the drone user farmers belonged to the middle-aged category (72.22 per cent), followed by young farmers (21.11 per cent). This might be due to the fact that middle-aged farmers constituted the major farming

population and were actively engaged in agricultural operations. Their greater farming experience and better access to resources might have encouraged them to adopt drone technology. The presence of young farmers might be due to their greater interest in new technologies and willingness to adopt innovative agricultural practices. The findings are in accordance with the results of Laxmi *et al.* (2023) [2] and Sihag *et al.* (2026) [3].

Education

The data in Table 15 depicted that majority of the drone users had education up to high school level (35.55 %). This might be due to improved access to educational facilities in rural areas and the impor

tance given to formal education among farming households. The relatively higher educational level might have facilitated farmers' understanding and acceptance of new technologies such as drones. The results are in line with findings of Noor *et al.* (2023) [4].

Farming Experience

The results in Table 15 showed that a majority of the respondents (64.44 %) had medium farming experience. This is due to the fact that farmers with moderate farming experience possessed adequate practical knowledge, their farming experience have enabled them to compare the limitations of conventional spraying with the advantages of drone spraying, thereby encouraging technology adoption. The findings are in accordance with the results of Laxmi *et al.* (2023) [2] and Sihag *et al.* (2026) [3].

Land Holding

The findings presented in Table 15 revealed that more than half of the drone user farmers belonged to the marginal farmer category (54.44%) followed by small farmers (22.22%) and medium farmers (21.11%). This is attributed to the availability of drone spraying services on a rental basis through drone operators, which eliminated the need for farmers to invest in purchasing expensive drone equipment. The pay per acre service model made drone technology affordable even for marginal and small farmers. In addition, drone spraying required only about 20 litres of water per acre compared to nearly 200 litres under conventional knapsack spraying reduced labour requirement and ensured timely pesticide application, thereby making the technology economically attractive for farmers with limited land resources. The findings were in accordance with Laxmi *et al.* (2025).

Psychological characteristics of drone users in agriculture

Extension Participation

The findings presented in Table 16 revealed that a majority of the drone user farmers had medium level of extension participation (67.78 %). This might be due to their occasional participation in extension activities such as farmer meetings, training programmes, demonstrations and interactions with extension personnel. The medium level of participation indicates that farmers were involved in extension activities whenever relevant programmes or opportunities were available, particularly those related to new agricultural technologies such as drone spraying. The findings are in line with the findings of Kumari *et al.* (2025) [5].

Scientific Orientation

It was observed from Table 16 that majority of the respondents had medium level of scientific orientation (66.67 %) because most farmers had experienced the benefits of improved agricultural technologies such as HYV seeds, soil testing and mechanized farming before adopting drones. They preferred technologies only after observing their performance in neighbouring fields and were convinced about the effectiveness of drone spraying in reducing labour and ensuring uniform application.

Economic Motivation

From the Table 16 revealed that majority of the respondents belonged to the medium level of economic motivation (66.67%). This is because of rising labour wages, scarcity of agricultural labour during peak seasons and increasing costs of cultivation encouraged farmers to look for cost saving technologies. Farmers perceived that drone spraying reduced labour requirement, saved time and minimized pesticide wastage thereby improving net returns.

Planning Orientation

It was presented in the Table 16 that more than half of the respondents had medium level of planning orientation (58.89%). This is due to the fact that farmers usually planned their cropping operations according to weather conditions, labour availability and irrigation schedules. Since drone services had to be booked in advance during the spraying season, farmers with better planning were able to utilize the services effectively and complete spraying operations on time. The results are in accordance with the results of Maddikunta *et al.* (2021) [6].

Production Orientation

It was showed in the Table 16 that majority of the respondents had medium level of production orientation (92.22%). The probable rea-

son could be farmers were mainly concerned with obtaining higher yields and reducing crop losses due to pest and disease incidence. They believed that timely and uniform drone spraying provided better crop protection, resulting in healthier crop growth and improved productivity.

Marketing Orientation

It was observed from Table 16 that majority of the respondents had medium level of marketing orientation (88.89%). This is because of most farmers sold their produce through local traders, commission agents and nearby regulated markets. Although they had moderate market awareness, they realized that better quality produce obtained through efficient crop management could fetch better prices and improve farm profitability.

Information accessibility characteristics of drone users in agriculture

Access to formal source of information by drone users in agriculture

Among the formal sources, extension officials of the Horticulture Department and Panchayat officials were the major source for drone users (66.66 %). This might be because farmers usually contact nearby government officials during crop seasons for technical guidance, input recommendations and government schemes, while regular interaction with university scientists and NGOs is comparatively less.

Access to informal source of information by drone users in agriculture

Among the informal sources, family members were the major source of information for both drone users (71.11 %) followed by progressive farmers and neighbours (68.88 %). This is due to the fact that family members and fellow farmers are readily available in the village and farmers trust their practical experience while making farming decisions.

Access to mass media source of information by drone users in agriculture

With regard to mass media, television was the most preferred source among drone users (64.44 %) followed by social media, mobile applications and newspapers. This is because of television and mobile phones are easily available in rural households and provide timely information on weather, crop protection and new technologies in the local language, whereas radio and farm magazines were less preferred due to changing media habits.

Overall Access to source of information by drone users in agriculture

It was observed from Table 17 that majority of both drone user farmers had medium level of access to sources of information (68.15 %). The finding may be attributed to the farmers regular interaction with extension personnel, fellow farmers and other information sources. The results conform to the findings of Ashwini (2023) [7].

Influence of profile characteristics on the knowledge and attitude of drone users towards drone technology

Factors influencing Knowledge of drone users towards Drone usage,

The hierarchical multiple regression analysis performed to determine the contribution of different set of independent variables to the knowledge of farmers towards drone usage indicated the statistical significance of the model by meeting the condition of goodness of fit at each successive block. The Independent variables were entered into the regression model in four successive blocks, namely personal characteristics, information characteristics, psychological characteristics and management orientation, to capture the incremental contribution of each set of variables to the knowledge of farmers.

The findings of the Hierarchical Regression Analysis in the Table 18 indicated that the selected independent variables collectively explained a substantial proportion of the variation in farmers knowledge regarding drone usage. The explanatory power of the models increased progressively from 70.60 per cent in Model 1 to 80.80 per cent in the final model. However, the relatively small increase from 80.50 per cent in Model 3 to 80.80 per cent in Model 4 indicated that management orientation contributed only marginally to explaining knowledge beyond the other variables.

Education emerged as the most influential factor across all four models, with a consistently positive and highly significant effect β value

of 0.828 in Model 1, 0.558 in Model 2, 0.460 in Model 3, 0.471 in Model 4. This might be due to better educated farmers are more capable of understanding technical information, interpreting recommendations and adopting modern agricultural technologies such as drones. Educated farmers are also more likely to access information and comprehend the operational, economic and safety aspects of drone technology, mass media exposure became a significant positive determinant after the inclusion of extension and information variables and remained significant in subsequent models with β value of 0.248 in Model 2, 0.219 in Model 3, 0.226 in Model 4. This is due to exposure to television, newspapers, radio, social media and digital platforms enhances farmers awareness and knowledge of drone technology by providing timely information on its applications, benefits and operational procedures. Farmers who frequently access mass media are more likely to remain informed about technological innovations and government initiatives related to drone services.

Among the psychological variables, scientific orientation showed a significant positive influence on farmers knowledge with β value of 0.212 in Model 3 and standardized β coefficient was 0.20 in Model 4. This might be due to Farmers with a higher scientific orientation are generally more receptive to new technologies, willing to seek technical information and capable of understanding the scientific principles underlying drone operations. Such farmers tend to evaluate innovations objectively and acquire knowledge before adopting new technologies. In contrast, age, landholding, farming experience, extension participation, informal sources, formal sources, economic motivation, planning orientation, production orientation and marketing orientation did not significantly influence farmers knowledge in the final model. The non-significant effect of these variables, this might be attributed due to knowledge about drone services depends more on farmers educational background, access to mass media and scientific outlook than on demographic characteristics or farm management practices. This indicates that drone technology is still an emerging innovation, where knowledge acquisition is primarily by information access and learning ability rather than by farming experience or farm size.

Overall, the hierarchical regression analysis clearly established that education emerged as the single most consistent and important predictor of farmers knowledge towards drone usage across all four models, with mass media exposure and scientific orientation making significant incremental contributions at Model 2 and Model 3 respectively. The non-significant F-change observed in Model 4 indicated that management orientation, while relevant to farm-level decision-making, did not extend farmers technical knowledge of drone usage beyond what was already explained by personal, informational and psychological factors.

Factors influencing attitude of drone users towards Drone usage,

Hierarchical multiple regression analysis was carried out to determine the contribution of different sets of independent variables to the attitude of farmers towards drone usage. The variables were entered into the regression model in four successive blocks. Model 1 included personal characteristics, namely age, education, land holding and farming experience. Model 2 included information variables, namely extension participation, informal sources, formal sources and mass media, in addition to the variables entered in Model 1 and 2. Model 3 incorporated psychological variables, namely economic motivation and scientific orientation. Finally, Model 4 included management orientation variables, namely planning, production and marketing orientation.

The Hierarchical Regression Analysis in the Table 19 showed that the explanatory power of the models increased steadily as additional groups of variables were included. The proportion of variation explained increased from 75.10 per cent in Model 1 ($R^2 = 0.751$) to 90.10 per cent in Model 4 ($R^2 = 0.901$). This indicates that farmers' attitude towards availing drone services is influenced by multiple factors, including personal characteristics, sources of information, psychological characteristics and management orientation. The improvement in the explanatory ability across the four models showed that these factors collectively contribute to shaping farmers perceptions

and acceptance of drone technology. Among the personal characteristics, education consistently exhibited a positive and significant influence on farmers' attitude throughout all four models. The probable reason could be farmers with higher educational attainment are generally more capable of understanding the technical features, operational procedures and economic benefits associated with drone services, thereby facilitating a favourable attitude towards technological innovations.

Farming experience became a significant predictor after the inclusion of extension and sources of information related variables and remained significant in the final model. Farmers with longer farming experience are more familiar with the practical challenges of crop production and are therefore better able to recognize the advantages of drone services, such as timely pesticide application, reduced labour dependence and improved operational efficiency. Their accumulated experience enables them to evaluate new technologies more effectively before making adoption decisions. The extension participation had a positive and significant effect on farmers attitude. Participation in extension programmes, demonstrations, training programmes and farmer meetings exposes farmers to practical information regarding drone operations and their benefits. Such interactions reduce uncertainty and improve farmers confidence in using modern technologies, thereby enhanced a favourable attitude.

Although mass media exposure contributed significantly in the earlier model, its influence became non-significant in the final model after psychological and management variables were included. This was due to mass media mainly creates awareness during the initial stages, whereas farmers attitudes are more strongly influenced by personal motivation, scientific thinking and direct learning experiences. Among the psychological variables, scientific orientation and economic motivation significantly improved farmers attitude towards drone services. Farmers with a stronger scientific orientation are more willing to evaluate innovations objectively and adopt technologies based on their demonstrated advantages rather than on traditional beliefs. Likewise, economically motivated farmers are more likely to appreciate technologies that reduce production costs, save labour and improve profitability.

The addition of management orientation variables further increased the explanatory power of the model. Among these, planning orientation and marketing orientation significantly influenced farmers attitude. Farmers who plan their farm operations systematically are more likely to recognize the importance of timely drone based spraying for efficient crop management. Similarly, farmers with a stronger marketing orientation are more conscious of producing better quality produce and improving market returns, making them more receptive to advanced technologies such as drones.

In contrast, age, landholding, informal information sources, formal information sources and production orientation did not show a significant influence in the final model. This might be due to these characteristics alone are insufficient to shape farmers attitudes towards drone services when educational, psychological and management-related factors are taken into consideration. The findings indicated that favourable attitudes are primarily developed through knowledge, exposure to extension activities, scientific outlook and a desire to improve farm efficiency and profitability. These findings are supported by Chi *et al.* (2024) [8].

Conclusion

The study concludes that drone-based pesticide spraying services have considerable potential to improve the efficiency and accessibility of crop protection practices in agriculture. The study reveals that personal, informational and psychological factors together shape farmers knowledge and attitudes towards drone technology, with personal characteristics contributing the most. This highlights the need for strong capacity building programmes and sustained extension support to enhance farmers' knowledge, skills and confidence in using drones, emphasizing holistic approach to promote its adoption in agriculture.

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