

RESEARCH PAPER

Effectiveness of Digital Extension Platforms in Enhancing Farmers' Knowledge and Decision-Making Ability: A Field-Level Assessment

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ABSTRACT

Digital agriculture seems to be a promising solution to enhance access to scientific information, to boost extension services, and to promote sustainable farming. Evidence of the impacts of digital extension platforms to increase farmers' knowledge and decision-making is still relatively scarce, especially in semi-arid agricultural areas. The present study was undertaken to evaluate the effectiveness of the digital extension platforms in enhancing the knowledge and decision-making ability of farmers in Northern Karnataka, India. An ex-post facto research design was used and data collected from 150 farmers using a structured and pre-tested interview schedule. The effectiveness of digital extension services was evaluated using knowledge improvement, decision making capability, adoption pattern of digital platforms and constraints analysis. The findings show that farmers' overall agricultural knowledge significantly increased when they were exposed to digital advisor platforms (54.6%). The area with the greatest improvement was in the use of information for weather-based decision making and information related to markets. Digital extension services were also used to improve the capacity of the farmers to make informed decisions on their crop management, irrigation scheduling, pest management and marketing. The results of regression analysis showed that the digital literacy, frequency of using smart phone and exposure to education and extension training were major factors affecting the improvement of knowledge. Lack of access to good internet connectivity, lack of digital literacy and difficulty in understanding technical information were highlighted as significant restraints. The study finds that digital extension platforms can be useful complements of traditional extension systems to enhance access to information and farmer decision-making. Enhancing digital infrastructure in rural areas, increasing digital literacy and creating farmer-friendly extension services are crucial to secure inclusive and sustainable digital agricultural transformation.

HIGHLIGHTS

- ① Evaluated the role of digital extension platforms in strengthening farmers' knowledge and decision-making ability in Northern Karnataka.
- ② Provided insights into digital advisory adoption, influencing factors and constraints for improving sustainable agricultural extension services.

Keywords: Digital extension, agricultural advisory services, digital literacy, farmer knowledge, decision-making ability, ICT in agriculture

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Today agriculture is facing several challenges globally such as rising food demand, climate change, natural resources deterioration, loss of biodiversity and uncertainties in agricultural production systems. The challenges are strongly linked to the United Nations Sustainable Development Goals (SDGs), especially SDG 2 (Zero Hunger), SDG 1 (No Poverty), SDG 12 (Responsible Consumption and Production) and SDG 13 (Climate Action) which highlight food security, sustainable resource utilization and climate resilience (FAO, 2023; United Nations, 2023; Ray *et al.* 2025). In order to be sustainable, agricultural systems should increase productivity, increase farmer resilience and ensure efficient use of natural resources while minimizing environmental impacts (Pretty *et al.* 2018; Rockström *et al.* 2026). Smallholder farmers, who face the high risk of climate variability and market uncertainties, and have relatively low access to scientific knowledge and extension support, make significant contribution to global food production (Lowder *et al.* 2021; Sairam *et al.* 2025). Traditional extension systems have been important in disseminating technologies and developing farmers' capacities, but they are frequently under-resourced in terms of extension staff, geographic limitations, and the timeliness of information and technology transfer and farmer-expert relationships (Feder *et al.* 2011; Birner *et al.* 2021). As climate and socio-economic conditions are continually changing, farmers now need timely, place-specific and reliable information to guide their crop production, input management, resource conservation and marketing decisions (Fabregas *et al.* 2022; Atapatakar and Vasanthi *et al.* 2025). Digital transformation and knowledge-based agricultural systems have been identified as key pillars to enhance agricultural extension, make information more available and support sustainable agricultural development (Klerkx *et al.* 2019; Yuan and Sun, 2024; Maitra *et al.* 2026a).

Digital transformation of agriculture has become one of the key methods to enhance the delivery of agricultural information and agricultural extension. Digital Agricultural Extension platforms such as Mobile App, agricultural extension social media platforms, weather platforms and online extension agricultural resources allow information targeting farmers in real time and customized manner. These technologies enhance access to

agricultural knowledge, promote technology uptake and promote evidence-based decision making. The implementation is only successful if digital infrastructure, affordability, digital literacy and the quality and relevance of information provided (Choruma *et al.* 2024; Maitra *et al.* 2026b) are in place.

Digital extension services overcome some of the shortcomings of traditional extension services that are able to facilitate two-way communication between farmers, experts and service providers. Mobile advisory helps in giving weather, pest and disease management, crop practice and market information in real time. According to Anteneh and Melak (2024), ICT-based extension services can improve the accessibility of information and advisory services to smallholder farmers, but there are significant challenges in connectivity, digital skills and institutional support.

Digital agriculture is emerging as an important part of agriculture modernization in developing countries such as India. The growing penetration of the smart phone and Internet has opened the door to a revolution of reengineering traditional extension programs to become a digital advisory service for the general public. Farmers use WhatsApp groups, mobile applications, online videos and weather advisory platforms to get the information they need for farming. The effectiveness of using the technology, however, relies on the education of the farmers, their digital literacy, the perceived usefulness, and level of trust and frequency of interaction with the digital platforms (Billah *et al.* 2021; Gao *et al.* 2024).

Digital extension platforms play a role in sustainable agriculture by enhancing the efficiency of using resources and facilitating climate-smart decision-making. Real-time weather data helps farmers draw up their sowing and watering plan; it helps them manage pests; and digital market information helps increase market access and minimizes information gaps. Access to digital agricultural technologies has been linked to improving productivity and income, among smallholders, by providing better information and data to guide decisions (Krishna *et al.* 2024; Mhlanga and Ndhlovu, 2025). Poor connectivity, lack of digital skills, language barriers and low awareness of small and marginal farmers



are, however, posing a significant challenge to the digital divide.

Enhancing digital agricultural extension systems is crucial to inclusive agricultural development in India. A few digital advisory programs have been launched, but not many studies have tested the effectiveness of these programs for raising farmers' knowledge and ability to make decisions. Most of the previous research has been on awareness and uptake of digital technologies, but not on the impact of digital technologies on farmer-level outcomes.

The region of northern Karnataka is a significant agricultural area with a variety of cropping systems, semi-arid climatic situation and reliance on agriculture for the rural livelihoods. The rainfall unpredictability, scarcity of water, farmers' problems with pests and diseases, rising input costs, and market uncertainties are the key issues faced by farmers in this region, underscoring the importance of prompt and reliable agricultural advice for farmers. There is limited evidence of the effectiveness of digital extension platforms in enhancing farmers' knowledge and decision-making capacity, although they are becoming more popular.

For this reason, the current study was initiated to assess the effectiveness of the digital extension platforms to improve the knowledge and decision-making capacity of the farmers in Northern Karnataka. The study sought to determine the socio-economic attributes and characteristics of the farmers, and their access to digital extension tools; measure changes in knowledge after exposure to digital extension tools; measure changes in farm decision making capacity; measure factors affecting changes in farmers' knowledge; analyses constraints associated with utilising digital extension tools.

MATERIALS AND METHODS

Description of the study area

The study took place in the North of Karnataka, India, to assess the effectiveness of digital extension platforms on enhancing farmer's knowledge and decision-making skills. It is a significant farming region with a wide variety of agriculture systems, semi-arid climate, low consistency of precipitation and small and mediumholder predominance. The study was undertaken in the major agricultural districts, viz., Dharwad, Belagavi, Vijayapura,

Bagalkot, Gadag and Haveri. The farming system here is primarily cereal, pulse, oilseed, cotton and horticultural crops. Climate change variability, pest and disease infestation, input management and market uncertainties are common problems faced by farmers. The region is also well suited for evaluating the potential of digital extension platforms to improve farm level knowledge and decisions, as internet access and the availability of smartphones are increasing, and mobile internet use is rising.

Research design and sampling procedure

An ex-post facto research design was used to evaluate the effectiveness of the existing digital extension platforms utilized by farmers. The selection of the respondents was done in a multistage sampling procedure. The study was conducted in a purposive location in the state of Karnataka in the north, due to its agricultural significance and growing adoption of digital advisory services. Seven districts (Dharwad, Belagavi, Vijayapura, Bagalkot, Gadag, Haveri) were chosen and villages in which there was a user base for digital agricultural services were identified with the help of extension staff. A proportionate random sampling of 150 farmers was done. The data were gathered in the 2025-2026 farming season using structured and pre-tested interview schedule through personal interview. Socio-economic data, digital extension use, knowledge and decision making capacity and constraints related to digital extension services were gathered.

Development of research instrument

A questionnaire was designed to guide the interview process, reflecting the study's goals and previous studies on agricultural extension through ICTs and digital tools. The schedule contained details regarding socio-economic characteristics, use of digital platforms, enhancement of knowledge, decision-making capacity and its limitations with digital extension services. Socio-economic variables of farmers were age, education, land holding size, farming experience, income and usage of smart phone by farmers. How this is being used virtually was measured by: (1) type of platforms accessed; and (2) frequency of use and purpose of information seeking. Crop production practices, pest and disease management, irrigation, nutrient management, weather advisories and market

information were assessed for knowledge. Decision-making skills were assessed in crop selection, pest management, irrigation scheduling, fertilizer usage, planning according to weather conditions, marketing decisions, and access to government schemes. The content of the interview schedule was validated for its face and content using experts from the field of agricultural extension and agricultural engineering/ digital agriculture. A preliminary survey was carried out outside the study area and the pertinent modifications were put in before the final data collection.

Measurement of farmers' knowledge level

The knowledge acquired by farmers on digital extension platforms was evaluated through a structured knowledge test of crops production and farm management practices. One point was given for each correct answer and a zero for incorrect or unknown answers. Individual knowledge scores were determined by adding the responses and improvement was judged by comparing the pre- and post-exposure knowledge scores.

The percentage knowledge improvement was calculated as:

$$\text{Knowledge improvement (\%)} = (\text{Post-extension knowledge score} - \text{Pre-extension knowledge score}) / \text{Pre-extension knowledge score} \times 100$$

The significance of difference between pre- and post-exposure knowledge scores was tested using a paired t-test.

2.5 Assessment of farmers' decision-making ability

The impact of digital extension platforms on farmers' decision-making capacity was evaluated through the key indicators of farmers' farm management such as crop selection, pest and disease identification, scheduling irrigation, fertilizer management, weather-based planning, marketing decisions, and access to government schemes.

A decision-making ability index was calculated as:

$$\text{Decision-making ability index} = (\text{Obtained score} / \text{Maximum obtainable score}) \times 100$$

Assessment of digital extension platform adoption

The extent to which digital extension platforms have been adopted was measured by frequency and intensity of use. Data were gathered on WhatsApp advisory groups, mobile agricultural applications, weather services, YouTube agricultural videos and SMS advisories and internet market information platforms. The farmers were grouped into regular, occasional and non users based on the frequency of usage. The adoption index was calculated as:

$$\text{Adoption Index} = (\text{Total obtained score} / \text{Maximum possible score}) \times 100$$

The most preferred sources of agricultural information were identified by ranking the digital platforms based on their adoption index values.

Identification and ranking of constraints

Constraints for the digital extension use were determined with a structured schedule, including technological, social and infrastructural constraints. Farmers were requested to rank the constraint in terms of degree of constraint. Garrett's ranking technique (Garrett & Woodworth, 1969) was used to analyze the data. The percentage position was calculated as:

$$\text{Percentage position} = (100 (R_{ij} - 0.5)) / N_j$$

where R_{ij} represents the rank assigned to the i^{th} constraint by the j^{th} respondent and N_j represents the total number of constraints ranked. Garrett scores were obtained from percentage positions, and constraints were ranked based on mean scores.

Statistical analysis

The data collected was analyzed by using descriptive and inferential statistics. Socio-economic characteristics and pattern of digital extension usage were described using frequency, percentage, mean and standard deviation. Paired t-test was used to test the improvement of the farmers' knowledge following exposure to digital extension. Pearson correlation was calculated to look at the relationship between socio-economic variables and improvement



of knowledge. To find the factors affecting the improvement in knowledge using digital extension platforms, multiple linear regression analysis was carried out. Education, landholding size, income, frequency of using the smartphone, exposure to digital literacy and extension training were the independent variables and the knowledge improvement score the dependent variable.

The regression model used was:

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + \dots + b_nX_n + e$$

where Y represents knowledge improvement score, a is the intercept, b represents regression coefficients, X represents independent variables and e represents error term. Statistical significance was tested at 5% and 1% probability levels.

Ethical considerations

Ethical research practices were followed in the process of data collection in the study. The respondents were briefed on the objectives of the study and their participation was voluntary. Each child's response was kept confidential and any information collected for research use only.

RESULTS AND DISCUSSION

The socio-economic profile of the respondents along with their digital extension access pattern is presented in Table 1. The results showed that most of the respondents (50.7%) were in the middle age of 35 – 50 years, 25.3% were below 35 years and 24.0% were above 50 years old. In terms of educational qualification, 37.4% of the respondents were secondary educated farmers, 35.3% were graduated and above level while only 8.0% were illiterate farmers. Most of the farmers were in small (40.7%) and medium (32.0%) categories. With regard to various digital extension channels, agricultural advisory groups through WhatsApp were the most accessed channel (68.0%), followed by mobile extension applications (52.0%), weather advisory services (47.3%) and agricultural videos on YouTube (42.0%). The results showed the mobile based digital platforms as a significant medium of agricultural information among farmers in the northern part of Karnataka.

Lack of mobile technology knowledge and education are linked to the lack of acceptance of digital extension services, as seen in the dominance of middle-aged and educated farmers among the users of digital extension services. The higher the level of education of the farmers, the more able they are in searching, interpreting and utilizing digital agricultural information. Bohara and Gurung, 2025 conducted a study to explore digital competency and communication skill for digital knowledge among farmers, which resulted in an ICT-based farmer digital literacy scale, and highlighted the importance of digital knowledge, competency, and digital communication skills in the process that shape farmers' interactions with agricultural ICTs. This indicates a higher adoption of WhatsApp and mobile apps in the present study, which can be linked to lower cost of the applications, ease of use, and the ability to quickly share location-specific information. Digital agricultural extension and advisory services are also important, with a strong potential to help make information available and accessible to smallholder farmers, but digital skills and infrastructure still play a significant role in how well these services are used, said the Food and Agriculture Organization (FAO). Odera *et al.* (2025) highlighted the need to strengthen the digital agricultural extension by enhancing connectivity and digital capacity, along with the service delivery mechanisms for reaching farmers.

The impact of digital extension platforms on the enhancement of farmers' knowledge is shown in Table 2. All aspects of knowledge increased significantly following digital extension services. The overall knowledge score rose by 54.6% from 69.1 before exposure to digital extension platforms to 106.8 after digital extension platform adoption. Paired t-test value ($t = 25.73$) showed that the improvement was significant at 1% probability level. Maximum improvement was attained in knowledge domain of weather based decision making (65.7%), market information and price forecasting (64.3%), pest and disease management (56.1%), irrigation management (51.2%) and crop production technologies (48.4%), among the various knowledge domains. The results from these findings suggest that digital extension platforms have been successful in increasing farmers' access to timely and relevant agricultural information.

Table 1: Socio-economic profile and digital extension access characteristics of farmers in Northern Karnataka ($n = 150$)

Characteristics	Category	Frequency (No.)	Percentage (%)
Age group (years)	<35 years	38	25.3
	35–50 years	76	50.7
	>50 years	36	24.0
Educational status	Illiterate	12	8.0
	Primary education	29	19.3
	Secondary education	56	37.4
	Graduation and above	53	35.3
Landholding size	Marginal (<1 ha)	25	16.7
	Small (1–2 ha)	61	40.7
	Medium (2–4 ha)	48	32.0
	Large (>4 ha)	16	10.6
Farming experience	<10 years	28	18.7
	10–20 years	67	44.7
	>20 years	55	36.6
Smartphone usage frequency	Daily	96	64.0
	Weekly	42	28.0
	Occasionally	12	8.0
Digital extension platforms used	WhatsApp advisory groups	102	68.0
	Mobile agricultural applications	78	52.0
	YouTube agricultural channels	63	42.0
	Weather advisory services	71	47.3
	SMS/IVR services	39	26.0

Table 2: Effect of digital extension platforms on farmers' knowledge improvement (before and after assessment)

Knowledge components	Before digital extension (Mean score)	After digital extension (Mean score)	Improvement (%)	t-value
Crop production technologies	12.6 ± 2.8	18.7 ± 2.2	48.4	18.62**
Pest and disease management	11.4 ± 2.5	17.8 ± 2.3	56.1	20.14**
Irrigation and water management	12.1 ± 2.6	18.3 ± 2.1	51.2	19.36**
Nutrient management practices	13.0 ± 2.7	19.0 ± 2.4	46.2	17.25**
Weather-based decision making	10.2 ± 2.4	16.9 ± 2.3	65.7	22.41**
Market information and price forecasting	9.8 ± 2.2	16.1 ± 2.5	64.3	21.08**
Overall knowledge score	69.1 ± 8.2	106.8 ± 7.6	54.6	25.73

Note: Values represent mean ± standard deviation; Significant at $p \leq 0.01$.

The dramatic increase in the farmers' learning, following the use of the digital extension platforms, is an indication of the potential of ICT-based extension delivery to address challenges of conventional extension delivery. Digital platforms can offer round-the-clock access to the advice of experts, weather forecasts, pest warnings and market data, helping farmers make informed decisions. The

greater improvement reported for weather-based decision-making and market information could be attributed to the growing significance of climate variability and market uncertainty at the present time in today's agriculture. Digital agricultural extension services can enhance the access to, timeliness and quality of agricultural information, especially for smallholder farmers who often lack



access to traditional extension personnel (FAO 2023). More recent research also revealed that farmers' cognition and understanding of digital technologies are significant factors that impact their willingness to utilize sustainable digital agricultural extension services. The current findings have helped confirm the notion that digital extension is not an alternative to traditional extension, but a complement to better disseminate knowledge and improve extension-farmer linkages.

The impact of digital platforms that provide extension services on farmers' decision making is summarized in Table 3a. It was found that there was a significant improvement in all the evaluated parameters of decision making following the use of digital advisory services. The largest improvement was in farm planning based on weather (42.0%), pest and disease identification (41.3%), irrigation scheduling decisions (38.0%), access to government schemes (37.4%) and fertilizer management decisions (36.0%). The number of farmers in the high category of decision making ability rose from 7.3% to 49.3% after digital extension adoption, while those in the low category decreased from 54.0% to 13.3% after adoption. These findings show that digital extension services increased farmers' ability to make informed and timely farm decisions.

Real time information, farmer's advisory messages and farmer's networks online have led to better decision making by farmers. Digital extension platforms can help farmers make better use of resources by offering them crop-specific recommendations at the right time in the crop lifecycle, minimizing uncertainty around input management. The results are similar to what Miine *et al.* (2023) found, that access to digital agricultural services enabled farmers to better access production information and market intelligence and agricultural advisory services. They are especially helpful in the context of climate change, as they deliver weather predictions and risk management data to enable adaptation-driven decision-making. Such integration can then enhance the capacity of agricultural extension to support farmers in adapting to climate change and boost their livelihoods. But, for effective decision support, it is important to have reliable information, place based recommendations and farmer trust in digital advisory sources.

Table 3a: Influence of digital extension platforms on farmers' decision-making ability

Decision-making indicators	Before adoption (%)	After adoption (%)	Improvement (%)
Selection of suitable crop varieties	46.7	79.3	32.6
Pest and disease identification	42.0	83.3	41.3
Irrigation scheduling decisions	39.3	77.3	38.0
Fertilizer application decisions	45.3	81.3	36.0
Weather-based farm planning	34.0	76.0	42.0
Market-oriented selling decisions	37.3	72.7	35.4
Access to government schemes	31.3	68.7	37.4

Table 3b shows the distribution of farmers based on the extent of their decision-making power before and after exposure to digital platforms for extension. Prior to digital extension, the farmer low decision making group accounted for 54.0%, the medium group 38.7% and the high group 7.3% of farmers.

Table 3b: Overall decision-making ability index

Category	Before digital extension (%)	After digital extension (%)
Low (<50%)	54.0	13.3
Medium (50–75%)	38.7	37.4
High (>75%)	7.3	49.3

The percentage of the farmers in the high ability to make the decision has decreased significantly from 4.8% before exposure to 49.3% after exposure, while the percentage of farmers in the low ability to make decision has decreased from 15.3% before to 13.3% after exposure and the percentage of farmers in the medium ability to make decision has decreased from 37.4% before to 37.4% after exposure. This change meant there was an improvement in farmers' capacity to access the digital information in time to make informed decisions on crop management, irrigation, pest and disease management, input use, and weather-based decision making and marketing. In other studies, the use of digital agricultural extension has been found to have a positive impact

on access to information and the ability of farmers to make informed decisions on their farms, as long as the services are accessible and relevant to farmers' needs (Nwangwu *et al.* 2024; Gumbi *et al.* 2024).

The factors affecting the improvement of farmers' knowledge on digital extension channels are summarized in Table 4a. Multiple regression analysis showed that digital literacy, frequency of using a smartphone and extension trainings exposure and level of education were significant factors in determining knowledge improvement. The model of regression accounted for 67% of the variation in the improvement of knowledge ($R^2 = 0.67$), which suggests that there is a strong relationship between the variables selected and the improvement in farmers' knowledge. Digital literacy showed the highest positive influence ($\beta = 0.382$, $p < 0.01$), followed by smartphone usage frequency ($\beta = 0.254$, $p < 0.05$), extension training exposure ($\beta = 0.221$, $p < 0.05$) and education level ($\beta = 0.218$, $p < 0.05$). The results suggest that farmers' capacities to access, understand and use digital information are important for the effectiveness of digital extension.

The impact of the digital literacy is significant and means that farmers who have higher digital literacy are more likely to be able to access, understand, and utilize agricultural information provided digitally. The shift to digital tool use does not bring about knowledge improvement without the skills and confidence of farmers using the tools. The findings align with Yin *et al.* (2025) who noted that digital awareness and cognitive capacity of the farmers is a crucial factor in the adoption and successful use of digital agricultural extension services. The positive impact of the use of mobile phones and extension training shows that the frequency and capacity development of people is crucial for a successful digital extension. Repeated use promotes familiarity with digital advisory platforms, and training fosters understanding and uptake of recommendations. Fabregas *et al.* (2019) and Klerkx *et al.* (2019) highlighted the need for digital agriculture to be accompanied by training of farmers and institutional support to obtain tangible results. Thus, enhancing the digital literacy programs and extension-based training can make a difference in the impact of digital advisory services to farmers.

The major constraints of the farmers to use digital extension platform are presented in Table 4b. Lack

of internet connectivity was mentioned as the most critical constraint followed by lack of digital literacy, lack of understanding of technical information, lack of knowledge about existing digital platforms and language barriers. The results highlight the need for skills gaps and limitations in infrastructure which hinder effective use of digital agricultural advisory services, even as mobile phone penetration among farmers has grown.

Table 4a: Factors influencing effectiveness of digital extension platforms

Independent variables	Regression coefficient (β)	Standard error	t-value	Significance
Education level	0.218	0.067	3.25	**
Landholding size	0.142	0.061	2.33	*
Annual farm income	0.176	0.068	2.59	**
Smartphone usage frequency	0.254	0.073	3.48	**
Digital literacy score	0.382	0.081	4.72	**
Extension training exposure	0.221	0.065	3.40	**

The lack of sufficient internet connection is the major constraint, which underlines the need for good digital infrastructure in rural areas for effective digital extension services. Yuan and Sun (2024) noted that connectivity constraints and access inequities to digital resources are significant challenges in digital transformation for smallholder farmers. The FAO (2023) underscored the need for affordable connectivity and enabling digital infrastructure for inclusive digital agriculture as well.

The barriers associated with digital literacy and technical knowledge indicate the need for proper training for farmers as well as availability of digital services. According to Anteneh and Melak (2024), the use of ICT-based extension services can enhance farmers' access to information, however, the success of such interventions is dependent on the digital literacy and institutional support of farmers. The lack of linguistic capabilities also underlines the importance of locally relevant and farmer-friendly digital content. Foreseeing the potential of digital



advisory systems, Ofosu-Ampong *et al.* (2025) argued that user behaviour, accessibility, and trust should be taken into account to boost adoption and long-term impact. Therefore, the enhancement of connectivity, digital literacy and local content production are crucial to support digital extension.

Table 4b: Constraints affecting utilization of digital extension platforms

Constraints	Mean score	Rank
Poor internet connectivity	78.4	I
Lack of digital literacy	72.6	II
Difficulty understanding technical information	66.2	III
Lack of awareness about digital platforms	61.8	IV
Language barriers	55.7	V
Limited smartphone access	53.4	VI
High mobile data cost	46.8	VII
Lack of trust in online recommendations	42.5	VIII

CONCLUSION

The present study showed the digital extension platforms are important in enhancing farmers' knowledge and boosting their decision making capability among farmers in Northern Karnataka. The results showed that mobile based advisory systems, such as agricultural groups on WhatsApp, mobile applications, and weather advisory systems are emerging as significant sources of agricultural information for farmers. Farmers' knowledge regarding crop production technology, management of pests and diseases, irrigation schedule, nutrient management, and weather-based advisories and market information has significantly improved after their exposure to digital extension platforms. The access to digital advisory services had a significant effect on the overall knowledge score, showing the potential of the digital platforms to improve farmers' access to timely and relevant agricultural knowledge.

The study also found that digital extension services had a positive effect on the farmer's decision-making at the farm level, as farmers were empowered to make informed decisions about crop selection, pest management, irrigation scheduling, fertilizer application and weather-based planning and marketing. The positive changes in decision making

authority of farmers after exposure to digital extension indicate the role that digital extension can play in supporting traditional extension methods. Regression analysis revealed that digital literacy, frequency of using smartphone and exposure to education and extension training were significant factors impacting digital extension platforms' effectiveness. The results highlight the need to equip farmers with digital skills along with the provision of digital infrastructure.

While the advantages were noted, there were also a number of limitations in the use of digital extension services, including weak internet connectivity, lack of digital literacy, challenges in interpreting technical information and lack of knowledge of the available digital platform. Hence, future digital agricultural extension strategies should aim to improve the internet infrastructure in the rural areas, creation of digital content in local languages of the rural regions and for farmers' benefit, digital literacy training programmes and the incorporation of digital tools into the existing extension networks.

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