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Determinants of e-readiness among agricultural extension personnel: Evidence from Punjab

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Abstract

The study determined the preparedness of agricultural extension personnel toward the use of Information and Communication Technology using a standardized E-Readiness index developed to assess digital readiness in agricultural development. The present quantitative study was conducted among 104 extension personnel working in Farm Science Centre or Krishi Vigyan Kendra and the State Department of Agriculture in Punjab. Data were collected through personal interviews using simple random sampling. Principal factor analysis and Likert scaling techniques were employed to construct and validate a composite E-Readiness Index for the agricultural extension system. Findings revealed that 36.53 percent of extension personnel exhibited a high level of E-Readiness, while the overall composite E-Readiness Index score was 0.50, indicating a moderate level of preparedness. The study concluded that awareness and willingness among personnel were high; however, limited access and skill constrained effective utilization of ICT tools. Strengthening institutional infrastructure and enhancing ICT competencies through regular training are essential to bridge the gap between awareness and practice and to promote a digitally empowered extension system.

Keywords: Composite index, e-readiness, extension personnel, extension system, ICT

1. Introduction

Rapid advancement and increasing availability of digital tools are leading agriculture towards digitalization which refers to the use of digital technologies for effective management and decision-making in agriculture (Daum *et al*., 2021) [20]. India, with its diverse agricultural landscape and varied agro-climatic zones, stands at the nexus of agricultural innovation and development (Sondarva *et al*., 2023) [70]. Agricultural extension acts as a staple mechanism for information exchange from lab to land in agriculture. Hence, it becomes essential in this digital age to create a robust digital agricultural extension system in disseminating knowledge and technologies generated by the research system to the diverse stakeholders groups thereby enhancing productivity and sustainable agricultural growth (Suresh *et al*., 2022) [73]. Extension professionals serve as intermediaries between governmental, non-governmental, and farming communities, facilitating two-way communication and technological dissemination (Mavhunduse & Holmner, 2019).

Amidst ongoing digital transformation, integration of Information and Communication Technology (ICT) has increased significantly over the past few years in agriculture for achieving efficiency and inclusivity in agricultural development (Potluri & Vajjhala, 2021; James & Minithra, 2023) [59, 28]. An E-ready extension educator, an E-ready service provider, and an E-ready farmer are critical enablers for digital readiness as it also promises technology-driven benefits for its stakeholders (Rai *et al*., 2018; Patil *et al*., 2023) [63, 58]. ICT based extension brings opportunities which facilitates farmers empowerment, agricultural productivity strengthen value chains and supports food security (Gow *et al*., 2020; Rodriguez *et al*.,2022) [24,]. Digital transformation in agriculture, often termed "Agriculture 4.0," is characterized by high-tech, data-driven, and interconnected innovations that revolutionize advisory services (Klerkx & Rose, 2020) [32].

At both national and global levels, the concept of E-Readiness representing the preparedness and capacity of individuals or systems to use ICTs effectively is gaining prominence (Navani & Ansari, 2020) [50]. In agricultural extension, it reflects the capacity of extension personnel and farmers to utilize digital tools for knowledge dissemination and development (Koyu *et al*., 2018; Rai *et al*., 2018) [33, 63]. In agriculture, E-Readiness assessment provides a strategic basis for evaluating digital capabilities, infrastructure, and human competencies that underpin ICT adoption. Measuring E-Readiness in the agricultural extension system is essential to bridge the digital divide and empower extension personnel and farmers with digital skills, tools, and confidence (Samdder & Rao, 2023) [67]. Widespread adoption of mobile phones has modernized extension

services, enabling farmers and extension agents to exchange agricultural information efficiently. In India, particularly in Punjab, mobile-based applications, social media, and digital advisory systems have become integral components of extension services. However, disparities persist in ICT accessibility, ownership, and competency levels among extension personnel, resulting in uneven digital engagement (Navani & Ansari, 2020) [50].

Assessing E-Readiness of extension personnel is, therefore, crucial for identifying technological gaps, skill deficiencies, and behavioural readiness toward ICT integration. Understanding these aspects provides valuable insights into the factors influencing digital adoption and supports the development of targeted interventions to strengthen digital extension ecosystems. Based on these considerations, the present study examines the determinants of E-Readiness among agricultural extension personnel in Punjab. It is hypothesized that extension personnel exhibit a moderate level of E-Readiness, primarily influenced by their access, awareness, skills, and willingness to utilize ICT tools and platforms. The study aims to contribute to the growing discourse on digital capacity-building in agricultural extension, offering empirical evidence to guide policy and training strategies for an inclusive and technology-enabled agricultural development system.

2. Materials and Methods

The study was carried out in the agriculturally progressive state of Punjab, located in the northwestern region of India, renowned as the *food basket of the nation* due to its intensive and diversified agricultural practices. The state comprised twenty-three districts, representing five distinct agro-climatic zones, and housed the Punjab Agricultural University (PAU), a premier agricultural institution established in 1962. Data were collected through personal interviews using a pre-tested semi-structured interview schedule from 104 respondents including 74 Agricultural Development Officers (ADOs) and 30 Subject-Matter Specialists (SMS) working in Farm Science Centres or Krishi Vigyan Kendras (KVK) and the State Department of Agriculture and Farmers Welfare across five districts *viz.* Ludhiana, Gurdaspur, Ropar, Ferozpur, and Bathinda functioning under the administrative control of PAU. The selection of respondents followed a simple random sampling method to ensure representativeness of all agro-climatic zones.

The instrument elicited information on demographic characteristics, communication behaviour, educational background, ICT exposure, training, and utilization of ICT tools in advisory and administrative work. The descriptive research design was adopted, and data collection was conducted through extensive field visits and personal observations to ensure accuracy, reliability, and diversity in responses.

An E-Readiness Index was developed to assess the individual-level preparedness of extension personnel toward ICT use. The construct of E-Readiness was operationally defined through twelve potential ICT-related indicators identified from literature (Naik, 2014; Raksha *et al*., 2014) [49, 61] and expert consultation. These included *E-accessibility, E-skill, E-frequency of use, E-ownership, E-awareness, E-willingness to pay, E-availability, E-motivation, E-infrastructure, E-affordability, E-literacy,* and *E-governance.* These indicators were circulated among 300 extension experts from four State Agricultural Universities in India for ranking on a five-point Likert scale through Google Forms, which resulted in 107 responses. The rank scores were subjected to Principal Component Analysis (PCA) by modifying method of Rabii & Abdelaziz, (2015) [60] which extracted six principal indicators *E-skill, E-ownership, E-accessibility, E-frequency of use, E-awareness,* and *E-willingness* that explained over 80 percent of the total variance.

The factor loadings of the indicators derived from PCA were applied as weights for computing the composite E-Readiness Index, following the methodology adopted by Naik (2014) [49]. The values were taken as Wi and the composite E-Readiness index was constructed using the formula below.

$$\text{Composite E-Readiness Index} = \frac{\mathbf{WiXi}}{\mathbf{Wi}} = \frac{W1X1+W2X2+W3X3+W4X4+W5X5+W6X6}{W1+W2+W3+W4+W5+W6}$$

Where,

X_i signifies the sub index value of the concerned indicator

W_i signifies the Weights associated with Xi indicator

The final composite scores, ranging from 0 to 1, were classified into five categories *very low*, *low*, *moderate*, *high*, and *very high E-Readiness* following the modified framework of Aydin and Tasci (2005) [6]. The content validity of the index was ensured through literature support and expert review, while reliability was tested using the test–retest method wherein the same instrument was administered to 30 respondents outside the sample area after an interval of 15 days yielding a correlation coefficient of 0.80, indicating high reliability. It was ensured that all critical aspects of ICT readiness were captured. The Statistical Package for Social Sciences (SPSS, Version 26) was used for analysis employing frequency, percentage, mean, correlation, and regression to interpret results.

3. Results and Discussion

3.1 Construction of E-Readiness index

All twelve ICT-related indicators were subjected to Principal Component Analysis (PCA) to identify the key variables explaining maximum variance in the E-Readiness of extension personnel. Six principal indicators *viz.* E-skill, E-ownership, E-accessibility, E-frequency of use, E-awareness, and E-willingness were extracted, accounting for about 80 percent of the total variance, indicating their strong contribution to the composite construct (Table 1). By assigning appropriate weights to these indicators based on their respective contributions to the explained variance, a weighted composite index score was computed to represent the overall level of individual E-Readiness. The retained indicators reflected multiple dimensions of ICT readiness among the respondents ranging from their awareness and accessibility to the skills and motivation required for ICT use.

Table 1: Factor loadings of indicators

Composite index	Major indicators	Factor loadings	Percent of variation explained by composite sub-indicators
E-Readiness index	E-access	0.421	34.031
	E-skill	0.165	13.367
	E-frequency	0.125	10.159
	E-ownership	0.107	8.681
	E-awareness	0.095	7.726
	E-willingness	0.083	6.713
	Cumulative%		80.678

The factor loading values obtained from PCA were treated as *Wi* and were used as weights for constructing the index. Each indicator's standardized score (*Xi*) was multiplied by its corresponding weight to derive the weighted sub-index. The composite E-Readiness Index for each respondent was then computed using the formula:

$$\text{Composite E-Readiness Index} = \sum(Wi \times Xi)/Wi$$

The PCA results validated that E-skill and E-ownership contributed most prominently to E-Readiness, followed by E-accessibility and E-awareness, emphasizing the multidimensional nature of ICT preparedness. The computed index thus provided a statistically reliable measure of individual readiness to adopt and integrate ICT tools in extension delivery. This aligns with findings by Naik (2014) [49] and Raksha (2014) [61], who also reported that skill and access remain critical determinants of digital preparedness among agricultural professionals. The index values were classified into five categories very low, low, moderate, high, and very high based on the modified e-learning readiness framework used by Aydin and Tasci (Figure 1) This classification enabled a clear interpretation of respondents' preparedness towards ICT use in extension delivery.

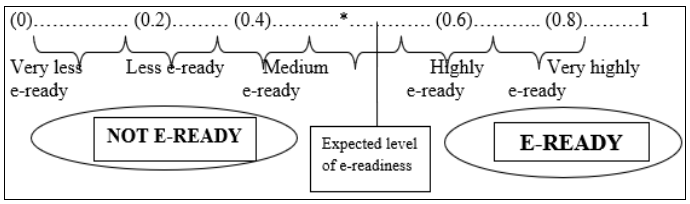

Fig 1: Assessment of E-Readiness level (Modified after Aydin and Tasci 2005) [6]

3.2 Components of E-Readiness among Extension Personnel

Awareness and Willingness towards ICT tools

Awareness of e-resources is the foremost and most important factor to quantify E-Readiness that was operationally defined as the individual's ability to understand real use of ICT tools and devices. Findings revealed a pronounced level of ICT awareness among extension personnel. Nearly all respondents were *well-acquainted* with mobile-phone functionalities and mobile operating system Awareness regarding computer operations was at par with mobile awareness while WhatsApp was most prominent ICT tool as some important functions of WhatsApp aids the extension personnel in directing the farmers. Conversely, awareness of institutional based social media platforms such as the PAU's YouTube channel, Facebook page and Instagram account remained comparatively limited (Figure 2).

These findings indicate that extension personnel are conceptually well-informed yet selectively engaged with the digital ecosystem. Their strong awareness of mobile and computer system suggests that technological exposure has permeated the grassroots level. However, the relatively lower familiarity with institutional digital initiatives points to fragmented awareness diffusion, likely due to limited internal promotion and inadequate cross-platform visibility. They showed less awareness regarding Instagram, Facebook and YouTube channel of PAU. Similar results obtained by Raksha (2014) [61]; Kale *et al*. (2015) [30]; Bhaumika and Priyadarshni (2020) [10]. Hence, the extension personnel can be sensitized towards incorporation of social media apps in advisory services as it can aid in real-time problem solving and networking with other stakeholders.

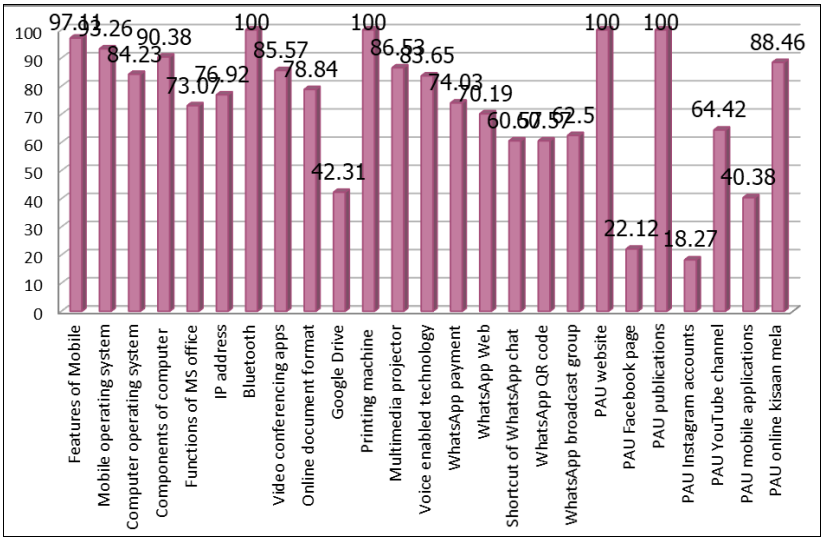

Fig 2: E-Awareness of extension personnel towards ICT

E-Willingness reflects the preference of the individual towards ICT tools and devices to continue using them. As presented in Table 2, extension personnel displayed a highly affirmative disposition toward ICT adoption with overall mean score of 2.60 with the highest mean score recorded for willingness to pay for internet services also willing to continue using ICT. These results indicate a strong intrinsic motivation to invest in and engage with digital platforms. Such behavioural intent is an important psychological factor for technology adoption and shows that the personnel can act as drivers of digital change.

These findings reflects positive orientation toward ICT-based interventions, suggesting that technology is perceived not merely as a tool but as an integral medium for professional efficiency and outreach. Sustained institutional support through periodic skill-upgradation, incentives, and recognition mechanisms is, however, essential to convert this willingness into regular, effective practice. Similar motivational trends have been documented by Raksha (2014) [61], Afzal *et al*. (2016) [1] and Onu & Ezhim (2019) [56] reinforcing that a favourable attitudinal environment can significantly accelerate digital assimilation in agricultural extension.

Table 2: E-Willingness of extension personnel

Statements	Mean score	Rank
Continue using ICT tools	2.44	VI
Advising and counseling using ICT	2.59	IV
Learn about modern ICTs	2.70	II
Online training through ICT	2.60	III
Ready to pay for internet services	2.86	I
Support government policies for ICT based extension	2.57	V
Overall Mean Score	2.60	

Note: Scores based on a 3-point Likert scale (3 = Very much willing; 2 = Somewhat willing; 1 = Not at all willing).

Ownership and Accessibility towards ICT tools

E-Ownership reflects as the number of ICT tools and devices possessed by participants at individual level while E-Accessibility was defined as the ease of being able to use ICT tools and devices The analysis (Table 3) revealed differential patterns of ICT ownership and accessibility among the surveyed extension personnel. The mean ownership score for gadgets was 0.46, indicating that nearly half of the respondents personally possessed major ICT tools such as smartphones, laptops, or personal computers. The corresponding accessibility score (0.51) was marginally higher, implying institutional sharing or occasional access to these devices at the workplace. Smartphones registered complete ownership and accessibility signifying ubiquitous penetration of mobile technologies. Networking technologies exhibited moderate levels of ownership and accessibility (mean = 0.39), reflecting fair individual connectivity primarily through Wi-Fi and dongle services. Storage devices such as printers, webcams, and recording instruments recorded comparatively low mean scores (0.20–0.21), suggesting restricted access to advanced ICT hardware within institutional settings.

The findings suggest that the digital environment of extension personnel in Punjab is predominantly mobile-oriented, where smartphones serve as the principal ICT medium. This trend corroborates earlier reports by Das (2019) [18] and Singh & Algawadi (2021) [69], who highlighted similar mobile-led digital engagement among extension workers in developing contexts. Accessibility patterns largely paralleled ownership, indicating commendable personal readiness but limited institutional facilitation. Respondents frequently reported reliance on personal devices for professional communication and data handling, underscoring deficiencies in office-based ICT resources. This scenario reveals an individual–institutional asymmetry in ICT preparedness. While extension personnel exhibit high personal digital readiness, inadequate infrastructural support at the organizational level constrains effective utilization. Strengthening institutional ICT provisioning through the supply of official laptops and smartphones, reliable internet facilities, and regular technical maintenance is imperative to enhance operational efficiency and ensure seamless digital knowledge dissemination.

Table 3: E-Ownership and E-Accessibility of extension personnel

ICT Tools	Mean Ownership Score	Mean Accessibility Score
Gadgets		
Landline, Smartphone, Laptop, Personal computer	0.46	0.51
Storage Devices		
Pen Drive, Recording devices, Digital Camera, Printer, External Hard disk, Webcam	0.20	0.21
Networking technologies		
Wired Internet, Wi-Fi / Dongle, Webcam	0.39	0.39
Pen Drive, Recording devices, Digital Camera, Printer, External Hard disk, Webcam	0.20	0.21
Networking technologies		
Wired Internet, Wi-Fi / Dongle, Webcam	0.39	0.39

Skill level and Frequency of ICT tool use

E-Skill of extension personnel determine as the confidence of an individual in capabilities required for effectively installing, designing, producing, selling, operating, managing, maintaining and researching on ICT based tools and devices. E-Skill levels demonstrated notable proficiency in computer which infers that extension personnel are knowledgeable and had the ability to effectively use a computer and related technology efficiently while also showing almost similar trend in gadget operation. Internet navigation skills were adequate but improvable, whereas social-media skills remained comparatively under-developed (Figure 3).

This implies that there is still a gap in operational knowledge of extension personnel; hence adequate training on efficient operation of ICT is required. The findings

demonstrate a partial digital proficiency where extension personnel exhibit confidence in conventional computing tasks but face limitations in multi-platform adaptability and content creation. The high frequency of smartphone use aligns with the global shift toward mobile-first communication, yet dependence on a single device may restrict technological versatility and reduce the potential for complex data handling or multimedia advisory services. The findings were similar as Reddy (2018) [64] and Yadav *et al*. (2019) [79].

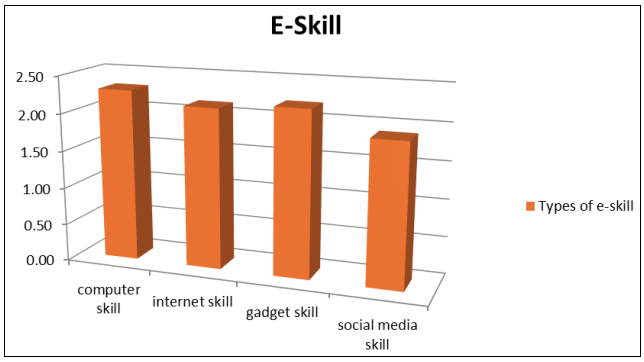

Figure 3: Assessment of E-Skill of extension personnel towards ICT tools

E-Frequency of use was described as the number of times an individual use ICT tools and devices during the period of study. It was assessed using a three point-continuum scale and was grouped into three major categories *viz.*gadgets, networking technologies and storage devices (Table 4). The cumulative mean score for Gadgets was 1.77, indicating higher level of use. Among these, smartphones emerged as the most frequently used tools, reflecting its accessibility, affordability, and familiarity in both professional and personal contexts. The mean score for Networking Technologies was 1.57, which falls in the moderate range. This suggests that although most personnel had access to internet facilities, their use was primarily limited to basic connectivity through Wi-Fi or mobile data, rather than for advanced knowledge management or data-sharing applications. In contrast, Storage Devices registered the lowest mean score (1.27), signifying infrequent use of tools such as external drives, printers, and recording devices. This limited usage can be attributed to both low perceived necessity and lack of hands-on training in handling peripheral ICT equipment.

This pattern underscores the need for capacity-building initiatives focusing on advanced digital skills and practical exposure to a wider range of ICT resources. The moderate frequency of ICT use observed in this study corroborates the findings of Patil *et al*. (2024) [58], who reported similar patterns among para-extension professionals, attributing them to limited training exposure and infrastructure also the results were in accordance with Naik (2014) [49]; Regan (2021) [65] and Dludlu (2020) [21]. Enhanced institutional support and periodic digital literacy programs can strengthen operational efficiency and foster greater ICT integration in extension delivery systems. This justifies that most of the respondents were not really utilizing several gadgets for functions in extension service but relying mostly on smartphone, so more education and awareness is required to improve frequency of ICT utilization.

Table 4: E-frequency of ICT use by the extension personnel

ICT tools	Cumulative Mean Score
Gadgets	
Radio, Television, Landline, Smartphone, Laptop, Personal computer	1.77
Storage devices	
Pen Drive, Recording devices, Digital camera, Printer machine, External hard disk	1.27
Networking technologies	
Wired Internet, Wi-Fi/Dongle, Webcam	1.57

3.3 Composite E-Readiness index score of extension personnel

The overall E-Readiness index calculation provides a basis to understand and compare the readiness of each extension personnel as a potential user of digital tools and technologies. The computed composite E-Readiness Index values ranged between 0.21 and 0.87, yielding an overall aggregated composite mean score of 0.50 (Table 5). According to the modified Aydin and Tasci (2005) [6] framework, this average reflected a moderate level of E-Readiness among the surveyed personnel. This provides a holistic diagnostic measure of the respondents' preparedness for digital engagement. A mean score of 0.50 suggests that the extension system in Punjab is functionally poised for digital transformation yet still evolving. It can be elicited that large-scale adoption of ICT may not be easily achieved, particularly services that utilize advanced technologies. Extension personnel are ready but needed few improvements in terms of their access and use of ICT. The hierarchy of sub-indices shows that awareness and motivation are higher than actual ICT use, indicating that operational competence still lags behind cognitive readiness. According to results extension personnel are highly aware regarding availability of e-resources and skilled enough to continue using ICT in agriculture while the frequency of ICT use was less which should be the focus of improvement and a point of concern that how to increase the use of e-resources in extension dissemination and advisory services. Such a configuration typifies the intermediate stage of technological diffusion, where awareness and willingness act as enablers but infrastructural and skill limitations temper practical adoption. For policymakers, these asymmetries underscore the necessity to convert cognitive potential into behavioural implementation through continuous, skill-intensive interventions and performance-linked digital mentoring. Study finds similar aspect as of Yekinni & Olniyi (2007) [80]; Raksha & Meera (2014) [61, 44]; Naik (2014) [49], Lakshmi & Punima (2018) [34]; and Olaolu *et al*. (2018) [53].

Table 5: Composite E-readiness index score

Sub-indicators	Weightage value	Mean score	Sub-index value (Weightage value * Mean score)
cfE-Awareness	0.451	2.78	1.17
E-Willingness	0.365	2.63	0.93
E-Ownership	0.125	2.37	0.30
E-Accessibility	0.107	2.31	0.25
E-Skill	0.09	2.25	0.21
E-Frequency	0.08	1.48	0.13
Composite E-Readiness score			0.50

3.4 Level of E-Readiness among extension personnel

Classification of respondents based on composite index values revealed that 36.53 percent were highly e-ready, 34.61 percent exhibited moderate readiness, and 28.84 percent fell into the low-readiness category (Table 6). No respondent was categorized as very low or very high, reinforcing the mid-range distribution of readiness levels across the sample. It was noteworthy that perceived roles and responsibilities of the extension personnel acts as a motivating factor which strongly affects methods for addressing the sharing of information by extension personnel to farmers. Considering the results and the type of ICT that are currently being developed, there is a strong basis to conclude that there is a major mismatch between the readiness of technology and the readiness of the users. High-readiness personnel can serve as peer catalysts, diffusing knowledge and motivation to their moderately ready counterparts through collaborative digital learning ecosystems. The presence of different readiness levels shows variation in how extension personnel adapt to technology, mainly due to differences in access, training, and institutional support. The finding of this research clearly shows that awareness, willingness, ownership and e-skill acts as the crucial factor in enhancing E-Readiness of extension personnel.

From a systems perspective, the findings affirm that the Punjab agricultural extension network stands at a strategic inflection point. Similar constraints were reported by Sondarva *et al*. (2023) [70], where it was observed that poor connectivity, inadequate institutional facilitation, and limited access to devices hindered ICT adoption among field-level extension personnel in Gujarat. Also similar trend by Reddy (2018) [64] and Yadav *et al*. (2019) [79], Naik (2014) [49]; Raksha (2014) [61]; Akintunde (2019) [3]; Nwabugwu *et al*. (2019) [51]; Bonephace *et al*. (2022) [11]; and Mukherjee *et al*. (2023) [47] was found. With targeted infrastructural investment, structured ICT curricula, and policy coherence, the system can transition from moderate readiness to a digitally empowered, knowledge-driven extension paradigm. This transformation holds the potential to redefine communication efficiency, enhance data-supported decision-making, and strengthen farmer–advisor connectivity, aligning regional extension practices with global digital-agriculture standards.

Table 6: Level of E-Readiness towards ICT tools

S. No.	Category	Percentage
1.	Least e-ready (0.45-0.48)	28.84%
2.	Moderately E-ready (0.48-0.51)	34.61%
3.	Highly e-ready (0.51-0.54)	36.53%

4. Conclusion and Recommendations

The study establishes that agricultural extension personnel in Punjab exhibit a moderate level of digital readiness, confirming the hypothesis that awareness and willingness precede operational proficiency. Drawing from the study findings demonstrated a mismatch between expected and realistic E-Readiness level, especially regarding the current capabilities and opportunities of Punjab's extension personnel. However, high awareness and motivation among personnel demonstrate their preparedness to adopt digital technologies, while limited access and skill constrain effective utilization. This underscore the need to upscale e-competencies related to social media and some ICT tools by providing them with necessary ICT infrastructure to create a giant stride towards creating information society and participate in knowledge economy which affirm that digital readiness in agricultural extension now depends more on institutional facilitation than individual intent. Future intervention should focus on strengthening computer and social-media competencies through regular training and ensuring adequate digital infrastructure are essential to enhance performance and bridge the gap between awareness and practice. Consequently there is high need to integrate ICT trainings in the system to encompass their capacity and state of preparedness in the electronic world. It will make the extension personnel ready and equipped with the required skills to deal with current e-scenario and to contribute in digital revolution. In essence promoting a digitally empowered extension system will enable efficient knowledge dissemination and greater inclusion of farmers in the evolving digital agricultural landscape.

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