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Bridging the digital divide in agricultural extension: ICT tool adoption, impact, and barriers among extension personnel in Haryana

¹Robin, ¹Pardip Singh Shehrawat, ²Danveer Singh, ²Aditya, ³Rahul and ⁴Suryapal Singh

¹Department of Extension Education, Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana, India

²Department of Agronomy, Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana, India

³Department of Soil Science, Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana, India

⁴Department of Seed Science, Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana, India

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Corresponding Author: Danveer Singh

Abstract

Information and Communication Technology (ICT) tools have emerged as critical enablers of agricultural extension services, offering new avenues for efficient and timely technology transfer to farming communities. This study examined the perceived impact, utilization patterns, and constraints associated with ICT tool adoption among agricultural extension personnel. Data were collected from 120 respondents and analyzed using Mean Percent Score (MPS), Utilization Index, Constraint Index, and Mean $\pm$ Standard Deviation-based categorization. Findings revealed that all seventeen impact dimensions recorded MPS values above 80 per cent, with enhancement of information dissemination speed (87.33%), real-time advisory services (85.17%), and improvement in farmers' knowledge and awareness (84.50%) ranking highest. The majority of respondents (79.17%) fell in the medium impact category. Mobile phones (90.33%) and internet services (89.83%) were the most extensively utilized ICT tools, while traditional media such as radio and kiosks recorded the lowest utilization. Most respondents (65.00%) were categorized under medium utilization. Inadequate technological infrastructure (CI = 93.89%), high cost of ICT tools (87.78%), and excessive workload (85.28%) were identified as the most serious constraints. Attitude towards ICTs and innovativeness emerged as significant predictors of utilization, while information management orientation was the strongest predictor of perceived impact. The study underscores the need for strengthening ICT infrastructure, building personnel competencies, and fostering innovation-oriented work cultures to maximize the effectiveness of ICT-enabled agricultural extension services.

Keywords: ICT tools, agricultural extension, technology transfer, utilization, perceived impact, constraints, extension personnel

Introduction

Agriculture continues to be the backbone of rural economies in developing nations, and the effective dissemination of improved agricultural technologies to farming communities remains a central mandate of agricultural extension systems (Davis, 2008; Rivera & Alex, 2004) [6, 18]. Historically, extension services relied on conventional approaches such as farm visits, demonstrations, field days, and group training programmes to bridge the knowledge gap between research institutions and farmers. While these methods have yielded considerable results, they are frequently constrained by limited outreach, high operational costs, inadequate personnel, and geographic barriers that impede timely information delivery (Swanson & Rajalahti, 2010) [20].

In recent decades, the rapid proliferation of Information and Communication Technologies (ICTs) has opened transformative possibilities for agricultural extension and rural development (Aker, 2011; World Bank, 2012) [1, 22]. ICT tools — encompassing mobile phones, internet services, agricultural information portals, computers, email, video conferencing, and digital advisory platforms — have demonstrated the potential to transcend conventional barriers of distance, time, and resource constraints (Mittal *et*

al., 2010; Qiang *et al.*, 2012) [12, 17]. By enabling real-time communication, remote advisory services, and wide-scale information dissemination, ICTs can significantly enhance the efficiency and reach of extension systems (Lio & Liu, 2006; Ozowa, 1995) [9, 16].

Extension personnel, as the primary interface between agricultural research institutions and farming communities, play a pivotal role in harnessing ICT tools for effective technology transfer (Anderson & Feder, 2004) [3]. Their capacity to utilize digital technologies determines not only the quality and timeliness of information delivered to farmers, but also the overall responsiveness of the extension system to evolving agricultural challenges such as climate variability, pest outbreaks, and market fluctuations (Feder *et al.*, 2011; Tata & McNamara, 2018) [8, 21]. Previous studies have highlighted that the adoption and effective utilization of ICT tools by extension personnel are shaped by a complex interplay of individual attributes — including attitude, innovativeness, and information management orientation — alongside organizational and infrastructural conditions (Arokoyo, 2005; Lwoga *et al.*, 2011) [4, 11].

Despite the growing discourse on digital extension, empirical evidence on the perceived impact and actual

utilization of ICT tools among extension personnel, as well as the barriers they encounter, remains limited in several agricultural contexts (Chipeva *et al.*, 2018; Oladele, 2011) ^[5, 14]. Existing literature reveals that while mobile phones and internet-based tools have gained considerable traction in extension practice, traditional ICT media such as radio, television, and kiosks continue to play supplementary roles in reaching remote farming populations (Aker & Mbiti, 2010; Muto & Yamano, 2009) ^[2, 13]. Furthermore, infrastructural deficits, financial constraints, heavy workloads, and insufficient training opportunities have been consistently identified as major impediments to effective ICT adoption among extension workers (Lwoga, 2010; Ommani & Chizari, 2008) ^[10, 15].

A comprehensive understanding of impact perceptions, utilization patterns, and systemic constraints is therefore essential for designing targeted interventions that can strengthen digital extension capacities and improve agricultural outcomes at the grassroots level (Davis *et al.*, 2010; Saravanan, 2010) ^[7, 19]. Against this backdrop, the present study was undertaken with the following specific objectives: (i) to assess the perceived impact of ICT tools on agricultural technology transfer, (ii) to examine the extent of ICT tool utilization among extension personnel, and (iii) to identify the key constraints limiting their effective use. The findings are expected to provide actionable insights for policymakers, extension administrators, and development practitioners seeking to leverage ICT tools for more inclusive and effective agricultural extension services.

Materials and Methods

Study Area and Sample

The study was conducted in Haryana, India, targeting extension personnel from agricultural development and extension organizations across the state. These included personnel from Krishi Vigyan Kendras (KVKs), the Agricultural Technology Information Centre (ATIC), and the Saina Nehwal Institute of Agricultural Technology, Training and Education (SNIATTE) of CCS Haryana Agricultural University (CCSHAU), as well as Agricultural Development Officers (ADOs) and Horticulture Development Officers (HDOs) from the State Department of Agriculture and allied departments. Haryana was selected due to its well-established agricultural extension system and the active engagement of extension personnel in technology dissemination and advisory services (Swanson & Rajalahti, 2010) ^[20].

A total of 120 extension personnel were selected using a random sampling technique, comprising 40 personnel from KVKs/ATIC/SNIATTE of CCSHAU, 40 ADOs from the Department of Agriculture and Farmers Welfare, Haryana, and 40 HDOs from the Department of Horticulture, Haryana.

Research Design

An ex post facto research design was adopted for the study, as the variables under investigation had already occurred and were beyond the researcher's control. This design was considered appropriate for examining associations among selected variables under naturally occurring conditions (Kerlinger, 1986) ^[24].

Variables

Independent variables encompassed socio-personal characteristics (age, sex, educational qualification, years of working experience, annual income, number of ICT trainings attended), communication variables (social participation, social media/ICT tools utilization, ICT tools used for transfer of technology), and psychological variables (attitude towards ICT tools, perceived ease of use, innovativeness, and information management orientation). Attitude was measured using a scale developed by Raksha (2014) ^[26], perceived ease of use was assessed using a modified scale of Davis (1989) ^[23], innovativeness using a modified scale of Moulik (1965) ^[25] as used by Raksha (2014) ^[26], and information management orientation using a modified scale of Raju (1997) ^[27].

Dependent variables included: (i) knowledge of ICT tools, (ii) perceived impact of ICT tools on transfer of technology, (iii) utilization of ICT tools for transfer of technology, and (iv) constraints faced in ICT utilization.

Data Collection

Data were collected personally by the researcher through a structured interview schedule administered via face-to-face interviews at respondents' workplaces. The interview schedule was developed following a thorough review of literature and validated through expert consultation with scientists and faculty of CCSHAU. The schedule was pre-tested on 20 extension personnel not included in the final sample, and necessary modifications were incorporated prior to final administration. Each interview required approximately 40–55 minutes to complete. Respondents were assured of confidentiality, and participation was voluntary.

Measurement of Dependent Variables

Perceived impact of ICT tools was measured using 17 statements assessed on a five-point Likert continuum ranging from Strongly Agree (5) to Strongly Disagree (1). The Mean Percentage Score (MPS) was computed for each statement using the formula:

$$\text{MPS (\%)} = (\text{Mean Score} / \text{Maximum Possible Score}) \times 100$$
 Respondents were categorized into low, medium, and high impact groups using the Mean $\pm$ Standard Deviation (SD) method (Mean = 71.23; SD = 13.24).

Utilization of ICT tools was assessed across 15 ICT tools on a five-point frequency continuum ranging from Very Frequently (5) to Never (1). The Utilization Index (UI%) was computed as:

$$\text{UI (\%)} = (\text{Actual Score Obtained} / \text{Maximum Possible Score}) \times 100$$

Respondents were classified into low, medium, and high utilization categories using the Mean $\pm$ SD method (Mean = 57.04; SD = 10.10).

Constraints in ICT utilization were assessed using 10 constraint statements rated on a three-point continuum: Very Serious (3), Serious (2), and Not Serious (1). The Constraint

Index (CI%) was computed as:

$$CI (\%) = (\text{Total Score Obtained} / \text{Maximum Possible Score}) \times 100$$

Constraints were ranked in descending order of their CI values.

Statistical Analysis

Data were processed through coding, tabulation, and classification. Descriptive statistics including frequency, percentage, mean, and standard deviation were used to characterize the sample and summarize responses. The Mean Percentage Score (MPS), Utilization Index (UI%), and Constraint Index (CI%) were computed for ranking impact statements, ICT tools, and constraints, respectively. Respondents were categorized into low, medium, and high

groups using the Mean $\pm$ SD method. Correlation and regression analyses were performed to identify significant predictors of perceived impact and ICT utilization among extension personnel.

Results

Impact of ICT Tools for Transfer of Technology Definition

Impact refers to the extent to which the utilization of ICT tools contributes to improving the effectiveness, efficiency and reach of agricultural extension services and facilitates the transfer of agricultural technologies to farmers. The perceived impact of ICT tools was assessed using seventeen statements covering various dimensions of technology transfer. The responses were obtained on a five-point continuum and analyzed using Mean Percent Score (MPS).

Table 1: Distribution according to Impact of ICT Tools on Transfer of Technology

Sl. No.	Impact Statement	SA	A	N	D	SDA	MPS (%)	Rank
1	ICT tools enhance the speed of information dissemination	72	33	10	5	0	87.33	I
2	ICT tools help in real-time advisory services	68	32	15	5	0	85.17	II
3	ICT tools improve farmers' knowledge and awareness	65	36	14	5	0	84.50	III
4	ICT tools support climate-smart agriculture practices	64	35	16	5	0	84.42	IV
5	ICT tools facilitate wider coverage of farmers	63	36	16	5	0	84.38	V
6	ICT tools reduce the cost of extension services	60	39	16	5	0	84.33	VI
7	ICT tools improve market information access for farmers	57	39	18	6	0	84.17	VII
8	ICT tools improve feedback mechanisms with farmers	56	39	19	6	0	84.08	VIII
9	ICT tools help in timely problem solving	58	39	18	5	0	83.83	IX
10	ICT tools help in early warning of pests and diseases	55	39	20	6	0	83.67	X
11	ICT tools strengthen linkages between research and farmers	54	39	20	7	0	83.58	XI
12	ICT tools improve accessibility of agricultural information	54	38	21	7	0	83.33	XII
13	ICT tools increase the adoption of improved agricultural technologies	52	40	21	7	0	82.83	XIII
14	ICT tools enhance decision-making ability of farmers	50	39	24	7	0	82.50	XIV
15	ICT tools improve communication between farmers and extension personnel	49	40	24	7	0	82.33	XV
16	ICT tools improve accuracy of information delivered to farmers	48	41	23	8	0	82.17	XVI
17	ICT tools contribute to enhancing agricultural productivity	46	40	26	8	0	81.67	XVII

SA: Strongly Agree A: Agree UD: Undecided DA: Disagree SDA: Strongly Disagree

The data presented in Table 1 reveal that enhancement in the speed of information dissemination recorded the highest impact (MPS = 87.33%) and secured the first rank, followed by real-time advisory services (85.17%) and improvement in farmers' knowledge and awareness (84.50%). Climate-smart agriculture practices and wider farmer coverage also recorded relatively higher impact scores. On the other hand, information accuracy (82.17%) and agricultural productivity (81.67%) recorded comparatively lower impact scores.

However, all the statements recorded MPS values above 80 per cent, indicating a highly positive perceived impact of ICT tools on transfer of technology.

Categorization of Respondents According to Perceived Impact of ICT Tools on Transfer of Technology

The overall impact scores obtained by the respondents were categorized into low, medium and high categories using the Mean $\pm$ Standard Deviation method.

Table 2: Distribution of Respondents According to Perceived Impact of ICT Tools on Transfer of Technology

Category	Score Range	Frequency	Percentage (%)
Low Impact	Below 57.99	15	12.50
Medium Impact	57.99 – 84.48	95	79.17
High Impact	Above 84.48	10	8.33
Total	—	120	100.00

Mean = 71.23; SD = 13.24

The data presented in Table 2 indicate that a majority of the respondents (79.17%) belonged to the medium impact category, followed by 12.50 per cent in the low impact

category. Only 8.33 per cent of the respondents were found in the high impact category.

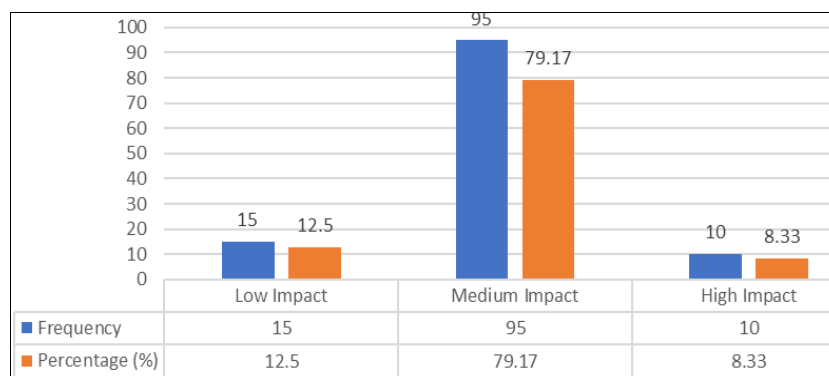


Fig 1: Distribution of Respondents According to Perceived Impact of ICT Tools on Transfer of Technology

Utilization of ICT Tools by Extension Personnel for Transfer of Technology

Definition

Utilization of ICT tools refers to the extent to which extension personnel use various information and communication technologies in their routine extension activities for dissemination of agricultural information,

communication with farmers, advisory services, and transfer of agricultural technologies. The level of utilization was assessed by obtaining responses on the frequency of use of different ICT tools on a five-point continuum ranging from Very frequently to Never. The utilization index was computed to determine the extent of use of various ICT tools by extension personnel for transfer of technology.

Table 3: Distribution according to Impact of ICT Tools on Transfer of Technology

S. No.	ICT Tool	VF	F	R	VR	N	Utilization Index (%)	Rank
1	Mobile Phone	78	28	10	3	1	90.33	I
2	Internet Services	76	29	11	3	1	89.83	II
3	Web-based Agriculture Information Portals	58	32	18	8	4	82.50	III
4	Computer	56	33	19	8	4	82.17	IV
5	Email	48	35	22	10	5	79.17	V
6	Web Browsers & Search Engines	47	35	23	10	5	79.00	VI
7	Video Camera	42	36	24	12	6	76.00	VII
8	Telephone	40	36	26	12	6	75.17	VIII
9	Decision Support System	38	35	28	13	6	74.17	IX
10	Video Conferencing	37	35	29	13	6	74.00	X
11	E-agricultural Magazines	36	35	29	14	6	73.50	XI
12	E-newspapers	35	35	30	14	6	73.17	XII
13	Television	33	35	31	15	6	72.33	XIII
14	Radio	24	30	36	20	10	68.50	XIV
15	Kiosk	23	30	36	21	10	68.33	XV

VF: Very frequently, F: Frequently, R: Rarely, VR: Very rarely, N: Never

The data presented in Table 3 indicate that Mobile Phone recorded the highest utilization index (90.33%) and secured the first rank, followed by Internet Services (89.83%) and Web-based Agriculture Information Portals (82.50%). Computer and Email also recorded relatively higher utilization indices. On the other hand, Radio (68.50%) and Kiosk (68.33%) recorded the lowest utilization indices and

secured the fourteenth and fifteenth ranks, respectively.

Categorization of Respondents According to Utilization of ICT Tools

The overall utilization scores obtained by the respondents were categorized into low, medium and high categories using the Mean $\pm$ Standard Deviation method.

Table 4: Distribution of Respondents According to Utilization of ICT Tools for Transfer of Technology

Category	Score Range	Frequency	Percentage (%)
Low Utilization	Below 46.94	24	20.00
Medium Utilization	46.94 – 67.14	78	65.00
High Utilization	Above 67.14	18	15.00
Total	—	120	100.00

Mean = 57.04; SD = 10.10

The data presented in Table 4 indicate that a majority of the respondents (65.00%) belonged to the medium utilization

category, followed by 20.00 per cent in the low utilization category and 15.00 per cent in the high utilization category.

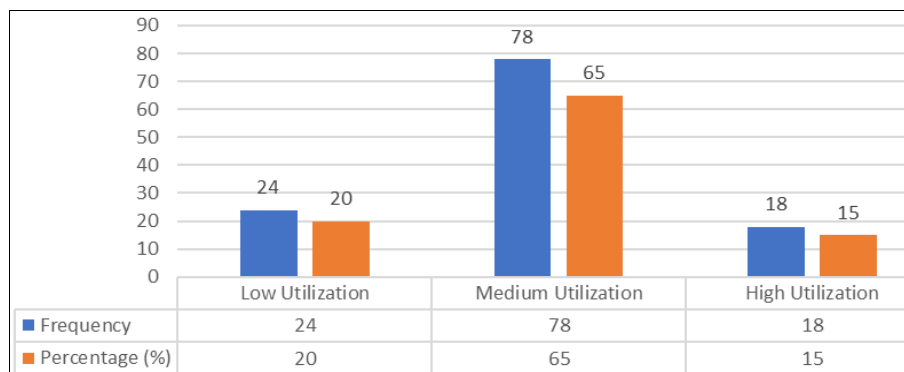


Fig 2: Distribution of Respondents According to Utilization of ICT Tools for Transfer of Technology

Constraints faced by extension personnel in usage of ICT tools

Constraints refer to the difficulties or barriers experienced by extension personnel while utilizing ICT tools for transfer of technology. The severity of constraints was measured on

a three-point continuum comprising Very Serious (VS), Serious (S) and Not Serious (NS). A Constraint Index (CI) was computed to determine the relative severity of different constraints faced by the respondents.

Table 5: Constraints Faced by Extension Personnel in Utilization of ICT Tools

S. No.	Constraint	Mean Score	CI (%)	Rank
1	Lack of technological infrastructure	2.82	93.89	I
2	High cost of ICT tools and lack of funds	2.63	87.78	II
3	Excessive workload and insufficient resources	2.56	85.28	III
4	Few opportunities to improve ICT skills and proficiency	2.53	84.17	IV
5	Being too busy with official work	2.49	83.06	V
6	Assignments are risky and complicated	2.47	82.22	VI
7	Lack of clarity in work objectives	2.45	81.67	VII
8	Inability of extension personnel to use ICT tools	2.41	80.28	VIII
9	Not enough time to spend on technology	2.35	78.33	IX
10	Lack of cooperation among employees	2.27	75.56	X

The data presented in Table 5 reveal that lack of technological infrastructure was perceived as the most serious constraint in the utilization of ICT tools, with a Constraint Index of 93.89 per cent and secured the first rank. This was followed by high cost of ICT tools and lack of funds (87.78%) and excessive workload coupled with insufficient resources (85.28%), which secured the second and third ranks, respectively. Further, limited opportunities for improving ICT skills and

proficiency, being too busy with official work, and assignments being risky and complicated were also reported as major constraints by the respondents. Comparatively lower severity was reported for inability of extension personnel to use ICT tools, lack of sufficient time to spend on technology, and lack of cooperation among employees. Among all the constraints, lack of cooperation among employees recorded the lowest Constraint Index (75.56%) and secured the last rank.

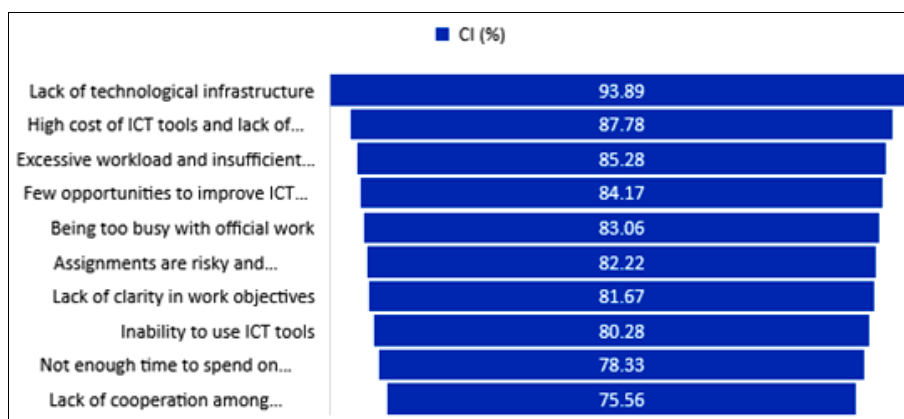


Fig 3: Constraints Faced by Extension Personnel in Utilization of ICT Tools

Discussion

Perceived Impact of ICT Tools

The findings indicate that extension personnel perceived

ICT tools as highly beneficial for transfer of technology activities, with all impact dimensions recording high mean percent scores. The greatest perceived impact was observed

in enhancing the speed of information dissemination, facilitating real-time advisory services and improving farmers' knowledge and awareness. This suggests that ICTs are primarily valued for strengthening communication efficiency, information accessibility and extension service delivery. Higher scores for climate-smart agriculture support, wider farmer outreach and market information access further demonstrate the diverse utility of ICT tools in extension work. However, comparatively lower scores for productivity enhancement and information accuracy indicate that respondents perceived ICTs as having a more direct influence on extension processes than on long-term agricultural outcomes.

Most respondents belonged to the medium impact category, indicating overall positive perceptions while also suggesting scope for improving ICT effectiveness. Correlation and regression analyses revealed that information management orientation and innovativeness significantly influenced perceived impact, with information management orientation emerging as the strongest predictor. Extension personnel who actively seek, manage and disseminate information and who are more receptive to innovation tend to perceive greater benefits from ICT applications. These findings highlight the importance of strengthening information management competencies, fostering innovative work cultures and promoting active engagement with digital technologies to maximize the impact of ICT-enabled extension services.

Utilization of ICT Tools by Extension Personnel

Mobile phones and internet services were the most extensively utilized ICT tools, followed by agricultural information portals, computers and email services. Their widespread use reflects the increasing integration of digital technologies into extension functions and their effectiveness in facilitating communication, information dissemination and farmer advisory services. Conversely, traditional ICT tools such as television, radio and kiosks recorded lower utilization levels, indicating a shift towards interactive and internet-based communication platforms.

The majority of respondents fell within the medium utilization category, suggesting that while ICT adoption is widespread, its full potential remains underutilized. Relationship analysis showed positive associations between ICT utilization and several communication and psychological variables. However, attitude towards ICTs and innovativeness emerged as the only significant predictors of utilization. Extension personnel with favourable attitudes towards technology and greater openness to innovation were more likely to use ICT tools extensively. These findings emphasize that effective ICT utilization depends not only on access to technology but also on users' behavioural orientation. Therefore, interventions aimed at improving ICT utilization should focus on fostering positive attitudes, encouraging innovation and providing opportunities for practical ICT engagement.

Constraints Faced in ICT Utilization

Extension personnel encountered several constraints in utilizing ICT tools effectively, with inadequate technological infrastructure emerging as the most severe challenge, followed by high costs and limited financial

support, excessive workload and insufficient opportunities for ICT skill development. Poor internet connectivity and inadequate ICT facilities restrict the effective use of digital technologies, highlighting the need for improved infrastructure within extension organizations.

Financial limitations also hinder the acquisition, maintenance and upgrading of ICT resources, while excessive workload reduces the time available for learning and applying ICT tools. Furthermore, inadequate training opportunities and limited technical competencies among some personnel indicate the need for continuous capacity-building initiatives. Overall, the findings suggest that successful ICT utilization depends not only on individual competence and willingness but also on supportive infrastructure, adequate financial resources and conducive organizational conditions. Strengthening these areas will be essential for enhancing ICT-enabled agricultural extension services.

Conclusion

The study demonstrates that ICT tools are perceived as highly effective instruments for agricultural technology transfer, with extension personnel recognizing their significant contributions to information dissemination speed, real-time advisory services, and farmer outreach. Mobile phones and internet services dominated utilization patterns, while traditional media such as radio and kiosks recorded comparatively lower usage, reflecting a broader shift towards digital and interactive communication platforms. However, the predominance of respondents in the medium categories of both perceived impact and utilization suggests that the full potential of ICT-enabled extension services remains unrealized. Inadequate technological infrastructure, financial constraints, and excessive workload emerged as the most critical barriers to effective ICT adoption. Attitude towards ICTs and innovativeness were identified as significant predictors of utilization, while information management orientation strongly influenced perceived impact. Strengthening ICT infrastructure, enhancing training opportunities, and cultivating positive behavioral orientations among extension personnel are therefore essential for maximizing the effectiveness of ICT-driven agricultural extension services.

References

1. Aker JC. Dial "A" for agriculture: a review of information and communication technologies for agricultural extension in developing countries. *Agricultural Economics*. 2011;42(6):631-647. doi:10.1111/j.1574-0862.2011.00545.x.
2. Aker JC, Mbiti IM. Mobile phones and economic development in Africa. *Journal of Economic Perspectives*. 2010;24(3):207-232. doi:10.1257/jep.24.3.207.
3. Anderson JR, Feder G. Agricultural extension: good intentions and hard realities. *The World Bank Research Observer*. 2004;19(1):41-60. doi:10.1093/wbro/lkh013.
4. Arokoyo T. ICTs in the transformation of agricultural extension: the case of Nigeria. In: *ICT Transforming Agricultural Extension*. 5th ed. Wageningen: CTA; 2005. p. 1-14.
5. Chipeva P, Cruz-Jesus F, Oliveira T, Johansson B.

- Digital divide at individual level: evidence for Eastern and Western European countries. *Government Information Quarterly*. 2018;35(3):460-479. doi:10.1016/j.giq.2018.05.003.
6. Davis KE. Extension in sub-Saharan Africa: overview and assessment of past and current models, and future prospects. *Journal of International Agricultural and Extension Education*. 2008;15(3):15-28. doi:10.5191/jiaee.2008.15302.
 7. Davis K, Swanson B, Ameer C. Strengthening agricultural extension and advisory systems: procedures for assessing, transforming, and evaluating extension systems. Washington, DC: World Bank; 2010.
 8. Feder G, Anderson JR, Birner R, Deininger K. Promises and realities of community-based agricultural extension. In: Chuhan-Pole P, Angwafo M, editors. *Yes Africa Can: Success Stories from a Dynamic Continent*. Washington, DC: World Bank; 2011. p. 283-295.
 9. Lio M, Liu MC. ICT and agricultural productivity: evidence from cross-country data. *Agricultural Economics*. 2006;34(3):221-228. doi:10.1111/j.1574-0864.2006.00120.x.
 10. Lwoga ET. Bridging the agricultural knowledge and information divide: the case of selected telecenters and rural radio in Tanzania. *Electronic Journal of Information Systems in Developing Countries*. 2010;43(6):1-14. doi:10.1002/j.1681-4835.2010.tb00309.x.
 11. Lwoga ET, Stilwell C, Ngulube P. Access and use of agricultural information and knowledge in Tanzania. *Library Review*. 2011;60(5):383-395. doi:10.1108/00242531111135263.
 12. Mittal S, Gandhi S, Tripathi G. Socio-economic impact of mobile phones on Indian agriculture. Working Paper No. 246. New Delhi: Indian Council for Research on International Economic Relations; 2010.
 13. Muto M, Yamano T. The impact of mobile phone coverage expansion on market participation: panel data evidence from Uganda. *World Development*. 2009;37(12):1887-1896. doi:10.1016/j.worlddev.2009.05.004.
 14. Oladele OI. Agricultural information sources and ICT needs of extension agents in North West Province, South Africa. *Life Science Journal*. 2011;8(2):336-340.
 15. Ommani AR, Chizari M. ICT and extension in Iran: extension agents' barriers and competencies. *American Journal of Agricultural and Biological Sciences*. 2008;3(4):667-671. doi:10.3844/ajabssp.2008.667.671.
 16. Ozowa VN. Information needs of small-scale farmers in Africa: the Nigerian example. *Quarterly Bulletin of the International Association of Agricultural Information Specialists*. 1995;40(1):1-5.
 17. Qiang CZ, Kuek SC, Dymond A, Esselaar S. Mobile applications for agriculture and rural development. Washington, DC: World Bank; 2012.
 18. Rivera WM, Alex G. Demand-driven approaches to agricultural extension: case studies of international initiatives. Washington, DC: World Bank; 2004.
 19. Saravanan R. ICTs for agricultural extension: global experiments, innovations and experiences. New Delhi: New India Publishing Agency; 2010.
 20. Swanson BE, Rajalahti R. Strengthening agricultural extension and advisory systems: procedures for assessing, transforming, and evaluating extension systems. Agriculture and Rural Development Discussion Paper No. 45. Washington, DC: World Bank; 2010.
 21. Tata JS, McNamara PE. Impact of ICT on agricultural extension services delivery: evidence from the Catholic Relief Services SMART Skills and Farmbook Project in Kenya. *Journal of Agricultural Education and Extension*. 2018;24(1):89-110. doi:10.1080/1389224X.2017.1387160.
 22. World Bank. ICT in agriculture: connecting smallholders to knowledge, networks, and institutions. Report No. 64605. Washington, DC: World Bank; 2012.
 23. Davis FD. Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*. 1989;13(3):319-340. doi:10.2307/249008.
 24. Kerlinger FN. *Foundations of Behavioral Research*. 3rd ed. New York: Holt, Rinehart and Winston; 1986.
 25. Moulik TK. Factors associated with adoption of improved farm practices [doctoral dissertation]. New Delhi: Indian Agricultural Research Institute; 1965.
 26. Raksha. ICT utilization by extension personnel for transfer of technology [master's thesis]. Hisar: CCS Haryana Agricultural University; 2014.
 27. Raju G. Information management orientation scale. Bengaluru: University of Agricultural Sciences; 1997.