PERCEIVED INNOVATION ATTRIBUTES AND ADOPTION OF ICT TOOLS AMONG SMALLHOLDER PADDY FARMERS IN NEPAL

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ABSTRACT

Agricultural innovation and digital adoption are key drivers for transforming smallholder farming. In developing economies like Nepal, Information and Communication Technology (ICT) tools offer unprecedented opportunities to bridge information gaps in cereal crop production. This study analyzes the perceptions of paddy farmers from Jhapa, Kapilbastu, and Bardiya districts regarding the attributes of ICT tools used in paddy farming. A total of 390 paddy farmers, selecting 130 randomly from each district by using a multistage random sampling technique, were interviewed about their perception of relative advantage, complexity, compatibility, observability, and predictability of ICT. The collected data were analyzed using descriptive statistics, scaling techniques, chi-square, and F-test. The majority of respondents believed that ICT tools are more complex, require more skills, and face maintenance issues, which were viewed as barriers to adoption. Among the core innovation attributes, trialability and observability features emerged as the primary facilitators, while complexity functioned as the dominant perceived innovation barrier. Significant variations across the study districts in results indicated differences in socio-demographic, organizational, and institutional contexts. Additionally, this study clarifies the importance of co-operatives and local-level organizations to enhance adoption through access to credit and need-specific extension and implementation strategies to promote better adoption of ICT tools among paddy farmer.

1. INTRODUCTION

Information and Communication Technologies (ICTs), which are advancing rapidly, have transformed many sectors, including agriculture. ICTs are a broad category of technical tools that enable communication and information exchange between individuals across various media, including computers and mobile devices (Nkambule & Agholor, 2021). In modern agricultural extension systems, digital dissemination serves as a conduit for maximizing productivity, where the perceived attributes of these digital tools determine their ultimate field-level integration (Regmi & Schulz, 2023).

Many countries already use ICT tools for various purposes to enhance productivity and competitiveness (Salampasis & Theodoridis, 2013). Better communication among stakeholders is crucial for better results in the agricultural value chain, improving farmers' decision-making (Ghimire et al., 2022). Within the scope of digital extension, ICT tools do not operate in isolation; rather, they serve as the operational interface for managing, tracking, and scheduling information, weather alerts, plant protection, and market data (Shrestha & Bhattarai, 2022).

The Agriculture Information and Communication Center (AICC) is a separate division under the Department of Agriculture (DoA) to promote digital extension services from the government side. Existing knowledge and information systems in the agricultural extension system are not enough to promote research and learning, hindering proper adoption of improved technologies (FAO, 2018). The major challenge is the poor linkage between education, research, and extension. Apart from this, the unavailability and poor access of the farmers to the findings and information on time negatively affect the overall adoption of innovation. Increasing use of mobile phones and the internet has significantly improved the ICT sector in agriculture (Sharma & Rijal, 2018).

Mobile phones and the internet are used to provide essential agricultural information to low-income farmers in an affordable way, promoting agricultural production and productivity through the adoption of improved technologies (Tiwari & Gartaula, 2021).

The traditional extension system cannot meet the increasing demand for information. Modern institutional frameworks emphasize that integrating digital advisory platforms across agricultural steps-from pre-production planning to post-production logistics-preserves the original structural purpose of public extension systems (Poudel et al., 2024).

The timely availability of information in paddy farming with the use of ICT tools enhances the production and productivity of paddy, whereas various apps like Smart Krishi Project provide information on weather conditions, production-related information, and market linkages on time lead to better returns to farmers (Bhandari et al., 2021). Despite these advancements, a prominent research gap persists in South Asian literature: there is a lack of empirical clarity on how localized geographic and district-level disparities affect a farmer's psychological scaling of innovation attributes. This research directly addresses this gap by mapping how smallholders evaluate specific technological traits within the unique institutional landscapes of Nepal's lowland Terai region.

Even having the potential to transform the agricultural extension system of the nation, the government is still not active in promoting ICT tools for widespread use across the nation, as it is seen that there is a disparity of awareness, infrastructure, and use of ICT tools across the urban and rural areas of the nation (Tiwari & Gartaula, 2021). Farmers' knowledge, perceptions, and attitudes regarding ICT tools are the key factors that influence the uptake and use of ICT tools. Additionally, farmers' perceptions of these technologies, such as utility, complexity, compatibility, and observability of the results, may affect their decisions to adopt them (Debele et al., 2020).

However, the emphasis on digital agriculture and ICT-enabled extension is growing, but there is still limited evidence regarding the innovation attributes of the ICT tools. Previous studies were primarily focused on awareness, access, and utilization of ICT tools as compared to understanding the farmers' perception on their characteristics that may influence their adoption behavior.

To understand the farmer's perception of ICT tools' features, Rogers' diffusion of innovation framework was considered.

2. METHODOLOGY

Jhapa, Kapilbastu, and Bardiya were selected for the study because these districts represent the lowland Terai region, which serves as the primary rice bowl of the nation from east to west, and are recognized as prominent paddy producers by the government. Paddy was purposively chosen as the focal crop for this study because it represents Nepal's primary agricultural staple, handles the highest volume of input mobilization, and stands as the priority crop for national digital extension applications. A total of 390 respondents, with 130 from each district, were selected using multistage sampling techniques from the list provided by the respective NAMP offices. Primary data were collected in 2020 using a structured interview schedule and verified through Focused Group Discussion (FGD), Key Informant Interview (KII), and observation. Socio-demographic characteristics, organizational involvement, access to credit, ownership of ICT tools, and farmers' perceptions of various attributes of ICT tools were collected. Perceived attributes of ICT tools were measured using scaling techniques based on multiple statements under six attributes of ICT technologies.

The collected data was analyzed using descriptive statistics such as frequency, percentage, mean and standard deviation. Chi-square tests were conducted to observe variations in categorical variables—specifically gender distribution, family structures, institutional affiliation, and credit source channels—across the three districts. - F-test (One-Way ANOVA) was deployed to analyze the differences in continuous mean index values for perceptions across the study locations. This test is highly appropriate because the perception indices span continuous scale intervals, and the three distinct districts serve as independent categorical groups, enabling a robust assessment of spatial variation in innovation evaluation.

3. RESULTS AND DISCUSSION

3.1 Socio-demographic characteristics of respondents

The socio-economic characteristics of the respondents were collected, analyzed, and presented in Table 1 in Annex 1 with chi-square values after comparing frequencies across the study districts. These individual attributes of the surveyed household heads provide the basic analytical foundation, as household heads act as the primary decision-makers regarding technology adoption and capital deployment. The table revealed a predominance of male respondents in all districts, and the chi-square test shows a statistically significant association between gender and district.

The table shows that the age of the respondents ranges from 20 to 82 years, with a mean age of 47.62 years and a standard deviation of 11.73 years, indicating a predominance of middle-aged respondents and significant age differences among districts.

Most of the respondents were Hindu, with only 3 being Buddhist, and 5 being Muslim from Jhapa. The majority of the respondents were Brahmins and Chhetri, who were involved in agriculture and lived in nuclear families, although joint and extended families were common in Kapilbastu and Bardiya.

Jhapa had more respondents with education beyond the secondary level, whereas Bardiya had more illiterate respondents. The average land area of the respondents was 0.35 hectares, showing a predominance of medium landholders. All baseline socio-demographic parameters collected were utilized as independent control variables to evaluate variations in the primary ICT perception indices.

The majority of the respondents in the study area show that the demographic insights of Nepal reflect poor involvement of the youth in agriculture. The average age of the respondents from the study area is 47.62 years, which aligns with the national data, which is 48 years (CBS, 2022; ICIMOD, 2020). The data reflects that there would be long-term impacts on labor availability, innovation adoption and sustainability of digital agriculture and ICT adoption. The majority of the male respondents relate that the patriarchal society of Nepal reflects that decision-making roles are assigned to males, and the data aligns with the national data, which shows 60 % of the household heads are male in Nepal (CBS, 2022). This further shows the disparities based on gender in resource access and decision-making. The findings of ethnic distribution in study areas also align with the national data as Brahmin and Chhetri are the dominating castes of Nepal, and Agriculture as the primary occupation for the majority of the households (Adhikari, 2016). Land area is a very important variable regarding the adoption of ICT tools by the paddy farmers as the average size of the land parcel of the study area is 0.35 hectares as they need more agricultural information (Koirala, Thapa, & KC, 2020). These baseline demographic attributes are deeply intertwined with digital extension outcomes; older, illiterate household heads with fragmented lands face steeper learning curves, lowering their scalability marks on relative advantage and inflating their perceived complexity indices (Maharjan & Devkota, 2023).

Differences in the findings across the study districts show the heterogeneity, as the majority of respondents with nuclear families and literacy in Jhapa, as compared to other study areas, reflect variation in social structure and development throughout the nation, which is important for extension approaches and technology dissemination.

3.2 Organizational characteristics and access to credit

Data related to organizational characteristics and access to credit were collected, analyzed, and presented in Table 2 in Annex 2. The large majority of the respondents were found to be associated with at least one organization. Further chi-square analysis was performed to determine a significant association between organizational involvement and study districts.

Co-operatives were the dominant type of organization in Kapilbastu, while group-based organizations were more prevalent in other districts. Most of the respondents were ordinary members in the organization, with only 13% holding leadership roles. On average, respondents were affiliated with organizations for 6.6 years, ranging from 1 to 32 years.

In addition, access to credit also showed significant variation across the study districts. Respondents from Jhapa and Kapilbastu had better access compared to those in Bardiya. In these areas, co-operatives were the primary sources of credit for the farmers.

Farmers' affiliation to organization is very important to have access to resources and information for them. In Nepal, high levels of participation in farmers' groups and co-operatives are prevalent. Poor incidence of multiple organizations suggests limited institutional networking among farmers, restricting services and opportunities.

The role of co-operatives as the primary source of credit aligns with previous studies showing similar results as co-operatives are the most trusted and accessible for credit access. This also aligns with national data showing poor access to formal bank financing for agricultural households (CBS, 2022). Farmers without credit access contradict the argument that credit is widespread showing financial exclusion.

3.3 Perceived attributes of ICT tools

Table 3 in Annex 3 displays the index values calculated for the perceptions of respondents on various attributes of ICT tools based on statements asked. Six perceived attributes were ranked according to the index values calculated. In terms of relative advantage, respondents considered ICT tools as time saving and informative but disagreed on easy to use and cheaper technologies. The analysis did not show any differences across the study districts. Respondents perceived ICT tools as more complex requiring skills and expertise among other aspects so difficult to learn and understand. Respondents from Bardiya considered the ICT tools more complex significantly. This district-level cross-comparison provides vital spatial insights, revealing that rural infrastructure gaps directly shape local smallholder psychology.

Respondents viewed compatibility positively believing that ICT tools was culturally and socially compatible. However, trialability received mixed responses as some disagreed with trying out ICT tools before adoption due to limited opportunities for experimentation.

Additionally, observability and predictability were perceived positively by respondents indicating that it is better to see visible results and performance of ICT tools.

The overall index value (0.35) indicates a moderate level of agreement on the perceived attributes of ICT tools. This analysis shows variation across districts in three features except for relative advantage, compatibility, and observability.

Perception on various attributes of ICT tools is important for understanding adoption behavior. Findings under relative advantage align with previous studies indicating that it is important for ICT adoption (Uddin et al., 2019). Ghimire et al. (2022) focused those advantageous technologies improves ICT tools' adoption.

Complexity was perceived as a constraint, as ICT tools require more skills and operations and maintenance. These findings align with previous studies showing that farmers need technical capacity and post-adoption support (Uddin et al., 2019). Higher and positive perceptions of compatibility reflect that economic factors are more influential than cultural norms in technology adoption, aligning with the previous studies (Uddin et al., 2019). Similar results on trialability show the importance of demonstrations and opportunities to test ICT tools before adoption, as in previous studies.

Observability was also valued by respondents as visible results and timely feedback were positively perceived for better decision-making aligning with previous research (Davis, Bagozzi, & Warshaw, 1989). Predictability received mixed responses indicating, that ICT advancements could improve forecasting and planning, showing growing awareness of digital tools.

Overall, the discussion highlights the importance of socio-demographic features, organizational involvement and district level variation in developing context specific strategies and policies for better results (CBS, 2022; ICIMOD, 2020; Rogers, 2003).

4. CONCLUSION: The study finds that the adoption of ICT tools among paddy farmers is a complex interaction of socio-demographic characteristics, organizational features, and perceived attributes of ICT tools. Local co-operatives serve as trusted nodes that channel credit and technical info to smallholders, satisfying the core institutional objectives of providing localized agriculture safety nets. ITC tools' attributes are major contributing factors to adoption, with relative advantage strongly perceived as saving time and labor, while complexity adversely affects adoption. Compatibility, trialability, observability, and predictability were positively perceived and positively affect adoption. Therefore, less complex and better compatible ICT tools with relatively advantageous features, along with quality trialability and observability, would have better adoption among paddy farmers. To foster scalable adoption, it is recommended that longitudinal studies to examine the structural sustainability of ICT adoption; (b) conduct impact evaluation of ICT use on productivity, costs, and income; (c) analyze gender and socio-demographic disparities in digital tools utilization; and (d) compare the operational effectiveness of different digital delivery models across varying agronomic zones.

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Annexures
Annex 1
Table 1. Distribution of respondents by various social characteristics (n=390)

Characteristics		Districts				Chi-square value
		Jhapa	Kapilbastu	Bardiya	Total	
		Frequency	Frequency	Frequency	Frequency	
Gender	Male	105 (80.8)	69(53.1)	86(66.2)	260(66.7)	22.45***
	Female	25(19.2)	61(46.9)	44(33.8)	130(33.3)	
Age (yrs)		Mean: 47.27 ±10.95 Min:21yrs, Max:74yrs	Mean: 47.48±11.33 Min:21yrs, Max:74yrs	Mean: 45.44±12.04 Min:23yrs, Max: 77yrs	Avg: 47.62±11.79 Min:20yrs, Max: 82yrs	
	Young	10(7.7)	19(14.6)	27(20.76)	56(14.35)	9.58**
	Adult	102(78.5)	96(73.84)	91(70)	289(74.1)	
	Old	18(13.8)	15(11.56)	12(9.24)	45(11.55)	
Religion	Hinduism	122(93.8)	130(100)	130(100)	382(97.9)	
	Buddhism	3(2.3)	0(0)	0(0)	3(0.8)	
	Muslim	5(3.8)	0(0)	0(0)	5(1.3)	
Ethnicity	Bhramin	49(37.7)	77(59.2)	52(40)	178(45.6)	123.98***
	Janajati	10(7.7)	37(28.5)	42(32.3)	89(22.8)	
	Madheshi	36(27.7)	0(0)	0(0)	36(9.2)	
	Chhetri	34(26.2)	13(10)	23(17.7)	70(17.9)	
	Dalit	1(0.8)	3(2.3)	13(10)	17(4.4)	
Family type	Nuclear	118(90.8)	66(50.8)	6(48.5)	247(63.3)	101.53***
	Joint	12(9.2)	53(40.8)	27(20.8)	92(23.6)	
	Extended	0(0)	11(8.5)	40(30.8)	51(13.1)	
Educational level	Illiterate	7(5.4)	13(10)	37(28.5)	57(14.6)	31.43***
	Only read and write	40(30.8)	41(31.5)	29(22.3)	110(28.2)	
	Up o SLC	58(44.6)	53(40.8)	45(34.6)	156(40)	
	More than SLC	25(19.2)	23(17.7)	19(14.6)	67(17.2)	

Characteristics		Districts: Jhapa	Kapilbastu	Bardiya	Total	Chi-square value
		Frequency	Frequency	Frequency	Frequency	
Occupation	Agriculture	119(91.6)	118(90.8)	98(75.4)	335(85.9)	17.82***
	Non-agriculture	11(8.4)	12(9.2)	32(24.6)	55(14.1)	
Land Area	Small	3(2.3)	8(6.1)	16(12.2)	27(6.9)	33.73***
	Medium	98(75.4)	116(89.2)	106(81.5)	320(82.1)	
	Large	29(22.3)	6(4.6)	8(6.3)	43(11)	

Source: Field Survey, 2020 Note: Figures in parentheses indicate percentage
*, **, *** indicates 10, 5 and 1 percent level of significance

Annex 2

Table 2. Distribution of respondents by organization characteristics (n=390)

Organizational characteristics		Districts: Jhapa	Kapilbastu	Bardiya	Total	Chi-square value
		Frequency	Frequency	Frequency	Frequency	
Involved in the first organization	Yes	123(94.6)	130(100)	82(63.1)	335(85.9)	85.38***
	No	7(5.4)	0(0)	48(36.9)	55(14.1)	
Type of the organization involved	Group	88(71.54)	51(39.2)	51(62.20)	190(56.72)	117.10***
	Co-operative	35(28.46)	79(60.8)	31(37.80)	145(43.28)	
Position in organization	Ordinary member	81(65.85)	105(80.8)	56(68.30)	242(72.24)	95.60***
	Executive member	15(12.20)	8(6.2)	7(8.53)	30(8.95)	
	Secretary	10(8.13)	4(3.1)	7(8.53)	21(6.27)	
	President	17(13.82)	13(10)	12(14.64)	42(12.54)	
Duration of the involvement (yrs)		Mean:6.74±3.55	Mean:6.35±4.75	Mean:6.8±5.87	Mean:6.60±4.66	

Organizational characteristics		Districts				Chi-square value
		Jhapa	Kapilbastu	Bardiya	Total	
		Frequency	Frequency	Frequency	Frequency	
Involved in second organization	Yes	45(36.59)	64(49.2)	21(25.60)	96(28.65)	
	No	78(63.41)	66(50.8)	61(74.40)	239(71.35)	
Position in organization	Ordinary member	42(93.33)	57(43.8)	16(76.20)	78(81.25)	
	Executive member	3(6.67)	4(3.1)	3(14.28)	9(9.38)	
	Secretary	0(0)	1(0.8)	2(9.52)	5(5.20)	
	President	0(0)	2(1.5)	0(0)	4(4.17)	
Duration of the involvement (yrs)		Avg: 1.6±1.05	Mean:7.78±5.85	Mean:5.52± 2.36	Mean:6.78±5.14	
Access to credit	Yes	104(80)	125(96.2)	55(42.30)	284(72.8)	100.29***
	No	26(20)	5(3.8)	75(57.70)	106(27.2)	
Type of credit source	Group	18(17.3)	57(43.8)	14(25.45)	89(31.34)	
	Co-operative	73(70.2)	68(52.3)	27(49.10)	168(59.16)	
	Bank	13(12.5)	0(0)	14(25.45)	27(9.50)	
Credit taken from organization	Yes	25(24.04)	85(65.4)	38(69.10)	148(52.11)	65.09***
	No	79(75.96)	40(30.8)	17(30.90)	136(47.89)	

Source: Field Survey, 2020 Note: Figures in parentheses indicate percentage

*, **, *** indicates 10, 5 and 1 percent level of significance

Annex 3

Table 3. Perceived attributes of ICT tools (n=390)

S.N.		Perceived attributes		Index value			Average	F-value
				Jhapa	Kapilbastu	Bardiya		
1	i	Relative advantage	Time saving	0.71	0.95	0.76	0.81	1.50
	ii		Economical as to reach many	0.85	0.18	0.48	0.50	(P-value; 0.24)
	iii		Informative	0.52	0.83	0.68	0.68	
	iv		No time limitation to use	0.09	0.53	-0.12	0.17	
	v		Low investment	0.09	-0.12	-0.51	-0.18	
	vi		Up to date	0.10	0.81	-0.03	0.29	
	vii		Easy to use	0.22	-0.10	-0.55	-0.14	
	viii		Social recognition	0.55	0.35	0.07	0.33	
			Average	0.39	0.43	0.10	0.31	
2	i	Complexity	Need skills and expertise	0.78	0.77	0.95	0.83	4.33**
	ii		Difficult to learn	0.68	0.33	0.88	0.63	(P-value; 0.04)
	iii		Difficult to maintain	0.66	0.12	0.88	0.55	
	iv		Difficult to understand	0.08	0.35	0.84	0.42	
			Average	0.55[b]@10%	0.39[b]	0.89[a]	0.61	
3	i	Compatibility	Applicable to all without social discrimination	-0.12	0.85	0.51	0.41	
	ii		No language barriers	-0.15	-0.67	-0.42	-0.42	0.74
	iii		No cultural barriers	0.21	0.82	-0.03	0.33	(P-value; 0.49)
	iv		No social barriers	0.23	0.83	0.22	0.43	
	v		Felt need of farmers	0.41	0.35	0.44	0.40	
			Average	0.12	0.44	0.14	0.23	
4	i	Trialability	Try even without purchasing	0.37	-0.72	-0.18	-0.17	35.09***
	ii		Ease in trying majority of features	0.19	-0.58	-0.33	-0.24	(P-value; 0.008)
			Average	0.28[a]	-0.65[c]@10%	-0.26[b]	-0.21	
5	i	Observability	Immediate feedback	0.45	0.19	0.37	0.33	0.02
	ii		Gives accurate information	0.24	0.57	0.34	0.38	(P-value; 0.97)

S.N.		Perceived attributes		Index value			Average	F-value
				Jhapa	Kapilbastu	Bardiya		
			Average	0.35	0.38	0.36	0.36	
6	i	Predictability	Impacts may predict easily	-0.06	0.04	0.36	0.11	3.6*
	ii		Results may predict easily	0.08	0.04	0.39	0.17	(P-value; 0.091)
	iii		Future needs due to ICT can be identified	0.33	0.14	0.25	0.24	
			Average	0.12[b]	0.07[b]	0.33[a]	0.17	
			Overall average of the attributes	0.31	0.29	0.26	0.29	0.09 (P-value; 0.91)

Source: Field Survey, 2020 Note: Index value ranges from -1 to +1

*, **, *** indicates 10, 5 and 1 percent level of significant