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Exploring Cognitive Dimensions of Information and Communication Technology (ICT) Use in Agriculture among Rural Farmers in Nagaland, India

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ABSTRACT

Background: Information and communication technology (ICT) plays a crucial role in modern agricultural development, yet its effective utilization among rural farmers remains limited, particularly in remote regions like Nagaland, India. While several ICT tools are available, there is a gap in farmers' cognitive ability to meaningfully apply these tools in agricultural practices.

Methods: A study was conducted from 2022 to 2025 involving 360 rural farmers selected from six districts in Nagaland. Data were collected using structured interviews and focus group discussions. The study assessed farmers' knowledge across six cognitive domains: remembering, understanding, applying, analyzing, evaluating, and creating. Descriptive statistics such as frequency, percentage, mean and standard deviation along with statistical tools such as pearson correlation, regression and chi-square test were used to analyze the data.

Result: Findings revealed that while basic awareness of ICT tools (remembering) was relatively high, cognitive skills involving evaluation, analysis, application, and creation were significantly low. Socio-economic factors such as age, education level, and access to information were found to strongly influence the extent of ICT engagement. The study underscores the need for targeted, localized ICT literacy programs that go beyond awareness-building and aim at developing higher-order cognitive skills among rural farmers.

Key words: Agriculture, Communication, Information, Knowledge, Technologies.

INTRODUCTION

Agriculture continues to be the prevalent occupation and rural livelihood in Nagaland, with around 70% of its population engaged in farming. Although critical, the state's agricultural productivity is typically low, often due to lack of access to good information, market information and current techniques. At the same time, India has witnessed fantastic growth in its Information and Communication Technology (ICT) industry, contributing over 13% of national GDP. However, adoption of ICT by rural agricultural communities, especially in remote areas like Nagaland, is uneven.

ICT in agriculture is technology and platforms like mobiles, SMS, internet, mobile applications and satellite imagery that provide access to real-time information, market information, weather and extension services.Studies show that mobile telephony is widely adopted among farmers, but the ability to utilize advanced features of ICT for decision-making, market linkage and farm management remains limited (Ansari and Pandey, 2013; Shinde and Pingle, 2020).

The importance of ICT in the field of agriculture research and extension is becoming indispensable. Research, education and extension and farmers are the leading stakeholders of agricultural system (Lemma and Tesfaye, 2016; Deneke and Gulti, 2016). The performance and capability of each stakeholder to ensure rural food security depends on the continuous flow of agricultural knowledge and information among all stakeholders. Generally, the importance of information is well established in the life of every human being as it serves as a source of knowledge and skills for individuals (Odiaka, 2015). Particularly in the field of agricultural development access to information is one of the basic ingredients to increase farm productivity (Pandey, 2017). To encourage adoption of technologies, there is need of better exchange of information among farmers (Aguilar-Gallegos *et al.,* 2015). This augments the vital importance of agricultural information among farmers to decide uptake of innovations.

The ICT adoption process in agriculture can be understood through established frameworks such as the technology acceptance model (TAM), the unified theory of acceptance and use of technology (UTAUT) and diffusion of innovations (DOI) theory. These models highlight the

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importance and influence of factors such as the usefulness and ease use of the technology, social influence and the surrounding infrastructure support which are crucial determinants for adoption of technologies.

Similar challenges have been documented in rural Africa, Southeast Asia and Latin America, where socio-economic conditions, education, infrastructure and cultural factors influence ICT adoption (Donner, 2008; Qiang *et al.,* 2011).

Nagaland's geographically scattered and tribal population also faces other infrastructural and educational issues in embracing ICT tools. Though initiatives such as e-Arik, Kisan Call Centres and mobile services are in the correct direction, the real cognitive ability to utilize these tools is not being realized. This research will bridge this gap as it will analyze the extent of knowledge of farmers in cognitive areas and the socio-economic determinants that affect ICT use.

MATERIALS AND METHODS

The current research was carried out in Nagaland State, India, spanning 3 years 2022-2025. Nagaland is the 16th State of India located in the northeastern part of India and characterized by hilly topography and a diversified tribal population. The research sought to investigate the cognitive knowledge and application of information and communication technology (ICT) tools among rural farmers who are involved in farming. To secure a representative sample of both farming systems and tribal groups, six districts were purposively chosen: three from more developed tribal groups (Wokha, Mokokchung and Kohima) and three from less developed tribal groups (Mon, Tuensang and Phek). Two blocks were randomly chosen for each of the selected districts, totaling 12 blocks for the study.

A sampling design was developed in consultation with district agricultural officers from whom 30 innovative farmers were randomly selected from each block. The total sample size thus totaled 360 respondents. The data pertinent to this study were collected through personal interviews using a pre-tested, standardized interview schedule and focus group discussions carried out at each block level. The interview schedule was designed based on socio-economic conditions and the respondents' level of knowledge concerning the use of ICT tools in agriculture.

The primary data were complemented by the secondary data relevant to the subject that were collected from government reports, academic journals, annual reports and other literature on the subject. The cognitive involvement of the respondents towards ICT was measured in six dimensions: remembering, understanding, applying, analyzing, evaluating and creating. A four-point Likert scale was used for each item with ratings on a scale ranging from 'strongly disagree' to 'strongly agree'. Data were described using descriptive statistical measures such as frequency, percentage, mean and standard deviation. To ascertain the respondents' overall level of knowledge in each cognitive area.

Knowledge index (KI) was computed using the formula:

$$KI = \left(\frac{\sum K_i}{n \times K_{max}}\right) \times 100$$

Where,

K_i = Score obtained by the respondent on the i^{th} knowledge item.

K_{max} = Maximum possible score per item.

n = Total number of knowledge items/questions.

$\sum K_i$ = Sum of scores obtained across all items.

KI = Knowledge index expressed in percentage.

To assess the relationships between dependent and independent variables pearson correlation, muti linear regression and chi-square test were carried out. Pearson's correlation coefficient was done to know the linear relationships between Knowledge level with independent variables, where statistical significance was set at $p<0.05$. Multiple linear regression analysis was used to assess the combined and individual effects of all independent variables on Knowledge level with a level of significance of $p<0.05$. Chi-square test of independence was done to determine the association between Knowledge level and selected categorical independent variables. $p<0.05$ was considered statistically significant.

Pearson correlation formula

$$\rho xy = \frac{cov\,(XY)}{\sigma X \sigma Y}$$

Where,

cov = Covariance.

σX = Standard deviation of X.

σY = Standard deviation of Y.

Multi linear regression formula

$$Y = \beta 0 + \beta 1\ X1 + \beta 2\ X2 + ... + \beta k\ Xk + \varepsilon$$

Where,

Y = Dependent variable.

$\beta 0$ = Intercept.

βi = Regression coefficients for predictors.

Xi= Independent variables.

ε = Error term.

Chi-square test formula

$$x^2 = \sum_{i=1}^{r} \sum_{j=1}^{c} \frac{(o_{ij} - E_{ij})^2}{E_{ij}}$$

Where,

O_{ij} = Observed frequency in the i^{th} row and j^{th} column.

E_{ij} = Expected frequency.

r = Number of rows.

ccc = Number of columns.

RESULTS AND DISCUSSION

Socio-economic characteristics of the respondents

To understand the cognitive use of information and communication techmology (ICT) tools in agriculture, it is essential to examine the socio-economic characteristics

Table 1: Socio-economic characteristics of respondents. N=360

Variable	Category	Frequency	Percentage (%)
Age	Young (<41 years)	60	18.06
	Middle-aged (41-61 years)	235	65.28
	Old (>61 years)	65	16.67
Education	Illiterate	39	10.83
	Up to secondary school	201	55.83
	Higher secondary and graduate	120	33.34
Annual income	Low (< `215,031)	70	19.44
	Medium (`215,031 - `557,652)	218	60.56
	High (> `557,652)	72	20.00
Land holding	Low (<4 acres)	58	16.11
	Medium (4-6 acres)	238	66.11
	High (>6 acres)	64	17.78
Farming experience	Less than 11 years	45	12.50
	11-21 years	259	71.94
	More than 21 years	56	15.56
Primary occupation	Farming	360	100.00
Secondary occupation	None	207	57.50
	Collection of NTFPs	69	19.17
	Govt./Business/Other	84	23.33

Table 2: Sources of information accessed by respondents. N = 360

Source type	Source	Percentage (%)
Extension contact	ATMA professionals	46.39
Mass media	Mobile phone (Internet)	57.78
	TV	10.56
	Radio	16.11
	Print media (Poster/Leaflet)	17.22

most directly influencing access, comprehension and application.

From Table 1 it was discovered in the survey that 65.28% of the respondents were in the middle-aged group (41-61 years), a class generally considered to be vulnerable to innovation but remaining firmly entrenched in conventional practices which were in line with the findings of (Osondu *et al.,* 2015). Farmers aged less than 41 years made up just 18.06% of the respondents and that means ICT interventions may need to reach an older group with potentially lower digital literacy.

The levels of education were relatively low, with over half (55.83%) having only attained secondary education and only 33.34% having attained higher secondary or graduated. This level of educational attainment is sufficient for simple interaction with information and communication technologies (ICT), like reading text messages or accessing simple mobile applications, but might not support higher-level analytical interactions with digital platforms (Ajijola *et al.,* 2015, Osondu *et al.,* 2015 and Kabir, 2015). The income levels were predominantly in the middle since 60.56% was in the middle-income category (`215,031-`557,652), indicating the ability to acquire basic ICT tools like mobile phones but presumably with limited access to smartphones or data packages for accessing the internet.

Land holding size and experience in farming are good predictors of resource stability and exposure to farm innovations. Approximately 66.11% possessed medium-sized landholdings (4-6 acres) similar findings have been reported by Singh *et al.,* (2023) where most farmers had medium sized land holdings. 71.94% possessed 11-21 years of experience in farming. They are therefore good candidates for focused ICT interventions that can improve farm management if the interventions are contextually appropriate and user-friendly.

Occupational data showed that while all the respondents were farmers by principal occupation, 42.5% of them had secondary occupations as well, such as collecting forest products (19.17%) and government/business occupations (23.33%). They can be engaged in other activities, which may affect their exposure to information systems aside from agriculture and thus increase their ICT adoption readiness.

Sources of information accessed by respondents

To assess how rural farmers in Nagaland cognitively engage with ICT tools in agriculture, it is essential to explore the pathways through which they access agricultural information. Table 2 illustrates the extent to which different sourcesboth institutional and media-basedare utilized. These include extension personnel, mobile internet, radio, television and print materials.

From Table 2, the data show that mobile internet is the most accessed source of agricultural information, used by 57.78% of farmers, indicating a growing shift toward digital tools. In contrast, traditional media like radio (16.11%) and

Table 3: Distribution based on knowledge level of the respondents towards the use of ICT tools.

		SDA		DA		A		SA		Total per cent score	Mean per cent score	Rank
		f	%	f	%	f	%	f	%			
Remembering	I know the dial or hotline number of the krishi call center.	276	76.67	25	6.94	52	14.44	7	1.94	16.39	16.76	I
	I can identify social media platforms relevant to agriculture (*e.g.*, Facebook, You tube).	276	76.67	21	5.83	57	15.83	6	1.67	17.50		
	I can recognize the basic parts of a computer.	283	78.61	18	5.00	46	12.78	13	3.61	16.39		
Understanding	I understand what ICT (Information and communication technology) stands for.	280	77.78	32	8.89	19	5.28	29	8.06	13.33	11.67	II
	I understand how social media helps in sharing or getting agricultural information.	276	76.67	48	13.33	15	4.17	21	5.83	10		
	I understand the general functions of mobile phones in communication.	280	77.78	38	10.56	19	5.28	23	6.39	11.67		
Applying	I know how to protect my computer or smart phone from virus attacks.	296	82.22	24	6.67	15	4.17	5	1.39	5.56	7.78	VI
	I can take photographs using mobile or digital cameras.	108	30.00	228	63.33	17	4.72	23	6.39	11.11		
	I know how to get internet connectivity through mobile data.	112	31.11	228	63.33	21	5.83	3	0.83	6.67		
Analyzing	I understand why mobile phones are suitable for agricultural extension activities.	287	79.72	40	11.11	16	4.44	17	4.72	9.17	9.35	IV
	I understand why call centres are becoming popular among farmers.	121	33.61	217	60.28	20	5.56	2	0.56	6.11		
	I know why passwords are used in ICT tools to ensure security.	282	78.33	32	8.89	24	6.67	22	6.11	12.78		
Evaluation	I believe ICTs in agricultural extension can save time and reduce costs.	131	36.39	201	55.83	26	7.22	2	0.56	7.78	9.44	III
	I think ICT-based advisory services are better than traditional extension methods.	113	31.39	218	60.56	26	7.22	3	0.83	8.06		
	I think agriculture-related TV programs are helpful and easily accessible.	290	80.56	25	6.94	22	6.11	23	6.39	12.50		
Creating	I know how to download and install a new mobile app (Android).	129	35.83	210	58.33	16	4.44	5	1.39	5.83	8.52	V
	I know how to increase the storage capacity of my mobile phone.	290	80.56	37	10.28	17	4.72	16	4.44	9.17		
	I know how to transfer data from a computer using pen drive, data cable, or bluetooth.	285	79.17	37	10.28	19	5.28	19	5.28	10.56		

TV (10.56%) are less commonly used. Print media (posters/ leaflets) reached 17.22% of respondents. Among extension contact it was found that ATMA professionalswere in touch more with the farmers at 46.39%.

ICT knowledge level

It is imperative to understand cognitive distribution of ICT knowledge among the farmers in order to measure not only awareness but also the degree of their utilization of digital technologies in agriculture. In this study, the level of knowledge was measured in six cognitive domains: Remembering, Understanding, Applying, Analyzing, Evaluating and Creating. They represent a spectrum from simple recollection of facts to more sophisticated, analytical and creative application of ICT. Results depicted from Table 3.

Among the six categories, “Remembering” recorded the highest mean score (16.76%). This shows that most of the respondents could recall ICT-related information such as mobile applications, helpline numbers, or agriculture call centers. This is the lowest level of cognitive engagement and shows that even though farmers know ICT tools are available, their knowledge is superficial and recognition-based. For instance, Raghuprasad *et al.* (2013) established that 85% of the respondents mentioned television as a source of agricultural information, a sign of high recall but not necessarily understanding or usage.

The “Understanding” category then had a mean score of 11.67%, indicating a moderate ability among farmers to comprehend the purposes and benefits of ICT in agriculture. Farmers at this level were aware, for example, that mobile phones can be used to access weather forecasts, expert opinion, or to call other farmers. But the seeming drop from Remembering to Understanding indicates a lack of conceptual clarity and interpretive ability about ICT usefulness in farming settings. This is in line with Rahman *et al.* (2015), who noted that although 37.3% of farmers used mobile phones for farm information, many lacked more advanced higher functional understanding than basic use.

“Evaluating” (9.44%) and “Analyzing” (9.35%) categories were placed in the middle category but still reflect limited ability. These categories test the capacity to critically analyze ICT tools, contrast online information with offline sources and pass judgment on credibility and relevance. The low values reflect that farmers did not possess the evaluative judgment to recognize credible online content or make ICT-based choices. Musa *et al.* (2015) also found the same, where farmers identified the simplicity of radio and TV due to their wide coverage but only 3.3% utilized the internet, reflecting low analytical exposure to varied ICT sources.

“Creating” (8.52%) and “Applying” (7.78%) categories, which are indicative of higher-order thinking abilities. These categories assess competency to utilize ICT tools creatively-*e.g.*, to reconfigure mobile setups to farm operations, download and utilize software, or adapt technologies to local agriculture needs. Low scores in these categories are indicative of a significant problem: farmers are not yet capable of integrating ICTs into their everyday farm operations in a significant or transformative manner. Kabir (2015) also found that although 98.9% of farmers were utilizing mobile phones, few had direct experience or exposure to computers or internet services-limiting their capacity to develop or utilize ICT solutions. Similarly, Luqman *et al.* (2019) reported that over half of the respondents had only medium ICT knowledge and skill levels, restricting extended use.To enable higher levels of cognitive engagement particularly in applying, analyzing and creatingextension services must go beyond awareness campaigns and invest in hands-on digital literacy training, locally contextualized ICT platforms and continued user support.

The findings demonstrate a gap between awareness to application, farmers are quick to identify ICT tools, but they are less proficient in applying, analyzing/evaluating and creating. This is consistent with data showing that income and education help farmers move up the ICT access ladder (Nagar *et al.,* 2025). The extent and effective ness of ICT use are greatly increased by training, media exposure and other profile factors (Chaudhary *et al.,* 2024) indicating that focused capacity-building can transform awareness into action.

Relationship of knowledge level with socio economic variables

Table 4 depicts that age showed a positive and significant correlation with Knowledge (r = 0.242) and was a significant predictor in regression, indicating that as age increases knowledge level of the respondents also increases. Education had the strongest correlation value (r = 0.673)

Table 4: Association of knowledge level with socio economic variables.

Variables	Pearson correlation (p<0.05)*	Regression (p<0.05)	Chi-square test (p<0.05)
Age	0.242*	p<0.001	-
Education	0.673*	p<0.001	p = 3.4e-40
Family type	-0.521*	p<0.001	p = 1.9e-19
Primary occupation	NS	p<0.001	-
Total land holding	-0.144*	NS	-
Social participation	NS	NS	p = 0.0177
Source of information	0.275*	NS	-

and significant predictor in regression, which shows that higher educational level increases knowledge level of the respondents substantially. Chi-square results (p = 3.4e-40) also confirmed that knowledge distribution differs significantly across education categories. Family type had a negative correlation (r = -0.521) and was significant in regression, indicating that family structures are associated with lower knowledge scores. Knowledge level tend to increase with nuclear family structure as in this kind of family type there is more independence and autonomy in decision making. The Chi-square test (p = 1.9e-19) also confirmed a significant association. Primary Occupation (Farmer) did not show any significance in correlation analysis but was significant in regression (p<0.001), depicting that farming influences the respondents knowledge level towards ICT in agriculture. Social Participation was not significant in correlation or regression but showed a significant Chi-square result (p = 0.0177), showing categorical differences in knowledge levels among different participation groups in social setting. Total Land Holding showed a weak negative correlation with knowledge (r = -0.144). Smaller landholders are more motivated to maximize and increase productivity through improved cultivation practices by engaging in seeking more information through ICT. Source of Information showed a significant positive correlation with knowledge level (r = 0.275), showing that farmers who accessed a wider range of information sources tend to have higher knowledge. These findings are consistent with the results given by Nagar *et al.,* 2025; Babu *et al.,* 2025; Chaudhary *et al.,* 2024; Panda *et al.,* 2019.

CONCLUSION

The findings of the study reflect a wider gap between awareness and actual cognitive utilization of ICT tools among Nagaland's rural farmers. While most respondents reported awareness of ICT platforms such as mobile phones and farm hotlines, their cognitive ability to use, analyze, evaluate or customize these tools to make decisions at the farm level was significantly below average. This cognitive gap was particularly pronounced in the less sophisticated areas of application, analysis and creation, suggesting a capacity-building intervention above exposure.

Socio-economic factors such as age, education, income and farming experience were instrumental in deciding the intensity of ICT usage. Middle-aged farmers with intermediate education and holding levels were the predominant user group, but their ICT usage tended to be passive in the sense of communication alone and not of knowledge integration. Institutional channels such as extension personnel and media were also not being utilized to their full potential, suggesting not only a knowledge gap but also a delivery gap in ICT-based agricultural services.

To achieve this, one must create and conduct contextualized ICT literacy programs that extend beyond the single sensitization workshop. These programs must address tangible skills like using agricultural apps, accessing and interpreting real-time market or weather data, downloading advisories and interaction with e-extension services. Content needs to be contextualized to the local linguistic and cultural environment, by utilizing vernacular media and low-tech delivery modes wherever feasible. Experiential, participatory training emphasizing utilization of existing rural institutions like Krishi Vigyan Kendras (KVKs), Agricultural Technology Management Agency (ATMA) and local Self-Help Groups (SHGs) can minimize the cognitive divide better.

Additionally, a feedback loop between users and service providers should be integrated to ensure that ICT platforms evolve in response to the cognitive and contextual realities of farmers. This two-way engagement can help shift ICT usage from basic awareness toward empowered, decision-supportive action.

Conflict of interest

All authors declared that there is no conflict of interest.

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