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Exploring the Catalysts of Farmer's Access to ICT for Agricultural Technical Advice: Evidence from Western Uttar Pradesh

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ABSTRACT

Background: This study addresses the challenges faced by farmers in accessing Information and Communication Technology (ICT) tools for agricultural advice in Western Uttar Pradesh, India.

Methods: The research involved the analysis of primary data, which was collected from 420 farmers using a structured questionnaire. To assess ICT access, the study employed an ordered logit model, categorizing access into three distinct levels: Poor, fair and good.

Result: The analysis indicated that factors such as the age, income and higher education levels of household heads have a positive influence on ICT access. On the contrary, variables like group membership and ownership of a Kisan Credit Card were found to negatively affect ICT access. These findings highlight the significant role that specific socio-economic characteristics play in shaping the level of ICT access among farmers in this region.

Key words: Agricultural advice, Digital divide, ICT access, Ordered logit model, Technology adoption.

INTRODUCTION

The Sustainable Development Goals (SDGs) hinge significantly on the dissemination and application of knowledge and information, which have become integral components of modern life. It is widely acknowledged that substantial investments in information and communication technology (ICT) for local populations, particularly in vulnerable and remote areas, are essential to achieving SDG 9 and the broader 2030 Agenda. Specifically, SDG 4, which emphasizes quality education for all, is directly tied to the notion that sustainable development cannot be realized unless learning is integrated with technology. There is much at stake in this process. To begin, individuals must learn to leverage data and technology in ways that align with their needs and goals. ICT becomes relevant not only in terms of access but also in its capacity to facilitate innovation in people's daily lives. Technological innovation is deemed successful when it catalyzes social innovation.

As the world becomes increasingly complex, the meanings of key concepts also evolve. The digital divide, for example, is no longer solely about basic connectivity to resources (Van Dijk, 2006). Recent studies and observations suggest that the digital divide is layered, determining disparities between individuals. The first layer of the digital divide pertains to disparities in basic physical and material accessibility. Physical access refers to connectivity to equipment such as desktop and laptop computers, while material access pertains to the ability to afford broadband services. These forms of connectivity vary across sociodemographic parameters, including gender, age, profession and nationality. Furthermore, global disparities in access often align with wealth and privilege. As ICT became more ubiquitous, attention shifted from mere access to addressing the skills divide. This second level of the digital divide concerns the gap between individuals and communities who possess the skills to utilize ICT effectively and those who lack such capabilities.

Among nations, the second level of the digital divide is reflected in communities segmented by job status, academic attainment, geographical location (urban vs. rural), gender and age. Across economies, educational achievement is a key predictor of proficiency in using ICTs. Individuals with higher levels of education, particularly university degrees, are significantly more likely to possess the technical skills necessary to utilize ICT effectively. Consequently, regions with a higher proportion of university graduates are more likely to have residents with advanced ICT skills. The third layer of the digital divide focuses on the benefits derived from using ICT, particularly how differences in capabilities lead to varied outcomes. This layer underscores the disparities in the advantages individuals and communities gain from their use of ICTs

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(Valdez *et al.,* 2021; International Telecommunication Union, 2018).

The application of ICTs in agricultural extension services has been a focal point of research, identified as a crucial channel for disseminating agricultural information and improving access to advisory services (Dimo *et al.,* 2022; Dlamini and Worth, 2019). ICTs in agriculture encompass various domains, including income generation, sustainability, market access, weather forecasting and profit enhancement. They have demonstrated substantial impacts on productivity, market access and the promotion of sustainable practices (Dheebakaran *et al.,* 2024; Das *et al.,* 2021).

Access to ICTs among farmers is influenced by several factors. Studies indicate that barriers such as inadequate knowledge of ICT, lack of awareness about its benefits and the absence of comprehensive information systems significantly hinder farmers' ability to utilize ICT-based resources (Manjuprakash *et al.,* 2017). Key factors that facilitate farmers' access to ICT include the availability of ICT infrastructure, farmers' familiarity with ICT tools and the training they have received on ICT usage (Khalak *et al.,* 2018). Moreover, the perceived advantages of ICTs, their compatibility with existing practices, ease of use, observability, social influence and information quality positively affect their use in accessing agricultural inputs, while the cost of ICT services remains a significant deterrent (Khalak *et al.,* 2018). The adoption of ICTs among farmers is also influenced by socio-economic and demographic variables, as well as farm characteristics and business orientation (Rabbi *et al.,* 2020). Additionally, the lack of training has been identified as a major limitation in the acceptance and use of ICT in agricultural activities (Narmilan, 2017). Other factors, such as unreliable power supply, slow internet connections, inadequate extension services and a general lack of awareness, have also been cited as barriers to ICT access in agriculture (Sule *et al.,* 2021). Furthermore, ICT literacy levels and demographic factors significantly influence farmers' adoption and use of ICT for agricultural purposes (Alant and Bakare, 2021). The importance of ICTs for farmers is evident in their ability to access critical information, including agricultural updates, weather forecasts, new farming techniques, market prices and storage technologies (Ajani, 2014).

Marshall *et al.* (2020) examined the digital landscape of Australia's agricultural sector, emphasizing the significance of rural communities to the national economy. The study highlighted efforts to address historical gaps in internet connectivity and ICT skills within the agricultural sector through the digital inclusion agenda, based on the "Australian Digital Inclusion Index (ADII)." Mburu (2013) studied the factors influencing smallholder farmers' access to agricultural information *via* ICT channels in Ndeiya, Kiambu, surveying 217 participants. The study revealed a significant correlation between farmers' age, education and their preferred ICT channels.

Previous studies have identified several social and demographic factors that predict variations in internet usage, including age, gender, educational background, socioeconomic status, job type, online experience and geographical location. A cluster analysis conducted across five European countries by Brandtzaeg *et al.* (2011) revealed that age, gender, household size and internet connectivity type significantly influence an individual's classification into one of five user categories: Non-users, sporadic users, instrumental users, entertainment users and advanced users. Research has also shown that women tend to use the internet primarily for communication, while men use it for business, entertainment and gaming (Hargittai and Shafer, 2006). Moreover, younger individuals typically use the internet for social interaction, while older users primarily engage in business activities and information-seeking (Jones and Fox, 2009).

In response to the research gap, this study focuses on the limited scholarly exploration of ICT accessibility in agriculture in India, particularly at the household level. The motivation behind this research stems from the critical need to understand how socio-economic factors influence farmers' access to ICT tools, an area largely underexplored in existing literature. This paper aims to bridge this gap by analyzing the various dimensions of accessibility and identifying key barriers that impact ICT usage in Western Uttar Pradesh.

MATERIALS AND METHODS

Sampling design

Uttar Pradesh is one of India's top agricultural producers and the western region contributes significantly to this output, making it a representative area to study agricultural practices, out of all districts, Meerut and Muzaffarnagar have high agricultural activity, with over 60% and 70% of their populations, respectively, engaged in farming. The study conducted a primary survey of 420 farmer households which was determined using Cochran formula, ensuring a 95% confidence level and a 5% margin of error (Cochran,1977). The data was collected during 2023-24, from 2 districts of Western Uttar Pradesh, namely Meerut and Muzaffarnagar, 3 blocks were selected from each district. an equal sample of 35 farmers was collected from 3 villages of each block. The questionnaire had questions on access of various ICT tools like Mobile phone, TV, YouTube and also on farmer's education, age *etc*. It also included information on the barriers farmer face while accessing.

The dependent variable was Access to ICT tools. It was calculated as an ordered dependent variable and divided into 3 categories: Poor access, Fair Access and Good Access. Hence ordered logit regression was employed for determining the factors affecting access to ICT tools.

Ordered logit regression

Ordered logit regression is a statistical technique used for modeling ordinal dependent variables. This method is

appropriate when the outcome variable is ordinal and the goal is to understand the relationship between this outcome and one or more predictor variables (Agresti, 2010). In ordered logit regression, the log-odds of being in a higher category of the outcome variable are modeled as a linear function of the predictor variables. The model assumes that the relationship between each pair of outcome groups is the same, which is known as the proportional odds assumption (Long and Freese, 2014).

The general form of this regression's equation is:

$$\text{logit}\,[P\,(Y \leq j)] = \alpha j - \beta' X$$

Where,

logit [P(Y≤j)]: Log-odds of being in a category less than or equal to.

αj: Threshold parameter for category.

β: Coefficients for the predictor variables.

X: Predictor variables.

(McCullagh,1980)

Several independent variables related to the farmers themselves are included in the model. These encompass:

Household size (*hhsz*)

Religion (*rlgn*)

Education (*edu*): Years of education for the head of household and the most educated household member.

Farming experience (*farmex*): Years of farming experience of head of the household.

Work effort (*wrkeft*): Hours dedicated to field work each day.

Income (*inc*): Total annual income.

Farm Size (*farmsz*): Land size holding of the household.

Kisan Credit Card (*kcc*): Availability of Kisan Credit Card.

Technology access and knowledge (*techaccess*): Understanding of ICT.

Mobile phone (*phonetyp*): Type of mobile phone.

Group Membership (*grpmmbr*): Involvement in any group or organization.

The regression model hence is represented as:

$$\text{logit}\,[P(Y \leq j)] = \alpha j - (\beta_1 edu + \beta_3 age + \beta_4\, farmex + \beta_5 wrkeft + \beta_6 hhsz + \beta_7 sclgrp + \beta_8 rlgn + \beta_9 inc + \beta_{10}\, kcc + \beta_{11}\, farmsz + \beta_{12}\, grpmmbr + \beta_{13}\, techaccess + \beta_{14}\, phonetyp)$$

This equation represents a linear relationship between the independent variables and a latent variable underlying the ordered categories of ICT access. The regression analysis was performed using STATA 18.

Since the data used in this study are cross-sectional, there is no need to check for stationarity, a concern typically associated with time series data. Cross-sectional data capture information at a single point in time across various subjects, making issues related to unit roots and stationarity irrelevant. To ensure the robustness and validity of our cross-sectional data analysis, several diagnostic tests were conducted.

First, we tested for multicollinearity using the Variance Inflation Factor (VIF). After fitting the ordered logit model, we calculated VIF values for each predictor variable. VIF values below 10 indicated that multicollinearity was not a significant issue in our model.

Next, we checked for heteroscedasticity using the Breusch-Pagan test. This test examined the residuals of our model to determine if the variance of errors differed across observations. A non-significant p-value from the Breusch-Pagan test suggested that heteroscedasticity was not present, confirming that the error variance was constant across observations.

To assess the normality of the residuals, we applied the Shapiro-Wilk test. The results indicated that the residuals were not normally distributed. However, since normality of residuals is not a strict requirement for ordered logit models, the non-normality does not invalidate the model. Nevertheless, non-normality can affect the efficiency and validity of inferences, so we used robust standard errors in the model to account for this.

Finally, we conducted the Ramsey RESET test to check for model specification errors. This test helps determine whether any important variables were omitted or if the functional form of the model was incorrect. The non-significant p-value from the Ramsey RESET test indicated that our model was correctly specified, with all relevant variables included and no indication of specification errors.

RESULTS AND DISCUSSION

The data from primary survey shows that farmers use a range of ICT tools (Fig 1) from one to ten. They predominantly accessed mobile phones, with a universal usage rate of 100%. Other significant tools included the E-Ganna app, used by 92% of farmers and agricultural TV programs such as DD Kisan and Krishi Darshan, both accessed by 62% of farmers. Internet usage was notable at 46%, paralleled by YouTube, which also saw 46% utilization. Social media was another significant platform, used by 27% of the farmers. Computers were less common, with only 3% of farmers accessing ICT tools via this medium. Additionally, a small percentage of farmers, 0.5%, accessed various TV channels and GPS technology was minimally accessed.

The results of the regression analysis unveil compelling insights into the factors influencing access to Information and Communication Technology (ICT) tools among individuals within the agricultural sector.

The analysis reveals that individuals aged 30-44 years (OR = 7.27), 45-59 years (OR = 7.15) and 60 years and above (OR = 7.70) have significantly higher odds of good access to ICT tools compared to younger individuals, *ceteris paribus*. This trend may be attributed to greater exposure to and experience with technology among middle-aged and older individuals. Similarly, education plays a pivotal role, with odds increasing progressively from just literate (OR = 2.88) to graduation and above (OR = 4.20),

highlighting the critical impact of higher educational attainment in fostering digital literacy and ICT adoption. (Table 1).

The type of mobile phone also matters significantly, as owning a smartphone (OR = 3.37) enhances ICT access substantially. Moreover, a good understanding of ICT (OR = 5.44) emerges as a strong positive determinant of access, underlining the need to promote digital awareness.

Conversely, certain factors negatively affect ICT access. Possession of a Kisan Credit Card (OR = 0.42) decreases the odds, possibly due to the card's focus on immediate agricultural needs, leaving limited scope for technology-related investments. Similarly, group membership (OR = 0.55) is negatively associated, which may reflect inefficiencies or limited ICT engagement within such groups.

While total annual income shows no clear directional influence, the nuanced relationships identified emphasize the interplay of socio-economic and demographic factors in determining ICT accessibility.

Predominantly, the barrier of ″Not Available″ is the most cited, with 166 instances, underscoring the critical issue of infrastructure inadequacy. Following this, "Not Required" is the second most common barrier, noted 143 times, indicating a perceived lack of necessity for ICT tools among many farmers. Interestingly, ″Not Aware″ ranks third, with 108 mentions, reflecting a substantial gap in awareness and digital literacy (Fig 2).

These findings delineate a complex landscape of accessibility challenges, where infrastructural availability and perceived necessity markedly influence access, suggesting significant portion of the farming community does not recognize the relevance of these tools and infrastructural and resource constraints. With the advancement of agriculture in Indian farming, it is important to look into these barriers (Sharma *et al*., 2021).

Age and education: Pillars of digital inclusion

Age emerges as a significant determinant, with individuals aged 30-44, 45-59 and 60 and above exhibiting higher odds of good ICT access compared to younger groups. This finding aligns with Olaniyi *et al.* (2013), who observed greater ICT use among mature farmers. However, the relationship between age and ICT access is nuanced; while some studies suggest a "grey digital divide", with age negatively associated with ICT access (Mubarak and Suomi, 2022; Alant *et al.,* 2021). Older farmers often leverage their extensive experience, established networks and community engagement to access ICT resources more effectively including organized groups or cooperatives, enhanced knowledge sharing, access to subsidies and agricultural extension services critical for adopting technology (Mendes *et al.,* 2024; Candemir *et al.,* 2021). Despite their higher risk aversion, targeted training and support can help older farmers overcome barriers and maximize the benefits of ICT adoption (Ding *et al.,* 2023). The pivotal role of education in fostering digital inclusion is evident, as higher educational attainment correlates strongly with improved ICT access. Notably, individuals with graduation and above education showcase the strongest association, highlighting the transformative potential of education in bridging the digital divide (Panda *et al*., 2019; Chaudhary and Gardhariya, 2024).

Financial instruments and technological literacy

The negative relationship between Kisan Credit Card (KCC) possession and ICT access may arise from prioritizing agricultural inputs over technology investments, as farmers often allocate credit to essentials like seeds and fertilizers. This contrasts with earlier studies linking credit access to increased use of agricultural information (Daniso, 2022). In contrast, smartphones bridge traditional farming with

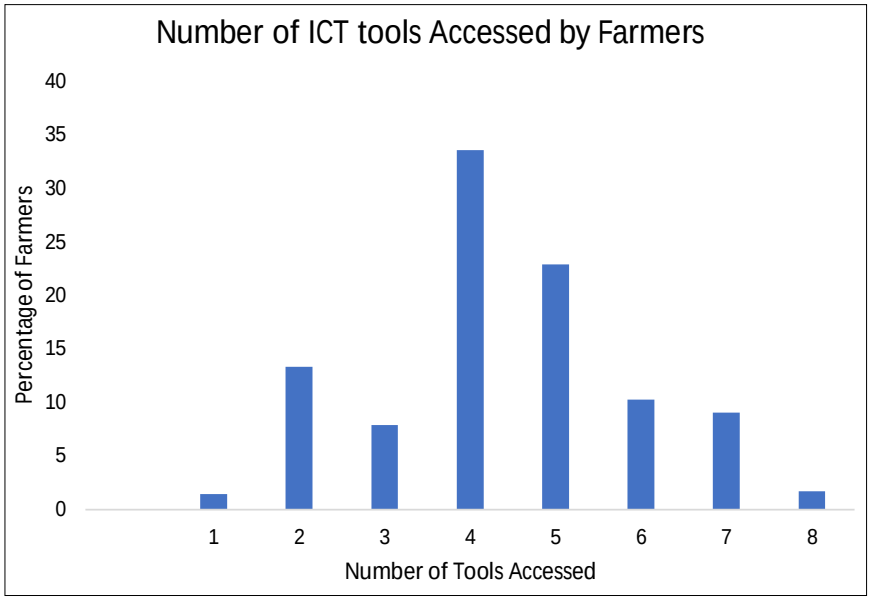


Fig 1: Number of tools accessed by farmers.

Table 1: Estimates of ordered logit regression model.

Source: Authors' calculation
Access to ICT tools. (Dependent variable)
Poor access= 1.
Fair access= 2.
Good access= 3.

Independent variable	Category	Odds ratio	Standard error	P value
Age	30-44	7.268545	5.456116	0.008***
	45-59	7.153621	6.047659	0.02**
	60 and above	7.697464	7.818182	0.044**
Household size		0.975398	0.092781	0.793
Religion (1=Hindu, 2= Muslim)	Muslim	0.565724	0.229299	0.16
Social group (1=Scheduled tribe)	Scheduled caste	0.536126	0.303491	0.271
	Other backward class	0.589313	0.321156	0.332
	Others	0.707726	0.390664	0.531
Education (illiterate)	Just literate (1-4)	2.880221	1.517572	0.045**
	Primary to middle (5-9)	2.298525	1.054777	0.07*
	Secondary to senior secondary (10-12)	2.685404	1.156905	0.022**
	Graduation and above	4.200417	2.138663	0.005***
Years of schooling of most educated		0.983299	0.054124	0.76
Farming experience		0.961362	0.024698	0.125
Field hours per day		1.071053	0.11692	0.529
Total annual income		1.00E+00	6.18E-07	0.079*
Kisan credit card (1=yes)		0.416851	0.127859	0.004***
Understanding of ICT	Fair	1.217283	0.344607	0.487
	Good	5.443829	3.828725	0.016**
Mobile phone type	Smart phone	3.371569	0.997473	0***
Group membership		0.552752	0.146719	0.026**
Farmer category-land size	Medium farmer	0.848856	0.310861	0.655
	Small farmer	0.870992	0.26532	0.65
/cut1		-1.012049		
/cut2		3.101743		

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

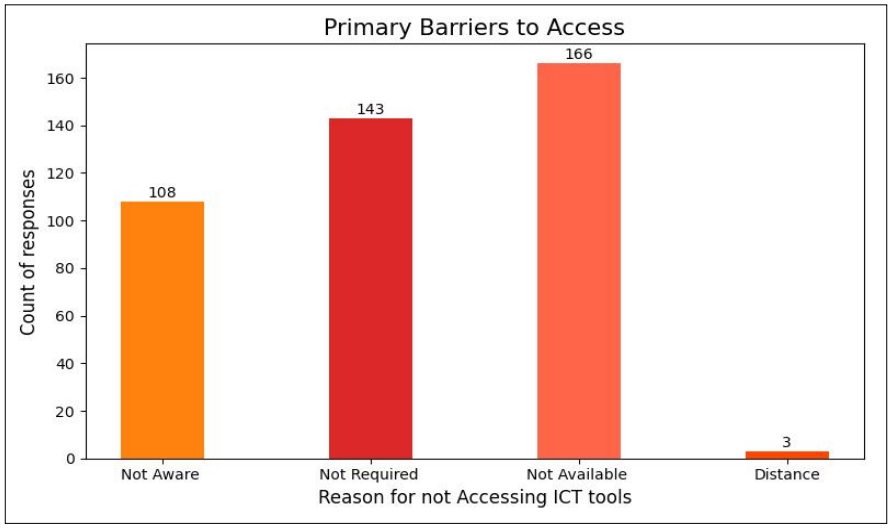


Fig 2: Primary barriers to ICT access among farmers.

modern solutions, specially after pandemic, providing timely information and tools, Broader smartphone and internet access also foster financial inclusion, crucial for rural economic sustainability (Upendra *et al.,* 2023; Baumüller, 2022).

Group membership and digital exclusion

Surprisingly, group membership within agricultural communities demonstrates a negative association with ICT access, suggesting potential barriers to digital inclusion within group dynamics. It is contrary to findings by Daniso (2022). Fostering an environment that encourages collaboration rather than competition can enhance digital inclusion and empower individuals to leverage ICT for agricultural productivity (Heng and Tang, 2023).

CONCLUSION

The primary data analysis of 420 farmers using an ordered logit model classified ICT access into poor, fair and good levels. Key findings reveal that age, income and higher education positively influence ICT access, while group membership and Kisan Credit Card ownership have a negative impact, highlighting farmers' reluctance to invest in digital tools. Additionally, inadequate infrastructure, lack of perceived necessity and low digital awareness further hinder access. Policymakers can promote inclusion through ICT tool subsidies or community ICT centers, targeted policies that enhance digital infrastructure, promote ICT awareness and integrate technology into agricultural practices to foster inclusive digital empowerment in rural communities. This study provides a foundation for evidence-based interventions and contributes to the discourse on digital inclusion for socio-economic progress.

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Conflict of interest

All authors declare that they have no conflict of interest

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