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Analysis of Challenges Faced by Farmers in Using ICT for Agricultural Knowledge and Information Management (AKIM)

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ABSTRACT:
Several empirical studies have highlighted that use of ICT for agricultural knowledge and information management (AKIM) have helped farmers to increase yield, lower input costs, and adopt sustainable practices. Despite high access to ICT facilitated by increased tele-density and affordable internet services in rural areas of Delhi-NCR, adoption and usage of ICT sources for AKIM among farmers is still below potential. Field survey of 667 farmers of Delhi-NCR and extensive literature review is carried out to explore the challenges faced by farmers in application of various ICT sources to manage their agricultural knowledge and information needs and a hierarchical model is developed using Interpretive Structure Modelling (ISM) and MICMAC analysis methodology. The study finds that despite high access to ICT sources the usage frequency of these tools for AKIM purposes is very low. Majority farmers strongly agreed that poor ICT literacy and skill, complexity of usage, lack of relevant contents and customized information are the major challenges directly linked to the low usage of ICT sources for AKIM. Lack of political will, supporting institutions, ICT and other infrastructure facilities are indirect challenges of high driving powers capable of influencing the challenges having direct linkage to the problem of low usage of ICT among farmers for AKIM.

KEY WORDS: AKIM, ICT, Challenges, ISM, MICMAC
JEL Codes: Q16, J15, O33

1. Introduction

The traditional modes of information and knowledge sharing among farmers have become less effective and are not able to meet the growing information need of farmers for the introduction of modern, sustainable & precision agricultural technology and avail market opportunities (Feng et al., 2005; Glendenning et al., 2010). The high cost of delivering face-to-face interaction, crumbling extension services and poor market information has paved the way for the use of modern ICT to disseminate agricultural information to targeted farmers (Mittal & Mehar, 2012). Ali & Kumar (2011) in their review have documented several possible benefits of ICT in agriculture which include conducting research, market efficiency, dissemination of relevant information, global networking in agricultural activities, self-reliance and economic growth. Rajkhowa & Baumüller (2024), using data from 86 countries for the period 2000 to 2019 have found that productivity of both land and labour in agriculture sector globally had a positive and significant association with ICT adoption. Lio & Liu (2006) in their study of 81 countries from 1995–2000, have presented empirical evidence on the positive relationship between the adoption of ICT and agricultural productivity. Their results suggested that ICT infrastructure helps in adoption of modern agricultural inputs which can be a reason for the difference in agricultural productivities across countries.

Farmers use various traditional and modern ICT tools such as Radio, Television, Mobile Phones (Call & SMS) and use internet services to seek knowledge and information through farm applications, websites, social media applications etc. Use of mobile phones provide information on crop prices, reduce middlemen and increase arbitrage opportunities which improves market efficiency and welfare transfer in favour of farmers (Aker, 2011; Jensen, 2010). Mobile phones reduces the information asymmetries of rural and undeveloped markets, reduces price fluctuations making them more efficient and improves productivity (Abraham, 2006). The ease of using mobile applications have increased their utility for small farmers (Pliakoura et al., 1 C.E.). Adesiji et al. (2024) in their study of use of Agricultural Mobile Apps (AMPAs) by Cassava growers in Nigeria found that its use reduced wastage of herbicides and provided access to valuable advice and information on cassava production anytime. Internet usage has a significant positive impact on financial performance of small farm business households as it reduces income risk by facilitating sources of off-farm income and also reduced marketing, storage and transportation costs (Chang & Just, 2009; Khanal & Mishra, 2016). Increased internet access has also encouraged use of social media apps such as Facebook and Twitter as convenient and vital source of information to farmers by providing interactive learning space for sharing and exchange of knowledge from remote locations. (Bhattacharjee & Raj, 2016; Phillips et al., 2021). The ability to use and adapt these ICTs (especially mobile and web technologies) is critical in generating and accessing wealth, power, and knowledge in smallholder farming communities (Mukhebi et al., 2007 and Misaki et al., 2018). However, they face challenges such as poor network access, power shortages, and costly charges when accessing the internet (Wangu, 2014). The full potential

of ICT use is not yet realised due to several challenges faced by farmers in their adoption and application (Yadav et al., 2015).

NSS (77th Round) report on 'Situation Assessment of Agricultural Households and Land and Livestock Holdings of Households in Rural India, 2019', suggests two stark features of technical advice accessed by farmer households, they are very low ICT access and relatively poor adoption of accessed information. It says 42.2 percent households accessed technical advice from any source and only 13.2 percent farmer households accessed ICT for technical advice. This include Kisan Call Centre (0.7%), print media (4.1%), radio/TV/ other electronic media (8.2%) and smart phone apps-based information (0.8%). The adoption ratio of technical advice accessed through ICT is lower (around 68%) as compared to high adoption ratio (around 90%) of information accessed through direct/face to face methods such as progressive farmers/input dealers/ FPOs/Co-operatives/ Extension agent etc.

2. Review of Literature

The extensive literature review suggests that there are several direct and indirect factors acting as barriers in accessing, adoption and usage of ICT by farmers for their AKIM needs to its full potential. Several researchers have found that education of farmers has a positive association with the level of use of ICTs in rural areas. The low literacy among farmers pose difficulties in communicating through messages and poor understanding or wrong interpretation of data by them (Tulinayo et al., 2022). Low level of education also causes low awareness about benefits of ICTs and thus impacts ICT skills of farmers (Luqman et al., 2019; Misaki et al., 2018; Narula & Arora, 2010; Singh et al., 2015). Low awareness about the use of mobile phone and applications to access farming information on prevailing technologies results in poor adoption of these technologies (Ajani & Agwu, 2012; Dlamini & Worth, 2019; Misaki et al., 2018; Syiem & Raj, 2015). Narula & Arora (2010) found that farmers' unawareness about the services provided through ITC and Gyandoot Kiosks in Madhya Pradesh was a major constraint in using ICT based KM intervention. Dipankar Saha et al. (2006) says that low ICT literacy is the major constraint in using available information on the internet for agriculture and rural livelihood in the developing countries like India. Mbagwu et al. (2017), in their study have also showed that rural farmers in developing countries especially in Africa are illiterate and lack the skills to operate computers. ICT literacy is a key challenge of using ICT by small holders for modern farming practices such as climate smart agriculture (CSA) than the much discussed affordability (Alant & Bakare, 2021; Choruma et al., 2024; Kale et al., 2015). Most farmers are hesitant in using ICT enabled information services due to either being uneducated or unskilled and didn't go to the kiosk (Narula & Arora, 2010). Many find it difficult to handle ICT and navigate digital menus, download apps and open hyperlinks (Choruma et al., 2024). They lack confidence in operating ICTs particularly mobile phone application due to inadequate training and practical exposure for using ICT as effective mode of information and knowledge seeking source (Anyan & Frempong, 2018; Misaki et al., 2018; Syiem & Raj, 2015). Technology based ICT solutions formed without integrating farming communities into the innovation process are perceived complex by farmers as they lack adequate skill and education to handle these ICT solutions(Tulinayo et al., 2022). The one size fit all model can't satisfy the diverse information need of the farmers. They require locally relevant and customized information on area, crop variety, soil and market (Glendenning et al., 2010; Raabe, 2008). The technological complexity and lack of customized solutions creates overall negative attitude towards ICT among farmers resulting in low probability of adoption of ICT by them (Anyan & Frempong, 2018; Dlamini & Worth, 2019; Syiem & Raj, 2015). Some researchers have reported that farmers do not trust the ICT information sources and this lack of transparency between farmers and ICT service providers results in low acceptability and adoption of technology for practical application (Kumar et al., 2017; Misaki et al., 2018). (Braimok, 2017) found that both men and women farmers in Kenya did not act upon messages (SMSs) as they considered them unsafe. Information received on Radio is also not considered trustworthy source as they do not see the person disseminating the information face to face (Braimok, 2017). Adequate understanding of rural famers information need helps in determining the best approach for forming internet information system and is therefore essential for quality internet-based information services (Mbagwu et al., 2017). In a study on use of Rice Knowledge Management Portal (RKMP) by farmers in Andhra Pradesh, (Kumar et al., 2017) found that poor content quality was one of the reasons quoted by farmers as a reason for low utilization of information provided on portal. (Singh et al., 2015) in their study in Maharashtra and Tamil Nadu has found that lack of updated information as most severe constraint in using the mobile messaging service provided by mKRISHI. Technological interventions such as web-portals collect information from diverse sources and provide single access point for information and knowledge management in agriculture sector. However, availability of relevant and contextualized contents for dissemination in usable format is still a challenge (Kumar et al., 2017). Information disseminated in regional languages are easily understood by less educated farmers. Use of foreign languages such as English is unable to consider the appropriate cultural context of the community and are not understood by farmers causing a barrier in using ICT (Kale et al., 2015; Misaki et al., 2018; Syiem & Raj, 2015; Tulinayo et al., 2022). Information disseminating agencies can foster partnerships among stakeholders to disseminate needed information to farmers in the rural areas. Lack of such agencies in rural areas under utilizes the potential of internet-based service among rural farmers (Mbagwu et al., 2017). Current institutions are inefficient and unable to support building partnerships with Private Sector, NGOs,

farming groups and implementing partners for ICT based knowledge management (Kale et al., 2015; Kumar et al., 2017; Tulinayo et al., 2022).

Availability of ICT and electrical infrastructure and their affordability are paramount for accessibility. Electricity and ICT infrastructure in rural areas of developing countries are in bad shape causing major challenge of utilizing potential of ICT based information services for farmers which could be accessed through websites, online forums and social media etc. (Kale et al., 2015; Mbagwu et al., 2017; Saidu et al., 2017). The poor access to ICT infrastructure slowdowns the information and knowledge dissemination process from research centres to farmers (Dlamini & Worth, 2019; Kale et al., 2015; Mbagwu et al., 2017; Misaki et al., 2018). Frequent power cuts and low level of electricity coverage in rural areas hinders the ICT expansion in such areas (Braimok, 2017; Dlamini & Worth, 2019; Freeman & Mubichi, 2017; Kale et al., 2015; Kalusopa, 2005; Kumar et al., 2017; Luqman et al., 2019; Saidu et al., 2017; Syiem & Raj, 2015; Tulinayo et al., 2022). Low income in rural areas poses difficulty in affording modern ICT tools and services creating a rural-urban digital divide (Dlamini & Worth, 2019; Syiem & Raj, 2015). Long distance to repair and high cost of software and ICT hardware is a problem for poor farmers in using ICT (Braimok, 2017; Freeman & Mubichi, 2017; Kale et al., 2015; Kalusopa, 2005; Kumar et al., 2017; Luqman et al., 2019; Misaki et al., 2018; Syiem & Raj, 2015; Tulinayo et al., 2022). Farmers of lower castes face difficulty in accessing ICT sources due to social structures and its norms specially when the ICTs such as Kiosks/Computers etc.are installed at the sites belonging to people of upper castes (Cairns et al., 2022; Narula & Arora, 2010). Societal norms favouring males in owning smartphones and digital literacy gaps among women are barriers faced by female farmers in accessing and usage of digital services such as online/mobile banking (Kulkarni & Ghosh, 2021; Kumar et al., 2017). Women undertake several household and caregiving responsibilities which limits their mobility causing time constraints for participation in digital learning programs related to agricultural activities (Braimok, 2017; Voss et al., 2021). The awareness and the use of ICT-based information service is driven by farmer and farm characteristics as well as various capital endowment factors such as land size (Alant & Bakare, 2021; Okello et al., 2014). Poor access to these productive assets limits the opportunities offered by markets to the resource poor farmers due to their small production and marketable volume. Due to small and subsistence level of agricultural production smallholders don't have any incentive to use ICT for AKIM.

Political will is a vital enabler in meeting all the challenges mentioned above. Poorly designed market entry policies, weak regulatory framework, provision of institutions having low technical capabilities and regressive usage taxes undermines the accessibility and affordability of ICT for resource poor and small farmers (Dlamini & Worth, 2019; Saidu et al., 2017).

3. Data and Methods

The study uses both primary as well as secondary sources of data to analyse the challenges faced by farmers in the application of ICT for the purposes of AKIM. In the initial stage an extensive literature review was carried out to prepare an exhaustive list of challenges faced by farmers in the application of ICT sources for their AKIM needs. After this, a primary survey of 667 farmers from 12 districts of three constituent states (except NCT-Delhi) of Delhi-NCR region was conducted.

Table 1: Socioeconomic Profile of Farmers (N=667)

Item	Socioeconomic Group	Frequency	Percentage
Gender	Female	32	4.8
	Male	635	95.2
Social Class	General	319	47.83
	Minority	27	4.05
	OBC	198	29.69
	SC	71	10.64
	ST	52	7.8
Age	Below 30	7	1.05
	30-45	159	23.84
	45-60	274	41.08
	60-75	202	30.28
	75 & above	25	3.75
Education Level	Illiterate	150	22.49
	Primary	52	7.8
	Middle School	80	11.99

	High School	186	27.89
	Sr. School	128	19.19
	Graduation	55	8.25
	Post-Graduation	16	2.4
ICT Training	Yes	103	15.44
	No	564	84.56
Land Size (in acres)	Marginal (<1 Acre)	107	16.04
	Small (1-2 Acre)	92	13.79
	Semi-Medium (2-4 Acre)	195	29.24
	Medium (4-10 Acre)	189	28.34
	Large (10 Acre & Above)	84	12.59
Annual Income	Below ₹ 2 Lakh	63	9.45
	₹ 2 Lakh - 5 Lakh	172	25.79
	₹ 5 Lakh - 10 Lakh	215	32.23
	₹ 10 Lakh - 20 Lakh	158	23.69
	Above ₹ 20 Lakh	59	8.85

The Table 2 below shows that 97 percent farmers of Delhi-NCR have access to any of the ICT source and 95.8 percent of these farmers have used (adopted) ICT for AKIM. Mobile (Call/SMS) is more frequently used and is followed by YouTube in social media segment. Usage of internet and farming applications is also substantial as compared to traditional ICT sources such as Radio and Landline. However, frequency of usage of various ICT sources is a major concern. Among traditional ICT tools Radio and Landline have lost their popularity and are rarely used whereas Newspaper is still used to some extent as AKIM source. Mobile (Call/SMS) is most popular and frequently used (3.29), popularity and usage of modern ICT sources such as YouTube, Farm Apps and WhatsApp is rising. Farmers portal, Facebook, Twitter (X) and Magazines are rarely used for AKIM by farmers.

Table 2: Status of ICT Access and Adoption for AKIM by Farmers (N=667)

ICT Source	Access / Owned	Adoption for AKIM	Frequency of Usage* for AKIM (percentage of farmers)					
			1	2	3	4	5	Mean Usage
Radio	105 (15.74)	97 (92.38)	84.7	9	3.6	1.8	0.9	1.25
Television	464 (69.57)	372 (80.17)	44.5	34.5	12.9	7.5	0.6	1.85
Landline	2 (0.3)	2 (100)	99.7	0.3	0.0	0.0	0.0	1.00
Mobile (Call/SMS)	632 (94.75)	618 (97.78)	6.4	28.0	19.0	23.4	23.1	3.29
Internet	323 (48.43)	291 (90.09)	56.1	13.2	10.2	15.1	5.4	2.01
Farm Apps	257 (38.53)	255 (99.22)	61.8	9.9	15.0	10.6	2.7	1.83
Farmers Portal	37 (5.55)	33 (89.19)	94.8	3.4	0.9	0.9	0.0	1.08
YouTube	424 (63.57)	421 (99.29)	36.3	12.4	15.0	25.9	10.3	2.62
WhatsApp	261 (39.13)	238 (91.19)	63.4	15.0	9.7	11.5	0.3	1.69
Facebook	77 (11.54)	51 (66.23)	90.9	4.9	2.7	1.5	0.0	1.15
Twitter (X)	30 (4.5)	22 (73.33)	96.7	1.2	0.9	1.2	0.0	1.07
Newspaper	302 (45.28)	299 (99.01)	54.0	19.5	14.1	8.1	4.3	1.89
Magazine	22 (3.3)	22 (100)	96.4	3.3	0.3	0.0	0.0	1.04
Any Source	647 (97)	639 (95.8)						

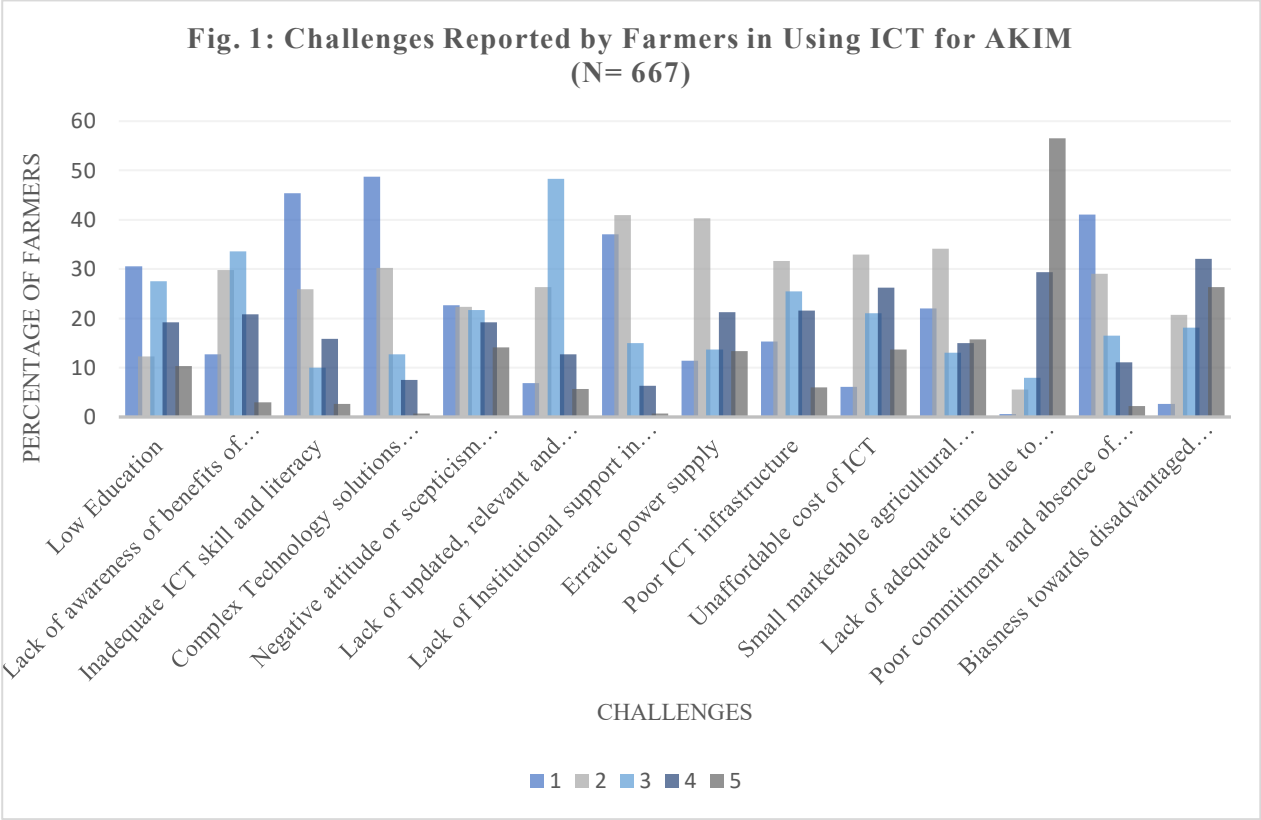
* frequency of usage is expressed on Likert Scale from 1 to 5 where, 1=Never, 3=Moderate and 5 = Very often

Source: Field Survey by Author

The responses of the farmers were sought on 14 identified challenges they faced in using ICT sources for AKIM. These responses were marked on Likert scale from 1 to 5, where '1' refers to 'strongly agree' and '5' refers to 'strongly disagree' to a challenge a respondent faced (Fig. 1). As is evident from bar chart farmers strongly agreed to 'low education (31%), Inadequate ICT skill and literacy (45%), complex technology solutions (49%), lack of institutional support (41%)' and poor commitment & absence of political will (41%)' as challenges in usage of ICT sources for AKIM. Challenges to which farmers disagreed or strongly disagreed are 'lack of time due to their involvement in other activities (83%) and biasness due to social barriers (58%) related to cast and gender discrimination.

In addition, identified challenges were further analysed using Interpretive Structural Modelling (ISM) and MICMAC analysis methods. This methodology is used to identify the key challenges and their hierarchical relationship with the core issue of usage of ICT for AKIM by farmers. Developed by Warfield in 1974, this framework has been used by researchers to represent the interrelationship among different variables in order to provide a meaningful understanding of a complex system. ISM is an interactive process of understanding the complex relationships among different variables influencing the system under study by presenting them in a systematic and hierarchical structured model using words and graphics (Ravi & Shankar, 2005). It is a qualitative method which transforms complex articulated structural models into well-defined conceptual models illustrating interrelationships among variables (Gupta & Sahu, 2013; Sushil, 2012). Several researchers have used ISM to analyse the barriers and challenges of different systems. Poduval et al. (2015) have used it to analyse barriers in implementation of Total Productive Maintenance (TPM), Khalid et al. (2016) used ISM to model barriers to collaboration among auto-parts manufactures. Chaudhary et al. (2022) uses ISM and MICMAC to model the enablers and barriers of AI-based conversational agents.

In order to build the inter-relationships between variables (challenges) expert opinion is crucial in analysing contextual relationships. For the current study, help of 4 experts, 2 from academia and one each from agricultural research and government organisation (ADO) was taken. The experts selected have good academic and research credentials in the field and thus have high understanding of the problem.



Source: Field Survey by Author

Results and Discussions

The study has followed the following steps in order to develop the final ISM model and MICMAC analysis:

Step 1. Identifying the challenges associated with the 'Low ICT Usage for AKIM':

In the first stage, the exhaustive list of 34 challenges was prepared through extensive literature review and presented before the field experts for discussion. After discussion with experts 14 broad group of challenges/variables (Table 3) were identified for the study as some of them were merged due to their similar nature and placed under broad headings.

Table 3. Identified broad group of challenges after experts' opinion

Low Education	C1
Lack of awareness of benefits of ICTs	C2
Inadequate ICT skill and literacy	C3
Complex Technology solutions and lack of customized ICT applications	C4
Negative attitude or scepticism towards ICT	C5
Lack of updated, relevant and customized contents	C6
Lack of Institutional support in rural areas	C7
Erratic power supply	C8
Poor ICT infrastructure	C9
Unaffordable cost of ICT	C10
Small marketable agricultural produce	C11
Lack of adequate time due to involvement in other activities	C12
Poor commitment and absence of political will	C13
Biasness towards disadvantaged sections of society	C14
Low ICT Usage for AKIM	C15

Step 2. Development of structural self-interaction matrix (SSIM):

After finalising the list of key challenges, a matrix showing pairwise contextual relationships among variables was prepared with the help of experts. The experts were presented with the questionnaire seeking contextual relationships among all 15 variables (challenges) including variable related to issue itself. The SSIM (Table 4) was developed by assigning codes (V, A, X, O) to each pairwise relationships between challenges based on their mutual relationships in the following manner:

i. V – variable i helps in achieving variable j;
ii. A – variable j helps in achieving variable i;
iii. X - Both variables i and j help achieve each other;
iv. O - Variables i and j are not related to each other

Thus total (N)*(N-1)/2 i.e. 15*14/2 = 105 pairwise comparisons were done to mark contextual relationships among 15 variables. For example, the relationship symbol between all other challenges and C15 is entered with letter 'V' because all challenges help achieving challenge C15. Lack of awareness of benefits of ICT in AKIM (C2) is influenced by lack of support from institutions (C7) entrusted with the responsibility of spreading awareness about available AKI services by various agencies. Here, C2 is achieved by C7 hence contextual relationship between C2 and C7 is entered with letter 'A'. Low ICT skill and literacy among farmers (C3) causes negative attitude and scepticism towards ICT use (C5) and vice-versa i.e. both causes each other hence, relationship symbol between challenges C3 and C5 is entered with letter'X.' Similarly, relationships between other challenges were filled in SSIM in the manner defined above.

Table 4: Structural self-interaction matrix (SSIM)

Challenges	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15
C1		V	V	O	V	O	O	O	O	O	O	A	A	A	V
C2			V	O	X	O	A	O	A	A	A	A	A	O	V
C3				A	X	O	A	A	A	A	O	A	A	A	V
C4					V	V	A	O	O	O	O	O	A	V	V
C5						A	A	O	A	O	A	O	O	O	V
C6							A	O	A	O	O	O	A	V	V
C7								O	V	V	V	O	A	V	V
C8									O	O	V	O	A	O	V
C9										V	O	O	A	O	V
C10											A	O	O	V	V
C11												V	O	V	V
C12													O	V	V
C13														O	V
C14															V
C15															

Step3. Preparation of reachability matrix from SSIM

Relationships represented by letters in SSIM are transformed into binary (0,1) numbers to prepare initial reachability matrix (IRM) from SSIM following the under mentioned criteria and subsequently final reachability matrix (Table 5) is prepared using transitivity rule of relationships. For example, if $C1 \rightarrow C3 \rightarrow C8 \Longrightarrow C1 \rightarrow C8$. The entry in cell $C_{1,8}$ will be changed to 1 from 0. All such changed values are superscripted with star (*).in FRM.

i. A cell (i, j) containing letter 'V' in SSIM is transformed into '1' and '0' is entered in corresponding cell (j, i).
ii. A cell (i, j) containing letter 'A' in SSIM is transformed into '0' and '1' is entered in corresponding cell (j, i).
iii. If cell (i, j) contains letter 'X' in SSIM then '1' is entered in both cells (i, j) and corresponding cell (j, i).
iv. If cell (i, j) contains letter 'O' in SSIM then '0' is entered in both cells (i, j) and corresponding cell (j, i).

Table 5: Final Reachability Matrix (IRM)

Challenges	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	Driving Power
C1	1	1	1	0	1	0	0	0	0	0	0	0	0	0	1	**5**
C2	0	1	1	0	1	0	0	0	0	0	0	0	0	0	1	**4**

C3	0	1*	1	0	1	0	0	0	0	0	0	0	0	0	1	**4**
C4	1*	1*	1	1	1	1	0	0	0	0	0	0	0	1	1	**8**
C5	0	1	1	0	1	0	0	0	0	0	0	0	0	0	1	**4**
C6	1*	1*	1*	0	1	1	0	0	0	0	0	0	0	1	1	**7**
C7	1*	1	1	1	1	1	1	0	1	1	1	1*	0	1	1	**13**
C8	1*	1*	1	0	1*	0	0	1	0	1*	1	1*	0	1*	1	**10**
C9	1*	1	1	0	1	1	0	0	1	1	0	0	0	1*	1	**9**
C10	1*	1	1	0	1*	0	0	0	0	1	0	0	0	1	1	**7**
C11	1*	1	1*	0	1	0	0	0	0	1	1	1	0	1	1	**9**
C12	1	1	1	0	1*	0	0	0	0	0	0	1	0	1	1	**7**
C13	1	1	1	1	1*	1	1	1	1	1*	1*	1*	1	1*	1	**15**
C14	1	1*	1	0	1*	0	0	0	0	0	0	0	0	1	1	**6**
C15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	**1**
Dependence Power	**11**	**14**	**14**	**3**	**14**	**5**	**2**	**2**	**3**	**6**	**4**	**5**	**1**	**10**	**15**	

Step 4. Level portioning of reachability matrix

Level partitioning is done after the development of the final reachability matrix with an objective to determine the relative levels or positions of the variables in the final hierarchical model (Attri, 2017; Attri et al., 2013; Warfield, 1974). It organizes the set of challenges, barriers or variables into a hierarchical structure based on their mutual relationships. For each challenge, a Reachability Set comprising the current challenge itself and all those challenges which it helps achieve, an Antecedent Set comprising the current challenge itself and all those challenges which help achieving the current challenge and an Intersection Set of common elements, are prepared. A challenge having same elements in its reachability and intersection sets is set at the top level and its elements are removed from subsequent iterations that stops when all variables get assigned their levels in the process (Table 6).

Table 6: Level Partitioning (LP)

Challenges	Reachability Set	Antecedent Set	Intersection Set	Level
C1	C1	C1, C4, C6, C7, C8, C9, C10, C11, C12, C13, C14	C1	**3**
C2	C2, C3, C5	C1, C2, C3, C4, C5, C6, C7, C8, C9, C10, C11, C12, C13, C14	C2, C3, C5	**2**
C3	C2, C3, C5	C1, C2, C3, C4, C5, C6, C7, C8, C9, C10, C11, C12, C13, C14	C2, C3, C5	**2**
C4	C4	C4, C7, C13	C4	**6**
C5	C2, C3, C5	C1, C2, C3, C4, C5, C6, C7, C8, C9, C10, C11, C12, C13, C14	C2, C3, C5	**2**
C6	C6	C4, C6, C7, C9, C13	C6	**5**
C7	C7	C7, C13	C7	**7**
C8	C8	C8, C13	C8	**7**
C9	C9	C7, C9, C13,	C9	**6**
C10	C10	C7, C8, C9, C10, C11, C13,	C10	**5**
C11	C11	C7, C8, C11, C13	C11	**6**
C12	C12	C7, C8, C11, C12, C13,	C12	**5**
C13	C13	C13	C13	**8**
C14	C14	C4, C6, C7, C8, C9, C10, C11, C12, C13, C14	C14	**4**

C15	C15	C1, C2, C3, C4, C5, C6, C7, C8, C9, C10, C11, C12, C13, C14, C15	C15	**1**

Step 5. The final ISM model and the digraph:
In this step, the final model is drawn by placing all the challenges in their respective levels and their mutual relationships are shown through appropriate arrows between them. As evident from the Table 6 and Fig 2 below, the challenge placed at the bottom (level 8) is 'poor commitment and absence of political will' (C13) which causes 'lack of Institutional support in rural areas' (C7) and 'erratic power supply', both placed at level 7. Lack of dedicated institutions in rural areas which can support in disseminating customised AKI to farmers and train farmers to handle complex issues involved in application of ICT for AKIM reaches to challenges of 'complex technology solutions and lack of customized ICT applications' (C4) and 'poor ICT infrastructure' (C9) at level 6. 'Erratic power supply' causes inadequate irrigation leading to the challenge of 'small agricultural produce' (C11) at level 6. Challenges placed at level 5 (C6, C10 & C12) creates 'biasness towards disadvantaged sections of society' (C14) e.g. females, backward castes and smallholders and thus C14 finds its position at level 4. This further leads to challenge of 'low education' (C1) at level 3. Low education influences challenges of level 2 (C2, C3 & C5) i.e. 'lack of awareness of benefits of ICT', 'inadequate ICT skill and literacy' and 'negative attitude or scepticism towards ICT'. These challenges influence each other and directly impacts variable under study which is 'low ICT application for AKIM' (C15) at level 1.

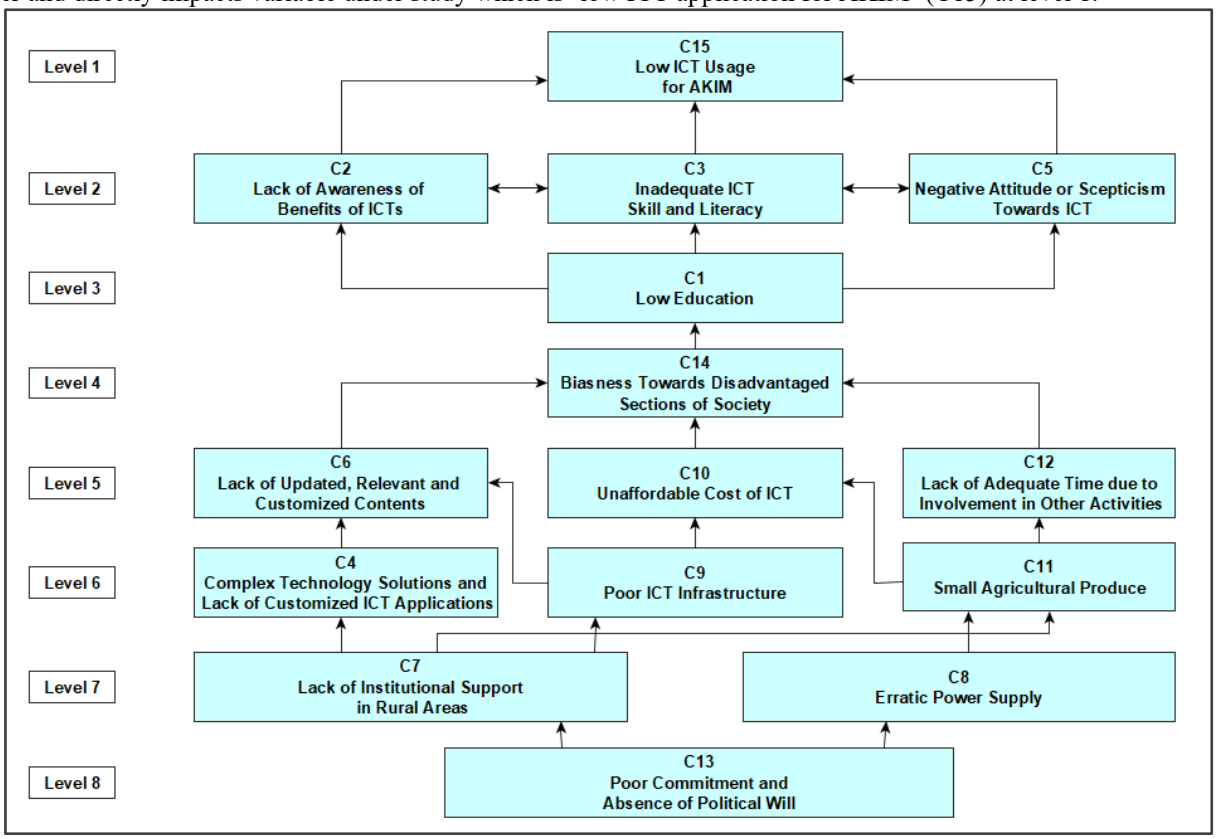


Fig. 2: The final model of 'Challenges in Usage of ICT for AKIM among Farmers

Step 6. MICMAC analysis
In the MICMAC analysis (Fig. 3), all challenges are classified in four categories: autonomous variables, dependent variables, linkage variables and independent variables (Duperrin & Godet, 1973). The challenges/variables having weak driving and dependence power known as autonomous variables are placed in quadrant I of the MICMAC graph. There are three autonomous variables (C6, C10 & C12) in this study. The quadrant II of the graph contains dependent variables (C1, C2, C3, C5, C14 and C15), the challenges with weak driving power and strong dependence power. The variable under study, 'low ICT Usage for AKIM' (C15) has least driving power 1 and highest dependence power 15. Variables lying in quadrant III are known as linkage variables as they have strong driving and dependence power. Variables of quadrant IV are independent variables due to their weak dependence power and strong driving power. These independent challenges are C4, C7, C8, C9, C11 & C13. They primarily influence the other variables and are fundamental drivers of the variable under study.

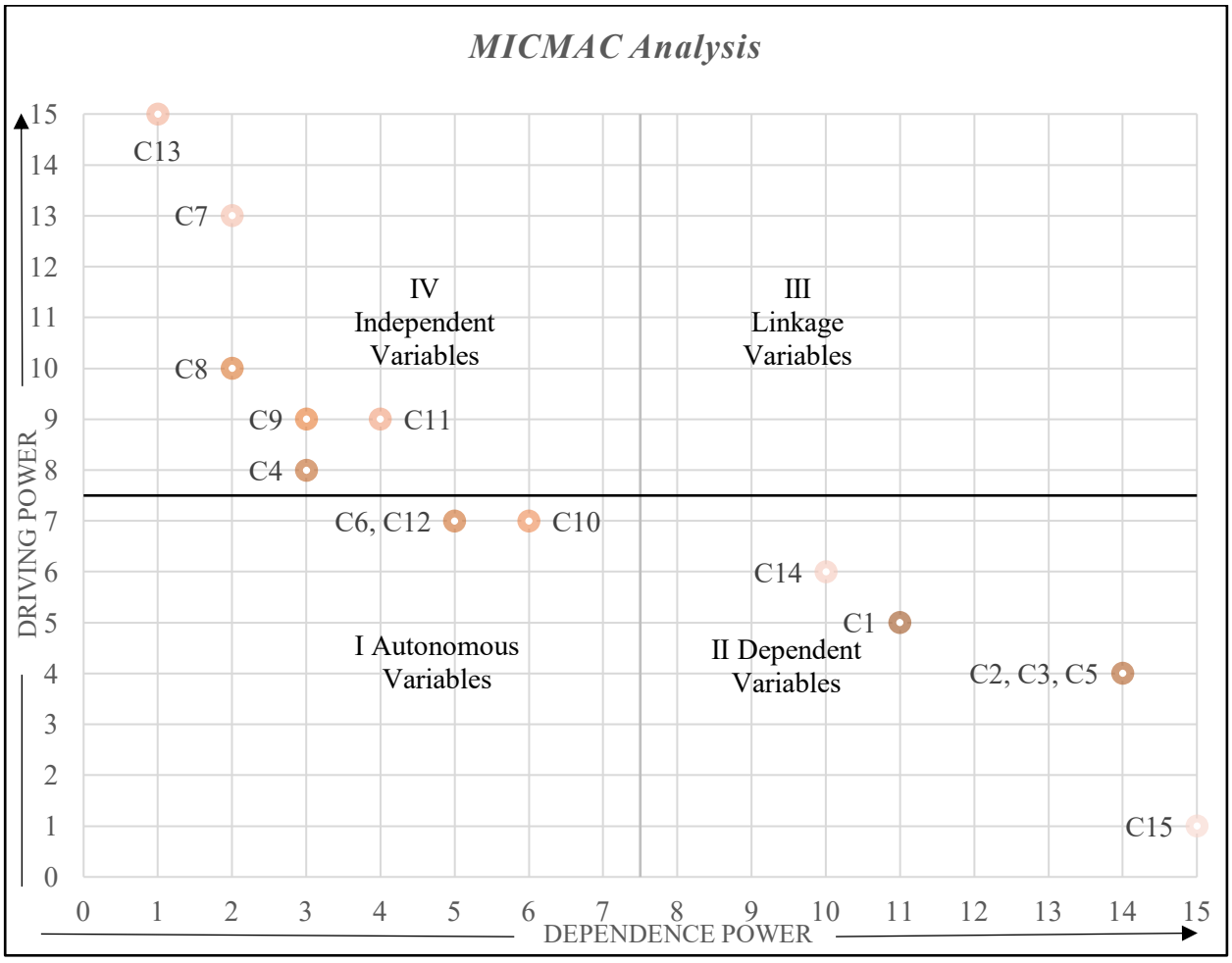


Fig. 3: Categorization of 'challenges in ICT Application among farmers'

4. Conclusion

Poor access and low adoption of ICT for any technical advice, highlighted in the report 'Situation Assessment of Agricultural Households and Land and Livestock Holdings of Households in Rural India, 2019' and very less frequent usage of ICT vis-à-vis non-ICT sources of AKIM by farmers in the current study shows that farmers are yet to harness the full potential of ICT to manage their information and knowledge needs for agricultural purposes. The study has explored systematic and heirchical relationships among 14 broad barriers or challenges that are hindering the potential exploitation of ICT sources for AKIM. Lack of commitment or political will, weak institutional support in rural areas, poor ICT infrastructure and complex & non-customized ICT based AKIM solutions are the key deriving barriers leading to low education, low ICT skill and literacy, lack of updated & relevant contents, low awareness and scepticism about using ICT for AKIM purposes ultimately hindering the application of ICT based solutions for AKIM to its full potential. In addition to this, underprivileged sections of society such as females, backward castes and smallholder farmers face natural bias against them in using ICT due to deprived education opportunities, small agricultural holdings and poverty. Therefore, focus should be on developing supporting rural institutions which can provide customised, trustworthy and relevant knowledge in more user-friendly manner.

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