Linkage Between ICT and Agriculture Knowledge Management Process: A Case Study from Non-Government Organizations (NGOs), India

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Abstract. This paper addresses the linkage between information and communication technology (ICT) and agriculture knowledge management (AKM) process in non-government organizations (NGOs) in India. Sample of 145 respondents were collected using questionnaires in two NGOs. The analysis and hypothesis testing were implemented using structural equation modeling (SEM). The analysis shows that there is a significant ($\beta = 0.61$ at p = 0.001) and positive relationship between ICT and AKM process. The results obtained would help managers to better understand the linkage between ICT and AKM process in their organizations. They could use the results to improve their ICT infrastructure and tools for effectiveness of AKM process.

Keywords: Agriculture, Agriculture Knowledge Management (AKM), Confirmatory factor analysis (CFA),Information and Communication Technology (ICT), Non-Government Organizations (NGOs), Structural Equation Modeling (SEM).

1 Introduction

Agriculture is an important sector of Indian economy. Nearly 60 - 70% of the Indian population depend upon agriculture and allied fields. As much as 67% of India's farmland is held by the small and marginal farmers[1]. Many of these small and marginal farmers are illiterate and have meager resources to access modern technology in agriculture [1]. It has been widely recognized that transfer of relevant knowledge plays an important role in agricultural growth and productivity. Transfer of relevant knowledge to small and marginal farmers can help them to improve their yields and get better market prices [2].

Management of agricultural knowledge takes place at different levels: individual, within communities, within organizations or institutions and networks

[1] `http://www.business-standard.com/article/news-ians/nearly-70-percent-of-indian-farms-are-very-small-census-shows-115120901080_1.html`

of them [3].The knowledge for agriculture development is often not created, documented or disseminated by one single source or organization [4]. Different organizations produce different kinds of knowledge and the lack of coordination or linkage between these organizations (public, private, agricultural research and extension institutions) [5] are often cited as a reason for ineffective transfer of knowledge to farmers. The interrelated activities of these organizations may or may not converge at the field level. In this context, the notion of an agriculture knowledge management (AKM) is often put forth. AKM refers to the process of creating knowledge repositories, improving knowledge access, sharing and transfer and enhancing the knowledge environment in the rural communities [2]. Exchange of knowledge and its bidirectional flow (i.e. from farmers to experts and vice versa) is beginning to be recognized in this domain [6].

In the Indian context, the main agencies engaged in creating agriculture knowledge resources can be broadly classified into three categories: Public, Private, and Non-Government Organizations (NGOs). NGOs is any non-profit, voluntary citizens' group which is organized at local, national or international level. NGOs, as a third sector institutional framework have been playing an important role in Indian agriculture. Their main activities are: to promote and develop weaker sections of the people, to create and establish the means of food security among the poor people, to promote sustainable agriculture, to mobilize, inspire and enable tribal through a participatory approach working towards their own rehabilitation using their own resources.

Table 1: List of ICT initiatives projects in Indian agriculture

Categorize	**Name of the projects**
Web-based Technology	Agropedia, Rice Knowledge Management Portal (RKMP), AgriTech, KISSAN Kerala, AGRISNET, AGMARKNET, eKirshi, iKisan, Almost all questions answered(aAQUA), Electronic solution against agriculturepest (e-SAP) SasyaSree
Human intermediaries (between ICT and user)	e-Sagu, Arik, e-Choupal, Digital Green Tata Kisan Sansar, MSSRF-VKC
Mobile technology or telecommunication	Kissan Call Center, IFFCO-IKSL, RML, mKrishi Nokia Life Tool, Spoken Web, Fisher Friend Project, Lifelines

The term, information and communication technology (ICT) has been defined differently by many authors. UNDP[2] defined ICT as the combination of microelectronics, computer hardware and software, telecommunications, and storage of huge amounts of information, and its rapid dissemination through computer networks. ICT has a prominent role to play in knowledge management (KM) in an organization. It helps in achieving organizational effectiveness and is considered as an essential tool to manage organizations' knowledge assets. ICT can make Indian AKM more competitive by providing affordable, relevant, searchable and up-to-date agriculture information services to the farm communities [2]. Table 1 summarizes some of the ICT project initiatives in Indian agriculture which have been broadly categorized into three categories viz. web-

[2] http://hdr.undp.org/en/content/human-development-report-2001

based technology, human intermediaries (between ICT and users), and mobile technology or telecommunication.

ICT tools deployed for agriculture knowledge management in India includes organizational web pages and special portals created for specific commodities, sectors, and enterprises and for e-commerce activities [7]. These ICT projects in Indian AKM revealed that they primarily focused on the transfer of knowledge to the farm communities, following a one-way flow of knowledge i.e. from experts to farmers without many opportunities for interaction. Many ICT projects are pushing external content towards local people based on what experts think the community needs [8]. Hence there is a need to focus on knowledge acquiring, creating, storing, organizing, and sharing or disseminating at the organization level for effective AKM in the agricultural organizations taking into account the need for bidirectional flow of knowledge.

Studies so far focused on the importance or impact of ICT in Indian agriculture. For example, Gummagolmath et al, discussed ICT initiatives in Indian agriculture [9]. Xiaolan Fu and Shaheen Akter, examined the impact of a mobile phone technology-enhanced service delivery systems on agricultural extension service delivery in India [10].There have been very limited studies on knowledge management process at the organizational level and still fewer on the relationship between ICT and knowledge management process at agricultural organization level in the Indian context. It is not clear how the ICT competency and agriculture knowledge management process works are influence each other. Empirical work in this area is required. Our studies focuses on establishing a relationship between ICT and agriculture knowledge management process in NGOs working in Indian agricultural organizations.

2 Research framework and Hypotheses

The main objective of this study is to understand the relationship between knowledge enablers like ICT and the knowledge management process in Indian agricultural organization specifically in NGOs. Figure 1 is proposed research model depicting a relationship between ICT and KM process.

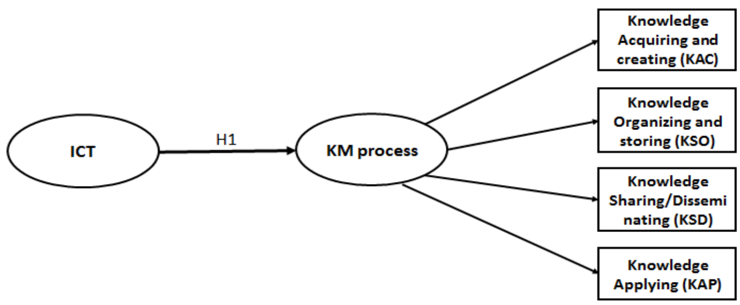

Fig. 1: Research framework

2.1 Knowledge Management process (KM process)

KM process includes activities of acquiring, creating, storing, sharing, diffusing, developing and deploying knowledge by individuals and groups [11]. According to Davenport and Prusak, KM has three processes that have received most consensus viz. knowledge generation, sharing and utilization [12]. On other hand, Alavi and Leidner proposed four processes of knowledge management viz. creation, storage, transfer and application [13].The present study examines the following four processes: acquiring and creating, organizing and storing, sharing or disseminating and applying as proposed by in early studies for agricultural organization [14].

Knowledge Acquiring and Creating (KAC) : Knowledge acquiring and creating is a process where members in the organization gain, collect, create and obtain required and useful knowledge to perform their job functions. It involves updating existing content or developing new content by using organization's tacit and explicit knowledge [15]. KAC is about obtaining knowledge from external and/or internal sources or capturing of the knowledge (explicit or tacit) that resides inside the people working in the organization [16].

Knowledge Organizing and Storing (KOS) : This process involves structuring, indexing, evaluating and storing the knowledge in organization's repository. Knowledge is validated, codified (to represent a useful format) before it can be used [17]. Once knowledge is evaluated, it is categorized and represented in a structured manner with indexing or mapping to enable efficient storage in the organizations repository and for effective usage at a later point [18].

Knowledge Sharing and Disseminating (KSD) : It is the process in which sharing of knowledge take place among individuals and/or groups within and outside the organization. Knowledge sharing is considered as a core process of knowledge management because one of the main goals and objectives of knowledge management is to promote sharing of knowledge among individuals, groups and organizations [19][20]. Knowledge in organization is transferred through social networks, collaboration, and daily interaction like chatting, face-to-face, formal (meetings) and informal (over a cup of tea) conversations[12].

Knowledge Applying (KAP) : Knowledge applying is to put the knowledge to good use. The members or employees of the organizations can apply and adopt the best practices in their daily work [21]. According to Davenport and Klahr, the effective application of knowledge can assist the organization to improve efficiency and reduce cost [22]. This process also implies putting knowledge into practice, where the employee should use lessons learnt from previous experience or mistakes made in the past[23].

2.2 Information and Communication Technology (ICT)

ICT plays an important role in facilitating communication between different parts of the organization that often inhibits through normal channels of communication [24]. Many researchers have found that ICT plays a crucial element for knowledge management process [13][12]. ICT tools help in capturing the knowledge created by knowledge worker and making it available to the large community [25]. Information technology has been widely used in organizations, and thus qualifies as a natural medium for the flow of KM process in the organization [24]. Thus, we hypothesize:

H1: ICT has significant and direct effect on Knowledge Management process.

3 Research methodology and Data collection

The quantitative research approach was used to empirically test the research hypothesis. A survey questionnaire was designed to determine and understand the linkage between ICT and KM process. The critical metrics for measuring ICT and KM process (acquiring and creating, organizing and storing, sharing/disseminating and applying) that were derived from the literature were used [26][27][28]. Respondents were asked to rate the extent to which these metric were practiced in their organization using a Likert scale (five-point scale from 1 = strongly disagree to 5 = strongly agree). For the details of items used to measure research constructs refer [29].

Two non-government organizations (NGOs) were selected for this study. Unit of analysis in this study were middle-level managers, veterinary doctors, agriculture extension officers, project coordinators, cluster in-charge or supervisor and field workers/operators. These people were surveyed as they played a key role in managing knowledge. These people were positioned at the intersection of both vertical and horizontal flow of knowledge. Therefore they could synthesize the tacit knowledge of both top (scientist group) and bottom (farmer group) level, convert them into explicit knowledge, and incorporate the same into the organizational knowledge repository.

There is no prior personal or formal relationship between researchers and interviewees or the organization as a whole. This allowed for triangulation and also helped to validate data interpretation and findings [30]. The questions were well-structured, understandable and were developed in four languages namely English, Hindi, Gujarati and Telugu keeping in the mind there geographical location and the composition of people working in NGOs that were the part of the study.

Responses from 148 respondents were collected from these two organizations. Data was collected during their weekly and monthly meetings in the organization. During these meetings, questionnaires were distributed to participants and they were asked to fill the form. Before filling the form, the objectives of the research and questionnaire were well explained to them.

4 Data analysis and Results

Data analysis was most crucial as it helped us to establish the relationship between ICT and KM process in Indian agricultural organizations Data analysis data was performed by using Statistical Package for the Social Sciences (SPSS version 20.0). Further analysis was conducted by using structural equation modeling (SEM) via the Analysis of Moment Structures (AMOS version 20.0) software. SEM is a multivariate statistical analysis technique that is used to analyze structural relationships.

4.1 Demography of the respondents

Out of 148 responses, 0 were discarded from our study due to insufficient information. Thus our study consider of 139 respondents. Table 3 summarizes the profile of the respondents.

Table 2: Demography of the respondents

Sample characteristics	Frequency (n=139)	Percent (%)
Gender		
Male	102	73.4
Female	37	26.6
Education		
High school	47	33.8
Bachelor Degree	62	44.6
Master Degree	30	21.6
Working position		
Regional Managers	3	2.2
Project managers/Program managers	20	14.4
Project officer/Supervisor	24	23.0
Field in-charge/Cluster Assistant	92	60.4
Work Experience		
0 5 years	56	40.3
6 10 years	49	35.3
11 15 years	18	12.9
Above 15 years	16	11.5

4.2 Analysis and results

After analyzing the descriptive statistics, further analysis was conducted by using SEM via the AMOS. Confirmatory factor analysis (CFA) provides an appropriate means of assessing the efficacy of measurement among the items [28]. In this study, the analysis was divided into three parts, viz. the first-order CFA and second-order CFA for the measurement models, and third, the structural model analysis and overall model fit.

First, the measurement models have been assessed for reliability, validity, and unidimensionality. The term reliability refers to the consistency of a research study or the degree to which an assessment tool produces stable and consistent results. Cronbach's alpha, has been one of the most commonly used methods to assess the reliability [31].To satisfy the reliability criterion, a Cronbachs alpha value of more than or equal to 0.7 is required [32][33]. Referring to Table 4, this condition has been satisfied by all the constructs.

Validity is defined as the degree to which a measurement assesses what it is supposed to measure. Convergent validity and discriminant validity have been checked for each construct. Convergent validity refers to the degree to which the items that should be related are in actual reality related [17]. For convergent validity, the composite reliability (CR) value must be more than or equal to 0.7 and the average variance extracted (AVE) value must be greater than or equal to 0.5 [32]. As shown in Table 4, all the constructs have satisfied these two requirements.

Unidimensionality is achieved when the items have acceptable factor loadings that are greater than or equal to 0.5 [32][17]. During the process, ICT2, KAC5, KAC6, KOS1, KOS2, KSD2, KSD8, KSD9 were dropped due to poor factor loading of less than 0.5. The results of unidimensionality for all the constructs have been showed in Table 3

Table 3: Results of unidimensionality, reliability and convergent validity

First order consturcts	No. of items	Indicators	Factor loadings	CR ($\geq$0.7)	AVE ($\geq$0.5)	Cronbach's alpha
Information Communication Technology (ICT)	5	ICT6	0.849	0.836	0.561	0.791
		ICT3	0.749			
		ICT1	0.755			
		ICT5	0.691			
		ICT4	0.640			
Knowledge acquiring and creating (KAC)	4	KAC1	0.789	0.854	0.532	0.723
		KAC2	0.759			
		KAC3	0.723			
		KAC4	0.637			
Knowledge organizing and storing (KOS)	4	KOS3	0.823	0.845	0.610	0.771
		KOS4	0.790			
		KOS5	0.772			
		KOS6	0.694			
Knowledge sharing / disseminating (KSD)	6	KSD7	0.779	0.914	0.628	0.78
		KSD1	0.728			
		KSD4	0.721			
		KSD3	0.720			
		KSD5	0.696			
		KSD6	0.694			
Knowledge Applying (KAP)	3	KAP2	0.779	0.888	0.594	0.703
		KAP3	0.777			
		KAP1	0.756			
Note:Items with low factor loading (<0.5) have been dropped						

Next, the second-order CFA was conducted for the first-order constructs of the study. It was used to confirm that the underlying measurement constructs loaded into their respective theorized construct (KM process) [17]. In this respect, the factor loadings between first-order constructs and second-order constructs must be greater than or equal to 0.5 [32]. The result of second-order CFA are displayed in Table 4 and the finalized model of second-order CFA of KM process construct are illustrated in Figure 2.

The final stage was structural model analysis. In this, the structural equation modeling (SEM) was tested using the maximum likelihood method. It has been designed to judge how good a proposed conceptual model can fit the data collected and also to find the structural relationships between the sets of latent variable [34]. The final model of the study is illustrated in Figure 3.

To ensure the fitness of the structural model, i.e. how well the data set fits the research model, there are several indicators which are computed by using

AMOS. The most fundamental measure of overall fit in a structural equation model is the likelihood-ratio chi-square statistics. As suggested by Bagozzi and Yi, a p-value exceeding 0.05 and a normed chi-square value (χ^2/df) that is below 3, are normally considered as acceptable [35]. Along with this, the fitness of the structural model can be studied by using the Comparative Fit Index (CFI). This must be greater than or equal to 0.9 [36], Root Mean Squared Error of Approximation (RMSEA) must be less than or equal to 0.08 [37], Goodness-of-Fit Index (GFI) must be greater than or equal to 0.9 [32], and Adjust Goodness-of-Fit Index (AGFI) must be greater than or equal to 0.9 [32]. The developed model has been proven to meet all the requirements and the results are shown in Table 6. Therefore, the model was utilized to test the hypothesis relationships among the constructs.

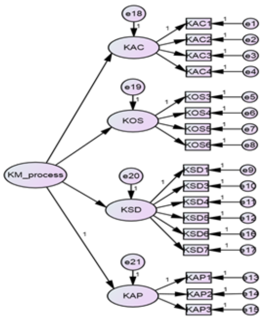

Fig. 2: Second-order CFA

Second order construct	First order construct	Factor loading ($\geq$ 0.5)
KM process	KAC	0.93
	KOS	0.895
	KSD	0.945
	KAP	0.768

Table 4: Results of Second-order CFA

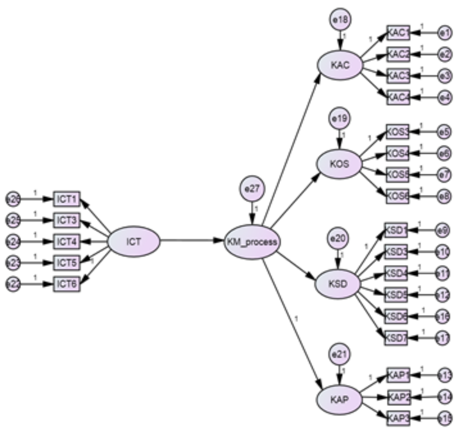

Fig. 3: Final model fo the study

Name of the index	Value obtained	Accepted Fit	Results
chi-square (χ^2/df)	1.849	Below 3	satisfied
CFI	0.902	>=0.90	satisfied
RMSEA	0.08	=<0.08	satisfied
GFI	0.931	>=0.90	satisfied
AGFI	0.911	>=0.90	satisfied

Table 5: The Fitness of the model

Table 6 presents the hypothesis testing result for the causal effect of ICT on KM process. The results revealed that ICT has a significant (β = 0.61 at p

= 0.001) and positive effect on KM process. Therefore H1 was supported and accepted.

Table 6: Results of hypothesis

Hypothesis	β value	p-value	Comment
H1:ICT KM process	0.61	***	Significant

Note*** significant at 0.001

5 Discussions

This study has applied SEM approach to examine and prove the existence of significant impact of ICT on KM process. Our analysis showed that ICT had a significant effect on KM process in the organizations that were part of our study. The result is also consistent with the findings from past studies. For instance, Chadha et al. found that ICT enhances the visibility of knowledge and facilitate the process of acquiring, creating, storing and disseminating[25]. Allahawiah et al. also verified that there is the positive impact of information technology on knowledge management processes [38].

In case of the two organizations, there were clear indications that the staff at various levels and experts has been using Internet, emails, mobile technology for acquiring, storing and sharing knowledge among individuals, groups and organizations. The majority of the respondents were field in-charges and supervisors, who are actively involved in agriculture knowledge management process. Most of the respondents in the sample of the study owned a cell phone and used it to access agriculture knowledge from neighbors, friends, families and subject experts in the organizations. In Digital Green, digital videos were created on local relevant agriculture and livelihood practices by using ICT tools like video cameras. Then these videos were screened for farm communities using battery-operated Pico projectors. All these videos were organized and stored in organization repository, for accesses in both off-line and on-line mode.

From the observations and discussions with members and employees, we that understand that there is a limit of using ICT in organizations. For an instant, we observed that only top and senior management in DHRUVA had access to laptops and Internet facilities. The field supervisors used a mobile phone to communicate with peer and farm communities. Most of the time in DHRUVA, face-to-face, group meetings and personal visits were used for disseminating agriculture knowledge to farm communities because of low bandwidth of the Internet, ICT infrastructure.

6 Conclusion

The availability of ICT has had a significant (β= 0.61 at p = 0.001) effect on AKM process in the two organizations that were part of our study. ICT was found to assist in the process of getting required knowledge and enabling easy communication among and between the farm communities and organizations. The availability of ICT is seen to enhance dissemination of explicit and tacit knowledge and sharing of best practices effectively among the farm communities and expert groups in the organizations. For example, we found that Digital Green is using ICT tools like Picos to disseminate agriculture knowledge (videos) to farmers. These videos are downloaded or streamed online which are stored in organization repository. DHRUVA provides access to their materials (like best practices, success stories, annual reports) on their websites. They show audio and video clips on water resources development, sericulture, agroforestry, post-harvesting product development to farm communities using DVD and television.

The rapid development in the field of ICT, for example, mobile technology, availability of the internet, web technologies and mode of communications like emails, video conference etc. helps in faster creation, storing, sharing of knowledge within and outside the organization. In organizations where face-to-face meetings are used very frequently, ICT tools can play a supportive role in recording such meetings for future use.

We believe that our results will contribute in several ways to the knowledge management theory and practice specific to Indian agriculture. An attempt has been made to conduct this kind of research study in Indian agriculture organizations to establish the relationships between ICT and AKM process. The study will help managers at different levels in selecting tools and technologies that can be used to support AKM process in their organizations. The proposed set of metrics used in this study may also be used in future as basic tools to measuring the effectiveness of ICT on AKM process in agricultural organizations.

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