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Review

Factors affecting the use of ICTs on agricultural input information by farmers in developing countries

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Abstract: Information and Communication Technologies (ICTs) play a key role in the dissemination of information on agricultural inputs for more access to and use of agricultural input information. Farmers have been exposed to diverse ICTs channels access and use of agricultural input information in developing countries. Though efforts have been made to apply ICTs in the agricultural input information sector, the contribution does not clearly reflect how ICTs influence access and use of agricultural input information by farmers. It is therefore imperative for an investigation to be taken to identify the factors affecting the use of ICTs on agricultural input information in developing countries. In this paper, we inform our audience on the factors affecting the use of ICTs on agricultural input information by reviewing ICTs and published articles on ICTs on agricultural input information. We use grounded theory to synthetize the status of the use of ICTs on agricultural input information access and factors supporting or not supporting the use and adoption. It is observed that farmer's perception such as the relative advantage, compatibility, simplicity, observability and social influence of ICTs and information quality are positively affecting the use of ICTs on agricultural input information in developing countries while the ICTs' high service cost is negatively affecting their use.

Keywords: ICTs; agriculture; input; farmers; access; use

1. Introduction

Information and Communication Technologies (ICTs)[1] play a key role in the dissemination of

[1] By ICTs, we mean the new ICTs such as mobile phone and telecentres.

information on agricultural inputs for greater access and use of agricultural input information. Reviews of empirical work conducted over the last 15 years [1-7] have provided a general picture of the use of ICTs by farmers in access to and use of agricultural input information. However, it is not clear why there is no significant use of ICTs to access agricultural input information.

While it is well established that farmers have been exposed to ICTs on agricultural input information [2,8-11], there is no appreciation of whether farmers have access to agricultural input information and if they are using that information. For instance in India, the usage of IFFCO-Airtel Kisan (Indian Farmers Fertilizer Cooperative Limited and Airtel—a telecom operator service for Indian farmers on agricultural input information launched in 2008) by farmers was very low [2]. One important question to be addressed is: what are the factors affecting the use of ICTs in the access and use of agricultural input information and how are they affecting these ICTs?

2. Materials and method

2.1. Data sources

First, we reviewed some selected ICTs on agricultural input information in India, Indonesia, Tanzania, Kenya, Pakistan, China and Mali.

Secondly, in order to efficiently perform our systematic literature search according to the grounded theory, we defined the criteria for inclusion or exclusion of an article in the data set. The main inclusion criteria was that the article should have been published within the last 15 years. Else it was excluded. Then, we identified our fields of research and we decided on the specifics search terms (Table 1).

Table 1. Research source and terms definition.

Inclusion	
Time	Between 2001–2016
Fields	Information System, Computer Science and Agriculture
Appropriate sources	Researchgate.net, google scholar, sciencedirect.com, aisnet.org, PubMed, webofscience.com
Search terms	ICT; ICT4D; Agriculture; agricultural inputs; developing countries; information; access to information on agricultural inputs; use of information on agricultural inputs; ICT in developing countries; ICT and agriculture; ICT in agriculture; ICTs and agricultural input information; ICTs' contribution in agriculture.

From a time consuming search, we refined our sample based on some criteria. Our primary data set was compiled from 53 studies on ICTs on agricultural input information published between 2001 and 2016 in: *MIS Quarterly, Computers and electronics in agriculture, Journal of Research in International Business and Management, International Food Policy Research Institute, Journal of Chemical Information and Modelling, ICT in Agriculture Sourcebook, International Food Policy Research Institute, Computers & Education, Agricultural Economics, The information manager, Journal of Agricultural Extension, American Journal of Economics and Business Administration, GSMA, Journal of Agriculture and Social Research (JASR), Interactive Educational Multimedia,*

American Journal of Health Behaviour, Journal of Research in International Business and Management and Economics of Agriculture.

Finally we mapped these articles and the reviewed ICTs in developing countries.

2.2. Data description

In our data set, we extracted: 1) information on the availability of ICTs on agricultural input information in developing countries; 2) Factors affecting the use of ICTs by farmers in developing countries in the access to and use of agricultural input information.

2.3. Data analysis

We applied the key principals of Grounded Theory [12]. These principals are: open coding; axial coding and selective coding.

We picked each paper and read and highlighted any findings and insights in the text that seemed relevant to our scope and research questions. Every word, sentence or paragraph that was highlighted in each of the paper represented a relevant excerpt. We started then to re-read excerpt after excerpt. While perusing through them a number of concepts that captures parts of the excerpt data set and their underlying studies were analysed and synthesized. That led us to incorporate each set of excerpts into a set of concepts and insights. Doing so, we performed the open coding of the grounded theory. After that, we did the axial coding which consisted of grouping these concepts into categories. That led us to selective coding whereby we integrated and refined the main category of each to our research question.

3. Results

3.1. Selected ICTs on agricultural input in selected developing countries

3.1.1. Experiences from India

Information and communication technology is expected to play a central role in improving the farm's operations, facilitating inputs procurement transactions, overcoming the low rural agricultural production. In a national survey of Indian farmers, it was found that most small-scale farmers reported some increase in convenience and cost savings from using their mobile phones to seek information such as input availability [13].

E-choupal

The Indian Tobacco Company (ITC) Limited's e-choupal project is an ICT based project, which aims at building effective farmer-agribusiness linkages. The model has been designed to tackle the problems of fragmented farms, weak infrastructure and large number of intermediaries in the Indian farming sector [14]. The leveraging of information in this system takes place through:

i) Delivery of real time information and customized knowledge to the farmers to improve their decision making ability for better alignment of produce to the market and improving the quality of their products.

ii) Aggregation of demand at the village level for accessing higher quality inputs and knowledge at lower costs.

Practically, farmers can access the latest local and global information on weather, scientific farming practices as well as market prices at the village level through a portal. The e-choupal also facilitates supply of high quality inputs as well as purchase of commodities at the farmer's doorstep.

The farmers' information needs on agricultural inputs addressed by e-choupal include: weather information, advice on the activities in agricultural lifecycle, agricultural best practises organized by crop type and buying inputs such as seeds, fertilizer and pesticides. It facilitates supply of high quality farm inputs as well as purchase of commodities at the farmer's doorstep [15,16].

IFFCO Airtel initiative

Indian Farmers Fertiliser Cooperative Limited (IFFCO) and Airtel launched a service for Indian farmers on agricultural input information in 2008 [17]. Farmers can buy a mobile phone which is already registered for the initiative and look for agricultural input information through SMS (Short Message Service) or a call centre.

3.1.2. Experiences from Indonesia

Nokia Life

Nokia Life suite is an information service through mobile phone (Nokia) launched in India in 2009 and scaled the same year in Indonesia, and currently used in Nigeria and China. The service is cheapest in Indonesia than the other four countries. The service cost is: 5 Chinese Yuan (0.76US$) in China per month, 60 Indian Rupee (0.88US$) in India per month, 500 Indonesian Rupiah (0.03US$) in Indonesia per month and 250 Nigerian Naira (1.25US$) in Nigeria per month [18]. In Indonesia, Nokia heads the ranking as reported [19]. Indonesia was chosen for this study because the Indonesian experience on this service is different from the other three countries. Nokia Life delivers Education, Health, Agriculture and infotainment services to address the information gap and enable consumers in emerging societies to be better informed and to improve their livelihoods [18]. The service delivers information on agricultural inputs via SMS. Nokia Life Agriculture services provide farmers with tailored crop tips, agriculture news, market prices, weather information and advisory via richly formatted messages using SMS as the delivery channel.

3.1.3. Experiences from Tanzania

TigoKilimo

TigoKilimo is an agricultural value added service (Agri VAS), operated by the mobile network operator Tigo in Tanzania. The service offers relevant, timely and actionable information via mobile phones to farmers in Tanzania across three domains: agronomic practices on major crops, market price information, and weather forecasts. Content can be accessed via three mobile channels: Unstructured Supplementary Service Data (USSD), Interactive Voice Response (IVR) and helpline [6]. And as a result, 88% of respondents who reported making changes based on TigoKilimo information

also reported accruing benefits from using TigoKilimo information. The benefits included better crop yields (45%), more knowledge about farming practices (37%), and greater ability to predict the weather to plan farming activities (23%) [6].

Some farmers gave their testimonial on this ICT. For instance, "Previously I used to weed the field, remove all grasses, and take them away from the field. But through TigoKilimo, I obtained knowledge that I should not take the weeds away from field but to leave them there. So, now I do as they advised me to" [6]. In the same sector, Zantel (a telecom operator) launched Z-Kilimo.

Z-Kilimo

Z-Kilimo is an SMS-based application in Tanzania, utilizing mobile phone capability and ubiquity to provide access to comprehensive farming methods. Farmers can access this service by dialling *149*50#. The menu screen will display a list of general information on the daily weather forecast, details on soil management, pest control methods and information on livestock knowledge and bird flu as reported [20].

3.1.4. Experiences from Kenya

Kenya has made significant strides in improving agricultural productivity through increasing access to credit, market information systems, strong agro-dealer networks and use of inputs [7].

M-farm

M-Farm is a mobile service and a web platform that aims to improve Kenya's agricultural sector by connecting farmers with one another because peer-to-peer collaboration improves market information [21]. The service assists farmers to know when to plant and connect to sell as reported [22]. The farmers can have the price of agricultural inputs and make a decision on when to buy and where to buy it. With M-Farm, Kenyan farmers can send text messages to get information on retail prices of their products, buy their farm inputs directly from manufacturers at favourable prices and find buyers for their produce [23].

NAFIS

The National Farmers Information Service (NAFIS) is an agricultural Value Added Service (VAS). Its integrated mobile app and internet service provides farmers with broader access to key agricultural information, which farmers can access by sending a text message or by calling [23].

MFarmer

MFarmer Kenya is a wing of Zevan Limited which focuses on developing mobile-phone based tools for agriculture [24].

These three apps (Mfarm, mFarmer and Nafis) have unlocked the door to better market and information access for smallholder farmers in the five Kenyan counties: Nairobi, Kajiado, Narok, Nyandarua and Nandi [23].

3.1.5. Experiences from Pakistan

Ukisaan

Ukisaan is an agricultural value service added launched by Ufone (a telecom operator) for farmers in Pakistan. With UKisaan farmers can listen to information related to agricultural crops, non-conventional crops, weather alerts in local languages. It provides information through a call made by the farmers. It is only available for the users of this telecom operator.

Kissan

This is another value added service managed by ZONG (a telecom operator) in Pakistan for its users (farmers). It provides information through a portal on inputs (fertilizers, pesticides, weather alerts, and best practices).

3.1.6. China

NOVA

The agricultural information dissemination is done by NOVA (agriculture and production information system) [25]. It is a web based agricultural service. There were users who achieved remarkable productivity by using the functions of this system for selection, development and sales of agricultural products, and even users who claimed that agricultural operations would not be possible without this system. The system is generally accepted by farmers on site, proving that it gives the assistance required. In particular, the system of installing a help centre which provides the same services on telephone as online in environments without PC access was highly assessed, as was the function of achieving immediate results of exploring new sales channels to farmers [25].

SOUNOUNG

The information dissemination in the agricultural sector in China is done by another project called SOUNOUNG. The project through an internet search engine aggregates information from the internet and provide it to farmers [26]. In 2009 there were 1276 households using the website and by 2010, that figure doubled [26] indicating an indisputable success for the project. Where does this success come from? The project works with farmers organisations as partners. The organizations were well established and had good management. Members of farmer organizations can access information from the SOUNOUNG site through their computers, mobile phones and personal digital assistants (PDAs). Depending on network conditions, regional characteristics and farm conditions, farmers can select the appropriate option for their local network capacities and skill level. For members who may not have access to computers, mobile phones or PDAs, cooperatives can also print information and recommended actions [26].

In most developing countries, the mobile phone is the most popular ICTs to access agricultural input information. In China, surveys found the mobile phone option to be popular because of its timeliness and convenience [26].

3.1.7. Mali

SENEKELA

"SENEKELA" is an ICT service provided by Orange Mali (a telecom operator) to help Malian farmers to increase their farm productivity and to provide the ingredients which can help the farmers to increase their productivity. The project uses an SMS service for farmers to access market information. It is currently deployed in two out of eight regions. But the cereals concern is addressed only in the Sikasso region while the shea nut is addressed in Koulikoro [27].

"SENEKELA" has been launched in Mali and relies on a call-centre with agronomists who give advice to the farmers—in French and in Bambara—on all their daily questions in the agricultural domain including: planting methods, seeds, sowing time and fertilizer use [28]. The telecom operator (Orange Mali) which launched the project works with the state through its division IER (Rural Economic Institute) and some NGOs.

MyAgro

MyAgro is a social enterprise helping smallholder farmers in rural Mali to break the cycle of poverty by assisting them to plan, save for, and purchase inputs to make their farms more profitable [29]. It enables farmers to purchase high-quality agricultural inputs (certified seeds and fertilizer) on layaway through an SMS-based platform and a network of local vendors. MyAgro helps farmers to get information that would increase their crop yields by using modern planting techniques and providing access to simple agricultural machines that can make their work more effective and more profitable. It also provides technical training for farmers and market access for their goods to enable them to sell extra produce at a higher profit margin. The model rotates around: a SMS platform and a network of associate in the villages who can work with around one thousand farmers. The project is currently concentrating on cereals mainly maize, sorghum and peanut [30]. The project has shown some advancement for farmers as noted here. "*Two years ago Amadou visited the myAgro store during market day where he met with one of our agents and was told how he could substantially increase his productivity. He purchased a seed/fertilizer package from us on layaway and saved up using our mobile-phone savings platform. Later that year myAgro delivered his package and he planted half of his family's 2.5 acre field using myAgro planting/fertilizing methods. The previous year his fully planted fields yielded only 11 sacks of corn, the year he started with myagro, he increased his yield by 40%"* [31].

3.2. Factors affecting the use of ICTs on agricultural input information

After mapping the selected studies and selected experience from developing countries, relative advantage, simplicity, compatibility, observability, social influence and information quality of ICTs were identified as factors positively affecting the use of ICTs on agricultural input information in the access to and use of agricultural input information (Table 2). The cost of ICTs' services was identified as one of the factors negatively affecting the use of ICTs on agricultural input information.

Table 2. Concept matrix.

Concept	Authors	Countries
Relative Advantage	[5,6,32-39]	Benin, India, Indonesia, Iran, Kenya, Mali, Nigeria, Pakistan, Tanzania, Uganda, Senegal
Compatibility	[2,3,17,32,33,37,39,40]	Benin, India, Indonesia, Iran, Kenya, Mali, Nigeria, Pakistan, Tanzania, Uganda, Senegal
Simplicity	[2,6-8,11,23,32,33,37,40]	Benin, India, Indonesia, Iran, Kenya, Mali, Nigeria, Pakistan, Tanzania, Uganda, Senegal, Latin America
Observability	[9,11,27,32,33,39]	Benin, Iran, Mali, Tanzania, Uganda
Cost	[5,6,10,11]	Mali, Tanzania, Uganda
Social Influence	[10,11,30,35,39,41]	Guinee Conakry, Iran, Mali, Tanzania, Uganda
Information Quality	[5,10,11,13,27,31,42-44]	India, Kenya, Mali, Nigeria, Tanzania, Pakistan, Uganda

3.2.1. Relative advantage

Relative advantage (or superiority) is the degree to which an innovation is perceived as being better than the idea it supersedes, and is often expressed in terms of economic profitability and/ or social prestige [32]. We refer to the relative advantage of an innovation as its perceived usefulness, that is, "the degree to which the user believes that using a specific system will enhance his or her productivity" [29].

3.2.2. Compatibility

Another important characteristic of an innovation affecting its rate of adoption is its perceived compatibility or acceptability [29]. The compatibility is the degree to which an innovation is perceived as consistent with the existing values, past experiences, and needs of potential adopters [33]. Such compatibility helps the individual give meaning to the new idea so that it is regarded as more familiar [45].

3.2.3. Simplicity

Simplicity is the degree to which an innovation is perceived as relatively easy to understand and use. Any new idea may be classified on the complexity-simplicity continuum. Some innovations are clear in their meaning to potential adopters while others are not [32]. In most studies, simplicity is used instead of complexity [33] as it positively affects the use of an innovation. One issue for the effectiveness of ICTs in the Tanzanian agricultural sector especially production is the inadequate supporting technological infrastructure [46]. And in Kenya, farmers found the access to production

information via mobile phone complicated [47]. For the use of the mobile phone more easily by farmers in the agricultural inputs sector, studies proposed the use of Video training on best practices [10,21]. In a survey in Tanzania, the respondents considered some ICTs more useful than others [3].

3.2.4. Observability

The Observability, also known as communicability, demonstrability or describability, is the degree to which results of an innovation are visible to others [32]. It positively affected the intention to adoption of ICTs on precision farming in Iran [39]. In another case in Mali, farmers said that other farmers come to them every month for farming advice [27].

We can conclude that there is a relation between the observability and the use of ICTs on agricultural input information.

3.2.5. Cost

The high cost of ICT service constitutes a barrier to its use on agricultural input information. For instance in Tanzania, the cost of mobile handsets and mobile services, excluded many poor rural farmers from accessing TigoKilimo [6]. In Mali, 95% of SENEKELA users find that the cost is prohibitive [5]. Moreover, in Tanzania, the cost was a barrier to the uptake of ICTs on agricultural input by farmers [11]. We therefore conclude that the cost is a barrier to the use of ICTs on agricultural input information by farmers in developing countries.

3.2.6. Social Influence

Farmers are known to share information among themselves. The major sources of information for farmers were predominantly local (neighbours, friends and family) [9].

Social influence is defined as the degree to which an individual perceives that others important people believe he or she should use the new system [35]. In this study, the construct is defined as the degree to which an individual perceives that other people believe he or she should start using/keep using the new system. It has been found that Social Influence has significant effects on usage [33,39,47]. In Mali, farmers do share the information they gather from the SENEKELA service: 74% of repeat users in the phone survey said they had recommended SENEKELA to farmers outside of their household, and 63% reported sharing the advice they received with other farmers [27]. Therefore, the use of ICTs on agricultural input information is influenced by the social influence as observed by the users.

3.2.7. Information quality

The agricultural input information has to be relevant, accurate and complete for the farmers to apply it. Sometimes, while farmers have access to agricultural input information, they do not apply that information. They question the effectiveness of this information.

The information relating to the availability of agricultural inputs and prices was also perceived as “less appropriate” by 72.5% of Gyandoot (a district in India) farmers [48]. This finding was similar to another study on an agricultural value added service (VAS) conducted in Mali [5] which

found that the information provided was incomplete. In Kenya, there is still room for improvement since a large number of the country's 3.5 million smallholder farmers still work without basic agricultural inputs [7].

In addition, many farmers do not have adequate information on how to use the inputs that they have access to. And in Uganda, the value of information depends on many factors including: accessibility, relevance, accuracy and currency [11]. For the information to be useful or valuable, it needs to be timely, understandable, directed, from a trusted source, inclusive and non-subversive [49].

The information should be: complete, relevant, accurate, timely and appropriate [42]. The lack of access to information especially information which is complete, accurate, reliable, timely and appropriately presented exposes individuals and communities to vulnerabilities and poverty [42]. To leverage the full potential of information dissemination enabled by mobile telephony along with supporting infrastructure and capacity building amongst farmers, it is essential to ensure the quality of information, its timeliness and trustworthiness [13]. Therefore, the quality of the information will contribute to the frequent use of ICTs in the agricultural input information sector.

The farmers' perception (relative advantage, simplicity, compatibility, observability, social influence) of ICTs is positively affecting the use of ICTs on agricultural input information (Table 3). For instance in Benin, it was found that the use of ICTs on agricultural input information requires positive attitude [32]. And in Tanzania, TigoKilimo users were reluctant to sign to the service if they could not use the USSD (Unstructured Supplementary Service Data) menu [6].

Another barrier to the use of agricultural input information by farmers is the cost of these services. That is the case in Tanzania, Mali, Pakistan, India, Zambia, Kenya and Uganda [5,6,10,11,15,23,46,51]. The quality of the information provided is questioned in some countries. In Tanzania, the participants in a survey responded that they have not used TigoKilimo information on their farm because the advice was irrelevant to their situation and not what they were looking for (6). This was similar to the finding that the incomplete content was a barrier to the use of Senekela [30] in Mali. It is also emphasized in the Kenyan situation where it was found that access to information via the MFarm, mFarmer and Nafis application is limited [47].

Another issue faced by these ICTs is their limited number of users. For the Indian farmers' fertiliser cooperative limited (IFFCO) initiative in India; Nokia life in Indonesia, Nigeria, India and China; TigoKilimo in Tanzania; Ukisaan and Kisan in Pakistan; and Senekela in Mali, only the customers of the respective telecom operators can use the services. For instance in Mali Senekela has 177,817 users [30]. This number is very small compared to the potential users in the country where 73% of the population working the agricultural sector and the operator (Orange Mali) has two-third of 12,832,814[2] customers in the country. Another ICTs service MyAgro serves 3500 farmers in Mali and Senegal [29]. This limited use in Mali and Senegal was similar to that of Tigokilimo in Tanzania which had reached 6% of its addressable market [6]. We categorized the concepts identified into categories with their properties (Table 3).

4. Discussion

Developing countries have set up ICTs to provide agricultural input information to farmers. The main goal for the reviewed ICTs is to disseminate agricultural input information. But finding the

[2] Malian Regulatory Authority of Telecommunications 2015

Table 3. Categories matrix.

Category	Concepts	Properties
Perception	Relative advantage, Compatibility, Simplicity, Observability and Social Influence	Positive effect
Information quality	Completeness, Accuracy, Relevancy, Timeliness and appropriateness	Positive effect
Cost	High cost	Negative effect

right approach to disseminate agricultural information to farmers is not easy [8]. We have picked out factors affecting the use of ICTs on agricultural input information in developing countries.

Our findings were similar to the findings of two other studies in developing countries [32,39]. Moreover, they were similar to the factors of the Diffusion of Innovation Theory (IDT/DOI). It attempts to predict the behaviour of individuals and social groups in the process of adoption of innovation, considering their personal characteristics, social relations, time factor and the characteristics of the innovation [52]. The theory has the characteristics which determine the rate of adoption are: relative advantage, compatibility, complexity (simplicity), trialability and observability [36]. We have identified the information quality and the high cost of ICT service as factor affecting the use of ICTs.

Some of our factors were identified in developed countries as barriers affecting the use of ICTs in general. For instance, the compatibility, complexity, and relative advantage were found as the main barriers for ERP (Enterprise Resource Planning) adoption in Dutch horticulture sector [53]. Studies found that the relative advantage, compatibility, the simplicity, the observability and social influence are positively affecting the use of ICTs on agricultural input information while others found the cost to have a negative effect on the use of ICTs on agricultural input information. The information quality was also found to affect the use of agricultural input information accessed through ICTs [7,48,49,54].

5. Conclusion

Our review and analysis of factors affecting use of ICTs on agricultural input information by farmers in developing countries has pointed that despite the availability of ICTs, farmers are facing some challenges in the use of ICTs on agricultural input information. That has led to less contribution of ICTs in the agricultural input information sector. We identified that there are some factors affecting the use of ICTs by farmers in the access to and use of agricultural input information: relative advantage, compatibility, simplicity, observability, social influence and information quality of ICTs are positively affecting while the ICTs service's cost is negatively affecting its use on agricultural input information.

The findings from this study suggest future line of inquiries. For instance, a study could be undertaken to support/or not support these hypotheses and consequently inform the ICTs' designers. Moreover, other factors can be established through the review of more literature and specifically in the context of developing countries.

Conflict of interest

All authors declare no conflicts of interest in this paper.

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