SYSTEMATIC MAPPING STUDY OF INFORMATION TECHNOLOGY FOR DEVELOPMENT IN AGRICULTURE (THE CASE OF DEVELOPING COUNTRIES)

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ABSTRACT

With its rapid proliferation in the developing world, information and communication technology (ICT) has been accepted as an opportunity to assist disadvantaged people. Many projects have piloted ICT supporting rural communities in developing countries. Such rural communities are socially complex and infrastructurally weak environments that demand clear understanding of the social, economical, cultural and political preconditions when implementing ICT innovations. To provide a comprehensive overview of what kinds of ICT intervention and research contributions have been achieved, a systematic mapping study (SMS) was carried out. This work presents the state-of-the-art based on related journal and conference papers published between 2006-2014. The review indicates that ICT supporting farmers has gained attention over the past few years with a growing number of contributions. However, the field is still in a consolidating phase. Theoretical concepts are sparse, so it is difficult to generalize and transfer the findings. Specifically, there is limited research in IT design and development process; user-interface design for illiterate people; and user and community involvement in the design process.

KEYWORDS

Design Method, Information Systems, Development, Agriculture

1.   INTRODUCTION

Information and communication technology for development (ICT4D) is relatively new field of study. However, there is a growing consensus among academics and different government bodies: design and implementation of ICTs can benefit the development goals. Walsham (2006) poses two main questions to guide researchers working on ICT and development: "what are the keys issues being studied related to ICTs? And what is the "development" to which ICTs aim to contribute?" For instance, ICT interventions provide rural farmers with the knowledge to make decisions to improve their income and enhance their economic livelihood.

In response to this, there are number of ICT for development initiatives introduced to communities in developing countries, but the ICT benefits are still far from reaching those who are most disadvantaged (Dodson et al., 2012; Heeks, 2010a; Maail, 2011). The failure of large complex ICT for development initiatives to meet their stakeholder expectations are not only due to failures of technology, but also due to the challenges of interventions in socially complex and infrastructurally weak environments. ICT interventions in rural contexts demand an understanding of social issues, like community organizational settings, social and economic issues, and political situation, among others (Thapa & Sæbø, 2014). The lack of physical resources such as devices and telecommunication infrastructure, the digital information resources such as appropriate software, localized and location oriented content, and skills to interact with the digital system, illiteracy, poor design, and lack of awareness of ICT benefits are mentioned in literature as challenges. Not only computer hardware and software, but also methods and techniques to design and implement information technology

must be re-considered in order to be used for developing countries (van Reijswoud, 2009; Heeks, 2009). Shaping technology to fit into a given messy human situation or context is "highly relevant to the success of IT artifacts" (Baskerville et al., 2009).

Though number of projects have been implemented and reported, there is no consolidated understanding of what it takes to design and implement ICT for agriculture (ICT4A) in developing countries. A compressive overview of research contributions is missing. To this effect, this article presents a systematic mapping study (SMS) that investigates in-depth of the current state-of-art in ICT4A research. While doing the SMS, five categories of research contributions were identified, namely: Understanding context and lesson learned; defining dimensions of development and ICT initiatives impact assessment; designing methods; user interface design; and Framework.

The remaining sections of the study are structured as follows: The second section deals with research methods, which informs on the different journals and conference proceedings; inclusion and exclusion criterion, and research methods employed to collect and analyze the data. The third section explains about data synthesis along with qualitative description. The fourth section discusses the findings with respect to related work. Finally, section five sums up with the conclusion and outlines future research directions.

2.   REVIEW METHOD

The review protocol was formulated based on the guidelines of systematic review (mapping) study presented in (Keele, 2007). The approach begins with identification of research objectives (or research questions) followed by identification of publication venues. Then, searches are performed on the selected data sources (Journals and/or Conferences). In order to select relevant studies for this investigation, inclusion/exclusion criteria were defined. Finally, data was extracted from the selected list of data sources, and results were synthesized.

2.1.   Research Questions

The objectives of this systematic mapping study are twofold: to systematically search, evaluate and report studies on ICTs for agriculture; and to highlight potential future research directions. Towards this, the following list of research questions were formulated:

[RQ1:] What developmental dimensions are addressed in the reported research?
[RQ2:] What research contributions are covered?
[RQ3:] What theoretical underpinnings are used?
[RQ4:] What kinds of research methodology (methods) have been used?

2.2.   Searching Journals and/or Conference

The selection of journals and/or conferences is an important boundary to the findings of this study. Hence, we have chosen three ranked journals based on Heeks ranking (Heek, 2010b). Namely: Information Technology and Development (ITD); Electronic Journals of Information Systems in Developing Countries (EJISDC); Information Technology and International Development (ITID). In addition to these, Journal of Community Informatics (JoCI), which has direct relation to ICT for agriculture was considered for review. With respect to conferences, based on the (Heek, 2010b) ranking, Information Communication Technology and Development (ICTD) conference proceedings was selected. Table 1, shows the selected journals and conferences in this study.

Table 1: Over All Publications by Selected Journals and Conferences

Acronym	Journal / Conference Name	Started	Rank	Total Number of Publications	Total Number of Selected Papers
ITID	Journal of Information Technologies and International Development	2003	1	213	12
EJISDC	Electronic Journal of Information Systems in Developing Countries	2000	2	290	12
ITD	Journal of Information Technology for Development	1986	3	126	7
JoCI	Journal of Community Informatics	2004	NA[1]	25	8
ICTD	Information communication Technology and development	2006	Top	182	9
Others Source	Papers collected through snowballing			10	9
Total				**846**	**57**

2.3. Study Selection

Study screening and selection comprised of a three-step process (see Figure 1). First and foremost all papers from the above identified journals and conferences that were published within 2006-2014 were collected. Second, based on the study title, abstract and inclusion and exclusion criterion, each study article was marked as either 'Include' or 'Exclude'. Third, the full texts of articles were reviewed using a standard form. Initially a total of 846 publications were collected. After inclusion and exclusion criterion (see Table 2) a total of 75 publications were selected. After investigating title, abstract, conclusion and reading the whole texts of each paper 48 were considered for further study. In addition to this, another 9 papers were obtained through snowballing and included for further investigation. The main reason for complementing the search-based selection with snowballing was that some of the articles referenced additional projects that were only reported in local conferences or not ICT4D related venues. All in all a total of 57 papers were reviewed.

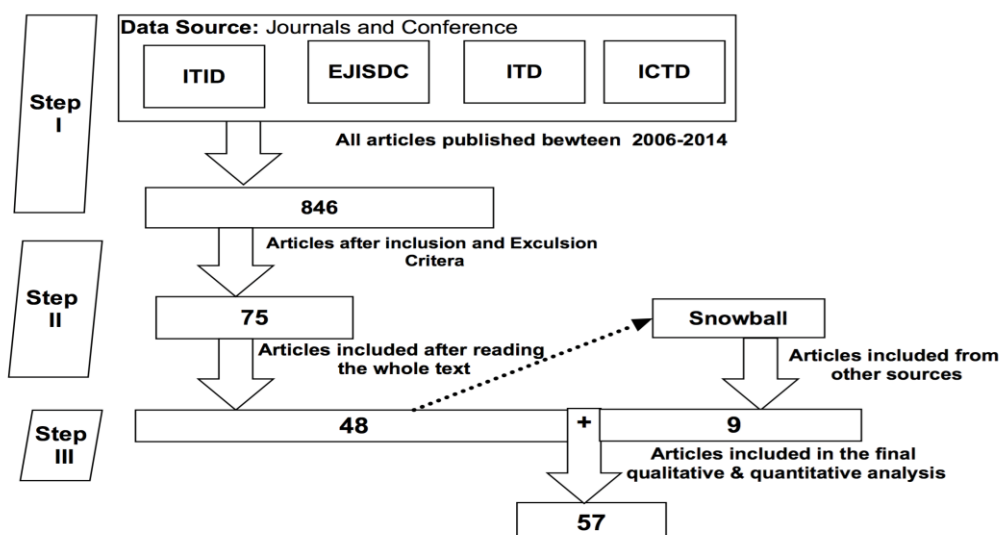NA[1] : Journal type not ranked by Heeks (2010c)

Figure 1: Paper Searching Strategy and Selection Process

2.4.   Inclusion and Exclusion Criteria

From the initially collected articles, any paper that did not emphasize agriculture, or farming, including ICT, community and development was excluded. This was simply done by search word or string: agriculture, farmer, ICT, rural community or development, inside each paper's text. Second, paper title and abstract were used to check the relative importance of a paper to the research questions. Table 2 describes further about the inclusion and exclusion criterion used at the preprocessing stage of the review. Third, to make the review result more comprehensive, additional papers from other data sources were also included using snowballing method. Fourth, only empirical papers that reported from actual observations, interviews, experiments or questionnaires were considered.

Table 2: Inclusion and Exclusion Criterion

Description	Inclusion Criteria	Exclusion Criteria
Research paper venues	Top ranked Journals and conferences that focus on ICT4D	Journals and conference which is not top-ranked and less related to Agriculture
Publication Year	Published within 2006-2014	Published before 2006
Application Domain	Agriculture, rural community	Exclude all except Agriculture related issue
Major discipline (subject)	Computer science; information system; and HCI, developmental study	Any paper that was not conducted in the developing countries.
Language	Papers published in English languages	Non-English papers published in other languages
Words (strings)	(Agriculture AND ICT) OR ((Farmer OR Rural Community) AND (ICT OR Informatics))	Any paper when there is no word (string) about Agriculture, Farmer, ICT, and development in the body of their text

2.5.   Data Extraction and Analysis Process

To extract data from each paper, fifteen data extraction variables were used. Namely: Title, Authors, Publication venue (or journal and conference), year, research questions, finding (contribution), research method, technology, theoretical underpinning, scope of analysis and knowledge base (discipline) among others. These data extraction variables were purposefully defined to answer the research questions. In order to keep consistency and improve validity about data extraction variables, other systematic mapping studies (Gomez, 2013; Chepken et al., 2012) were considered as a benchmark.

Figure 3, depicts the classification used to analyze and categorize the reviewed papers. We chose to focus on core disciplines studying ICT4A; research contribution; technology used or investigated to answer the research questions; theoretical underpinnings used to guide the research process; and methods (methodology) used for research and data analysis. Each of these will be discussed in the following subsections.

Discipline:	Computer Science		Technology under Study	Mobile phone(eg,SMS, IVR)
	Human Computer Interaction(HCI)			TeleCenter
	Information System			Desktop computer or labtop
	Development Informatics			others: General ICT
Research Focus	Understanding a context		Theoretical Underpinnings	Diffusion Theory
	Dimension of development			structuration Theory
	Design method			Stakeholders Theory
	User Interface design			Soft System theory
	Framework			Institutional Theory
				Developmental Theory
Research Methodology	Ethnography study			Constructive Technology Theory
	Survey			Appropriate Technology Theory
	Action Research			Actor Network Theory
	Participatory Design			Socio-Technical theory
	Design Science research			Other: Undetermined
Data Analysis Method	Qualitative		Data collection tools	Questionnaire
	Quantitative			Interview
	Mixed Methods			Observation
				Focus group
				Document analysis

Figure 3: Summery of in Depth Description of the Reviewed Results

2.6.   Tools for Managing Reference and Analysis

All the above 846 papers were managed using an open source desktop based application which could be synchronized with the cloud vision. This software is a kind of database used to classify, tag, and reference each paper using various attributes in an easy to use manner. Once the selection and pre-processing phases were finished, all selected articles were exported to Microsoft Excel file format for data extraction and analysis. In order to export these papers from Mendeley to Microsoft file format another tool, namely JabRef, was used. Thereafter all statistical distribution or figures, which is defined in the data extraction section, were computed using the Microsoft excel tools.

3.   DATA SYNTHESIS

3.1.   Publications Trends Over Years

Steps to conduct the data synthesis involve the use of descriptive statistics and discussion of extracted data. The data shows that there are very few publications produced not only across years but also among the different data sources (see Table 3). About 42% of the total publications are contributed from the two journals: EJISDC and ITID. None of these publication sources shows any kind of consistent increments overtime. Even in 2014, the total numbers of publications were very few, only 4 papers, compared to the previous years.

Table 2: Distribution of Publications by Data Source and Years (2006-2014)

Journals/ Conference	2006	2007	2008	2009	2010	2011	2012	2013	2014	Total	%
ITID	-	1	1	3	1	1	3	2	-	**12**	21
EJISDC	-	-		1	1	1	3	5	1	**12**	21
ITD	-	1	1	1	1	-	1	1	-	**6**	11
JoCI	-	1	-	1	4	-	1	1	-	**8**	14
ICTD	3	2	-	-	-	-	4	1	-	**10**	18
Others source:	-	-	2	1	1	2	-	1	2	**9**	16
Total	3	5	**4**	**7**	**8**	**4**	**12**	**11**	**3**	**57**	**100**

3.2.   Distribution of Research Papers by Location (Country)

Classifying articles based on geographical location in which the research was undertaken shows that research papers were conducted from Asia, Africa, and Latin America. An analysis of the review reveals that five from Asia (India, Bangladesh, Cambodia, Malaysia and Sri-Lanka); eight countries (Tanzania, Ghana, South Africa, Uganda, Lesotho, Nigeria, Mali and Malawi) from Africa; and Peru and Colombia from South America found to publish in the aforementioned journals or conferences (see Figure 2). When we look at the proportion of papers across countries, almost half (43%) of the publications were from India, and 9% from Tanzania but the remaining countries shares around 6% the total.

Figure 2: Papers Contribution by Project Location

In Africa, it has been reported that Kenya and Uganda have a good reputation in ICT penetration across the country, however, there are no single papers published in the researched data sources. This review also confirmed with Gomez (2013) findings from reviewing 948 ICT4D papers demonstrating that only 6% of the publications were related to ICT for agriculture. Given the fact that agriculture is the main economic backbone (more than 80% of labor force engage in agriculture) the current ICT for Agriculture researches are very few.

3.3.   Disciplines

ICT4D is an interdisciplinary field which spans across many disciplines, namely: computer science (CS) (including human computer interaction); telecom and networks; information systems (IS); media Studies; development studies (DS), sociology, political science, among others (Heeks, 2006). In this review, only papers that were initiated from the three research disciplines: CS including HCI, IS and DS, were considered. The CS research in view of ICT4D places a strong emphasis on design of a technical intervention that should be evaluated in underprivileged environments. Likewise, Human computing interaction (HCI) discipline deals with appropriating interactive computing systems using human centered approaches to design ICT that can be used by people to improve lives, and freedoms (Ho et al., 2009). The information system knowledge area strives to understand problems and offers models for understanding the human, political, and contextual reasons used to analyze "What is feasible with digital technology?" DS provides guidance to understand and fit digital technologies with development paradigms, processes and structure (Heeks, 2008).

Out of the three core research disciplines, IS has the highest number (30 papers or 53%) of publications. About 35% of the IS articles were published in EJISDC followed by ITD and ICTD with the same coverage (20%). Computer science (the technical discipline) stands next to IS with a total of 21 (37%) papers. Each one of these three core domains offers an input towards the successful implementation of ICT4D/A. However, amalgamating knowledge from these disciplines into the development cycle is lacking.

Table 3 Distribution of Publication by Discipline Types and Data Source

Sources	Disciplines			
	DS	IS	CS and (HCI)	Total
ITID		4	8	12
EJISDC		10	2	12
ITD		6		6
JoCI	6	2		8
ICTD		6	4	10
Snowballing		2	7	9
Total	6	30	21	57

3.4.   Research Contributions

To address the real problems of society via ICT, the proposed ICT should be designed with tangible impact, and should be sustainable down to the grass roots. Scholars, for example, Walsham (2010) propose three research thematic areas in ICT4D. Namely: Understanding the link between ICTs and development; Understanding the cross-cultural and multi-cultural implications of ICTs; and Understanding how developing countries appropriate (adapt) ICTs. In a similar manner, (Bon et al., 2016) classified the scientific literature on ICT for Development as being roughly divided into three categories: (i) Social-science, often ethnographic, field studies that analyze the effects and impact of ICTs on people in developing regions; (ii) technical studies that describe developed local or regional ICT deployments or present technical tools; and (iii) desk research studies that consider various policy aspects at a high conceptual level. In this paper, we rephrased these into five research categories: linking ICT initiative with development; understanding context; method: ICT4A system design & development; user interface: designing interaction interfaces for illiterate users systems; and framework. The reviewed papers show that about half of the contribution falls into understanding the context including experience sharing from the field, and best practices of field studies of which EJISDC shared 9 articles. As can be seen in Figure 3, there are very few (less than four) articles that were contributed to design and development method

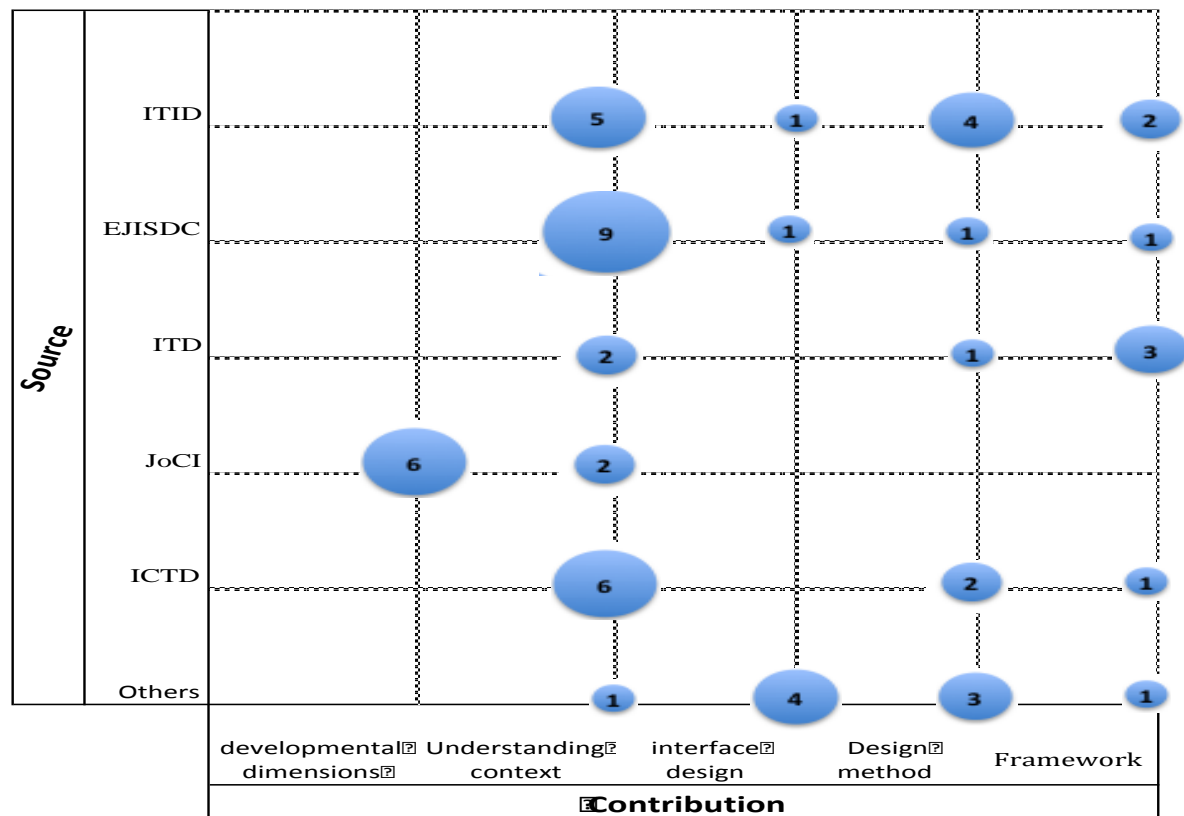or user interface design by any of the data sources.

Figure 3: Distribution of Research Contribution Types by Data Source

3.4.1. *Developmental Dimensions*

As the rapid proliferation of ICT in the developing world proceeds, it has been accepted as an opportunity to assist disadvantaged people (Gigler, 2011). To this effect, most research studies implicitly addressed development dimensions, particularly the JoCI mainly focus on development dimensions that contributed with 6 out of 8 articles (Alam et al., 2010; Garudachar, 2010; Goswami, 2010; Grunfeld, 2014; Hedberg, 2010; Rao, 2009). For instance, (Rao, 2009) argues that empowering poor people reduces the digital divide, thus ICT projects should be developed in local language prioritizing local needs and content. They should also be low cost solutions. Similarly, (Alam et al., 2010) viewed development as "empowering marginalized populations". Hedberg (2010) Analyzed the impact of a particular ICT initiative namely: 'Telecenter" in Malaysia. The study demonstrates that "ICT has a positive impact on empowerment of women in terms of economic, and social progress as well as decision-making capacity". According to Vincent and Cull (2013), the link between mobile phones and development was exemplified by offering ten mobile phones ("Ten seeds") to remote rural women-led cooperative farmers in Lesotho. The study found that the ten-seeds brought economic growth via improved communication which in turn helps them to seek markets, reduce wastage, reduce travel costs associated with seeking markets at the capital city, among other benefits. In addition to this, mobile phones are also reported to have empowered farmers by improving their mathematical literacy (using calculator), and to facilitate community by building their social networking capital. In northern Ghana, (Schmidt et al., 2012) examines the effects of a low-cost audio computer ("Talking Book"), which enabled farmers to create, listen to, and copy recordings. The results show that development dimensions were observed in terms of learning, behavior change, and crop yields in a village.

3.4.2. *Understanding Context*

These kinds of research contributions are primarily concerned with descriptions of field experience, analyzing context, assessment and evaluation, benefits, barriers, success factors of ICT initiatives. As shown in figure 1, around 25 (44%) of the reviewed papers fall in this category. Specifically, the following list of papers': (Amariles et al., 2007; Baro & Endouware, 2013; Bello-bravo & Baoua, 2012; Cáceres & Fernández-Ardèvol, 2012; Cloete & Doens, 2008; Dearden et al., 2011; Dearden et al., 2010; Dissanayeke & Wanigasundera, 2014; Dittoh et al., 2013; Lwoga, 2010; Futterman & Shuman, 2010; Gollakota et al., 2012; Kameswari et al., 2011; Kuriyan et al., 2006; Madon et al., 2009; Martin & Abbott, 2011; Mpazanje et al., 2013; Muthiah et al., 2013; Srinivasan, 2007; Patel et al., 2012; Siyao, 2012; Tomitsch et al., 2010; Mtega & Msungu, 2013; Yusop et al., 2013), main study areas focus on understanding context and documenting best practices. For instance, over five months field pilot of a voice telephony-based information service, (Futterman & Shuman, 2010) and (Yusop et al., 2013) assess the information needs and interests of rural populations in Uganda and Malaysia respectively. As a result, agriculture related information requirements were found to be the major ones compared with health, education, sport, politics, and news, etc. Dissanayeke and Wanigasundera (2014) discusses the impact of mobile phone penetration in rural areas for farmers to contact input suppliers, buyers and agriculture extension officers via voice calling. For ICTs to be effective, it is important to have adequate infrastructure, affordable tariffs, skills and information services that should be broadcast at relevant times. With this in mind, (Mtega & Msungu, 2013) investigates the role of ICT (radio, mobile phone, television, computer and internet) to enhance agricultural information services. However, not all ICT tools used by stakeholders are reported as suitable neither for providing agricultural information services, nor for communication across all categories of actors.

Muthiah et al. (2013) describes experience from India on a project that aimed to establish a call-center where farmers can post their query with mobile phone based multimedia agriculture advisory service dashboard; and then agriculture experts at the center respond accordingly. However, this study reported that usability of the project was very low and farmers were skeptic about the design due to: local language; unavailability of location specific information to farmers; and unavailability of diversified information. Similarly, Siyao (2012) reported that access to agricultural information in this rural setting is difficult due to various obstacles. These obstacles include: poor communication facilities, poor transport systems, poor electricity transmission, high illiteracy level, lack of knowledge on how to access information, and lack of financial resources. As a recommendation, agricultural information being re-packaged into an appropriate format, size, language, and disseminated regularly, was documented.

Lack of access to ICT was documented by number of scholars as a barrier. Nevertheless, (Kameswari et al., 2011) reported that ownership of ICT (eg. mobile phone) by a rural farmer and the ability to use it does not alter the relationship between farmer and middlemen, or does not bring economical change in rural India. This is because the middlemen are the major creditors for smallholder farmers. On top of this, a middleman happens to be a person known to the farmers personally and seen as trustworthy one. Likewise, (Tomitsch et al., 2010) argues that access to mobile phones as a solution for improving the economical situation turns out not to be feasible in the context of seaweed farms in Tanzania. Patel et al., (2012) investigate the difference between university scientists and peer farmers when disseminating the same Agricultural information (Tips) for rural farmers. As a finding, farmers' follow-up was significant to agricultural tips when peer farmers delivered them, compared to agricultural scientists. This is because there is a strong social tie, and more trust among the rural community members than an external information provider. Hence, ICT should not be considered as the easy remedy to all problems in developing countries. Rather, careful investigation and consideration of the local context as

well as political and ethical issues need to be applied.

3.4.3. Design Method
Not only computer hardware and software, but also methods and techniques to design and implement information technology, are developed in the developed countries in order to be used in developing countries (van Reijswoud, 2009; Heeks,2009). The limitation of this approach is that context and culture are not the same even within a single country, let alone between developed and developing countries. In response to this, about 11 papers (Agarwal et al., 2010; Blake & Garzon, 2012; Dearden & Rizvi, 2008, 2009; Doerflinger & Dearden, 2013; Gandhi et al., 2009; Islam & Grönlund, 2012; Maunder et al., 2007; Medhi & Toyama, 2007; Moens et al., 2010; Plauché & Nallasamy, 2007) propose new design methods. For example, (Doerflinger & Dearden, 2013) develops a software development methodology "Distributed Agile Methodology Addressing Technical ICT4D in Commercial Settings". The methodology covers from initial team setup through ICT system design, development, and prototyping, and scaling up to other settings. Their approach was refined and implemented in pilots in Ghana and Burkina-faso for its effectiveness in supply chain operations for cashew and shea agriculture produce. Agarwal et al. (2010) adapt participatory design processes (design, development, and usage pattern) to design a voice based information system for rural people in India. Testing the artifact was also done with the villagers to evolve a participatory design, which in turn contributed to wider user statistics.

To integrate ICTs in agriculture, and demonstrate how to apply ICT in a development context, (Moens et al., 2010) develops a Round Table (RT) workshop methodology. This Methodology consists of two parts: RT workshop, and its preparation with a total of 15 steps. Moreover, it is a participatory approach, which includes process- and product-oriented evaluation criteria. The process criteria track whether the method is properly applied; and the output criterion evaluates the level of match between achieved and intended results. Taking argument that "Design Science Research (DSR) is positivist perspective but ICT4D research type is an interpretive one", (Islam & Grönlund, 2012) adopted DSR for ICT4D research with a case study: Mobile based Agriculture market information system for Bangladesh farmers.

3.4.4. User Interface Design
According to world demographics profiles (Indexmundi, 2016), there were 775 million illiterate adults who are mostly living in developing countries, which indicates the necessity of designing an appropriate user interface to make current Information Technologies useful for those people. To improve information system usability for low-literacy populations (Medhi & Toyama, 2007; Medhi-Thies et al., 2015) propose requirement criteria for user interface (UI) designs: ease of learning; ease of remembrance; graphics (Icons) with speech annotation in local language; and ease of use. To this effect, around six papers (Agrawal et al., 2013; Edim & Muyingi, 2014; Edim & Muyingi, 2010; Medhi-Thies et al., 2015; Rege & Nagarkar, 2010; Schmidt et al., 2012) were contributed towards user interface design issues. For instance, in the study of technology usage and media sharing in India, (Rege & Nagarkar, 2010) analyze shared social norms and practices, flows of information, and existing information access. Their finding shows that non-literates get help from individuals in the community who can read or who know how to use a technology. As a result, they argue that technological interventions will be more effective if the underlying human infrastructures (intermediation) in a community are taken into consideration. A text free system UI for farmers in India using speech recognition technology was designed by Medhi-Thies et al., (2015). They identified dialectical variation, multilingualism, culture, choice of appropriate content, and the expense of creating the necessary linguistic resources for effective speech recognition as a barrier to the system's usability. To allow farmers time-sensitive dynamic

information about best practices, the advice of experts, and the experiences in India, Agrawal et al., (2013) designed, implemented, and evaluated a voice mobile phone based interface: Interactive voice response(IVR). In their comparative study of voice verses touch-tone keypad input they reported that users' performance and learnability were found to be much less difficult using touch-tone than voice based input. A study (Edim & Muyingi, 2010) designed a UI with audio-visual-textual for low-literate rural farmers to access market information. This UI supplements two-way interaction between farmers and agricultural experts, which they reported as easy. Considering the advent of smart phones with touch screen, and hoping that it will soon be financially within the reach of illiterate rural people, designing text free user interface applications could allow illiterate users to interact in an easy to use manner.

Although there have been solutions proposed using appropriate user interface design, still problems do exist. This is because, first, people in different cultures hold different perceptions about technology and how they use it. Second, most people in rural area are illiterate and could not understand text-based user interfaces. Third, even if users are educated, they often find the language of presentation difficult to understand. In addition to this, user interface design studies in ICT for development mainly originate from the field of human-computer interaction (HCI). These studies focus on contextualization of user interfaces to local culture and on usability of systems for end-users, but do not cover the complete lifecycle of ICT service development, from user-centered needs assessment to design, deployment and evaluation of ICT4A projects.

3.4.5. *Framework*
The last categories of contribution encompass different social and technical components to implement ICT4A. For example in the context of ICT, Urquhart et al. (2008) present a framework that relates ICT infrastructure with social capital formation and cultural dimensions. Their framework has four stages - the process of Information system development, the information system intervention, the evaluation of the impact of the ICT intervention and the process of poverty reduction. There are several iterations and interactions between stages and each stage of the framework is exemplified using practical development projects. The following papers (Islam & Alawadhi, 2008; Parmar, 2009; Pick et al., 2014; Puri & Sahay, 2007; van Reijswoud, 2009; Sambasivan & Smyth, 2010; Tongia & Subrahmanian, 2006; Veeraraghavan, et al., 2009) were categorized as contributing some kind of framework. van Reijswoud (2009) develops an integrated and participatory design process model that is suitable for the cultural, environmental, organizational, economic and political conditions in which it is intended to be used. The author extended the traditional systems' development life cycle with tools and processes. On the contrary to providing computers and installing internet connections in rural areas as a solution for information poverty, Parmar (2009) argues that offering rural users relevant and personalized information is a possible solution, and suggests a framework on how to integrate knowledge from multiple disciplines and stakeholders to design and develop a sustainable information system. Considering the challenges of setting out a proper information system design and implementation process, Islam and Alawadhi (2008) propose a framework for rural information system implementation process for developing countries. Considering the fact that ICT4D issues are ill-structured and "wicked problems" (Tongia & Subrahmanian, 2006) elaborate the dimensions of design such as incorporation of stakeholders, incentive structures, and design participation that are critical to successful deployment. To this effect, the study proposes a framework of product and service identification and development.

3.5.   Technology Considered

Medium for interaction is an important consideration if users, especially those with low literacy, are to have full advantage from ICT services. Mobile phones, computers, telecenters and Internet are used in rural community but not all technologies are suitable for all categories of actors in the agricultural community. Figure 4, depicts the distribution of different technologies that were studied.
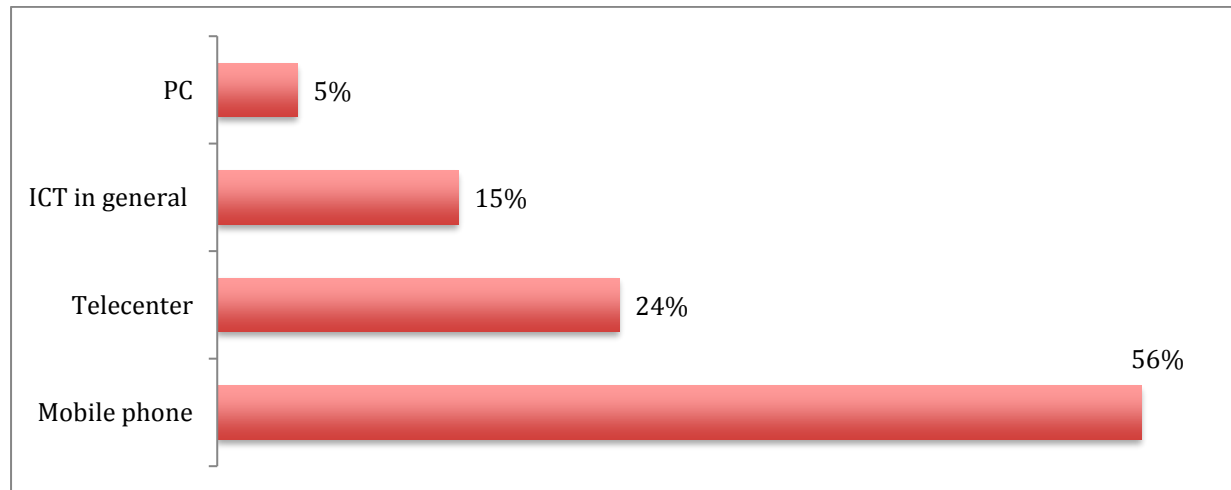

Figure 4: Distribution of Technologies Studied

More than half of the reviewed papers studied mobile phones as the most preferable technology in rural area. Several studies (Tomitsch et al., 2010; Martin & Abbott, 2011; Agarwal et al., 2010; Cáceres & Fernández-Ardèvol, 2012) report that using mobile phones improves relationships, reduces travel costs; facilitates communication with their community; and enables easy design and deploy content creation and dissemination by-and-for users in rural areas. A group of researchers (Bello-bravo & Baoua, 2012) initiated a project "Scientific Animations without Borders" and demonstrated that mobile phones could not only be used as a communication tool but could also be used as a valuable educational tool. They produce agriculture related technical messages using multimedia clips that can be downloaded to cell phones so as to share among the farming communities. Although there is an abundance of mobile phones in developing nations, most common underserved rural communities own very basic phones, and use of mobile Internet is extremely rare or non-existent. This in turn, limits the designing of different mobile-based apps.

Telecenters, about (24%), which can be equipped with computers, internet and printers, were found to be the most used communication point to enhance communities' access to and usage of agricultural information. Telecenters however, face a number of problems related to dissemination of agricultural information. For instance (Lwoga, 2010; Srinivasan, 2007; Amariles et al., 2007), examined a wide range of telecentre projects and concluded that lack of assistance, awareness, skills, language barriers, and adequate service delivery were reported as reasons for very low usage rate of telecenters.

3.6.   Theoretical Lens
Scholars (Truex et al., 2006) describe theory as a lens through which researchers can focus and magnify certain things, while filtering out others things presumed to be noise. Likewise, Gregor (2006) argues that theories guide the type of research to be conducted, which she categorized into four distinct classes (see Table 5, column 1). This paper adapted these classifications to identify and categorize theories used in the reviewed papers. About 60% (34) did not clearly define their theoretical lens to guide their research work.

Table 4: Taxonomy of Theory and Types of Theory Used in the Reviewed Papers

Category of Theory	Theory Name	No. of Papers	Reference
Thick Description (De)	Stakeholder Theory	1	(Bailur, 2007)
Understanding & Explanation (UE)	Actor Network Theory Structuration theory Institutional theory Developmental Theory	5	(Mpazanje et al., 2013; Muthiah et al., 2013; Sambasivan & Smyth, 2010; Vincent & Cull, 2013; Mtega & Msungu, 2013)
Explanation and Predication (EP)	Technology Acceptance Model (TAM) and/or diffusion theory Boundary object	12	(Bello-bravo & Baoua, 2012; Blake & Garzon, 2012; Cloete & Doens, 2008; Dissanayeke & Wanigasundera, 2014; Lwoga, 2010; Edim & Muyingi, 2010; Gandhi et al., 2009; Gollakota et al., 2012; Grunfeld, 2014; Islam & Alawadhi, 2008; Martin & Abbott, 2011; Pick et al., 2014),
Design and Action (DA)	Constructive Technology Assessment Appropriate Technology Soft system Theory Socio-Technical Theory	5	(Dearden & Rizvi, 2009; Doerflinger & Dearden, 2013; Madon et al., 2009; Moens et al., 2010; Parmar, 2009; van Reijswoud, 2009)
	Sub total	23	
No explicitly theory or undermined		34	
Total		**57**	

Theories used for **thick description of a study** - this category of theory is the most basic type of theory, which is used to describe or classify specific characteristics of situations by summarizing research insights. Among the reviewed papers, although most studies not mentioned explicitly theory used in the study, research types that contribute to "understanding context", see section 3.4.2, belongs to this category.

Theories for **understanding and explanation** - used to explain how and why some phenomena happened in a particular real-world situation. For instance, (Mpazanje et al., 2013) used Actor Network Theory (ANT) to explore how various human and non-human networks come together to act as a whole system, so as to get a depth of understanding about Information system designing process and outcome. Madon et al. (2009) adopted Institutional theory to deliver telecenter agriculture information service as institute (organization) service. They followed a process of institutionalization, which encompasses: getting acceptance by the community, telecenter business model, and structuring means for government to support the telecenter, among others. Vincent and Cull (2013) adopted "development theory", and empirically demonstrated how to link ICT to development (e.g. economic growth, and empowerment) using mobile phones in women-led cooperative farming.

Theories for Explanation and predication - used for both understanding underlying causes and prediction, as well as description of theoretical constructs along with the

relationships among them. In most case, these kinds of theories are often being used to evaluate the feasibility of existing technologies. For instance, (Dissanayeke & Wanigasundera, 2014; Parmar, 2009; Martin & Abbott, 2011) applied technology acceptance and diffusion theory(TAM) to investigate mobile phone usage, awareness and limiting factors for use among agriculture communities. Similarly, Pick et al. (2014) use TAM to understand influences on use of rural Telecenters in India. Considering a large number of illiterate people in rural areas, (Gandhi et al., 2009) used diffusion theory to investigate usability of multimedia content generation and dissemination system among farming communities. Cloete and Doens (2008) uses TAM to adopt and investigates e-commerce for agricultural supply chain in South Africa, which integrates interests of different stakeholders like farmers, buyers, and exporters of agricultural products.

Theories used for design and action - can be viewed as the highest level of classification, which provides the means to do something. In response to the aim to move away from techno centric to community centric, theories in these themes give explicit prescriptions (e.g., methods, techniques, principles of form and function) for constructing a new software artifact. The provision of these theories will cause an artifact of a certain type to come into being. For instance, (Dearden & Rizvi, 2009) demonstrates the applicability of socio-technical perspective to design ICT4D by combining approaches from participatory development practice and participatory methods of ICT design. For their argument, they adopt this theory in their project called: "Rural e-Services project". The focus of their project was to work with marginal farmers in rural India to design new software to communicate with their agricultural advisors. Soft system theory to design a software development methodology, which encompasses the participation of different stakeholders from team building to information system usability evaluation phases, was used by (Doerflinger & Dearden, 2013).

To sum up, few of the reviewed papers make their theoretical underpinning explicit. If theory is clearly stated, the most common theories were those explaining the phenomena of adoption, uptake and resistance of technology from a positivist perspective.

3.7. Research Methodology

Methodology can be defined as sets of recommended means that includes: definition of phases, procedures, activities, techniques, tools and guidance. For example, exploratory case studies are used as initial investigation of some phenomena to derive new hypothesis and build a theory. Avison and Fitzgerald (2006) define information system development methodology as sets of recommended means that includes: definition of phases, procedures, activities, techniques, tools and guidance. In a more general form, it is a master plan specifying the methods and procedures. However, one of the difficulties for any researcher to select methodology (mix of methods) from an existing source is that different aspects of different methods are overlapped. For example, several authors compared action research (AR) and design research (DR) mode of knowledge production, and claim their similarity, as long as action research considers "action" as an artifact (Papas et al., 2012). Similarly, Foth and Axup (2006) in their paper: "participatory design (PD) and action research: identical twins or synergetic pair?" argue the similarity between PD and AR. As a result, identifying and categorizing research methodology (methods) was for some time a challenging task. This challenge became worse because some papers did not state their research methods or the description of research processes was not clear. See Figure 5, for the distribution of different research methods used in the reviewed papers namely: survey, ethnographic filed, participatory design and/or action research, design research.
Survey, and Ethnographic (Field) Study

Survey methodology informs research by collecting generalizable information from a known sample of people or cases. It is also used to understand a phenomenon, to gather data about the user experience or to gather satisfaction rates of specific ICT design. The reviewed papers were classified in these categories, if the study followed a questionnaire to collect different data and analyzed it quantitatively. The result shows that a large proportion of the reviewed papers, 26 (46%) used survey methods. Ethnographic field studies research is characterized by taking place in a real world setting and the researcher spends significant amounts of time in the field. The phenomena being studied are placed in a social and cultural context via descriptions, which can help to provide rich data explaining phenomena, involving the use of ICTs in a given context. Survey and ethnographic field study were used most within the EJISDC and ICTD data source. However, surveys suffer and rely highly on the subjective views of respondents, compared to ethnographic field study.
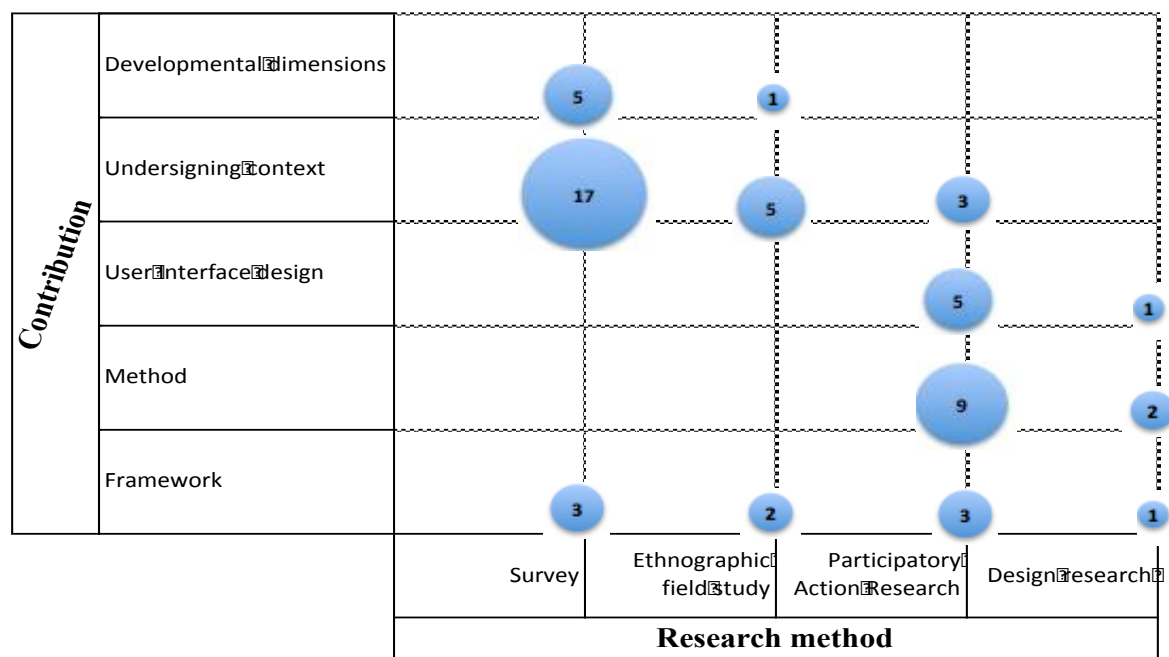

Figure 5: Distribution of Research Contributions by Research Methods

(Participatory) Action Research
 According to Spinuzzi (2005), PD is viewed as research methodology, which characterizes it as a way to understand knowledge by doing. To get different perspectives, users should be provided with the appropriate tools to express their perceptions. Tools such as future workshops, focus group discussions, and paper prototyping were proposed to build common understanding among users and researchers. On the other hand, action research describes the overall process to discover a problem area and provides a solution with a simple two-stage process. First, the diagnostic stage involves a collaborative analysis of the social situation; second, the therapeutic stage involves collaborative change experiments (Baskerville, 1999). The basic assumption in AR is that introducing changes and observing the effects of these changes can help to study complex social processes. Thus, AR offers methodological approach and pragmatic guidance for constructing credible knowledge, while addressing social challenges. The reviewed papers were classified into participatory design, if users participation and participatory design concepts were practiced starting from the problem identifications until system usability evaluation. Whereas, a given paper was classified in action research, if the study explicitly defined participatory action research as a research method or the process of designing a solution and evaluating the result in the actual setting

through consultation with users. To this end, 20 reviewed papers followed participatory action research, in which 8 papers used participatory design or process.

Design Research (DR)
Hevner et al. (2004) describe design research with a predefined step, namely: problem identification; definition of the objectives for a solution; design, and development; and evaluation of the designed solution. The main focus of design research is to solve a given problem for a generalizable class of stakeholder. The reviewed papers were grouped into this category if a technological alternative was deigned purely by a developer or a researcher and user participation conducted only during usability evaluation, without conducting any initial survey or ethnographic field study. Design research is dominated by an implicit positivist epistemology but ICT4D/A demands an explicitly constructivist standpoint. This might be a reason for only 7% of papers making use of this research method.

To sum up, ethnographic field studies mostly explain complex social situations without any intention of changing them. Only very few papers use this methodology compared to quantitative surveys. Action research aims to achieve action (solution) based on understanding complex social situations. Action research extends ethnographic field studies by introducing solutions and evaluating their effect. The ICT4D/A demands end user involvement as co-creators and experimentation in real world settings. As ICT4D/A aims at introducing technology, the role of ICT4D/A research cannot be confined to understanding the problematic situation, but has to reflect changes through the introduction of technology. The review reveals that ICT4D research lacks the implementation of appropriate research methods to cover the entire development lifecycle: design, development, deployment, and evaluation. Such research methods could e.g. be participatory action & design research. Such a method conceptualizes the research process as an inseparable activity of IT artifact building, intervening in the communities and evaluating the use of the artifact.

3.8.   Data & Data Analysis Methods
Once the research method has been selected, the researcher must decide which data collection techniques or methods are most suitable for gathering data based on the studies' unit of analysis (Jabar et al., 2009). These methods are commonly classified into three categories: quantitative, qualitative or mixed methods. Qualitative methods enable researchers to study social and cultural issues and summarize text through interpretive analysis. Quantitative methods enable researchers to study phenomena using numerical measures and statistical procedures. The mixed method takes advantages from both the qualitative and quantitative methods to investigate the given phenomena in a more rigorous way. Qualitative data collection methods were questionnaires, interviews, observations, field visits, focus group discussions, and document analysis. Data analysis methods are somehow related to the type of research method used. For example, 82% of the papers used quantitative data analysis methods with the three-research method: survey, participatory action research and design science. We argue that more mixed or qualitative data has to be practiced to gain a deeper understanding of a context and avoid respondents' subjectivity.

4.   DISCUSSION
The World Bank, the United Nations, the Bill & Melinda Gates Foundation (Wikipedia, 2016) have funded numerous ICT for development projects. Despite these investments and efforts, high rates of failure are reported for ICT4D deployments (Dodson et al., 2012; Heeks, 2010a; Maail, 2011). There seems to be a frequent mismatch between deployed technologies and local goals, needs and contexts, resulting in unsustainable solutions. Failures in ICT4D deployments may have various root causes. To make better use of invested resources, we

need to understand what are the challenges and what is successful. The SMS shows that very few papers presented field-validated methods to address ICT4A design and deployment. It further confirms Gomez' (2013) study on ICT4D where research contributions towards design methods were the least frequent compared with other types contributions. This section discuss the results of the systematic mapping studies with respect to the dimensions of development addressed in the studies; lack of in-depth understanding of the local context in the reported research, and the lack of community driven participatory design processes and methods.

4.1.   What are the Dimensions of Development Addressed in the Studies?

With the rapid proliferation of ICT in the developing world, it has been accepted as an opportunity to further the development of disadvantaged communities in diverse dimensions: Some focus on economic growth; some on the millennium development goals; some concentrate on people's livelihoods; some on broadened definitions of development as freedom of opportunity. These developmental dimensions are continually evolving with new objectives and approaches. Recently Heeks (2014) analyzed and re-categorized 15 development agendas for post-2015 millennium development goals. In general, economical empowerments, social cohesion or networking, and the rights of individual to access digital information, are among the most commonly known dimensions of development. However, Walsham (2010) reports that many ICT4A initiatives have taken place in India over the last decade, but without actually improving the situation of the intended beneficiaries. Our SMS confirms this: many articles do not define a precise notion of what development they address. The way that ICTs can promote development is often implicit or underemphasized. In other words, many of the articles lack a clear development focus or do not indicate development outcomes based on the reported ICT interventions. Only few articles address sociality development targets at all. Islam & Grönlund (2012) underscore that ICT4D initiatives should clearly describe three main strategic questions to make ICT for agents of development: "A sort of technological artifact; sort of development goals, and how these two can be fitted together".

4.2.   Lack of In-Depth Understanding of the Local Context

Technical ICT4D in general, and ICT4A in particular, differ from conventional software projects in number of ways. Existing literature on ICT4A systems has mostly focused on identifying technical designs and quantitative evaluations with limited details on development processes and lack of in-depth understanding about the local context. For example, although there are 25 articles aiming to understand context among the reviewed papers, 17 of these papers (68%) do so by implementing a survey. Extensive ethnographic field studies with qualitative description and analysis, maybe triangulated by a survey, would provide better ways to understand the local context. Dearden and Tucker (2016) highlight a need to shift from what they call 'bungee-jumping' research to a research model based on 'semi-permanent presence' that 'provided numerous benefits regarding ethnographic understanding, training for researchers, data collection, capacity building, and troubleshooting' We agree that it seems unlikely for a researcher to be able to observe and report clear development outcomes over the course of few weeks of usability evaluation in a pilot. More long-term studies demonstrating concrete development outcomes are needed.

4.3.   Theoretical Approaches

Our analysis of the theoretical underpinnings used in the ICT4A literature confirms Avgerou's (2010) analysis for the whole ICT4D literature: A large percentage of ICT4D research has remained stuck on the "transfer and diffusion: TAM" discourse. Similarly,

Andersson and Hatakka (2013) reported that TAM was appropriate in the early days of ICT4D research but lacks an understanding of the relationship between ICT and socio-economic development. A challenge of selecting and using theory for a particular research study might be that many of the theories about socio-technical systems originate from the social sciences. It might be difficult for technical researcher to embrace and apply them in their studies. To better understand the complex relation between technical design and social-economic development, different theoretical approaches need to be explored.

4.4.   Participatory IT Design Process and Method

Computer scientists often have an optimistic attitude, over-emphasizing the role of technology and somewhat disregarding socio-cultural issues (Sutinen & Tedre, 2010). Similarly, Heeks (2010a) argues that the development informatics community has been informed much more by technical bias than the development studies community. "The implementation of ICTs for development is not simply a technical process of delivering services to the poor, but is a highly political process that involves tradeoffs and prioritization of particular goals to attain sustainability" (Kuriyan et al., 2006). A paradigm shift from developing technologies for users to developing technology with users can facilitate a collective idea generation, and provides a better understanding of the cultural context that can easily affect the usefulness of an intervention. In other words, ICT4A needs a pragmatic approach, which is characterized by experimentation in real-life and user participation make the system usable. However, very few projects applying participatory action and design research have been implemented in ICT4A. This confirms Sutinen and Tedre's (2010) findings. The reason could be that ICT4D is a young research domain and lacks awareness about the possible contribution of such research.

Inappropriate analysis of environmental constraints, a lack of adequate input from end-users regarding their specific needs and socio-cultural context leads to incomplete software requirements, which in turn to leads to failure of a system (Blake, 2010; Pitula & Radhakrishnan, 2011). ICT4A design and implementation process has been affected by technical and social challenges to make the final output suitable for underprivileged people in developing regions. For instance, (van Reijswoud, 2009) argues that selection of inappropriate hardware, software, and/or design and development approaches affect the overall ICT project success. In addition to this, rural users are unfamiliar with computing technology and they are unable to easily articulate their needs in technical terms.

Involving users in the design process allows for in-depth insights about users' current situation, users' needs, the difficulties the users are experiencing and what users want to achieve. Thus, rather than externally driven and technology-centered design approaches, a move towards community-centered approach is more useful. Local people know more about their needs, and they demand a system that addresses those needs from their own perspectives. For instance, Winschiers-Theophilus (2009) argues that an interpretive approach is needed to understand the socio-cultural context and proposes adapting existing participatory design methods, or designing a new one. Community driven IT design processes can lead to mutual learning and create shared understanding between various participants (Winschiers-Theophilus, 2010).

Although we analyzed a large number of papers in the context of the SMS that used participatory action research, user participation was only applied partially in the ICT development lifecycle. In many cases, core design concepts were determined before engaging with the community. Surprisingly, out of these eight papers that use participatory design, half came from the same group of researchers (Dearden & Rizvi, 2008, 2009; Dearden et al., 2010; Doerflinger & Dearden, 2013). In summary, the full ICT4A design process with extensive field research in collaboration with a local community is still scarcely practiced.

Halskov and Hansen (2015) argue that how a specific PD method translates into a new domain, and how this method issued with specific groups of people or context, are still a relevant research area. More research publications are needed to understand how specific methods need to be adapted to the ICT4A and ICT4D contexts.

5.   CONCLUSION

The growth of ICT in developing countries offers a new opportunity for rural communities in developing countries. At the same time, ICT-based agricultural information sharing has long been hampered by problems. This SMS reviewed how ICTs have been chosen, designed, developed, deployed and used for and in the agriculture sector in developing countries. The analysis shows that there are numerous ICT4A initiatives in developing countries, particularly in India. Appropriate design solutions that take social as well as technical issues into account are still scarce. The results of the analysis show that sustainability and transferring ownership to the target community is one of the main issues that need in depth understanding in ICT4A initiatives. For example, a Telecenter equipped with computers, Internet and printer was assumed to be the best information access point for remote farmers. However, lack of assistance, farmers' skill levels, and language barriers, attributed to a very low usage rate of Telecenter. To address this lack, we recommend that a bottom-up process that involves the local community should be used, rather than a technology-centric approach.

In the reviewed articles, the legitimation of participatory design in ICT4A initiatives was emphasized. For example, when involving users in the early stages of design, local people are likely to develop a feeling of ownership of a project and ensuing products. A project can benefit by enabling knowledge and information exchange between the researchers and ICT developers and the local communities. More reports of such projects are necessary in order to be able to systematize how participatory design and development can be organized in ICT4D contexts.

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