
# Systematic mapping study of information communication technology research for agriculture (in case of developing Countries)

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IT University Technical report series TR-2015-190
ISBN 978-87-7949-355-1 October

ISSN 1600-6100

ISBN 978-87-7949-355-1

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**Abstract**

**Context:** A rural community in a developing country is a socially complex and infrastructural weak environment that demands clear understanding of the social, economical, cultural, and political precondition before implementing information commutation technology (ICT) innovations.

**Objective:** This work aims to conduct a *Systematic Mapping Study (SMS)* to get an in-depth understanding about ICT based researches for agriculture in developing countries.

**Method:** A systematic mapping study was carried out to investigate and distill the state-of-the-art from ranked journals and conference publications. In doing so, data extraction task was carried out using fifteen variables. Eg. What kinds of research challenges and contributions were reported to design ICTs based solutions? Which disciplines (knowledge areas) were most explored?

**Result:** ICT in agriculture has gained attention over the past few years with number of contributions but still there is long ways to go. The review shows that currently there are limited knowledge areas in methods, user interface design, and theory in how to design information system for rural community settings.

**Conclusion**: This paper first presents an overview of research topics and trends from selected top ranked ICT4D Journals and conference proceedings. Second, the detailed explanation about the proposed and/ or used frameworks, theoretical underpinning, methods and Technology used were discussed, among others. Third, the paper also motivates others researchers for an ongoing discourse to fill identified gaps from software engineering, computer science or information system research perspective.

**Keywords**: design method, information system, development, agriculture.

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## 1. Introduction and motivation

Information Communication and Technology for Development (ICT4D) is relatively new field of study, but the issue of ICTs pups-up with a growing body of consensus at academics and different government bodies arguing: design and implementation of ICTs can benefit development goals. For instance, ICT interventions at agriculture information service provide rural users (farmer) with the knowledge to make decisions to improve their wellbeing and enhance their economic livelihood.

Intervention for socially complex and infrastructural weak environments (such as rural contexts) demands an understanding of several design issues. Some ICT4D initiatives introduced to communities in developing countries but the promises of ICTs benefits are still far from reaching those who are most disadvantaged (Dodson et al., 2013; Heeks, 2010; Maail, 2011). There are several recognized barriers mentioned in literature including: The physical resources such as devices and Telecom infrastructure; the digital information resources such as appropriate software, localized and location oriented content; and skills of people needed to interact and extract with the digital system, to mention few.

Walsham et al (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?" Involving community members in design process provides the best chance to link ICT with development and long run sustainability. Reijswoud [1] argues that designing ICTs should follow a *participatory approach with tools and processes for considering cultural, social, organizational, economic and political conditions of a given context.*

While doing a systematic mapping study (SMS) five categories of contributions to design and implement information system for agriculture (IS4A) in developing countries were identified. These categories are: Explorative analysis and lesson learned from best practice; defining dimensions of development; designing methods; user interface design; Framework (including theory). The review also shows that there are limited knowledge areas in methods, user interface design, framework and theory to design information systems for rural community settings.

This paper seeks to investigate in depth understanding of characteristics and the current state-of-art in the ICT4D research literature. The remaining sections of the paper are structured as follows: The second section deals with research methods, which informs about 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 and discussion. The fourth section deals about discussion and answering research question. The fives section highlight the current research gaps and future research directions; and finally the conclusion section.

## 2. Review method

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

### *2.1. Research objective*

The major objective of this *systematic mapping study* is to provide an overview of the current research status and trend related to ICT4D with especial attention to agriculture. Towards this, list of research questions are formulated:

[RQ1:] What is the publication trend, venue and project location?
[RQ2:] Which knowledge areas (disciplines) are most explored?
[RQ3:] What research challenges (or contributions) are being addressed?
[RQ4:] What kinds of technologies are being under study?
[RQ5:] What theoretical underpinnings are being used?
[RQ6:] What kinds of research methodology (methods) have been used?
[RQ7:] What kinds of data, data capturing and data analysis are used?

### *2.2. Journals and conference considered*

The selections of journals and/or conferences are an important boundary to the findings of this study. The main objective of the identifying journals and conferences is to collect as much peer reviewed papers as possible that considered different dimensions of ICT4D research thematic areas. Hence, we have chosen three ranked journals based on Heeks ranking (Heek, 2010a). Namely: Information Technology and Development (ITD); Electronic Journals of Information System 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. Table 2, shows the selected journals and conferences for the study. With respect to conferences, based on the (Heek, 2010b) ranking, Information Communication Technology and Development (ICTD) conference proceedings was selected.

### *2.3. Inclusion and exclusion criteria*

*First* and fore most all papers from the above identified journals and conferences that are published within 2006-2014 were collected. But any lecture note, presentation, book, and Book chapters were excluded. *Second*, from these total collected articles, we excluded any papers that were not given emphases on agriculture, farmer, ICT, community or development. This was simply done by search word or string: agriculture*, farmer, ICT, rural community or development,* inside paper's text. *Third*, paper Title and abstract were used to check relative importance of a paper to the research questions. *Forth*, as ICT4D is a multidisciplinary field, research contribution interested in the impact of technology using ethnographies to explore its use was also considered. Table -1- describes further about the inclusion and exclusion criterion used at the preprocessing stage of the review. *Fifth*, to make the review result more comprehensive, additional papers from other data source were also included using snowballing method. In general, theoretical papers are excluded but empirical papers that reported from actual observations, interviews, experiments or questionnaires were considered for review.

*Table 1: Inclusion and exclusion criterion*

| Description | Inclusion Criteria | Exclusion Criteria |
|---|---|---|
| Research papers venues | Top ranked Journals and conferences that focus on ICT4D | Journals and conference which is not ranked top and less related to Agriculture |
| Year of publication | Published within 2006-2014 | Published before 2006 |
| Application Domain | Agriculture, rural community | Exclude all except Agriculture related issue |
| Major subject Area | Computer science; software engineering; Information system; and Human computer Interaction, Developmental study. | Papers oriented only to social science focuses and any paper that were not studied on developing countries. |
| Language | Papers published in English languages | Papers published in languages other than English |
| Words (strings) found inside a paper | ((Agriculture AND ICT) AND Development)) OR (Farmer OR Rural Community) OR (Agriculture AND ICT) OR (Rural community informatics) OR (Information) System AND Developing countries)) | Any paper when there is no word (string) about Agriculture, Farmer, ICT, and development in the body of their text |

### *2.4. Data extraction*

We used 16 major variables for data extraction from each paper. Some of these variables are: Title, Authors, Publication venue (or journal and conference), year, research questions, finding (contribution), method used, Technology studied, Theoretical underpinning, scope of analysis and knowledge base (discipline), see Appendix A. These data extraction variables were purposively defined to answer the research questions. In order to keep consistency and improve validity about data extraction variables, related work (Dodson et al.,2012; Chepken et al,.2012; Gomez et al.,2012) were considered as a bench marking. First a total of 838 publications within 2006-2014 were collected and followed by the second inclusion and exclusion criterion (see Table 2: "key words or strings"). As the result a total of 113 publications were selected. After investigating title, abstract, and conclusion part of each paper (including papers form snowballing methods) 57 Papers were included for further investigation.

**Table 2: Over all publications by selected journals and conferences**

| Acronym | Journal / Conference Name | Active since | Rank | Total publication | Selected papers |
|---|---|---|---|---|---|
| ITID | Journal of Information Technologies and International Development | 2003 | 1 | 213 | 13 |
| EJISDC | Electronic Journal of Information Systems in Developing Countries | 2000 | 2 | 282 | 12 |
| ITD | Journal of Information Technology for Development | 1986 | 3 | 126 | 7 |
| JoCI | Journal of Community Informatics | 2004 | NA[1] | 24 | 8 |
| ICTD | Information communication Technology and development | 2006 | Top | 181 | 11 |
| | Others source: Snowball | | | 12 | 12 |
| | | | **Total** | **838** | **57** |

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

### *2.5.* Mapping research questions and data extraction variables

Around sixteen data extraction variables were deliberately designed to get the necessary information about the given paper. However, the first eight most important variables were mapped to the research questions and discussed in the following sections.

Table 3: Mapping research question to relevant sections

| *Data Extraction variables* | *Research questions* | *Relevant section* |
|---|---|---|
| Publication venue | [RQ1] | Section 3.1 and 3.2; Table 4,Figure 2 |
| Publication year | | |
| Project location | | |
| Core discipline | [RQ2] | Section 3.3; Figure 3 |
| Main research contribution type | [RQ3] | Section 3.4; Table 5 |
| Technology studied | [RQ4] | Section 3.5; Figure 4 |
| Theory used | [RQ5] | Section 3.6;Table 6 |
| Research methodology | [RQ6] | Section 3.7; Table 7 |
| Data and analysis methods | [RQ7] | Section 3.8; Figure 5 |

## 3. Data synthesis and discussion

Steps to conduct the data synthesis undergoes through descriptive statistics and discussing extracted data; Figure 1, depicts an overall classification of reviewed papers which include: core discipline studying ICT4D oriented research focus and their research areas; Technology used or investigated answer the research questions; theoretical underpinning used to guide the research process; and method used for research and data analysis.

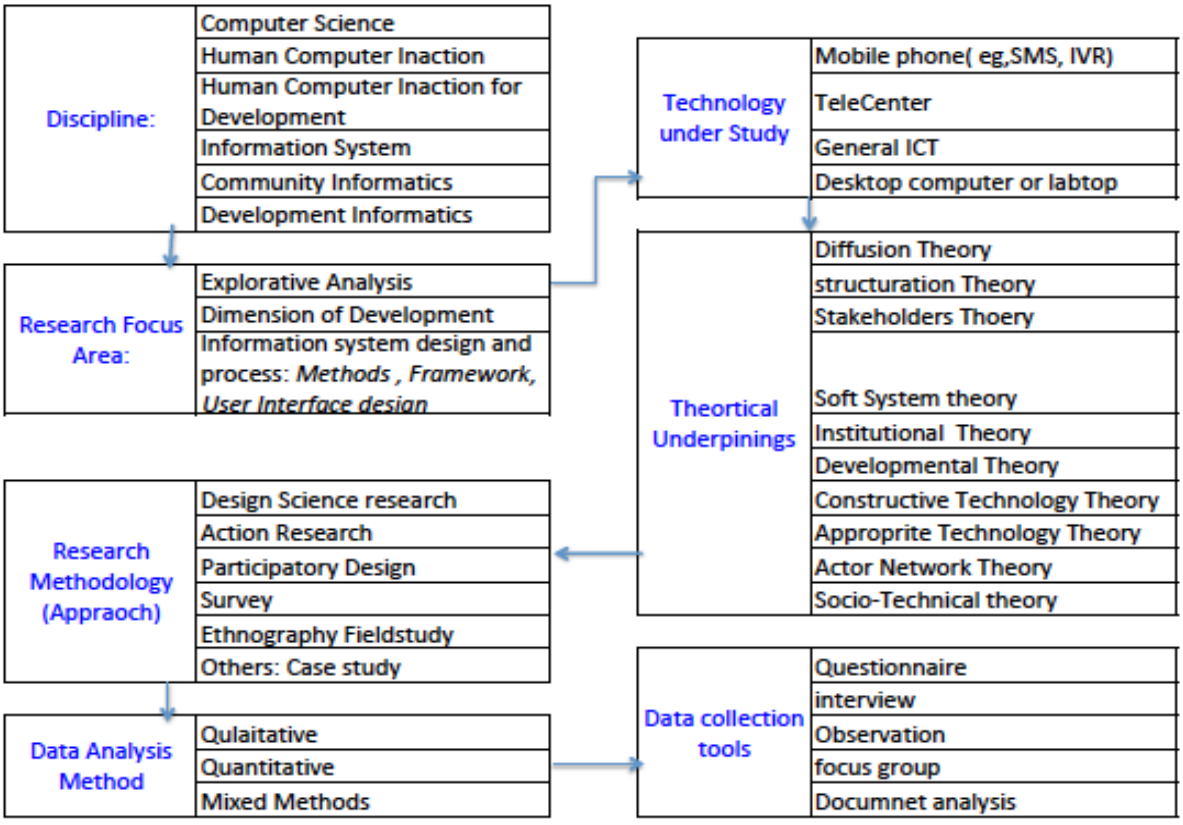


Figure 1: Overview of components used for classifying and discussing the reviewed papers

### *3.1.* Publications trends over years

Out of the 57 reviewed articles, fifty came from journals. The data shows that there are very few publications produced not only across years but also among the different data sources. On top of this publications do not show any kind of consistent increments within a given data source as time goes. The most probable reason could be lack of awareness or due to the fact that ICT4D is a young research area.

**Table 4: Distribution of publications by data source and years (2006-2014)**

| Journals/conference | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | **Total** | **%** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ITID | | 2 | 1 | 2 | 1 | 1 | 2 | 3 | | **12** | **21%** |
| EJISDC | | | | 1 | 2 | 1 | 2 | 4 | 1 | **11** | **19%** |
| ITD | | | 1 | 2 | 1 | | 1 | 1 | | **6** | **11%** |
| JoCI | | 1 | | 1 | 3 | | 1 | 1 | 1 | **8** | **14%** |
| ICTD | 3 | 1 | | 1 | 3 | | 1 | 1 | | **10** | **18%** |
| Others source: | 1 | | 2 | 2 | 2 | | 2 | | 1 | **10** | **18%** |
| **Total** | **4** | **4** | **4** | **9** | **12** | **2** | **9** | **10** | **3** | **57** | |

### *3.2.* Distribution of papers by research location (country*)*

Classifying articles based on geographical location in which the research was undertaken shows that, though some countries in Middle East belong to developing country category, papers were originated from only Asia, Africa, and Latin America. An analysis of the review reveals that three from Asia (India, Bangladesh, Cambodia and Sri-Lanka); eight countries (Tanzania, Ghana, South Africa, Uganda, Lesotho, Nigeria, Mali and Malawi) from Africa; and Peru & Colombia from South America found to publish in the aforementioned journals or conferences. When we look at the proportion of papers across countries, almost half (43%) of the publications came from India and 9% from Tanzania but the rest countries shares around 6% the total (See Figure 2).


**Figure 2: Contribution papers by project location**

In Africa, It is often reported that Kenya, and Uganda has good reputation in ICT penetration and uses across the country, however, there is no single papers published in the used data source. Gomez et al(2012) findings from reviewing 948 ICT4D papers demonstrate that only 6% of the publications were related to ICT for agriculture. Given the fact that in African, 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 dealing with ICT4D research

Technological intervention with developmental issues for socially complex and

infrastructural weak environments, such as rural contexts, demands an understanding of several issues. This is because, solutions to these developmental issues are not often found in a single discipline [2]. To this effect, ICT4D main research focus is to understand the link between ICTs and development, and how this development leads to the prominence of marginalized groups. (Walsham, 2013;Gitau 2010;Heeks, 2006) present that ICT4D is an interdisciplinary field which spans across computer science (CS) (including human computer interaction); telecoms and networks; information systems (IS); media Studies; development studies (DS), sociology, political science, among others. Based on the recommendation of Heeks(2008) about necessity of knowledge integration form three core disciples(CS, IS, and DS), the reviewed papers were classified towards these .

As can be seen from Figure 4,out of the three core research areas, IS has the highest number of documents, with 26 papers of which EJISDC contributes more than (8 papers) over others sources .The result is supported by the fact that IS has been the pioneer field and rarely build technology in their research made them to be seen most often. Computer science (19) has been seen more often than before, particularly after the advent of the ICTD series of conferences since 2006.

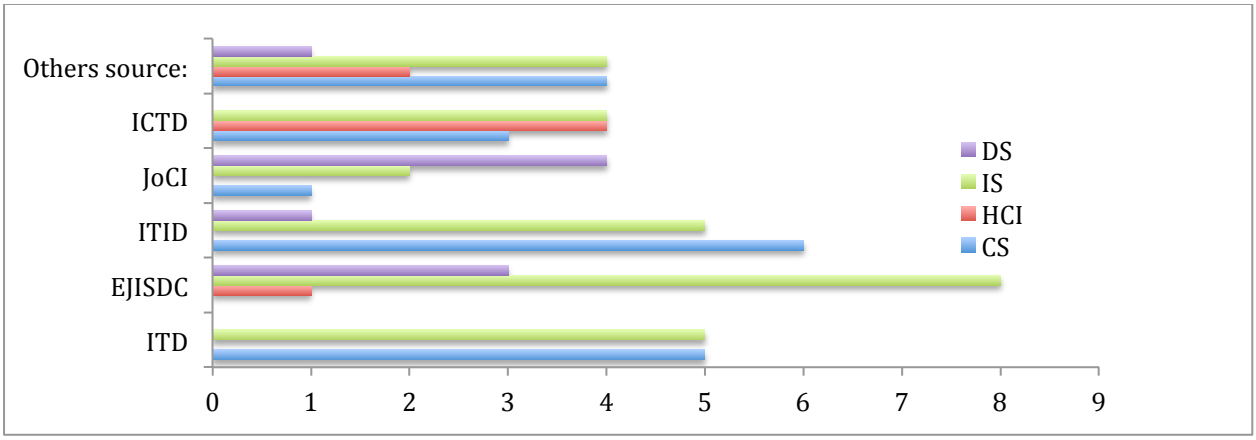


**Figure 3: Distribution of publications contributed by core discipline to ICT4D by data source**

### *3.4.* Research thematic areas

To address the real problems of the society via ICT, the proposed ICT should be designed in a environment-friendly with tangible impact, and sustainable down to the grass roots (Eshete et al. 2010). Scholars for example, (Walsham, 2006), propose three research thematic area in the 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 this paper, we reclassified into five thematic areas (research contributes). These thematic areas are Developmental dimensions; Explorative analysis; Information system design & development components: Method, User Interface, and Framework.

#### *3.4.1. Linking ICTs initiatives with development*

As the rapid proliferation of ICT throughout the developing world, ICT is accepted as an opportunity for agent of development or assist disadvantaged Gigler (2011). Islam et al. [3] underscore that ICT4D should comprises of three main strategic questions: "A sort of technology or artifact; sort of development goals, and how these two can be fitted together in order to achieve developmental goals". Furthermore [4] explored the need for distinguishing between ICT use in developing countries , and ICT for Development. In the former case, the focus of studies is generally related to the issues of technology within developing countries

which is often measure technology adoption or appropriation, and might not necessarily include contribute to the poor (development). For instance [5] argues that many ICT-based initiatives have taken place in India over the last decade, but the beneficiaries are not the poorest or most disadvantaged groups. To this effect, the "D in ICT4D" has got a very wide range of positions. 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. For example recently, Heeks (2014), analyzed and re-categorized development agendas for post-2015 due to the time given to millennium development goals is approaching to end.

Though there exist different stand points of the 'D in ICT4D', number of researchers (e.g. (Thapa et al., 2014;Andersson et al., 2013; Heeks, 2006) argue that much of the literature does not clearly address the question: "what is meant by development or do not have a clear development focus". The scope of development in this review only covers if it considers social, economical, info-structural challenges of people in rural developing regions. To this end, our review (see Table 5, column 3) shows that the precise notion of what development means, and how ICTs can promote development, is implicit or underemphasized. Very few papers have explicitly mentioned what they mean by development. For instance, [7] viewed development as "empowering marginalized populations".

Ashraf[8] analyze the impact of a particular ICT initiative namely 'Village Phone' in Bangladesh reported 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 [9] the link between mobile phone and development was exemplified by offering Ten mobile phones("Ten seeds)" to remote rural women-led cooperative farmers in Lesotho. As finding the ten-seeds brought economic growth via improved communication which in turn help them to seek markets, reducing wastage, reduce travel costs associated with seeking markets at the capital city among others. In addition to this, mobile phone is also empowered the farmers by improving their mathematical literacy (using calculator), facilitate them to be united by build their social networking capital.

*Coming back to the research question: "What is development that ICT is looking for?" the review result shows that economical, empowerment, the right of individual to access digital information are among the most used dimensions of development. However, it seems unlikely for a researcher to be able to observe clear development outcomes over the course of few weeks or months usability evaluation in a pilot study. As a solution, long-term studies demonstrating concrete development outcomes due to the application of the knowledge that the community should be used.*

#### *3.4.2. Explorative Analysis*

This kind of research contributions primarily concerned with description of field experience, understanding context, assessment and evaluation, benefits, barriers, success factors of ICT initiatives, see Table 5 column 2. For instance, over five months field pilot of a *voice telephony-based information service* [10] and [11]assesses the information needs and interests of *rural population* in Uganda and Malaysia respectively. As a result, agriculture related information requirements were found to be the major one compared with health, education, sport, politics and news etc. Dissanayeke [12] discuss 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 service that should be broadcast at relevant time. With this in mind, [13] 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 for providing agricultural information service, and for communication across all categories of actors.

Muthiah et al [14] 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, (ibid)reported that, usability of the project was very low and farmers were skeptic about the project due to: local language; unavailability location specific information to farmers; and unavailability of diversified information. Similarly [15] 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 to be re-packaged into an appropriate format, size, language and disseminates regularly was documented.

Lack of access to ICT was documented by number of scholars as a barrier. Nevertheless, [16] reported that owning ICT (eg. mobile phone) by a rural farmer and ability to use them does not alter 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 farmer. On top of this, a middleman happens to be a person known to the farmers personally and seen as trustworthy one. Likewise [17] argues that access to mobile phone as a solution for improving the economical situation was not turned out to be feasible in the context of seaweed farms in Tanzania. Patel et al[18] investigate the difference between university scientists, and peer farmers to disseminate 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 trust among the rural community members than external information provider. Hence, ICT should not be easily considered as the remedy to all problems in developing countries, rather a careful investigation and consideration of the local context as well as political and ethical issues need to be considered.

*In relation to the third research question, Heeks(2006) and Gomez et al. (2012) argue that explorative analysis studies are focused in descriptive and insufficiently analytical. On top of this, such type of research was so much important at early years of ICT4D research and Heeks(2009), proposes a new ICT4D research areas, which he labeled as ICT4D 2.0 manifesto. However, still most of the reviewed research papers are showed up as "explorative analysis "types of contribution.*

### *3.4.3. IS4A design and implementation process*

ICT 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, socioeconomic, political, cultural, and financial factors from the social factor (Thapa et al., 2014), and selection of inappropriate hardware, software, and/or design and development approaches from the technical side[1] affect the overall system, if they are ignored or not considered well. Given lack of clarity in ICT4D design process (Blake et al.,2012) offers framework with step-by-step approach to implement, and evaluate ICT4D projects. The approach recommends using empirical research with concrete methods and tools to facilitate effective practice. In light of this background, Table 5 (column 4-5), shows IS4A design contributions: method, user interface (UI), or Framework (model).

Table 5: Summery of research thematic areas by data sources

| *Source* | **Research contribution areas** | | | | |
|---|---|---|---|---|---|
| | ***Explorative Analysis*** | ***Developmental Dimensions*** | ***Methodology (Method)*** | ***User Interface*** | ***Framework*** |
| ITID | [18] | [9] | [20],[21] | | [2] |
| EJISDC | [14],[16],[13],[15], [16] | | | | [1] |
| ITD | [22],[23],[24],[25] | | [26] | | |
| JoCI | [11] | [27],[28],[29],[30] | | | |
| ICTD | [10],[17] | | [31] | [32],[33],[34] | |
| Other source | | [7],[8] | [35],[3] | [36],[37] | [38],[39] |

#### *3.4.3.1. Methods for designing IS4A*

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 for developing countries. ([1], 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. Nowadays, these cases call for a need to move from externally driven and technology-centered approaches to community-centered approach. In response to this (Dearden et al.,2010; Winschiers- theophilus,2009; Dearden et al. 2008; Maunder et al, 2007) adapt existing ICT tools, and software methodology(methods) but this is still at start up phase. For instance, Winschiers-theophilus(2009) argues that, an interpretive approach is needed to understand the context (eg. culture), and propose how to adapt the design methods.

To this end, some of the reviewed papers investigate, how well-established method can be translated into new contexts; how they are modified to fit specific purposes by adapting or, creating a new method. Although almost all the papers mention methods, this category comprises those in which use of methods is their primary focus. For instance, Doerfinger et al [20] develop 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 [21] adapt participatory design process (design, development, and usage pattern) to design 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 a wider user statistics.

To integrate ICTs in agriculture, and demonstrate how to apply ICT in a development context, [26] 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 included 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. To address user participation challenges while designing information system with low literacy users, [35] used '*facilitated focus group'* method and reported it as a supportive one. Taking argument that "Design Science Research (DSR) is positivist perspective but ICT4D research type is an interpretive one",[3] presents how can DSR methodology be adopted in an ICT4D research

with an illustrative case study (*Mobile based Agriculture market information system for Bangladesh farmers*) in the process of constructing an ICT artifact.

#### *3.4.3.2. User Interface Design*

To improve the information system usability for low-literacy populations ([41],[42],[43]) propose requirement criteria for user interface (UI) designs : Ease of learning; ease of remembrance; graphics (Icons) with speech annotation in local language; and easy to use. To this effect, some of the reviewed papers that contributed towards UI design are discussed as follows.

In the study of technology usage and media sharing in India, [33], [44] 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 (eg. Friends, relatives) who can reads or knows 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. Taking lesson form the human-infrastructure method,[45] designed, and evaluated, an audio-visual Social Networking (SN) mobile application for to low-literate farming communities in India. With respect to usage of the system, using different people at the center of a social hub such as a village shop as mediators not only increased the use but also builds trust for farmers' decision to start using the system.

In response to language barrier [35], designed speech user interface to a rural community to interact and have access to a mobile commerce service. A text free system UI for farmers in in India using speech recognition technology was designed by[43]. They identified dialectical variation, multilingualism, cultural, choice of appropriate content, and the expense of creating the necessary linguistic resources for effective speech recognition as a barrio to make the system usable. To allow farmers time-sensitive dynamic information about best practices, the advice of experts, and the experiences in India, ([46],[37]) 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 was found to be much less difficulty using touch-tone than voice based input.

A study [32], designed a UI with audio-visual-textual with familiar metaphors for low-literate rural farmers to access market information. This UI supplements two-way interaction between farmers and agricultural experts, which they reported it as easily understood not just by literate but also by the illiterate and semi-literate farmers. Likewise, [47] used text free cultural metaphors/Icons to design interface. Considering the advent of smart phones with touch screen, and hopping that it will be financially reached soon in the hand of illiterate rural people, [34] design 'Easy-Texting' user interface application that allows illiterate users to compose and listen to SMS with touch-initiated text-to-speech support.

#### *3.4.3.3. Framework (model)*

A framework for information system design could be perceived from product or process perspective. The product perspective is concerned with a software system used to offer information and communication services. Whereas, viewing framework as design process encompasses different social and technical components while designing the information system. In light of this, if their major contribution of the reviewed papers focuses on framework, they are classified here and discussed as follows.

Reijswoud [1] develops an integrated and participatory designing model for developing information systems that is suitable for the cultural, environmental, organizational, economic and political conditions in which it is intended to be used. This author extended the

traditional systems development life cycle with tools and processes. On the contrary to giving computers and installing internet connections in rural areas as solution for information poverty, [2] argues that offering rural users relevant and personalized information is a possible solution and suggests a framework integrating 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, [38] propose a framework for rural information system implementation process for developing countries. To mention one limitation of this framework, the proposed implementation process is generic in nature and needs to be tested by empirical works.

*On top of the above aforementioned contributions types and/ or challenges with respect to the third research question, Heeks(2009) also propose a new ICT4D paradigm, which he labeled as ICT4D 2.0 manifesto. This paradigm indicates the research types to be on new technologies priorities (Hardware and Applications), new business models, and implementation process models. This paradigm is against explorative analysis, which is reflected as such studies are focused in descriptive and insufficiently analytical. We argue that IS4A research in particular and ICT4D in general lacks appropriate research methods along the entire development lifecycle spanning from requirement elicitation to usability evaluation.*

### *3.5. Technology (Terminal) studied for communication*

Medium for interacting is an important consideration if users, especially low literacy users to have full advantage from ICT services. Mobile phones, computers, telecenter 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 under studied.

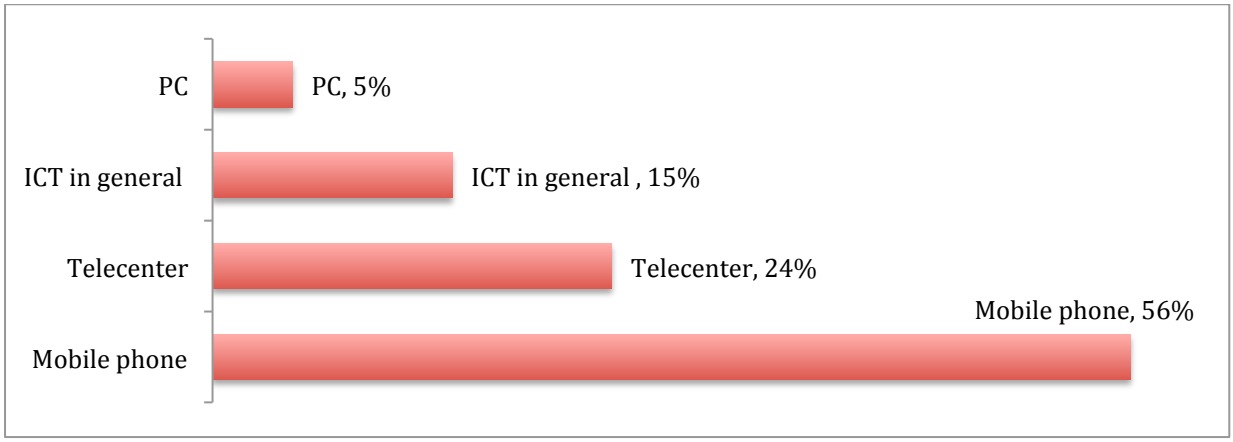


**Figure 4: Distribution of technologies under study**

More than half of the reviewed papers studied mobile phone as the most preferable technology in rural area. Study ([17],[48],[21]) reported that using mobile phone improves relationships, reduced 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 [49] initiated a project "Scientific Animations without Borders" and demonstrated that mobile phones were not only be used as a communication tool but also could 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 abundance of mobile phones in developing nations, most common underserved rural communities owns very basic phones, and use of mobile Internet is extremely rare or none. This in turn, limits, designing different mobile-

based apps.

Telecenter(24%) equipped with computers , Internet and printer were found to be the most used communication channels to enhance communities access and usage of agricultural information. Telecenters, however, face a number of problems to disseminate agricultural information. For instance, ([50];[22]), 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 telecenter.

### *3.6. Theoretical underpinnings*

A conceptual framework (theory) is set of principles that are background of methodology, which consists of paradigm, objectives, domain, and applications areas (Yaghini, 2009) Truex et al. (2006) describe theory as a lens through which we focus and magnify certain things, while filtering out others things presumed to be noise. Likewise, Gregor (2006) in her paper "*Nature of the theory*" argues that, theories guide the type of research to be conducted and categorized information system theories, based on the primary goal of a theory, into four distinct classes (see Table 6, column 1). We also adapted these classifications to identify and categorize theories used in the reviewed papers.

Theories used for ***description and Analysis*** – this category of theory is the most basic types of theory, which is used to describe or classify specific characteristics of situations by summarizing in discrete observations. Among the reviewed papers, although didn't explicitly state which theory they used, research types that area categorized into "explorative analysis" thematic area (see section 3.5.1) used *description & Analysis* types theory. For instance, Considering Human Computer Interaction for Development (HCI4D) as a young field, [53] used Grounded thoery to explore stories from the field. In so doing, 55 stories were collected and synthesized into the 19 ideas which in turn help them to identify research challenges and offered practical strategies for dealing those challenges.

Theories for **Understanding and Explanation**- *used to explain* how and why some phenomena happened in some particular real-world situation. For instance, [53] 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[54] adopted Institutional theory 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 et al[9] adopted "development theory", and empirically demonstrated how to link ICT to development (eg. economic growth, and empowerment) using mobile phone at women-led cooperative farming.

**Table 6: Taxonomy of Theory and types of theory used in the reviewed papers**

| Theory used for | Theory Name | Authors |
|---|---|---|
| Description & Analysis | • Grounded Theory<br>• Stakeholder Theory | [51], [52] |
| Understanding & Explanations | • Actor Network Theory<br>• Structuration theory<br>• Institutional theory<br>• Developmental Theory | [53];<br>[54];<br>[44];<br>[9] |

| | | |
|---|---|---|
| Explanation and Predication | • Technology Acceptance Model (TAM) and Diffusion theory | [12],[22],[48],[2], [55],[25],[56] |
| Design and Action | • Soft system Theory<br>• Socio-Technical Theory<br>• Design science theory | [39],[20],[3] |

***Theories for Explanation and predication*** - used for both understanding underlying causes and prediction, as well as description of theoretical constructs along with relationships among them. In most case, these kinds of theories are often being used to evaluate the feasibility of existing technologies. For instance, [12], [2],[48] applied technology acceptance and diffusion theory to investigate mobile phone usage, awareness and limiting factors to use among agriculture communities. Similarly, Pick et al[22] use TAM to understand influences on use of rural Telecenters in India. Considering the high ICT penetration rate in one hand, and existence of large numbers of illiterate people in rural area on the other hand, Gandhi et al [55], and Bello-bravo et al [56] used diffusion theory to investigate usability of multimedia content generation and dissemination system among farming communities. Cloete [25] 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 viewed as a highest level of classification, which provided means on how to do something. In response to the claim that we should move away from techno centric to community centric, these kinds of theory gives explicit prescriptions (e.g., methods, techniques, principles of form and function) for constructing an artifact (Information system). The provision of the recipe implies that the recipe, if acted upon, will cause an artifact of a certain type to come into being. For instance, [39] 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 in their project called: "Rural e-Services project". The focus of their project was to working with marginal farmers in rural India to design new software to communicate with their agricultural advisors. Doerfinger et al[20] used soft system theory to design a software development methodology, which encompass the participation of different stakeholders from team building to information system usability evaluation phases.

*Coming back to the research question: "What kind of theoretical underpinnings have been used?" Avgerou (2010) argues that a large percentage of ICT4D research has remained stuck on "transfer and diffusion: TAM" discourse. Andersson et al.(2013)* [57]*reported that TAM was good in the early days of ICT4D research but not for the current problem because it lacks understanding of the relationship between ICT and socio-economic development. In this review, first, most of the papers didn't state the types of theory they had used. Second, among the stated theories still most commonly, theories were used for understanding the phenomena of adoption, uptake and resistance of technology. The probable challenges of selecting and using theory for a particular research study could be lack of understanding. Because, many of the ICT4D theories were originated from social science which make it difficult for technical ICT4D researcher to understand in their context and focus. This call for moving out from TAM model, and design new ICT4D theory or borrow from other related discipline.*

### *3.7. Research methodology*

Avison(2006) defines information system development methodology as sets of recommended means that includes: definition of phases, procedures, activities, techniques, tools and guidance. However, One of the difficult parts for any researcher to select methodology (mix of methods) from existing sources is that, different aspects of different methods are overlapped. Several Authors compared *action research* and *design science* mode of knowledge production, and claim their similarity, as long as Action research considers "*action*" as an artifact (Papas et al, 2012; Järvinen, 2007). Forth et al.,(2006) in their paper "participatory design and action research: identical twins or synergetic pair?" argue similarity between them. As a result, identifying and categorizing research methodology (methods) was sometime a challenging task. This challenge sometime became worse because, some papers did not state *their method* or *description of* research processes were not enough. See Table 7, for the distribution of different research method used in the reviewed papers namely: e*thnographic field study, survey, action research, participatory design, and design scienc*e.

***Ethnographic (field) study, and survey***

Ethnographic field studies are characterized by taking place in a real world setting and researcher spends significant amounts of time in the field. The phenomena being studied are placed in a social and cultural context via descriptive. As ICT4D is young research domain, this research methodology provides rich data explaining phenomena involving the use of ICTs in a given context. That is why large proportion of the reviewed papers (33%) used Ethnographic field study. Survey methodology informs research by collecting generalizable information from a known sample of people or cases. For instance, survey was used to understand a phenomenon, to gathering data about the user experience or to gather satisfaction rate of specific ICT design. It is the second most used methodology (28%) following ethnographic field study. Ethnographic field study, and Survey methodology were used most within the EJISDC and ICTD data source. However, surveys suffer and rely highly on the subjective views of respondents.

**Table 7: Distribution of Research methodology by data source**

| Source | Research methodology (approach) | | | | | |
|---|---|---|---|---|---|---|
| | Survey | Ethnographic (field) study | Action research | Participatory design | Design science | Total |
| ITID | 2 | 2 | 2 | 4 | | **10** |
| EJISDC | 4 | 5 | 1 | 2 | | **12** |
| ITD | 4 | 1 | | 1 | 1 | **7** |
| JoCI | 1 | 4 | 1 | | 1 | **0** |
| ICTD | | 4 | 1 | 2 | | **7** |
| Other source: | 1 | 1 | | 1 | 2 | **5** |
| % | **28%** | **33%** | **10%** | **24%** | **8%** | **41** |

***Participatory approach (Design)***

According to Spinuzzi(2005) PD is viewed as research methodology, which characterizing it as "*a way to understand knowledge by doing : the traditional, and often invisible ways that people perform their everyday activities and how those activities might be shaped productively*". Tools like future workshop, focus group discussion, and a paper prototyping were proposed to build common understanding among users and a researcher. As can be seen from Table 7, column 5, some of research publications (25%) use participatory approach (eg. [58];[22], [28], [33], [41], [45], [63]) but it was used only partially from the entire

information system development lifecycle, or many core design concepts determined before engaging with the community.

***Action Research*** (AR)
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 observes 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. However, see Table 7, surprisingly very few numbers of reviewed papers (10%) used it.
Electricity

***Design science (DS)***
Hevner et al (2004) describe DS design science methodology in six steps: problem identification; definition of the objectives for a solution, design, and development; demonstration; evaluation; and communication. The main focus of DR is solving problems for a generalizable class of stakeholders that is dominated by an implicit positivist epistemology. Due to this assumption, Table 7 shows only 8% of usages.

*To answer the research question: "What kind of research methodology (methods) have been used?" Ethnography field study explains one complex social situation without any intention of changing it. Action research aims to achieve action (solution) by understanding complex social situation. Action research extends ethnographic field study by introducing different solutions as well as evaluating their effect. It is also common to see in literature review that different ICT project combined ethnographic study and participatory design. The technical ICT4D concept demands end users involvement as co-creators and experimentation in real world settings. In addition to this, t*he role of ICT4D researchers should not be confined to understanding the problem, but should also involve trying to introduce changes as well. *Of course the reviewed papers reveal that ICT4D research lacks practice of using appropriate research methods along the entire development lifecycle: design, development, deployment, and evaluation. Thus,* ICT4D can be studied by applying research methods such as participatory action-design research. Such method conceptualizes the research process as inseparable activities of IT artifact building, intervening in the communities and evaluating the use of the artifact concurrently.

### *3.8. Data & data analysis methods*

Empirical research uses empirical data analysis methods, which is commonly classified into three namely: *quantitative, qualitative or mixed* methods. Qualitative methods enable researchers to study social and cultural issues and summarize text through interpretive analysis. On the contrary, the quantitative method enables researcher to study phenomena using numerical measures and statistical procedures. The mixed method takes advantages from the both qualitative and quantitative methods to investigate the given phenomena in a more rigors way. Most rigorous used techniques for data collection were questionnaire, interview, observation, field visits, focus group discussion, and document analysis.

Data analysis methods are some how related (depends on) to the type of research method used, see Figure 2. For example, 13 papers (32%) used qualitative data analysis method with Ethnographic field research method. About 10 papers (24%) used mixed analysis method

with PD and AR. Particularly, PD uses an ethnographic field study to inform the design process; and action research extends ethnographic field study while researchers participate in real world to introduce solutions & evaluate its effects. Because of the positivist epistemological standpoint in DS, only quantitative method was used. *With respect to the research question: "What kind of data, data capturing and data analysis methods were used?" using mix methods helps to understand the social and the technical requirement of ICT4D research domain.*

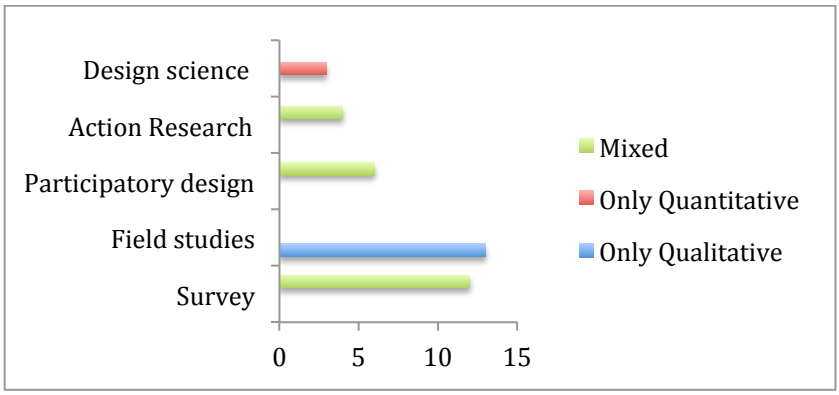


**Figure 5: Distribution of data analysis methods by research methods**

## *4. Conclusion*

The growth of ICT in developing countries offers a new technology and new opportunities for accessing information in poor countries. At the same time, ICT-based agricultural information sharing has long been overwhelmed with problems. This paper aims to contribute to a deeper understanding of how ICTs are chosen, designed, developed, deployed and used to the agriculture sector in developing countries. The systematic mapping study from top ranked ICT4D journals and conference publications (2006-2014) were reviewed. To this effect, the following research gaps are identified.

*Method for participatory information system design process* - system development methodology for community-oriented in underprivileged rural areas is totally different from system development process in an organizational context. In rural communities users are unfamiliar with computing technology thus they are unable to easily articulate their needs in technical terms. On top of this, rural settings are constrained by infrastructure, and skills to use the digital resources. Participatory design specifies sets of methods or techniques to increase mutual learning between designer and users; and facilitates active involvement of users in the software development life cycle. However, participatory design methods have to be adapted (or newly designed) to new cultural contexts, and to local social settings.

*User interface design* - using relevant icons or graphics, which are memorable, nameable, and concrete accommodate the limitations of illiterate people to use information system. However, they still face many problems because; users must be able to interpret what the graphics mean but the ability to interpret icons is influenced by knowledge of the users and their abstract thinking ability. An opportunity for addressing these challenges is to augment the graphical UI with Audio supplements. That means a touch screen mobile phone with multimedia (graphical UI with Audio) interface design should be designed and empirically evaluated for its usability.

*Theoretical underpinning* - ICT4D research is constrained by complex political, cultural, economic and infrastructural factors. Currently there are very limited theories, which does

not provide a clear foundation for a future study to build on. Thus, either adapt (borrow) more theories from other disciplines have to be adopted or developing ICT4D specific theory is needed.

## Appendix A: Data extraction Form

***Attributes***

1. Title
2. Authors
3. Publication venue: Journals or conference name
4. Publication year:
5. Abstract:
6. Keyword:
7. Research questions (Objectives)
8. Main contribution:
9. Research Methodology:
10. Data and Analysis methods:
11. Research paradigm:
12. Theory used:
13. Specific application domain:
14. Technology studied
15. Researcher's major discipline
16. Project location

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