THE USE OF PARTICIPATORY APPROACHES IN DEVELOPING ICT-BASED SYSTEMS FOR DISSEMINATING AGRICULTURAL KNOWLEDGE AND INFORMATION FOR FARMERS IN DEVELOPING COUNTRIES: THE CASE OF TANZANIA

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ABSTRACT
This paper provides an insight on the use of various participatory approaches to develop ICTs to the rural farming communities. The paper shows how collective groups of farmers can be empowered through involvement of different stakeholders in a participatory action research. The paper also discusses how participatory action research will help the farming community in adopting ICT-based solutions for agriculture. This in turn will contribute in solving problems as well as assisting decision making in identifying technological and agricultural needs. In this study, a total of 64 researchers and extension workers and 320 rural farmers were involved. Primary data were collected using a self-administered questionnaire and interviews. Data were analyzed using descriptive statistics tool. The results indicate that many ICT- based solutions for agriculture are not adopted by farmers and other stakeholders in various agricultural value chains because those ICTs were developed without using participatory approaches. Moreover, the results from study indicate that participatory action research approaches such as Participatory Communication (PV), Participatory Video (PV), Participatory Learning and Action Research (PLAR), Farmer Participatory Research (FPR), Informal-Mobile Learning Research (IMLR) have a significant impact on the effective use of ICTs in rural farming community and the agricultural domain in general. Among of these participatory approaches, the IMLR and PLAR have shown to be more effective because of availability and interactive mobile learning environments that excite interests, commitments and encourages participatory attitudes among famers and researchers. This study provides an evident that ICTs has a dominant position to alleviate rural poverty and strengthen the agriculture productivity through participatory approaches. We recommend that a strong commitment of all actors in agriculture value chain is needed so that they can collaborate to identify the problem, analysis and design possible solutions and finally, implement and later on use those developed ICTs to increase agriculture productivity.

Keywords: ICTs, agriculture, researchers, farmers, participatory approaches, action research, Tanzania

1. BACKGROUND INFORMATION

The importance of agricultural sector in the Tanzanian economy cannot be overemphasized owing to its relationship between its performance and that of key economic indicators like GDP, employment, export earnings, and supply of raw materials for industries (URT, 2013). The application of Information and Communication Technologies (ICTs) in agriculture, just like in the other sector has been gaining popularity and become progressively more

widespread in Africa and Tanzania, in particular (URT, 2013;Purnomo and Lee 2010).The National Agriculture Policy 2013 (NAP 2013) aim to enhance a nation-wide ICT systems to support agricultural development by promoting utilization and applications of ICTs for increased efficiency in information sharing in the agricultural value chains. With the world witnessing an unprecedented growth in the area of ICTs during the last two decades (Hosseini *et. al.,* 2009), the use of conventional communication channels such as farm or home visit, personal letters, and the use of meetings in the village such as local meeting / leisure places, market places, churches, mosques and funeral gatherings for disseminating agricultural information is counterproductive (Churi et al., 2012). This calls for champions who can spearhead the adoption of ICTs in agriculture to both agriculture researchers and extension workers to transmit relevant information to farmers in a most efficient and effective way (FAO, 1993; Salau and Saingbe, 2008).

ICTs are technologies that can facilitate communications, enable processing and transmission of information electronically. ICTs can collect, process, store, retrieve and disseminate data and information using microelectronics, optics, telecommunications and computers (Richardson, 2006; FAO, 1993). ICTs includes contemporary social networking aspects, read/write interfaces on the Web, besides file sharing systems online, policies and laws that govern the widespread use of media and devices (Yakubu et al., 2013a). In fact, ICTs have the potentials of bridging the existing communication gap among agriculture researchers, extension workers, farmers and other stakeholders by providing a network among key stakeholders in Research-Extension-Farmer-Inputs-Linkage System (REFILS) (Yakubu et al., 2013b). ICTs enhance farmers' ability to collate demands, collaborative learning, exchange of time sensitive information (e.g. market prices, disease outbreaks), make extension systems and communicate more efficient, engage farmers in assessing their own needs and solutions (Richardson, 2006). ICTs also can facilitate multi-stakeholder brainstorming, exploring alternative production technologies, facilitating access to markets and credits, training and demonstration, community learning, searching, selecting and compiling information for individual clients, early warning for disasters and weather forecast, peer to peer sharing and exchange among extension (Richardson, 2006). ICTs when embedded in systems through the use of participatory approaches can bring agriculture development and growth in any developing country including Tanzania. Participatory approaches are methods of involving all actors of agriculture value chain while solving a problem of interest to them. Participatory approaches consist of tools, methods and techniques that can facilitate knowledge generation and enhance the ability of agricultural researchers in interpreting the needs of rural communities.

The use of Community Researcher Participation (CRP) has a great potential in developing and promoting agricultural knowledge to farmers (FAO, 2009). CRP also is very significant in adopting ICTs in order to meet the total aspirations and socio-economic needs of the farming communities in developing countries. The CRP involves co-operations by the farming community in agricultural activities and decision making in the development of ICT based solutions for agriculture which can enhance productivity of smallholder farmers (FAO, 2009). A number of participatory approaches to facilitate the development of ICT-based agricultural solutions have been formulated. These approaches increase the efficiency and effectiveness of the farming community in decision making. CRP has been recognized as the knowledge base of the rural farming community by means of involvement and fully collaboration in agricultural activities. The uses of participatory approaches have been witnessed to help mutual learning between farmers and other actors in different agriculture value chains (Joseph, 2010).

In order the farming community to benefit from ICT-based solutions, participatory approaches have to be conducted in all stages (Figure 1) of the ICT-farming cycle as defined

in the Delloite (2012) report on e-transform Africa in agriculture sector. The stages of ICT farming cycle where participatory approaches should take place include: P*re-cultivation, Crop cultivation and Harvesting and Post-harvest stage.*

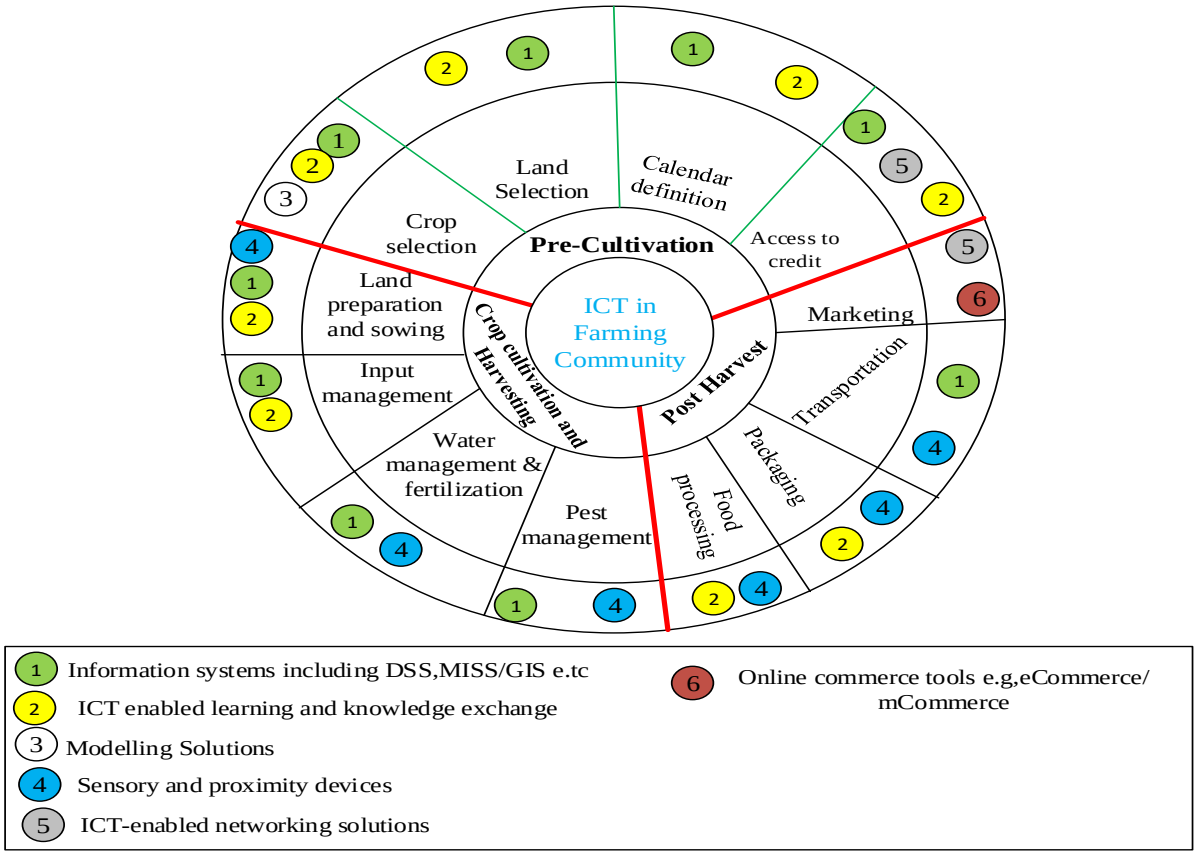

Figure 1: ICT-Farming Cycle from Farmers' Perspective (Adapted from Delloite, 2012)

Agriculture researchers, extension workers and farmers have to participate in all stages of ICT farming cycle during the development and promotion of ICT based solutions for agriculture. Researchers play a pivotal role in leading the development of information systems to support different agriculture activities. Information systems including Decision Support Systems (DSS), Management Information Support Systems (MISS), Expert Support Systems (ESS) and Geographical Information System (GIS) can provide accurate and timely information to farmers related to land selection, preparation and sowing, calendar definition, water management and fertilization, and pest management etc (Worldbank, 2011). ICT-enabled learning and knowledge exchange in agricultural sector can help extension workers, researchers and farmers to communicate information and knowledge related to input management, access to credit, food processing, post harvesting and packaging.

1.1 Participatory Approaches in Agriculture Productivity

Participatory approaches in agriculture can empower collective groups of people and put decision-making in the hands of different stakeholders in the farming community (Joseph and Andrew, 2008). Participatory approaches include different methods in which participation with local farming community takes place. Examples of participatory approaches are Farmer Participatory Research (FPR) (Ashby, 1987; Selener, 2007), Participatory Learning and Action Research (PLAR) (WARDA, 2007), Participatory Communication (PC)(Selener, 2007), Participatory Information and Communication Technology Development (PICTD), Informal Mobile-Learning Research (Uvasara et al., 2013) and Participatory Video

(PV)(Yoon, 2007; Gadhi et al., 2007). FPR is a practical process for bringing together the knowledge and research capacities of the local farming communities with that of the commercial and scientific institutions in an interactive way (Haverkort *et al*, 1988). In fact, FPR is a process where the farmer acts as a subject who investigates, measures, and studies by collaborating with researchers (Ashby, 1987). For agriculture productivity to be at the maximum level there is a need for wider participation between the farming community and the agriculture researchers since other than data collection it will help farmers to address farming issues and get more control over the research results and allows decision-making in the hands of farmers (Joseph and Andrew, 2008).

Different participatory approaches like FPR, PLAR, PV and PC are used to exchange information with different stakeholders and diagnose ICT needs of rural farmers. Participatory communication enhances learning and encourages researchers to consult farmers to identify their basic needs during the needs assessment process. The participatory approaches allow decision making in the hands of farmers and allows them to participate in developing ICTs. This is the quest for the future agenda in ICT4D which is towards participatory user-centred approach in development of the agricultural systems supported by ICTs (Walsham, 2012). Agricultural extension workers, researchers and technologists use participatory approaches to diagnose and solve technical problems. This helps mutual learning and PICTD (Figure 2) that improves wider adoption of ICTs, allowing experimentation of ICTs and enabling researchers to get access to farmers' indigenous knowledge systems (Joseph and Andrew, 2008). With PICTD, after the ICTs have been integrated in the farming environment farmers are consulted directly to evaluate the frequency of usage of the ICT, and to validate farmers' experiences in technology adoption. Thus, participatory approaches act as a feedback mechanism to all participants, farmers, researchers and other actors.

This paper explores to what extent agriculture researchers participate with farmers using participatory approaches in developing and promoting ICT-based solutions for enhancing agriculture productivity in Tanzania.

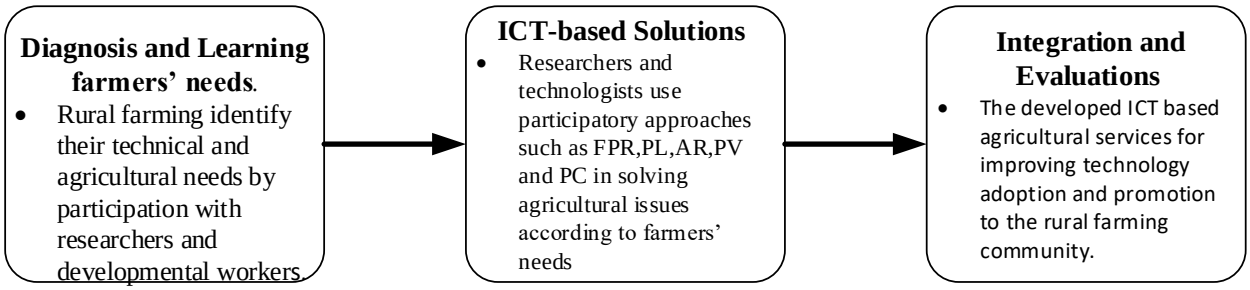

Figure 2: PICTD Using Participatory Approaches Between Farmers and Researchers

Tanzania, an agrarian country, has Agriculture Research Institutes (ARIs) in place for the purpose of strengthening the development of agriculture through the provision of science-based agricultural advisory, innovations generated from research and teaching which inrturn can improve farm practices. It is through participatory approaches, researchers from ARIs provide agricultural advisory services to farmers in order to make rational decisions concerning agricultural production and post-harvest practices (Mtega and Malekani, 2009). The use of ICTs in dissemination and communicating agriculture research output to the rural farmers and other actors remains to be important (Barakabitze et al., 2015). The participatory ICT developments in the agricultural sector can be achieved only if agricultural researchers and ARIs can learn from farmers by using the participatory approaches (Joseph and Andrew,

2008). Table 1 show the comparison of different participatory approaches which can be used in developing ICTs for agriculture.

Table 1: Comparison of Participatory Approaches (Adapted from Joseph and Andrew, 2008)

Participatory Approaches (PA)	Participants	Participation Methods	Outcomes of PAs
Farmer Participatory Research (FPR) Participatory learning and action research (PLAR)	• Agriculture workers, NGOs, farming community and researchers participate and farmers are allowed to make decisions. •Before making the final decisions, the leader of the farming community is consulted.	•Ensure farmer –to-researcher collaboration and participatory research. • Farmers are encouraged to become researchers since research is conducted on farm fields. • Participation is ensured through field visits, farm experiments and discussions. • Encouragement to farmers in evaluating and making observations for further action.	•Encourages participation to farmers, agriculture workers and researchers. •Improve agriculture productivity through use of technology. •ICTs can empower capacity building. •ICTs enable mutual learning and transfer of knowledge. •Enables changes in agriculture productivity to be observed using technology
Participatory communication (PC) Participatory Information and Communication Technology Development (PICTD)	•Agriculture workers, Researchers, Technologists Consult farmers while developing agricultural ICTs.	• Community centers, farmers' group discussions, and agriculture stories enable oral communication. •Motivating more participants through token of appreciation. • E-mail, digital storytelling and e-discussions enables Electronic communications. •Exhibitions to showcase and Communicate with other farmers and developmental workers. •Ensure participation when developing ICTs through ARIs. •Through training provided on how to use the developed ICTs. •More women can be motivated to use ICTs through working sessions. •Use innovative ideas specific to The community to develop their ICT skills and adapt to new technology.	•Ensures expression of agricultural needs in local languages •Increases social ties via electronic and oral communication. •Allows researchers to observe how farmers empower themselves by using ICTs. •Mobile phones and e-mails Creates community bonding and caters for mutual learning. •Farmers get to test the ICTs before they adapt to technology.
Participatory Video (PV)	•Agriculture workers, men and women farmers and researchers.	•Ensure farmer participation in audio visual center. •Ensure training via the use of video cameras and other audiovisual equipment. •Ensures women farmers' participation by taking videos relevant for women farmers. •Build confidence in using ICT.	•Feedback instrument which reflects participants' feelings. •Ensures expression of agricultural needs in local languages.
Informal Mobile-Learning Research.	•Agriculture workers, farmers and researcher officers.	• Mobile technologies in Promoting learning. • The use of mobile devices in the mediating process	Encourage participatory attitudes, excite interest and commitment among farmers and thus become important in adult learning.

1.2 Study Objectives

Participatory approaches (Table 1) can be used by researchers from ARIs in the development of ICTs to support farming community in order to raise agriculture productivity. It is well known that, if new farming techniques using ICT tools are effectively used, then agriculture productivity can be raised in a way that can help to eradicate poverty in Tanzania (URT, 2013). Participatory approaches have the capability to support and help in attaining socio-economic development in Tanzania. The significance of this study is towards informing the farming community and researchers' readiness towards using approaches which allow

collaborative involvement of different stakeholders in development and promotion of ICT-based agricultural systems**.**

The overall objective of the study was to provide an understanding on how agricultural researchers from ARIs use participatory approaches to develop, promote and introduce ICT-based agricultural systems to the farming community.
Based on this objective, the study also intended:

a) To examine how agriculture researchers and farmers are using ICTs for agricultural productivity.
b) To identify agriculture researchers' perceptions on the role of ICTs in agriculture sector**.**
c) To identify the extent agriculture researchers participate with farmers using participatory approaches in development of ICT for agriculture.
d) To assess challenges which hinder farmers to adopt the use of ICTs for agriculture.

From these specific objectives, the ultimate outcome was to encourage a strong commitment, involvement and collaborations of all actors in the agriculture value chain (the Government of Tanzania, policy makers, agriculture managers, processors, traders, transporters, researchers, extension officers and the whole farming community) to be aware and use effectively the readily available ICTs in order to increase agriculture productivity in Tanzania.

2. CONCEPTUAL FRAMEWORK

This study was guided by the modified framework of UNDP (2012) which provides 'the blue print of different entities involved in agriculture knowledge creation, knowledge storage, knowledge dissemination / communication as well as knowledge use. In short, the framework provides a linkage between agriculture knowledge chain and ICT-based solutions, agricultural knowledge management, processes and tools and knowledge management systems. The agricultural knowledge and information is created from universities, ARIs, farmers and other sources which flow to the ICT platform and eventually to the farmers again (Figure 3). The ICT based solutions and agriculture information to be transmitted to farmers is formulated, customized, written or recorded (Glendenning and Ficarelli, 2012). The transmission mechanism requires setting up of an IT infrastructure, content sourcing (from modern and indigenous sources), managing, and creating a help line for a two-way communication using the farmer-back-to-farmer technology generation (Figure 4) and transfer system model (FAO, 2007).

The UNDP framework was chosen because it was developed to solve problem related to conventional extension delivery service system prevailing in developing countries. It was tested in a number of countries including Ethiopia before its use being advocated in other developing countries. The perceived benefits of various agricultural information shown in UNDP framework (Figure 3) vary according to the region, crop, infrastructure and socio economic conditions of the farmers, and necessary conditions for these information to have impact is that, the farmers acts on the received agricultural information through a mix of participatory approaches(Mittal and Mehar, 2012). This two-way process which provides feedback from farmers to researchers can make relevant ICT based solutions and agricultural knowledge to be directly accessible to the farming community. This will then results into an improved agriculture productivity and brings higher returns (FAO, 2007). Agricultural knowledge sharing between farmers and researchers is very important for effective PLAR (Joseph, 2010). This knowledge sharing enables also to extract specific geographical and indigenous data from the farming community which is relevant to a particular area under study. The weakness of UNDP framework is that it does not explicit show agriculture

information in the framework. Furthermore, UNDP framework does not include any approach for participatory methods which must guide agriculture knowledge creation, storage and use. Thus the proposed framework extended UNDP framework with some components of agriculture knowledge and information. Also, the proposed framework fuses participatory approaches in all the stages of UNDP framework. Thus the combined framework is 'the blue print of different entities involving participatory in agriculture information and knowledge creation, information and knowledge storage, information and knowledge dissemination / communication as well as information and knowledge use'. Generally, the framework provides a linkage between agriculture information chain and ICT-based solutions, agricultural knowledge management, processes and tools and information systems (Figure 3).

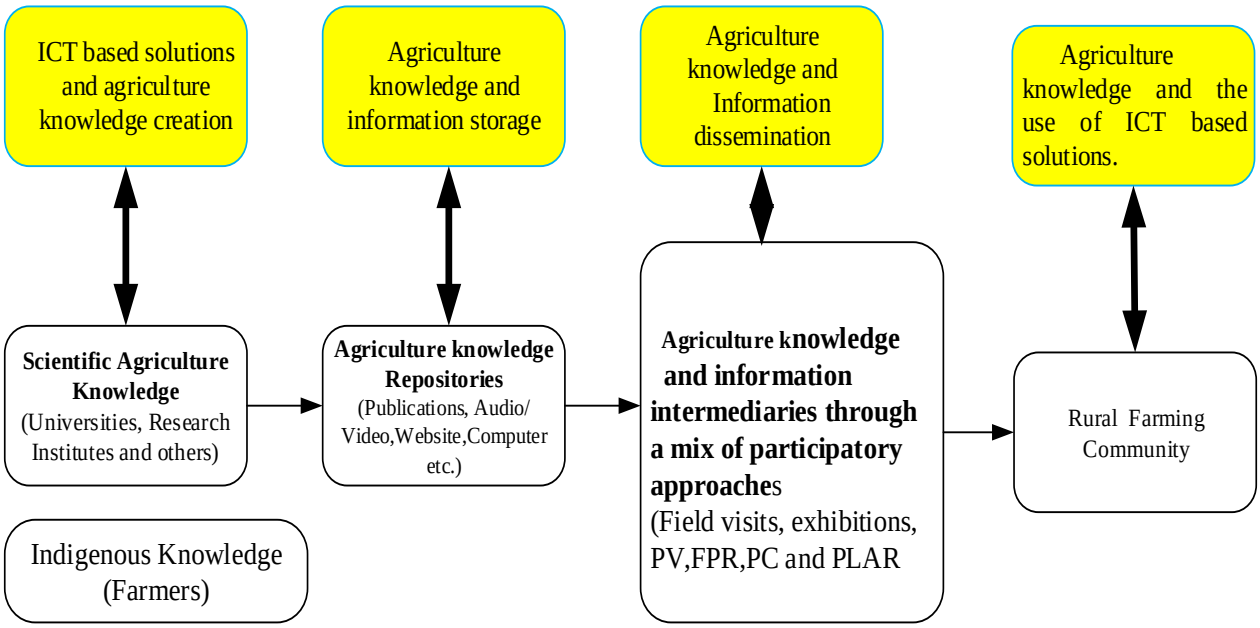

Figure 3: ICT Based Agriculture Knowledge and Information Dissemination Through a Mix of Participatory Approaches

Figure 3 shows that ICT based solutions and agriculture knowledge and information system is mainly created from modern and indigenous sources. With modern agriculture knowledge and information created from universities and ARIs through scientific research while indigenous or tacit knowledge and information is created from farmers using their traditional knowledge, innovations and farming practices outside the formal education system (FAO, 2007).The created knowledge and information is then stored in repositories like video, audio, publications, computers, websites etc. The ICT based solutions, agriculture knowledge and information stored is then disseminated to the rural farming community through a mix of participatory approaches which involves PV, FPR, PC and PLAR. All stakeholders in the agriculture sector (farmers, farmer organizations, research scientists, policy makers, extension agents and the private sector) must have a systematic and a continuous interaction in order to have an effective ICT based solutions and agriculture knowledge and information sharing, dissemination, communication and management (ASARECA, 2011).

In order to improve the two way-communication models depicted in Figure 3, this study adopted the farmer-back-to-farmer technology generation and transfer system model where researchers, farmers and agriculture extension workers are involved in the research process in an active manner. The Farming System and Research (FSR) have to start and end with the farming community (FAO, 2007). This is the concept of putting farmers at the centre of ICT for agriculture intervention. Figure 4 from FAO (2007) shows the depiction of this

concept which is proposed to be embedded in Figure 3 wherever there is involvement of a farmer.

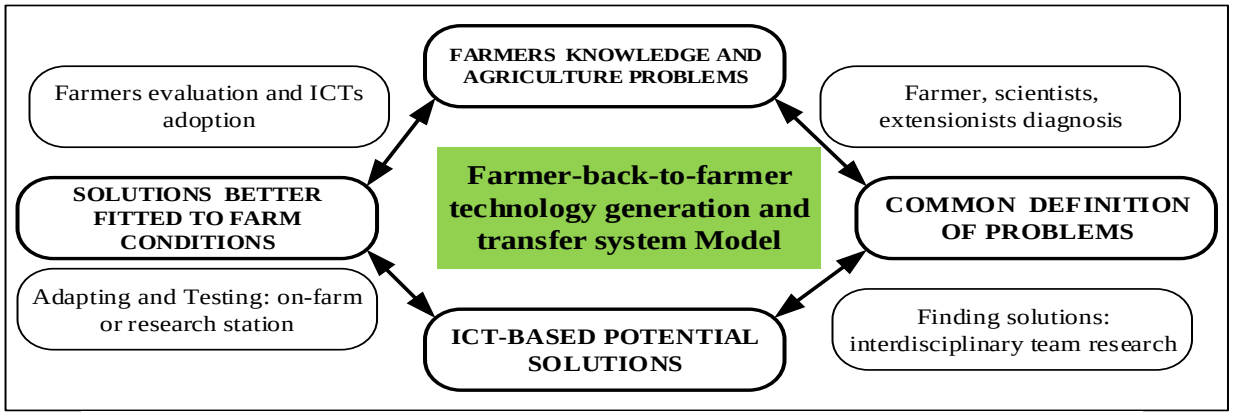

Fig.4: Farmer-back-to-Farmer Technology Generation and Transfer System Model

The farmer-back-to-farmer model involves mainly diagnosis to define agriculture and farmers' problems; performing interdisciplinary team research to develop potential solutions using a mix of participatory approaches; performing on-farm and experiment station testing and adaptation of proposed solutions to farmer's conditions using participatory approaches, farmers' evaluation and monitoring and adoption of the technology (Stoop,1988). The farmer–researcher participation and ICT based solution integrations between on-station and on-farm research will eventually result into an improved productivity and performance of the agricultural sector. However, the results and the overall potential of ICTs developed should then be discussed with the farming community via a feedback mechanism, which will lead to the wider adoption of ICTs (Joseph, 2010).

This study therefore extends earlier studies which co-authors involved using participatory action research method (Sanga et al., 2013a, 2013b; Sanga et al., 2014a, 2014b; Barakabitze et al., 2015) in order to identify the extent agriculture researchers participate with farmers in developing ICTs-based systems for agriculture with the inputs from farmers themselves using participatory approaches.

3. RESEARCH METHODOLOGY

3.1 The Study Area

This study was conducted in four agricultural zones from Tanzania mainland. The four zones selected under this study include: the Eastern, Northern, Southern Highlands and the Southern zone. Regions covered from these four agricultural zones are Morogoro, Dar Es Salaam, Tanga, Kilimanjaro, Mbeya, Mtwara and Arusha. The four zones were selected because is where most of the ARIs are located (Barakabitze et al., 2015). In order to determine the extent at which farmers and researchers participate in agriculture using participatory approaches, four (4) rural farming communities in these four zones were involved. In this case, Kilosa, Mvomero, Arusha and Morogoro rural farming communities participated in the study. These farming communities were selected because of availability of rural ICT infrastructure and also due to different agricultural activities conducted in these areas (Sanga et al., 2013a, 2013b; Sanga et al., 2014a, 2014b).

3.2 Research Design and Strategy

This study employed the cross sectional research design and structured questionnaire as well as interviews strategies. However, before distributing questionnaire to respondents, the survey instrument was developed and pre-tested by agriculture researchers working at Sokoine

University of Agriculure (SUA).The copies of questionnaire and interview's questions were sent to them in order to determine the ambiguity and relevance of the questions. The protocol was strategically adopted in order to ensure the matching of research questions and targeted sample of respondents. In other meaning, to have a relevance of respondents towards addressing research objectives and research questions (Barakabitze et al., 2015). Agriculture researchers from SUA reported that, the questions were clear, unambiguous and relevant to the research being conducted. The instrument was then piloted and adjustments were made with the support of four academic researchers with expertise in survey study approaches and a particular emphasis and attention was given to overall structure of wording and presentation of the interview items. The developed survey instrument consisted of structured and open questions to collect data about demographic characteristics of respondents, the type of agriculture information accessed by farmers through ICTs with the help of participatory approaches and related challenges which hinder farmers towards adopting the use of ICTs in agricultural activities. The instrument also intended to identify agriculture researchers' perceptions on the role of ICTs in agriculture sector and to know whether agriculture researchers perform on-field visit regularly and use any of participatory approaches in order to know farmers requirements. However, the questions were designed and formulated from the conceptual framework as well as from the literature covered above. The final questionnaire was distributed in 2 phases. The first phase involved collecting data using a structured questionnaire which was distributed to farmers in the selected four farming communities for a period of 4-5 months. The second phase focused in collecting data from agriculture researchers for a period of 2-3 months.

The purposive sampling technique (non-probabilistic) was adopted in the process of recruiting the respondents under the study. This technique ensured only relevant respondents who were mostly likely to provide quality, fruitful and meaningful data in the context of examining on how the use of ICT based systems and the exchange of agriculture knowledge between farmers and researchers in an agrarian economy can be catered through various participatory approaches. The purposive sampling procedure was also adopted in order to ensure there is a matching pattern between research questions and the sampling frame under the study (Bryman, 2008).

In case of respondents from rural farming communities, equal number of sampling population was recruited from four farming communities. However, this recruitment considered farming communities that have good ICT infrastructure which includes coverage of radio and TV and radio, availability of telecentres and mobile phone networks. In addition, the rural farming community included those with different socio-economic characteristics. Recruitment also considered farmers who have been doing agriculture activities for more than 5 years consecutively. The quantitative and qualitative paradigm elements were also adopted in the study. This was adopted because of allowing a mixed research method strategy (Rufai, 2014). The mixed research method strategy was adopted for the purpose of: enabling the possibility for findings collaboration through triangulation; allowing the potential weaknesses of methods associated with each strategy to be offset to each other; allowing in-depth, comprehensive and broad investigation as well as better understanding of the phenomenon through research completeness (Rufai, 2014). Moreover, the aim was also to enhance the research credibility and the likelihood of results/findings integrity as well as eliciting respondent's diversity from the sample (Bryman, 2008).

3.3 Study Population and Sampling Techniques

The rural farming communities from Kilosa district, Mvomero, Arusha, Morogoro rural and agricultural researchers from ARIs were involved in the study. Agricultural researchers/managers came from 12 ARIs that were used in our recent research study

(Barakabitze et al, 2015). The selection of these ARIs considered those that have good ICT infrastructure and could easily be reached by researchers for data collection. Eighty farmers in each of the four farming communities were involved in the study making a total of 320 respondents from the farming community. The sampling frame had 72% males and 28% females. Agricultural researchers from the selected ARIs located in four agricultural zones were involved in the study based on the fact that, the ICT based systems for agriculture knowledge from their institutes is shared among agricultural stakeholders in the country. A total of 64 agricultural researchers participated in the study where 60.94% (39) were males and 39.06 % (25) were female. Table 2 shows a phased approach and the sampling frame of the study.

Table 2: Phased Approach and the Sampling Frame of the Study.

Research Phase	Kilosa	Mvomero	Arusha	Morogoro	Total	Research method
Phase I	80	80	80	80	320	Survey -Structured Questionnaire and Interviews
Phase II	64 agricultural researchers from the selected ARIs				64	Survey-Structured Questionnaire and Interviews

3.4 Data Collection

As shown in Table 2, the study was conducted in two phases. The first phase involved collecting data using a structured questionnaire which was distributed to farmers in the selected four farming communities for a period of 4-5 months. The second phase focused in collecting data from agriculture researchers for a period of 2-3 months. In-depth interviews were also conducted among agriculture researchers and farmers in order to know if researchers collaborate with farmers in developing ICT based systems for agriculture knowledge using participatory approaches.

Secondary data were collected using documentary reviews of previous studies on ICTs for agriculture in Tanzania as well as research reports from ARIs, data from the Ministry of Agriculture Food Security and Cooperative (MAFSC), seminar papers, articles from journals and conference proceedings and the Internet. Reports on the status of agriculture in Tanzania from Sokoine National Agricultural Library and University of Dar es Salaam Library were also reviewed. The use of questionnaires, interviews and other relevant literature provided the grounds for thorough comparisons of the data and assisted in looking for validity and reliability of study findings.

3.5 Data Analysis

The quantitative information was analyzed using the Statistical Package for Social Sciences (SPSS version 20). For qualitative data, the pattern matching technique was used where the information collected was arranged in groups with similar meanings. However, in drawing conclusions, emerging patterns were matched and analyzed. This is the advantage of the mixed research methods used in this study which allowed triangulation of research findings which were expressed in-terms of tables, figures and descriptions using percentages, frequencies, and graphical representation.

4. RESULTS AND DISCUSSION

The first group of respondents (farmers) was asked to state their social-economic characteristics such as sex, age, education, annual income and their family size. Results in Table 3 shows that 60.34% (193) were male farmers and 39.66% (127) were female which shows that males participate more in agriculture activities than female. 89.37 % (286) had age ranging from 21-50 years and 62.50% (200) having completed primary education indicating a low literacy level among farmers. However, 48.75% (156) had family size with number of children less than 5 while 65% (208) farmers have a medium annual income.

Table 3: Socio-Economic Characteristics of the Farming Community Respondents (N=320)

S/N Item		N	Percentage (%)
1. Sex	Males	193	60.31
	Females	127	39.69
2. Marital Status	Married	254	79.38
	Single	66	20.62
3. Age in Years	21-30	86	26.87
	31-40	162	50.62
	41-50	38	11.88
	>50	34	10.63
4. Highest Level of Education completed	M.Sc/M.A	12	3.75
	B.Sc/B.A	38	11.88
	Secondary Certificate	70	21.87
	Primary School	200	62.50
4.Family Size (No. children)	<5	156	48.75
	5-10	88	27.50
	11-15	72	22.50
	>15	4	1.25
5. Annual income (Tshs) 1USD=2100Tshs	$<10^4$ =Low	72	22.50
	(10-50)x10^4 =Medium	208	65%
	(50-100)x10^4 =High	40	12.5

4.1 Access to Agriculture Information Using ICTs and Participatory Approaches

ICTs have been cited as the most significant tool for providing information services to farmers (FAO, 2007; Barakabitze et al., 2015). This is so because ICTs allows sharing of agricultural information, enable a two way communication and can provide several services needed for agricultural production (Mtega, 2008; Sife et al., 2010; Mtega and Msungu, 2013; Sanga et al., 2013a, 2013b; Sanga et al., 2014a, 2014b). Farmers were asked to indicate more than one type of agriculture information that is accessed through ICTs. Table 4 indicates that there is limited agriculture information accessed through ICTs and participatory approaches. 31.87 % (102) indicated to access information regarding to farming problems through ICTs than any other kind of information. Among others, is the information on water management and fertilizer with 28.75 %(92), information on weather update and agricultural market prices for products with 27.81%(89), information on farm crop diseases with 28.75%(92),

information on ICT training schedule for farmers with 21.87%(72), information on researchers field visits or "farm walks'' with 25.31%(81) and information on companies/organizations that provide loans for agriculture to farmers having 24.68%(79).

Table 4: Agriculture Information Accessed Through ICTs Developed under Participatory Approaches

S/N	Item	N	Percentage (%)
1.	Pest management and control techniques and calendar definition	56	**17.5**
2.	Information on weather update and agricultural market prices for products	89	**27.813**
3.	Information on Nitrogen fixation, cropping methods and organic culture	30	**9.375**
4.	Information on soil and water conservation system for a particular region	42	**13.125**
5.	Information on companies/organizations that provide loans for agriculture to farmers	79	**24.688**
6.	Information on researchers field visits or "farm walks	81	**25.313**
7.	Information on assessing community's farming problems or to provide feedback to researchers.	102	**31.875**
8.	Information on farmer training on how to use farming machinery	69	**21.563**
9.	Information on ICT training schedule for farmers	70	**21.875**
10.	Information on crops for sale in the international market	38	**11.875**
11.	Information on farm crop diseases and how to overcome	92	**28.75**
12.	Information on land owned by farmers, seeds availability and how to monitor plant growth.	43	**13.438**
13.	Information on land preparation and sowing	56	**17.5**
14.	Information on land selection and crop selection	45	**14.063**
15.	Information on water management and fertilization	92	**28.75**
16.	Information on food processing, packaging and transportation	31	**9.688**

4.2 Type of Communication Channel used by Farmers for Accessing Agricultural Information

Figure 5 shows that, 80% of farmers access agricultural information through Short Message Service (SMS), and Multimedia Messaging Service (MMS) services followed by 79% using telephone calls and community radios having 68%. This is so because; many farmers have mobile phones and therefore become easy for agriculture researchers and extension workers to communicate with farmers through this communication channel. The study also indicates that, community radios are mostly used to access agricultural information due to presence of community radio in the surveyed area under this study (Sanga et al., 2013a, 2013b; Sanga et al., 2014a, 2014b).

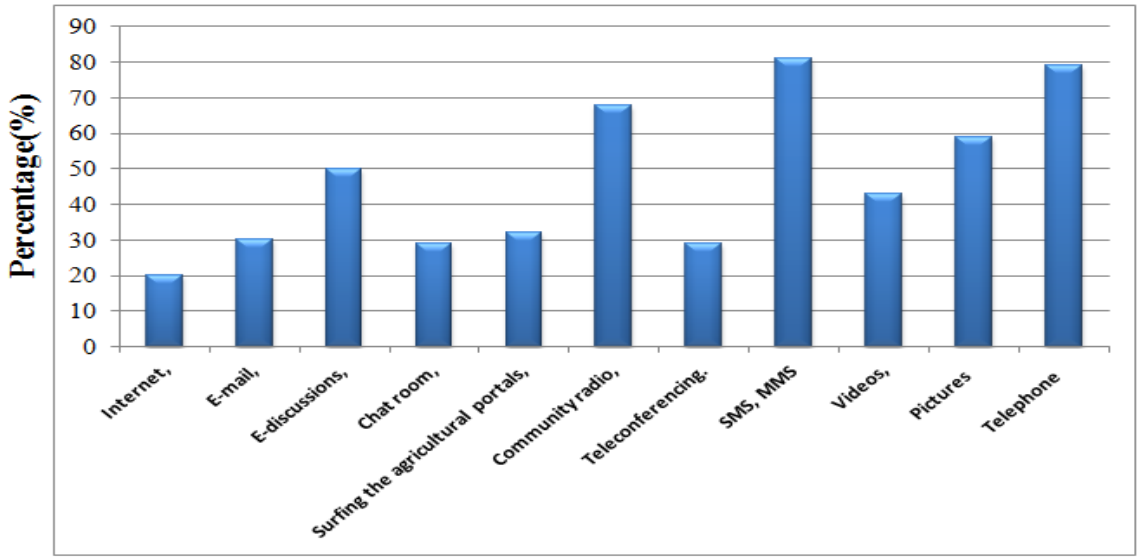

Figure 5: Type of Channel used by Farmers for Accessing Agricultural Information

Findings of this study are in line with the previous study of Mtega and Msungu (2013) and Sanga et al. (2013a) who found that, mobile phones, radio and television are very suitable for the provision and dissemination of agricultural information to/among farmers. However, other communication channels such as Internet, teleconferencing and television were not used due to unreliable access to electricity in rural areas. This is also supported by the studies of Oyegbami and Fabusoro (2003) and Sife et al. (2010) who emphasize that television access in rural Tanzania is mainly constrained by lack of electricity and terrestrial connections.

4.3 Agriculture Researchers' Perceptions on the Role of ICTs in Agriculture

Table 5 summarizes results of agriculture researchers' perceptions on the acceptability of the role played by ICTs in agriculture. The results indicate that the agricultural researchers have very high perceptions of ICTs usage for agricultural development. A total of 90.2% agree that ICTs can raise agriculture productivity even in smallholders' fields while 96.07% agree that ICTs enable collaboration with other researchers and is a source of literatures and journals related to agriculture.

Table 5: Researchers' Perceptions on the Role of ICTs in Agriculture

S/N Items	Strongly Agree (%)	Agree (%)	Partly Agree (%)	Disagree (%)	Strongly Disagree (%)
1. ICTs can raise agricultural productivity, even in smallholders' fields.	43.14	47.06	9.8	0	0
2. ICTs can be used to visualize agriculture environments, make field maps, soil classification and sampling.	17.56	72.55	9.8	0	0
3. ICTs can be used in vegetation vigor, drought monitoring and assessment of crop phonological development.	20	54	20	6.0	0

S/N Items	Strongly Agree (%)	Agree (%)	Partly Agree (%)	Disagree (%)	Strongly Disagree (%)
1. ICTs can raise agricultural productivity, even in smallholders' fields.	43.14	47.06	9.8	0	0
2. ICTs can be used to visualize agriculture environments, make field maps, soil classification and sampling.	17.56	72.55	9.8	0	0
4. ICTs can be used for field monitoring, events documentation, training to farmers and conferences purposes during participatory learning.	54	34	12	0	0
5. ICTs enable collaboration with other researchers and can be a source of literatures and journals related to agriculture.	60.78	35.29	3.92	0	0

4.4 The Impact of Farmer-Researcher Participation and the Use of ICTs in Agriculture.

Through interviews with 20 different agriculture researchers from ARIs, we needed to know if researchers conduct participatory approaches with farmers in order to give them knowledge on the use and adoption of ICTs for their farms productivity. Also the aim was to evaluate if there is any information exchange between the farming community and researchers. Through interviews, agricultural researchers acknowledged on the impacts of farmer-researcher participatory approaches in using ICTs for agriculture productivity and provided justification (Table 6) on how technology and farming community involvement in agriculture researches increases crop yields (Mruma, 2013). Table 6 shows the crop yields either after technology is used or without using technology on farms.

Table 6: The Impact of Technology on Agricultural Productivity (Mruma, 2013)

Crop	Without Technology	With Technology	Farmer Group	Total yields
Tomato	2-5 tons	50-60 tons	Police Academy, Moshi	64 tons
Green pepper	1-3 tons	15-20 tons	Ijumaa Mkuapa,Morogoro	19 tons
Onions	18 bags of 140kgs	90-100 bags of 140kgs	Rundugai FG,Moshi	98 bags of 140kgs
			Rundugai FG B,Moshi	96 bags of 140 kgs

From the conducted interviews, one senior agriculture researcher highlighted that

> *"all stakeholders are involved in all levels of decision making from planning phase to the implementation (collaborative management) and most of the trials are on-farm where they normally collaborate with farmers. They also normally develop agriculture technologies, for example technologies for soil fertility improvement on-farm with inputs/ideas from researchers and farmers".*

Another researcher from Tanzania Coffee Research Institute (TaCRI) pointed out that,

> "*as a coffee breeder they normally conduct on farm evaluation/test of their advanced selections to accommodate their farmers' opinions and practices to ensure that their varieties fit with farmers' common practices in producing the crop. He further continued that, before new varieties are approved for official release, they carry out farmers' varieties assessment in order to check their preference and their reasons for particular choice of crops."*

In fact, farmer-researcher participatory approaches such as PC, PV, and PLAR have a significant impact on the effective use of ICTs in rural farming community and the agricultural domain in general (Sanga et al., 2013a, 2013b; Sanga et al., 2014a, 2014b). Agriculture researchers and farmers have to work together in testing the new agriculture technology, know how to use and finally integrate the technology on their farms. The researchers need to diagnose their farming needs and find solutions by frequent field visits. Field visits by researchers may help real participation and trust in the agriculture researchers or scientists who are trying to find solutions for technology development (Joseph and Andrew, 2008). Once the solutions are suggested to farmers, new technology should be demonstrated to farmers in order to give knowledge and the required skills on how to use the technology in agriculture.

4.5 Challenges Hindering Farmers in Adopting the Use of ICTs in Agricultural Activities

The following are the challenges which were explored through interviews with farmers towards adopting the use of ICTs in their agricultural activities.

a) **Poor infrastructure**

Some rural communities have no access to electricity, proper roads to link to towns where they can attend some agricultural training, mobile network connectivity problems and unreliable internet. Farmers complained on the lack of relevant technological tools in their communities which hinder their implementation of the acquired knowledge in their farms.

b) Limited access to updated agricultural knowledge/information.

No regular agricultural training to farmers for providing the latest developed ICTs based systems for agricultural activities. Limited access to TV channels because of frequent power cuts off was also a problem in accessing the latest agricultural information.

c) **Lack of updated market information**

Farmers stressed that, they are in a poverty cycle for a long time due to poor market price of their yield products which demoralize their farming activities. Some of the agricultural inputs (e.g. pesticides) are very expensive and they cannot afford because of their economic situations.

d) Limited farming monitoring capacity

Extension workers and agricultural researchers from ARIs don't monitor famers' activities regularly.

e) Poor implementation of ICTs for agriculture

The developed Nation ICT policies for agriculture have not been fully implemented. The policy should be in local language so that, farmers become aware what ICTs can do in the

farming communities. Also, implementation of ICT based system for agriculture should be guided by National ICT policy for agriculture.

5. CONCLUSIONS

This study intended to explore the extent agriculture researchers and extension workers from ARIs collaborate with farmers through different participatory approaches in developing, promoting and adopting ICT-based systems for agriculture. This paper provides an insight on the use of various participatory approaches to develop ICTs to the rural farming communities. In addition, the paper discusses how participatory approaches will help the farming community in adopting ICT-based systems for agriculture; contribute to solving problems as well as assisting them in identifying their technological and agricultural needs.

The results indicate that, rural farmers have limited access to agriculture information through ICTs. The study has indicated that, farmer-researcher participatory approaches such as PV, PV, PLAR, FPR and IMLR have a significant impact on the effective use of ICTs in rural farming community and the agricultural domain in general. Few ICTs for agriculture in Tanzania have been implemented using a mix of participatory approaches (Sanga et al., 2013a, 2013b; Sanga et al., 2014a, 2014b).

Some of the challenges which hinder farmers towards adopting the use of ICTs in agricultural activities includes: Lack of relevant technology, poor infrastructure and language constraints, limited access to updated agricultural information, economic, agricultural inputs and yield products pricing problems, poor access to appropriate agricultural ICT policies for farmers and limited farming monitoring capacity and lack of appropriate incentives and loans. This study recommend that,the Government of Tanzania should have strategies in place to raise awareness of agriculture governmental policies to agriculture researchers and the farming community and make these policy documents be on their hands so that they can know the potential impact of ICT on poverty alleviation through agriculture sector.

Strong commitment, involvement and collaborations is also needed from different actors in agriculture value chain (the Government of Tanzania, policy makers, agriculture managers and the whole farming community) so that they become aware of the importance of ICTs in increasing agriculture productivity. The commitment in implementation of ICTs should be done with a clear vision of ICT integration in ARIs. This need to be shared to all members of the farming community in order to have a great pre-knowledge and up-scaling towards enhancing effective use of ICT in the ARIs and in the community farms.

Successful integration of ICTs in ARIs and adoption of agriculture technologies in the farming community is brought by a more realistic model of technology transfer and a cross-sectional approach to agricultural information sharing (Barakabitze et.al. 2015).

6. RECOMMENDATIONS

This study provides an evident that ICTs has a dominant position to alleviate rural poverty and strengthen agriculture productivity through ARIs (Barakabitze et al., 2015). ICT can contribute to achieve the first Millennium Development Goal which deals with '*eradicating extreme hunger and poverty*" by raising the income of small-scale farmers and strengthening the agriculture sector (Pingali et al., 2006). Findings under this study guided the authors to make the following recommendations on what can be done in order to have full integration, implementation and effective use of ICTs in Tanzania for raising the agricultural productivity.

a) The Government of Tanzania should implement projects aiming at financing the procurement of specialized ICT tools to agricultural research activities in the farming communities and ARIs. This also should go in line with strengthening and improve

capacity building and provide agriculture researchers the knowledge and skills through training on how to use different agricultural computer software, analytical programmes and empirical models related to increasing agriculture productivity.

b) ARIs should strengthen and improve collaboration with the farming community in sharing research outputs and research information so as to develop more relevant ICT based solutions for agriculture especially of bio-information, geographically related data, crop data etc.
c) Strong commitment, involvement and collaborations of all actors in the agriculture value chain (Government of Tanzania, policy makers, agriculture managers, processors, traders, transporters, researchers, extension officers and the whole farming community) is needed so as to be aware and use effectively ICTs in order to increase agriculture productivity in the country. The commitment in implementation of ICT should be done with a clear vision of ICT integration in ARIs. This need to be shared to all members of the farming community in order to have knowledge and up-scaling towards enhancing effective use of ICT in the ARIs and in the community farming.
d) ARIs should make efforts in developing and implementing regional agricultural learning centre (i.e. telecentre or call centre with virtual cloud libraries and research information directories) which will be used by agriculture experts and farmers in providing advisories services.
e) Improving ICT infrastructure in all ARIs by providing more computers and agricultural experimental facilities and laboratories which need to have Local Area Networks (LANs) connected with a reliable Internet.
f) Agriculture Universities, extension agency organizations, farmers' organizations, cooperatives and other actors of agriculture should be linked to a common framework of Agricultural Knowledge and Information System (AKIS)
g) Strategies and proper ICT policies should be formulated for encouraging both men and women farmers to be part of the adoption of agricultural technologies. Policy-makers must pay more attention to accommodate all actors in the agricultural chain in adopting and integration of ICTs in agriculture.
h) Researchers involved in developing ICT based systems for agriculture should adopt participatory approaches while developing software systems.

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APPENDIX A

1. What is your sex?
   (a) Male (b) Female
2. What is your marital status?
   (a) Single (b) Married
3. What is your Age?
   (a) 21-30 (b) 31-40 (c) 41-50 (d) 51-60 (e) Above 60
4. What your highest level of education?
   (a) MSc/M.A (b) BSc/BA (c) Secondary education (d) Primary education
5. How many children do you have?
   (a) Less than 5 (b) 5-10 (c) 11-15 (d) More than 15
6. What is your monthly income?(Tanzanian shillings)
   (a) Less than 10^4 (b) (10-50)x10^4 (c) (50-100)x10^4 (d) More than 100x10^4
7. Indicate the type of information that you access through ICTs with the help of participatory approaches like Participatory Video, Participatory Communication (PC), SMS, and telephonic calls etc (√ **Tick at least one item**).
   - □ Pest management and control techniques and calendar definition.
   - □ Information on weather update and agricultural market prices for products
   - □ Information on Nitrogen fixation, cropping methods and organic culture.

- Information on soil and water conservation system for a particular region
- Information on companies/organizations that provide funding for agriculture to farmers.
- Information on researchers field visits or "farm walks"
- Information on assessing community's farming problems or to provide feedback to researchers.
- Information on farmer training on how to use farming machinery.
- Information on ICT training schedule for farmers
- Information on crops for sale in the international markets
- Information on farm crop diseases and how to overcome.
- Information on land owned by farmers, seeds availability and how to monitor plant growth.
- Information on land preparation and sowing.
- Information on land selection and crop selection
- Information on water management and fertilization.
- Information on food processing, packaging and transportation.

8. Which type of communication channel normally uses to access agriculture information? **(√ Tick at least one item)**

- Internet,
- E-mail,
- E-discussions,
- Chat room,
- Surfing the agricultural portals,
- Community radio,
- Teleconferencing.
- SMS, MMS
- Videos,
- Pictures
- Telephone

9. What is your perception on the role of ICTs in agriculture development in Tanzania?

Items	**Strongly Agree**	**Agree**	**Partly Agree**	**Disagree**	**Strongly Disagree**
ICTs can raise agricultural productivity, even in smallholders' fields.					
ICTs can be used to visualize agriculture environments, make field maps, soil classification and sampling.					
ICTs can be used in vegetation vigor, drought monitoring and assessment of crop phonological development.					
ICTs can be used for field monitoring, events documentation, training to farmers and conferences purposes during participatory learning.					

Items	Strongly Agree	Agree	Partly Agree	Disagree	Strongly Disagree
ICTs can raise agricultural productivity, even in smallholders' fields.					
ICTs can be used to visualize agriculture environments, make field maps, soil classification and sampling.					
ICTs enable collaboration with other researchers and can be a source of literatures and journals related to agriculture.					

10. What are the challenges which hinder you (farmers) towards adopting the use of ICTs in agricultural activities?
11. Do agriculture researchers perform on-field visit regularly and use any of participatory approaches in order to know your (farmers) requirements?
12. Do agriculture researchers develop ICT based solutions for agriculture related to crops, soil health, soil nutrients with inputs from farmers?