ANNEX 2: TEMPLATE FOR AFS RESEARCH OUTPUT TITLE AND ABSTRACT PAGE

Each research output submitted to IDRC must include a title page, abstract, and keywords. The kind of information that should be included is listed below. Items marked with an asterisk (*) are particularly important and **must** appear. A blank title and abstract page follows.

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***Abstract:** Despite gains in agriculture yields, access to food remains a serious challenge in many parts of the world. It is now recognized that improving food security requires a more integrated

understanding of food systems and that key under-explored areas of these systems are likely to be crucial in developing effective policy change. In Kenya, institutional changes have occurred to facilitate knowledge integration within the agriculture sector. Drawing on the experiences and understandings of key stakeholders in Kenya, this paper aims to identify and better understand the barriers to knowledge integration for improved agriculture technologies and their adoption. A number of barriers to the flow of knowledge to and from those working to develop new agricultural technologies and farmers are identified. The results of this study suggest a potential link between levels of community organisation and levels of trust with levels of knowledge integration surrounding agriculture technologies and their adoption. The findings suggest that increasing the planning and follow up of newly introduced agriculture technologies has the potential to encourage interdisciplinary approaches and improve food security outcomes.

***Keywords:** *food success, knowledge integration, agricultural technologies*

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ORIGINAL PAPER

Knowledge integration and the adoption of new agricultural technologies: Kenyan perspectives

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Abstract Despite gains in agricultural yields, access to food remains a serious challenge in many parts of the world. It is now recognized that improving food security requires a more integrated understanding of food systems and that key under-explored areas of these systems are likely to be crucial in developing effective policy change. In Kenya, institutional changes have occurred to facilitate knowledge integration within the agricultural sector. Drawing on the experiences and understandings of key stakeholders in Kenya, this paper aims to identify and better understand the barriers to knowledge integration for improved agricultural technologies and their adoption. A number of barriers to the flow of knowledge to and from those working to develop new agricultural technologies and farmers are identified. The results of this study suggest a potential link between farmers' levels of community organization and levels of trust with levels of knowledge integration surrounding agricultural technologies and their adoption. The findings suggest that increasing the planning and follow-up of newly introduced agricultural technologies has the potential to encourage interdisciplinary approaches and improve food security outcomes.

Keywords Knowledge integration · Food policy · Innovation · Sustainable development · East Africa

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Introduction

Producing enough food to feed a growing human population has been an important factor in policy debates ever since Malthus wrote his *An Essay on the Principle of Population* (1798). Despite concerns that agriculture would not be able to keep up with human population growth, recent decades have seen a general increase in global food production per capita [Food and Agriculture Organization of the United Nations (FAO) 2010a]. This increase can be attributed to both the expansion of cultivated land and technological advances, leading to increased agricultural yields (Tilman 1999; Lal 2009). However, notwithstanding the agricultural gains achieved on a global scale, many unresolved issues remain surrounding the challenge of ensuring lasting food security for all.

As population continues to rise, technology will continue to be relied upon to increase the productivity of the land already under cultivation. This reliance on technology has a substantial track record of generating negative environmental impacts (Tilman et al. 2002). Agricultural intensification involving heavy reliance on fertilizers and pesticides is amongst the most controversial aspects of modern agricultural technologies (Matson et al. 1997), leading the sustainability of food systems to be strongly questioned (Foley et al. 2005; Nah and Chau 2010). Yet, even if these long-term environmental sustainability concerns are put aside, it is clear that current approaches to agriculture and agricultural technology are not going to be adequate to address food security issues going forward.

Current estimates indicate that there are 925 million hungry people worldwide, with around 98% of the world's hungry concentrated in developing countries (FAO 2010b). Large variation in levels of hunger within countries is another concern [e.g., as reported in Kenya by the Kenya Food

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Security Steering Group (KFSSG) in The 2010 Short Rains Season Assessment Report]. This situation exists despite widespread political commitment to reduce poverty and hunger [e.g., Millennium Development Goal 1 of the United Nations (UN) General Assembly 2000)], and increasing financial commitments [e.g., the Chinese government's 3.7 billion USD investment in genetically modified rice (Qiu 2008)].

There are many factors that help to explain why food insecurity remains so prevalent. Economic issues such as the lapse in agricultural funding, or the Global Financial Crisis of 2007–08 have played a role in contributing to food insecurity (FAO 2009), as have climatic factors such as changes in temperature and rainfall (Gregory and Ingram 2008). However, increasingly it is being recognized that food insecurity is a chronic and persisting structural problem, which cannot be fully explained by acute disturbances to the production system alone (von Braun 2009). For example, the issue of low adoption rates of new and potentially beneficial agricultural technologies in many Sub-Saharan African countries continues to contribute to food insecurity and low productivity in those areas (see for example, Ngigi 2003), despite years of research on the issue.

There is a recognized need to further examine the contextual factors associated with the development of new and environmentally sustainable agricultural technology (see for example, Ellis et al. 2010; Cavatassi et al. 2011; Mati et al. 2011). Reducing hunger through increasing agricultural yields to keep up with population growth while increasing access to food for marginalized populations requires a better understanding of the dynamic and complex relationships between the social, political, scientific, environmental, and economic factors that underpin food security. However, research aimed at investigating these wider issues is lacking. Filling this gap requires a change from the predominant mode of scientific knowledge production, in which academics work in relative isolation from each other in disciplinary 'silos', to a more interdisciplinary and context specific mode of knowledge production, designed to investigate complex issues (see Gibbons 2000). As a result, there has been a call for innovative and interdisciplinary approaches to agricultural research, technological development, and policy (see Ericksen 2008; Stringer 2009).

A truly interdisciplinary approach to food security and agricultural productivity demands knowledge integration to a much greater extent than commonly occurs. Knowledge integration describes a situation in which an established body of knowledge is combined with and modified by knowledge from another source, either another existing body of knowledge or newly developed knowledge. A first step in achieving knowledge integration is knowledge communication and sharing across scales, from the international, regional, and national levels to the farmer level, as well as across a broad array of disciplines and sectors. The magnitude of this challenge requires supportive institutional frameworks, which can facilitate knowledge integration, or at the very least not hinder it (Kristjanson et al. 2009).

The Government of Kenya has recognized the need for improved agricultural sector-wide communication and responded in 2005 by creating the inter-ministerial Agricultural Sector Coordination Unit (ASCU). ASCU is tasked with coordinating the key actors from the public and private sectors, to facilitate interdisciplinary communication and integration of knowledge, for the implementation of the Agricultural Sector Development Strategy (ASDS) (Government of Kenya 2010). In line with the Comprehensive Africa Agriculture Development Programme (CAADP), the ASDS is Kenya's national policy for the agricultural sector, which emphasizes food security for all Kenyans as well as the major role to be played by the agricultural sector in achieving the goal of 10% annual economic growth, described in Kenya's broader country plan 'Vision 2030'.

Despite decades of agricultural extension programs, participatory research approaches, and the constructive changes being undertaken in Kenya to encourage knowledge integration and sharing, the number of people suffering from hunger has risen (KFSSG 2010) and adoption rates of new agricultural technologies remain low. Recent estimates from the FAO (2011) suggest that there are approximately 11 million people suffering from food insecurity in Kenya. This serves as a stark reminder that although it is now recognized that innovative and interdisciplinary approaches are required to solve complex problems (see Ericksen 2008), the processes of knowledge integration and technology adoption are extremely challenging.

According to Cooksey (2011), perspectives on what knowledge is considered to be valuable and innovative can differ greatly between groups, affecting knowledge sharing and contributing to low adoption rates of technologies. Given the important role that the adoption of new agricultural technologies must play in improving food security, as well as the low rates of adoption which currently exist (see Suri 2011), Kenya provides a unique opportunity to better understand the challenging process of integrating knowledge to develop sustainable solutions to food security. This exploratory study aims to identify and better understand the contemporary barriers to knowledge integration for improved agricultural technologies and their adoption by farmers. In doing so, it serves as a starting point for further research into the process of enhancing knowledge integration within the Kenyan agricultural sector,[1] while at the same time re-examining the persistent problem of low adoption rates of agricultural technologies.

[1] This study forms part of a broader exploration of the institutional factors affecting knowledge integration for sustainable food security in Kenya (Hickey and Muhammad 2011).

Methodology

Working within a grounded theory research paradigm (Glaser and Strauss 1967), this study explored the barriers to integrating knowledge for improved technology adoption in the agricultural sector of Kenya, from various perspectives. A grounded theory approach was well suited to this study because it provided a structured process for exploratory research aimed at generating hypotheses and deriving theories from an analysis of the patterns, themes, and categories discovered in the data (Babbie 2001). Combining case study analysis with our grounded theory approach offered an excellent framework for exploring contemporary phenomena within their 'real life' context (Yin 1994). Case study analysis provided a systematic approach to coordinating knowledge, collecting data, analyzing the information, and reporting the results (Miles and Huberman 1984).

Interview data were the main source of evidence for this case study because key informants were well positioned to provide important insights into situations and human affairs, leading to the identification of other relevant sources of evidence to be further followed up (Yin 1994). Also, interviews were useful for learning about events and activities that could not be observed directly. Key informants were able to provide insight on their own views and experiences and also to describe how situations were viewed by others (Taylor and Bogdan 1998). Given the exploratory nature of this study, the line of questioning for all interviews was open-ended, evolved as the study progressed, and was modified with respect to the participants' positions, specializations, etc. However an initial interview outline was developed and agreed upon by a team of researchers. The interview outline was then reviewed by Kenyan colleagues in order to ensure that the line of questioning was appropriate.

Phase I interviews

Referrals from existing contacts were used to build an initial sample of participants (n=7) who acted as knowledgeable key informants. This sample was what Weiss (1994) referred to as a convenience sample. Participants from ASCU (3) were initially included given that one of ASCU's main objectives is the facilitation of communication and integration of knowledge within the agriculture sector. The aim was then to conduct interviews with people in different positions, levels, and relationships to the agricultural sector, in order to generate an overall picture of the contemporary issues surrounding knowledge flow within the sector, particularly regarding the adoption of new agricultural technologies [as recommended by Weiss (1994)]. Consequently, further interviews were conducted with highly knowledgeable members of organizations including the Kenya Ministry of Agriculture (1), the Kenya Agricultural Research Institute (KARI) (1), Mount Kenya University (1), and the European Commission (1).

Potential study participants were contacted via e-mail and provided with a summary of the study and its objective. They were then invited to participate as informants to the study. Written consent to participate in this study was obtained from all informants and they were free to end their commitment to the study at any time before, during, or after the interview. If consent was given to record, interviews were audio recorded and later transcribed. If consent to record was not given then handwritten notes taken during the interview served as transcripts. All interviews occurred over a 2 week period in August 2010. They were conducted in person and varied from 45 min to 1.5 h. Interviews were held in and around Nairobi, Kenya.

Phase II interviews

During Phase I it became increasingly clear that, according to the participants interviewed, a breakdown in knowledge flow and therefore technology transfer was occurring between farmers, the ultimate adopters or non-adopters of new agricultural technologies, and those involved in various stages of the development and implementation of these technologies (such as the participants in Phase I). Therefore, as suggested by Yin (1994) early interviews led to the incorporation of additional evidence in the form of farmers' perspectives. Phase II therefore adjusted the focus of the study towards obtaining the perspectives of farmers.

Convenience sampling (Weiss 1994) was once again chosen, with referrals from existing contacts used to build a sample of knowledgeable informants (n=16). Participants were contacted and invited to participate in one of two group interviews, or focus groups (see Tonkiss 2004). Each focus group consisted of male and female, small-scale to medium-scale farmers from Makueni district, a drought-prone semi-arid region of Kenya where both adoption rates of agricultural technologies and levels of food security remain low. Written consent to participate in this study was obtained from all informants and they were free to end their commitment to the study at any time before, during, or after the focus group. Consent was given to audio record all focus groups. The focus group recordings were then transcribed. The focus groups were held in Wote, Kenya over a 2 day period in May 2011. They were conducted in person by two researchers and a facilitator who also assisted in translation when necessary.

Data analysis

Once the interviews were transcribed, the analytic technique used for data reduction was constant comparison (Glaser and Strauss 1967). Individual data items ("incidents"),

which ranged from a single word to a few pages of text (Merriam 2009), were initially identified based on their relevance to the research question. As they were identified, incidents were tacitly placed into categories. As conflicts arose in the placement of incidents into categories, the properties of these categories gradually became more clearly defined. This led to the development of provisional definitions and provisional rules which determined if a given incident should or should not be included in a given category. This process continued until the majority of incidents were placed into existing categories. As the process progressed, the categories and rules became increasingly explicit, allowing categorization to move gradually from an intuitive process to an explicit process (Grove 1988).

This categorization process, known as coding, allowed for comparisons to be made both within and between data sources. Comparisons within a single data source (an individual interview) allowed for the conceptualization of the central meaning or significance of each data source (Boeije 2002). Comparisons between data sources further aided in conceptualizing the meaning or significance of each data source and additionally made evident certain combinations and patterns of categories, leading to the development of clusters (Boeije 2002). Clustering involved grouping and then conceptualizing categories that had similar patterns or characteristics, and led to a better understanding of the phenomenon (Miles and Huberman 1984). In this way the beginnings of a grounded theory, consisting of categories and hypotheses, which are conceptual links between and among the categories (Merriam 2009), was developed to address the research question.

Results

Categories

Two overriding categories emerged from the interview data: 1) Knowledge flows between those working to develop new agricultural technologies and farmers; and 2) Knowledge integration at the farm level. Within each of these categories there are multiple subcategories which are discussed in more detail below. For a full classification scheme of all categories presented, see Fig. 1.

1) Knowledge flows between those working to develop new agricultural technologies and farmers

Within the agricultural sector, both those working to develop new agricultural technologies and farmers were identified as key actors who need to share knowledge in order to develop practical and integrated solutions to agricultural productivity and food security. From the perspectives of interview participants, the importance of these actors in knowledge sharing was two-fold. Firstly, the knowledge of new agricultural technologies must flow to farmers, who ultimately choose to incorporate the new technology, or not, into their farming practices. Secondly, knowledge must flow from farmers to those involved in technological development so that: 1) the process and subsequent innovations do not conflict with existing norms and practices; and 2) effective existing farming practices can be incorporated into the technological development process and up-scaled. These flows of knowledge between those working to develop new agricultural technologies and farmers were raised in all interviews to varying degrees and constituted a major focus of four of the seven interviews conducted in Phase I and both of the focus groups conducted in Phase II.

1a) Knowledge flow from those working to develop new agricultural technologies to farmers

Study participants identified many ways in which knowledge concerning new agricultural technologies is channeled to farmers. Phase I participants emphasized the use of participatory training demonstrations in the form of workshops, forums, and field days, and also the use of books and pamphlets. As one participant from ASCU summarized,

> And so we've got this agricultural research station that also has adaptive research literally everywhere. They carry out field work and they invite farmers to come and see what they are doing... There are plenty of brochures and books that are written to disseminate information, very many, in English and in Swahili mainly.

However, it was recognized by Phase I participants that these means of disseminating knowledge are not always effective for a number of reasons. One reason identified repeatedly was the way in which information is packaged. When researchers package information it is often in written format, in English, and contains scientific jargon, creating a barrier for many farmers. According to the European Commission participant,

> The packaging itself, the issue of packaging becomes an issue or a challenge because we are having people who have done very well in university, with the PhD and the like, they are packaging information for people who may not have been to formal education. So you find that there is a disjoint.

Another barrier to effectively communicating with farmers was the format of participatory workshops, forums, and

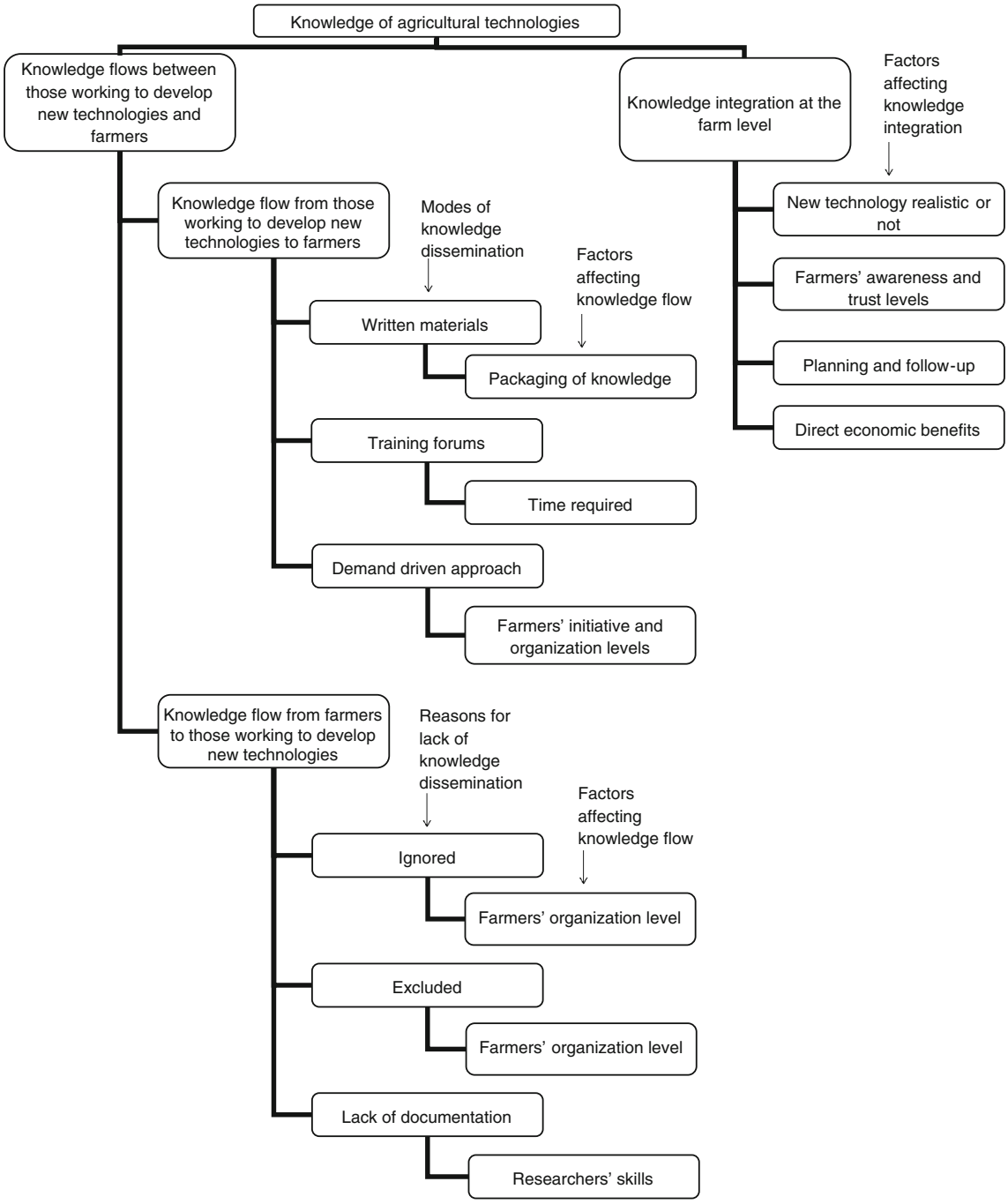

Fig. 1 Emergent categorization scheme from Phase I and Phase II data regarding the flow and integration of knowledge of agricultural technologies. Data incidents have been categorized into increasingly explicit final categories that were then clustered to produce the categorization scheme

field day demonstrations. For example a Phase I participant discussed how the farmer forums can be biased against women, indicating that this stemmed from the fact that women are usually the ones taking care of children. Because they cannot leave the children unattended for days at a time, they are excluded from these events. Furthermore, as was reported with regards to packaging, these formats were said to create a disconnection between farmers and those working to develop agricultural technologies. According to the European Commission participant,

> When we bring a group of farmers to a research station they tend to think they are too junior compared with someone with a PhD… So to me those forums are

> more ritualistic. They are just being done because they are there. But I don't see them being used as tools to implement and that's a big, big bottle-neck.

The farmers who made up the Phase II participants, while also acknowledging the means of knowledge dissemination and barriers already mentioned, emphasized the role of Agricultural Extension Officers (AEOs) in disseminating knowledge to farmers. They collectively agreed that there has been a switch to what they referred to as a 'demand driven' approach to the flow of knowledge about new agricultural technologies from AEOs to farmers. Whereas in the past AEOs would actively seek out farmers to pass on new knowledge concerning agricultural technologies and the policies surrounding them, now farmers are expected to actively seek out AEOs and request the knowledge they desire. The following quote from one farmer summarized this point,

> Before we could see AEOs going to the farmers, but these days it is vice versa. It is you who goes to the AEO's Office to ask for help or anything which you don't understand. But there are not many local farmers who know where the offices are or who have the access to the offices. So the policies don't go down to the farmers the way they are supposed to go.

According to the farmers who participated in our study, this system is not effective in facilitating the flow of knowledge because farmers often do not actively seek out AEOs for solutions to their problems, as touched on above. The result of this approach, according to Phase II participants, is well summed up in the following quote from one of the farmers, *"They used to train people but now you are trying to do research to find out what is wrong with Kenya, why people don't have food, why people are suffering. It is because of lacking proper training to our people"*. The demand driven approach to the dissemination of knowledge represents a change to farming practices and, according to participants, many farmers do not actively participate in this new process for a range of reasons such as: 1) they fear going to the AEO's office, 2) it has not occurred to them to ask about innovative approaches, and 3) they can not specify the exact problem with which they need assistance. By way of summary, one farmer reflected on how Kenyan farmers are accustomed to receiving knowledge about new agricultural technologies,

> I guess the other major problem that we have is that we are so much used to being spoon fed by the government in that every new thing, we expect the government to do it for us… So it has taken very long for us to realize that the government cannot do everything for us… So I guess there is still that lack of information that we can get these things and we should find how we can implement it ourselves, instead of waiting.

A second issue identified with the demand driven approach was that there are so few AEOs. Phase II participants collectively agreed that often when famers go to seek out the AEOs for information, the AEOs are out of the office or too busy. There are simply not enough AEOs to deal with all of the farmers individual problems in their locality. For example, one participant said in frustration that, "*You come from far, you go to the office and you will not find the extension worker*". Therefore, there was agreement that farmers would benefit by organizing themselves into common interest groups, which already occurs to some extent. According to one participant,

> What I have seen working a lot these days are the common interest groups because in those groups actually they even source the AEO so that they can come and talk to them about a similar issue or a similar crop they are interested in… The groups are helping the whole community in the problem to the flow of information to the people.

The farmer participants of Phase II agreed that by coming together into common interest groups famers can better utilize the AEOs and gain the knowledge they desire regarding agricultural technologies. This allows the few AEOs to either address a group regarding an issue or to address an individual member of a group and have them spread the information throughout the community. This option was also thought to be beneficial by participants as it encourages individual farmers to take initiative when it comes to sharing knowledge regarding new agricultural technologies within their communities, rather than waiting for the AEOs to do it for them. One farmer participant emphasized the importance of this when she said, *"Because it will make people now start thinking they can do things for themselves. So I think what we can do is to look for some people who can support capacity building the communities. Giving them this knowledge so that now they can start thinking they can do things for themselves"*.

> 1b) Knowledge flow from farmers to those working to develop new agricultural technologies

The sharing of knowledge in the other direction, from farmers to those working to develop new agricultural technologies was perceived by study participants as a much newer concept in Kenya, despite decades of academic rhetoric surrounding participatory approaches.

Phase I participants felt that more recently measures have been put in place to facilitate the sharing of knowledge in this direction. The importance of farmers' knowledge, according to the participant from the Mount Kenya University, has been recognized by funding agencies. He reported that in order to be awarded funding for research, it has become essential to incorporate farmers' knowledge into the project. According to a participant from ASCU,

> For a long time it was top down. You know the scientists, the universities had all the research they were doing and then they brought it down. But I think they have also realized that it is not working or it has not been working well. And now they are going back to the farmers and asking… what they want. There's that two way communication, yes, it's there.

However, farmer participants from Phase II of the study did not think that the flow of knowledge from farmers to those working to develop new agricultural technologies is being facilitated. They collectively felt that they are often ignored. For example one farmer gave this example concerning the introduction of a new agricultural technology involving millet, *"We exchange ideas with them. They may for example tell us, let us grow millet and the farmers say we don't like to eat millet. Then what do you think we should grow. But they insist millet because it is drought resistant"*. They also reported that it is often only large-scale farmers who are invited to participatory knowledge sharing forums of this nature. According to one farmer,

> They involve big farmers, those who have got plantations or big farming and you know so many people here are peasants. That's where the problem lies because so many farmers are peasant farmers and they are not well involved in policy making. Actually, they just come and tell them what to do. They don't involve them.

Participants from Phase II identified the lack of organization of farmers into groups as a barrier to the flow of knowledge from peasant farmers to those involved in the development of new agricultural technologies and an explanation as to why peasant farmers are ignored or excluded from participatory forums. They collectively agreed that coming together in common interest groups would give them a higher capacity to advocate their demands and share their knowledge. One of the participating farmers summed this up when speaking of farmers' influence on technological development and policies surrounding it,

> Very little influence let me say, very little influence because the levels of advocacy in this country are still yet to improve. Farmers are yet to organize themselves into dealing with issues that are really their problems. And to organize them into a group that knows what it really demands and wants would take a bit of time. This is why the problem is there. I have a problem, he has a problem, she has a problem but we never come together to look at our problems.

The lack of documentation of farmers' knowledge was seen as a barrier by Phase I participants. Also, it was pointed out that although the importance of farmers' knowledge is now being recognized, researchers are often not equipped with the skills to gain this knowledge. For example the participant from the European Commission expressed this point as follows, *"What I have seen to be the weakness is most researchers… are much more trained in skills, but these skills of extracting information from the farmers, branding skills, motivation skills, it's a technical discipline by itself"*.

Just as researchers do not always have the skills to effectively package knowledge to be shared with farmers, also they often do not have the skills to collect the knowledge that they desire from farmers. This is tied into another problem discussed by a participant from KARI; that farmers have a long history of involvement with researchers in Kenya and have learned to, *"Tell researchers what they want to hear"*. Here he was describing a situation in which researchers may be obtaining knowledge from farmers however it may not be the desired knowledge.

2) Knowledge integration at the farm level

Based on the interviews conducted in this study, the above provided a discussion of knowledge sharing between two groups. However, it was evident, particularly from the perspectives of participants in Phase II that knowledge integration, the actual modification of one body of knowledge by combining it with another body of knowledge, occurs at the farm or household level. Therefore the process of household decision-making integrates farmers' current agricultural practices with newly gained knowledge surrounding agricultural technologies. This new knowledge may be implemented to varying degrees, or may not be implemented at all, for a variety of reasons. However, multiple participants from Phase I identified conflict between existing norms and realities with new knowledge as a barrier to the adoption of new agricultural technologies. As described by the European Commission participant, *"That delays the adoption because when you take the so-called research information, it confronts the traditional knowledge which is generated"*. Again, this was captured when the same participant stated, *"You may bring very modern methods but they may be so expensive and not compatible"*.

An example of this situation was given by the participant from the Mount Kenya University. He explained a common scenario in which a new seed variety was developed and disseminated but not adopted into practice because of the fertilizer requirements. Often new seed varieties require fertilizer levels that are outside the economic capacity of farmers. However, farmer participants from Phase II thought that although new technologies are often expensive, the issue of non-adoption has more to do with ignorance and lack of trust than costs. One farmer participant stated,

> Our people are ignorant, peasant farmers are ignorant of the advice they are given by these AEOs. If for example they are told to plant certified seeds. They say no they are expensive. Of course there is poverty, but when we buy certified seeds they do well and better than our traditional maize or seeds.

This summarizes the perspective that if farmers were better informed about the potential benefits of new agricultural technologies, they may be more likely to find a way to afford them. Furthermore, when farmers are informed of the potential benefits, there remains a lack of trust that the new technology will perform as it is said to. For example, another farmer participant stated, *"At household level, people go back to their homes. They are being fed with information. Then they sit down and they decide if it is millet let us plant just a little of it. And they plant a little of it to see if it will work as they are being taught".* These two factors contribute to the lack of adoption of new agricultural technologies and their integration into farming practices.

Another issue raised during Phase II was the lack of planning and follow-up surrounding new agricultural technologies and their introductions into communities. According to participants, when new technologies are introduced to farmers there are often initial problems such as pest infestations. Participants from Phase II felt that these types of problems should be anticipated and planned for and that follow-up measures should be undertaken in order to correct problems when they do arise. If this does not occur participants indicated that farmers will not only lose trust in the new technology and abandon it, but will also be more apprehensive in their decisions regarding the adoption of future technologies which may be introduced. One farmer gave the following example,

> The impact on households of these national policies actually there are no follow-ups. Like whenever a variety is brought to the farmers like recently we had the gadam sorghum, many people planted that sorghum but then it was invaded by bugs. And the policies, nobody could come up with any solution with what could be done with the bugs. So the bugs came and they destroyed everything. Now you cannot tell a farmer to plant that sorghum because the bugs will come and they will be left with nothing.

Another factor that came up in multiple interviews during Phase I was that farmers were receiving what was referred to as 'dry information'. According to the participant from Mount Kenya University, although a researcher may have had the time to conceptualize links between the knowledge they are sharing and the priorities of the farmers, the farmers require direct benefits. According to him,

> They are interested in direct benefits. So there is that issue that quite often research may not have a product for farmers… It is very difficult sometimes to know how to deal with it. One thing is ensuring that farmers especially see the economic benefit of your research, the actual benefit… They say we are wasting time. We must have a real end product which research sometimes does not have. So I think we should identify research that is of economic benefit.

All participants from Phase II agreed that in order for farmers to integrate knowledge of new agricultural technologies into existing farming practices they must see the direct economic benefits. This included not only increased agricultural productivity but also means of processing, storing, and selling these agricultural products. The farmer participants saw the need for knowledge surrounding new agricultural technologies to be accompanied by knowledge surrounding markets and pricing. One farmer expressed this when saying, *"We were shown by the agricultural people how to peel these mangos, you have got the technology. So what? Where is he going to take it? But like he had said if we could collectively join as a group then we could advance that technology into a plant".* This point also echoes the earlier-mentioned consensus that forming groups is beneficial for famers.

Discussion

This exploratory study started off with a focus on identifying and better understanding the barriers to integrating knowledge with regards to agricultural technologies and their adoption. The study began by interviewing members of ASCU, given their role in the facilitation of knowledge integration from a sector-wide perspective. The intention behind this starting point was to look at an issue often examined through the lens of agricultural extension and farmer participation (see for example Sutherland et al. 1999), from the broader perspective of those who work in the field of knowledge integration more generally. As

evident in the emergent categories, the perspectives of Phase I participants indicated that despite the long history of agricultural extension efforts and various forms of participation, these approaches are not always successful in facilitating knowledge integration between farmers and those involved in the development of new technologies due to a number of barriers.

The term 'participation' itself covers a broad array of approaches ranging from more complete forms, for example the co-production of knowledge involving both formal researchers and farmers, to forms in which the flow of knowledge is intended from the onset to be mostly unidirectional with a small amount of farmer input to meet project objectives or lend legitimacy to a project. There have been various typologies of participation developed (see for example, Pretty 1995; White 1996) which suggest that at the high end of the participation spectrum the outcome is empowerment of participants, while at the low end it is essentially only the pretence of participation. Phase II participants indicated that often they do not feel their knowledge is valued or considered seriously, suggesting their experiences with participation have been closer to the low end of the spectrum. Another factor which affects participation outcomes is who participates (Cornwall 2008). Participants in this study indicated that not all farmers feel represented in participatory forums, particularly small-scale farmers and women.

Types of participation which approach the low end of the participation spectrum as well as the exclusion of certain participants represent barriers to knowledge integration and potentially impede the adoption of agricultural technologies. It is now being acknowledged that in order to move past the earlier ideology of the more participation the better, participation must be critically examined and optimized for a given location and objective, rather than simply maximized (Neef and Neubert 2011). The barriers identified in this study support the idea that participation needs to be critically examined and potentially restructured to better meet the objective of increasing knowledge integration.

Furthermore, many of the barriers to knowledge integration identified by Phase I participants were more specifically barriers to the early stages of knowledge integration, namely communicating and sharing knowledge between groups. For example the way in which knowledge is packaged prevents knowledge from being shared effectively. However this says nothing about issues or barriers that may arise when knowledge coming from those involved in developing new agricultural technologies is actually combined with or modified by traditional farmers' knowledge, or vice versa. This further suggests that participation is not typically near the high end of the spectrum where actual co-production of knowledge occurs. The scenario that emerged was one in which knowledge integration does not occur between these two groups at all, but rather knowledge is channeled from those involved in the development of new technologies to farmers and also farmers' knowledge is sought out by researchers, with knowledge flow in both directions having multiple barriers, see Fig. 2.

Despite the barriers identified, some knowledge is successfully transferred and knowledge integration does eventually occur at some level, as farmers do use a mixture of new agricultural technologies and traditional farming practices. The mixture of new agricultural technologies and traditional farming practices can be considered an indicator of knowledge integration because it represents the modification of an existing body of knowledge by another body of knowledge. Therefore the hypothesis emerged that it is at either the level of the farm and/or the level of technology development where knowledge about new agricultural technologies is integrated with traditional farming practices, rather than in participatory forums, which appear to be more for the purpose of sharing knowledge.

To explore this hypothesis further, Phase II included the perspectives of farmers to gain a better understanding of what they identify as barriers to knowledge integration regarding agricultural technologies and their adoption. As in Phase I, most of the categories that emerged were barriers to knowledge sharing rather than integration. However, the results from both Phase I and Phase II support the hypothesis that knowledge integration does occur at the farm or household level where farmers take what new knowledge they have gained and decide how to incorporate it into their usual farming practices, or not incorporate it at all. One of the key hindrances to this process, as discussed above, is that there are multiple barriers to the flow of knowledge to farmers and therefore they are left to make decisions in relative ignorance, without access to the full body of existing knowledge.

A promising solution to these barriers, based on the results of this study, is increasing farmers' levels of organization within communities. The current perception of the failure of the demand driven approach to knowledge dissemination by AEOs may potentially be altered if farmers' can increasingly organize themselves into common interest groups. In groups, farmers may be able to better articulate specific problems and have more influence in demanding solutions. This is supported by other work done in semi-arid Kenya, suggesting that farmer groups are the most effective way to diffuse innovative knowledge to peasant farmers and also contribute to the spread of innovation (Darr and Pretzsch 2008). Overall, groups can be considered important players in the dissemination of knowledge to small-scale farmers (Davis et al. 2011). Farmer groups play an important role in the agricultural sectors of many developed countries as

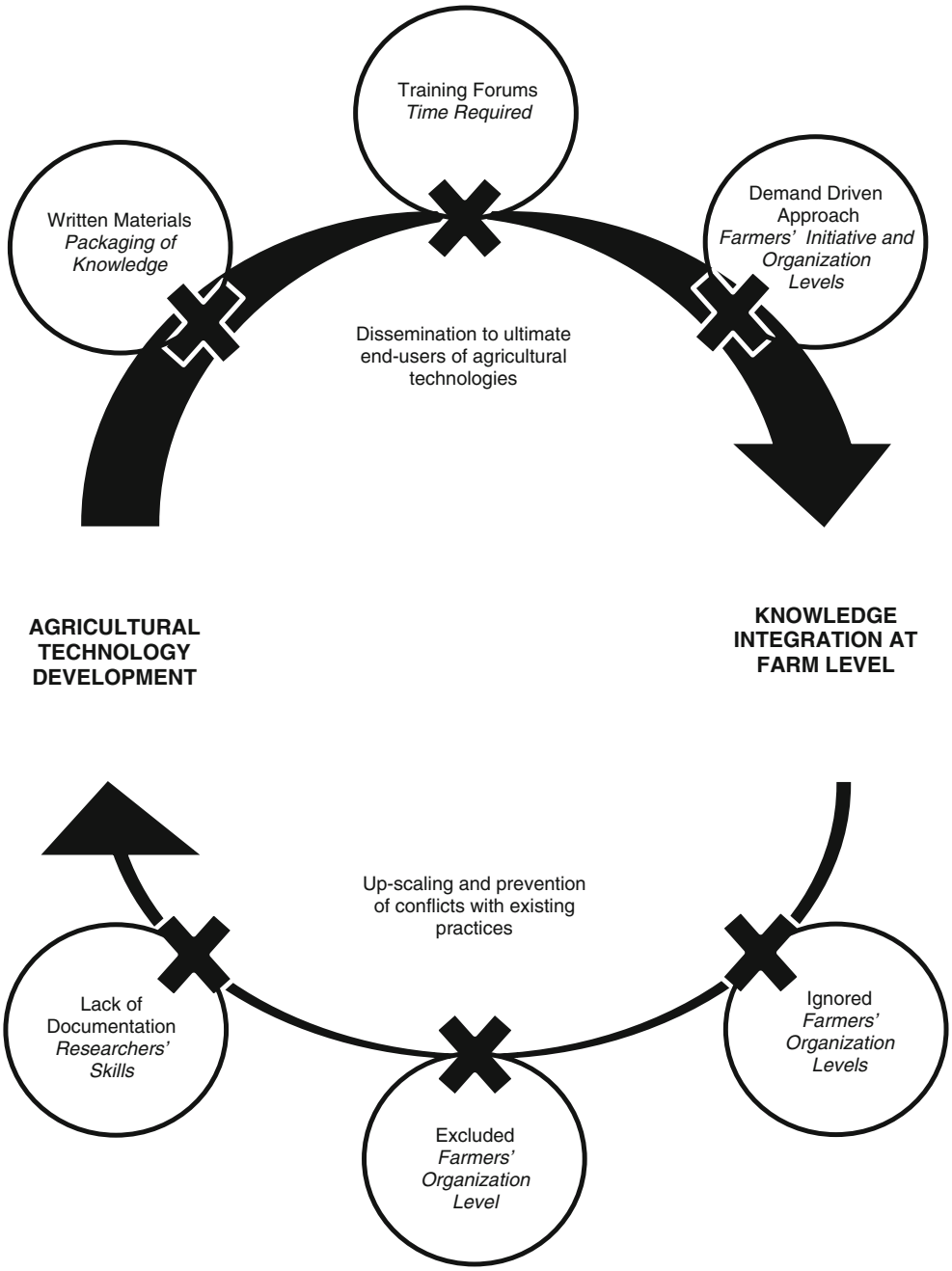

Fig. 2 Flows of knowledge of agricultural technologies depicted as connections between emergent categories. Knowledge flows are represented by arrows and arrow width represents the perceived level of knowledge transmission, with a thicker arrow representing a higher amount of knowledge transfer. Xs represent perceived barriers to the flows of knowledge. The circles provide details about each barrier

well. For example, in Australia farmer groups are highly influential in disseminating knowledge to other farmers, who were found to be more willing to pay for research information when the knowledge came from a local group (Llewellyn 2007). Furthermore, common interest groups have more power to make their voices heard than individual farmers and therefore may also be able to decrease the problem of small-scale farmers' knowledge being ignored or excluded from the development process of agricultural technologies.

Additional barriers to the integration of new and traditional agricultural technologies at the farm level also emerged. Trust in the relationship between farmers and those involved in the development of agricultural technologies and the policies surrounding them may be a key factor in increasing the integration of new technologies with existing practices. Consistent with the idea that levels of trust and adoption rates of new technologies are linked, Todt (2011) reports that perceptions of the

uncertainty of adequate management of technology, as well as lack of trust and legitimacy in decision-making, adversely affect public acceptance of the governance of technology. Increasing farmers' trust that the technology will do what is being claimed, and also increasing trust that if problems arise there has been some form of planning for follow-ups to correct or alleviate the problems (thus mitigating potential risks) could improve adoption rates. This may involve agricultural policies which make potential risk reports public domain and follow-ups mandatory.

Increased planning and follow-ups to newly introduced agricultural technologies also have the potential to promote the interdisciplinary and holistic approach to food security now being called for (see Ericksen 2008; Stringer 2009). As problems are identified and arise, ranging from pest management and fertilizer requirements to the need for processing plants and markets, planning for, and solving, these problems will require a range of specialists to work together in good faith on genuinely integrated solutions.

Future Needs

In seeking to identify some of the barriers associated with knowledge integration for improving the adoption of new agricultural technologies in Kenya, this study has also highlighted gaps in knowledge which need to be explored through further research. The potential role of participatory research approaches and participatory forums in facilitating knowledge integration between those involved in developing new agricultural technologies and farmers needs to be critically examined in the context of semi-arid Kenya. The development of a location-specific framework for farmer participation could contribute to the strategic optimization of knowledge integration through participation.

Our study has begun exploring the process of knowledge integration at the farm or household decision-making level, however this process remains to be examined in greater depth. Levels of community organization among farmers, and patterns of farmers' interactions more generally, need to be further explored as potentially influential factors affecting levels of knowledge integration. Levels of trust between farmers and those involved in the development of agricultural technology, as well as policy makers, also need to be explored in relation to levels of knowledge integration. Furthermore, additional location-specific attributes of the semi-arid region of Kenya, which are influential in household decision making regarding the adoption of technology, need to be determined. The process of knowledge integration at the technology development level, which was not addressed in this study, requires further empirical investigation in order to develop a more complete understanding of the system. Finally, the policy implications of suggestions such as mandatory public risk assessment reports, follow-ups to newly introduced agricultural technologies, and location-specific frameworks for participation, also require further exploration.

Conclusion

This study, using key informant interviews and focus groups, sought to further our understanding of the barriers to integrating knowledge with regards to agricultural technologies and their adoption. This was completed with a view to informing further research into the institutional factors affecting food security outcomes in Kenya. Using an exploratory research design, we have identified a number of barriers to the flow of knowledge to and from those working to develop new agricultural technologies and farmers. We have also suggested that knowledge integration generally occurs at the farm or household level, rather than in participatory research forums, which serve more as knowledge sharing forums. The results of this study suggest a potential link between farmers' levels of community organization and levels of trust with levels of knowledge integration surrounding agricultural technologies and their adoption. Further, the results suggest that increasing the planning and follow-up of newly introduced agricultural technologies has the potential to encourage interdisciplinary approaches and improve food security outcomes.

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