Learning about success and failure - A systems perspective on Food Security Innovation processes for small-scale farmers in Tanzania

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Abstract

Food insecurity is still relevant for 16,8 mill. Tanzanians (FAO, 2015). Introduction of e.g. innovative techniques is a widely accepted approach to food insecurity (e.g. Alarcon, 2011). Causes of food insecurity are multi-level and multi-issue evolving e.g. from interplays of poverty, insufficient awareness, environmental degradation or price instabilities (Ashley, 2016).

We argue that to successfully implement and disseminate food security innovations, an adequate understanding of the context is needed. So far, innovation system approaches (used as analytical frameworks) have proven to be appropriate tools to study these multi-level and multi-issue problems in a holistic way (Hall, 2003).

In this context, we focus on food security innovations for small-scale farmers in two Tanzanian regions. Based on empirical research, the paper presents findings on:

1) food security innovation processes within the study area.
2) selected food security innovation examples from which we attempt to derive the initial conditions for successful dissemination.

Methodologically, an explorative mixed-methods approach was applied starting with a literature review and then fieldwork including semi-structured expert interviews at national and regional levels and farmer group discussions at the local level.

Preliminary results from system analysis show that the ability of farmer groups to connect to other system-levels and actors would be a critical success factor, but knowledge flows occur when there are levels of trust on the horizontal level. For the local level, knowledge sharing systems are an important condition to enable dissemination processes.

1. Introduction

Food security is a prevailing challenge in Tanzania, and it has been addressed by numerous projects conducted by universities, NGOs and governments in many ways, as the addressing of the causes of food insecurity can really differ from case to case. This contribution has developed from a research project*, which addresses food security by applying a people centered approach to two case study sites (CCS) in rural Tanzania. It is designed to identify upgrading food security strategies/ or innovations along food value chains (FVC) on a local level (Graef et al.: 2014). The causes of in Tanzania food insecurity are low productivity, lack of agricultural inputs, high rural poverty, low adoption of innovations, lack of markets and weak infrastructure- to mention a few (Ashley, 2016).

Taking into account the conclusions by other authors, innovations (technical, social, process) can help to alleviate food security problems (Ashley, 2016). There is no overall definition for the term innovation, therefore here we use a definition that originates from a majority world context: *"the process of introducing something new and the new thing itself"* (Dyamett, 2012). However, regardless of how the definition of the term is framed, it can be stressed that anything that is new to the user/ adopter is an innovation (Rogers, 2003). This paper addresses the concern that not enough is known about food security innovation processes in general, such as why only a small percentage of innovation directed at food security is actually taken up and implemented on a local level (Hounkonnou et al. 2012) and more specifically -regarding the case study site - what conditions influence people to take decisions of adoption or rejection. Being given the task to inform a project dissemination strategy, that was inclusive and legitimate on a village level (Hendricks, 2010), the authors wanted first to shed light on the setting in which food security innovation processes take place in the study area. From there, a way forward to develop possible conditions to make these food security innovations more successful and then to enhance dissemination processes is discussed.

Agriculture is a mainstay in Tanzania's economy, contributing more than 30 % of the GDP. In contrast, across Africa, the average contribution of agriculture to GDP is around 20 %. More than 80 % of the Tanzanian population depends on agricultural production for their living. Regardless of the importance of agriculture to the economy, the reinvestment in the sector is truly very low, both compared to the importance of the sector to the country and by international standards (Diyamett, et al. 2012). Therefore, in Tanzania, poverty alleviation and food security programs have been integral parts of national policy for more than 30 years. Due to several shifts in policy, no long term strategy has been drafted (Haug and Hella, 2013). Another challenge to formulating a coherent strategy is the aforementioned manifold causes of food insecurity. In 2014, almost 34 % of the population (17 mill.) suffered differing degrees of food insecurity. Geographical regions are affected by different degrees: whereas between 50 and 85 % of people in the more semi-arid regions like Dodoma or Singida suffer increasingly from food insecurity problems, the more semi-humid regions like Morogoro or Tanga have reduced rates of 10 - 20 %. The case study sites for this research include both; Morogoro is a semi-humid area. The main crops grown in this area are maize, sorghum and rice. The precipitation is between 600-800 mm. On the contrary, the other case study area, Dodoma, is a semi-arid area, based on sorghum and millet and a strong involvement of livestock. The annual precipitation in the Dodoma region is between 350 – 500 mm.

The next chapter presents the analytical framework used. The methods section will elaborate on the selected methods including literature review, semi-structured expert interviews and farmer group discussions. Finally, the results and discussion section will introduce results from the aforementioned methods on selected aspects of innovation and will discuss possible consequences for dissemination.

2. Approaching Food Security from an innovation systems perspective

As the causes of food insecurity are manifold and cannot be traced back to one aspect, the solutions also need to be manifold and specific. For innovative solutions that address e.g. the right levels, actors or knowledge gaps, a thorough analysis of the context is needed. In this regard, system frameworks are recognized to be suitable tools – in the sense of analytical frameworks- to study agricultural innovations on different levels; both in this case and in the majority world (Hall, 2003). The literature mentions different approaches: the

National Agriculture and Research System (NARS) approaches assume for instance that all knowledge comes from research, leaving out farmers from innovation processes and are therefore exclusive in this regard. Most widely used in the majority world is the Agricultural Knowledge and Information System (AKIS), also including intermediate structures and farmers as important actors (Assefa et al., 2009; Engel, 1997). Next, on an analytical level, the Agricultural Innovation System (AIS) approach studies the complex relationships that emerge from such systems (Assefa et al., 2009). These system approaches also influence decisions of policy makers, scholars or institutions. However, the sectoral innovation system approach as suggested by Malerba (2002, 2004) provides us with a suitable conceptual framework for the description of innovation systems, because it offers an opportunity to study the environment food security innovation processes are found in on different system levels and according to different (so called) system elements (Fig.1). Relevant levels identified are: the national level, as major food security and governance policies are decided here. Policy is a key actor, as food security is ranked as an issue of high importance which needs national support in TZ. Furthermore the regional / district level is involved, as the project operates on a regional level,entailing two regions with rather different characteristics in terms of culture, religion, natural conditions or climate. The project addresses four villages in total, two in Dodoma and two in Morogoro, therefore this level is included. Finally, the farmer group (FG) level is where innovative solutions are implemented and tested. This is thus the starting point for dissemination of the respective strategies and solutions.

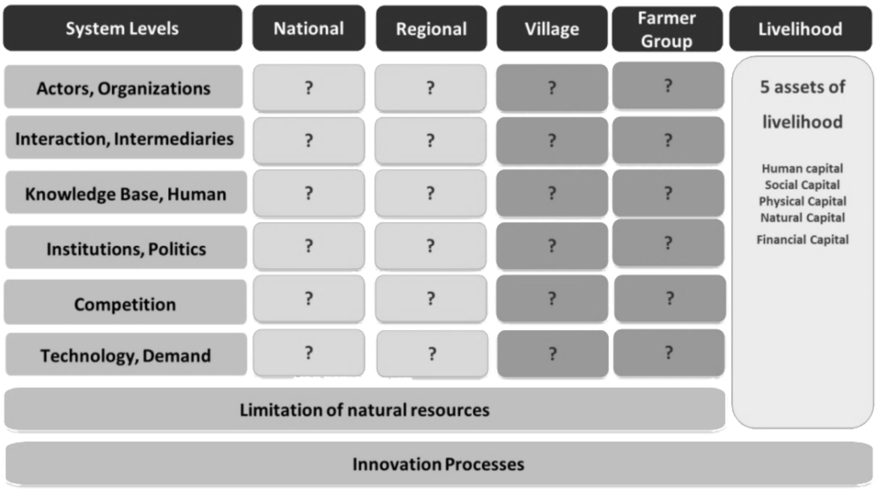

*Figure **Error! No sequence specified.** Analytical framework to study food security innovations (adapted by: Malerba 2002, Bokelmann et al. 2012)*

In the following, the system elements are briefly described:

Actors and Organizations: Characteristics of existing organizations and actors are described. The element contains e.g.: individuals/groups of individuals, enterprises, universities, financial institutions, local authorities, training institutions. Agents and organizations can be on different organizational levels.

Interaction and Intermediaries: Intermediaries are networks, extension services specific intermediaries of agricultural /food systems. E.g. extension has to adapt to different dimensions of challenges: to answer problems associated with changing social and environmental conditions, to cope with new information technologies or changing structures and finally they have to assume their role as translator and negotiator between different actors.

Knowledge Base and human capital: This element includes indigenous, sector specific or cross-sectoral knowledge bases within the system. It also includes mobility of labor, spreading of sector-specific knowledge, learning processes and knowledge access, training and education.

Institutions and politics: Describes implicit and explicit rules, standard behaviors and routines for interaction between the actors and/or organizations within the specific innovation system. Actors within the innovation system are mainly influenced by the legal framework. Describes the impact of specific policies on food security innovation processes.

Technology and demand: Analysis of existing technologies, trends (products and services). Demand can give information on how the sector will develop in future and which central developments-and future potential - can be awaited.

Natural resources: The limitation of natural resources and effects of climate change are among the main reasons for food insecurity in Tanzania. This is therefore taken up as an additional system element.

Competition: The competitive situation in the innovation field in national and international is described in this analysis element.

Innovation processes: This system element was added to the analytical framework in order to gain knowledge about how innovation processes emerge in specific settings. This element adds the process perspective.

Literature provides the important insight that the type of innovation and innovation activities can differ greatly among sectors (Malerba, 2005). From that, we hypothesize that different types of innovations and different types of innovation activities during an innovation process require different functions from an innovation system. Empirical information on the type of innovation and the attributes of an innovation might provide more specific explanations for barriers in an innovations system e.g. a specific characteristic might call for a specific actor or knowledge within the innovation system the developer or the user needs to implement the innovation. Conceptual attributes of innovations are provided in the work of Rogers (2003) which link these attributes to the user perspective and the process of diffusion. Our overall research question is, what explanations for the enabling or hindering of food security innovations we can obtain through linking the meta-perspective on innovation systems with the study of innovation attributes during innovation processes. If an actor/ innovation system function is missing something which an innovation would require to be further developed/ disseminated, this probably has an impact on the innovation process and finally on the outcome in terms of food security.

Attributes of innovations are (Rogers 2003): Relative advantage, Compatibility, Complexity, Flexibility and Observability. It is important to note that in contrast to the innovation system approach, this attributes are all based on the users' perspective, while innovation system research focuses on the entrepreneur/ a company's perspective.

A **relative advantage** perceived by farmers can be expressed as both an economic advantage and social prestige (Rogers, 2003: 229) or,in the case of our research, as the improved quality of a product or living conditions. **Compatibility** refers to the consistency with pre-existing values, norms or practices (Rogers, 2003: 240). This is based on the assumption that the higher the compatibility is, the less uncertainty and risk is the users perceive (Rogers, 2003). Compatibility is (and can only be) assessed by the adopters in comparison to previous practice, knowledge or ideas. Therefore, local knowledge should be taken into consideration when introducing an innovation into a local context. It can also refer back to the innovation system. If the system only provides technologies that are too complex or not compatible, they are likely to be rejected. **Complexity** refers to the ability of the adopter to understand and use an innovation in an everyday setting (ibid. 257). High complexity can be a high barrier for individuals and make them reject a measure. **Trialability** tells us something about how possible it is for the user to change or improve the innovation. This attribute is important where dissemination is the major aim. Rogers also stresses that a higher degree of trialability can reduce the perception that an innovation is risky or uncertain. **Observability** means that the results, the outcome of an innovation, are visible for others. The higher the degree of observability, the more likely the innovation be adopted.

Thus, considering the attributes of an innovation as an additional analytical element in empirical innovation system research can provide explanatory information as to why some innovation processes are more successful than others or why some innovations are preferred by the users. Attributes can also refer back to the analytical frame and the broader setting in which innovation processes take place.

3. Methods

Some theories or frameworks suggest - or even require - methodology. However, innovation system frameworks do not predefine specific methods. They mainly provide empirically developed heuristics for a way to structure thinking and embed the empirical work into an analytical frame. A structuring, analytical lens is used here. The literature states that the methods still have to be developed (Assefa, 2009; Spielmann, 2009). For the Tanzanian case, so far not much is known on the nature of food security innovation processes in the selected case study sites; and there is certainly a lack of written information. To give a comprehensive overview of the state of FS innovations in the study regions, an exploratory approach is needed, in order to access useful information on the different system levels.

On a *national and regional* level explicit (written) information is accessible, whereas on a village, farmer group (FG) or individual level, this information is lacking. An intensive literature review was thus carried out, including policy briefs, scientific articles or NGO reports. Additionally, semi- structured expert[1] interviews were conducted to answer open questions from the literature review and get an initial insight into the system.

On *a local /farmer group level*, two field phases have taken place so far. The *first field phase* in 2015 aimed to understand what food security innovation processes there required and to understand the practices of farmer groups facing food insecurity. In this phase, three farmer groups from outside the project were interviewed because project farmer groups had just been founded and had not yet experienced any innovation processes . The groups worked on different innovative solutions including poultry keeping, machinery and saving and credit / rice growing. The groups interviewed were real farmer groups (see Przyborski and Wohlrab – Sahr, 2014 and Lamnek, 1998) that had either established themselves or were formed by MVIWATA (which is the farmers' association) .They had added more activities like rice growing later by themselves.

The *second field phase* (February / March 2016) was based on the results from the first phase and tried to identify the initial conditions required to arrive at successful food security innovation processes. Twelve farmer groups were interviewed, nine of them were formed as part of the project activities and three groups were established outside the project groups. Again, the groups selected from outside the project worked on similar innovation examples tothe project groups. One major aim during the second phase was to anticipate problems that project based FG could possibly face once the project was over. Learning how other groups dealt with certain problems was therefore a major motivation to include the outside groups. New adopters of certain innovation examples (e.g. kitchen gardens or improved cooking stoves, machines…) as well as project group dropouts were also considered in the research.

4. Results and Discussion

4.1 Results from system analysis.

The results section will present results from different methods jointly. The structure and focus is on three selected system elements. In the positioning of the results from the field, we will refer back to literature if it helps with comprehension. Here the system elements "interaction and intermediaries", "knowledge base and human capital", as well as "innovation processes" proved to be most relevant with regard to uptake of innovation as well as likeliness of dissemination. The results section attempts to give a glimpse of how the different system elements and levels relate to one another and influence food security innovation processes.

Interaction and intermediaries

Literature shows that the agricultural extension system, as both an important intermediary in the system and link to the farmers is still mainly provided by the government, which has been withdrawing the financial support necessary for this system to work properly (Temu et al., undated). This is in contrast with the fact that the regions have become powerful entities after the decentralization process in the 80ies, and more responsibilities have been handed over to region and district levels since the 90ies (Haug and Hella, 2013). The literature supports the findings from interviews stressing low reinvestment rates in agricultural innovation, research and extension (e.g. Diyamett et al., 20112). *Farmer groups* have thus become more important in dissemination and knowledge sharing processes (Barham and Chitemi, 2009) as the extension services often fail to work. Literature suggests that smaller FG which hold shared values and norms, and have stronger ties to outside organizations and actors, are more successful than others (Agrawal, 2001).

[1] experts are persons who have: relevant knowledge of the FS system or a specific system element

Results from *interviews* consistently show that the *agricultural extension system* is still an important intermediary between science and farmers. On the one hand, it has a clear mandate and mission to act as a link between system levels and actors; but on the other hand, it faces the challenge of drastic underfinancing for many years (Interview #2). In TZ, the needs of extension services generally mismatches the number of available personnel: the extension officer to farmer ratio is documented to be at least 1:700 (interview # 2). Some advisers mentioned that they have no transportation vehicles, making it impossible for them to supervise all farmers in their very widespread catchment areas. The experts interviewed evaluated the present situation as follows: coverage of services and availability of funding decreases from the higher (national) to the lower (farmer) levels. In short, availability of funding, equipment and human resources on the target level (farmer level) has decreased to approximately 30 % of total needs (interview #2). On the extensionist` side, a high fluctuation of extension workers was reported. This was due to bad or irregular payments and complicated working conditions. Due to these facts, both government officials and NGOs were not perceived as trustworthy and their activities were evaluated as *"to be not sustainable for the farmers"* (FG #1).
The system analysis revealed the following *discussion* points: firstly, the aim of extension services to be intermediaries and kick-starters of innovation is no longer reflected in service numbers, which show low reinvestment rates in agricultural innovation, research and extension (e.g. Diyamett et al., 20112) and a low rate of integration for farmers in everyday decision making processes , *"there is no link"* (Interview #2). Rogers (2003: 254) calls this problem an "empty vessels fallacy", when innovators and actors assume that the potential users (here: farmers) have little or no experience to contribute to a problem and no relationship to a new idea.
The inclusiveness of farmer groups also has its limitations, as farmer group interviews revealed that FGs have high entry barriers for their members (member fees etc.) and can therefore exclude certain individual farmers who do not fulfill these requirements, as they often do not have the financial and human resources for their activities.

Additionally, *literature* mentions *innovation platforms (IPs)* as a tool which is often supported. This aims to be a means of coordinating innovation activities (Spielmann, 2009). These platforms have been criticized for not being appropriate and not being tested sufficiently in real life settings. So far, they do not represent all the steps in a value chain and can be very exclusive when it comes to farmer involvement (Nederlof et al., 2011). On the regional and local levels, *empirical findings* support literature and specify that "job descriptions" for innovation platform workers are unclear and stakeholders are not carefully selected, weakening the effective outcome of an intervention with such tools (Interview # 8 and 2). Thus it can be *discussed*, that the lack of success of interaction activities can often be traced back to the time and/ or resources factors: NGOs such as MVIWATA (National Network of Small-Scale Farmers Groups in Tanzania) and international NGOs often show a short term or project based involvement in the villages (Interview #2).
As a consequence, on a local scale, the interaction and communication processes between levels are hindered due to restrictions in funding and lack of trust. The task of feeding information back and forth between levels is not properly carried out either. The results from the system element "knowledge base and human capital" which complement the results on the "interaction and intermediaries", fit in well here and follow below.

Knowledge base and human capital

Results from *literature* show that a number of actors on different system levels express a high demand for specific information and knowledge (e.g. Mwalukasa, 2013). As is explained below, this contradicts with knowledge sharing routines. There are knowledge flows from the national / regional levels down to the local level, but presenting this knowledge in written form often creates insurmountable obstacles if the local population want to assess this knowledge by themselves. This is also confirmed by literature (Eidt et al., 2008). Whereas there is little evidence that knowledge transfers from the local to the district or national level (Mwalukasa, 2013).
Adding to this, *empirical results* from almost all farmer groups consistently show that even the transmission of knowledge between relevant actors in the system is disturbed e.g. due to lack resources which constitute a

major obstacle to unimpeded knowledge exchange between levels. Reverse knowledge flows between the farmer level and the regional/district level are often interrupted(Interview #2). This leads to a situation where two separated spheres of knowledge appear. Fig. 2 is an attempt to illustrate this; it displays the shared perception on knowledge sharing mechanisms by farmers and experts with regard to food security innovation processes. They report that knowledge exchange happens horizontally. Furthermore, interaction between farmers and official actors is often not participatory, resulting in the fact that local knowledge systems and traditional solution pathways are still disregarded; this was particularly stressed during the interviews (#1, 2, 4).

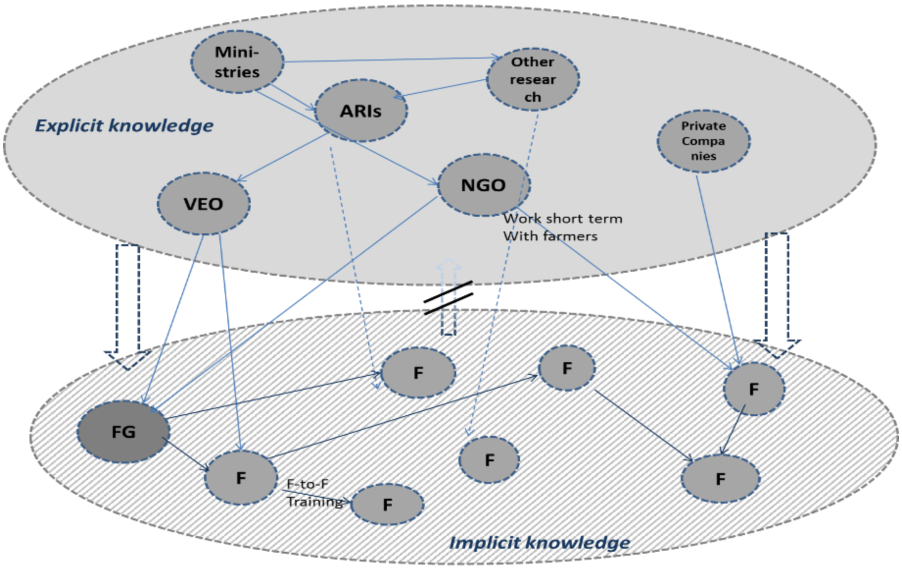

Figure ***Error! No sequence specified.****: Spheres of knowledge (own Figure)* [2]

When asked about the way knowledge was shared among fellow farmers and what the information routines were, the farmers from the groups stated consistently that they had never used written information to find out about innovations or new practices and that the extension service often had no resources to "translate" the material for the local context and adapt itto the problems the farmers were facing.

From a more conceptual angle, empirical results show that on a local level *implicit knowledge* (Know-How) is accessible for farmers. This generally originates from fellow farmers, friends or family and is not available in written form (FG, 1,2,3, Interviews #2 and 8). Implicit knowledge is indispensable for learning processes but it needs input from outside. In contrasting, results show that knowledge rotates horizontally, rather than interacting with other levels. The farmers mentioned, that they lacked information on marketing possibilities or on keeping different kinds of livestock (FG 1, 3). On a district and national level, research institutions, universities and other actors only produce *explicit knowledge. It is labeled "Know-Why" and may be generated* by researching.

The consequences such routines have for food security innovation processes on the ground can be *discussed*. During the FG interviews, farmers were asked for knowledge gaps in the innovation they were testing. It seems that gaps often relate to what Rogers called "Know-to knowledge" (Rogers, 2003:173) and the learning process: both types of knowledge are necessary for integrating new insights into local knowledge bases and thus to initiate learning processes. Learning creates knowledge necessary for the successful implementation of an innovation: a central reason for discontinuing the adoption of processes or rejection is that users did not learn about the specific requirements that come with an innovation. An example of this is shown in the following section.

4.2 Processes, attributes and conditions.

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[2] VEO- village extension officer, ARI- Agricultural research Institute, FG- Farmer Group, F- Farmer.

The main result from this research is that innovation processes are strongly influenced by the other system elements (e.g. by lack of knowledge sharing as mentioned above) and this also happens in the reverse sense; the innovation's characteristics give hints on how the system could be improved. In general, the interviews revealed that there was only a very imprecise understanding of how decision processes influence the adoption of food security innovation on the ground (Interviews #1,2 and 4). (see methods) There was information on necessary characteristics for innovations to be successful in the first field phase: innovative approaches that promise to solve clearly visible and observable changes in the landscape (soil degradation, erosion processes) that have a direct impact on yields etc. are more likely to be taken up than solutions for problems that are not observable. If the farmers feel a perceived need, like e.g. higher yields, improved seeds etc., innovations are more likely to be adopted. Innovations also need to be simple or even able to be divided up. If they can stand for themselves and do not require other inputs and so forth, it is easier to understand and use them. They also need to show results after a short period of time. An example is given in the following to illustrate how and why farmers take decisions for rejection or adoption. This example thus sheds light on a specific part of the innovation process: neither the invention of a machine, nor the construction of an improved stove, but the adoption process on the users' side.

The case of improved cooking stoves (ICS): In rural Tanzania, this innovation was introduced to a group of farmers (mainly woman). The group was informed about the goals of the project and received training from a local NGO on ICS. In the next phase, the group members were given the task of collecting the materials that were needed to build the stove and which were available locally (e.g. claysoil). Having collected the materials, the group member who was chosen to build the stove, built it for every group member. For the cooking holes, the woman in the family was asked to bring her biggest pot to make sure, it fitted inside the new stove. Several months after implementation, we asked the group members about their motivation to join the stove group and not one of the other groups. They could not exactly say, but mentioned that they enjoying being on the project. When interviewed about their experiences with the ICS, they reported back positively. But they also mentioned that ignition in the morning sometimes took longer than with the traditional three-stone-stoveas firewood collected could be wet and would not burn properly. However, they reported that they used the ICS on a regular basis instead of the stove they had been using before. On visiting some of the families (including the family that hosted us) in the village we lived in, we realized that in many cases they did not use the new stove, but had reverted back to the old stove they had before.

In the same village, we observed that some villagers not included in the project had started to adopt the idea of ICS and build some on their own. When these people were interviewed and questioned about their motivation, they told us that they had long wished for ICS in their households: it reduces eye diseases, is faster, makes it possible to cook two things at the same time, and it is less dangerous because children often get burned when playing too close to the fireplace. In contrast to the original group members, they had already started to improve the stove and added additional functions to it by e.g. by widening the hole for the firewood. Surprisingly, they reported no problems. They told us that the fire lit easily after having used the stove several times because it had dried out. They also stored and dried the firewood. They knew each other and sometimes met to discuss problems and solutions almost as a group. For the future they mentioned that they wanted to acquire more knowledge on the building process of the stove, so that everybody could build them and so that they could create a small stove business to increase household income.

This is not a unique story; the question is why the process in the two groups described ran so differently even though the existing conditions were the same: people from the same village, with similar educational background or eating habits? The innovation attributes innovation were the same for both "groups" too: the relative advantage was the same for both sides. Both used traditional three stone stoves in the beginning of the adoption phase. Both had the same opportunities to compare the suggested innovation of an ICS to the previous practice used and see if they felt the need to change their situation. The same applied to the complexity of the innovation, which required an understanding how that innovation can be used in an everyday setting. Flexibility also plays a role here: it is possible for the user to improve and adjust the innovation to the specific needs and so forth. Nevertheless, the adoption of the innovation took a different course in both examples. It also needs to be stressed, that similar observations could be made for the other cases (e.g. kitchen gardens, use of machines or crop production). Results based on all methods used so far have therefore led to the assumption that additional determinants, not directly related to the characteristics of the innovation itself and its technical or social compatibility, influence the decision to either reject or adopt.

In this regard, it can be *discussed* that the twelve selected innovation examples could give plausible indications for other influential factors which could either be related to the external situation individuals face (which they cannot change) or to personal aspects. We could call this situational internal and external conditions. We argue that understanding these conditions is important to initiate successful dissemination processes. Situational conditions derived from these case studies are not generally applicable to other cases or situations. Empirical results so far indicate that conditions are different for different types of innovation (e. g. technically based innovations, social innovations or knowledge innovations and so forth). Initial conditions developed can be introduced by re-employing the above mentioned example of the ICS; which can be characterized as a knowledge based innovation as the ability to build the stove as well as the ability to readjust it individually present the main challenge. The state of knowledge about the innovation on the users` side determines the dissemination rate of the innovation.

Situational Internal Conditions:

The most important condition for successful dissemination and implementation of ICS is *availability of a knowledge sharing system.* Encouraging schemes to govern the dissemination process and give incentives for farmers to share their knowledge with others is a major issue, as interviews with FG as well as with experts have revealed that farmers tend to keep their knowledge about innovations to themselves if they are not encouraged to share. In the case of ICS, we see two possibilities: either to appoint the task of knowledge sharing to the ICS farmer group and create a community based knowledge sharing system. Dissemination and knowledge sharing often takes place through group members' social networks along levels of trust with family or friends. This might exclude people who do not belong to the network, but follow traditional pathways. Another possibility is to create a system that is based on a small individual business. This is not yet very common in rural Tanzania so far and would exclude people who cannot pay for the service.

Furthermore, a *proper understanding of the specifics of the innovation* itself favors permanent adoption and makes discontinuance less likely. Literature and interviews indicated consistently that if the handling of the innovation is not fully understood, adopters often change their mind and go back to their previous practice (traditional cooking). For ICS, this was the case if the users were not knowledgeable about the fact that the stove needed to dry out before it can work properly. When they observed that the ignition phase was longer than with the traditional three stone stove, they stopped using the stove. Some of them did not know that once the stove dried out, ignition was much faster and wood consumption decreased by two thirds.

Situational external conditions.

A condition that will also influence the degree and pace of the dissemination of ICS is the *agro-ecological setting* (e.g. the degree of deforestation resulting from collecting firewood, availability of firewood or other fuels like charcoal). Poor facilities and highly degraded soils favor a more immediate adoption of this innovation. In the case of the semi-arid area of Dodoma, the scarcity of wood due to deforestation has raised the awareness on the need to reduce firewood consumption, which is addressed by the ICS. Fetching firewood from far away does not leave people enough time to do other income generating activities to improve their food security situation. In contrast, in the Morogoro case, people tended to use more charcoal and did not face such an immediate stress because of firewood unavailability. That had an impact on the degree of adoption.

5. Conclusions

It could be shown that due to several restrictions and limitations which are rooted in the system, several functions of the system could not be fully guaranteed. This refers to coverage of public extension services, but also to FG which exclude certain groups of farmers (e.g. very poor or remote), as well as to knowledge sharing and learning processes for food security innovations. Furthermore, using the example on innovation processes, it was possible to show how the attributes (by Rogers, 2003) refer back to, are linked and add to the concept of innovation system frameworks (by Malerba, 2002).

Finally, the observation, that farmers in the same situation take different adoption decisions, has led us to the assumption that we still need to get a deeper insight into the individual situations and decision making processes with regard to food security innovations. However, it also reveals that even though selected methods were appropriate for observing FS innovations on different system levels, these methods are limited and other methods would be needed to get a more comprehensive picture. Nevertheless, it is already apparent that the conditions developed so far are able to support the implementation and dissemination processes by formulating recommendations for the specific innovative solutions tested for adoption here. This will be the next step in this research.

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