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# Social network analysis of stakeholder groups implementing upgrading strategies to enhance food security in rural regions of Tanzania

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# Introduction

Sub-Saharan African countries are undergoing the fastest global population growth rates (World Bank 2015) and are currently facing challenges of food accessibility and production (FAO 2014). Smallholder farmers in Tanzania are more and more threatened with environmental instabilities resulting in increased food insecurity (Foley 2011). Given the challenges of poverty, rising demand for food and unpredictable climate, resilience is needed to upgrade small-scale agricultural structures resulting in enhanced livelihoods and production increase against forthcoming threats. Upgrading smallholder production systems can be done, for instance, rainwater harvesting using the techniques of tied ridging, infiltration pits and terracing (Reij et al., 2013). Likewise, the use of mobile maize shelling machines and millet shelling machines helps reduce highly intensive human threshing/shelling labor, improve capacity building for better processing methods including participatory business plans for machine investments (Mejia, 2003; Trans-SEC, 2016). The aforementioned tied ridges and fertilizer micro dosing, millet thresher and maize sheller are so-called upgrading strategies (UPS), in this framework outlined as good mechanisms securing food at the local to regional level. Implementing UPS was the focus of the Trans-SEC project in Tanzania, on which the current research builds. The large multi-disciplinary project in Tanzania is designed to enhance the food condition of the poor by securing food upgrading practices along regional and local food value chains. This study was carried out in four villages (Ilolo, Idifu, Ilakala, Changarawe) located in two agro-climatically different regions of rural Tanzania.

#### **Research objectives**

The general objective was to assess and understand the role of actors and the interlinkages among the UPS groups implementing the UPS. It is vital to deeply apprehend the relationships which then will enable assessment of the long-term sustainable potential of the upgrading strategies that are being implemented.

#### **Materials and Methods**

#### In-depth interviews

The research was carried out across eight different UPS groups of the Trans-SEC project implementing two UPS: a) tied ridges and fertilizer micro dosing, b) millet thresher and maize sheller). Eight to eleven actors of each UPS group were randomly selected for in-depth interviews based on generic criteria to represent the diversity of actors in the group. A total of sixty-five in-depth interviews were administered.

#### Participatory Net-Map

Net-Map was applied on a large sheet of paper to gather information and discuss further for later analysis (Schiffer 2007). Linkages of knowledge, money and material flows were identified by the interviewees. Perceptions about motivations for each actor were investigated (*more income, enhancing food availability, more time, more joy, better recognition, more research, less chemicals, preventing shocks, better social relations, etc.*) for taking part in the UPS were discussed and noted next to each

actor on the Net-Map. Finally, respondents were asked to rate the perceived influence of each actor in the UPS implementation. Five influence categories were established (*importance, income, trust, food and knowledge*). A total of sixty-five Net-Maps were carried out.

# Focus group discussions (FGDs)

The participants of the individual interviews of each UPS group were called upon to participate in a FGD. The combined network maps of each UPS were presented during the focus group sessions for discussion and clarifications on certain irregularities. At the same time, first research results were fed back to the participants. A total of eight FGDs were conducted.

# **Results and Discussion**

The results represent the networks and accompanying features of eight actor groups implementing two different UPS: tied ridges and fertiliser micro-dosing (four groups), improved processing (i) maize shelling (two groups), and (ii) millet threshing (two groups).

# 1. Network of knowledge centrality measures

Each UPS group is explained by the centrality measures (figures 1 and 2), the main motivations of the group members taking part in the UPS (Table 1) and the influence categories (Tables 2 and 3) of the various actors implementing the UPS.

# 1.1 Tied ridges and fertilizer micro dosing UPS knowledge centrality measures

The indegree centrality measures the ties where the actor receives knowledge; the outdegree centrality measures the ties where the actor provides knowledge and the betweenness indicates the actor's potential to control the knowledge flow.



Figure 1. Group knowledge network maps for tied ridges and fertilizer micro dosing UPS

All UPS members stated the importance of exchange of ideas, advice, information sharing with the field assistant, researchers and trainers. The experienced small farmers teach labourers how to construct tied ridges for water capture. The small farmers are at the top of the indegree centrality with

customers and the village chief having low indegrees. There is zero betweeness in the knowledge network for the Idifu TR-FMD UPS thus, there is equal sharing of knowledge. Only the small farmers have high ranks in betweeness centrality and are also at the top of the degree centralities. The benefits these farmers get from implementing the tied ridges has also led to better crop yields. Farmers are now able to use small plots to get a much larger harvest.

# 1.1.1 Village difference

Small farmers have a high indegree and outdegree in all four villages showing their engagement for the group's' success. Labourers are not important stakeholders in Idifu and Ilolo for the implementation of tied ridges a reason being the small farmers themselves are the labourers and do not hire expensive labour for the tied ridges. In Changarawe and Ilakala, labourers are important stakeholders as some small farmers hire labour for their tied ridges; since it is a difficult task constructing a tied ridge.

# 1.1.2 Regional difference

Although researchers and trainers channel inputs for the UPS implementation, they are seen as having a remarkable level of influence due to influencing knowledge flows. In the sub-humid region there is water available throughout prolonged periods of the year compared to the semi-arid region in which there is higher water scarcity. Hence, the UPS appears more efficient in the sub-humid region compared to the semiarid region.



# 1.2 Improved processing UPS knowledge centrality measures

Figure 2. Group knowledge network maps for the improved processing UPS

The group members receive trainings regarding business management and machine operations from researchers; they also promote the innovation among farmers along with researchers and the village authorities (for example village chief, councilor and village executive officer). Overall it can be noticed that group members are located at the top of the indegree centrality followed by the group leaders and customers. Group members learn constantly from researchers in terms of machine

operation and group management. They get feedback from the customers regarding prices and they also get advice regarding operation processes and strategies from the groups' leadership.

# 1.2.1 Village difference

Group members and customers have the highest indegree centrality in the knowledge flows in all four groups of the improved processing UPS. Thus, they receive the most knowledge in the network. It is also an indicator that knowledge has spread within and beyond the group, reaching other farmers that are their potential customers. In all villages customers have a high indegree centrality in all villages; especially in Ilakala and Idifu where they have the highest indegree centrality among all actors, as they receive information promoting the innovations form different actors, such as group members, researchers and governmental authorities.

# 1.2.2 Regional differences

Regional differences can be appreciated since the groups in the semi-arid region have a relatively lower flow of knowledge compared to those in the sub-humid region. Furthermore, it can be observed that most frequently mentioned ties or links in the groups are mainly reciprocated structures, meaning that knowledge is dynamic inside the groups. The presence of laborers, machine operators and supervisors suggests the groups have developed different roles and integrated different actors that are important for the groups' functioning. A possible explanation for these results might be the implementation stage of the groups since UPS groups in the sub-humid region have started operating the shelling machines while in the semi-arid region the operation has not yet started.

# 2. Motivations

The motivations for actors taking part in the different UPS are presented in table 1.

Table 1. Motivations for implementing tied ridges and fertilizer micro dosing (TR-FMD) and improved processing (MS and MT) UPS (averages per group, each actor was to select three most important motivations)

Village	More income	Enhancin g food availabilit y	More joy	Better social relatio ns	More knowledge	Prevent ing shocks	Better reputation	More time						
	Tied ridges and fertilizer micro dosing (TR-FMD)													
Changarawe	0.5	0.6	0.2	0.4	0.5	0.0	0.2	0.2						
llakala	0.4	0.5	0.1	0.5	0.6	0.0	0.3	0.2						
ldifu	0.4	0.5	0.5	0.4	0.5	0.1	0.3	0.1						
llolo	0.4	0.5	0.4	0.4	0.4	0.0	0.2	0.1						
				Maize	sheller (MS)									
Changarawe	0.5	0.2	0.5	0.4	0.4	0.0	0.4	0.1						
Ilakala	0.4	0.4	0.4	0.3	0.4	0.0	0.3	0.3						
		Millet thresher (MT)												
Idifu	0.4	0.4	0.6	0.5	0.4	0.2	0.5	0.2						
llolo	0.5	0.5	0.5	0.6	0.4	0.1	0.4	0.1						

# 2.1 Tied ridges and fertilizer micro dosing motivations for the UPS

In the semi-arid region, *enhancing food availability, more knowledge* and *more joy* followed by *more income* and *better social relations* (see table 1) are important motivations among most actors in contrast to the sub-humid region. *Enhancing food availability* in the semi-arid region is very important due to the severe food scarcity in that region. Acquired technological knowledge helps UPS members upgrade their farming skills. Labourers are sometimes hired to construct tied ridges thus, are motivated for *more income, enhancing food availability* and *better social relations*.

# 2.2 Improved processing motivations for the UPS

For the MS and MT groups regardless of the actor's role we find *more food availability, better social relations* and *more knowledge* as the most frequent motivations (see table 1). *Better social relations* is important in all the groups as actors feel more supported in daily life and critical times (poor harvest or sick/deceased relatives), as well as they are important for their success. *Better reputation* was highlighted as an important motivation for the secretary in both MT groups. For the MS groups *more income* is a frequent motivation for their participation. Researchers are perceived as one of the biggest source of knowledge as they bring the innovations to the villages. *More joy* was perceived as a

frequent motivation in the semi-arid region as they feel happy about the project bringing benefits to villages, while in the sub-humid *more income* is a high motivation.

#### 3. Influence categories

The influence categories of the various actors implementing the tied ridges and fertilizer micro dosing and the improved process UPS is presented in tables 2 and 3 respectively.

	Importance				Income			Tru	ist		Food	Knowledge				
Village	Ν	Mean	Std. Dev	Ν	Mean	Std. Dev	Ν	Mean	Std. Dev	Ν	Mean	Std. Dev	Ν	Mean	Std. Dev	
	Researchers and trainers															
Idifu	8	4.8	0.5	8	1.1	1.8	8	4.8	0.7	7	1.6	2.1	8	4.8	0.7	
llolo	8	5.0	0.0	8	<b>2.6</b> ª	2.6	8	4.9	0.4	8	2.5	2.4	8	4.5	1.4	
Ilakala	8	4.8	0.5	8	0.0 ⁵	0.0	8	5.0	0.0	8	1.9	2.1	8	5.0	0.0	
Changarawe	8	5.0	0.0	8	0.8	2.0	8	4.8	0.7	7	2.9	2.1	8	4.9	0.4	
	Field assistant															
Idifu	8	4.3	1.8	8	1.0	1.9	8	4.8	0.7	8	2.9ª	2.0	8	4.6	0.7	
llolo	8	4.6	0.5	8	2.5°	2.4	8	4.6	0.7	8	1.9	2.2	8	4.8	0.5	
Ilakala	8	4.6	1.1	8	0.1⋼	0.4	8	4.8	0.7	8	1.3	1.9	8	4.8	0.7	
Changarawe	8	4.9	0.4	5	0.0	0.0	8	4.8	0.7	6	0.0	0.0	8	4.6	0.7	
							Ş	Small fa	armers							
ldifu	8	4.4	0.9	8	2.4	2.1	8	4.5	0.8	8	3.4	1.8	8	4.9	0.4	
llolo	8	4.1	0.8	8	3.6	1.1	8	4.5	0.5	8	2.4	1.6	8	4.0	0.9	
Ilakala	8	4.5	1.1	8	1.0	1.9	8	4.4	0.7	8	3.1	1.6	8	4.4	0.7	
Changarawe	8	4.5	0.9	7	2.1	2.4	8	4.3	1.0	8	2.8	1.8	8	4.3	1.2	
								Secre	etary							
Idifu	8	4.5	0.8	8	1.4	1.6	8	4.6	1.1	8	3.4	1.2	8	4.3	1.2	
llolo	8	3.9	1.2	8	3.8	1.0	8	4.3	0.7	8	2.3	1.5	8	4.1	0.8	
Ilakala	8	4.6	0.7	8	0.5⁼	1.1	8	4.5	1.1	8	2.9	1.8	8	4.1	1.4	
Changarawe	8	3.9	1.4	7	0.6⁵	1.1	8	4.0	1.1	5	2.6	1.8	8	3.8	1.2	
	Group leader															
ldifu	8	4.4	1.4	8	0.9 <sup>в</sup>	1.2	8	3.9	1.9	8	2.9	2.0	8	3.9	1.9	
llolo	8	3.9	1.4	8	3.9	1.1	8	4.4	0.7	8	2.5	1.6	8	4.1	1.0	
Ilakala	8	4.3	1.4	8	0.6 <sup>в</sup>	1.2	8	4.1	1.1	8	2.5	1.6	8	4.0	1.3	
Changarawe	8	4.4	0.7	6	1.3	1.5	8	3.9	1.1	5	3.2	1.1	8	3.9	1.1	

Table 2. Influence categories of the most important actors for tied ridges & fertilizer micro dosing UPS

Mann-Whitney-U test: a, b = significantly different at p < 0.05; A, B = significantly different at p < 0.01

#### 3.1 Tied ridges and fertilizer micro dosing influence categories

In all four villages, respondents identified *trust, knowledge* and *importance* as categories with the most influence by actors in the UPS implementation (see table 2). The distribution of *income* for the group leader in Ilolo (3.9) (p < 0.01) is considered significantly higher than the distribution of *income* in Idifu (0.9) (p < 0.01) and Ilakala (0.6) (p < 0.01) indicating that he has more tied ridges, harvests more food and sells the surplus. The distribution of *income* for the researchers and trainers in Ilolo (2.6) (p < 10.05) is considered significantly higher compared to the distribution of *income* in Ilakala (0.0) (p < 10.05). The researchers and trainers provide funding and inputs for the UPS implementation. They also want the small farmers to have a proper mastery of the technology in order to improve their food security. Similarly, there are significant differences for the secretary's influence on *income* in Ilolo (3.8) (p < 0.01) and Ilakala (0.5) (p < 0.01) and between Ilolo (3.8) (p < 0.01) and Changarawe (0.6) (p < 0.01). This indicates that the secretary sees the technology promising for improving food security, is able to construct more tied ridges, has a proper mastery of fertilizer application and is able to market some of his crops. The distribution of *income* for the field assistant in Ilolo (2.5) (p < 0.05) is significantly higher compared to the distribution of *income* in Changarawe (0.0) (p < 0.05) and Ilakala (0.1) (p < 0.05), possibly because the UPS members are still highly dependent on the field assistant for inputs for the UPS implementation. Furthermore, the distribution of *food* for the field assistant in Idifu (2.9) is significantly higher (p < 0.05) than the distribution of *food* in Changarawe (0.0), indicating that the field assistant harvests more food from the tied ridges. In Ilakala and Changarawe, labourers are highly influenced by more knowledge and trust reason why they are always called up to construct tied ridges. This has also led to better earnings for them.

Table 5. Influence categories of the most important actors for the inflict theshelf & maize sheller OFS													3			
		Importance			Income			Trust			Food			Knowledge		
UPS	Village	Ν	Me an	Std. Dev	N	Mea n	Std De v	N	Mea n	Std De v	Ν	Mea n	Std De v	N	Mea n	Std. Dev
		Secretary														
MS	llakala	8	4.6	0.7	8	0.6	0.9	8	4.9	0.4	8	1.4	1.8	8	4.1	1.4
MS	Changarawe	7	4.6	0.8	7	0.9	1.1	7	4.6	0.5	7	2.3	1.7	7	4.1	0.9
MT	ldifu	8	4.1	1.2	8	0.0ª	0.0	8	4.3	1.2	8	0.0	0.0	8	4.1	1.0
MT	llolo	8	4.5	0.9	8	0.0	0.0	8	4.1	1.1	8	0.0	0.0	8	3.4	1.5
		Group Members														
MS	Ilakala	8	4.6	0.7	8	3.9*	1.4	8	4.5	0.8	8	3.9*	0.8	8	4.3	1.2
MS	Changarawe	8	4.1	0.6	8	2.25*	0.5	8	4.0	0.8	8	2.50*	1.2	8	4.1	0.8
MT	ldifu	8	4.1	0.6	8	0.0⁵	0.0	8	4.0	0.9	8	0.0	0.0	8	3.5	1.7
MT	llolo	9	3.7	0.9	9	0.0	0.0	9	3.8	1.0	9	0.0ª	0.0	9	3.3	1.4
		Researchers														
MS	llakala	8	5.0	0.0	8	0.0	0.0	8	5.0	0.0	8	0.6	1.8	8	1.6	2.3
MS	Changarawe	8	5.0	0.0	8	0.0	0.0	8	4.5	0.8	8	0.4	1.1	8	1.9	2.1
MT	Idifu	8	5.0	0.0	8	0.0	0.0	8	4.9	0.4	8	0.0	0.0	8	2.3	2.5
MT	llolo	9	4.9	0.3	9	0.9	1.8	9	4.6	0.5	9	0.9	1.8	9	2.4	2.4

Table 3. Influence categories of the most important actors for the millet thresher & maize sheller UPS

1. Assessment comparison between same actor role across different UPS groups: \* = p < 0.05

2. Assessment comparison across different actor roles in the same UPS group: a, b = p < 0.05

Actors identified as the most *important* for the implementation of the improved processing UPS were group members, the secretary and researchers (table 3). The results suggest there might be a lack of commitment of some group members as they have not yet started operating. Also other factors affecting the group members' commitment is the seasonality of work as there is not a lot of motivation to have meetings through the off working seasons. *Trust* is important for the success of the groups as they can rely on each other. Group members are assumed to be at the top of the *income* distribution followed by the secretaries. The group members assumed *income* is significantly lower for Changarawe compared to Ilakala. Actors assumed to receive more *food* out of the implementation were the group members in Changarawe are assumed to receive significantly lower (p<0.05) amounts of *food*. A high distribution of *knowledge* among the secretaries is observed followed by group members and researchers.

#### **Conclusions and Outlook**

The specific actors and network structures were different across the UPS networks. The presence of adopters in most of the UPS groups helped improve the likelihood for group sustainability. All networks indicate a fairly equal rank of participation of all actors. One interesting aspect of all UPS network is that knowledge exchange is seen as almost entirely bi-directional. Thus, all UPS networks illustrate the aspect of free knowledge flows instead of the classic model of, for instance, giving information to a lone policymaking body. The findings indicate that UPS members are the most leading sources of information for other UPS members. Furthermore, the findings indicate the UPS (TR-FMD, MT and MS) are providing income and food for the UPS members through better crop yields and production. The most common shortcomings include: access to inputs, problems of pests and diseases, labour, climate, shocks (floods, droughts), and capital.

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