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Conservation agriculture and sustainable development in Africa: insights from Tanzania

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Abstract

In recent years, conservation agriculture (CA) has been increasingly promoted as the best solution to sustainable agricultural development in Africa. Proponents argue that it offers increased yields, reduced labour requirements, improved soil fertility and climate mitigation benefits. At the same time, a growing number of scholars have questioned its promises, impacts and applicability to small, resource-poor African farmers. To add to the debate, this paper draws on fieldwork from two case study villages in the Lindi region of Tanzania. It scrutinizes CA farmer field schools' performances, the impact on villagers' perceptions of core principles and socio-economic/institutional constraints related to its adoption. It demonstrates how farmer field schools failed to meet initial expectations because of challenges associated with economic benefits, labour demand, availability and accessibility of inputs, infrastructure, governance, and stakeholder relations. It argues that the applicability to and adoption of CA depends on the transformation of individual perceptions as well as structural constraints, including credit facilities, markets for inputs, infrastructure and availability of labour, which has long been a limitation of donor-initiated programmes. Under constraining socio-economic and institutional conditions, questions continue to loom large over the long-term applicability of CA to African smallholder farmers.

Keywords: Conservation agriculture; REDD+; Tanzania; sustainable development.

1. Introduction

> *"I insist that you all visit those CA [Conservation Agriculture] plots so that you can thoroughly understand and implement the technology back home. For the districts, try to assist the farmers as much as possible in adopting the technology for the benefit of our farmers. We have a challenge on climate change, and by adopting CA we can contribute towards mitigating the challenge."* (Minister, Hon. Mathias Chikawe in LIMAS Newsletter, 2013)[1]

Over the past decade, a growing movement of international organizations, governments and individuals have promoted conservation agriculture (CA) as the best solution to sustainable agricultural development in Africa (Andersson and D'Souza, 2014; Baudron *et al*., 2012; Giller *et al*., 2009). Proponents of CA argue that it offers win-win outcomes to farmers and the environment including: (i) higher productivity gains through improved and sustained yields with less time, labour and inputs required; (ii) contribution to climate change mitigation efforts through increased soil carbon sequestration benefits; and (iii) strengthening farmers capacity to adapt to future changes through improved soil organic matter and water retention (FAO, 2009, 2014; Govaerts *et al*., 2009).

Although CA has featured in global agricultural policy for decades, its prominence has risen, especially in recent years, within global climate change mitigation efforts, particularly with the establishment of the United Nations' REDD+ mechanism (reducing emissions from deforestation and degradation, conserve and enhance forest-carbon stocks and sustainably manage forests) and other forestry-carbon projects (Antle and Stoorvogel, 2008; Bryan *et al*., 2010; Govaerts *et al*., 2009). Conservation agriculture (CA) is seen to support REDD+ efforts by: (i) increasing soil carbon sequestration and (ii) reducing agricultural expansion into forests through increased crop yields on existing farmlands (sustainable intensification) (Antle and Stoorvogel, 2008; Bryan *et al*., 2010; Govaerts *et al*., 2009).

[1] The former honorary Minister of Justice and Constitutional Affairs Mathias Chikawe made this passionate plea as the Guest of Honour at the 'Nanenane agricultural fair' in Ngongo, Lindi, Tanzania in August 2013.

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As CA has become the 21st century 'climate smart' agricultural development policy and initiative for Africa, a growing number of scholars have questioned its promises, impacts and applicability to small, resource-poor African farmers (Baudron *et al*., 2012; Giller *et al*., 2009). Its three core principles and practices: (i) no-tillage or minimum mechanical soil disturbance; (ii) maintaining permanent soil cover with organic mulch; and (iii) practicing of crop rotations and/or associations (FAO, 2009, 2014);[2] have been at the centre of scientific debates. Recent studies have questioned the carbon sequestration potential of no-till agriculture (Govaerts *et al*., 2009; Paul *et al*., 2013; Stockmann *et al*., 2013) and suggested that it is substantially less than commonly claimed (Powlson *et al*., 2014). With regard to crop productivity gains, it was found that no-tillage agriculture actually reduces yields, although this varies and under certain conditions can be as high or even greater than conventional tillage (Pittelkow *et al*., 2015). The latest research thus seems to suggest that CA may be inappropriate in many contexts, although it appears to offer crop productivity and climate adaptation benefits in rain-fed dry climates, but only if no-tillage is practiced in combination with the other two principles (Pittelkow *et al*., 2015). However, this is very difficult to achieve in African contexts due to various socio-economic, cultural and institutional constraints (Andersson and D'Souza, 2014; Baudron *et al*., 2012; Giller *et al*., 2009).

In a seminal paper, Giller *et al*. (2009) criticized donors and development actors' blind support for CA, and highlighted the significance of socio-economic, institutional and farm-level factors in determining the potential, impacts and adoption of the technology. They argued that more research is required to understand if, when and for whom CA could be an appropriate pathway into the future. For instance, since short-term yield losses are commonly experienced under CA (Pittelkow *et al*., 2015), the average cash-poor, resource-constrained smallholder African farmer will struggle to adopt the key three principles, even if they offer positive ecological benefits in the longer-term (Giller *et al*., 2009). Most notably, the increased need for herbicides and fertilizers during the first years represents real material obstacles for low-income farmers (Baudron *et al*., 2012; Giller *et al*., 2009; Kassam *et al*., 2009; Knowler and Bradshaw, 2007). Additionally, barriers related to deficient infrastructures and markets, land tenure arrangements and small farm sizes, labour requirements (especially during cropping cycles), low educational levels, limited crop residues for mulching and lack of capital/credit facilities have all been mentioned as explanations for low or limited uptake in Africa (Baudron *et al*., 2012; Giller *et al*., 2009; Kassam *et al*., 2009; Knowler and Bradshaw, 2007).

Against this background, Andersson and D'Souza (2014) argue that adoption figures of CA principles seem overly optimistic since farmers might only practice the technology during promotion, research and donor programmes, but return to their conventional ways of crop cultivation once support fades (cf. Giller *et al*., 2009).

This paper adds to the debate about the applicability of CA in Africa by examining the potential and adoption of the technology in the context of the Lindi region in Tanzania. More specifically, it examines CA farmer field schools in two case study villages in the Liwale and Lindi rural districts to scrutinize their performances, local perceptions of the technology and socio-economic/institutional constraints related to its adoption. Although my study design and personal skills did not allow for a comprehensive examination of the ecological potentials and pitfalls of CA in a specific context, this paper provides insights into the individual, socio-economic and institutional factors that may hinder or promote its adoption.[3] The paper proceeds as follows: in the next section, I place the study in a theoretical framework of technology adoption in African smallholder farming systems. The third and fourth sections describe the methods used for data collection and the case study context, respectively. In sections six and seven I analyse local perceptions and constraints of CA in the villages. The paper comes to a close in section eight, with a discussion and conclusion.

2. Understanding innovation in African smallholder farming systems

It is generally acknowledged that there is enormous potential for African smallholder farmers to increase crop productivity, which would have positive effects on social welfare, economic development and environmental sustainability (World Bank, 2008). It is equally accepted that agricultural innovation and the uptake of new technologies and practices play an important role in raising the productivity of African agriculture (Larsen *et al*., 2009; van Rijn *et al*., 2012; World Bank, 2008). However, so far the uptake of new technology has been rather slow and insufficient across the continent (Ndjeunga and Bantilan, 2005; Suri, 2011). Farmers often experiment with different aspects of innovation and sometimes only adopt parts of it, neglecting

[2] In trying to integrate the management of soil, water and biological resources, CA is often presented as a 'green agricultural technology', similar to organic farming and agroforestry. In contrast to organic farming, however, CA does not abstain from chemical inputs (herbicides, pesticides, fertilizers); it only aims to minimize their usage to the most efficient level, i.e. understood as ways that do not interfere with, or disrupt, the biological processes (FAO, 2014).

[3] It is important to note that the data presented are limited, and should not be taken as an overall assessment of the technology in the region, or even the village. Conservation agriculture (CA) was promoted to villagers in the form of an agricultural modernization package that included aspects that are *de facto* unrelated to this technology. This makes critical assessments over the costs and benefits difficult, if not impossible, leaving us with much uncertainty about the potential of its particular aspects (cf. Giller *et al*., 2009).

other elements. Changes in farming practices are much more incremental than radical and wholly transformative (Knowler and Bradshaw, 2007; Kristjanson *et al*., 2009).

The literature on agricultural innovation tells us that the uptake of a new technology or agricultural practice is a complex and complicated process that requires changes in individuals as well as larger socio-economic and institutional structures at different spatial levels (community, group, nation and global) (Klerkx *et al*., 2012; Leeuwis and Aarts, 2011; Meijer *et al*., 2014). Scholars have increasingly applied farming systems analysis in understanding different roles of and interactions among actors, institutions and infrastructures in the innovation process (Kebebe *et al*., 2015; Schut *et al*., 2015). From this perspective, innovation can be seen as an interactive and collaborative process that results on one hand through changing individual perceptions and social practices, and on the other hand through changing structural conditions, including physical infrastructure and assets, knowledge and communication systems, institutions governing markets and interactions between stakeholders (Kebebe *et al*., 2015; Klerkx *et al*., 2012; Knickel *et al*., 2009; Schut *et al*., 2015).

In recent years, community-based or farmer-to-farmer extension approaches have become popularized in Africa as a cost-effective way of supporting agricultural innovation in smallholder farming systems (Wellard *et al*., 2012).[4] Farmer field schools have been promoted within agricultural donor initiatives as a 'community-based, demand-driven, non-formal education programme that appears to stimulate both empowerment and agricultural growth' (Friis-Hansen and Duveskog, 2012: 415). However, studies have shown that farmer field schools and other participatory extension approaches have often collapsed as soon as external donor and government support was withdrawn (Friis-Hansen and Duveskog, 2012; Islam *et al*., 2011; Wellard *et al*., 2012). Islam *et al*. (2011) identified five important aspects that frequently contribute to the sustainability and success of farmer-led extension groups. These include group savings-credit performance (economic benefits), gender-based usefulness of microcredit, group governance and leadership, social capital among group members and social capital between the members and the professional facilitators.

3. Data collection methods

This paper draws on my PhD research on REDD+ in Tanzania, which I conducted between August 2011 and July 2012 in the Lindi Region of the country (Scheba, 2014). For seven months, I lived in Mihumo/Darajani[5] and Ruhoma, which are two remote and forest-dependent villages that are part of the AVLFR (Angai Village Land Forest Reserve)/LIMAS[6] (Lindi and Mtwara Agribusiness Support) and TFCG/Mjumita 'Making REDD work for communities and forest conservation in Tanzania' development projects, respectively (LIMAS, 2011; Mustalahti *et al*., 2012; TFCG, 2010). The two villages – Mihumo/Darajani and Ruhoma – are located in Liwale district and Lindi rural districts, respectively. Liwale has a mostly flat landscape that is covered by sandy soils, which are deep and nutrient-poor (Mukama, 2010). The district is part of the Eastern African Miombo Woodlands ecoregion, and it is estimated that it contains 1,736,100 ha of forests (Taku Tassa, 2010). Mihumo/Darajani has a village population of 3,000 inhabitants (690 households), and spans across nearly 30,000 ha. The village of Ruhoma is situated in the Lindi Plateaux and Valleys landscape that covers most of the 753,800 hectares in the Lindi rural district. The predominant soil types in the district are sands, loamy sands and sandy loams, whereas valleys are characterized with clay soils, while sandy-loamy soils are found in the upland areas (TFCG, 2012). Ruhoma is located on the Noto plateau, which is predominantly covered by dry evergreen forests (TFCG, 2009). The village of Ruhoma has 475 residents (169 households), who live across 3,817 hectares.

Within a broader ethnographic research strategy, I predominantly used qualitative methods for the collection of empirical data. During my seven month stay in the villages, I conducted participant observation, ethnographic

[4] Famer field schools consist of a group of farmers who meet regularly (usually weekly) with a facilitator/trainer on a collectively managed field, where farming methods are practiced, analysed and debated according to their various socio-ecological benefits. In farmer field schools, active participation and group dialogue shall enhance the learning process and knowledge dissemination, ultimately extending beyond the group members to all households in the villages of the participants (Davis *et al*., 2012; Friis-Hansen and Duveskog, 2012). The approach aims to facilitate participatory and experimental learning in groups that encourage the farmers to actively engage with each other in knowledge creation and exchange. The trainer becomes more of a facilitator rather than an authoritative instructor, and assists farmers in developing their technical, social and managerial skills for the use of self-empowerment (Davis *et al*., 2012; Friis-Hansen and Duveskog, 2012).

[5] At the time, the Darajani village had split from the Mihumo village, which until then had been one village. The official process of dividing the two villages had only just started during my fieldwork. Nevertheless, a CA group was established in each of the two parts of the village. I refer to the village as Mihumo/Darajani but when I refer to the groups specifically, I use Mihumo or Darajani.

[6] The contemporary efforts to implement REDD+ in Angai village land forest reserve build on previous interventions by Finnish development assistance directed at establishing community-based forest management in Liwale district (Scheba and Mustalahti, 2015). Finland and Tanzania have had a long development cooperation relationship, particularly in the Lindi Region and Liwale district (Seppälä and Koda, 1998; Sundström, 2010). In 2010, a new Finnish-led development programme, LIMAS, started in Liwale. LIMAS is a 5-year programme aimed at increasing agricultural productivity, business opportunities and forest management in selected districts in the Lindi and Mtwara regions. One of its key strategies was to introduce CA to villagers (LIMAS, 2011).

interviewing, 116 recorded semi-structured interviews, 116 household surveys, one focus group discussion and document analysis. I triangulated findings from one source with data from other sources to generate robust and credible data. For the recorded interviews, I purposefully selected research participants from different village groups, village councils, sub-village chairmen, CA farmer field schools, village natural resource committees and district officials. I conducted one focus group discussion in Ruhoma with members from the village council, village natural resource committee, village land use planning committee, REDD+ committee and ordinary villagers. In addition to my qualitative methods, I conducted a small-scale household survey with 76 and 39 respondents in Mihumo/Darajani and Ruhoma, respectively. I sampled respondents randomly from the village populations, which made up 690 and 169 households in Mihumo/Darajani and Ruhoma, respectively.

4. Promoting conservation agriculture: the REDD+ donor context

In Tanzania, international donors and local non-governmental organizations have introduced CA to smallholder farmers as an alternative to existing practices of 'shifting cultivation',[7] which together with logging and fire, are considered major drivers of deforestation and forest degradation in the country (Forrester-Kibuga and Samweli, 2010; LIMAS, 2011; Mukama *et al*., 2011; Owenya *et al*., 2011). Conservation agriculture technology and practices have been promoted within larger, well-financed REDD+ initiatives, which have become central strategies by donors and forestry-sector agents to direct forestland use towards sustainable trajectories in the country (Lund *et al*., 2017; Scheba and Rakotonarivo, 2016). Conservation agriculture (CA), as a form of sustainable intensification, shall help to mitigate agricultural expansion into forests, consequently reducing carbon emissions from deforestation and degradation that would occur otherwise (Forrester-Kibuga and Samweli, 2010; LIMAS Newsletter, 2013; Scheba, 2014). At the same time, it is suggested that the technology will result in agricultural productivity increases on existing farmland, allowing farmers to meet rising food demands and achieve economic development (LIMAS, 2011; TFCG, 2012). Under the Lindi and Mtwara Agribusiness Support (LIMAS) initiative, around 130 demonstration plots were initiated in Newala and Liwale districts, based on the premise that the technology is the best way to achieve sustainable agricultural development in Africa (LIMAS Newsletter, 2011).

> *"Conservation Agriculture is promoted to assist farmers get better yields from their land. Conservation agriculture improves productivity, cuts down the workload in land preparation, and helps adaptation to climate change. The average yields increase as a result of improved soil fertility and favourable soil structure, which helps plants to effectively utilize water and nutrients. The need for fertilizer is minimized by systematic use of legumes in crop rotation. Conservation agriculture is implemented by millions of small and large scale farmers all over the world."* (LIMAS, 2012)

5. Local experience with conservation agriculture

In the two case study villages, CA was introduced in the form of a 'promotional package' (cf. Andersson and D'Souza, 2014) that included non-CA-related techniques such as improved planting and weeding, usage of agrochemicals, and farm management practices. In the villages, all of these agricultural techniques were summarized as CA, which created a dichotomy between 'backward' and 'expert' farming, with CA representing the latter.[8] It is not surprising then that villagers had high hopes when they first heard about the new technology.

> *"When we practice slash-and-burn agriculture (*kilimo sensa[9]*) and we use fire, the soil doesn't have any fertility. But with Conservation Agriculture we leave the residues, we don't use fire, we dig holes and put fertilizers. First lime, then 'planting fertilizer,' then we cover, and then 'growing fertilizer.' We then compare slash-and-burn*

[7] Farming in the Lindi province is often described as 'shifting cultivation' (Bolin, 2010; Forrester-Kibuga and Samweli, 2010; Johansson, 2008; LIMAS, 2011; Mukama, 2010; Mustalahti and Tassa, 2012; TFCG, 2012), which suggests that farmers cultivate one piece of land for a few years and then abandon it for the purpose of regeneration. It is suggested that farmers move to other areas to look for more fertile lands after experiencing declining soil fertility and increasing weed infestation on their farms. New farms are preferably opened up in the fertile lands of primary or secondary forests (Bolin, 2010; Forrester-Kibuga and Samweli, 2010; Johansson, 2008; LIMAS, 2011; Mukama, 2010; Mustalahti and Tassa, 2012; TFCG, 2012). Although it is said that shifting cultivation does not necessarily lead to long-term deforestation and forest degradation (Dove and Carpenter, 2008), recent changes in population growth, market access and commercialization of agricultural crops have been highlighted as the main reasons for making this form of agriculture unsustainable and detrimental to the environment (TFCG, 2012).

[8] Project proponents in both villages regularly referred to successes made by Zambian farmers who practiced CA. Zambia is presented as a prime example in which CA served to reverse degraded soils and helped to 'develop' poverty-stricken peasants. In Mihumo/Darajani, videos about the Zambian success stories were shown to village council members and district leaders, encouraging participants to believe in the positive short- and long-term effects. Some project staff from both projects were taken on a study tour in Zambia to get hands-on experience of the application of CA.

[9] In Mihumo/Darajani, villagers generally referred to slash-and-burn agriculture that involves cutting trees and/or removing crop residues from the field with the use of fire as *kilimo sensa*.

*agriculture and Conservation Agriculture. Conservation Agriculture will produce more crops, because we farm professionally (*kitalamu*)."* (M Interview 33)

I observed high hopes among donors and project staff during my fieldwork period, who expected that selected farmers would volunteer themselves to practice the new technology, followed by adopting the techniques on their private farms, which then would convince the remaining villagers to follow suit. However, in reality things turned out to be quite different.

In Ruhoma, the cultivation of maize on the CA demonstration farm failed, and the group collapsed after a few months. Only four group members remained, who then decided to replace the planted maize with sesame cultivation without any further consultation with the facilitator. As a consequence, disappointed villagers claimed that they did not obtain many benefits from the farmer field school and CA (R Interview 33). Similarly, the farmer field school in the Darajani part of the Mihumo/Darajani village practically lost 11 of its 15 members within the first two months. Within this short period of time, the group was reduced to only four members, who continued to work alone on the farm with little consultation with the facilitator. Despite this, they still managed to harvest maize, cowpeas, and pigeon peas, but they failed with soya cultivation and had problems with lack of manure and pests that infested cowpeas and rats and hares that damaged the maize. In the end, the remaining group members felt that they were left alone with the challenges (M Interview 27). The performance of the Mihumo group was better because all group members remained active, and ultimately achieved an average harvest from their one-acre demonstration plot. The group leader recorded the harvest, which amounted to 100 kg of maize, 92.5 kg of cowpeas and 80 kg of pigeon peas. However, soya did not prosper in their field, either. In total, they harvested 272.5 kg from their one-acre large field. In comparison and according to my quantitative household survey, the mean harvest of annual crops by other villagers amounted to 307 kg/acre in Mihumo/Darajani. Reasons mentioned for the lower yields were pest infestation on cowpeas and the theft of maize by local residents.

Undoubtedly, the three farmer field schools resulted in some positive outcomes for group members, including training, seminars and new knowledge on improved planting techniques, mulching, selection of seeds and crops, crop rotation and intercropping, the use of agrochemicals and natural fertilizers, improved harvesting techniques and proper recordkeeping.[10] At the same time, two of the three farmer field schools did not perform to the satisfaction of the villagers, group members and development actors. The third group achieved better results in terms of group participation and knowledge exchange, but it still struggled to produce the yields expected.

The donor's objective of disseminating CA knowledge among all villagers through farmer field schools experienced considerable challenges, at least in the first year. Out of 76 survey respondents in Mihumo/Darajani, 60 (79%) stated that they had not heard of CA, while only 16 (21%) respondents claimed that they had. On numerous occasions during my stay in the village in 2011/2012, I encountered ordinary farmers who were unaware of the key principles of CA. A lack of mobilization by demonstration plot members contributed to this situation, as people did not come to the demonstration plot to enquire about the technology and its progress. Apparently, they did not see the value in doing so, at least not before the group had achieved any substantial benefits.

"You can't force them. You can't force my husband. The lessons I get, I need to teach him. We need to educate villagers. We need to take 10 to 15 people and teach them CA. But they don't agree. They think they waste time when they go there. If you have money then we come. If you don't have posho *[allowance] we don't have time to waste. Can you force him?."* (M Interview 31)

In Ruhoma, the situation was different as 27 out of 39 survey respondents (71%) knew about CA, while 12 (29%) did not. Ruhoma is a much smaller village compared to Mihumo/Darajani, and therefore information spreads more easily. At the same time, the good general knowledge of CA in the village stemmed from the overall better functioning of the development project. As the project provided tangible benefits, especially REDD+ trial payments, residents became more aware and involved in the activities that were taking place (Mustalahti and Rakotonarivo, 2014; Scheba and Mustalahti, 2015; Scheba and Rakotonarivo, 2016).

6. Local perceptions of conservation agriculture principles

The performance of the farmer field schools impacted how participants perceived CA, as well as its potential to contribute to sustainable development objectives. Meijer *et al.* (2014) argue that farmers' adoption of new technology partly depends on their knowledge, perceptions and attitudes. These intrinsic factors differ among farmers, as they are shaped by access to information, exchange, training, learning opportunities, extension services, etc. It is

[10] In Mihumo and Darajani, both groups received 100 kg of fertilizers (two types), 4 kg of maize, 3 kg of cow peas, 3 kg of pigeon peas, 2 kg of soya, books, a measuring rod, one big hoe and one record keeping book for the chairman for the start up. In contrast to farmers in Ruhoma, group members in Mihumo/Darajani were not taken to the classroom or on a study tour for lessons. Instead, they were all given books to study in preparation.

therefore important to examine how farmer field school members thought of key aspects of CA.

6.1. No- or minimum, tillage

Despite the facilitators' emphasis on promoting zero or minimum tillage, some farmer field school participants in Mihumo/Darajani and Ruhoma remained of the opinion that ploughing the land is necessary, and should be practiced more widely. These participants believed that ploughing should be done at least in some areas to combat weeds and to increase soil fertility. It was seen as necessary to get rid of the nut grass weed (*Cyperus rotundus*), which is a very common problem in their area. They argued that so far, tilling has only proved to be beneficial for the land. If they could, they would till much more of their land, but because tilling is very labour-intensive, only wealthier families can do it on large areas. Therefore, CA's emphasis on no or minimum tillage was not easily accepted by some local farmers, who emphasized the challenge of weeding, and strongly believed in the benefits of ploughing for productivity increases.

6.2. Mulching

The principle of mulching seemed generally appreciated in the villages. However, some group members pointed at cultural barriers to its adoption. They explained that leaving crop residues on the field has always been associated with laziness. In the villages, a clean seedbed represented the outcome of a good farm preparation. Therefore, to convince farmers to leave their residues on the field, they would have to address these cultural perceptions/attitudes, which contribute to the use of fire to burn residues.

> *"Yes we used fire. We farm and we set fire. They said there are losses and benefits to using fire. We used fire because we thought the farm is dirty. We did not know that it was natural fertilizers."* (M Interview 33)

Another important barrier to mulching in the local context is related to wildlife. I was told that crop residues that are left on the field attract wild animals, including rats. They then feed on crop residues and multiply in their numbers, which causes further distress for the following season, as they like to raid farms for the crop seeds during the time of planting.

6.3. Crop rotation

The third principle of crop rotation was not commonly practiced by villagers and group members, partly because of lack of capacity. Intercropping and shifting cultivation was the preferred method of agricultural production (Forrester-Kibuga and Samweli, 2010; LIMAS, 2011). However, villagers acknowledged the potential positive benefits of crop rotation to their farms.

> *"And we learned that if you farm maize and it is harvested, don't go back there and plant maize again. You need to change the crop. They told us about crop rotation. You put maize, you remove them, then you plant cow peas. If you continue many rotations you can plant tomatoes, and again maize, but don't just harvest maize and plant maize again."* (R Interview 17)

7. Socio-economic and institutional constraints

Aside from challenges related to individual perceptions, socio-economic and institutional constraints influenced the potential and adoption of CA in the villages.

7.1. Poverty and food insecurity

The Lindi region in Tanzania is characterized by widespread poverty, which expresses itself in poor infrastructure (water, electricity, houses), low consumption rates, food insecurity, lack of assets, low education levels, low income levels and low levels of mechanization in agriculture (Covarrubias *et al*., 2012; Mashindano and Maro, 2011; Research and Analysis Working Group, 2011). My household survey confirmed that cash income levels in both villages were very low, suggesting that the mean cash income per adult equivalent per day amounted to mere US$0.3 (2011/2012 prices), although noticeable inequalities existed between wealth groups (Scheba, 2014).

Against this backdrop of rural poverty and food insecurity, the adoption of CA is influenced by the immediate economic benefits available to villagers. The weak performance of the CA farmer field schools, especially in Ruhoma and Darajani, partly stems from unfilled expectations regarding (immediate) economic returns. While three groups were told that group members were expected to volunteer, that no individual remuneration would be provided, and that the goal was that the collective harvest would be distributed among all members, many participants in Ruhoma and Darajani prematurely quit the exercise due to unfavourable cost-benefits calculations. Dropouts concluded that participation was too much of a risk early on in the process, as they contrasted the amount of future benefits with the costs required.

> *"People understood that the demonstration farm is about learning. But some people thought that if you return with some money for cooking oil, it would have been good. Now it was seen that they went once to Liwale, and then afterwards everyday they go there and they don't get*

anything. This broke their heart. This is why it has come to this situation." (R Interview 1)

7.2. Labour productivity

Villagers and group members expressed concern over the increased workload resulting from CA. Because in both villages the technology was introduced in combination with the preparation of basins for planting, most group members felt that the workload increases during field preparation. Digging holes based on exact measurements was something new and took much longer than traditional practices. However, group members also remarked that with time, this new labour task becomes easier and people will get used to the new mode of preparation. And because the holes can be used every year, the task of digging does not have to be repeated after every harvest. Some argued that the crucial aspect regarding labour requirements was to practice good time management, to prepare the field early and to plant and weed at the right time.

"You know, they say it is a lot of work, because they haven't tried it yet. Also we, we said this is a lot of work. We dug the holes but we didn't know exactly. The importance is that you start early, then it is not so much work. But if you start when the rain has come already, then it is hard work. You need to start early. In June or July. You dig holes until October." (M Interview 26)

7.3. Inputs, credit and markets

In addition to difficulties with providing labour for the group exercise, both groups were confronted with the challenge of purchasing inputs for the demonstration plot. Although groups in Darajani and Mihumo were provided with some agricultural inputs, they did not receive pesticides to combat pests and diseases. According to group members, the purchase of external inputs represented a challenge, as no group fund had been established, and individual members hesitated to provide their own money.

"We always complained that we struggle with the rats. But they don't listen and we only started the group recently. Where do we get the money to buy poison? Or to spray the pesticide? We don't have the money. We just leave it. If you don't have salt at home, do you take money to buy pesticide for the demonstration farm?" (M Interview 40)

The costs of the inputs were the single most discouraging factor to the ordinary villager. People complained that they do not have enough money to buy the inputs; that they suffer from food shortage and struggle with daily living expenses. To expect that they now should invest in expensive fertilizers and other inputs seemed unreasonable. On the other hand, several group members told me that even the ordinary villager could invest in external inputs if s/he manages his/her budget better. According to them, if villagers start with a small area, something like ¼ of an acre, they should be capable of purchasing the inputs necessary to follow CA.

"CA is good and it results in a lot of crops. But here we are not able [to practice it]. The problem is: for CA you need to spend a lot [of money]. You need fertilizers. If you just plant, you won't get anything. And here we use a lot of efforts to farm 4 or 5 acres, but the harvests are little. With CA you can farm a small area, and if you use what is required, then the income will be more compared to the big area." (M Interview 36)

Apart from affordability, also the availability of external inputs constituted a problem to some farmers, especially for those who lived far away from the village centre. During the planting season, everything must be available on time, and within a short period of time. Given the inadequate communication and transportation infrastructure in the village, farmers faced big challenges in obtaining the inputs in a timely manner.

7.4. Governance and leadership

Weak leadership and lack of good governance in the villages contributed to the high dropout rates in Darajani and Ruhoma. The chairman of the farmer field school group in Darajani did not follow up with the people who dropped out. While he continued to run the activities, he failed to sanction wrong behaviour and provide incentives for members to stay. At the same time, participants did not bother to excuse their absences, either. With each meeting, fewer people came to the demonstration plot. And in the end, the chairman was left with only three colleagues.

"We did not follow up on those who left. But after we agreed that we would work on this day we visited all the people and said tomorrow is farming. Then tomorrow they did not come. We just left it. We planned another day. Every day we said: why do we follow up on them and they don't want? We knew that they don't want. We said if we go on certain days then it is only us who go. And there was nobody who came to ask: how are you guys doing? People knew that they failed." (M Interview 40)

Communication was a serious problem. Information about group meetings, cancellations or changes, inputs, and future plans was not always communicated to all group members. Sometimes group members obtained false information about the project, which in one case led to the dropout of one member in Darajani, because he thought that the group had collapsed already.

In the Mihumo group, better governance and leadership contributed to the sustainability of the group. The leaders of the group were well respected and looked upon. Their instructions were generally followed without much questioning. The group drafted a constitution that penalized unexcused absence with 1,000 TShs (US$0.6 in 2011/2012). While this penalty was generally not executed, the agreement seemed to contribute to the practice to excuse oneself if attendance was impossible. Some members told me that if people became too lazy, they were requested to leave the group or they were excluded from any harvest.

7.5. Social capital and stakeholder relations

Good social ties among the members of the Mihumo group positively contributed to the sustainability of the farmer field school.[11] The Mihumo group also had a long and healthy relationship with the agricultural extension officer (who served as the facilitator). Group members felt that he cared about them. They respected his agricultural knowledge and sense of responsibility. At the same time, the facilitator appreciated their commitment.

> *"He facilitates us well. We follow him. Every Monday we are together. If he fails to come we know that he went to another farm. But we cooperate well and he comes and educates us. After he goes to a seminar he tells us about what he learnt. So we benefit from his knowledge. He teaches us on the farm."* (M Interview 33)

Among the group members in Darajani, there were less strong social ties among the members, as well as with the facilitator. The same agricultural extension officer was portrayed very differently. With time, considerable problems emerged between him and the group. The dissatisfaction about the lack of economic benefits, the high dropout rate and low successes on the farm contributed to the facilitator's loss of motivation in leading and facilitating the group. Some group members expressed dissatisfaction with the entire approach to how this project was run and a sense of envy, because the facilitator was the one being taken to seminars and workshops. The ordinary group members were not taken to any study tours, and they felt the agricultural extension officer did not transfer the knowledge with which he was provided. The fact that only limited inputs and no payments were provided caused anger and frustration among some participants, who directed them at the facilitator.

In Ruhoma too, there was conflict between the facilitator and the group members, which began when seeds got delayed and apparently jeopardized early planting. In the view of the facilitator, the failure of the maize was due to a lack of timely planting rather than availability of seeds. He explained the lack of success as a consequence of 'soft strike' or 'silent protest', meaning that group members refused to commit themselves to group work due to personal disagreements and other priorities. According to him, instead of officially leaving the group, they continued pretending to be interested and committed, but in reality they were not (R Interview 29). He thus interpreted the non-cooperation of some group members as a subtle form of everyday resistance and rebellion, something Scott (1985) famously pointed at decades ago in his seminal book 'Weapons of the weak'. According to this view, rural farmers challenged the facilitator and prevalent unequal social relations through small, everyday practices of resistance, rather than through overt and collectively organized acts of contestation.

8. Discussion and conclusion

In Tanzania and across the whole of Sub-Saharan Africa, governments and international organizations have promoted CA as the best way to solve Africa's agricultural development challenge. Numerous farmer field schools have been established on the continent to disseminate knowledge and to encourage farmers to adopt the technology. However, the rise of CA's prominence in global development policy has met growing criticism from the scientific community.

Building on scholarship that has questioned the promises, impacts and applicability of CA to smallholder farmers in Africa (Andersson and D'Souza, 2014; Baudron *et al*., 2012; Giller *et al*., 2009), this paper discussed associated benefits and challenges in the context of the Lindi region in Tanzania. More specifically, it examined the performance of CA farmer field schools in two case study villages, and scrutinized local perceptions and socio-economic/institutional constraints related to the technology's three key principles.

In the villages, CA farmer field schools did not perform to the expectations of project implementers, facilitators and other villagers. The paper found that the key principle of minimum tillage remained questioned by many villagers, who believed in the productivity-enhancing benefits of the plough. The principles of crop rotation and mulching encountered challenges related to capacity, long standing attitudes and cultural perceptions. Villagers expressed concerns over the increased workload associated with CA techniques, although others remarked that with time, this would become easier.

Because CA was introduced in the villages as a promotional package including training on fertilizers, pesticides and improved planting techniques, villagers associated the technology with increased costs and input requirements,

[11] The Mihumo group was established in 2005 in the context of an income-generating project related to crushing rocks. Since 2005, when they were more than 24 members, this group has also experienced many dropouts, corruption and governance problems. But when the CA project arrived, this group had already gone through a selection process that resulted in the most committed members remaining.

which deterred group members from pursuing it. This aspect of CA resembled and went hand-in-hand with the government's official agricultural modernization strategy 'Kilimo Kwanza', which similarly aims to increase farmers' use of fertilizers and pesticides to increase crop yields (Haug, 2016).

The farmer field schools struggled to perform well and experienced high rates of dropouts, management challenges and low performance. These problems have been common in participatory extension approaches, where a lack of economic benefits and of credit facilities, inadequate governance institutions, bad leadership, and insufficient social capital among group members and between the members and the professional facilitators has weakened performance (Islam *et al*., 2011). In addition to economic issues, weak leadership and poor governance, including poor communication between group members, have contributed to high dropout rates, dissatisfaction and low adoption of CA in the two villages, at least in the first year. Only in one group in which local rules were established, participation monitored, information exchanged and non-attendance sanctioned,[12] was the farm better managed than the two others, in which none of these mechanisms had been followed properly. Especially a lack of effective communication negatively impacted group performance (cf. Leeuwis and Aarts, 2011).

Aside from group governance challenges, a number of socio-economic and institutional factors have constrained the adoption of CA by group members and villagers. Against the backdrop of rural poverty and food insecurity, the important role of immediate economic benefits to villagers has been highlighted. Many members of the farmer field schools found it problematic to provide voluntary labour in a situation of great uncertainty and risk. Especially for food insecure farmers, it became a real challenge to spend time and labour on something with uncertain economic benefits. The farmer field schools failed to offer adequate financial incentives and means to alleviate risks and uncertainty, which could have helped in avoiding early disintegration. The lack of financial resources and access to credit facilities exacerbated challenges associated with managing the collective farms. Indeed, one of the most significant constraints mentioned was the purchase of inputs (fertilizers and pesticides) required when implementing CA. Lack of credit facilities, affordability due to low incomes and accessibility due to poor infrastructure affected villagers' capacity to acquire inputs at the right time.

A recent end-line evaluation survey on LIMAS's CA initiative seems to support some of the findings presented in this paper. The evaluation found that villagers practice only some techniques and principles, and only dedicate small patches (0.25–0.5 acres) of land to it. Making basins or ripping and leaving crop residues in the field are the most commonly adopted techniques, and more than half of CA farmers also applied mulching. The principle of minimum tillage was still widely questioned. The increased labour requirements and lack of access to inputs were mentioned as important constraints that hamper adoption (Huhta, 2015). In the TFCG/Mjumita project, the adoption of CA was also adopted only partially by villagers (NIRAS, 2015).

There is considerable debate taking place regarding the potential of CA in contributing to sustainable development in Africa (Giller *et al*., 2009). Scholars have examined the ecological impacts of its three main principles and found both benefits and risks, depending on the specific context (Pittelkow *et al*., 2015). Like Giller *et al*. (2009), this paper cautions against uncritical support regarding CA in Africa, and calls for more research to understand its potential, performance and impacts on rural farmers. It echoes previous arguments about the importance to acknowledge the complex socio-ecological processes behind the applicability and adoption of CA (Giller *et al*., 2009). Therefore, the future of CA does not only depend on the specific ecological context, but also on the transformation of individual perceptions as well as structural constraints, which is something many donor initiatives have continuously failed to sufficiently address (Cooke and Kothari, 2001; Dressler *et al*., 2010; Hickey and Mohan, 2005; Kamat, 2004; Mitlin *et al*., 2007). Unless this changes, the long-term applicability of CA to African smallholder farmers remains equivocal, even in the most ecologically suitable locations.

[12] Locally devised rules, communication, monitoring, enforcement and sanctioning are important factors that facilitate collective action according to common property theory (Gibson *et al*., 2005; Ostrom, 1990; Ostrom *et al*., 1999).

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