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Conservation Through Intensification: Adoption of Agricultural Technologies Introduced by a REDD Project in Kondoa, Tanzania

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CONSERVATION THROUGH INTENSIFICATION:

ADOPTION OF AGRICULTURAL TECHNOLOGIES INTRODUCED BY A REDD PROJECT IN KONDOA, TANZANIA

By

Santa Putniņa

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Declaration

I, Santa Putniņa, declare that this thesis is a result of my research investigations and findings. Sources of information other than my own have been acknowledged and a reference list has been appended. This work has not been previously submitted to any other university for award of any type of academic degree.

Signature………………………………..

Date…………………………………………

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Abstract

One of nine REDD pilot projects was implemented in Kondoa District. This pilot project had been managed by the African Wildlife Foundation (AWF) from 2010 to 2014. The aim of the project was to achieve strict forest conservation in the Kondoa-Irangi Hills. The main compensation for enclosure of the forest was the implementation of an agricultural component named ‘conservation agriculture’. This meant that 12 demonstration farmers in each of the 19 participating villages received support in the form of improved seeds, pesticides and fertilizers as well as advise to plant in straight lines. The actors behind the REDD project have especially highlighted the agricultural component when arguing for the project’s success.

This thesis evaluates the implementation and impact of the agricultural component of the REDD project in the Kondoa District. The case study was conducted in two out of the 19 participating villages - Mnenia and Bereko. For comparative purposes, a parallel survey was carried out in the two villages that decided not to participate in the REDD project (Itololo and Kisese Disa). It is assumed that data from both villages that did and did not participate in the project will display differences between the sites and, therefore, will allow to estimate the project impact. To assess the research questions, a mixed method research is applied. This involves gathering and integrating both quantitative and qualitative data. The primary data were collected in October and November 2018 using interviews and household questionnaires.

First, it is concluded that the label ‘conservation agriculture’ given to the agricultural component is misleading. The three principles of FAO's defined version of CA (permanent soil cover, minimum soil disturbance, crop diversification) was never promoted. While the agricultural component of the REDD project has been presented as a particular success, I find little evidence that the agricultural component had a significant effect on rural livelihoods and state of agriculture in Kondoa district. Generally, the results show modest adoption rates of practices promoted by the REDD project. The rate of agro-chemical use in Mnenia is the same as in villages that did not participated in the REDD project (with 6 % of farmers using synthetic fertilizers and 18 % using pesticides). Agro-chemical use in Bereko is higher than in control villages, however, it is hard to draw an adequate conclusion if REDD had any effect on it or it is the characteristics of Bereko village itself (mainly location) that facilitates high adoption rates. The REDD project’s agricultural component relies on investments into expensive inputs and, perhaps not surprisingly, the author finds wealth and asset ownership to be strongly correlated with the use of farming inputs.

Keywords: REDD, conservation, agriculture, adoption, mixed methods research, Tanzania

Contents

Abbreviations and Acronyms

ARKFor	Advancing REDD in the Kolo Hills Forests
AWF	African Wildlife Foundation
CA	Conservation Agriculture
FAO	Food and Agriculture Organizations of the United Nations
IPCC	Intergovernmental Panel on Climate Change
REDD	Reducing Emissions from Deforestation and Degradation
REDD+	Reducing Emissions from Deforestation and Degradation, plus the role of conservation, sustainable forest management and carbon enrichment
SSA	Sub-Saharan Africa
TFS	Tanzanian Forest Service
TZS	Tanzanian shilling
VAO	Village Agriculture Officer

1. Introduction

Forest conservation plays a significant role in contemporary climate change mitigation. Researchers and policymakers have acknowledged the multiple benefits of forests – it is estimated that forest products directly support 1.2 billion people worldwide. Besides, forests provide environmental services, for example, carbon sequestration that has become essential in climate change mitigation efforts (Noble et al., 2000). Because of this the UN and donor countries, in particular, Norway, have promoted Reducing Emissions from Deforestation and Forest Degradation (REDD) as a critical component in international climate change mitigation policies. Forest conservation in low-cost countries plays an essential role in Norway's climate change mitigation plan and through Norway's International Climate and Forest Initiative (NICFI), Norway is the leading donor of REDD (Beymer-Farris and Bassett, 2012).

One of the nine REDD pilot projects in Tanzania was implemented in the Kondoa District in Dodoma region where it was carried out from 2010 to 2014. The project aimed to protect the forest of the Kondoa-Irangi Hills. The REDD project included 19 of the 21 villages around the forest since two of the villages decided not to participate.

The main compensation for the enclosure of the forest was the implementation of an agricultural component. This meant that 12 demonstration farmers in each of the 19 participating villages received support in the form of improved seeds, pesticides and fertilizers as well as advise to plant in straight lines. This farming approach was labeled "conservation agriculture". The agricultural sector provides a livelihood for about 80 % of Tanzanians, with more than 90 % of agricultural-dependent households located in rural areas (Derksen-Schrock et al., 2011). Yet, there is a concern that agriculture in Tanzania faces serious challenges, while trying to increase food production to meet the needs of a growing population and simultaneously adapting to adverse effects of climate change – all that, without significantly increasing the farmland area (The Montpellier Panel, 2013; Westengen and Brysting, 2014).

Research by Svarstad and Benjaminsen (2017) found a substantial discrepancy between the success claims made by the donor and implementers of the project compared with empirical livelihood data obtained through qualitative fieldwork in project sites. In particular, the assertion that 'conservation agriculture' was successfully implemented as compensation for forest enclosure was problematized.

This research aimed to further assess the implementation of this agricultural component of the REDD project in the Kondoa District. Research in Kondoa district was carried out four years after the REDD pilot project has ended, meaning that it was possible to observe to what extent farmers have adapted the agricultural component. Another aspect that is in interest of this research is how well the agricultural component introduced by the REDD project corresponds to the concept of conservation agriculture.

1.1 Research objective and research questions

The overall **objective** of this research is to evaluate the implementation of the agricultural component of the REDD project in the Kondoa District. In order to assess this objective, the following research questions have been identified:

RQ1: On what basis was it decided to promote conservation agriculture as compensation for now prohibited forest-based livelihood strategies?

RQ2: To what degree have farmers involved in the REDD project adopted the farming methods introduced by the project?

- What farming methods promoted by the REDD-project are still used today?
- How well are farmers informed about efficient and sustainable use of agricultural inputs?
- If any, what are the differences in farming practices between the villages that participated in the REDD project and the two villages that decided not to participate?

RQ3: What are the reasons for farmers' adoption or non-adoption of the farming methods promoted?

1.2 Structure of the study

The thesis consists of six main chapters after the *Introduction.* Chapter 2 *Thematic background* provides background information on Tanzania, its forests and agriculture, as well as REDD development. Chapter 3 *Literature review* defines and describes concepts of conservation agriculture and adoption that are later employed throughout the study. This chapter reviews the conservation agriculture literature and debate surrounding the suitability of CA for Sub-Saharan Africa's smallholder farmers. Chapter 4 *Methods* explains the methodological approach, data collection, sampling and data analysis. This chapter also introduces the study area. Chapter 5 *Results* in its nine sub-chapters presents findings for the research questions. A discussion of those findings is provided in chapter 6. Chapter 7 *Conclusion* outlines some key results and provides answers to the research questions.

2. Thematic background

2.1 Country profile

The United Republic of Tanzania is situated in East-Africa, just south of the Equator. Tanzania's land area of 94.5 million hectares hosts a variety of ecosystems, including marine, coastal, mountain, freshwater, dryland, wetland and forest ecosystems. Generally, it could be said that Tanzania enjoys peace and stability; however, the country also faces a high level of poverty. Out of Tanzania's 55 million population, 38 % live below the poverty line and in rural areas, more than 80 % of the population struggles with poverty (URT, 2013).

2.2 The state of forests in Tanzania

About 55 % of the mainland is covered by forests and woodland that provide water catchment and habitats to wildlife and the country's unique natural ecosystems. More than 90% of this forestland consists of miombo woodland (Kajembe et al., 2015). These forests provide a wide range of benefits to the human population such as fuelwood, charcoal, timber, game meat, fodder, medicinal plants, nuts, fruits, bees-wax, and honey. Close to 90 % of Tanzania's 55 million population relies on forest resources as an important part of their livelihoods (Abdallah and Monela, 2007). This big demand for forest resources results in high rates of deforestation and according to estimates, Tanzania loses on average 1 % of forest per year (Abdallah and Monela, 2007). The National Environmental Policy of Tanzania (1997) identifies deforestation as one of the six significant problems for immediate attention (Malisa, 2007). Other five are land degradation, water scarcity and pollution, environmental pollution, loss of wildlife habitat and deterioration of aquatic systems. All types of forests are under pressure of transformation to other land uses such as agriculture, settlement and industrial development (Kajembe et al., 2015). Intensification of agriculture in shifting cultivation is one of the major sources of deforestation and environmental degradation in Tanzania.

2.3 The state of agriculture in Tanzania

Agriculture is Tanzania's leading economic sector that represents around 30 % of National Gross Domestic Product (GDP), 75 % of exports and provides a livelihood for about 80 % of Tanzanians, with most of agricultural-dependent households located in rural areas (Derksen-Schrock et al., 2011). In Tanzania, a wide variety of crops are farmed, ranging from staple crops such as maize, cassava and sorghum, to export crops such as coffee, tea, tobacco and cotton. Also, livestock farming has great importance, with around 40 % of households keeping livestock (Ministry of Agriculture Food Security and Cooperatives, 2008). While farm size varies across regions, most farms in Tanzania are from two to seven acres with the average being 5.9 acres (Derksen-Schrock et al., 2011). The agro-ecological zones in Tanzania differ from high rainfall areas on the coast and highlands to arid and semi-arid areas in the central part of the country.

Several studies have found significant yield gaps for all of the major staple crops in Tanzania (Malley et al., 2009; Mghase et al., 2010). Yield gap is defined as the difference between yield potential and actual yield over a given time (Global Yield Gap Atlas, n.d.). Yield gaps can be attributed to numerous challenges farmers are facing, including crop diseases and pests, limited access to support services (e.g., extension programs, research, financial services), access to inputs (fertilizers, pesticides, appropriate seed), poor rural infrastructure, declining soil quality and variation in climate pattern.

Several studies have identified climate change as one of the most critical challenges facing the agricultural sector in Tanzania (Rowhani et al., 2011; Rwehumbiza, 2014). The adverse impacts of the changing climate can are already be observed, these include poor crop yields because of droughts and floods, and reduced water availability (Rwehumbiza, 2014). World Bank study on climate volatility in Tanzania (Ahmed et al., 2009) found that in some cases, yield loss can be attributed to increasing temperatures. Tanzania's most popular staple crop – maize, which is grown by 86 % of the farmers, had a yield loss of 12% per degree Celsius (Ahmed et al., 2009). This means that agriculture in Tanzania is a very climate fragile activity, yet the majority of the country's people depend on agriculture for their livelihoods.

2.4 REDD in Tanzania

The REDD program is one of many market-based mechanisms to reduce carbon emissions from deforestation and offset emissions elsewhere (Leach and Scoones, 2015). Simply put – the program proposes a market-based solution to an environmental problem. The core principle underlying REDD is to pay forest owners for avoiding deforestation and by doing so increasing the carbon storage. For REDD donor countries the project is attractive since it is a cheap way to reduce emissions by investing in low-cost countries. It is expected that the Global South benefits the most, especially since that is where large areas of tropical forests are located, yet they have been struggling with deforestation, climate change and poverty. That is why the REDD program's strategy has often been presented as a "triple win scenario" where forest conservation, mitigation of climate change as well as poverty reduction are achieved (Suckall et al., 2015).

However, over time criticism of the program has surfaced, pointing to negative externalities such as corruption, lack of governmental capacity, violation of human rights, land grabbing, tenure conflicts and enforcement failures (Buizer et al., 2014). Nevertheless, these negativities are often overlooked, this is because for the donor countries of the REDD especially the dominant funder of the program – Norway has a particular interest in portraying the program as a success, since there lies the credibility of the country's climate change mitigation policy (Svarstad and Benjaminsen, 2017).

Tanzania is among the African countries with rich tropical forest areas and high rates of deforestation and forest degradation. In addition, climate change is becoming an increasing problem in the country where frequent droughts and floods threaten agricultural productivity, water supplies and biodiversity (Kangalawe and Noe, 2012). These factors alongside with stable socio-political situation made Tanzania an attractive country for REDD implementation. In 2010, with support and funding from the Norwegian government, Tanzania undertook nine REDD pilot projects at the sub-national level across various regions and ecosystems (Kajembe et al., 2013). Generally, there are two main REDD governance models – national approach and sub-national approach (Skutsch and Mccall, 2010). The national approach involves nationally accomplished reduced deforestation rates. In case of Tanzania, the REDD pilot projects were governed in sub-national level, meaning non-governmental actors, are responsible for the governance of REDD on the ground. The main argument for a sub-national approach is that it has smaller risk of corruption in countries where there is a high risk of rigged state administration system (Skutsch and Mccall, 2010).

One of nine REDD pilot projects was implemented in Kondoa District. This pilot project had been managed by the African Wildlife Foundation (AWF) from 2010 to 2014. The main effort of the project was to achieve strict forest conservation in the Kondoa-Irangi Hills. To compensate for the loss of access to forest and reduce poverty in rural communities, the project provided livelihood alternatives – improved cooking stoves, sustainable charcoal production, energy-efficient brick production, tree planting and an agricultural component. According to Svarstad and Benjaminsen (2017), the actors behind the REDD project have especially highlighted the agricultural component when arguing for the project's success. However, the evidence for the claimed success is lacking.

For around 80% of Tanzania's population, the agricultural sector provides the primary source of income (FAO, n.d.). Yet, there is a concern that agriculture in Sub-Saharan Africa faces serious challenges, while trying to increase food production to meet the needs of a growing population and simultaneously adapting to adverse effects of climate change – all that, without significantly increasing the farmland area (The Montpellier Panel, 2013; Westengen & Brysting, 2014). The case that shifting cultivation is one of the significant sources of deforestation and environmental degradation was also recognized by AWF, when establishing the baseline for the REDD project in Kondoa District (Mung'ong'o, et al., 2011): "Shifting cultivation could be discouraged by the introduction of intensive cultivation which will not only conserve the environment but will also increase productivity of crops which in turn will improve the economic status of the community members." The farming approach introduced by the REDD project was designed to intensify agriculture and consisted of support in the form of improved seeds, pesticides and fertilizers as well as advice to plant in straight lines given to 12 demonstration farmers in each of the 19 participating villages. This farming approach was labelled as "conservation agriculture' (CA).

More recently, CA has been used as a good example of a climate-smart agriculture method. However, in the case with the REDD project in Kondoa District, Svarstad and Benjaminsen (2017) doubt that the introduced agricultural component is actually in line with principles of CA, but rather resembles mainstream agriculture intensification methods with modern inputs.

Even more, it is quite challenging to distinguish the REDD project's impact on agriculture in Kondoa district. This is because, REDD activities to some extent overlap with other similar projects carried out in the area to improve agriculture (Svarstad and Benjaminsen, 2017). Most importantly, there exist state-based initiatives to strengthen smallholder farmers productivity in Tanzania. The leading example being the extension officers in ward level, who operate as advisors for farmers on how to improve their farming methods (Sanga et al., 2013). Next, through National Agricultural Input Voucher System (NAIVS) (established by the Ministry of Agriculture, Food Security and Cooperatives in the year 2008), some farmers could have received fertilizers and other agricultural inputs (Hepelwa et al., 2013). This program makes each household in a village entitled to a bag of fertilizer. According to Svarstad and Benjaminsen (2017), it is hard to distinguish which farmers received fertilizer from REDD and which farmers from NAIVS, and there is a possibility that some demonstration farmers were supported by both projects. Finally, during the implementation of REDD, AFW received funding from two other projects with the Kolo Hills as an impact area and similar components for agricultural modernization (Svarstad and Benjaminsen, 2017). The first was a five-year USAID project named "Scaling up Conservation and Livelihoods Efforts in Northern Tanzania" implemented during 2010-2014. Another project was a four-year project funded through EuropeAid (European Union funded) called "Enhancing Livelihoods through PFM in Northern Tanzania" implemented from the year 2012 to 2016. EuropeAid's project "sustainable agriculture" component to a great extent resembles the REDD project's "conservation agriculture."

3. Literature review

3.1 Conservation agriculture

The Food and Agriculture Organization of the United Nations (FAO) (2014) identifies CA as farming practices that improve yields through environmentally sustainable farming methods – minimizing soil disturbance, maintaining permanent organic soil cover and practicing crop rotation. Additionally, CA addresses the damages caused by the use of conventional agriculture practices (e.g., the use of plough) mainly soil erosion (Aune et al., 2012). Historically, CA was promoted as a plan of action to prevent soil erosion, however in late 1990s rationale for CA advocacy shifted and it evolved as a desirable tactic for resource-poor smallholder farmers that increases productivity and strengthens food security (Arslan et al., 2014). More recently, CA has also been used as a good example of a climate-smart agriculture method.

CA is composed of farming practices that is said do not disturb soil and conserve plant nutrients (Jat et al., 2013). Use of permanent soil cover boosts water use efficiency through reducing surface runoff and increasing infiltration (Palm et al., 2014). Further, the benefits of crop rotation in preventing pests and diseases and improving soil quality are well established (Giller et al., 2015).

However, recently the fitness and sustainability of CA in SSA have been much debated (triggered by the paper of Giller et al. (2009)). According to Giller et al. (2009) yield increase from CA can take longer than expected, affecting the perception farmers have towards CA. And, while donors of development projects publicly tend to claim widespread adoption of CA, several adoption studies (e.g., Corbeels, 2014; Giller 2009), estimate low uptake in most East African countries. The limited extent of CA adoption has led to debates over the applicability of CA practices and one-size-fits-all promotion techniques (Andersson and D'souza, 2014; Giller et al., 2009; Ngoma et al., 2016).

Critiques of CA point out that there is inconsistency in findings on the effect of CA on yields and its universal applicability (Pittelkow et al., 2015). Cases can be found where the application of CA results in the desired effect, yet there is equally convincing scientific research that challenges these cases. Adverse outcomes observed with CA include decreased yields, increased labour requirements (e.g., when herbicides are not used), increased labour burden to women and rivalry of crop residues for the use of mulch and livestock feeding resources (Giller et al., 2009). Moreover, the claims of environmental benefits from CA have been challenged. For example, research by Powlson et al. (2016) finds that reported soil carbon sequestration increases under CA have been overestimated or lacking evidence.

CA is more attractive to larger and better-resourced farms, that can support their minimum tillage activities with investments into herbicides, while for poor smallholder farmers CA will remain beyond grasp (Ellis and Mdoe, 2003; Giller et al., 2015 Ngoma et al., 2016). According to Ngoma et al. (2016) and his research on minimum tillage uptake by smallholder farmers in Zambia - it can be expected that adoption of minimum tillage is positively correlated with the presence of major minimum tillage promotion programs. Yet, Wall (2007) explains that even when zero or minimum tillage is economically feasible for the farmer, it is mindset or traditions that prevent farmers from adoption, since: "The plow is often thought of as the symbol of agriculture and making the leap to do away with tillage is difficult." Wall also to some level contradicts statements by previously mentioned researchers, implying that CA is more knowledge-intensive than input intensive in other words – even when farmers cannot afford expensive inputs for his farm, the desired effect can be reached by proper farming practices.

One also has to acknowledge the confusion that exists regarding the definition of CA within the academic literature. While reduced tillage seems to be the dominant rule for CA, if the definition is applied strictly, use of one out of three principles alone, does not constitute as conservation agriculture (Giller et al., 2009; Westengen et al., 2018). In fact, most CA adoption studies actually use only the component of minimum tillage as an indicator of adoption.

3.2 Adoption

In agriculture the adoption of new efficient technologies and farming practices is a necessity to increase production and its quality, to reduce labour burden and to reduce the farming impact on the environment. IPCC (2014) defines adoption as: "the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities." Yet, there is a common disagreement in the literature as to what constitutes 'adoption' by farmers. Ngoma et al. (2016) distinguish adoption as sustained use of technologies or practice over time and can be measured with panel data, while technology can be used in testing or experimental phase, which may or may not lead to adoption. Giller et al. (2009) point out numerous occasions where adoption of technologies has been declared during an active promotion project, however later revealed to be by virtue of the short-lived influence of the project, rather than a sustained change in agricultural practice.

Due to the nature of low adoption rates for introduced farming technologies in some cases, adoption studies attempt to examine the reason behind the issue. As concluded by Giller et al. (2009), most commonly the lack of uptake results from resource constraints - land, labour, feed for livestock, manure, lack of markets and money to invest are the key resources that are constrained. Indeed, several studies find differential rates of adoption by wealth groups and in particular low adoption rates by the most impoverished farmers (Cavanagh et al., 2017; Ellis and Mdoe, 2003; Ngoma et al., 2016). According to Cavanagh et al. (2017): “From a political economy point of view, this is not at all surprising or even sub-optimal: all households have differential asset combinations and constraints and the optimal production choices of what, how much, and how to produce will systematically vary between households on account of that. What is optimal or even sensible for some farmers will not be so for others.”

Resource-poor farmers often judge technology by its immediate costs, yet many benefits from practicing CA may become visible later down the line (Giller et al., 2009). This makes CA a risky investment, especially if after high initial investment costs CA in the short-term could present no net benefits, or even net losses (Arslan et al., 2014; Giller et al., 2009). Furthermore, Andersson and D’souza, (2014) point out that food security is common among smallholder farmers and even when net returns from CA practices increase, most often increased production is consumed by the household and thus will not be used as an additional investment requirement of CA.

The variety of factors influencing technology adoption are so broad it is hard to capture them in one study. For example, Arslan et al., (2014) recognize that farmers access to the tarmac road and markets influence the adoption of technologies. While developed infrastructure may increase farmers access to seeds and sales places, therefore, boosting adoption, it may also provide an opportunity for a farmer to participate in non-farm activities, thus minimizing farmers need to adopt new on-farm technologies. The same study by Arslan et al. (2014) revealed the connection between technology uptake and the community size. When the number of households in the village increases, it gets harder to change communal norms. As an example, regarding adoption of CA - in mixed farming systems in semi-arid areas where livestock possesses great cultural and economic value, the rivalry of crop residues for the use of mulch and livestock feeding resources emerge (Dugue et al., 2004). And even when farmers choose to keep crop residues for soil cover, traditional practices can require harvested fields to be burned or allocated for animal grazing (Arslan et al., 2014).Yet, even when there is no physical, social or economic constraints for the farmer to adopt technologies, there is still a possibility that he/she will decide not to adopt. Cavanagh et al. (2017) explain that the decision-making process is based on concern, where the primary worry is that adoption could result in adverse effects such as yield loss. Several authors also find a positive correlation between technology adoption and extension support (Arslan et al., 2014; Giller et al., 2015; Ngoma et al., 2016; Wall, 2007; Whitfield et al., 2015).

Andersson and D’souza (2014) recommend treating adoption figures cautiously for three reasons. First, often adopters are declared too soon when farmer still tests technology, but it does not necessarily lead to permanent adoption. Second, adoption figures may be biased towards project beneficiaries, since data collectors themselves are often involved in the promotion of the project. Finally, projects often subsidize inputs farmers could not otherwise afford without the support and often true adoption can only be assessed after a project has ended. For example, due to the lack of inputs such as fertilizers in East Africa, any project that subsidises fertilizers to farmers are seen as especially attractive, yet it does not mean that promoted technology is appropriate to the local conditions and will lead to permanent adoption (Andersson and D’souza, 2014).

In general, adoption literature indicates that for successful, long term technology adoption it is crucial to consider both agro-ecological and socio-economic factors (Arslan et al., 2014; Giller et al., 2009). It is essential to acknowledge that the adoption should not be defined as a binary outcome, recently adoption literature has noted that adoption tends to be partial and incremental (Arslan et al., 2014; Glover et al., 2016; Sumberg, 2005). According to Glover et al. (2016), the adoption process is not linear, because old technologies may continue to be used together with new ones, or new technologies may be integrated into old ones. This makes it possible for an adoption evaluator to report falsely.

It can be concluded that the outcomes from adopting CA as well as adoption rate itself is hugely case-dependent. This might seem peculiar, since the results from experimental stations have high internal validity, however as discussed by Giller et al., (2015), these results have minimal relevance since controlled environment eliminates real-life local agroecological and socio-economic factors. For CA adoption to local conditions, farmer involvement in tailoring strategies is required (Wall, 2007).

4. Methods

4.1 The overall methodology

To assess the research questions, a mixed method research is applied. This involves gathering and integrating both quantitative and qualitative data and doing so, helps create a more comprehensive account of the research topic (Bryman, 2016). This research combines structured interviews in the form of questionnaires for quantitative data collection as well as unstructured interviews and observations for qualitative data observation. The justification for choosing mixed method research was first and foremost having research questions that require different approaches. Also, mixed methods help to counteract the flaws of each of the methods individually. While through quantitative methods data on people's behavior and actions were gathered, qualitative data can explain the motivation behind them.

Throughout the research process, secondary sources of information such as academic publications, reports and government documents were reviewed to fill the information gaps and support the background of the thesis.

4.2 Data collection and sampling

Data was collected during fieldwork in October and November 2018 in two of the 19 villages that took part in the REDD project and two villages that declined to take part. Mnenia was one of the villages participating in the REDD project that was chosen since it is being used to present the project as a great success. The other village chosen for data collection was Bereko. For comparative purposes, a parallel survey was carried out in the two villages that decided not to participate in the REDD project (Itololo and Kisese Disa). It is assumed that data from both villages that did and did not participate in the project will display differences between the sites and, therefore, will allow to estimate the project impact.

In the REDD project pilot villages (Mnenia and Bereko), the aim was to interview all the 24 demonstration farmers, to probe to what extent they have continued to use the agricultural methods that were recommended by the REDD project. In reality though ten demonstration farmers from Mnenia and nine from Bereko were interviewed, as some were not present or not accessible for an interview at the time.

In addition, a household survey was carried out in these villages to assess to what extent other villagers have taken up the promoted farming methods. Quantitative research aims to make a generalization from the sample to a larger population, however, in order to make a generalization, the sample must be representative, meaning – it has to accurately reflect characteristics of a whole population (Bryman, 2016). The representative outcome is more likely to occur when each unit of the population has a known chance of being selected. In this research, survey questionnaires were administrated on average to 10% of the households. To make sure that the villages were covered evenly, 10% of households in each sub-village were interviewed (Table 1). In the sub-villages, the required number of households were selected randomly to minimize the bias in the data. In its four sections, the household questionnaire aims to learn about household characteristics, land use and farming practices as well as the direct and indirect impacts of REDD on farming practices and forest use (Appendix 1).

Table 1. Percentage distribution and number of questionnaires administered in the sample villages

Study Village	Total Households	Number of Questionnaires	% Sample
Mnenia	713	72	**10**
Bereko	1 065	105	**9.9**
Kisese Disa	643	64	**9.9**
Itololo	268	28	**10.4**
Total:	2 689	269	**10**

During the quantitative interviews, qualitative data were also gathered in the form of my observations and farmers comments. Besides, qualitative data was gathered in the introduction meeting in Kondoa district council as well as in introduction meetings in all four of the village councils. Additionally, an interview with Research Coordinator for Selian Agricultural Research Institute was held on October 2018 in Arusha Tanzania. And a Skype interview with the REDD project coordinator from AWF was conducted on February 2019 (Table 2).

Table 2. Overview of qualitative interviews

<table>
<tr><th>Date</th><th>Institution</th><th>Representative (present)</th></tr>
<tr><td>08.10.2018</td><td>Selian Agricultural Research Institute (SARI)</td><td>Research coordinator</td></tr>
<tr><td>09.10.2018</td><td>Kondoa district council</td><td>District administrative secretary, acting district executive director, official responsible for agriculture</td></tr>
<tr><td>09.10.2018</td><td>Mnenia village council</td><td rowspan="4">Meetings in the villages was generally attended by village chairman, sub-village chairpersons, agricultural extension officers and other interests.</td></tr>
<tr><td>21.10.2018</td><td>Bereko village council</td></tr>
<tr><td>30.10.2018</td><td>Itololo village council</td></tr>
<tr><td>01.11.2018</td><td>Kisese Disa village council</td></tr>
<tr><td>13.02.2019</td><td>AWF</td><td>The initial project coordinator</td></tr>
</table>

4.3 Data analysis

The gathered data was subjected to both content and statistical analysis.

Content analysis was applied to analyse qualitative data. All observations and interviews were transcribed and organized into smaller units of information, themes and categories. This method helped to outline the dominant trends in data.

Data from questionnaires was sorted into variables and analyzed using both Microsoft Excel 2016 and statistical software R.

Descriptive statistics such as measures of frequencies, measures of central tendencies, charts and graphs were used to describe the data. Data were descriptively analysed using “Data analysis” tool in Microsoft Excel 2016.

To test for associations between different categorical livelihood variables collected in the survey and adoption of agricultural practices promoted by the REDD project, Pearson’s chi-square test was performed using statistical software R. Pearson’s chi-square test allows to see the relationship between two categorical variables (Field et al., 2012). P-value in the chi-square test shows how significant the association between variables is. A p-value of 0.05 is used as the determination for significance. If the p-value is below 0.05, the null hypothesis is rejected, and it is concluded that there exists a significant association between variables. If the p-value is above 0.05, it cannot be concluded that a significant relationship between variables exists.

Cramer’s V is used as a post-test to determine the strength of the chi-square test association. Cramer's V value lies between 0 and 1. A value close to 0 shows a weak association and value close to 1 indicates a strong association (Field et al., 2012).

4.4 Research limitation and ethical considerations

To minimize quality restrictions on research methodology and conclusions, it is important to acknowledge possibilities of different limitations that can arise during the research process. First, interaction with villagers requires the knowledge of Swahili language. Although fieldwork was conducted with the help of a translator, there is a risk that some details were missed, or the information was otherwise misinterpreted. Second, due to the time restrictions, it was not feasible to conduct the interviews in all the 21 villages in the project area, only two villages that took part in the project and two that did not were studied.

While it is unlikely that any of the identified limitations had a strong effect on research quality, it could still be a challenge to capture the true drivers of adoption and non-adoption of the agricultural techniques promoted by the REDD project. The adoption of agricultural technologies is a complex process involving economic, political and demographic aspects, difficult to capture (Cramb, 1999).

A fundamental principle in research ethics is “do no harm”. The researcher is usually expected to adopt risk-minimizing strategies through informed consent, anonymity and confidentiality (Bryman, 2016). Before every interview, participants were informed about the research topic and intent and was asked to participate voluntarily. In order to provide privacy and make respondents comfortable, only I and my field assistant were participating in the interviews, unless the respondent expressed a desire for a family member or friend to remain nearby. Respondents are entitled to withdraw from participation at any stage of the research for any or no reason. All data collected was treated anonymously, by using pseudonyms in the interview transcripts and by any means making sure no information can be traceable back to participants. Fieldwork was carried out in a manner that respects local traditions, religion and ethics of the rural communities.

Following Tanzanian law, before conducting fieldwork, a research permit was obtained from the Tanzania Commission for Science and Technology. Next was a chain of procedures to introduce ourselves in the research area. First, the research and the research team (from NMBU and University of Dar Es Salaam) was introduced to the Regional Administrative Secretary of Dodoma Region. This was followed by an introduction to the Kondoa District Council, which provided us with the introduction letters to the study villages. Before conducting a data collection in the villages, an introduction meeting in each of the villages was set up. In these meetings the village council, chairperson and extension officer were usually present. Next was an introduction with sub-village chairperson, who finally introduced us to the respondents. While this seems lengthy and complicated, these introductions at different governance levels were crucial to assure collaboration with respondents as well as to ensure the safety of the research team. For example, in one of the sub-villages, the chairman was not informed about our intentions, since he did not attend the village meeting; therefore, he was hesitant to introduce us to the villagers and villagers declined participation in the interviews. However, after explaining our intentions the sub-village chairman, villagers agreed to participate in interviews, since they received assurance from the leader.

4.5 Wealth ranking

As presented in the literature review (chapter 3.) much of the adoption literature, including CA adoption literature, concludes that wealthier farmers are much more likely to adopt newly introduced farming practices (Andersson and D’Souza, 2014; Cavanagh et al., 2017; Ngoma et al., 2016). According to Andersson and D’Souza (2014), when project support is over, only wealthier farmers are able to generate the investment required for inputs to sustain long-term yield growth, therefore the promotion of CA for poor is bound to be unsuccessful. Based on this theory, it was decided to introduce an additional variable in data analysis – wealth ranking, to tests the importance of wealth in adoption or non-adoption of farming strategies promoted by the REDD project.

AWF conducted a wealth ranking exercise in Kolo hills region when the baseline conditions for the REDD project was established in 2010 (Mung'ong'o et al., 2011). This was mainly done to determine the socio-economic structure of the communities at the beginning of the project. AWF established wealth ranking using participatory research methods. Through wealth ranking criteria (Table 3) the sample population was divided into three groups: poor, middle and well-off. In eleven studied villages in Kolo hills region on average 28% of the population falls into the "poor", 11% can be considered "well-off" and the majority of the population – 61% fits into the "middle category". In the baseline study, AWF concludes that "poor people tend to depend more on natural resources, in this case ARKFor will have to concentrate its conservation efforts on less than 30% who are poor." This indicates that AWF planned to design project interventions so that poorest community members are specially targeted.[1]

Initially, for this study, it was planned to use the same criteria and same wealth groups as AWF did. However, after categorizing respondents in three wealth groups (in accordance with AWF's ranking), the vast majority referred to the "middle" category. Given the big difference in asset ownership between the people within "middle" category, it was decided to categorize the respondents into four wealth groups, since this way captures the socio-economic structure in the study area more in detail. Using the data from survey, respondents have been categorized into four wealth groups: very poor, poor, less poor and better off (Table 3). In this wealth ranking, it was decided to avoid the terms "well-off" or "rich", since asset ownership among the highest-ranking wealth groups was still modest.

Similarly, as done by AWF in the baseline study, the wealth ranking in this study is also based on assets. The ownership or access to assets can be used not only to determine one's ranking in the "wealth scale". Assets can also be used for "trading up" in sequence, for example, chicken to goats to cattle to land, hence assets can be used as ladders by which the poor can

[1] Yet, in the final review of the project, The Royal Norwegian Embassy in Dar es Salaam (2015) concluded that "The poorest members of the communities were not specifically engaged or targeted for project interventions."

climb their way out of poverty (Ellis and Mdoe, 2003). This is especially the case with the ownership of livestock. Large livestock herd ownership in rural Tanzania is associated with high wealth and implies high income, placing livestock owners in upper levels of the wealth scale. Ellis and Mdoe (2003) illustrate that livestock in rural Tanzania has an interlocking nature where it can be sold to invest in land or small business, and vice versa - nonfarm income can be used to build up herds.

For comparative reasons, this study poses wealth ranking criteria similar to AWF's baseline study, however, some criteria had to be changed since they have lost their significance or does not fit the current study. For example:

- It was decided to exclude the "house type" criteria since brick making is abundant in the study region, even the poorest of the households in study villages most often have simple brick buildings for living rather than a *tembe* type house (Fig. 1).

Figure 1. Brick making is a common livelihood activity in the study area. (Photo from the fieldwork 2018)

- This study excluded synthetic fertilizer use as criteria since this research aims to test how wealth impacts the adoption of fertilizer use on farms
- While land ownership can describe farmers' wealth, when looking at household's land ownership compared to average land ownership in the village, this wealth criterion is provided with context. For example, in Bereko village there is relative land scarcity with households owning 3.2 acres on average, while in Itololo village the farmland conditions are less constrained with average household owning 6.86 acres.

Table 3. On the left (column 1): wealth group ranking criteria in REDD project pilot villages by AWF (Mung'ong'o et al., 2011). On the right (column 2): wealth group ranking criteria within the current study

Ranking Criteria by AWF	Ranking criteria within this study
Well-off • Have at least one off-farm business; able to buy and sell goods, engaged in businesses such as shops; own big businesses within and outside of the villages. • Own up to 50 acres of land; have farm implements such as ox ploughs and tractors. • Extensive use of inorganic fertilizers. • Own more than one modern house with cement plastered brick walls and floors plus corrugated iron sheet roofs. • Highly food secure; managing three meals per day. • Have more than 20 heads of cattle; including draught oxen. • Can own motor vehicles such as trucks, cars, or a motorbike. • Can afford school fees for their children. • Own some milling machines.	**Better-off** • Highly food secure; managing three meals per day. • Can own motor vehicles such as trucks, cars, or a motorbike. • have farm implements such as ox ploughs and tractors. • Own double the land of the village average • Owns a significant amount of cattle or other livestock
Middle • Own 5-10 acres of land. • Own and/or rent farm implements such as ox ploughs and tractors. • Uses fertilizers and farmyard manure. • Own motorbikes and bicycles for transportation of goods. • Own normal house made of bricks and corrugated iron sheets roof; sometimes the iron-roofs have stones placed on top to prevent wind blows. • Food secured and can manage at least 2 meals in a day. • Livestock: have less than 20 heads of cattle. • Normally run small businesses such as shops, kiosks, etc. • They can meet basic needs such as food, education, and can educate their children. • Most have primary level of education.	**Less poor** • Owns around village average or more acres of land • Relatively food secure, can manage 2-3 meals per day • Can own valuable assets such as cart, oxen or motorbike • Owns less than 10 heads of cattle and/or other livestock

<u>Poor</u> • **Own land size 0.5 - 2 acres, but cultivates only 1 acre; renting the rest to middle group farmers; uses a hand hoe for farming; no fertilizers are applied in the farms.** • **Do not have any livestock.** • **Have poor grass-thatched houses (*tembe* type).** • **Food insecure; can manage only one meal per day.** • **Dependent on casual labour; a source of cheap labour for middle and well-off groups.** • **Many who live near forest resources indulge in charcoal production.** • **Illiterate (both parents and children).** • **Can't meet basic needs and are often dressed in tattered clothes.**	**<u>Poor</u>** • **Owns around village average or less acres of land** • **Relatively food insecure** • **Does not own any valuable assets such as oxen, cart or motorbike** • **Can own couple of head of cattle or other livestock** **<u>Very poor</u>** • **Owns less than 2 acres of land** • **Highly food insecure, can manage only one meal per day** • **Does not of cattle or any livestock** • **Does not own any valuable assets such as oxen, cart or motorbike**

4.6 Study area

The geographical focus of this research is the Kondoa-Irangi Hills in Kondoa District, Central Tanzania. Kondoa – Irangi Hills consist of Salanga and Isabe Forest Reserves in addition to some smaller village forests. These forest blocks hold the headwaters of the Tarangire River, which then provide ecological services to the whole region and stable water supply for Tarangire National Park, which is one of AWF's priority landscapes in Africa. The forest has also been important for supporting livelihoods of local people, since it has been traditionally accessed for firewood, timber products, farmland and livestock grazing (Kajembe et al., 2015). Salanga forest reserve is located in the highlands, where it is commonly humid with frequent rainfall. In contrast, in the Isabe forest reserve climatic conditions are drier (Kikula and Mwalyosi, 2004). Such differences in precipitation patterns affect the forest quality, resulting in highland forest being covered with predominantly miombo (*Brachystegia spp*.), whereas lowland areas are covered mainly by dry, scattered scrubs and dense high bushland (Kikula and Mwalyosi, 2004). Kondoa District is a sub-humid and semi-arid zone and is known for severe incidents of soil erosion. The driest period lasts from June to October (Makatta et al., 2015).

The Rangi and the Sandawe are two major ethnic groups, native to Kondoa. The other widely represented ethnicities are Waasi, Burunge, Gorowa (or Fyome), Nyaturu and Barabaig. Yet, Rangi people heavily dominates the study area. The Rangi are predominantly Muslim, therefore Islam is a dominant religion in Kondoa. The steady trend of population growth in the region has led to increased pressure on the land, forest and other natural resources.

The study area corresponds to the REDD project area in the Kondoa-Irangi Hills, Kondoa District. The research area includes 21 villages (Fig. 2). Fifteen of villages border the forest reserves, while six have community forests. Particularly, two villages that participated in the REDD project are studied – Mnenia and Bereko. These villages are referred to as the pilots. For the purpose of this study, two of the villages that decided not to endorse the REDD project, Kisese-Disa and Itololo are included and referred as control villages. It is assumed that data from both villages that did and did not participate in the project will display differences between the sites and, therefore, will allow to estimate REDD project's impact.

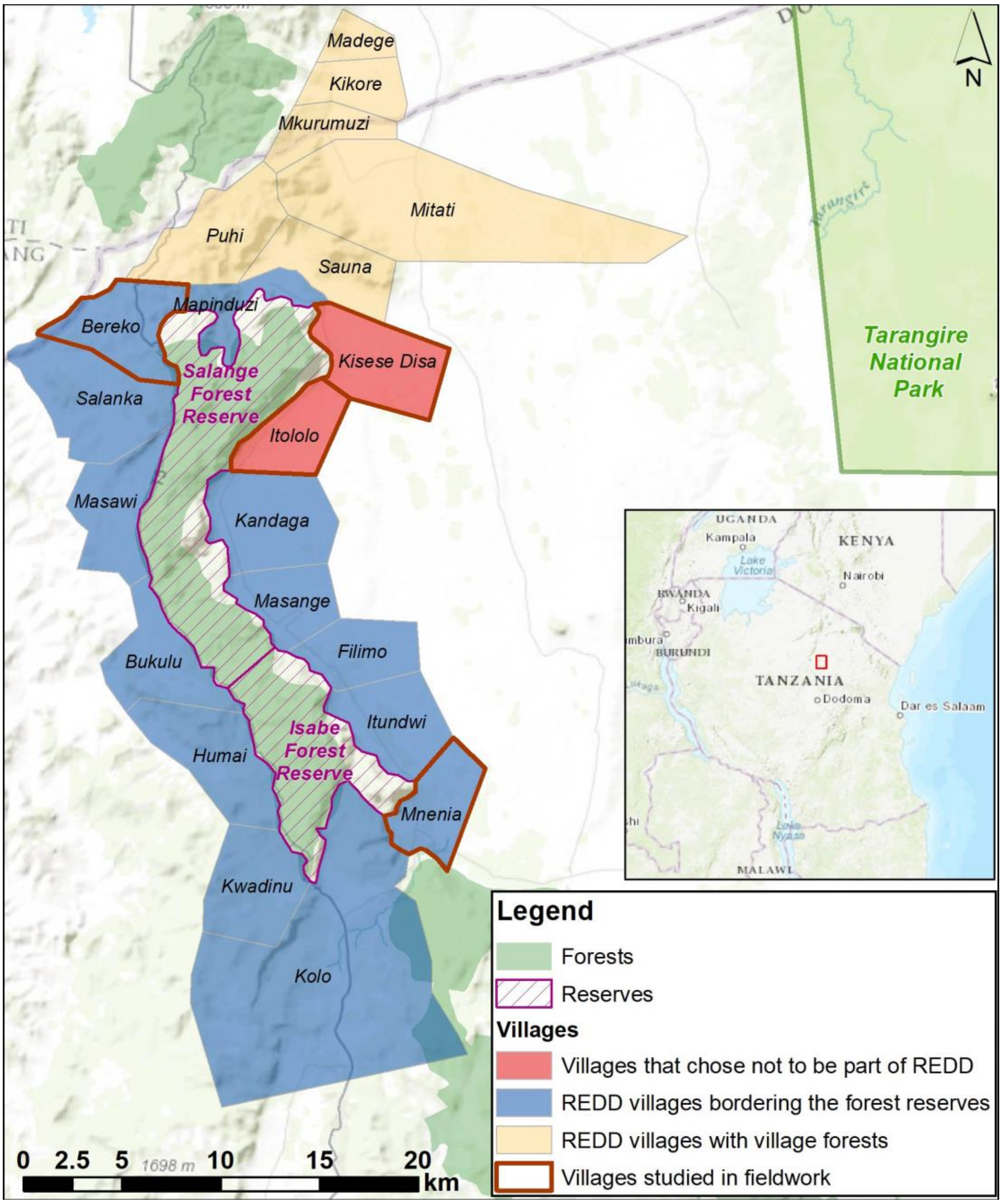

Figure 2. Map of the study area (modified from Svarstad and Benjaminsen, 2017) with 21 villages of the interest of research. (Background source: Topographic base maps provided by ESRI)

4.6.1 Pilot villages

Mnenia.

Mnenia is located 33 km from Kondoa town. Owing to Dodoma – Babati highway, Mnenia is easily accessible and only the last 7 km leading to the village is not tarmacked. The village borders with Isabe forest reserve, with most of the sub-villages located in only up to 1 km distance from the forest. Mnenia has a total population of 3328 people (URT, 2012), and almost all residents belong to the Rangi ethnic group. Average household size is 4.7 people per household (URT, 2012), however, larger households can consist of up to 10 people. Due to the little land and high population, the village encounters land scarcity with average households owning three to four acres of land. Grid electricity is accessible in the village, but less than 30% of residents had connected to it.

Bereko

Bereko is located 65 km from Kondoa town and 40 km from Babati town, which is the closest town in the neighboring district. The village is easily accessible, due to the Dodoma – Babati highway, which goes right through the village splitting it into two parts. Bereko borders with the Salanga forest reserve, however, most of the households are located not closer than two kilometers from the forest, and the most remote sub-villages can have up to five kilometers to the forest. The total population of the village is 7226 people, with an average family size of 4.7 people (URT, 2012). With a broad range of ethnicities being present, Rangi is the dominant one and Burunge, Mwasi and Iraqw are widely represented. The village is located in the highland, where water supply is generally good, presenting fine conditions for agriculture. Indeed, around 90% of land in the village area is utilized for agriculture, however, due to the high population, the village experiences land scarcity, with households cultivating only three to four acres on average. Since January 2018, grid electricity is accessible (The Bereko Community Partnership, 2018), and after ten months, around three percent of the Bereko population had made a connection to it.

4.6.2 Control villages

Itololo

Itololo is located around 83 km from Kondoa and 62 km from Babati. Itololo village is a fairly remote area, that can be accessed by a diverse quality of dirt roads. The village borders with the Salanga forest reserve and most of the households are located less than 1 km from the forest. With average household size 4.9 people, the total population in the village according to

Kondoa district population census (URT, 2012) is 1093 residents and the majority of them have Rangi ethnicity. Being so close to the forest, the village land can be described as a transfer zone between forest and savannah – with the presence of shrubs and trees, including large trees.

Kisese Disa

Kisese Disa borders with Itololo village and is located around 85 km from Kondoa and 60 km from the closest town – Babati. Similarly to Itololo, Kisese Disa can be described as a remote area that can be reached by dirt roads of varying quality. The village borders with Salanga forest reserve and while three out of four sub-villages (Mchafukoge, Mitaoni and Mitati) are located up to 1.5 km from the forest, the fourth one – Migungani sub-village is remote, with distance around 4 km to the forest. Kisese Disa has a total population of 3138 people, with an average of 4.8 members in the household (URT, 2012). While the dominant ethnicity is Rangi, a broad range of ethnicities are present and Iraqw and Fyomi are widely represented. Kisese Disa is the most electrified village of the ones presented, with more than 40% of the villagers being connected to the grid, but if we consider only the sub-villages where grid electricity is accessible (the remote Migungani, does not yet have access to the grid) more than 60% of the households have a grid connection. In 2002 National Irrigation Master Plan was launched and Kisese was one of ten areas where plan included an upgrade of electrification (Ministry of Water and Irrigation, 2009).

Both villages have a similar answer to why they declined participation in the project. Village officials explained that they based their decision on the neighboring village experience. Neighboring villages - Kisese Sauna, Kadanga an Mapinduzi warned them about violent clashes between farmers and the forest guards and villagers were concerned that under the REDD project they would lose access to the forest.

5. Results

5.1 Farming practices introduced by REDD and their justification

In its core, the farming approach introduced by the REDD project consisted of support in the form of improved seeds, pesticides and synthetic fertilizers to 12 demonstration farmers in each of the 19 participating villages. These demonstration farmers received training in ‘improved farming methods’ and committed to design one acre of their farmland as a demonstration plot. Additionally, farmers were advised to plant in straight lines and regular spacing as well as switching of two crops in every second row. On hilly terrains, farmers were encouraged to use terracing and constructing the rows parallel to the slope. The hope was that other farmers would adopt these practices following the example and success of these demonstration farmers.

Selian Agricultural Research Institute (SARI) is a governmental research organization that was subcontracted by AWF to facilitate design of the project’s agricultural component. When interviewed, the official of SARI (2018), explained that: “*AWF came with the concept of the conservation agriculture and SARI filled it with the content*”. In the article by Svarstad and Benjaminsen (2017), the inputs provided to the farmers are described:

- two types of improved seeds for maize: hybrid (Pannar and DuPoint Pioneer) for wealthier farmers and open pollinated varieties (produced by Tanzanian research statison)
- two alternatives for synthetic fertilizers: diammonium phosphate bought from foreign producers and cheaper fertilizer products produced by Tanzanian companies
- chemical pesticides (without a low-cost alternative)

In the interview, the project coordinator from AWF (2019) told that the use of organic fertilizers (animal manure and composting) was encouraged, however, there was not enough material available in the project area, therefore it was decided to also promote synthetic fertilizers.

In an interview conducted in October 2018, SARI official added that the intercropping of maize and legumes was also promoted. Most farmers chose to intercrop maize with pigeon peas, while some with beans. An emphasis was put on endorsing the cultivation of pigeon peas (*Cajanus cajan (L.) Millsp.*) since stems of the crop can be used as firewood. On top of that, according to Sakala (1998), pigeon pea is a perfect legume for intercropping with maize since it continues to grow after the maize crop has been harvested, yet pigeon pea’s slow initial growth provides little competition with cereal for water or light.

Both in interviews with SARI and AWF, officials were asked how the agricultural component promoted by the REDD projects fits in line with the commonly accepted definition of CA and its three principles: minimum tillage, permanent soil cover and crop rotation. The SARI official explained that the promoted permanent soil cover was restricted to 10-15% since crop residues for soil cover compete with fodder for livestock. Also, minimum tillage was not promoted: "*Farmers in the area are poor and they do not own a tractor or an ox plough, therefore they already were not able to do deep tillage. Naturally they already did conservation agriculture.*" Similarly, the project coordinator from AWF admitted that zero tillage was never promoted: "*It is true that in the project documents the practice is called conservation agriculture, but actually we should have called it the "sustainable agriculture" […] the main component related to conservation was soil and water conservation in the farm.*"

5.2 Demonstration farmers

For the agricultural component's implementation, in each of the REDD project villages 12 farmers were assigned as the demonstration farmers. These farmers received one day of training in improving agricultural productivity, by applying fertilizers, pesticides, improved seeds and planting crops in rows. To become a demonstration farmer, the person had to be elected by other villagers. However, the process of choosing the demonstration farmers has left many villagers displeased. As told by villagers, each sub-village chair was responsible for making a list of farmers from their sub-village that could qualify to be demonstration farmers. After, it was up to the village committee to approve these farmers by voting. Selection of leading farmers was also based on gender equality, with half of the farmers being women. Yet, several villagers implied that they believe that the choice of demonstration farmers was based on nepotism and friendship and sometimes sub-village chair included themselves in the list. Indeed, from 19 demonstration farmers interviewed (10 from Mnenia and 9 from Bereko), five of them were sub-village chairs and two were previous agricultural officers. In one case, a demonstration farmer told that before being selected, she was not even a farmer.

The purpose of the demonstration farmers was to share knowledge with other farmers. While basically all of the demonstration farmers told that other farmers visited their plots to learn about the improved farming practices, the evidence for that is lacking. First, in interviews we asked – how would other farmers know which ones are the demonstration farmers they should receive advice from? As it was admitted by the demonstration farmers themselves, it was not ever announced anywhere that 'these are the farmers one can learn from'. It was only in that village meeting where demonstration farmers were voted and approved where other villagers could learn about them. Second, when interviewed, the direct neighbors of the demonstration farmers often did not know that their neighbor had received some training in agriculture improvement. Also, villagers admitted that even if they would receive the training from demonstration farmers or others, to apply improved input-intensive agriculture would be too costly for them.

When interviewed, almost all the demonstration farmers report they had an impressive increase in agricultural production after the beginning of the project. However, they also said that it had been impossible to keep the high yields. All of the interviewed demonstration farmers have adopted planting crops in straight lines and the majority of them are using organic fertilizers, however, less than half of them still use synthetic fertilizers and pesticides.

5.3 Claims of a successful agricultural component

The agricultural component of the REDD project has been presented as a particular success both by AWF and the Norwegian Embassy (Svarstad and Benjaminsen, 2017). In the final review of the project, the Norwegian Embassy (2015) emphasizes that improved agricultural production in Kolo Hills area has contributed to reducing pressure on now restricted forest areas. A similar narrative is displayed by AWF (2013) and in their webpage review of the Kolo Hills Redd project AWF states: ” Because the deforestation is caused largely by agriculture, AWF provided more than 170 farmers with improved seed, fertilizer, and training in profitable conservation-farming techniques—which resulted in an eightfold increase in agricultural production—from 300 kilograms/acre to 2,400 kilograms/acre of maize output—in 2011". These numbers of eightfold increase were also repeated by the project coordinator from AWF in the interview in February 2019.

In both introduction meetings with village councils in Mnenia and Bereko, council representatives told that many farmers have adopted the project’s promoted techniques. While the village council in Mnenia was fond of the REDD project in general, the council in Bereko acknowledged the success of the project's agricultural component but was reserved to express an opinion on forest enclosure. According to Bereko village council representatives, after implementation of the REDD project and subsequent enclosure of the forest, candidates who were critical of the REDD project ended up being elected in the following village council elections.

Furthermore, the demonstration farmers also reported the successful adoption of promoted farming techniques. However, in most cases when demonstration farmers said that they had adopted farming techniques promoted by the project, they were actually referring to planting in straight lines with regular spaces between plants, and very few farmers also buy fertilizers, pesticides and improved seeds. Also, almost all the demonstration farmers interviewed told that other villagers visited their farms to learn about the improved farming techniques. According to Svarstad and Benjaminsen (2017), the villagers could have a particular interest in reporting high levels of adoption, since that would make the village attractive for future carbon payments from investors.

5.4 Adoption of CA principles

During interviews, 60 % of farmers in Mnenia answer that they practice conservation agriculture. This number is lower in Bereko 23 % and control villages 14 – 18 %. However, when farmers explain what they understand with "conservation agriculture" it comes clear that the concept resembles the one promoted by the REDD project, rather than FAO definition of CA. Majority of farmers understands CA as agricultural yield increase through the use of external inputs and planting their crops in straight, parallel rows. Also, 40 % of farmers in Itololo (and around 15 % in other villages) believes timely sowing, weeding and harvesting is a part of CA. Only in Mnenia, 20% of farmers said that for them, CA is all about reducing soil erosion.

REDD project has not been the pioneer in promoting agricultural intensification through the name of conservation agriculture in Kondoa district. First, farmers in the control villages, where REDD project was not present, also defines CA as agricultural modernization. In the pilot villages, 30 % of farmers in Mnenia and 76 % in Bereko said that they know about improved agriculture from other sources than REDD. Farmers noted that they learned the same practices named the conservation agriculture in various seminars, schools or from brochures given by agricultural officers.

It is clear that the REDD project never promoted three principles of CA (permanent soil cover, crop rotation and reduced tillage). Further in this chapter, the adoption rate of three principles of CA is described, to examine if the practices were already used in the study area before the REDD project. Complete table on significant associations between practice adoption and explanatory variables can be seen in appendix 2.

Permanent soil organic cover

One of the CA principles – permanent soil organic cover can be achieved through the use of cover crop and/ or leaving crop residues on the farm field. Farmers in the study prefer to practice mulching. In all the study villages adoption rate for mulching is high from 89 % in Mnenia and 70 % in Kisese Disa. There seems to be no substantial difference in the practice rate between villages that did and did not participate in the REDD project. It is a bit different from the use of the cover crop: 62 % of responders in Mnenia said that they practice cover cropping, while this number was lower in the other three villages (from 36 % in Kisese Disa to 46 % in Itololo).

In interviews, many farmers, who practice mulching told that they leave crop residues on the field, but also allows their cattle to graze there afterward. Or even when farmers intend to leave crop residues on the field for soil improvement, their fields are grazed by herds of other villagers.

Pearson’s chi-square test presents that there is a significant correlation between mulching and receiving assistance from the village agriculture officer. In Mnenia 96 % of respondents who left crop residues on the field, received a consultation from the officer (sig. 0.015). In Bereko, farmers who reportedly are not affected by pest problems, often reported the practice of mulching (87 %), however, while this association is statistically significant (sig. 0.039), it has small Cramer’s V value (0.008), indicating that the association is weak.

According to the results of Pearson's chi-square test, the use of cover crops did not have significant associations with any of the explanatory variables.

Crop rotation

Crop rotation is practiced by 80 % of farmers in Mnenia. In other villages, this number is lower – in Bereko and Kisese Disa 32 % and Itololo 43 %.

In interviews, many farmers told that they know about the importance of crop rotation from school or this knowledge has been passed to them by other farmers. Also, in all villages, farmers who receive assistance from extension officer are more likely to practice crop rotation. However, this association was statistically significant only in Mnenia (sig. 0.014).

In Bereko and Kisese Disa farmers who reported struggling with climate-related issues are more likely to practice crop rotation. This indicated that crop rotation is possibly used as a strategy to mitigate the impact of climate on farming production.

Tillage

Hand hoe for tillage was used by a small portion of interviewed farmers – around 10 to 13 % in pilot villages and 1 % in control villages. Tillage method does not have significant association with wealth groups, however farmers who practice tillage with hand hoe own on average not more than 2.5 acres of land.

From all the interviewed, only two households own a tractor. Yet around 30 % of farmers in Mnenia, Bereko and Itololo, and 45 % in Kisese Disa plough their land with a tractor. Farmers explain that they rent a tractor that turns their land. And while tractor ploughing is used mostly by farmers who own bigger plots (six acres on average), there are farms as small as one acre where tractor is used for ploughing.

The majority of farmers across all villages practice tillage with ox-plough (around 55 % to 65 % across all villages). Again, while less than half of the farmers own ox by them self, there exists a market for renting. From observations on the field, the tillage system used resembles conventional tillage (Fig. 3)

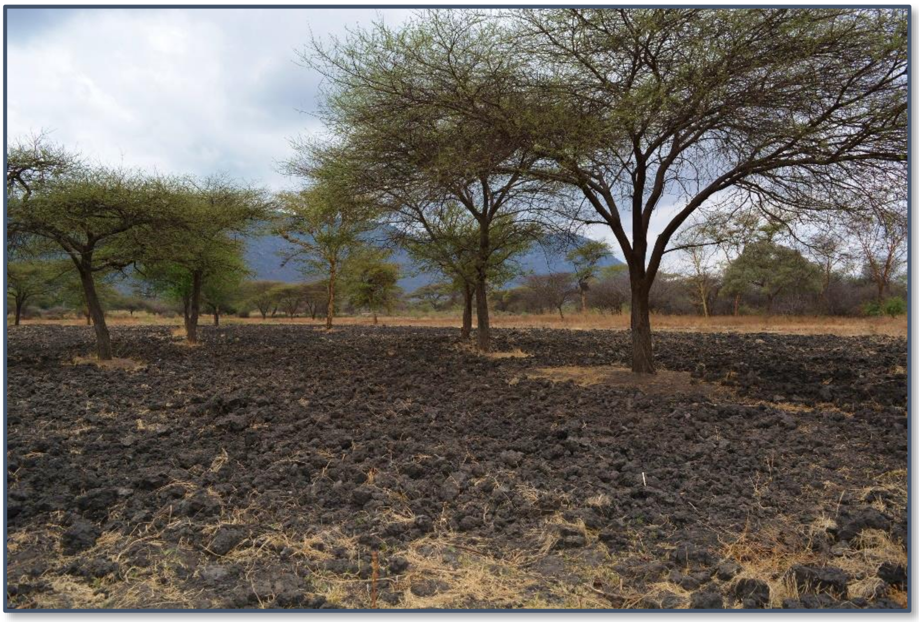

Figure 3. Photo from Itololo with farmland ploughed with ox-plough. (Photo from fieldwork 2018)

5.5 The adoption rate of introduced practices

This section provides an overview of how many farmers in the pilot villages have adopted the improved farming practices promoted by the project – use of fertilizers, pesticides and planting in straight lines. For comparative purposes, the use of these methods in control villages is also described.

Fertilizer use

Figure 4 presents the percentage of farmers that reported using synthetic or organic fertilizers the previous farming season. There are a couple of things to note here. First, in Mnenia the percentage of farmers that use synthetic fertilizers are similar as in the control villages. However, strikingly more farmers in Bereko than in other villages use synthetic fertilizers, with 55 % of respondents reported using last season. When it comes to use of organic manure, Mnenia stands out, with 86 % of farmers confirming the application of manure on their farm fields last season.

In the interviews, farmers were also asked to assess the fertility of their land. Generally, farmers in Mnenia and Itololo were the most satisfied with their farmland fertility, with close to 40 % of respondents in both villages describing land quality as good or very good. Yet, the most dissatisfied with land fertility were farmers in Bereko, with around 30 % describing their land as poor or very poor quality.

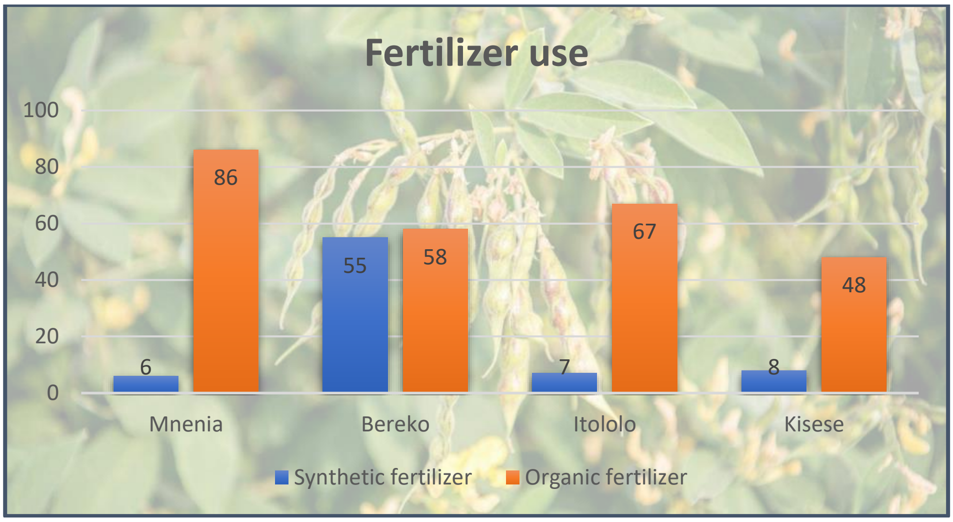

Figure 4. Percentage of farmers using fertilizer previous farming season

Pesticide use

Figure 5 demonstrates the percentage of farmers that reportedly struggles with crop pests and diseases, and the percentage of farmers that used pesticides the previous farming season. Generally, the number of farmers reporting pest problems is high in all four studied villages, with 86 % in both control villages and somewhat lower in Mnenia and Bereko, with 62.5 % and 70 % respectively. Most farmers told that they struggle with maize and pigeon pea pests and diseases, and some with sunflower pests.

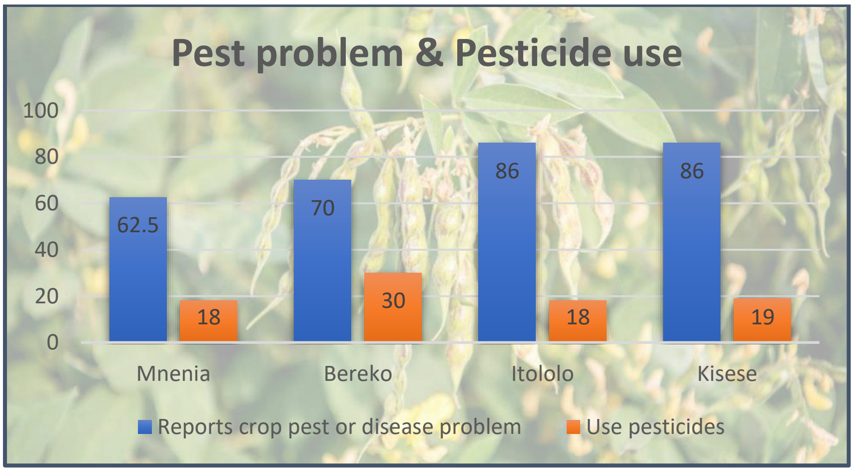

Figure 5. Percentage of farmers affected by pests and crop diseases and the percentage of farmers using pesticides.

According to Hillocks et al., (2010) pigeon peas are a target to a large number of pests and diseases, with most important pests being pod borer, *Helicoverpa armigera* and a wide range of insect pests. Yet, the most important pigeon pea disease in eastern Africa is Fusarium wilt, caused by a soil-borne fungus (*Fusarium udum* Butler) (Kimaro, 2016). Farmer described symptoms of pigeon pea disease resemble the symptoms of Fusarium wilt – wilting, leaf drop, losing plant's green color to brown or yellow and stunting. According to Kimaro (2016): “In Tanzania, the disease is widespread in most pigeon pea growing areas, causing yield losses up to 100% to susceptible genotypes. Controlling diseases through chemicals is difficult and not economical for most resource-limited farmers”. Indeed, many farmers reported that the pesticide they used to control pigeon pea crop diseases did not have any effect. When one farmer in Kisese Disa asked the extension officer for help to tackle the diseases, the extension officer had explained that this disease is a country-wide disaster, and nothing can be done to fight it.

Maize is a primary staple crop in the study area. In Itololo, Kisese Disa and Bereko maize is the most popular crop with 30 – 40 % of land attributed to this cereal (in Mnenia around 17 %) (Table 4). However, the research by Suleiman and Rosentrater (2015) recognizes that the Dodoma region has one of the lowest maize productivities in the country. Low maize yields can be attributed to a wide range of factors – post-harvest handling, weather variability and biotic factors such as insects, pests, pathogens and fungi (Suleiman and Rosentrater, 2015). During fieldwork, larger grain borer (*Prostephanus truncates*) was identified (Fig. 6). This insect is primary storage pest for maize and dried cassava (Gwinner et al., 1990) and a lot of interviewed farmers reported being affected by it.

Figure 6. On the left – holes "drilled" in maize grains by a pest. On the right – maize “eaten to dust” by Larger grain borer. (Photos from fieldwork 2018)

Pesticide use in the study area remains low, with 18 – 19 % of the farmers in Mnenia, Itololo and Kisese Disa reporting the use of pesticides last farming season. Similarly, as with synthetic fertilizer use, pesticides are used more by farmers in Bereko (30 %). Farmers in all villages told that access to pesticides is difficult – both economically and physically. Many explained that pesticides are delivered to the villages when crops are already heavily affected. Some farmers told that they use home-made pesticides by mixing ashes with water and different plant juices.

Herbicides

Chemical herbicides were used by only four of all the interviewed farmers – one in Mnenia and three in Bereko. A farmer from Mnenia, that reported using herbicides, can be described as resourceful and in wealth-ranking exercise is placed in 'better-off' category. However, it cannot be said that herbicides are generally used by wealthier farmers since herbicide users from Bereko are quite resource-poor. Majority of interviewed farmers (97 %) said that they use hand hoe for weeding. Also, the majority of farmers reduce weed pressure by ploughing their land with ox or tractor.

Planting in straight lines

As a part of the agricultural improvement package of the REDD project, farmers in pilot villages were taught to plant their crops in straight lines and with regular spaces in-between (Fig. 7). More than 60 % of the interviewed farmers in Bereko, Itololo and Kisese Disa practice planting in straight lines and even more in Mnenia (87 %). However, high use of this practice should not be immediately attributed to the REDD project's success. According to Svarstad and Benjaminsen (2017), the method of cultivating crops in straight lines has long been known in the area and encouraged already in the colonial times. Indeed, the majority of the respondents said that they knew of the practice before the REDD project. 31 % of farmers in Mnenia and 13 % in Bereko said that they organized their farm fields in straight lines before the year 2010 – before REDD. Around half of respondents from Mnenia and Bereko reported having adopted planting of straight lines after the year 2010 (half of those adopted recently – in last three years). In general, respondents in Mnenia tend to attribute this adoption more to the REDD project, while farmers in Bereko note the influence of the extension officers.

Figure 7. Farm in Bereko village where planting in straight lines with regular spacing between crops are practiced. (Photos from fieldwork 2018)

5.6 Reasons for adoption or non-adoption

Based on both qualitative and quantitative data, this chapter examines associations why some of the promoted practices have been adopted by some farmers in study villages, while some practices had not been taken up.

5.6.1 Significant associations to adoption

To study possible reasons for adoption of REDD project's promoted farming techniques, Pearson's chi-square test is performed to look for an association between uptake of farming techniques and explenatory variables. Variables vary from binary to categorical. Only associations with the significance below 0.05 are presented. Strength of an association is shown trough Cramer's V value, where 0 is no association and 1 is a perfect association. Complete table on significant associations between practice adoption and explanatory variables can be seen in appendix 2.

Synthetic fertilizers

While there was no significant association between synthetic fertilizer use and wealth group variable, there is a significant association between synthetic fertilizer use and other variables that can be associated with wealth. For example, in Bereko, synthetic fertilizers are used more by farmers who have an additional income besides agriculture (sig. 0.013) and who live in an improved house (sig. 0.004). However, farmers who have more cattle (a variable that can also be associated with wealth), use synthetic fertilizers less. Also, in Bereko, there is a significant association between the use of synthetic fertilizers and receiving assistance from village extension officer (sig. 0.001). Another thing to note is that in both pilot villages and Kisese Disa, agricultural production increase is associated with use of synthetic fertilizers.

In both villages that participated in the REDD project and Itololo, there is an association between the use of synthetic fertilizers and education. People who have finished primary school (seven years of education) are more likely to use synthetic fertilizers than those who have less than seven years of education finished (Mnenia sig. 0.436; Bereko sig. 0.128; Itololo sig. 0.498). However, Cramer's V value for all of these associations is close to 0, indicating that the associations are weak.

Organic fertilizers

Organic fertilizer use has significant associations with explanatory variables mostly in pilot villages. In both pilot villages, the use of organic fertilizers is significantly associated with wealth group variable – farmers from higher wealth groups are more likely to use organic fertilizers (sig.0.048 in Mnenia and 0.049 in Bereko). Use of organic fertilizers also correlates with other wealth associated variables – additional income besides agriculture, house type and area of land cultivated. In both pilot villages farmers who reported good land fertility, more often reported use of organic fertilizers.

Other socioeconomic variables that associate with the use of organic fertilizers are gender and education. In all the study villages, male farmers are more likely to use organic fertilizers than female farmers. However, a significant association exists only in Mnenia where 90% of men apply manure on their fields compared to 78 % of women (sig. 0.187). In both pilot villages, farmers who have finished seven years of education are more likely to apply organic fertilizers on fields than farmers who have less than seven years of schooling (sig.0.071 in Mnenia and 0.414 in Bereko).

In Mnenia, 94 % of farmers who are informed about REDD project's agricultural component use organic fertilizers. However, the p-value is 0.052, therefore it cannot be concluded that there exists a significant relationship between use of organic fertilizers and being informed about REDD project's agricultural component in Mnenia.

In interviews, the majority of responders said that they use animal manure as organic fertilizer. Therefore, the association between cattle ownership in Bereko and use of organic fertilizers is reasonable. With increasing the number of cattle farmers owns, increases the likelihood that farmer is using organic fertilizer (sig. 0.001). And 100 % of farmers who owns six or more cattle, applied organic fertilizers on their farm fields.

In both control villages farmers who report the use of organic fertilizers, more often indicates that they do not face climate problems in farming activities (Itololo: sig. 0.001; Kisese Disa: sig. 0.009). Also, 92 % of the farmers in Itololo who use organic fertilizer reports that they struggle with access to agricultural inputs (sig. 0.01).

Pesticides

In Bereko, where pesticides are used by 30 % of the survey respondents, pesticide use has a significant association with wealth related variables. Pesticides are used by 80 % of farmers in better-off wealth group and 53 % of less poor wealth group. Only 22 % of poor and 10 % of very poor wealth groups farmers reported using pesticides (sig. 0.002). In Itololo, there is a significant association between pesticide use and receiving assistance from village agriculture extension officer (sig. 0.001). 67 % of responders who received advice from agricultural officer reported the use of pesticides, while only 5 % of farmers who did not consult agricultural officer used pesticides.

In both villages that did not participated in the REDD project and Mnenia, the use of pesticides is associated with gender. Male farmers in both Itololo and Kisese Disa reported the use of pesticides in 29 % of cases, while none of the female respondents in Itololo and only 7 % in Kisese Disa reported pesticide use. In Mnenia 13 % of female farmers and 20 % of male farmers use pesticides. There was no such significant correlation between gender and pesticide use in Bereko. Similarly, as with fertilizer use, pesticide use also correlates with education. In Mnenia and villages that did not participate in the REDD project, farmers who have finished seven years of education are more likely to apply fertilizers on their fields than farmers with less than seven years of schooling (Mnenia sig. 0.132; Itololo sig. 0.25; Kisese Disa sig. 0.263).

Planting in straight lines

In both of the villages that participated in the REDD project, the adoption rate of planting in straight lines is quite high (87 % of respondents in Mnenia and 63% of respondents in Bereko practice organizing crops in straight, parallel rows). In both pilot villages, 98 % of farmers who received advice from extension officer, reported practice planting in straight lines (in Mnenia: sig. 0.001; In Bereko: sig. 0.003). In Mnenia, farmers more often attributed planting in straight lines to REDD project's impact: 95 % of farmers who are informed about REDD project's agricultural component practice planting into straight lines.

Also, in both villages that participated in the REDD project, farmers who report good land fertility are more likely to practice planting in straight lines than farmers who report average or poor land fertility.

When it comes to socioeconomic variables, crop planting in straight lines correlates with gender and education. In Mnenia and Bereko, men are more likely to practice planting in straight lines (~90 %) than women (83 %). In Mnenia, farmers who have finished primary school (seven years of education), practice planting in straight lines in 89 % of cases, while farmers who have less than seven years of schooling, practice straight lines in 78 % of cases (sig. 0.345). There is no significant correlation between the practice of planting in straight lines and wealth groups, however, people who live in improved houses (with iron sheet roof) are more likely to use the practice than people who live in unimproved house (iron sheet roof with bricks on the top) (Mnenia sig. 0.008; Bereko sig. 0.015).

5.6.2 Additional factors that could influence adoption

There is a chance that not all the variables that influence the adoption are captured in this study. Still, from the interviews and observation, some additional factors that could influence adoption rates are noted.

The village characteristics could explain some differences in adoption rates between villages (e.g., location, access to resources). Bereko stands out as the most “modernized” village, with more farmers using agro-chemicals than in other villages. The highway that goes through Bereko village makes it easily accessible and connects it to the markets in the nearby cities, but both control villages are relatively remote areas. Also, in Bereko village there is a shop where a farmer can buy some farming inputs. Farmers in Mnenia and control villages told that they had an experience where inputs (especially pesticides and improved seeds) arrives in the village when farming season has already started. In fact, 42 % of responders in control villages and 53 % of pilot villages said that they struggle with access to farming inputs, whether it is physical or economic access.

In Bereko and Itololo, extension officer visits are significantly associated with the use of chemical inputs. The situation regarding extension officers is different in each village. In Mnenia and Bereko officers are always present as they live in the villages, while in both control villages, extension officer visits, but does not live there.

In previous sections, it is described that use of inputs (organic fertilizers and pesticides) as well as practicing planting in straight lines has a significant correlation with socioeconomic variables such as wealth, gender and education. However, it is important to note that gender and wealth variable also correlates (Fig. 8). In all the study villages male farmers are more likely to be represented in the better-off and less poor wealth group, while poor and very poor categories have more women in them. This association between gender and wealth indicates that adoption of technologies depends on access to resources rather than on gender *per se*.

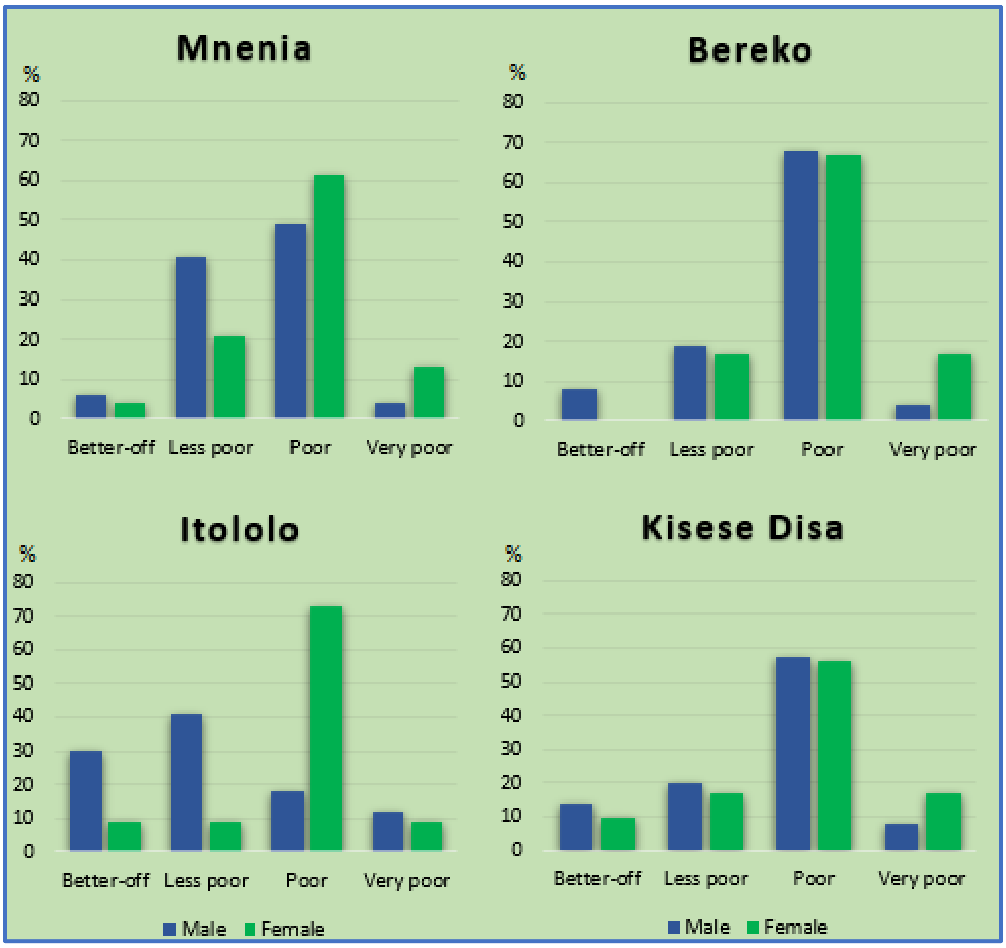

Figure 8. Gender distribution across wealth groups.

The author of this study acknowledges that some recent occurrences or conditions in the villages could have influenced the rates of input use. For example, several farmers in the study area reported that for the past years they have relied on incomes from pigeon pea sell, to be able to buy new farming inputs and seeds. This indicates that the recent drop in pigeon pea market price could also influence the rate of farming input use in the region.

5.6.3 Pigeon pea market price "crash"

In the Kondoa District, pigeon pea has been the leading cash crop for several years. That has been the case until August 2017, when India, which was the traditional market for pigeon pea, introduced a ban on import of this legume from East African countries. There are many speculations on reasons behind this ban, however, some official reports have credited the restrictions to India becoming self-sufficient in pigeon pea production (Lyimo et al., 2018).

According to report by Tanzania Agricultural Research Institute – Selian and International Center for Tropical Agriculture (Lyimo et al., 2018), Indian pigeon pea ban has reduced farmers' profitability in the region by 38%. In fact, 10.5% of farmers in Bereko and 9.7% of farmers in Mnenia reported that pigeon pea market price drop is one of the most important challenges they are facing in their farming activities. This number was slightly lower in Itololo and Kisese Disa with 7.1% and 6.2% respectively. Many farmers implied that under current conditions, pigeon pea farming is not profitable at all, especially since the crop is heavily affected by pests and considerable investments in pesticides are needed, only to gain harvest that cannot be sold afterward. An elderly female farmer from Mnenia revealed that she used a portion of money from pigeon pea sales to invest in improved maize seeds and farming manure, however, the upcoming season would be the second in a row where she must use farm-saved seed and no fertilizers. This implies that pigeon pea market failure has decreased income form many farmers in Kondoa region, making it difficult for farmers to invest in farming inputs.

Yet, pigeon pea remains one of the main crops cultivated in the study area (Table 4). Many of the interview respondents told that they trust the government would soon reach an agreement with India that would re-open pigeon pea trade or other markets for pigeon pea will be found. However, one farmer from Mnenia expressed a different opinion, when he said that due to climate stresses and pests, pigeon pea harvest in the area is generally low, therefore there is high demand for the legume in Kondoa markets, where he was able to sell pigeon peas for reasonable prices.

5.7 Crops and production

The most common crops grown in the study villages (both by the number of households cultivating them and by area allocated) are maize, pigeon pea and sunflower (Table 4). The situation differs in Mnenia, where top three crops grown are sunflower (32%), sorghum (20%) and maize (17%). Maize and sorghum are primarily grown as a food crop, while pigeon pea and sunflower have the dual function of being both a food and cash crop. Still, after pigeon pea price "crash" (see chapter 5.6.3) around 50 % of farmers in all study villages report planting pigeon pea for cash purposes.

Table 4. Land use by sample households, by study location.

Crop	Mnenia 314.39 acres		Bereko 339.11 acres		Itololo 201.48 acres		Kisese Disa 319.33 acres	
	acres	%	acres	%	acres	%	acres	%
Sunflower	99.4	32	23.4	7	42.3	21	66.9	21
Sorghum	62.9	20	14.9	4	10	5	16.5	5
Maize	52.9	17	139.7	41	70.2	35	101.5	32
Pigeon P	49.1	16	126.2	37	54.6	27	97.6	31
Sesame	23.3	7	0	0	8	4	1.5	1
Beans	0	0	30.1	9	2	1	0.5	0
Groundnut	4.7	1	0.6	0	0	0	30.2	9
Millet	11	4	0	0	6.7	3	1	0.31
Pearl Millet	3.1	1	0	0	0	0	3	1
Cassava	2.5	1	3.3	1	0	0	0	0
Cowpea	0	0	0	0	5	2	0.5	0
Lentil	2	1	0	0	2.8	1	0	0

In the survey, farmers reported their agricultural production in ‘bags' as a unit of measure. Farmers in pilot villages report higher yields for all most essential crops than in control villages. On average farmers in pilots report 4.9 bags of maize production per acre, while in control villages average maize production is 3.2 bags. For pigeon pea, the difference is somewhat lower with 2.6 bags in pilot villages and 2.1 in controls. Reported sunflower production is 6.1 bags per acre on average in Mnenia and Bereko and 3.8 bags per acre in Kisese Disa and Itololo. For sorghum, the stated output in pilot villages is 4.1 bag, but in control villages, it is almost half lower with 2.2 bags per acre.

In 4 % of cases, farmers in control villages reported complete failure in sunflower production, where harvest was absolute zero. No crash in sunflower production was reported from farmers in pilot villages. However, in all villages, there were cases with complete failure in maize and pigeon pea production. The numbers for maize and pigeon pea production failure were identical across all villages. Maize production was zero in 6-7 % and pigeon pea production failed in 5 % of fields where planted. Most farmers attribute their yield loss to biotic stress (Fig. 9) caused by crop pests and diseases or destruction of areas by wild animals.

Additionally, farmers blame limited access to farming inputs as well as climate-related stressed for creating small production.

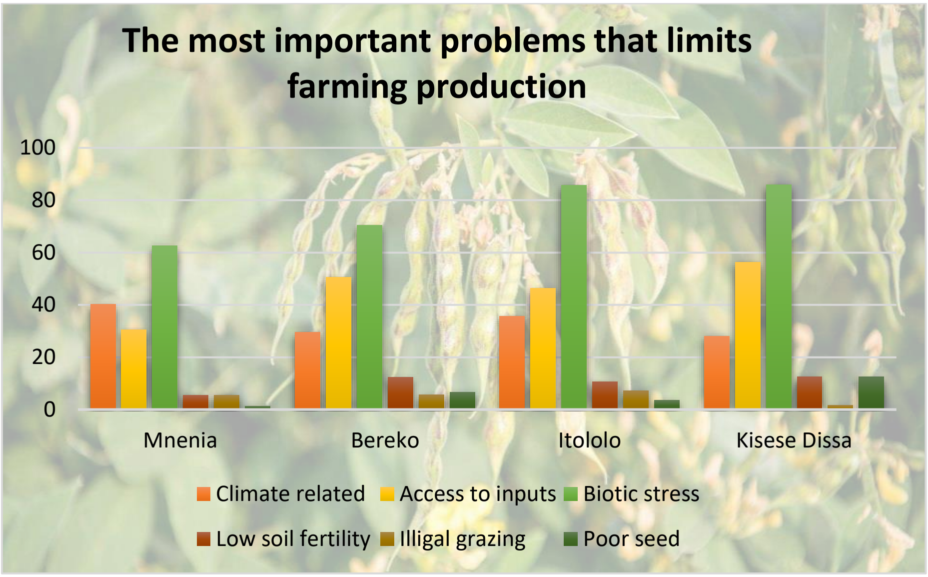

Figure 9. The most critical problems limiting farming production reported by farmers in the survey.

5.7.1 Seed system

The local seed system in the study area consists of both formal and informal seed elements. In almost all the cases the more significant proportion of seeds is sourced through informal channels for all the most popular crops in the study area (Table 5). The exception is maize in Bereko and Itololo villages, where most farmers acquire their seeds trough formal sources. In this research, seeds classify as obtained from informal channels if they are seeds from their harvest, exchange, gift and local markets. Seeds from a shop or government subsidies classify as formal channels. For all the crops, seeds acquired from informal seed sources in most cases originates from farmer's harvest and second most crucial informal seed channel is the local market. According to Westengen and Brysting (2014): “seeds are important assets for agriculture-based livelihoods and seed systems embody the institutions that mediate access to this asset." In this case, the informal seed system has greater importance than the formal system, since informal supply channels provide a more significant quantity of seeds in the study area. However, the formal system also has great importance, especially when considering maize seeds.

Table 5. Proportions of maize, sunflower, pigeon pea and sorghum seeds sourced from formal or informal seed channels. Seed source share is given as a percentage of the total number of households reported cultivating the crop.

Crop	Seed source (percentage)							
	Mnenia		Bereko		Itololo		Kisese Disa	
	Formal	Informal	Formal	Informal	Formal	Informal	Formal	Informal
Maize	27	**63**	**71**	25	**59**	41	31	**69**
Sunflower	17	**81**	25	**75**	14	**86**	22	**78**
Pigeon P	6	**92**	21	**78**	8	**92**	11	**89**
Sorghum	6	**84**	25	**67**	20	**80**	12	**88**

Both in pilot and control villages improved varieties dominates maize and sunflower cropping systems (Fig. 10). Farm saving and recycling of improved varieties are popular. For pigeon peas, local varieties dominate in all study villages. Since improved varieties much influence the informal seed system in the study area from the formal seed system, the distinction between two systems is not clear cut. In general pilot villages relies on formal seed sources more than control villages

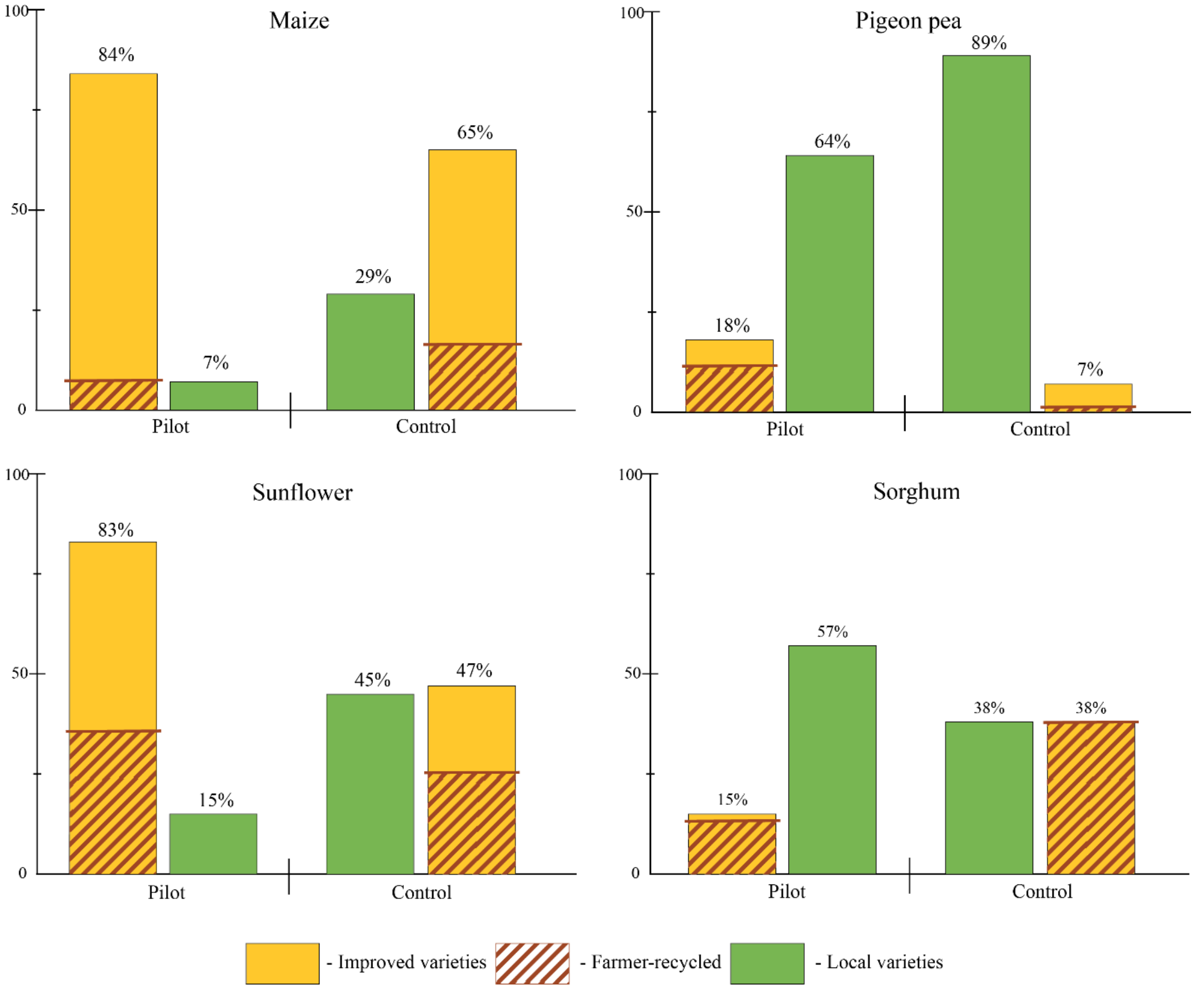

Figure 10. Diagrams showing percentage* of households cultivating improved, local or farm-recycled genetic resources of most important crops. (*Percentages does not add up to 100 % since some crop varieties were unknown, therefore not included).

5.8. Sustainability aspect

The rate of chemical input use (fertilizer and pesticide) remains low in the study area. The exception is Bereko, where 55 % of farmers use synthetic fertilizers and 30 % use pesticides, which is considerably more than in other villages where synthetic fertilizer is used by around 7 % of farmers and pesticides by 18 %.

To reach the yield improvement through the use of agro-chemicals, sustainable input use is crucial. Inappropriately applied inputs may negatively affect human health and the surrounding environment. In the interview, the project coordinator from AWF (2019), explained that the project aimed to help farmers recognize the genuine pesticides and fertilizers and proper ratios of using. This was confirmed by the demonstration farmers, who admit that in general, the introduced farming techniques were not new to them, but the project taught them about synthetic fertilizer, pesticide and manure selection, storage and proper application. In the interview, the project coordinator also implied that the project had an impact on helping farmers to switch from synthetic fertilizers to the use of manure. He said: "*Far more synthetic fertilizers were used before the project*", however, he also admits that: "*We* [the REDD project] *should have done more to help people to switch to organic fertilizers. Up until we left, the rate of chemical usage was still high, although there were a lot of opportunities to compost.*"

To reach the desirable effect of increased yields and improved soil quality, organic fertilizers also needs to be appropriately applied. If manure nutrients are over-applied or used at the wrong times, it can lead to nutrient loss by surface runoff and leaching (Shober and Maguire, 2014). In Mnenia and Bereko there is a significant correlation between farmers who reportedly have good quality soil and the use of fertilizers. However, the rate of farmers who apply manure on their fields and still reports poor quality soil is high. Half of farmers who complain about poor soil in Mnenia and 33 % in Bereko, reports applying manure on their farm fields.

In all of the villages, extension officer visits are associated with the use of chemical inputs (significant correlation for fertilizer use in Bereko (sig. 0.001) and pesticide use in Itololo (sig. 0.001)). According to Sanga et al., (2013) in rural Tanzania, public extension officers are expected to be the primary source for farmers to receive information on agricultural practices. However, Wall (2007) points out that officers themselves suffer from small funding and lack of access to new information. Village extension officers are present in Mnenia and Bereko, but in remote control villages, extension officer visits, but does not live there. In all the villages, farmers were critical about the extension officers. Agricultural extension services in Tanzania is supposed to be free of charge, but farmers in all villages complained that extension officers prioritize those who can afford to pay for a consultation. Farmers are expected to compensate the officer's fuel expenses, which is especially problem in Mnenia, where the majority of farm fields are located outside the village – around one hour or more walking distance from home. Also, several farmers in all the study villages told that they choose not to consult the extension officer since farmers do not have confidence in the skills of extension agents.

When it comes to efficient use of seeds, farm-saving of improved seeds is common in the study area (see chapter 5.7.1). Mostly farmers reported that they know or have observed themselves that by the time, recycled seed lose their properties. Some farmers after recycling for improved seed for several years have not experienced yield loss, therefore believe that the possibility of production decline is rumored. Five percent of farmers in pilot villages and ten percent in control villages, report that poor quality seed is one of the biggest problems they are facing in their farming activities and they wish to buy new seeds if they could afford it.

5.9 Agriculture intensification as compensation for forest enclosure

The agricultural component was introduced by the REDD project to reduce the pressure on forests (Mung'ong'o, et al., 2011). The idea was based on the knowledge that shifting cultivation is one of the major causes of deforestation. When AWF (Mung'ong'o, et al., 2011) established the baseline for the project, the need for agricultural intensification was justified with the need to conserve the environment. Therefore, for us to be able to evaluate the success of the agricultural component, we have to evaluate the forest status today as well as villagers' ability to cope with forest restrictions.

According to the rules established by the REDD project, many activities are forbidden in the Isabe and Salanga forest reserves, for instance, hunting, farming, cutting wood for timber and charcoal production. Additionally, activities like collection of dry wood, cutting grass, grazing, a collection of fruits, research and tourism are approved upon payment of a fee (Svarstad and Benjaminsen, 2017)

Despite the restrictions, villagers still have to find access to forest resources to meet their needs for timber, firewood, and other resources.

5.9.1 Use of forest resources in the pilot villages

Theoretically, both in Mnenia and Bereko forest access is strictly regulated, yet villagers can collect dry material from the forest upon payment of a fee. Ten percent of respondents from Mnenia and thirty per cent of respondents from Bereko report entering the forest regularly to collect firewood or other resources. However, there is contradictory information and confusion regarding access to the forest. Villagers from Mnenia explained that when the permit is bought, they are allowed to enter the forest on certain weekdays (usually Saturday or Sunday) to collect dry wood. Yet, two of the respondents challenged these claims and told that they visit the forest regularly without ever buying a permit and that if one does not carry a bush knife, forest guards will allow entry to the forest to collect dry material. In Bereko, where considerably more people collect forest resources than in Mnenia, all of the respondents who visit the forest regularly explained that no permit is needed if one collects only dry material. This indicated that there is confusion regarding rights of access to forest, since Bereko is has signed Joint Forest Management agreement that formally requires people to buy permit to access the forest (Scheba and Mustalahti, 2015).

Firewood is the main resource needed from the forest and forest enclosure has forced villagers to find other sources of firewood. Figure 12 presents data regarding where respondents acquire firewood from. Most respondents in both villages collect firewood from pruning and cutting trees around their homes and farms (74 % in Mnenia and 56 % in Bereko) (Fig. 11). Also, many households in Mnenia and some in Bereko explained that they have planted new trees next to their homes since the forest enclosure. Around 2 % of respondents in Mnenia and 11 % of respondents in Bereko buy firewood and/or charcoal. In Bereko, respondents mostly said that they do not know the source of forest products they buy; however, some admit knowing that products had been acquired illegally from the forest.

One of the reasons why pigeon pea crop was promoted by the project was that the crop's stem can be used as firewood, thereby reducing villagers’ dependency on the forest. However, only 5 % of respondents in both villages confirmed that agricultural products completely replace their need for firewood from trees. Also, in Mnenia, some resource-poor farmers reported that they struggle to acquire firewood on a day to day basis. These villagers as well as other in Mnenia said that they did not understand why one had to pay to collect dry food from the forest.

Besides the collection of firewood, before enclosure of access, forests were used for other purposes, for example, agriculture. Now, farming is strictly prohibited in the forest reserves. Especially challenging is to find grazing land for the cattle. During interviews, one of the farmers in Bereko told that he had to reduce his herd size after not being able to pay several fines he got after repeatedly being caught grazing in the forest. Other farmers complained that illegal grazing on farm fields had increased, because of forest restrictions. Also, one of the farmers in Bereko told that more than half of farmland she owned was confiscated by Tanzanian Forest Services (TFS) in the year 2017 because it is a part of Salanga forest reserve. She said that it is being rumored that all the farmers whose land was confiscated will be compensated, but it is not known for sure.

Figure 11. Tree on farmland (in Mnenia) pruned for firewood and poles. (Photo from the fieldwork 2018)

5.9.2 Use of forest resources in the control villages

Both Itololo and Kisese Disa decided not to participate in the REDD project. Both villages have a similar answer to why they declined participation in the project. Village officials explained that they based their decision on the neighboring village experience. Neighboring villages - Kisese Sauna, Kadanga an Mapinduzi warned them about violent clashes between farmers and the forest guards and villagers were concerned that under the REDD project they would lose access to the forest. The reality is though that for both villages forest access is also limited. Both villages border Salanga forest reserves and couple years after the beginning of the REDD project, TFS who manages the forest reserve, hardened its control in all forest reserve territory (pers. comment from Itololo village official). According to one of the persons from Itololo village office "*in the end, we got everything the same as others [REDD project villages], except we did not get the advantages*". Similarly, as in the REDD project villages, in the forest surrounding Itololo and Kisese Disa hunting, tree cutting and agricultural activities are forbidden, and collecting dry wood is allowed if a permit is bought.

The landscape in both control villages is different than in Mnenia and Bereko. Both villages are close to the forest, with the presence of shrubs and trees next to houses. In Itololo 82 % of respondents said that they collect firewood from the trees next to houses and farms (Fig. 12). In Kisese Disa this number was slightly lower, yet still noticeable; 69 %. In Itololo only one respondent reported collecting firewood in the forest, while in Kisese Disa around 19 % of the respondents did. Most of the respondents who reported visiting the forest regularly said that they acquired the permit for that. In control villages, the number of respondents saying that agricultural products (e.g. pigeon pea stems) compensate for the forest encloser are similar low as in the pilot villages, with around 4 % in Kisese Disa and 2 % in Itololo.

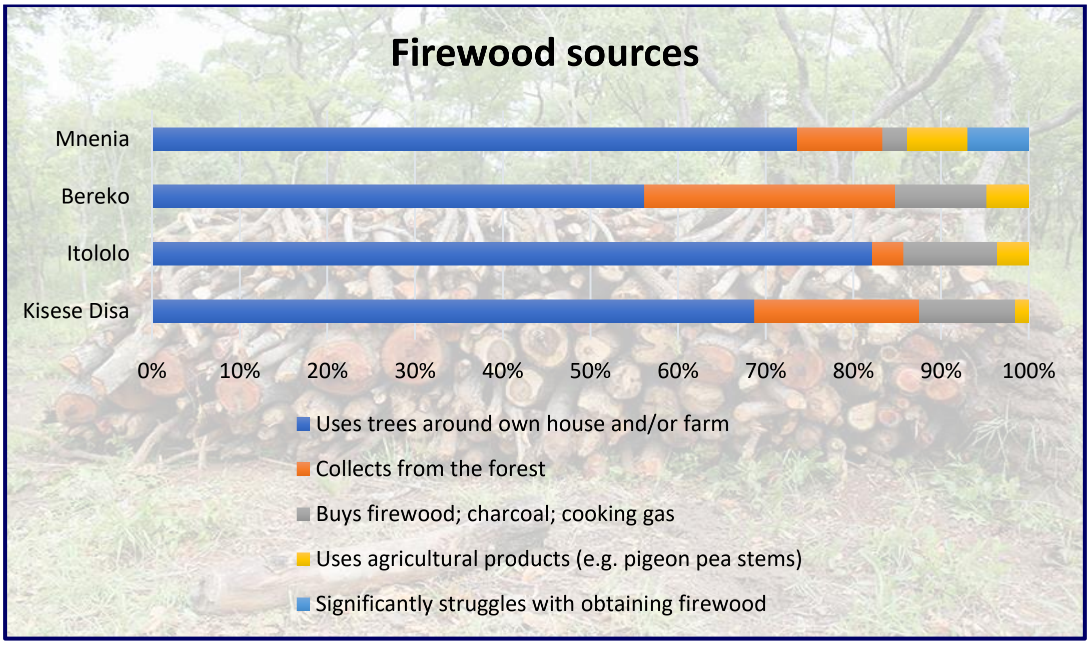

Figure 12. Firewood sources in study villages.

In the interview, the REDD project coordinator from AWF (2019) stated: "*We cannot say that they [REDD project villagers] lost access to the forest. A big chunk of the forest that was in the project planning was Central Government Catchment Forest Reserves. According to Tanzanian laws, these forests were not belonging to the local communities and the forest land was not part of the village land. […] Principally the project increased peoples access to those forests, because, before the project, they were strictly prohibited to go into the forest for any reason*". However, this increased access was not felt by the interview respondents. Nearly 90 % of respondents in both pilot villages said that they felt reduced or considerably reduced access to the forest since the beginning of the REDD project (Fig 13). Only one responded in each pilot village reported increased access to the forest. In both control villages, all the respondents reported that their access to the forest had been reduced since TFS enforced the restrictions.

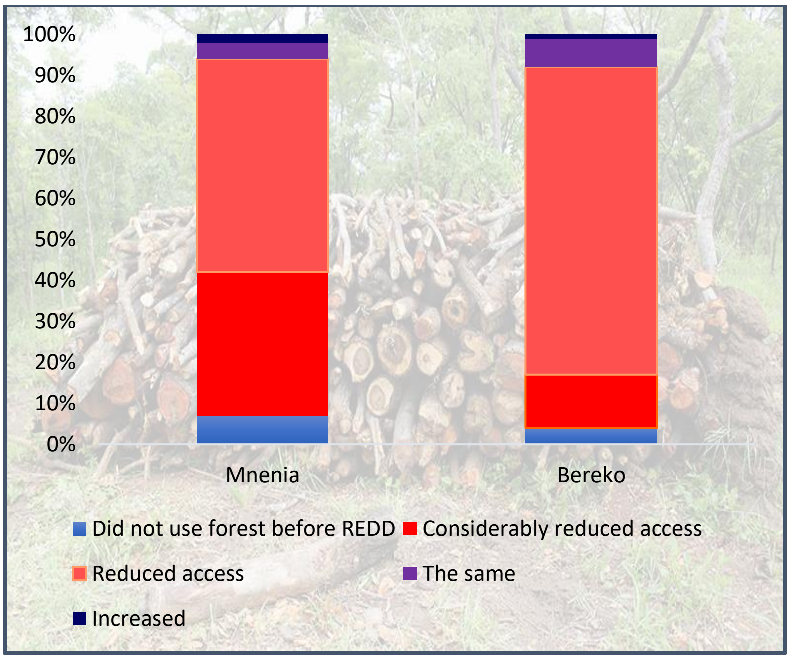

Figure 13. Changed in the access to the forest since the REDD project beginning

Generally, the situation in control villages and in pilot villages regarding forest use had minor if any differences. The agricultural component was included in the REDD project to reduce the pressure on forests and the pressure is reduced, since, in fear of fines and other consequences, villagers' have reduced their reliance on the forest. However, there is lacking evidence that agriculture improvement is contributing to reducing the dependency on the forest. One villager from Bereko explained: "*They were really efficient in enclosing the forest, but not so much with providing the alternatives for people who depend on the resources*".

6. Discussion

This thesis aimed to evaluate the implementation and impact of the agricultural component of the REDD project in the Kondoa District. The study has examined the situation in two REDD project villages in the pilot area. For comparative purposes, two control villages that decided not to participate in the REDD project were also studied. The analysis has focused on understanding whether the agricultural practices promoted by the REDD project are still in use today, and the reasons behind the adoption level identified.

The agricultural component was labelled "conservation agriculture", but the three principles of FAO's defined version of CA (permanent soil cover, minimum soil disturbance, crop rotation) was never promoted. Instead, a farming approach introduced by the REDD project consisted of support in the form of improved seeds, pesticides and synthetic fertilizers, and advice to practice planting crops in straight lines to 12 demonstration farmers in each of the 19 participating villages. When establishing the baseline for the REDD project in Kondoa District, AWF recognized that shifting cultivation is one of the significant sources of deforestation in the area (Mung'ong'o, et al., 2011). In the baseline study, AWF states: "Shifting cultivation could be discouraged by the introduction of intensive cultivation which will not only conserve the environment but will also increase productivity of crops which in turn will improve the economic status of the community members." Seemingly the agricultural component was sees as multi-win involving not only environmental conservation, but also as benefit for the local people. Interviewed demonstration farmers told that the practices introduced by the REDD project were not new, but the project was beneficial to them due to subsidized farming inputs. This is supported with what has been acknowledged in the literature that due to the lack of agro-chemical inputs in East Africa, any project that subsidises inputs to farmers are seen as especially attractive (Andersson and D'souza, 2014).

An interviewed SARI official (2018) said that farmers in the area are poor and they do not own equipment to practice deep tillage, therefore there was no need to promote CA. This statement falls into the category of a bigger trend that has been acknowledged in critical adoption literature that only the component of minimum tillage is used as an indicator of CA adoption (Andersson and D'Souza, 2014). Yet, while it is true that few farmers own tractors and ox-ploughs, the markets for renting these tools and machinery exist. In fact, most of the ploughing is done with oxen or tractors.

The REDD project implementors expected that the demonstration farmers would share their knowledge and gradually other farmers in the village would uptake promoted practices. However, it is challenging to distinguish the REDD project's impact on agriculture in Kondoa district, since the project had not been the only actor in the area intending to promote agricultural modernization. Therefore, this research carried out a parallel study in two villages that decided not to participate in REDD project (Itololo and Kisese Disa), and the project's impact is attributed to the differences between pilot and control villages.

Drawing upon mixed-method research, this study finds overall modest adoption rates for the REDD project encouraged practices. However, there are differences in the reported adoption rates of individual practices and between villages.

When it comes to the use of synthetic fertilizers and pesticides, there is no difference in adoption rate between Mnenia and control villages. Agro-chemical use in these villages remains low – synthetic fertilizers are used by 6 % to 7 % of farmers and pesticides by 18 % to 19 % of farmers. Therefore, it can be concluded that the REDD project did not increase farmer’s adoption of agro-chemicals in Mnenia. But Bereko stands out with more than half (55 %) of farmers using synthetic fertilizers and 30 % using pesticides. However, high adoption rates in Bereko village should not be immediately attributed to the REDD project’s success. Farmers in Bereko village has the least struggle with physical access to inputs since the highway that goes right through the village connects farmers with markets in Kondoa and Babati towns. The notion that farmers access to the tarmac road and markets boost the adoption has already been recognized in the adoption literature (Arslan et al., 2014; Giller et al., 2009).

According to the project coordinator from AWF (2019) the project promoted synthetic fertilizers, because there were not enough sources for organic fertilizers in the area, but generally use of organic fertilizers (animal manure and composting) was encouraged. In Bereko, the rate of manure use is approximately the same as in the control villages. In Mnenia 86 % of farmers applied organic fertilizers on their fields previous season. Of the farmers who are informed about the REDD project’s agricultural component 94 % use organic fertilizers. However, the p-value for this association is 0.052, therefore it cannot be concluded that there exists a significant relationship between use of organic fertilizers and being informed about REDD project’s agricultural component in Mnenia. Instead, organic fertilizer use has a significant association with wealth and cattle ownership. Farmers from higher wealth groups are more likely to use organic fertilizers (sig.0.048 in Mnenia and 0.049 in Bereko). Also, with increasing number of cattle owned by farmers, the likelihood that farmers are using organic fertilizers also increase (in Bereko sig. 0.001). And 100 % of farmers who own six or more cattle applied organic fertilizers on their farm fields.

There is no difference in adoption rates for practicing planting into straight lines between Bereko and control villages, therefore it is reasonable to believe that the REDD project did not have a significant influence on the adoption of this practice in Bereko. In Mnenia 87 % of farmers practice planting in straight lines. The method of cultivating along contour lines has long been known in the area and encouraged already during colonial time (Svarstad and Benjaminsen, 2017). Yet, most of the farmers have implemented straight lines on their farm fields after the year 2010, and farmers in Mnenia tend to attribute this adoption to the REDD project. These findings can imply that the REDD project increased the adoption rate of practicing planting crops in straight lines in Mnenia. However, it can also be that villagers could have a particular interest in reporting high levels of adoption. According to Svarstad and Benjaminsen (2017), the high adoption rate of the promoted technologies would make the village attractive for future carbon payments from investors.

Farmers in pilot villages report higher yields for all of the most essential crops than in control villages. Also, farmers in pilot villages rely on formal seed sources more than control villages. However, again it must be noted that both pilot villages are better connected to markets, from where to obtain the improved seeds. To estimate the REDD project's possible impact on farming production, today's yields have to be compared with the ones before the project. According to AWF (2013), the project achieved: "eightfold increase in agricultural production—from 300 kilograms/acre to 2,400 kilograms/acre of maize output—in 2011". In the survey, farmers reported their agricultural production in 'bags' as a unit of measure. The average production of maize is 4.9 bags per acre in pilot villages. Farmers said that the bag weights around from 50 to 100 kilograms, therefore it is challenging to convert bags into kilograms precisely. Yet, even if we assume that one bag of maize weights 100 kilograms and average production of maize in pilot villages is 4.9 bags per acre, the agricultural production is still far from 2,400 kilograms per acre as reported by AWF. Therefore, while the agricultural component of the REDD project has been presented as a particular success, this research finds little evidence that REDD in Kondoa has had a significant effect on rural livelihoods and state of agriculture.

Based on both qualitative and quantitative data, this study examined the associations why some of the promoted practices have been adopted by some farmers in study villages, while some practices had not been taken up.

The data shows that socioeconomic variables have a significant influence on the use of farming inputs. Adoption literature indicates that most commonly the disadoption of new technologies results from resource constraints, and that differential rates of adoption by wealth groups, and in particular low adoption rates by the most impoverished farmers can be expected (Cavanagh et al., 2017; Ellis & Mdoe, 2003; Giller et al., 2009; Ngoma et al., 2016). Sample in this research was disaggregated into four classes or wealth groups. The results show that 'better off' and 'less poor' groups exhibit significantly higher adoption rates of pesticide and manure use, relative to the 'poor' and 'very poor' wealth group. In Bereko, where pesticides are used by 30 % of the survey respondents, 80 % of farmers in better-off wealth group and 53 % of less poor wealth group apply pesticides on their fields. Only 22 % of poor and 10 % of very poor wealth group farmers reported using pesticides (sig. 0.002). While there was no significant association between synthetic fertilizer use and wealth group variable, there is a significant association with other variables that can be associated with asset ownership or wealth, such as house type and having an additional income besides agriculture.

The results of this research are consistent with some previous studies regarding gender and differences in technology adoption (Doss and Morris, 2011; Ndiritu et al., 2014). Technology adoption rate is bigger among male farmers than women farmers. However, it is essential to note that gender and wealth variable also correlates. In all the study villages male farmers are more likely to be represented in the better-off and less poor wealth group, while poor and very poor categories have more women in them. This indicates that a farmer's gender does not necessarily influence adoption decision *per se*, but instead reflects how the socioeconomic context and access to resources affect adoption.

In the baseline study, AWF concludes that "… poor people tend to depend more on natural resources, in this case, ARKFor will have to concentrate its conservation efforts on less than 30% who are poor." However, this research does not find evidence that poorest members of the communities were specifically engaged or targeted for project interventions. Overall, it might be said that it is easier for wealthier households to finance costly agriculture practices yet marginalised farmers are least capable of profiting from an expensive, input-intensive agricultural approach introduced by the REDD project.

Bereko village stands out in terms of higher adoption rates of pesticide and synthetic fertilizer use than other studied villages. However, the highway that goes right through the Bereko village, connects it with markets in Kondoa and Babati towns and, research by Arslan et al. (2014) revealed that communities' distance to a tarmac road and a marketplace might improve the adoption of technologies.

This research finds that use of agro-chemical inputs and the practice of planting in straight lines correlate with receiving assistance from extension officers. Agricultural extension services in Tanzania is supposed to be free of charge, but farmers in all villages complained that extension officers prioritize those who can afford to pay for a consultation. Also, some farmers chose not to consult the extension officer since they do not feel confident in the skills of extension agents. The trust in extension officer's competence is important: research by Kassie et al. (2015) outline that it is not simply access to information that matters for agricultural technology adoption, but the quality of information as well. The practices promoted by the REDD project are knowledge – intensive. Adoption of all the practices promoted correlates with education: farmers who have finished at least seven years of schooling are more likely to use farming inputs or plant crops in straight lines. In the REDD project, knowledge of input use was given to the demonstration farmers who were responsible for knowledge transfer to other villagers. Still, villagers are poorly informed about the very existence of demonstration farmers as they rely on extension officers for necessary information.

The idea behind the implementation of the agricultural component was that agricultural intensification would lead to increased production that would result in increased income for the farmers and reduced pressure on the forest since farmers would need to cultivate less land. Generally, the situation in control villages and pilot villages regarding forest use had minor if any differences. The pressure is reduced, since, in fear of fines and other consequences, villagers' have reduced their reliance on the forest. However, there is lacking evidence that agriculture improvement is contributing to reducing the dependency on the forest.

7. Conclusion

The overall objective of this thesis was to evaluate the implementation of the agricultural component of the REDD project in the Kondoa District.

The agricultural component of the Kolo Hills REDD project was named "conservation agriculture", but the research finds this label to be misleading. The three principles of FAO's defined version of CA (permanent soil cover, minimum soil disturbance, crop diversification) was never promoted. Instead, the agricultural component aimed to intensify agriculture and increase yields through adding inputs such as synthetic fertilizers, pesticides and improved seeds.

While the agricultural component of the REDD project has been presented as a particular success, involving not only environmental conservation, but also as benefit for the local people, this research finds little evidence that REDD in Kondoa has had a significant effect on rural livelihoods and state of agriculture. There exist differences in the reported adoption rates of individual practices and between villages, yet overall the author finds modest uptake rate for project-encouraged practices. Agro-chemical use in Bereko is higher than in control villages, however, it is hard to draw an adequate conclusion if REDD had any effect on it or it is the characteristics of Bereko village itself (mainly location) that facilitates high adoption rates.

After performing Pearson's chi-square test to search for significant associations between promoted technology adoption and explanatory variables, the author finds wealth and asset ownership to be strongly correlated with the use of farming inputs. The REDD project's agricultural component relies on investments into expensive inputs. Therefore, marginalized farmers are least capable of profiting from the agricultural approach introduced by the REDD project. The practices promoted by the are also knowledge – intensive. It is concluded that increased education and receiving assistance from extension officers facilitated farmers adoption of agro-chemical inputs and practice planting in straight lines.

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Appendix

Appendix 1:

Questionnaire

Interview information

Village:	**Questionnaire number:**
Start time:	**Finishing time:**
Date:	**Name of Interviewer:**

SECTION A: Farmer, household and land characteristics

Information on farmer

	A1[1)]	**A2**	**A3**	**A4**	**A5[5)]**	**A6**	**A7**	**A8**	**A9**
Farmer	Sex	Age (years)	Years of education finished	How many years have you been farming	Main occupation *specify	Additional incomes in the household 1=employ ment outside village 2= small business /shop/ kiosk 3= remittance s 4= Other (specify)	Which labor provides the most income for the family? 1=agricul ture; 2=other (specify)	Religion	Ethnicity

1) Codes: 1=male; 2=female

5) Codes: 1=agriculture; 2=forestry/forest use; 3=hunting; 4=fishing; 5=other **specify**

A10.1	How many members of your household are adults?	
A10.2	How many members of your household are children?	

A11	House type 1=brick or cement house with iron sheet roof; 2=brick or cement house with iron sheet + rocks 3= mud house with grass roof (*tembe* type)	

A12. Assets: Indicate amount of:

Goats	cattle	Sheep	Bicycle	Motorbike	Car	Ox plough	Cart	Tractor	Solar panel	Electricity from grid	Mobile phone

A13. How many meals did you have yesterday? ________

A14.	How do you perceive the economic wellbeing of your household, compared to other households in the community? **1=worse-off; 2=about the same 3=better-off**	

A15.	How do you perceive the economic wellbeing of your household today, compared to that before year 2010? **1=less wellbeing now; 2=about the same; 3=grater wellbeing now**	

<u>Information on the farmland</u>

	A16[16)]	A17	A18[18)]	A19	A20
Plot **(How many plots did you cultivate?)**	Ownership status of the farmland	Area of land - (Acres)	Who primarily decides how to use land?	Distance (minutes walking) from house to farm plot	Crop species
Plot 1					
Plot 2					
Plot 3					

16) Codes: 1=Owned; 2=rented; 3=community owned; 4=other (**specify**)

18) Codes: 1=Male head of the hh; 2= female head of the hh; 3= Both head and spouse; 4=other.

A21. List the most important varieties that your household has produced last agricultural season:

No.	Crop species	Crop variety	1=Local variety; 2=Improved	Area/ land (acres)	How often do you buy new certified seeds? 1=every year 2=every second year 3=every third 4=less than every third	Total output (bags)	Use 1=food 2=cash 3=other (specify)	Seeding source					
								1. Own harvest (kg)	2. Ex-change	3. Gift (kg)	4. Bought Local market (kg)	5. Shop (kg)	7. Other (Specify) kg
1													
2													
3													
4													
5													
6													
7													
8													
9													
10													

SECTION B: Adoption of proposed inputs and CA

B1	Have you heard about the REDD+ (MKUHUMI) project launched in this area? *1=yes; 2=no*	

B2	Have your farming practices changed since MKUHUMI project started? *1=yes; 2=no*	

B2.1. (If yes (1) on B2). Comment

____

B3	What has been the major trend in your agricultural production since the MKUHUMI project? *1=decreased; 2=stable; 3=increased*	

B4	Do you think REDD (MKUHUMI) had any effect in causing this outcome in your production? *1=yes; 2=no*	

B5	Are you practicing CA? *1=yes; 2=no; 0=I do not know*	

B6. What do you understand with CA?

____

____

B7. Do you practice CA because of MKUHUMI project or other?

____

B8.	Indicate what is the share of your farm land under CA as opposed to conventional farming systems?	

Codes: 1= Only conventional farming system is used; 2= Less than 50% farmland is under CA; 3=50%; 4= More than 50% of farmland is under CA; 5=Only CA farming system is used

B9. What input support have you received? (example: improved seeds; synthetic fertilizers etc.)

Input	Source (project/institution)	Year	Input	Source (project/institution)	Year

Agricultural practices & Technologies ***<u>* all questions refer to previous agricultural season</u>***

B10.	Do you practice planting in straight lines? **1=yes; 2=no**		
B10.1.	* if B8=yes	Since when/ for how long?	

B11.	How many times was the farmland sprayed with herbicides?	

B11.1.	* if B9>0	Since when do you use herbicides? (year)	
B11.2.	*if b9=0	How do you control weeds?	

B12.	How many times was the farmland sprayed with pesticides?	

B12.1.	* if B10>0	Since when do you use pesticides? (year)	
B12.2.	*if b10=0	How do you control pests?	

B13.	How much synthetic fertilizer (specify unit) was applied on the farmland?	

B14.	How much organic fertilizer (manure) (specify unit) was applied on the farmland?	

B15.	Before previous planting season, did you have cover crops remaining on the field? *1=yes; 2=no*	

B.15.1 (if b13=yes) What type of cover crop was left on the field?

____

____

B16.	Did you leave crop residues on the farm field after harvest (mulching)? 1=yes; 2=no	

B17.	What happened to the crop residues after previous season?	

Codes: 1=Burnt; 2=remained on field; 3=eaten by livestock 4=other (specify)

B18.	Did you practice crop rotation in two last seasons *1=yes; 2=no*	

B18.1. (if b14=yes) Which crops did you rotate?

____

____

B19.	What was the main tillage method used?	

Codes: 1= Conventional hand hoeing; 2=ox-ploughing; 3=tractor ploughing; 4=minimum tillage (basins or ripping); 5=zero tillage

SECTION C: Reasons for adoption/ not adoption of CA (as defined in B4)

C1	How was CA and use of chemical inputs communicated to you?	

Codes: 1=own research; 2=other farmers; 3=REDD project officials; 4=others (specify)

C2	How do you find the application of CA in practice? **1=easy; 2=difficult; 0=undecided**	

C2.1. Give reasons for C1 answer____

____

C3.	State driving forces for CA adoption.	

Codes: 1=Because it is encouraged by development organizations/ agents 2 = It pays; 3=Best farming practice; 4=Easy to manage; 5=Reduce farming failure risk; 6=other reasons (specify)

C4. What do you see as the main advantages of CA for your HH?

____

____

C5. What do you see as the main difficulties of CA for your household?

____

____

C6.	How do you assess the fertility of your land?	

Codes: 1=very poor; 2=poor; 3=neither good nor bad; 4=good; 5=very good

C7. What are the most important problems you are facing in your farming activities?

____

____

C8	How many times in last season did you seek assistance in applying any aspect and use of inputs from the project officials/researchers/extension officer/others	

Codes: 1=never; 2=once; 3=more than once; 4=other (specify)

C9	If and when seeking assistance what are your queries mostly about?	

Codes: 1=minimum soil disturbance; 2=maximum soil cover; 3=crop rotation; 4=use of chemical inputs; 5=crop diseases; 6=others (specify)

SECTION D: Forest resources

D1. How far (minutes walking) from your house to the nearest forest you often use?

____

D2. How important are forest products that the members from your household collect for own use and sale?

Nr.	Forest Product	Do not collect	Somewhat important	Important	Very important	Collected forest ownership	Own use (kg)	Sale (kg)
1	Fuelwood							

2	Poles							
3	Charcoal							
4	Timber							
5	Fodder							
6	Medical plants							
7	Nuts							
8	Mushrooms							
9	Wild fruits and berries							
10	________________							

D3.	How do you rate your access to forest products today compared to before year 2010?	

Codes: 1=considerably reduced; 2= reduced; 3=the same; 4=increased 5=considerably reduced

D4. Are the benefits from agriculture project enough to compensate for your loss of access to forest resources?

____

____

Appendix 2: Results from Pearson's chi-square test

* The percentages - percentage of people within a group (e.g., practice use of synthetic fertilizers or pesticides) reported their belonging according to explanatory variable

↓ Explanatory variable	Synthetic fertilizers				
	Mnenia	Bereko	Itololo	Kisese Disa	Meaning
Education	p-value=0.436 Cramer's V=0.092 Less than standard seven:0% Standard seven or more:6 %	p-value=0.128 Cramer's V=0.148 Less than standard seven:40 % Standard seven or more:59 %	p-value=0.498 Cramer's V=0.088 Less than standard seven:0% Standard seven or more:8 %		In Mnenia, Bereko and Itololo people who have finished standard seven-year education are more likely to use synthetic fertilizers than people who had less than seven years schooling.
Additional income besides agriculture		p-value = 0.013 Cramer's V=0.243 additional income: 71% no additional income:46 %			In Bereko people with additional income besides agriculture are more likely to use synthetic fertilizers than people with no additional income.
Land fertility		p-value = 0.015 Cramer's V=0.283 average fertility: 66% good fertility: 60%			In Bereko people with average land fertility are more likely to use synthetic fertilizers than people with good or bad land fertility.

		poor: 33%			
Assistance from village agricultural officer (VAO)		p-value = 0.001 Cramer's V=0.409 assistance 78% no assistance: 37%			In Bereko people who receive assistance from VAO are more likely to use synthetic fertilizer than those who do not receive assistance.
Production variation in last ten years	p-value = 0.073 Cramer's V=0.279 increased: 17% stable: 2% decreased: 0%	p-value = 0.01 Cramer's V=0.302 increased: 80% stable: 67% decreased: 44%		p-value = 0.046 Cramer's V=0.31 increased: 33% stable: 7% decreased: 4%	In Mnenia, Bereko and Kisese Disa people whose agricultural production has increased in past ten years are more likely to use synthetic fertilizers than those with stable or decreased production.
House type		p-value = 0.004 Cramer's V=0.325 iron sheet roof: 69% iron sheet with rocks: 40%			In Bereko people who live in an improved house with an iron-sheet roof are more likely to use synthetic fertilizers than people who live in an unimproved house.
Cattle ownership		p-value = 0.048 Cramer's V=0.302 no cattle: 64% up to five: 42% up to ten: 29% ten or more cattle: 0%			In Bereko, with cattle ownership increasing, use of synthetic fertilizers decreases.

↓ Explanatory variable	Organic fertilizers				
	Mnenia	**Bereko**	**Itololo**	**Kisese Disa**	**Meaning**
Gender	p-value=0.187 Cramer's V=0.155 Female=78% Male=90%				In Mnenia men are more likely to use organic manure than female.
Education	p-value=0.071 Cramer's V=0.213 Less than standard seven:67 % Standard seven or more:89%	p-value=0.414 Cramer's V=0.080 Less than standard seven:50% Standard seven or more:60%			In Mnenia and Bereko people who have finished seven years of education are more likely to use organic fertilizer than people who have less than seven years of education.
Additional income besides agriculture	p-value = 0.041 Cramer's V=0.241 additional income: 94% no additional income: 78%				In Mnenia people with additional income besides agriculture are more likely to use organic fertilizers than people with no additional income.
Is informed about the REDD project's agricultural activities	p-value = 0.052 Cramer's V=0.229 informed: 90% not informed: 69%				In Mnenia people who are informed about the REDD projects agricultural component are more likely to use organic fertilizers than people who are not informed about the project. However, p-value above 0.05 means that this association is not statistically significant.

Land fertility	p-value = 0.001 Cramer's V=0.492 good fertility: 100% average: 88% poor: 50	p-value = 0.004 Cramer's V=0.321 good fertility: 72% average: 66% poor: 33%			In Mnenia and Bereko people with good land fertility are more likely to use organic fertilizers than people with average or poor land fertility.
Wealth group	p-value = 0.048 Cramer's V=0.331 better-off: 100% less poor: 100% poor: 80% very poor: 76%	p-value = 0.049 Cramer's V=0.274 better-off: 80% less poor: 79% poor: 54% very poor: 30%			In Mnenia and Bereko people who belong to "better off" wealth group and "less poor" wealth groups are more likely to use organic fertilizers than people from "poor" or "very poor" wealth group.
Problem with access to agricultural inputs			p-value = 0.010 Cramer's V=0.487 problem: 92% no problem: 47%		In Itololo people who faces difficulties with access to agricultural inputs are more likely to use organic manure.
Climate related problems			p-value = 0.001 Cramer's V=0.604 problem: 30% no problem: 89%	p-value = 0.009 Cramer's V=0.328 problem: 22% no problem: 59%	In Itololo and Kisese Disa people who do not struggle with climate-related problems in their agricultural practices are more likely to use organic fertilizers than people who struggle with climate-related issues.
House type	p-value = 0.022 Cramer's V=0.27 iron sheet roof: 93%	p-value = 0.032 Cramer's V=0.256 iron sheet: 67%			In Mnenia and Bereko people who live in improved house with iron-sheet roof are more likely to use synthetic fertilizers than people who live in unimproved house.

	iron sheet with rocks: 74%	iron sheet with rocks: 44%			
Cattle ownership		p-value = 0.001 Cramer's V=0.431 6 or more cattle: 100% 3 to 5 cattle: 82% 0 to 3 cattle: 65% No cattle: 38%			In Bereko, with cattle ownership increasing, the likelihood of use of organic fertilizers increases.
Area of land cultivated (acres)	p-value = 0.004 Cramer's V=0.427 ten or more acres: 100% two or less acres: 57%				In Mnenia, with cultivated land area increasing, the likelihood of use of organic fertilizers increases.

↓ Explanatory variable	Pesticides				
	Mnenia	**Bereko**	**Itololo**	**Kisese Disa**	**Meaning**
Gender	p-value =0.488 Cramer's V=0.089 male: 20% female: 13%		p-value = 0.047 Cramer's V=0.375 male: 29% female: 0%	p-value = 0.027 Cramer's V=0.276 male: 29% female: 7%	In Mnenia, Itololo and Kisese Disa male farmers are more likely to use pesticides than women farmers.
Education	p-value=0.132 Cramer's V=0.177 Less than standard seven:13 % Standard seven or more:21 %		p-value=0.25 Cramer's V=0.217 Less than standard seven: 0 % Standard seven or more: 22 %	p-value=0.263 Cramer's V=0.140 Less than standard seven: 0 % Standard seven or more: 20 %	In Mnenia, Itololo and Kisese Disa people who have finished seven years of education are more likely to use pesticides than people who have less than seven years of education.
Assistance from village agricultural officer (VAO)			p-value = 0.001 Cramer's V=0.666 assistance: 67% no assistance: 5%		In Itololo farmers who receive an assistance from VAO are more likely to use pesticides.
Wealth group		p-value = 0.002 Cramer's V=0.376 better off: 80% less poor: 53% poor: 22% very poor: 10%			In Bereko people belonging to "better off" and "less poor" wealth groups are more likely to use pesticides than people from "poor" and "very poor" wealth groups.
Climate related problems			p-value = 0.023 Cramer's V=0.431 problem: 40%		In Itololo farmers who face climate related problems are more likely to use pesticides.

			no problem: 6%		
Cattle ownership		p-value = 0.001 Cramer's V=0.526 no cattle: 12% up to five: 65% more than five cattle: 86%			In Bereko with increased cattle ownership, the likelihood of pesticide use increases.
Area of land cultivated		p-value = 0.038 Cramer's V=0.283 up to two acres: 15% 2 to 5 acres: 35% More than 5: 54%			In Bereko with an increased area of land cultivated, the likelihood of pesticide use increases.

↓ Explanatory variable	Planting crops in straight lines				
	Mnenia	**Bereko**	**Itololo**	**Kisese Disa**	**Meaning**
Gender	p-value =0.389 Cramer's V=0.101 female: 83 % male: 90%	p-value = 0.412 Cramer's V=0.08 female: 83 % male:89 %	p-value = 0.386 Cramer's V=0.164 female: 54% male: 71%		In Mnenia, Bereko and Itololo male farmers are more likely to practice planting in straight lines than women farmers.
Education	p-value= 0.345 Cramer's V=0.111 Less than standard seven: 78 % Standard seven or more: 89%				In Mnenia people who have finished seven years of education are more likely to practice planting in straight lines than people who have less than seven years of education
Is informed about the REDD project's agricultural activities	p-value = 0.001 Cramer's V=0.478 informed: 95% not informed: 54%				In Mnenia farmers who are informed about REDD project's agricultural component are more likely to practice planting into straight lines.
Land fertility	p-value = 0.038 Cramer's V=0.302 good: 96% normal: 88% poor: 67%	p-value = 0.006 Cramer's V=0.314 good: 96% normal: 92% poor: 70%			In Mnenia and Bereko farmers who reports good land fertility are more likely to practice planting in straight lines than farmers who report average or poor land fertility.
Assistance from village agricultural officer (VAO)	p-value = 0.001 Cramer's V=0.415 assistance: 98% no assistance: 70%	p-value = 0.003 Cramer's V=0.23 assistance: 98% no assistance: 78%			In Mnenia and Bereko farmers who receive assistance from VAO are more likely to practice planting into straight lines.

Production variation in last ten years	p-value = 0.002 Cramer's V=0.43 increased: 100% stable: 75% decreased: 71%				In Mnenia farmers who report production increase for during past 10 years are more likely to practice planting in straight lines than farmers with stable or decreased production.
House type	p-value = 0.008 Cramer's V=0.339 iron sheet roof: 96% iron sheet with rocks: 74%	p-value = 0.015 Cramer's V=0.284 iron sheet roof: 95% iron sheet with rocks: 76%			In Mnenia and Bereko farmers who live in improved houses with iron sheet roofs are more likely to practice planting into straight lines than farmers who live in unimproved housing

↓ Explanatory variable	**Mulching**				
	Mnenia	**Bereko**	**Itololo**	**Kisese Disa**	**Meaning**
Assistance from village agricultural officer (VAO)	p-value = 0.015 Cramer's V=0.286 assistance: 96% no assistance: 77 %				In Mnenia farmers who receive an assistance from VAO are more likely to practice mulching
Pest problems		p-value = 0.039 Cramer's V=0.008 pest problem: 68 % no pest problem: 87 %			In Bereko farmers who are affected by crop pests and diseases are less likely to practice mulching

↓ Explanatory variable	Rotation				
	Mnenia	**Bereko**	**Itololo**	**Kisese Disa**	**Meaning**
Assistance from village agricultural officer (VAO)	p-value = 0.014 Cramer’s V=0.288 assistance: 71% no assistance: 30 %				In Mnenia farmers who receive an assistance from VAO are more likely to practice crop rotation
Problem with access to agricultural inputs		p-value = 0.001 Cramer’s V=0.323 no problems: 47 % problems: 17 %	p-value = 0.006 Cramer’s V=0.517 no problems: 67 % problems: 15 %	p-value = 0.041 Cramer’s V=0.256 no problems: 46 % problems: 22 %	In Bereko, Itololo and Kisese Disa farmers who report problems with access to agricultural inputs are less likely to practice crop rotation
Climate related problems		p-value = 0.006 Cramer’s V=0.266 climate problems: 52% no climate problems: 24%		p-value = 0.001 Cramer’s V=0.451 climate problems: 67% no climate problems: 20%	In Bereko and Kisese Disa farmers who reported struggling with climate related problems are more likely to practice crop rotation

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