

**Reasons for adoption and spread of  
conservation agriculture among small-scale  
farmers**

**Laikipia and Meru District, Kenya**

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## Preface

During my studies I attended several lectures and field courses organized by the CDE. I was always fascinated by the work of this research group and the approaches they followed. In the courses about sustainable resource use several case studies were introduced from all over the world. Also small scale farmers in Kenya, their livelihood strategies and the problems occurring because of the unreliable rains were part of this lecture. During the field course in sustainable land management I got in contact with Conservation Agriculture how it is practiced in Switzerland for the first time. I was very interested in the technology and also somehow skeptical because of the herbicides applied to kill the weeds. During the last year of my studies I had the possibility to work as an assistant to the student administration for the CDE. During this work I got in contact with Kenya again. I had to proofread an e-learning lesson, where the livelihood strategies of small scale farmers in Kenya were on topic.

I started this thesis circuitous: I commenced another thesis about the development of the soil conservation law in Switzerland. Somehow I realized after three month that I could not get contented with this literature work. After I took heard to break of the started thesis, everything went quickly. I consulted the list of proposed diploma topics again and found a very open topic: 'Conservation Agriculture – Kenya'. I remembered the lectures, and the course about Conservation Agriculture in Switzerland and my interest was caught. The first discussion about possibilities and requests of the work for the thesis at hand took place in June with Dr. Hanspeter Liniger from the CDE and Dr. Kiteme Boniface, the head of the Cetrad office in Nanyuki.

Beside of the opportunity to travel to Kenya, the motivation of this study was to provide an overview of the land-use forms applied and the reasons why farmers apply a certain technology in the study areas around the Mt. Kenya. The results could help on the implementation and spread of Conservation Agriculture technologies and contribute to the enhancement of subsistence production of small scale farmers in the region.

Several people contributed in many ways to this study. I want to thank Professor Urs Wiesmann, the leader of this thesis. His research in Kenya and the contacts built up over the past years paved the way for many studies and thus enabled my thesis.

I also want to thank Dr. Hanspeter Liniger, the co-leader of my thesis, who helped me during the whole study. His inputs and questions helped me to cope with the huge amount of data collected during my field work.

I am also very thankful for the support I got in Nanyuki. First, I want to thank Dr. Boniface Kiteme, the head of Cetrad, who organized the wherewithal for my fieldwork in Kenya and helped me with the planning of the interviews. Further I want to acknowledge the help of Grace Wambugu. She was the heart of the field work, tested the questionnaires and contributed valuable ideas to the sample planning. I also want to thank all people who assisted me during fieldwork: Our driver Deiga and the research assistants who carried out the interviews for and with me. Through this people I had the unique chance to get in contact with the farmers and we had many interesting discussions.

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The CDE is active in research projects and networks all over the world. One of these research projects is settled in the Laikipia District in Kenya. The CDE started its research there more than 20 years ago with the Laikipia Research Program (LRP). Till this day, the NCCR North-South contributes to the funding of CETRAD in Nanyuki. Thanks to the partnership of the ESAPP and the NCCR North-South with the CETRAD this study was possible.

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## Abbreviations

A	Agronomic
ASAL	Arid and Semi-Arid Lands
CA	Conservation Agriculture
CDE	Center for Development and Environment
CETRAD	Center for Training and Integrated Research in ASAL Development
ESAPP	Eastern and Southern Africa Partnership Program
FAO	Food and Agriculture Organization
FFS	Farmer Field Schools
KES	Kenyan Shilling
LRDP	Laikipia Rural Development Program
LRP	Laikipia Research Program
LU	Livestock Unit
MoA	Ministry of Agriculture
mt	Minimum tillage
NCCR	National Centers of Competence in Research
S	Structural
SWC	Soil and Water Conservation
V	Vegetative
WOCAT	World Overview of Conservation Approaches and Technologies
zt	Zero tillage

## Summary

Until 1963 Kenya was under colonial rule and the highlands around the Mt. Kenya were occupied by white settlers. Large scale ranches and farms dominated the landscape and the native population was forced to move to the 'Native Reserves', withdrawn by the colonialists. After Kenya became independent in 1963 some of the white settlers abandoned their farms and the former 'White Highlands' became a new settlement zone for small scale farmers. The Kenyan Government and private land buying companies purchased the land from the leaving settlers and subdivided it into small plots, which were sold to small scale farmers. Private land buying companies wanted to maximize their profit, thus they subdivided the purchased land into too small plots and did not consider the ecological capacities needed by the new owners. This political change thus led to a fundamental land use change in the area around the Mt. Kenya: The before sparsely settled area experienced a fast population growth and hence land use intensity increased too. Increasing population and intensity of land use led to a severe pressure on natural resources. The new settlers derived from areas more suitable for agriculture and did not adapt their land use technologies to the new circumstances.

Land use techniques, adapted to the natural environment could help to increase the sustainable resource use in the area. The study areas are located in the upper part of a Highland-Lowland system thus depletion of resources has severe impacts on the lower parts of the system. Conservation Agriculture technologies were introduced about 20 years ago in Kalalu and Mantanya, two of the three study areas to enhance sustainability of the agricultural production. At the same time, the technology allows small scale farmers, in an area with unreliable rains, to produce higher yields and thus enhance food security. The third study area is located outside the Laikipia District, thus Conservation Agriculture was not introduced there during the Laikipia Research Program.

One goal of the study at hand was to map the distribution of land use techniques in the study areas. More than 20 years after implementation an overview of land use and cultivation technologies in the areas should be established. The spread of Conservation Agriculture and other Soil and Water Conservation technologies in the area were in the center of interest. 150 short questionnaires to require information about land use techniques, farm sizes and the number of people living on the farms were carried out in each area. Quota sampling, a non probabilistic sampling method was used to choose the respondents. This sampling method allows a sampling where no information about the (statistical) population is known before. The evaluation of the 450 questionnaires showed, that the spread of Conservation Agriculture in the three study areas was little: Three to nine percent of the total areas of all visited plots were under Conservation Agriculture. In Gusishi, the study area where nine percent of the visited plots were under Conservation Agriculture, one farmer cultivated a 30 times bigger area than the average thus the percentage under Conservation Agriculture was so much higher than in the other areas. During evaluation it was noticed, that more than 40% of all interviewed farmers did not know about Conservation Agriculture technologies at all.

The second goal of the study at hand was to determine the reasons for adoption or non-adoption of Conservation Agriculture. 10% of the interviewees of the short questionnaire

were visited again. Three sampling frames were defined: Conservation Agriculture applied, not applied and once applied. For each sampling group a questionnaire was developed to determine the factors which influenced the decision making of farmers regarding to the cultivation technologies they apply. Among others, three things became apparent during data analysis: First of all, the knowledge about the technology and its advantages is a condition for adoption of Conservation Agriculture technologies. Second farmers need contact to a person who shows them how they can implement the technology and help them to solve problems with e.g. herbicide application. The third point is that farmers, who do not use Conservation Agriculture until now, have to realize the problems caused by the cultivation techniques they use as e.g. soil erosion. The realization of the problem has to evolve into the will to change the cultivation techniques. If one of these three points is not fulfilled, adoption of Conservation Agriculture is less likely.



# **1 Introduction**

## **1.1 Problem statement**

The study areas are located in the semi-humid to semi-arid foot zone of Mt. Kenya (Liniger, 1992). Most of the small scale farmers are subsistence farmer. They practice mixed farming with rain-fed crop cultivation and livestock keeping. Crop failures because of inadequate rains are frequently and subsistence production is not guaranteed (Wiesmann, 1998). In Gusishi many farmers irrigate their fields and are thereby independent of the unreliable rainfall pattern (own observations). The (illegal) irrigation in the upper parts of the highland-lowland system causes problems in the downstream water supply (Gichuki et al., 1998a).

Due to the population pressure less suitable, steep areas are cultivated in the whole area. Land use systems are not adapted to this marginal areas and the cultivation causes problems as soil erosion and thus a loss of soil fertility and declining agricultural productivity (Wiesmann, 1998).

Conservation Agriculture technologies (see section 2.5) help to prevent soil erosion, enhance the water infiltration and thereby the water storage in the soil. Another positive point is the accumulation of soil organic matter, enhancing soil fertility (Benites et al., 2002).

These technologies are adapted to the natural environment and were introduced in two of the three study areas within the Laikipia Research Program (LRP) from 1985 (Lewis and Ndungu, 2006).

The introduction of Conservation Agricultural technologies is now more than 20 years ago. Information about the actual spread of the technology and the reasons for adoption or non-adoption are unknown. Filling this knowledge gap will help to understand the farmers reason for their action and show up approaches to convince farmers of the new technologies.

## **1.2 Context of research**

### **1.2.1 Highland-Lowland System**

The main characteristic of a highland-lowland system is that the high-altitude regions constitute a resource-rich area, on which the lowlands depend. There is normally a transport of natural resources from the sources in the highlands to the sinks in the lowlands (Kiteme et al., 1998). Furthermore, there has been lack of effective participation by local communities and this has greatly contributed to erosion and weakening of hitherto effective community-based approaches (Hurni et al., 2004). The Laikipia plateau is part of a typical tropical highland-lowland system. After Liniger et al. (1998) the Ewaso Ng'iro basin system consists of three basic zones: The humid to semi-humid mountain slopes, the semi-arid to semi humid lower mountain zone including the highland plateau and the semi-arid to arid parts of the Laikipia plateau and the lower parts of the river basin.

### **1.2.2 Pressure on natural resources and resource degradation**

Today, pressure on natural resources is mainly related to land use changes which occurred in the last century. Wiesmann et al. (2000) reported that the upper Ewaso Ng'iro Basin was used by the Massai and Samburu at the beginning of the last century. They were pastoralists and followed the rainfall patterns with their animals. With the start of the colonial period, much of the high plateau and the foot-zone were annexed by the white settlers, and large scale ranges and farms were established. After independence in 1964, many of the white settlers left the so called 'White Highlands', and the farms and ranges were sold and subdivided to smaller holdings. Agro-pastoralists from surrounding areas, with better conditions for farming, moved to this only sparsely populated area. Results of these changes are the emerging of urban centers, densely populated small-scale farming zones, and some large horticultural companies.

During the time when Kenya was under colonial rule, there were about 30'000 people living in Laikipia which was a reduction of 50% compared to the situation before. After Kenya's independence, the population increased to 310,000 in 1995, equaling a growth rate of about 7% (Kiteme et al., 1998). The city of Nanyuki for example, grew from about 11,000 in 1969 up to 31,000 in 1999 (Brinkhoff, 2007).

This increased population growth rate, due to immigration, heavily increased the pressure on natural resources such as land and water. As the immigrants from the surrounding areas were not familiar with the new environmental conditions, they didn't adapt their farming and land use system to suit the new natural environment.

A further problem is the increasing use of irrigation for the production of horticultural products (Kiteme and Gikonyo, 2002), from which small-scale farmers hope for better harvests by increasing irrigation. The degradation of the water supply systems which once belonged to the large-scale farms is also intensifying the problems of water supply in the area (Wiesmann, 1998). In the low-lands, pastoralists and their livestock are depending on the outflow of the Ewaso Ng'iro, as well as the wildlife and the tourism industry is (Gichuki et al., 1998a).

The fact that the farms are very small is also increasing the pressure on the land, more than 90% of the families in the region own less than two hectares of land. Only a few people have the possibility to earn money from off-farm employment (WOCAT, 2007a).

The soils in the Laikipia District are diverse. As mentioned in Liniger et al. (1998), on one hand, there are soils with a good water storage capacity, and on the other hand, there are soils with nearly no water storage capacity. It is the same with nutrients, soil fertility and erosion potential of uncovered soils. In the upper Ewaso Ng'iro Basin, most of the soils are formed from volcanic material. As long as they are covered by forests, they are good at water infiltration and storage. Removing the soil layer leads to increased surface runoff and soil erosion. The best soils for rain-fed crop production are located on the lower mountain slopes. These soils possess high fertility, good water storage capacity and are easily worked. Unfortunately, these soils have a high degradation potential if the topsoil is removed, causing surface crusts to develop. This problem becomes even more severe for the soils of the

basement complex. Additionally, they are very vulnerable to gully erosion leading to high losses of soil.

### 1.2.3 Livelihood strategies

Small scale landholders are the central occupants in Laikipia. According to Wiesmann (1998), they make up 75% of the rural population, and thus also have a large influence on resource use and degradation. The farm sizes vary between one and 22 acres, with an average size of 5 acres what approximates 2 hectares (Lewis and Ndungu, 2006).

The predominant form of land use in the region is a mixed farming system that includes crop and livestock production. Some differences occur in the ratio between crop and livestock production, particularly if the majority of the farmers are pursuing a subsistence production. Some farms produce cash crops, or where possible, horticultural products for the market. Due to the different agro-climatic zones, adaptation of land use has taken place. In the semi-humid areas, crop production is more important, whereas in the semi-arid to arid regions, livestock keeping is more widespread. Marginal areas are less densely settled and more grazing land is available. Thereby keeping more livestock in these dry areas is not an ecological adaption, but an adaption to the settlement density (Künzi et al., 1998).

Mati (2005: 1) points out in his report that:

*“...the desire to own livestock among Africans still remains strong, not only by pastoralists, but also among smallholder mixed farmers.”*

This statement underlines the statement above: The proportion of crop land to grazing land is not (only) an adaptation to the ecological conditions, but also to settlement density. It would be more reasonable to grow crops in the more suitable semi-humid areas, but, livestock keeping enables families to generate some extra income, for instance to pay school fees.

In addition to crop farming, the mixed farming strategy of the households may include the relation to family networks, which are helpful e.g. in times of crop failures. These family networks are often widespread, due to part of the family moving out of the area of origin and living elsewhere (Wiesmann, 1992).

The establishment of self-help groups is another possibility to get better access to resources such as money, knowledge and materials. The goal of these groups is to upgrade the food security of the family and to increase income (WOCAT, 2007b). Off-farm employment is a further point pertaining to the multiple strategies of households. The aim of this strategy is to minimize the risks small-scale farmers face (Wiesmann, 1992).

### 1.2.4 History of Conservation Agriculture

The CA movement started in the early seventies in Brazil. Farmers realized that they had to change their land use system because of high soil erosion and water runoff. They realized that rain falling on the bare ground enhances soil erosion and soil fertility is reduced. At the same time, farm incomes were low and uncertain, droughts had stronger effects to the farms with poor, crusted soils. The first operations carried out by the farmers were terracing the land to reduce soil erosion. Because the effects of terracing were not good as anticipated, farmers

sought for more possibilities to stop soil erosion and enhance soil fertility. These included mulching, planting cover crops and abandoned the conventional plow (Benites et al., 2002).

In the study area, CA was introduced later than in Brazil. On large-scale farms as the Kisima farm for example, CA technologies were applied earlier (mid 1980) than on small-scale farms. Around 1998, CA was implemented by small-scale farmers. The first research on CA started in 1985 in Kalalu and Mantanya and was carried out through the Laikipia Research Program (LRP)<sup>1</sup>. Farmers became aware of this technology and embraced it for trials on their fields. Several organizations supported the introduction of CA in the region, such as the Ministry of Agriculture (MoA) and the LRP (Lewis and Ndungu, 2006).

Self-help groups were established for different reasons: On the one hand to increase income and ensure food security, on the other hand, to advance the adoption of the new technology and provide a platform to share knowledge. Within the self-help groups, conservation tillage equipment is shared and the group members who have the equipment carry out the work or provide their equipment at special prices to farmers who do not own equipment. Farmer to farmer training takes place, and there are meetings each month to plan further activities. There are also training courses for members offered by research institutes, as well as demonstration areas (WOCAT, 2007b).

### **1.2.5 FAO case study of conservation agriculture in the Laikipia District**

The Food and Agriculture Organization (FAO) carried out a study about CA as practiced in Kenya in 2005. Two case studies were published in 2007. One case study took place in the Laikipia District, the other in Siaya District. The objective of these case studies is to:

- *“Develop a framework for rigorously analysing ongoing conservation agriculture projects and experiences and for characterizing in a holistic way how conservation agriculture practices are adapted and adopted and their effect.*
- *Develop a number of contrasting conservation agriculture case studies by applying this framework in selected regions”* (Kaumbutho and Josef, 2007: xi).

The outputs from the study should help to improve planning and implementation of conservation agriculture projects.

To acquire the information, teams were set up. After literature review, interviews with different key informants were made and case study farms were visited several times. Participatory rural appraisals and focus group discussions with members of self-help groups and farmer field schools were held by the team to generate more information.

The study shows up, that CA technologies are mainly used on medium to large scale farms. Their reasons for adoption are mainly reducing production costs and increase the profitability of their production. Some of those farmers use the technologies since 30 years and invested in machinery that disturbs the soils only minimally. On the other hand, adoption of CA among small scale farmers is very little. The study ascribes this fact to the small amount of farmers

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<sup>1</sup> The LRP was introduced in 1976. Scientists of the University of Bern started research in ecology of the slopes of Mount Kenya. During the LRP basic research on natural resources as soil, river water, climatology but also socioeconomic factors of the Laikipia District was done. In 1984 the Laikipia Rural Development Program (LRDP) was initialized. The program was founded by the Kenyan Government and the Swiss Agency for Development and Cooperation (2003; Liniger, 1992)

who are in one of the field schools or self-help groups where CA technologies are promoted. After the results from the case study, farmers who are not in these groups do not adopt the technologies spontaneously, because they weren't attracted to CA. Small scale farmers often depend on a small piece of land and hold off trying a new technology they do not trust.

There are different farms and groups described in the case study. The large scale farms are neglected here and the focus is laid on the studies about small scale farmers and groups of them. The case study describes one self-help group, a farmer field school and an individual farmer who are applying at least partly CA technologies. One fact hindering adoption in the two groups is the lack of adequate equipment. The groups dispose of equipment but time for planting is short and not all members get the chance to use the group equipment.

The 'Thome Farmer Field School' has 26 members. 15 of them are practicing CA on their personal farms, whereas the other eleven farmers still use conventional technologies. 80% of the farmers who adopted CA technologies plant now Dolchios lablab as a cover crop. Farmers who still use conventional technologies are willing to change their cultivation techniques after they realized that those who already adopted the technologies could harvest better yields than themselves.

The 'Dume Soil Conservation Self-Help Group' has 42 members and was founded in 1997. From 1998 to 2001 ten farmers of the group were provided with seeds, fertilizers and equipment, by organizations. They had to provide a piece of their land as demonstration area. Today, 30% of the group members practice at least some conservation technologies on their farm, and the remaining members are willing to adopt the technologies, but they are limited by the lack of resources and equipment. Irish potatoes are one of the most grown crops in the region, what also hinders the adoption of CA. The study also shows up, that farmers have small landholdings and the residuals were normally used as fodder. Farmers, who are mulching their fields, leave about 30% of the residuals on the farm and the rest is used as fodder.

The study showed up, that farmers who are organized in a group adopt conservation technologies very likely. Especially women are interested in the technologies, because of the easy to handle planting equipment and thereby the labor reduction. The number of conservation groups in the district is still very little, and most of the farmers do not know about the technology, what makes adoption impossible as long as they do not get information. The study also points out some challenges of adoption in the Laikipia District. The most important challenge farmers' face after the study is the ability to get the needed farm inputs for CA. Unreliable rainfalls and the concurrence for crop residues are another problem. Most of the fields visited by the researchers were bare because residues are used as animal fodder. Another point listed in the study, is the missing access to information about modern farming technologies of most of the farmers living in rural areas.

One conclusions of the report is that small-scale farmers start to realize the advantages of CA and are slowly adopting it, because the technology is widespread among large-scale farmers. The best adoption rates are found in organized farmer groups, but these groups are too few to have an impact to the whole region. Another point that hinders adoption is after the FAO the problems farmer face when they have to get new equipment, which is too expensive or not available (Kaumbutho and Josef, 2007).

### **1.3 Goals of the study**

CA technologies were introduced in the study area more than 20 years ago. Large scale farmers are using them since this time on their farms. This thesis ought to provide answers to different questions around the CA as practiced by small-scale farmers in the study areas.

- i. Mapping the distribution of SWC technologies, with a special focus on zero and minimum tillage technologies in the study area.
- ii. Determine the spatiotemporal pattern of distribution.
- iii. Ascertain the reasons for adoption or non adoption and of Conservation Agriculture

### **1.4 Study areas**

The study areas are in the West, North-West and North of Mt. Kenya. They are part of a typical tropical highland-lowland system. As described in section 1.2.1. Two of the three study areas are part of the Laikipia plateau in Laikipia district. The third area (Gusishi) is located in Meru district, about six km in the east of Timau.

#### **1.4.1 Kalalu**

Kalalu is situated in the north-east of Nanyuki at 2040 m a.s.l. on the lower mountain slopes of Mount Kenya and is in the semi-humid to semi-arid area. The total annual rainfall is about 770 mm and evaporation amounts to 1325 mm. The rainfall pattern is trimodal (long-, continental- and short rains) with peaks in April/May, August and November. It is quite a densely settled area. Farm sizes are between 0.8 and 2 hectares respectively between 2 and 5 acres.

The main land uses are crop cultivation and mixed farming (cropland and pasture). Some farmers farm wheat as a cash crop. Due to population pressure, most of the plots are settled, which limits uncontrolled grazing, but also extends the crop production to the less suitable areas on the steeper valley slopes. This development leads to higher risks of soil erosion and crop failures (Kironchi, 1998; Liniger et al., 1998; Wiesmann, 1998)



**Image 1:** Location of the three study areas (source: Google Earth)

### 1.4.2 Mantanya

Matanya is located in the semi-arid highland plateau south-west of Nanyuki. The amount of annual rainfall is between 650 and 750 mm. The rainfall pattern is bimodal: The long rains are between March and June, whereas short rains last from October to January. The Abedare Ranges and Mount Kenya are responsible for the local and orographical differences. This area is not settled that densely as Kalalu. There are still large parts under uncontrolled grazing and treed grassland is the main vegetation type in this area. On the settled plots, crop cultivation and grazing are the main land use forms. Intercropping maize with beans or Irish potatoes is predominant. Crop production is difficult in this area, due to high evapotranspiration losses and sparse rainfall (Liniger et al., 1998; Otengi et al., 2007; Wiesmann, 1998).

### 1.4.3 Gusishi

The third study area is Gusishi located about eight km east of Timau on the leeward side of Mt. Kenya. The climatic information to this area refers to Karuri, located to the south of Timau, 2900 m a.s.l. The average annual rainfall varies between 800 and 900 mm and evaporation is around 1200 mm. The natural vegetation in this area would be mountain forest. Subsistence farmers have encroached part of the forest and felled the trees for crop production (Kironchi, 1998).

Gusishi, between 2400 and 2600 m a.s.l. on the upper slopes of Mt. Kenya (Gichuki et al., 1998b) is surrounded by several large scale farms. Most small-scale farmers produce some horticultural crops as e.g.: snow peas as cash crops for the export market. Some of them have contracts with the large scale farms and produce as out growers'. Unlike in Kalalu and Mantanya, most farms in Gusishi do not depend on rainwater but on irrigation water (own observations).



## 2 Theories and concepts

### 2.1 Active and passive social learning

The social learning theory of Bandura (1977), as mentioned in Glasser, (2007) describes human behaviour as a permanent interplay between cognitive, behavioural and environmental influences. Moreover, he parted prosperous behavioural modelling into four constituents<sup>2</sup>. First of all, the new technology or behaviour has to get the attention of the potential adopters. After that, the learners have to remember the changes of behaviour and they must have the ability to reproduce them exactly. As a last point, Bandura stated that the actions taken by the learners need to have consequences so that the motivation to change something is enhanced.

*“As long as learning, by individuals or collectives, involves some form of input drawn from others, I characterize it as social learning”*

That is how Glasser (2007: 49) defined social learning. He differentiated between ‘passive’ and ‘active’ social learning. Passive social learning is based on wisdom of others. Direct interaction between the two groups (those who already know something and those who learn something) or a feedback is not necessary. The learner is able to understand and reproduce an action through reading an article, watching someone doing something, observing interactions between other people and their practices, attending a speech or visiting a demonstration area. After Glasser it is the most common way of learning.

In Glasser’s example how Banduras framework would affect the adaption of eco-culturally sustainable behaviours, the weaknesses of the technology are revealed: Sustainable behaviours are not fetching; hence they fail to get the attention required to be remembered by the learner. Sustainable compartment often seems to be more complicated. Thus, it is less likely that people reproduce it. Adopting more sustainable technologies appears to be more expensive or community members do not apply them, which lowers the motivation of an individual for adoption (Glasser, 2007).

Active social learning is based on interaction between at least two human beings in which a dialogue is involved. Glasser (2007: 51) partitioned the active social learning into three groups:

- i. *“Hierarchical – based on predetermined, inflexible relationships between established teachers and learners;*
- ii. *Non-hierarchical – based on two-way learning, where each participant, as an ‘expert’ in their own tight shares their knowledge and experience; and*
- iii. *Co-learning – based on non-hierarchical relationships, collaboration, trust, full participation, and shared exploration.”*

An example for active social learning is a course, where the participants interact with the leader and question its statements. With this practice, learning can be improved through exchange of ideas, making active social learning more efficient than passive social learning. People are more motivated to change their behaviour due to direct feedbacks.

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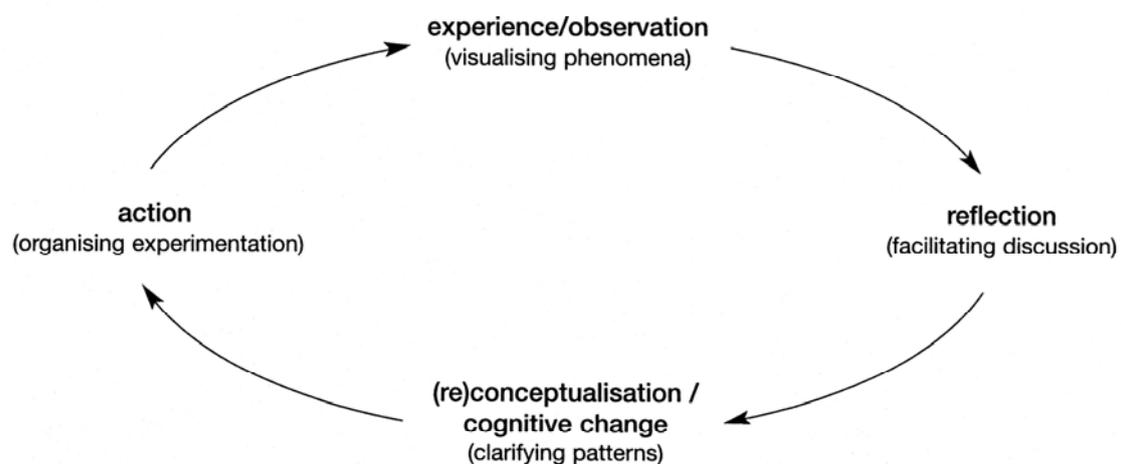
<sup>2</sup> Bandura is mentioned by Harold Glasser in the book edited by Arjen, E.J. Wals

A problem related with active social learning is the fact that in hierarchical structures it is possible to also support maleficent behaviour<sup>3</sup>. The second weakness is that decisions made by the group have to be supported by the majority of the society to realize a change (Glasser, 2007).

## 2.2 Experimental learning

In rural areas, mostly adults who are farming or following other activities are the learners. They face problems or changing conditions that require a solution/innovation. In this situation Kolb's model of 'experimental' learning is often applied. It explains how people learn from their own experiences. This kind of learning is more powerful than learning something invented by someone else and transferred to the people as an existing theory. People can identify themselves with their experiences and understandings of the problems (Leeuwis and Van den Ban, 2004).

A model of the learning cycle by Kolb (Figure 1, in Leeuwis, 2004) shows that actions lead to specific experiences. The experiences are reflected which leads to cognitive changes. Actors are now again at the beginning of the cycle and start their next actions with the new cognitive background.



**Figure 1:** The learning cycle with examples adapted from Kolb, 1984 (Leeuwis and Van den Ban, 2004: 149)

## 2.3 Decision-making of farmers

Agricultural decisions are not made by a single person in the household, but are influenced by the family members and their occupations as well as members of the same community and other actors in the production chain. Leeuwis (2004: 65) introduced a simple model developed by Rölting and Kuiper (1994) which helps understanding decision-making of farmers:

*“...what farmers (and other human beings) do or do not do depends on what they:*

<sup>3</sup> The author gives Hitler as an example for a person who utilized his position to stimulate the ethnic conflict.

- *BELIEVE TO BE TRUE* about the biophysical and social world (i.e. what they 'KNOW')
- *ASPIRE* to achieve (i.e. what they 'WANT')
- (think they) are *ABLE* to do
- (think they) are *ALLOWED* and/or *EXPECTED* to do.”

This model helps to identify reasons, why farmers do refuse to do something. The four points serve as a kind of check points in identifying the reasons for adoption or non adoption of a technology.

Whether a farmer will apply a technology or not is depending on different factors (Leeuwis and Van den Ban, 2004): The expected effects of a certain technology, the probability that the expected effects will arrive and the estimation of the effects compared with other possibilities a farmer has.

### **2.3.1 Reasons for adoption**

The following section refers to Vanclay's (2004) paper, in which he listed twenty-seven principles that are important to look at, when talking about decision-making of farmers and adoption of natural resource management strategies. Vanclay developed this list after 20 years of research he carried out on social dimension of farming linked with promotion of natural resource management.

He pointed out, that social processes influence and control farming practices. Farmers identify themselves with their occupation. The adoption of a new technology is not just an individual decision, but influenced by the social context. It is more likely that new farming practices are adopted if they are judged as good farming technologies by the community.

The stage in the lifecycle also influences the attitude to the future and thereby the will to adopt new practices. Young families want to stay on their farm and are more motivated to change things or try something new unlike families or persons which are later in the lifecycle and thus less willing to change from the known farming practices to new ones.

Individual farmers as well as groups of farmers create their own knowledge. The knowledge is based on own trial and theory construction. If an extension officer introduces a new (scientific) theory which is contrary to the knowledge of the farmers, their attitude towards the new technology is skeptical. The knowledge generated by individual farmers and farmer communities is also very important in improving and adjusting methods developed by scientists to local conditions.

### **2.3.2 Reasons for non-adoption**

In his paper, Vanclay (2004) listed also reasons for non-adoption given by farmers. As the principles in the section before, the reasons were a result of personal reflection after 20 years of research.

Complex innovations need more management skills and knowledge for implementation. The more complex a system is, the more difficult it is to understand. If farmers know about the research results and the scientific statements but do not agree with them, they will not adopt

the technologies. After Vanclay farmers act rational if they adopt less complex innovation and jettison the complex ones.

The probability that divisible techniques are adopted is higher than implementation of indivisibles. The facility of partial adoption is appreciated by the farmers. Farmers have to be convinced of the whole innovation if there is no possibility to subdivide it and therefore the chance of an adoption is reduced.

As long as farmers do not see the need for a change to a more sustainable, conserving technique, they are not ready to change something. The perception of soil degradation may differ between farmers and researchers.

High expenses for the implementation through new equipment, seeds or fertilizers keeps farmers from adoption if they are missing the required capital or it is already set apart for business or private investments.

## 2.4 The concept of sustainable development

Sustainable development is a common term since the report “Our Common Future” of the World Commission on Environment and Development was published in 1987 (Dasgupta 2007). After the World Commission on Environment and Development ” (1987) found that sustainable development has:

*“...to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs”*

It is also mentioned that sustainable development was limited, e.g. by the technological standards and the capacity of the environment to absorb the consequences of human activities. As a further point, it mentioned that population growth had to be in accordance with growth of production capacity to diminish poverty (Development, 1987).

After the 1992 Earth Summit in Rio de Janeiro, sustainable development became a headword. It was used in proposals, debates and publications. Because sustainable development and sustainability were not defined precisely, they were used as catchwords that sounded nice e.g. by politicians. Due to the missing definition, they were able to declare their plans as sustainable and take some extra profit from it. Therefore the term sustainable development needed to be redefined (Wiesmann, 1998).

As defined above, sustainability is a normative concept. It deals with target values, which:

*“...always reflect a standard established by society: i.e. the ‘ought’ (target values) cannot be derived from the ‘is’ (existing situation and dynamics)”* (Wiesmann, 1998: 180).

It is important to think about who (society/individuals) is defining the target values in a certain development context. Sustainable development is also aligned with the factor of time as is mentioned in the definition above. That means, that the values of future generations have to be considered too (Wiesmann, 1998).

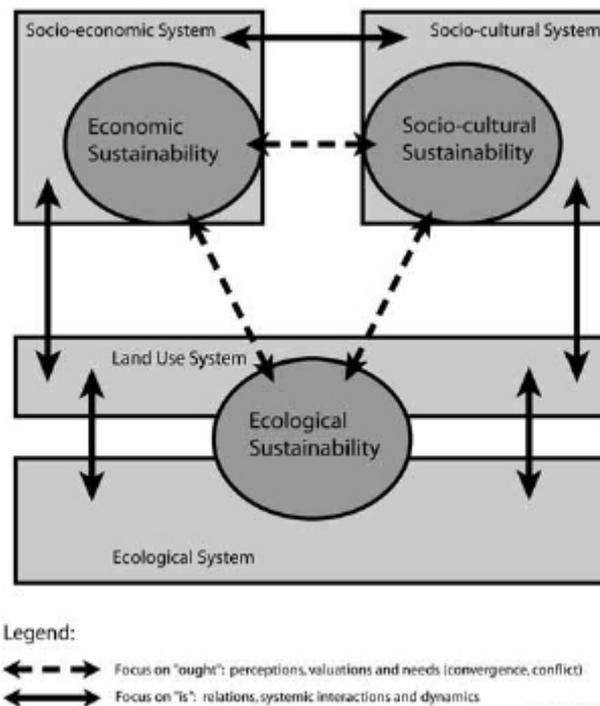
Considering the statements above,

*“The term ‘sustainable’ is meaningless unless it is associated with a specific reference quantity; it becomes meaningful only when it is related to a scale of values.*

*Sustainability will therefore involve establishing a target value on a particular scale of values.*" (Wiesmann, 1998: 183).

These target values have to be kept for a certain time. Thus it is possible to measure the degree of sustainability in a particular context: The detectable or supposed changes over time are compared with a target value that has been set up (Wiesmann, 1998).

The concept of sustainable development can be subdivided into three parts: The socio-economic-, socio-cultural- and ecological system. These three parts are merged into a triangle. The figure shows the relations and conflicts that occur between the different systems.



**Figure 2** 'Magical triangle' of sustainable development (Wiesmann, 1998: 184)

Figure 2 shows how the three dimensions are linked with each other. These linkages implicate, that a change in one of the three dimensions has effects to the other dimensions. These linkages are often a source of problems. If a positive change happens e.g. in the ecological system, this change is probably related with negative effects in the other systems.

#### 2.4.1 The concept of sustainable resource use

Sustainable resource use (Wiesmann, 1998) attends mainly human induced change. For this time, ecological change and natural variation are excluded. The use of resources has an arbitrate influence on ecological sustainability. Humans use natural resources either directly or indirectly, whether the use is conscious or not. The use of these resources has a key influence on the ecological sustainability.

Resource use takes place in a definable area, but the effects of this resource use do not have to affect the same area. Therefore, the spatial-ecological context has to be considered too, and programs to enhance sustainable natural resource use have to take place within a certain regional context.

As already pointed out in section 2.4, the term ‘sustainable’ has no meaning as long it is not conjunct with a scale of values. To establish this scale of values, the natural potential<sup>4</sup> is considered. Normally, two different levels of natural potential are considered in development practice and policy: The specific natural potential as perceived by the local people and the general natural potential defined by researchers with a scientific background of the industrialized, western societies. To develop scales of values for appraising sustainable development, any element of the specific or general natural potential can be considered. The contents of both natural potentials are arranged in four groups. For this study, the first of these groups is the most relevant: The so called ‘production –oriented natural potential’. In this group, all aspects of nature that are regarded as a part of any of the general or specific natural potential are considered. Additionally, the connection of the two natural potential and the production of goods is included.

Wiesmann (1998: 195) gives the following definition for sustainable use of natural resources:

*“The degree to which resource use is sustainable in a regional context is a function of the extent to which a society is willing to strike a balance between negative and positive fluctuations in the values of specific and general natural potential.”*

## **2.5 Conservation agriculture and conservation measurements**

CA is not just one simple approach, but a combination of different principles. After the FAO (FAO, 2007):

*“CA is a concept for resource-saving agricultural crop production that strives to achieve acceptable profits together with high and sustained production levels while concurrently conserving the environment. CA is based on enhancing natural biological processes above and below the ground. Interventions such as mechanical soil tillage are reduced to an absolute minimum, and the use of external inputs such as agrochemicals and nutrients of mineral or organic origin are applied at an optimum level and in a way and quantity that does not interfere with, or dispute, the biological processes. CA is characterized by three principles which are linked to each other, namely:*

- i. Continuous minimum mechanical soil disturbance.*
- ii. Permanent organic soil cover.*
- iii. Diversified crop rotations in the case of annual crops or plant associations in case of perennial crops.”*

To achieve the full advantages of CA, all three principles have to be applied. If one is neglected, it becomes more difficult to practice CA. As an example, more fertilizers or pesticide are needed. As a result, the whole system becomes less sustainable (Bwalya and Friedrich, 2002).

According to WOCAT (2007b), four different conservation measures types exist: Agronomic, vegetative, structural and management measures.

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<sup>4</sup> In Wiesmann (1998: 190) natural potential is described as follows: „Natural potential refers to all components of nature considered useful or valuable by a certain society at a certain point in time. [...] Hence the concept of ‘natural potential’ in a specific context does not have arbitrary and unlimited dimensions, like ‘ecosystem’ and ‘natural resources’.”

Agronomic measures include soil management such as contour cultivation, direct planting, soil cover, crop mixtures and rotations. These measures are normally cheap but very effective. Manuring and composting also belong to these measures and have a big influence on soil fertility. Agronomic measures are normally linked with annual crops and repeated every year or cropping season. Usually, they are not permanent and do not change the slope profile.

Vegetative measures such as grass stripes, hedges, windbreakers or agro-forestry help to protect the ground and reduce the wind speed. These measures are of long duration and often cause a change in slope. Water competition between crops and the plants of the vegetative measures can cause problems if water is short. Special management is needed to reduce this competition.

Terraces, bunds and banks are the structural measures. In most of the cases, they are built to prevent movement of eroded soil. The construction of such measures is related to earth movement and leads thereby to changes in slope profile. Structural measures require a considerable input for implementation and maintenance in terms of money and labor.

Management measures involve a fundamental change in land management. They are often applied where degradation is much advanced and other conservation measures would not be useful until a land use change is accomplished. Such changes can take place for example in overgrazed areas. Uncontrolled grazing is stopped and the vegetation gets the possibility to recover. These changes in management are often not related with great costs, but in certain circumstances, the conservation of one part can increase the pressure to other areas.

A combination of the measures described above is often applied by land users.



## 3 Methodology

### 3.1 Selection of the study areas

Mulching and minimum tillage (mt) or zero tillage (zt) increase water infiltration reduces runoff and evaporation. Thereby CA technologies are a good adaption to dry areas (Derpsch, 2007). To find out, if different climatic conditions influence the land use techniques of farmers, three areas in different agro-climatic zones<sup>5</sup> had to be defined. At first, the possible study areas are searched within the Laikipia District, where some research and promotion of CA is done since more than 20 years (LRP) and various information, e.g.: plan of parcels and land use are already available. Prof. Wiesmann and Dr. Liniger suggest two areas: Mantanya, located in the semi-arid zone and Kalalu in the semi-arid to semi-humid zone are both within the Laikipia District. The third, more humid area is Gusishi, located in Meru District. Gusishi is selected following Dr. Kitemes suggestions during field work planning in Kenya.

### 3.2 Sample planning

The situation at the beginning of sampling was special, because normally some information about an area and its population are known if a survey is done e.g. in Switzerland. The sample is selected from a defined, known population<sup>6</sup>, as for example a voting registers or a directory (Atteslander, 2003). For this study no detailed information about the population and the land use techniques of the single farmers were known.

#### 3.2.1 Questionnaire study area

Because there are no recent data available about the land use techniques small-scale farmers use in the three study area, the questionnaire study area is developed. The goal of this sampling is to get information about the spread of different land use techniques as well as information about the land size and the people living on the farm. Therefore, 150 questionnaires are collected in each of the three study areas.

The following section concerning planning and set up of sampling refers to Sapsford and Jupp (1996). The first thing to figure out doing some sampling is to identify the population. For this study, all small-scale households in the three study areas are considered as the population. In a next step, the population has to be subdivided to sampling units. All sampling units together make up the entire population. For this study it is evident to take each of the three study areas as a sample unit.

After Sapsford and Jupp, the sampling frame is used to identify each single component (elements or individuals) of the sampling units. It is important that the frame includes the whole population defined before. For this study the parcel plan of the three study areas is used as sampling frame. The problem using the parcel plan is on the one hand that on some parcels

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<sup>5</sup> See section „Study areas“

<sup>6</sup> Population is used as a statistical term in this section. Sapsford, R. and Jupp, V. (1996, 25f), describe the term as follows: “A population consists of individuals, or elements, and these could be persons, or events, or cabbages, [...] anything at all of research interest, including observations, judgements, abstract qualities, etc.”

more than one family is living respectively parcels were subdivided while others are unsettled. On the other hand, the plan of parcels is the only raster available covering the whole area.

To select the actual sample of the population described above a type of non probabilistic sampling is used: Quota sampling. In this kind of sampling, the population is split into several groups, which are not overlapping. After that, each of the interviewers has to carry out a given number of interviews with respondents who fit to the given quota criterions. For this study just one type of respondents is given<sup>7</sup>: Small-scale farmers living in the study area. In each of the three study areas about 150 questionnaires are done to get an overview about the technologies used.

A problem correlating with quota sampling is the missing randomization, whereby it is not possible to estimate the extent of sampling error.

### 3.2.2 Long questionnaires

The long questionnaires, Conservation Agriculture applied, -not applied and -once applied are based on the information collected with the questionnaire study area. Because of that, the population is now different to the population before. By now, all farmers interviewed with the questionnaire study area in the three areas represent the new population. The sampling units are now all visited plots in the three study areas. In each of the three areas 10% of the visited farmers are interviewed again.

The sample frame is based on the different land use techniques farmers apply on their farms. Three sample frames are set up:

Conservation agriculture applied: Farmers who practice conservation agriculture on their farm using zt or mt technologies.

Conservation agriculture not applied: Farmers who do not use zt or mt technologies or farmers who use some other soil and water conservation measures as mulching or tree planting are also in this group.

Conservation agriculture once applied: This group consists of farmers, who used zt or mt technologies on their farm but stopped again. It is possible that these farmers still use other soil and water conservation measures.

	<b>Kalalu</b>	<b>Mantanya</b>	<b>Gusishi</b>
Total number of questionnaires filled out	146	153	150
CA applied	8	3	7
CA not applied	133	149	143
CA once applied	5	1	0

**Table 1:** Sample frame for the long questionnaire.

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<sup>7</sup> The questionnaire study area is used for the mapping. The objective is to find out, how different land use techniques are spread in the three study area. To make a statement how the actual spread of the techniques is, it is not possible to search e.g. for farmers who are practicing CA techniques, because the group would be over-represented.

For the sampling of the group ‘CA not applied’, a combination between stratified and systematic random sampling was used. For this purpose, elements of the group were divided in two non overlapping groups, so called strata. The first group is composed of all farmers who did not apply any conservation technologies besides of planting trees or shrubs<sup>8</sup>. The second group consisted of all interviewed farmers who used some conservation technologies as e.g. mulching or building fanya juus. For each study area the strata were sorted by plot numbers. Then both strata were listed.

For the systematic sampling the first interviewee was determined by tossing a dice. To define the next respondents, the total number of filled out questionnaires ‘CA not applied’ was divided by the total number of questionnaires to be filled out in the area. The result was added to the first number determined by tossing the dice.

For the other two groups, ‘CA applied’ and ‘CA once applied’, the samples are very small compared to the group ‘CA not applied’. To acquire information of more than one farmer of these groups in each area, more than 10% were visited again. Table 2 shows the number of long questionnaires obtained in each area.

	<b>Kalalu</b>	<b>Mantanya</b>	<b>Gusishi</b>
Total questionnaires filled out	15	15	15
CA applied	3	3	2
CA not applied	10	11	12
CA once applied	2	1	0

**Table 2** Number of questionnaires filled out per study area.

### **3.3 Design of the questionnaires**

The set up of the questionnaires was done, considering the general framework of the expected interview situations. The interviews were held with small-scale farmers on their farms. Most of the interviewees did not speak English and the interviewers had to conduct the interviews either in Swaheli or one of the local languages. The interviewers had to translate the given answers and write them down in English.

#### **3.3.1 Standardized interview with open ended questions**

This section about interview types is based on Atteslander (2003), Sapsford and Jupp (1996), as well as on Kromrey (1998). Standardized, highly structured interviews are distinguished by little flexibility. All respondents are asked the same questions in the same way. Thereby, questions are standardized and the procedure of asking the questions is given. This type of asking questions allows comparing the given answers. If a respondent does not understand a question, the interviewer has to explain the circumstances without influencing the respondent. In the same time, the interviewers should encourage the respondents by nodding or smiling, whatever answers they get. This way of communication between the interviewer and the

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<sup>8</sup> The planting of trees and shrubs is not considered as a conservation technique for the separation of farmers to one of the strata, because most of the farmers have planted some trees on their plots. Most of them do not plant trees or shrubs as conservation measure but as a source of firewood or to fence their plots.

respondent could be influenced by this interaction. The way of asking a question is also important: The questions should be plain, so that the respondent is not influenced. The questions are already coded and thereby many answers are already predetermined.

The problem of this interview type is that not all kinds of questions can be asked and that the interaction between interviewer and respondent is very stiff. A further problem concerning the standardization of the interviews are the different interviewers who will also have different characters and the interaction with the respondent will not be the same in all interviews. A problem with highly structured interviews mentioned by Girtler (2001) is that the reality and the perceptions of the researcher are devolved to the respondent by the way how a question is posed or the predefined categories.

To make the questionnaires more interesting for the respondents and give them the possibility to answer in their own words (especially in the three long questionnaires) some open-ended, uncoded questions were embedded. The responses to these questions were written down by the interviewer. Because the questions were not categorized, the spectrum of possible answers was higher, yielding more detailed information about opinions and knowledge of farmers.

To answer open-ended questions, respondents have to remember something and then formulate an answer. It is easier to recognize a circumstance and then choose one of the given answers. Because of this,- it is more likely, that open ended questions are not replied.

### **3.3.2 Question types and question arrangement**

The question types used for the 'Questionnaire study area'<sup>9</sup> were closed questions and belonged to the identification type. This kind of question asks for a person, the size of something and so on. The questions are opened by question words as: Who, where, when, how many, etc. There are also two so called yes or no questions that have. These questions can be answered simply by yes or no (Atteslander, 2003).

These types of questions were chosen because the answers are easy to categorize, and it is possible to categorize them and make a comparison. This questionnaire was developed to map the spread of the land use techniques and thereby closed questions were suitable to acquire the information. The amount of questionnaires, a total of about 450, was a second reason for this type of questions. The analysis of the questionnaires had to be easy and provide the possibility to select the respondents for the long questionnaires within reasonable time.

After Sappsford and Jupp (1996), questions about civil status, children, family relations and so on should be at the end of the questionnaire, as these questions are not interesting for the respondents and the attention is better at the beginning of an interview. Because of that, relevant questions concerning the research topic should be asked in the beginning.

For the three long questionnaires, also open-ended questions are used. As mentioned above, open-ended questions make the questionnaire more interesting for the respondents. Furthermore, multiple choice questions were used in the three long questionnaires. The respondents had to choose the answer which was most applicable to them. Multiple choice questions were followed by a question about the reasons for the respondents' decision.

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<sup>9</sup> All four questionnaires are in the appendix.

The long questionnaires had the same structure for the three types 'CA applied', 'CA not applied' and 'CA once applied'. The questionnaires were subdivided into five sections:

- i. Questions about the land use techniques.
- ii. Natural factors influencing the decision-making of farmers.
- iii. Human factors influencing the decision-making of farmers.
- iv. Origin of equipment.
- v. Questions about the social environment.

In the three other questionnaires, different land use techniques were considered. One was for the respondents who applied CA technologies including zt or mt, one for those who never applied those technologies on their farm and the third was for respondents who had once used zt or mt technologies but changed back to conventional technologies again.

The structure of all questionnaires was the same. In the Introduction some questions from the 'Questionnaire study area' were confirmed. In the first part, questions about the land use technologies were posed. Respondents were asked which crops they grew, how they cultivated them and how they used the residues. Further, they were asked for some factors such as crop production or soil moisture as well as if and why they were content with the methods used. Respondents who practiced CA were asked to compare the same factors with the conventional technologies they used before and tell, if they are more content now than before or not.

The second section was about natural factors (rainfall pattern, soil conditions and suitability). Respondents were asked, whether factors influenced their decision to use a certain cultivation technology. At the end of this section, respondents had to rank the factors on a Likert scale (Sapsford and Jupp, 1996) in order of importance for their decision not to adopt or to adopt CA technologies.

The third part was about how human factors influenced respondent's decision-making. Respondents who used conventional technologies on their farm were asked, whether they got to know about CA technologies or not. Those who practiced CA or had practiced it once were asked how they got to know about the technologies. Furthermore all respondents who knew something about CA technologies were asked whether they knew a CA group or whether they ever participated on a course or on a field visit. The last section in the part human factors was about the influence of known CA respondents on the decision-making of the respondents.

The fourth part was about the origin of equipment used by the respondents. The emphasis in this section was put on the tools respondents needed to cultivate their land and on the question if they owned or hired them.

In the last part, questions about the social environment of the respondent were posed. The goal was to learn about the education level, age and occupation of the people living on the farm.

### 3.4 Data analysis

For the data analysis, answers from open-ended questions were coded first and then listed for each respondent in an excel table. Data from closed questions which were already coded were overtaken. Information of questions about farm size or the livestock owned was overtaken in the tables. Before data analysis was possible, the scale (ratio, interval, ordinal or nominal) of data for each question had to be defined. Depending on what scale the data were in, different possibilities of evaluation exist. Table 3 shows possible analyzes and the typical criteria for each of the scales.

	<b>Definition</b>	<b>Example</b>	<b>Possible (mathematic) operations</b>
Interval scales	<ul style="list-style-type: none"> <li>• Values can be ranked</li> <li>• Differences between two values can be determined</li> </ul>	Temperature, date and time	Ratio scale plus ranking and degree of difference
Ratio scales	<ul style="list-style-type: none"> <li>• Negative values are impossible</li> </ul>	Salary, age and weight	Ordinal scale plus average, difference and quotient
Ordinal scale	<ul style="list-style-type: none"> <li>• Differences can not be interpreted</li> </ul>	Age classes, marks	Nominal scale plus Comparisons between groups, Median
Nominal scale	<ul style="list-style-type: none"> <li>• It is only possible to test equality or inequality</li> </ul>	Sex, marital status	Define equality or inequality, Frequency

**Table 3:** Measurement scales and possibilities for data analysis according to Matthäus and Schulze (2008).

Data analysis was done using Excel. Most of the collected from the long questionnaire are ordinal scaled. This data level does not allow calculating averages. For that reason, data were displayed in bar charts to make a quick overview possible. For ratio scaled data (e.g. LU, farm size) averages and medians were calculated and correlations were tried to figure out.

## 4 Land use and livelihoods in the study areas

In this section, the different land use techniques of all the visited farmers in the three study areas are described. First, an overview is given on the relation between the different land use forms (area under cultivation, area for livestock production and area for housing) is given. After that introduction, a closer look at the factor livestock production and the cultivation technologies used in the three areas is taken.

	Kalalu		Mantanya		Gusishi	
	Acres	%	Acres	%	Acres	%
Total landholding of the visited plots	802	100	551	100	718	100
Area under conventional crop production	445	56	272	49	457	64
Area under zt or mt	25	3	27	5	64	9
Area for controlled grazing	49	6	47	9	3	0.4
Area for uncontrolled grazing	183	23	117	21	116	16
Area for houses and barns	99	12	89	16	78	11

**Table 4:** Land use on the visited plots in the three study areas.

The area which had the smallest percentage of cropland is Mantanya (54%), followed by Kalalu with 59%. Gusishi was the only area, where more than 70% of the visited plots were cultivated. Gusishi was also the area, in which the biggest percentage of the visited plots was cultivated using zt and mt technologies. This was due to one farmer who cultivated 60 acres. The other CA farmers in Gusishi cultivated small plots, like in the other two areas. The area used for cultivation has an influence on the area available for livestock grazing. Here an antithetic pattern was found: In Kalalu and Mantanya a bigger part of the area owned (29% and 30%) was used for livestock grazing then in Gusishi, where only 16% of the area was extended for livestock grazing. Uncontrolled grazing was more important than controlled grazing in all three areas.

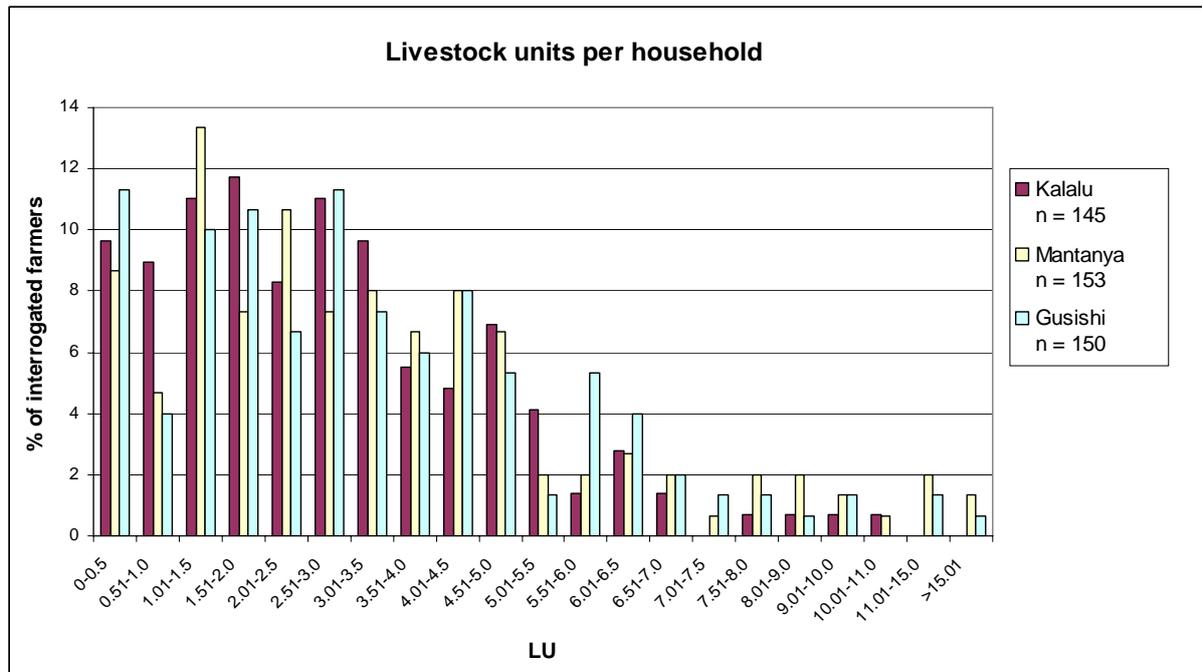
The land use in the three areas showed some differences. In Gusishi, crop cultivation was extended on a larger area, whereas grazing areas were reduced. These two facts suggest that crop production is more important in the area.

### 4.1 Livestock

Livestock keeping was widely spread in the three study areas. Figure 3 shows the number of livestock owned by the visited farmers in the three study areas. In all areas, beside of Gusishi, less than ten percent of the interrogated households had no livestock at all. On 51% of the visited farms in Kalalu, livestock units<sup>10</sup> (LU) between 1 and 3.5 were found. The same range

<sup>10</sup> Livestock units are defined as follows after Wiesmann (1998): "A livestock unit is here defined as representing one milk cow, while other livestock is calculated on the basis of : 0.7 for other cattle, 0.5 for hivers, 0.25 for calves, 0.1 for goats and sheep, 0.02 for other small stock like chickens, etc."

of LU was found by 46% of the respondents in Mantanya and Gusishi. In Kalalu, about 8% of the interrogated farmers owned more than 5 LU, whereas in Gusishi and Mantanya 18% of the visited households had more than 5 LU. This short overview shows on the one hand that the number of LU per household differed strongly within each study area. On the other hand, there was also a cluster found in each area: About 50% of all farmers owned between 1 and 3.5 LU.



**Figure 3:** Distribution of livestock units per farm in the three study areas.

The average LU, for all farmers who do not apply zt or mt technologies was between 2.74 and 3.43 LU (See Table 5). For zt and mt farmers, the data were different. The average of LU per household from farmers practicing zt or mt technologies in Mantanya and Gusishi was about twice as high as the one of farmers using conventional technologies to cultivate. In Mantanya, the median was also higher than the average of LU, which makes the data more reliable, whereas in Gusishi the median is nearly half the value of the average. The explanation for the results is the same: The sample sizes of  $n=4$  in Gusishi and  $n=3$  in Mantanya are small and a single outlier with a high number of LU was able to distort the result. In Mantanya one farmer owned 12 LU and in Gusishi two out of four farmers, who are practicing zt or mt technologies, owned more than 15 LU. The distribution was more equal in Kalalu and with a sample size of  $n=8$ , the average was also more resistant.

No pattern for the distribution of LU on the farms could be found. The correlation between LU and Landholding was between 0.2 in Kalalu and Mantanya and 0.5 in Gusishi. The correlation of 0.5 in Gusishi was influenced by the one farmer who owns 60 acres of land. If this farmer is neglected in the calculation, the correlation resulted in 0.35. The factors cropland and people living on the farm did not show a correlation with the LU as well.

Livestock products as milk and meat are a welcome source of income for the farmers and often the only possibility to generate some cash. Mantanya showed the highest livestock

average and also grazing area were slightly bigger than in Kalalu. Compared to Gusishi, farmers in Kalalu used 10% more of the area they owned for livestock grazing (See Table 4). This fact could be interpreted as an ecological adaption to the semi-arid zone, which is more suitable to livestock production than to crop farming. If Künzi's (1998) statement (see section 1.2.3) is considered, dry areas would be less densely settled and more grazing land would be available, what would equal more to an adoption to the settlement density.

	Kalalu		Mantanya		Gusishi	
	Average	Median	Average	Median	Average	Median
Livestock units per household practicing zt or mt.	3.6	3.1	7.8	6.6	5.9	2.5
Livestock units per household not using zt or mt.	2.7	2.5	3.4	2.8	3.3	2.9

**Table 5:** Average and median livestock units per household.

In Mantanya were still some unsettled plots<sup>11</sup>. These unsettled areas were used for livestock grazing and signs of soil degradation were visible. The observation, that farmers had the possibility to graze their livestock outside their own plots was confirmed by the following statements given by two respondents, Mr. Kimani and Mrs. Wangeki, both occupied a plot in Mantanya:

*“For grazing I use the unsettled land of my neighbors.”*

*“I have no livestock and so a friend grazes his cows on my land in exchange for milk.”*

In Mantanya ten respondents mentioned that they either graze their livestock on unsettled land or had an agreement with a landowner who had no livestock. These answers were additional information. It was not asked where people graze their livestock if not on their farm.

## 4.2 Area under crop production

The area under crop production of the total area, owned by a farmer, differed between the three areas. Table 6 shows three things:

- i. The percentage of the total area under cultivation owned or hired by zt or mt farmers.
- ii. The percentage of the total cultivated area zt or mt farmers cultivate using these technologies.
- iii. The percentage of total area under cultivation owned or hired by conventional farmer.

Mantanya shows from Table 4 as the area where farmers cultivate a smaller part of their plot than in the other areas. A look at Table 6 shows, that this average is only partly true: Farmers who were using zt or mt technologies in Mantanya cultivated 30% more of their land than

<sup>11</sup> It is not possible to give an exact estimation about the number of unsettled plots. The fact that there were still grazing areas and unfenced land was observed during the field work.

conventional farmers. In total they cultivated 82% of their land, whereof they 69% were under zt or mt technologies.

	Conventional crop production	Zt or mt applied	
	% of cultivated land of the total area owned.	% of cultivated land of the total area owned	% of cultivated land under zt or mt
Kalalu	63	58	45
Mantanya	52	82	69
Gusishi	77	75	72

**Table 6:** Part of the total owned or hired land under different cultivation techniques. Visited plots in all study areas.

In Kalalu farmers who were using zt or mt used 5% less of their total land for cultivation than those who applied conventional technologies.

In Gusishi both groups of farmers used nearly the same portion of their land to cultivate. Farmers, who applied zt or mt, used these technologies on 72% of the land they cultivated.

The point, that farmers did not cultivate the whole area they use with zt or mt technologies, can be explained, by the crops they grew: Maize, beans and potatoes are the typical staple food in the area and grown on nearly every farm. To plant potatoes, farmers plow their fields and disturb the soil. Only one farmer practicing zt in Mantanya and one in Gusishi was not planting potatoes on his fields. In Kalalu data about the crops grown from two farms where zt and mt was applied are missing, but the other six plant potatoes.

In Kalalu farmers who were applying zt or mt technologies cultivated 5% less of their total land than farmers who were using conventional technologies. This slight difference makes an interpretation difficult. Maybe the higher productivity of zt and mt systems allows the farmers to cultivate a smaller part and use the rest of the plot for livestock pasture.

Farmers who planted without soil disturbance in Mantanya cultivated 30% more of their land compared to those who applied conventional farming technologies. One explanation for this observation is the better crop performance under zt and mt. Reduced crop failures make it more profitable to cultivate a bigger portion of land.

In Gusishi the cultivated area was more or less the same for both technologies. In the very densely settled area where a big part of the farmers produce horticultural crops for the market as much as possible is cultivated. Only on 11% of the 151 interrogated farmers did not plant either snow peas or other vegetables for the market.

## 5 Conservation agriculture technologies and their spread in the study areas

In the study area several kinds of SWC technologies were found. According to WOCAT (2007b), they are grouped into three types: Agronomic-, structural- and vegetative measures.

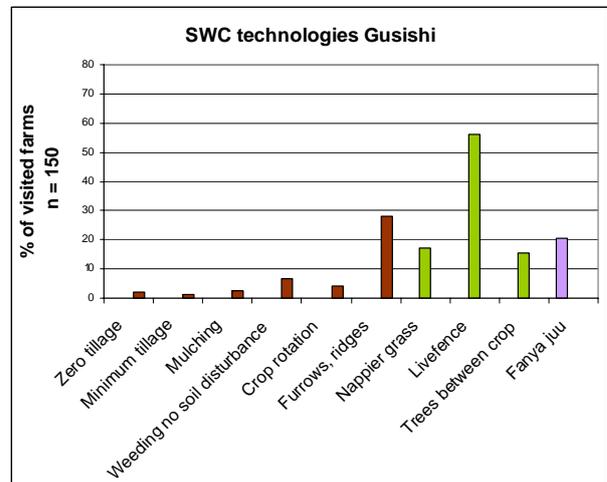
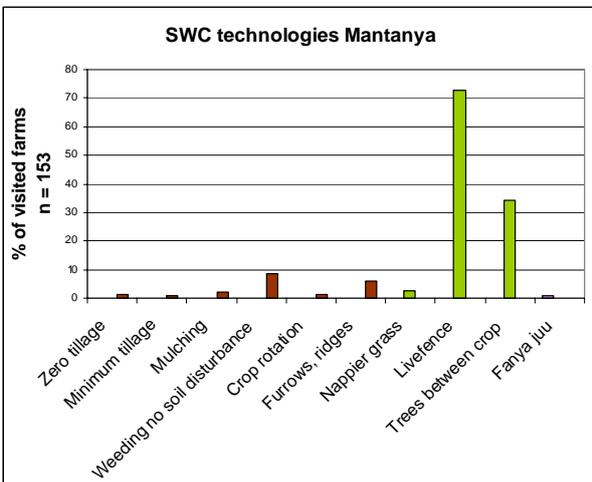
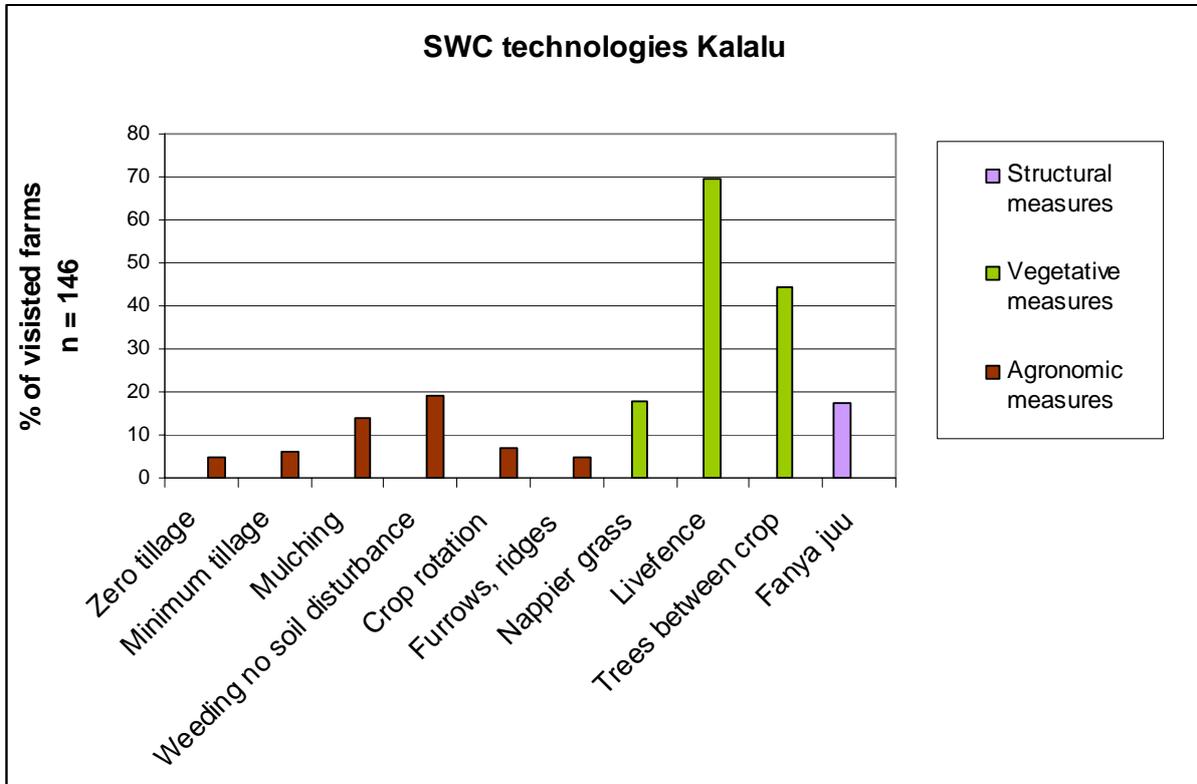
Measures	Conservation technology	Description
Agronomic	Zero tillage/Direct planting	Seeding is done directly in untilled land.
Agronomic	Mt	Soil is not inverted; the ripping enhances water infiltration of the soil.
Agronomic	Mulching	Soil is covered with slashed weeds, leaves or crop residues to reduce evaporation. At the same time also runoff and soil erosion is minimized.
Agronomic	Weeding without soil disturbance	Weeds are sprayed with herbicides and left on the field or slashed and used for animal fodder. In both cases, soil is not disturbed.
Agronomic	Furrows/Ridges	Furrows and ridges are made to harvest water and slow down runoff speed and soil erosion. They are yearly redone after plowing/digging the field.
Agronomic	Crop rotation	Crops are planted alternately on the same field to enhance soil fertility.
Vegetative	Contour line planting	Napier grass or bushes are planted along contour lines, often on terraces and fanya juus to stop runoff and soil erosion.
Vegetative	Tree and shrub planting	Trees and shrubs are planted around the plot or between the crops. They provide shade, firewood and building material.
Structural	Fanya juu	Terraces (fanya juu) are made, to stop runoff and soil erosion. To build fanya juus, a ditch is digged and the soil is thrown on the upper side. In most cases fanya juus are parallel to the contour lines (WOCAT, 2007b: 66).

**Table 7:** Soil and water conservation technologies observed in the study areas.

### 5.1 SWC measures in the study areas

All three measurement types described in Table 7 were applied in the three study areas. If trees and shrubs were considered, vegetative measures were the most applied by the

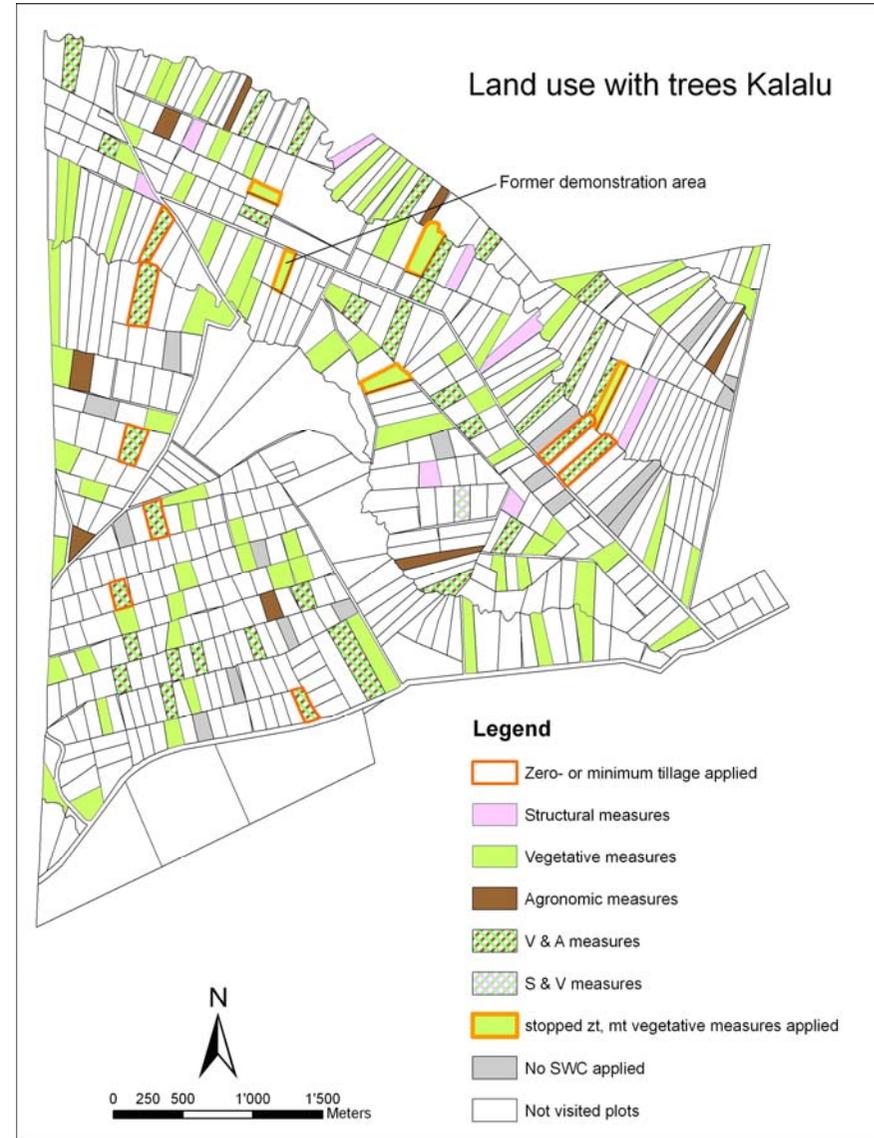
interviewed farmers. They were followed by agronomic- and structural measures. The following figure and the maps for each study area give an overview, which SWC technologies are used by how many farmers in the three areas.



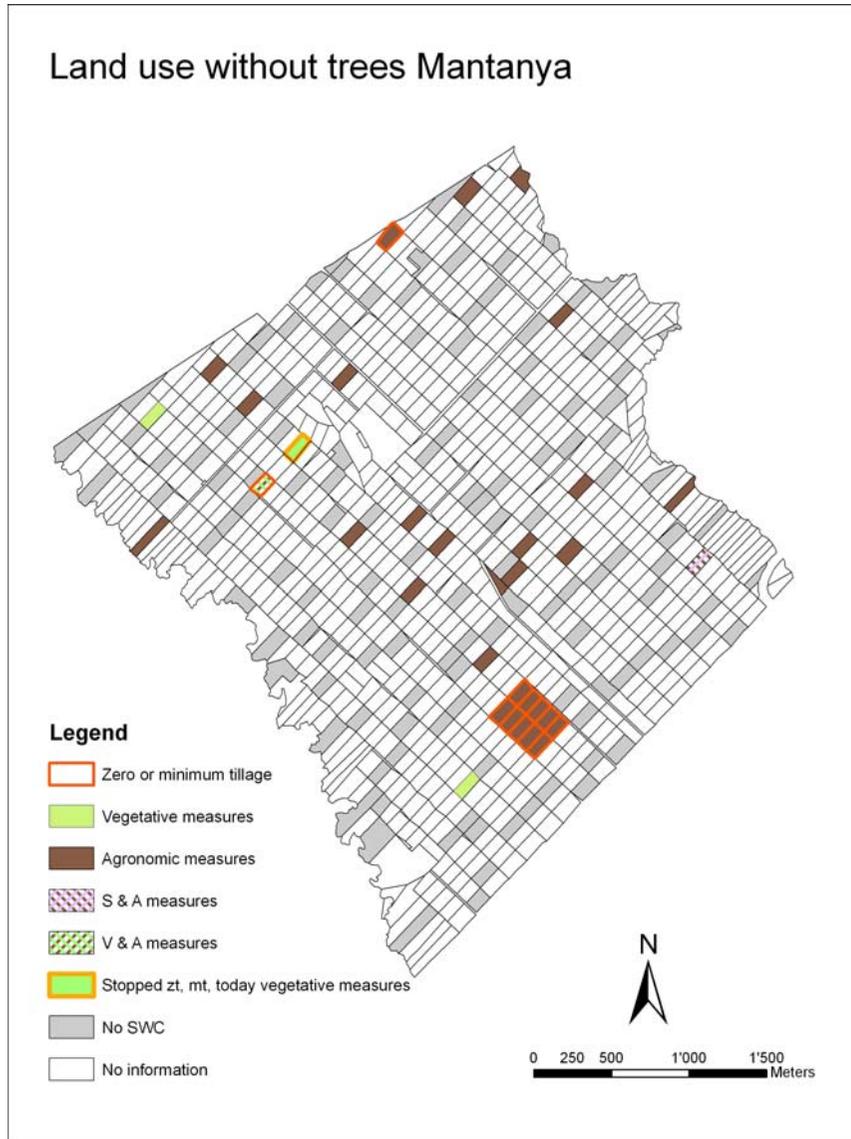
**Figure 4:** SWC technologies in the three study areas.



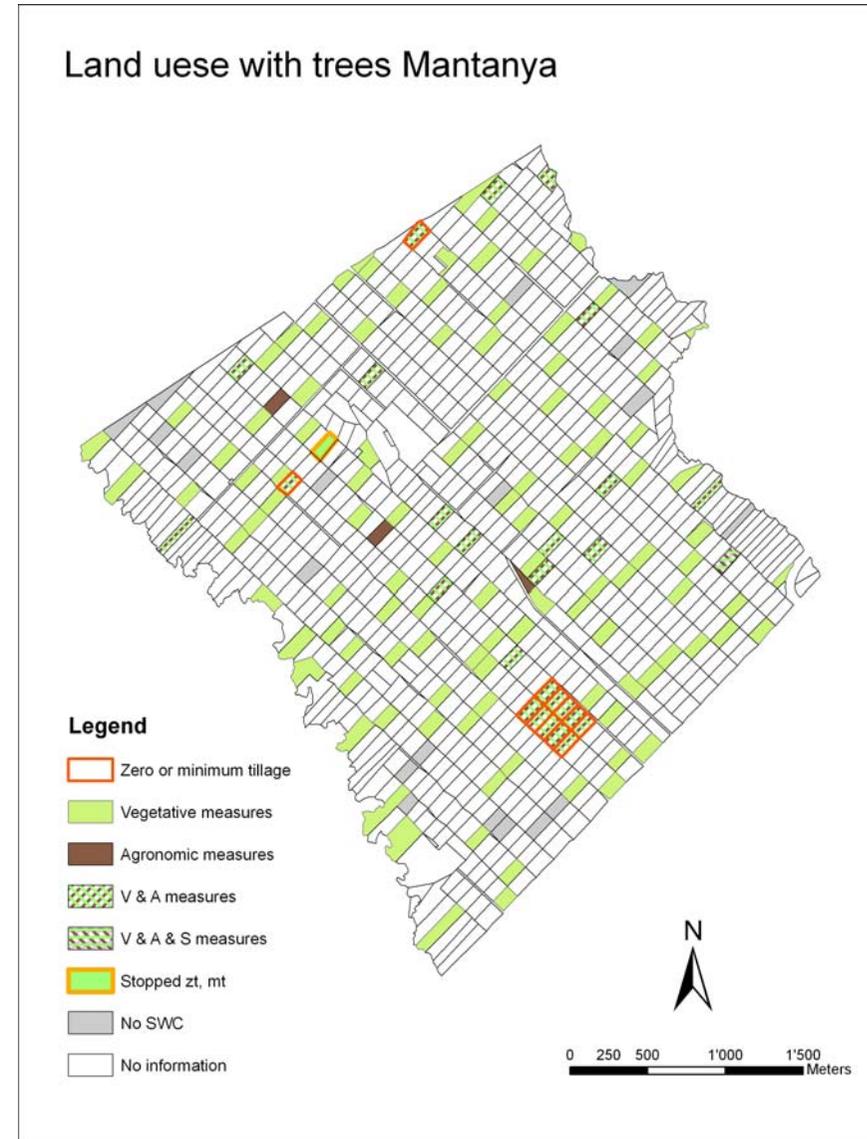
**Figure 5:** Land use without trees Kalalu



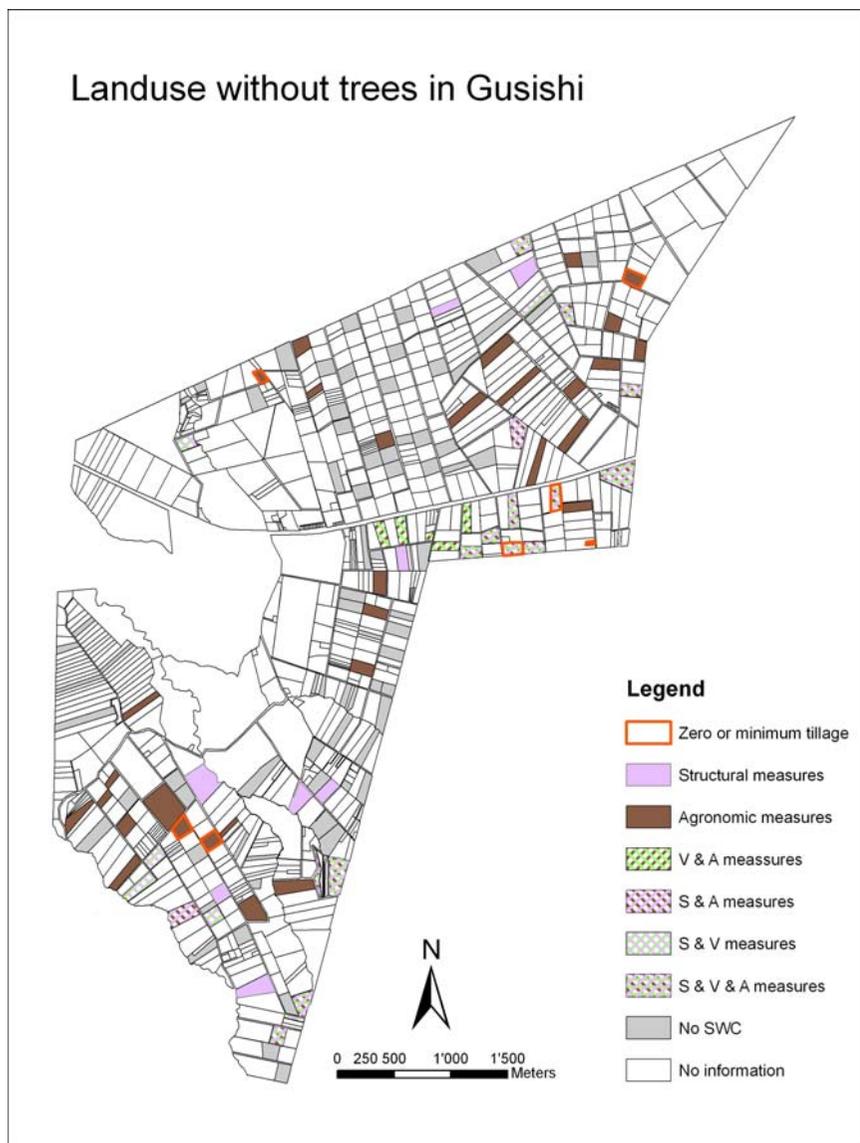
**Figure 6:** Land use with trees Kalalu



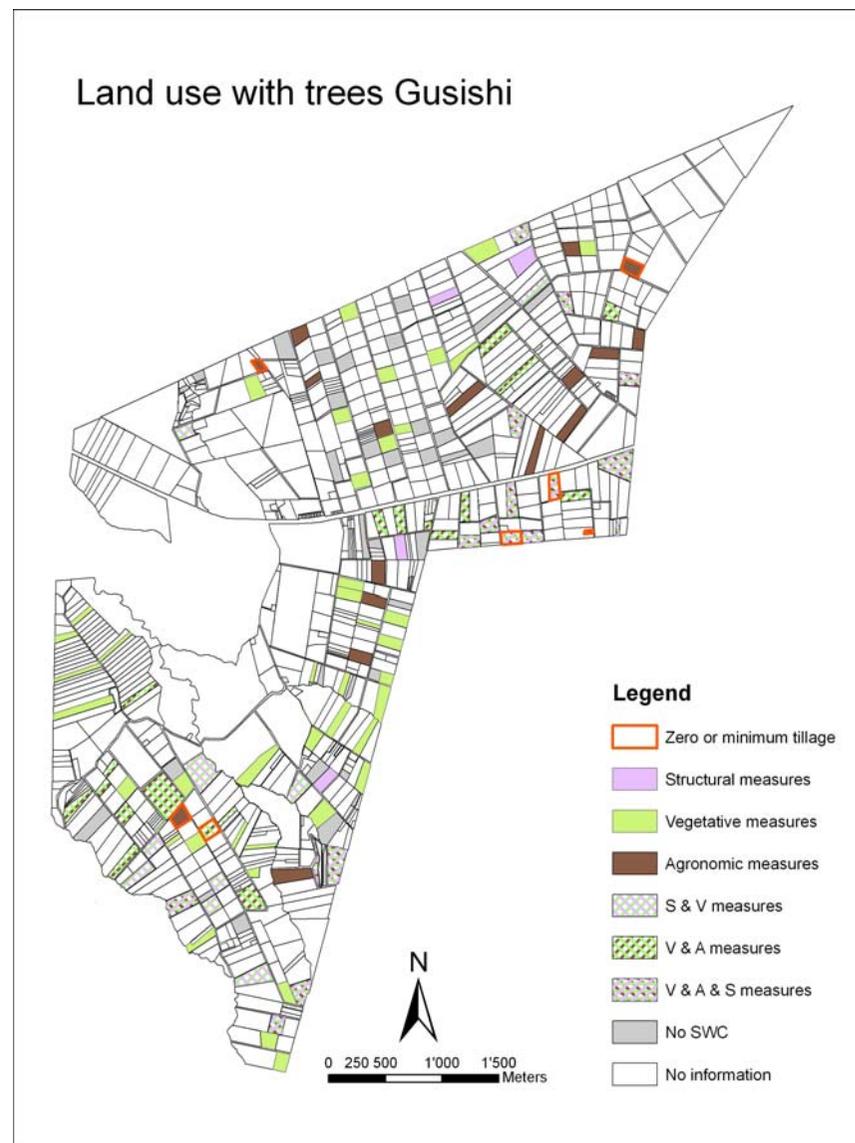
**Figure 7:** Land use without trees Mantanya



**Figure 8:** Land use with trees Mantanya



**Figure 9:** Land use without trees Gusishi



**Figure 10:** Land use with trees Gusishi

### 5.1.1 Agronomic SWC measures

The maps show the combination of SWC technologies which were applied on the visited plots in the three study areas. Zt and mt belonged amongst others to the agronomic SWC measures (Table 7).

On 30% of the 146 farms in Kalalu agronomic measures were applied. Figure 4 shows, what percentage of farmers used which measures. 6% applied zt or mt to cultivate their fields. 4% of the visited farmers used zt or mt technologies, but stopped due to different reasons again (See Figure 6 and Figure 7). The two most used agronomic conservation technologies in this area were mulching and weeding without soil disturbance.

In Mantanya 14% of a total of 153 interrogated farmers used agronomic SWC measures. Zt or mt was applied by 2% of the farmers what equals three farmers. One of them owned and cultivated a ten time bigger farm than most farmers in the area. Weeding without soil disturbance was the most mentioned point of agronomic measures in this area.

On 36% of the visited plots in Gusishi agronomic measures were applied. Zt and mt technologies were applied on 6% of the visited farms. Furrows and ridges were the most important measures applied in this area. More than 25% of the farmers used these measures.



**Image 2:** Fresh planted wheat under CA on Mr. Karobias farm, Kalalu (source: author)

### 5.1.2 Vegetative SWC measures

For each area two maps are displayed above: On the first map for each area trees were not considered as conservation measure and thus not displayed, whereas the second map trees were displayed. In the maps ‘without trees’, napier grass is the only vegetative measure considered, while in the other maps trees and shrubs planted around the plot or in between crops were also considered as vegetative measures. This is done, because trees and shrubs are an important, widely spread measure but most of the farmers did not know about the SWC

advantages of trees and shrubs planted around the plot or between the crops. Only two of all interrogated farmers in the three areas mentioned spontaneously that they were doing agro forestry. They knew about the advantages the planted trees had on soil moisture. One farmer said he would prune up the roots of the planted trees every year. Also if farmers were not aware of the SWC advantages, the planted trees and shrubs have a high value, because they provide the farm with fire and building wood.

In Kalalu for example, 77% of the 146 visited farmers applied a SWC measure if trees were considered, but only 2/5 used SWC technologies, if trees were not included. In this case, vegetative measures would be applied on 17% of the visited farms.

If trees and bushes were excluded as SWC measures, only 2% of the visited farmers in Mantanya used vegetative measures and about 16% of farmers applied any conservation measure. If the vegetative measures comprise napier grass as well as trees and shrubs, a total of 88% of the interrogated farmers applied any conservation technology. Vegetative measures were applied on 85% of the visited plots. Only 14% of the farmers in the area had neither trees nor shrubs on their plots.



**Image 3:** Contour line planting of napier grass applied in Gusishi on a plot next to a footpath (source: author).

17% of the 150 interrogated farmers in Gusishi applied vegetative measures if trees were excluded. All of them utilized vegetative measures in combination with structural and/or agronomic measures. If trees were considered, vegetative measures were applied on 60% of the visited plots.

It seems, as if farmers in all areas consider vegetative measures not only as conservation measures, but also as productive plants grown. Napier grass (see Image 3) planted along contour lines or to stabilize fanya. juus, is a welcome fodder plant for livestock. Farmers who had no livestock sold the napier graze as fodder. Also trees were planted for various reasons:

Wood is an important resource and used as firewood and to built houses and barns. Farmers also plant fruit trees on their fields between the crops

As stated before, only two farmers mentioned spontaneously, that they were practicing agro forestry. All the others had trees, but did not consider them as conservation measures and trees were planted due to different reasons: e.g. as a fence around the plot or to fence the grazing area. In Mantanya most farmer who had a live fence around their plot (105 of 110 interrogated farmers), planted finger euphorbia<sup>12</sup> (*Euphorbia tirucalli*). Live fence are built up from cuttings of other, healthy *E. tirucalli*. The plant builds a dense fence and is suitable to the dry area (Hines and Eckman, 1993). Different people said that they like this evergreen succulent plants because they stay green, also during the dry season and give some hope.

### 5.1.3 Structural SWC measures

The structural SWC measures are unequally distributed in the three areas. In Mantanya just one farmer has built fanya juus on his plot to reduce soil erosion. In Kalalu, structural measures are applied on ten farms and in Gusishi 31 of the visited farmers use structural measures.

Differences in the slop could be an explanation for this big difference between the areas. In Mantanya the slopes were moderate, whereas in Gusishi and Kalalu steep slops under cultivation were found.

In both areas where fany juus were applied, they seemed to be concentrated to the steeper parts of the w study area. In Kalalu fanya juus are found in the north-east, where the slopes are steep. Also in Gusishi structural measures were applied in the precipitous areas more often. Also agronomic measures as furrows were applied to slow down runoff and reduce soil erosion in the steep areas more often.

## 5.2 Spatiotemporal distribution

Of the approximately 450 interrogated farms CA technologies were used only on 4% of the visited farms. The distribution of CA technologies is shown in the land use maps (Figure 5 - Figure 10). Plots where the technologies were applied, have a red frame, those where the technologies were once applied an orange one.

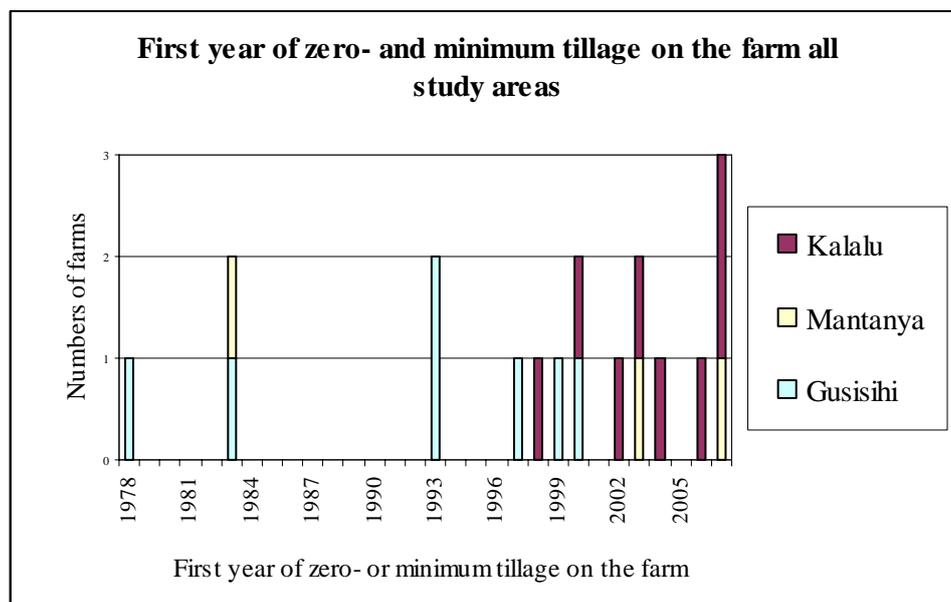
Of eight interviewed farmers who apply zt or mt in Kalalu two times two farmers were neighbors. There were at most two parcels between their farms. A second pattern is observed in Kalalu: The plots of farmers who stopped using zt or mt technologies were located in the area where the demonstration area of the LRP was built up and one is next to a plot where CA technologies were applied. One of the farmers who stopped to apply CA technologies living next to the former demonstration area, said that he had cultivated his farm using CA technologies to show other farmers the advantages, but there was no interest and because of that they stopped again and changed back to the conventional cultivation techniques.

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<sup>12</sup> *E. tirucalli* is a widely spread medium to fast growing succulent plant. The white milk is toxic hence animals do not feed of it. As a live fence *E. tirucalli* fulfills different functions: the dense hedge serves as a wind breaker and at the same time the soil is stabilized and soil erosion is reduced (Hines, 1993)

In Mantanya no pattern was found to explain the distribution of farms on which zt or mt is applied. The three interrogated no-till farmers were dispersed in the study area. One farm where zt technologies were applied is located just one plot away from a farm where the technologies were abandoned again. The cluster of eight plots on which CA is applied in Mantanya is owned by one farmer. He is the one who started using the technologies in 2007 (Figure 11). He cultivates the entire plot using the new technologies, because he expects high yields and the whole land could be cultivated at once by the use of a tractor.

In Gusishi zt or mt is used on eight farms, whereof only four farmers know, that they apply a conservation technology. The other farmers do not plow or dig their fields to save money or time. There is also no pattern in the spatial distribution visible.



**Figure 11:** Beginning of zero and minimum tillage in all three study areas.

Figure 11 shows, since when the interviewed no-till farmers are practicing the technologies. Apparent, more than 2/3 of the farmers started using the technologies within the last ten years. Four of the five farmers who started more than 15 years ago come from Gusisihi. The farmer who started in 1978 is the only one of the four, who knows that he is applying conservation technologies. The others use the technologies to save money or time as mentioned before. The farmer from Mantanya who started in 1983 was a convinced CA farmer. He was introduced to CA during the LRP and implements the technologies since then.

Between 2002 and 2007 eight farmers started using the technologies in Kalalu and Mantanya. Compared to the time before, a clear increase in adoption is ascertained. A possible reason for this could be the activities of the Syngenta Group<sup>13</sup> in Kalalu and the Farmer Field Schools (FFS)<sup>14</sup> of Lory Session who is working together with the Ol Pejeta conservancy<sup>15</sup> to promote CA in the area.

<sup>13</sup> The Syngenta Group in Nanyuki is supported by the Syngenta foundation. The foundation wants to “increase[ing] opportunities and choice for poor rural communities in semi-arid areas through sustainable development” (Syngenta Foundation for Sustainable Agricultur, 2007). For this reason they support projects which try to enhance sustainability of social livelihoods.

### 5.3 Overview SWC measures in the study areas

The maps of the spread of SWC measures showd big differences depending on whether trees and shrubs are considered as vegetative conservation technologies or not. Trees and shrubs are a very common landscape element in all three areas. Live fences define plot- and field borders, trees provide shade, firewood and building material.

Whether farmers applied structural measures or not, depends on the steepness of their land. The steeper the area is the more fanya juus were found. This explains why in Mantanya just one visited farmer used this measure. Structural measures were often combined with vegetative measures, e.g. napier grass planted on fanya juus to stabilize them.

Agronomic measures were found in all areas. In the steeper areas of Gusishi and Kalalu farmers used contour furrows to slow down the speed of runoff and reduce soil erosion. Another technology used in all areas is weeding without soil disturbance. Not all of the farmers knew that they were conserving soil moisture by using herbicides or a slasher to kill weeds.

Zt and mt technologies were not found that often as expected in the three areas. In Mantanya and Gusishi it is not possible to discover a spatial distribution pattern whereas in Kalalu four of the eight farmers who applied the technologies were neighbors. 13 of the 18 interrogated farmers, who used zt or mt technologies, apply them since less then ten years.

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<sup>14</sup> The FFS are a project routed by the Ol Pejeta conservancy presented through Mr. Sessions, a large scale farmer, Mr. Leringato, the communication program leader of Ol Pejeta and Mr. Kiama an agricultural extension officer worker. The goal of the project is to train farmers to become self sufficient in the local conditions (Information from the WOCAT interview with Lory Sessions and Josphat M. Kiama).

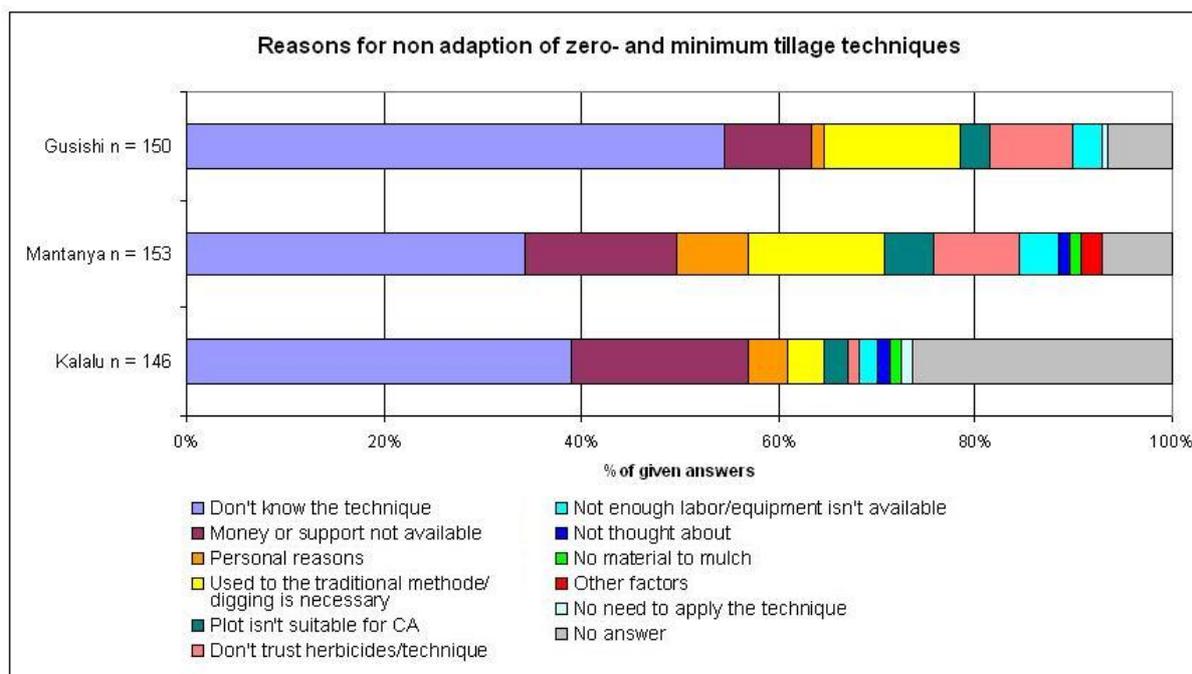
<sup>15</sup> More information to the reasons for adoption or non adoption of the techniques is found in section 6.

## 6 Reasons for adoption or non-adoption of SWC technologies

The results presented in this section are based on the questionnaires ‘CA applied, -not applied or -once applied’. The reasons for non-adoption of zt and mt technologies are based on answers from the short questionnaire ‘study area’. The reasons why farmers do adopt a technology or not and why they abandon a technology again are in the centre of interest. A high value is set on farmer’s satisfaction with the technology they use. Farmers were asked how natural and human factors influenced their decision not to adopt CA technologies and if they were content with the technologies they used.

### 6.1 Reasons why farmers do or do not apply zero and minimum tillage

All farmers who were using conventional technologies for planting their fields were asked in the questionnaire ‘study area’ for their reasons to not adopt SWC technologies. Also, farmers who applied some conservation technologies on their farm were asked why they did not apply zt or mt. Figure 12 shows the reasons given by the farmers.

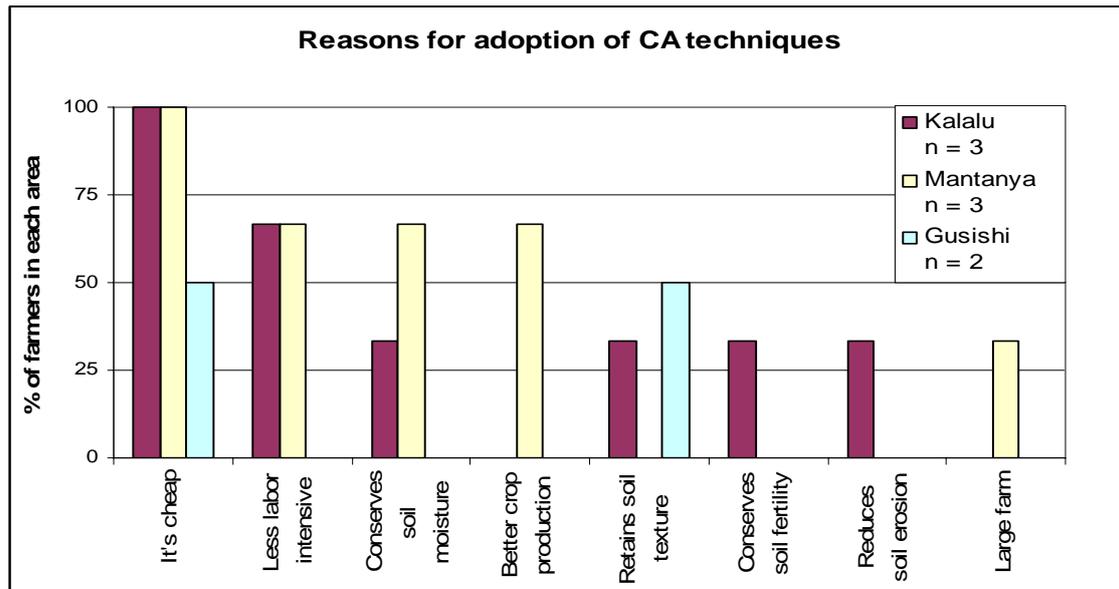


**Figure 12:** Reasons for non-adoption of zero and minimum tillage technologies.

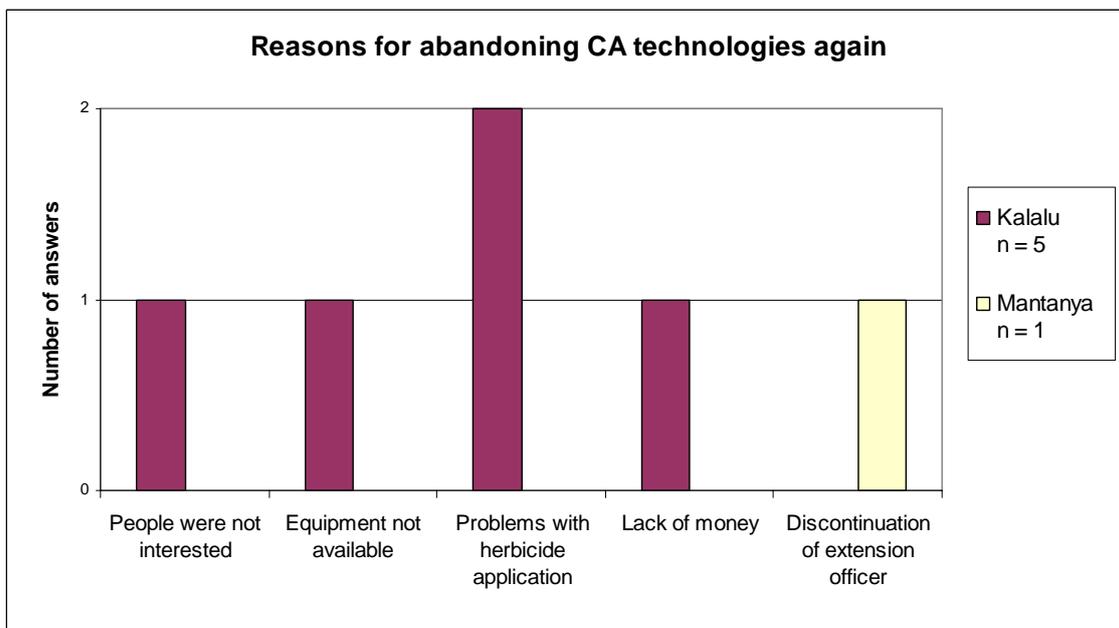
The distribution shows clearly that the three most given reasons were the same in all three areas. The reason ‘Do not know the technology’ was mentioned much more than all other reasons.

Figure 13 shows the answers given by farmers who practiced CA on their farms, including zt and mt. The answers come from the questionnaires ‘CA applied’. The most often mentioned reasons for adoption are the facts that CA is cheap and less labor intensive.

Figure 14 shows the reasons of farmers who had applied CA on their fields to change back to conventional farming. The total number of farmers found who stopped using CA technologies in the three areas was six.



**Figure 13:** Reasons for adoption of CA technologies including zero and minimum tillage in all areas



**Figure 14:** Reasons for abandoning CA technologies again and changing back to conventional cultivation.

### 6.1.1 Zero and minimum tillage technologies not applied

Figure 12 shows the reasons for non-adoption of CA technologies by all the farmers in the three study areas. The question why farmers do not adopt CA including zt and mt technologies on their farms was not replied by all the interviewees. In Kalalu 101 persons answered, in Mantanya 138 and in Gusishi 139. Some people gave more than one reason. The answer mentioned most often in all three areas was that people did not know the technology. In Kalalu, this answer was followed by the answers 'Money or support not available', 'Personal reasons' and 'Used to the traditional methods/digging is necessary'. These four reasons made up more than 60% of all answers given.

In Mantanya, the three most mentioned reasons besides missing knowledge about the technology were the same as in Kalalu. Only the reason 'Do not trust herbicides/the technology' replaced 'personal reasons'. These four answers together made up 76% of all given reasons by the respondents. For farmers in Gusishi, the same four reasons as in Mantanya were the most mentioned, even though the order of answers was different. The four answers covered 91% of the answers given in Gusishi. This accumulation shows which reasons must be kept in mind during further promotion activities. Farmers have to be convinced of the advantages of CA. The nescience about the technologies hinders farmer to adopt the technology. Farmers who consider herbicides as harmful or believe that digging is necessary will not adopt the technologies.



**Image 4:** Unsuccessful and successful herbicide application on two plots in Mantanya (source author).

The fact that so many farmers in Kalalu posted that they did not know the technology even though they were described during the interviews is surprising because in this area, programs to implement conservation measures were being carried out since more than 20 years within the LRP and nowadays, the Syngenta group is working in the area. Moreover, Stanley Muriuki, a small scale farmer in the area was promoting zt and mt technologies. He owned the required animal-drawn equipment and worked as a contractor. A possible explanation could be the number of farmers who answered the question: In Kalalu, 45 farmers did not answer the question or the answers were not applicable. Because of that, the total number of given answers was smaller in Kalalu than in the other two areas. The total number of farmers who posted that they did not know the technology was 65 in Kalalu, whereas in Mantanya, 62 farmers said that they did not know the technologies. However, because more farmers answered the question in Mantanya, the percentage was even lower.

Mantanya was the area where less than 40% of the interrogated farmers who were not practicing zt or mt did not know the technology. During the LRP, CA was introduced in that area. Nowadays, the Farmer Field Schools (FFS) program from the OI Pejeta Conservancy is promoting zt in bordering areas. The Syngenta group is also active in Sweetwaters, an area bordering Mantanya.

It is not known whether projects to introduce zt or mt technologies to the small scale farmers existed in Gusishi, but there had been large-scale farmers around practicing zt and mt. On the

Kisima farm for example, zt technologies were applied to plant wheat. On that farm, field days were organized to show farmers the possibilities of CA. None of the respondents mentioned a project to introduce zt or mt being carried out in the area. One farmer said that agricultural extension officers had showed him how to build fanya juus and stabilize the hillsides to prevent soil erosion.

The fact that money or support was not available was found within the three most mentioned reasons in the study areas. Farmers who mentioned this factor thought that CA would be more expensive to apply than conventional farming techniques. They did not consider the time they were working on the field to dig or weed as money because the labor was available and there were no alternatives to earn some money off-farm. Applying CA meant to this farmers buying herbicides and probably paying a contractor to plant their fields. Farmers shrank back from these extra expenditures.

The answers given by the farmers were difficult to understand, because even conventional farmers hired (at least sometimes) a tractor or oxen drawn plow to prepare their fields. Some conventional farmers posted that they would have hired people to dig or weed the fields. For these actions, they often spent more money than they would have spent for the application of zt technologies. In Mantanya for example, a tractor with a direct planter was provided by the FFS project of the OI Pejeta conservancy. Farmers had to pay only fuel, seeds and herbicides, but not for the use and depreciation of the tractor. Thus it would have been cheaper to hire the tractor from the FFS than from a commercially working contractor.

Farmers who answered that they needed money or support to implement the technology were probably also influenced by the researchers who visited their farm. Some farmers asked directly what they would get in return for the interviews and what the data were needed for.

For farmers in Gusishi and Mantanya, the reason ‘Used to the traditional method/digging is necessary’ seemed to be important. In Kalalu, this answer was still ranked on the fourth position. Farmers who gave this answer were content with the technology they used and believed that digging was necessary for good crop production.

*“Crops require loose soils in order for them to grow well”*

*“We were introduced to conservation agriculture, but didn’t implement it. We are used to the traditional techniques.”*

These two statements of Mr. Githinji from Mantanya and Mr. Kinyua from Kalalu show that beliefs and habitudes influenced the decision-making of farmers.

Another interesting answer given by 16 farmers in Mantanya, 14 in Gusishi and two in Kalalu was that they did not trust the new technologies and the herbicides. Zt farmers use herbicides to kill weeds before they start planting. That measure was considered as harmful to the soil and soil organisms by these farmers. Some of them also made the experience that herbicides did not kill the weeds or killed the crops (See Image 4). Due to insufficient knowledge about the proper application, farmers used the wrong herbicides, applied them at the wrong time or used a wrong mixture. Mr. Muthami, a farmer in Mantanya who applied zt reported that

people were laughing at him because the herbicide application failed on his fields and the weeds grew faster than the crops. Farmers who saw this malfunction were reinforced in their opinion that the use of herbicides is not successful.

Another reason why herbicides were not highly esteemed was discovered during conversations with different farmers: The prejudice that farmers who apply herbicides are late with preparing their fields. Weeding with a jembe takes more time. Farmers who apply herbicides are considered as slothful and unprepared for the rains and planting period.

Farmers in all areas stated that their plots were not suitable for CA respectively zt or mt. More than half of the answers given in this category described the plot as too small or stony. They said that they had enough time to dig the fields with their hands or use an animal drawn plow. One farmer mentioned that she needed all the weeds and residues from the small plot to feed the cows. A respondent in Mantanya said that his plot was not suitable because he planted napier grass for the livestock and had fruit trees planted in between the crops. Because of that, it was impossible for the tractor and the direct planter used in that area to enter the fields.

The last category why people did not adopt zt and mt technologies discussed here is: 'Not enough labor/Equipment is not available'. Two farmers in Mantanya and one in Kalalu said that animal or tractor drawn equipment that has to be hired was not available at the onset of the rains. The contractors served larger farms or group members first and afterwards it was too late for planting. In Gusishi, farmers said that they did not have the equipment zt farmers used in the whole area.

Half of the farmers whose answers turned up in this category stated that it takes too much time to use CA technologies. Three of them explained that mulching was the part of the work which was labor intensive. The other four respondents just said that to apply CA takes a lot of time, and not why they thought so.

### **6.1.2 CA applied**

Farmers who were practicing CA on their farms were asked for their reasons to adopt zt and mt technologies. Figure 13 shows the answers given by the farmers. Each farmer in Gusishi posted only one reason whereas farmers in the other two areas mentioned several points.

The fact that using CA technologies on the farm is cheaper than using conventional techniques was mentioned by all beside of one farmer. This is interesting because the evaluation of the short questionnaire (Figure 12) showed that farmers who were using conventional farming techniques considered CA to be more expensive than the techniques they applied. This statement by CA farmers takes the wind out of those conventional farmers' sails who state that they did not have enough money or did not get support. The main problem here was that conventional farmers did not know much about CA technologies and many of them had a wrong picture of the technologies.

The reason mentioned by half of all farmers was that CA was less labor intensive. Farmers described that they saved a lot of time since they stopped digging their fields. Also, the labor peaks during weeding periods were reduced because the application of herbicides is much easier than weeding using a jembe.

Three out of eight farmers applied the technologies amongst others because soil moisture is conserved. This reason was only mentioned by farmers from Kalalu and Mantanya and showed that farmers in Gusishi depended not only on rains but had the possibility to irrigate their fields. The last two reasons given by more than one farmer were that under CA the crop production was higher and that the soil texture was retained.

The reasons for adoption stated by the farmers showed that they were well informed before they started practicing zt or mt. If all the farmers got this information, adoption would be more likely.

### **6.1.3 CA once applied**

In Figure 14, all reasons mentioned by the farmers who once practiced CA on their fields but stopped again are displayed. The reason ‘problems with herbicide application’ was mentioned by two of the six farmers. They described that they did not know, which herbicide they had to use at which time. One farmer said that he got frustrated because the herbicides he applied did not kill the weeds.

One farmer in Kalalu declared that he was willing to apply the technologies, but not enough equipment was available. He said that there was only one ripper available for the whole area. Time of planting is limited and it was not possible for him to serve all the farmers in time which in turn forced willing farmers to plant with conventional methods.

One of the visited farmers who stopped using CA technologies had run a demonstration area during the LRP to show other farmers the advantages of CA. He said that the other farmers were not interested in the technologies they used and because of that they stopped using them again.

One farmer in Kalalu said that he stopped using the new technologies due to lack of money. He adverted to the high prices for herbicides and fertilizers on the market and that he was not able to buy them any more. Because of that, he prepared the land for planting again using a jembe or his oxen. Hence there was no need for him to spend money, because the labor and animal power was available on the farm.

Mrs. Ndungu from Mantanya made the following statement:

*“The people who used to disseminate information to us went and we lacked importance.”*

She said that the extension staff left the area and farmers did not get more information about the technologies and there was also nobody they could have asked for advice if problems occurred.

## **6.2 Satisfaction of farmers with the technologies used**

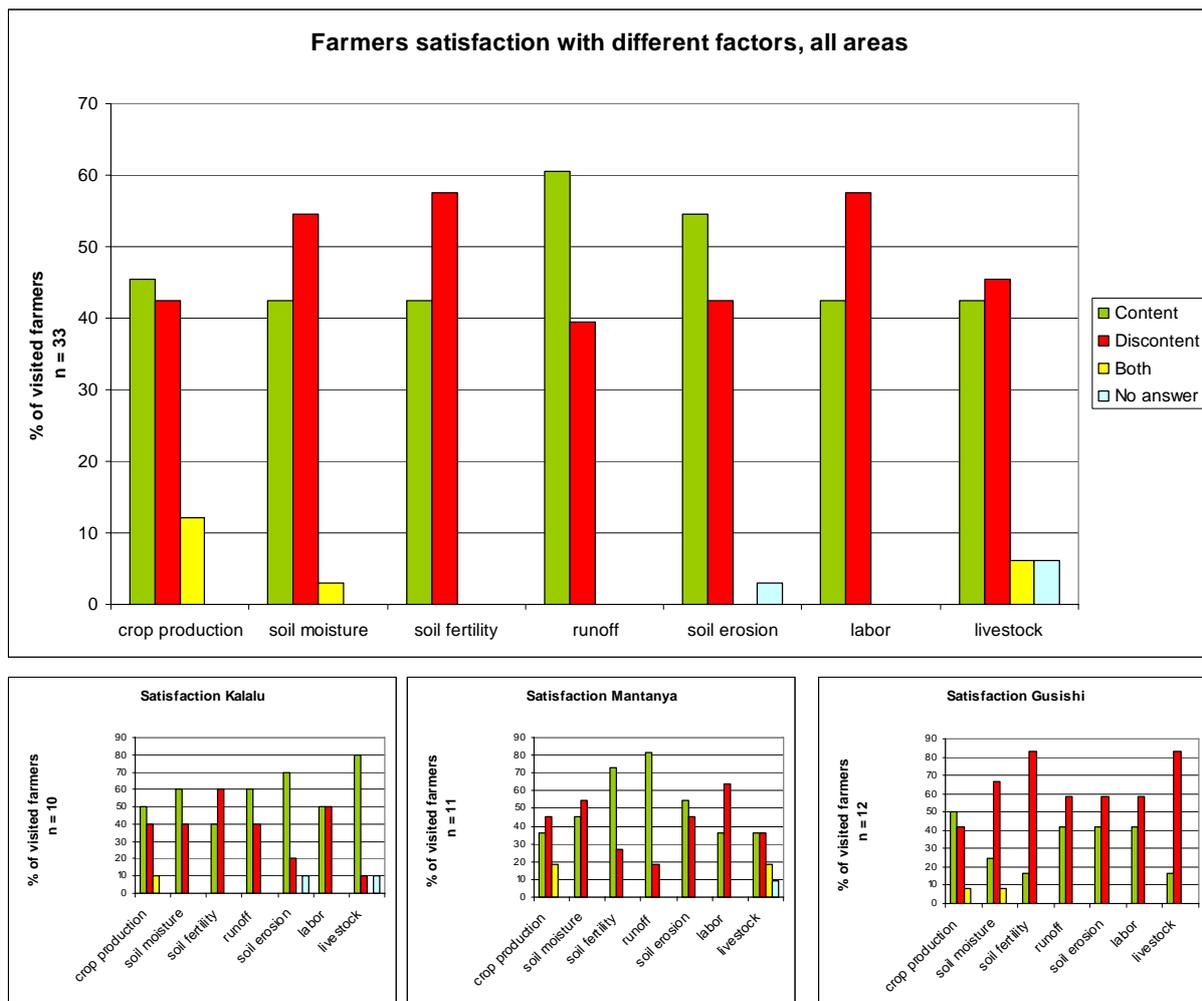
33 farmers who did not apply zt or mt were asked whether they were content with the technologies they used or not. Figure 15 shows whether these farmers were content with factors such as crop production, soil moisture, soil fertility, runoff, soil erosion, the required labor and livestock production. The overall view shows that about one half of the respondents were content whereas the other half was discontent with the different factors. Differences become clear as soon as the answers are separated to the three study areas. The satisfaction

seemed to be higher in Kalalu and Mantanya than in Gusishi, the area in which the red bars are predominant.

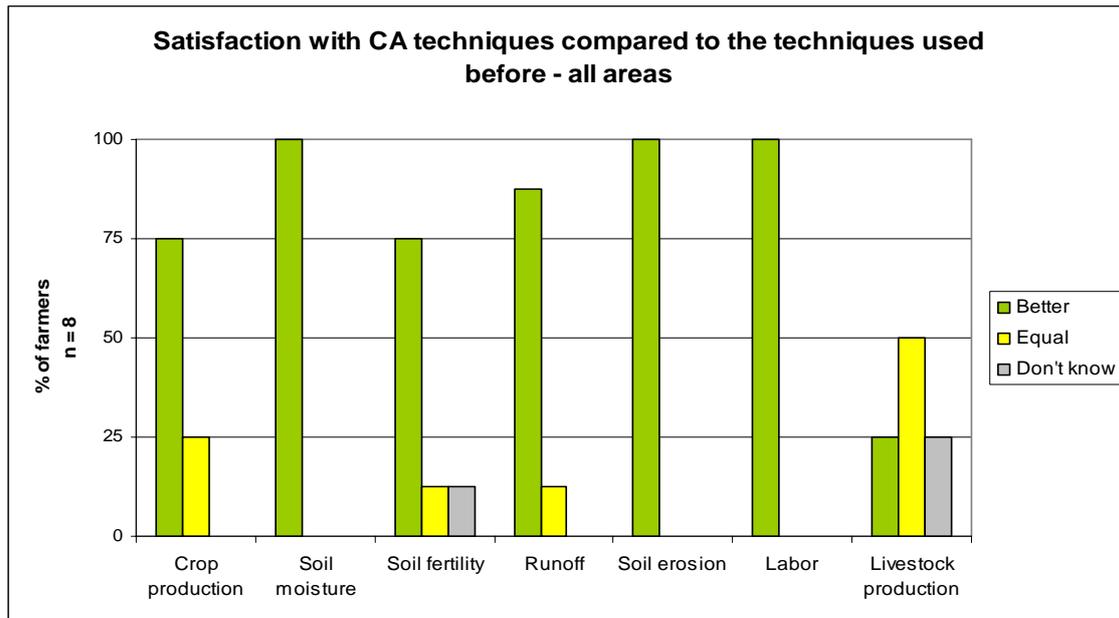
One third of all respondents said there was no problem using conventional techniques. They were content with the technology they used. The ability to produce enough food for their family as well as the opinion that it is easier to cultivate the fields as done were two of the advantages farmers mentioned during the interviews.

Differences between the three areas and within an area were expressed. Gusishi showed a higher percentage of discontent farmers whereas in Kalalu and Mantanya, about half of the respondents were content.

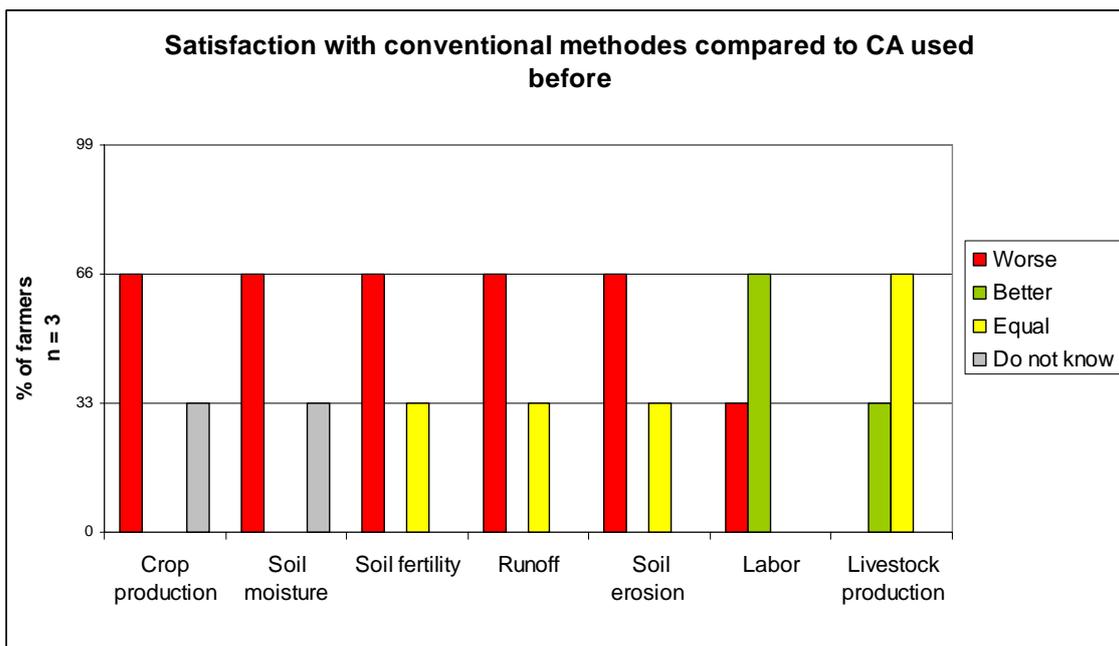
Satisfaction with the factor crop production was approximately the same in all areas. About half of the farmers were discontent. The reasons for that were variable: Farmers in Gusishi mentioned that the prices for seeds were too high and they faced problems to buy them. For some farmers, the bad water retention and unreliable rains were the problem whereas for others, soil fertility and erosion were the biggest problems. In Gusishi, nine of the twelve farmers irrigated their fields using sprinklers. Thereby, they were independent of rainfall patterns.



**Figure 15:** Satisfaction of farmers who did not practice zero or minimum tillage technologies with different factors in the three study areas.



**Figure 16:** Satisfaction of farmers practicing zero and minimum tillage technologies compared to the technology used before in the three study areas.



**Figure 17:** Satisfaction of farmers with conventional methods compared to zero or minimum tillage technologies practiced before.

The biggest difference between the areas was the factor livestock production. Farmers in Gusishi had the most livestock units per farm (median) and were the least content of all three areas. This shows that not only the number but also the quality of livestock and the possibility to get fodder for it was important.

Figure 16 shows the answers of eight farmers who used CA technologies including zt and mt on their farms. They were asked what differences they realized compared to the conventional farming techniques they used before. The factors they had to consider for comparison with the

technology they used before were the same as in Figure 15. Figure 16 shows that CA farmers in all three areas were more content since they were using CA technologies. Not a single farmer said that one of the factors worsened since CA technologies were applied on the farm. The factor livestock production was the only one where the majority of the farmers did not realize a change. In general, farmers who used CA technologies on their farm were more content than farmers practicing conventional agriculture. Half of the farmers also remarked some disadvantages; most of them were related to the use of herbicides or the exceeding weed growth.

The advantages stated by the farmers as well as the explanations to the question why they were content with the technology used showed that most farmers had a founded knowledge about the technologies applied. They knew that the mulch layer reduces evaporation and at the same time enhances soil fertility and water infiltration of the soils. For the factor runoff, only one farmer said that it is still the same as before. All others realized that mulch material slows the runoff down and the undisturbed soils are able to absorb more water.

Figure 17 shows the satisfaction of farmers who once practiced zt and mt but changed back to conventional farming. In general, farmers were less content after having stopped using CA. Only two factors (labor and livestock production) were considered to be better than when CA was applied.

### **6.2.1 Crop production**

#### **Zero tillage and minimum tillage technologies not applied**

For the factor crop production, the distribution of answers was similar in all three study areas. About half of the interrogated farmers were content whereas the other half was discontent. More than 50% of the farmers in all areas who were content with the crop performance stated that they were able to produce maximum yields. Two farmers in Kalalu, three in Mantanya and one in Gusishi said that they had good yields in years with enough rains. Most of the farmers in Gusishi had the possibility to irrigate their fields. Because of that, the rainfall pattern seemed not to be that important to the farmers of this area. The most mentioned advantage of conventional cultivation techniques used in Kalalu and Mantanya was the ability to produce enough food for the family. This statement was mentioned four times in Kalalu and five times in Mantanya.

Interestingly, in Kalalu more farmers were content than discontent with the soil moisture and in Mantanya only one more than half of the interrogated farmers was discontent. In Gusishi, eight of the twelve farmers mentioned that they were discontent with the soil moisture. Farmers who were content mentioned that their soils had good water contents and retained water well. Three discontent farmers in Gusishi said that the soils lost the water quickly and that irrigation was thus necessary.

*“I’m discontent with the soil moisture, for most of the water is taken away by the sun.”*

This statement given by Mr. Warui from Mantanya shows the most common reason why farmers were discontent in all three study areas: The evaporation is high and the soils dry up quickly. Farmers who were content with the soil moisture said that their soils retained water

well. One farmer from Gusishi and one from Mantanya said that the soil moisture was better if manure or compost manure was dispersed on the farm.

### **Zero and minimum tillage technologies applied**

Figure 16 shows that CA farmers were more content after they adopted the technologies. The two farmers who mentioned that crop production was still the same as before were from Kalalu and Mantanya. Both applied CA technologies for the first year and had not harvested by the time the field work was carried out and were thus not able to compare the yields. They said that the crops were performing well and they believed to harvest at least as much as the years before.

All other farmers said that the crop production was better than before. Mr. Thuita from Mantanya described the crop production as follows:

*“The produce has become better and the land is able to give the family food, clothing and pay the school fees after the sale of produce.”*

Rose Guantai from Kalalu stated that on her farm crop production had doubled compared to the years before. These two examples show that farmers using zt and mt technologies noticed a change in crop production.

### **Zero and minimum tillage technologies once applied**

For the factor crop production, two of the three interrogated farmers realized a worsening. As an explanation a farmer in Mantanya declared that by the time she was using CA on her farm, the extension officers were around and helped them to diagnose plant diseases and pests and find the best way to fight them. Now, the extension people left and it was hard for them to identify plant diseases. The second farmer said yields were less compared to the time he mulched the fields.

## **6.2.2 Soil fertility runoff and soil erosion**

### **Zero and minimum tillage technologies not applied**

Soil fertility also plays an important role for crop production. Here, the differences between the three areas are clearly visible on the diagrams in Figure 15. 88% of the interview partners in Mantanya were content with the soil fertility. In Kalalu still 40% of the farmers were content, whereas in Gusishi just 16% said that they were pleased with the soil fertility. All discontent farmers in Mantanya and Gusishi and all apart from one farmer in Kalalu mentioned that their soils would require regular addition of manure or fertilizers. The crops of seven farmers in Mantanya, two in Kalalu and one in Gusishi grew well without addition of fertilizers. There were also differences within the farms: Two farmers in Kalalu and one in Mantanya mentioned that some parts of the farm were fertile whereas others were not.

As observed during the interviews, most farmers in Gusishi planted some horticultural crops as snow peas or cabbages. Farmers in Gusishi produced for the export market and sold their vegetables to large scale farms in the area. Their products had to fulfill higher quality standards than crops grown for subsistence use or local markets. In the other two areas mainly

maize, beans and potatoes were planted on the farms. This could be an explanation for the enhanced application of fertilizers in Gusishi.

The statements given by the farmers show that about half of the farmers in Kalalu and Mantanya were satisfied with the crop production, soil moisture and soil fertility. The situation was different in Gusishi: even though half of the farmers declared that they were content with their crop production, more than 2/3 of the interviewees were discontent with soil moisture and soil fertility. Whether farmers change their land use techniques or not is certainly depending on their perception of the technologies they use. This would indicate that the potential to change something concerning cultivation techniques is higher in Gusishi than in the other two areas, because farmers in Gusishi were less content with the different factors. For the factors runoff and soil erosion, the collected data from the interviews indicate that farmers in Kalalu and Mantanya were more content with these factors than those in Gusishi. For the factor runoff, six out of ten interrogated farmers in Kalalu and nine out of eleven in Mantanya were content whereas in Gusishi only five out of twelve interviewees had no problems with the occurring runoff. In Kalalu, three of the four farmers who owned a sloping plot had problems with runoff. One content respondent cultivating a sloping plot was a farmer who used some conservation measures on his farm. He mulched to enhance the water infiltration and to protect the soil. In Mantanya, the two farmers who mentioned that they had problems with the runoff did not apply structural or agronomic SWC technologies, but one of them had a live fence around the plot consisting of *E.tiruncalli*. On this farm, there were also a few trees growing in-between the crops.

In Gusishi, five farmers who had problems with the runoff did not use SWC technologies. One of those farmers lived on a flat farm. He had problems with water coming from neighboring plots that stagnated on his farm. Water logging caused crops to turn yellow and die. Two farmers who also had problems with runoff used SWC technologies on their farm. For the factor soil erosion, eight out of ten respondents in Kalalu and six out of eleven in Mantanya had no problems on their farms whereas in Gusishi, only five of the twelve farmers were content. The two farmers in Kalalu who had problems concerning erosion on their plots did not apply structural or agronomic SWC measures, but both had a live fence composed of bushes and some trees around the plot. One of the farmers had also some trees planted in-between the crops. Six farmers in Mantanya declared that they were discontent with soil erosion, but only three mentioned that they were discontent with runoff. All but one farmer had a live fence around their plot and on two farms, trees were also planted in-between the crops. In Gusishi, more than half of the interrogated farmers mentioned that they faced problems concerning soil erosion. Farmers mentioned that runoff occurred especially during heavy rains. Mrs. Gichora described runoff during heavy rains as follows:

*“Sometimes, runoff water washes the crops e.g. potatoes away.”*

Two of the farmers who were discontent with the factor runoff were not using any conservation technologies on their farm. On three farms, a live fence was grown around the plot and two farmers used a combination of agronomic and vegetative measures. One of them also had terraces on his plot, yet there were still problems occurring.

The general pattern for the factors runoff and soil erosion is again the same as for the crop production: In Kalalu and Mantanya, the majority of farmers were content with the two factors whereas in Gusishi, the majority of the interrogated farmers were discontent. The landscape could potentially explain this observation. In Gusishi, a larger fraction of respondents had to cultivate a sloping plot than in the other two areas. All discontent farmers in Kalalu and Mantanya used either no SWC technologies or had a live fence or trees on their plot. It seems as if these measures alone were not sufficient to prevent soil erosion. Five of the seven discontent farmers in Gusishi also belonged to this category. The other two farmers faced problems with soil erosion and runoff although they had furrows or terraces on their farm. One of them even planted them with napier grass. The fact that erosion was still occurring after the sloping plot had been terraced and the terraces were planted with napier grass indicates that the conservation measures used were not enough. The situation could be different if farmers would cover their soils permanently and reduce the soil disturbance.

### **Zero and minimum tillage technologies applied**

For the factor soil moisture, again the two farmers who had started practicing CA a short time before the study was carried out remarked an enhancement. According to them, soils were able to retain moisture better since mt or zt technologies were applied. It is said that the sun is not able to penetrate the mulch layer and thereby evaporation is reduced. Mrs. Muthami from Mantanya was using CA technologies for the first season on a part of her farm. She compared the CA part with the part where she planted potatoes using conventional technologies and said that after two weeks of sun, there was more moisture in the undisturbed part than in the part where potatoes were grown. This understanding for differences between CA and conventional cultivation techniques is probably very important for further decision-making. Mrs. Muthami for example knows the advantages of CA now from own experiences. She is now able to compare the two technologies and in the next season she will probably change the way how she cultivates potatoes<sup>16</sup>.

For the factor soil fertility, the picture was pretty much the same as for crop production. The two farmers who said that fertility was equal as before or they did not realize a change were those two who had started using CA technologies a short time ago. All the other farmers in the three areas observed enhanced soil fertility since they used CA technologies. During the interviews, farmers ascribed the enhanced soil fertility to the mulch material they dispersed on the fields. It was mentioned by five of the eight interrogated farmers in the three areas that weeds and residuals left on the field return nutrients to the soil when they compost and humus accumulates in the soil.

In the opinion of one farmer in Mantanya, the runoff was equal as before. He posted that there were still the same soils and if there had been a lot of rain, runoff also occurred on fields where he used CA technologies. All the other farmers including the two CA novices observed less runoff since they were using CA technologies. Four of the interviewees pointed out that the mulch material helped to slow down runoff and three stated that the water absorption was better because the soils were not disturbed.

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<sup>16</sup> This kind of learning is called experimental learning. The theory is introduced in section 2.2.

### **Zero and minimum tillage technologies once applied**

Two farmers realized that soil moisture had been better while using CA. One farmer explained that the fields were not mulched anymore and therefore evaporation was higher and soils dried up quicker.

For each of the factors soil fertility, runoff and soil erosion, two farmers said that it was worse than before and one farmer said these factors did not change. One farmer who realized a worsening said that the water did not infiltrate in the soil that well as before and because the soils were not covered anymore, they were easily carried away by wind and water.

Mrs. Ndungu was the only one who said that these factors were still the same on her farm. When she applied CA on her farm she learned how to make trenches to stop runoff water and she planted grass along the contour lines to reduce soil erosion. When she stopped using zt and mt, she kept using the other technologies on her farm.

### **6.2.3 Labor**

#### **Zero and minimum tillage technologies not applied**

During the interviews, farmers were asked whether they were content with the labor they had to invest to cultivate their crops. In Kalalu, half of the farmers were content with the work they had. In Mantanya and Gusishi, more than half of the interrogated farmers posted that the workload was too big. For all the farmers who gave a reason why they were content with the workload, it was no problem to provide the required labor within the family. Only one farmer said that it was no problem to hire people to do the work.

Farmers experienced peaks of work over the year. The three peaks mentioned during the interviews were planting, weeding and harvesting periods. Farmers who prepared their land for planting with a jembe or tilled the land before seeding invested a lot of time in this work. Also, weeding the fields was time-consuming. If farmers adopted CA technologies, they could save a part of the time they invest for cultivation and avoid time bottlenecks.

#### **Zero and minimum tillage technologies applied**

All the visited farmers were content with the labor they had to invest compared with the technology used before. The general argument is that using CA technologies is less labor demanding than using conventional cultivation techniques. Four farmers said that they needed fewer workers on their fields during weeding periods than before. These labor economics make CA technologies cheaper compared to other methods.

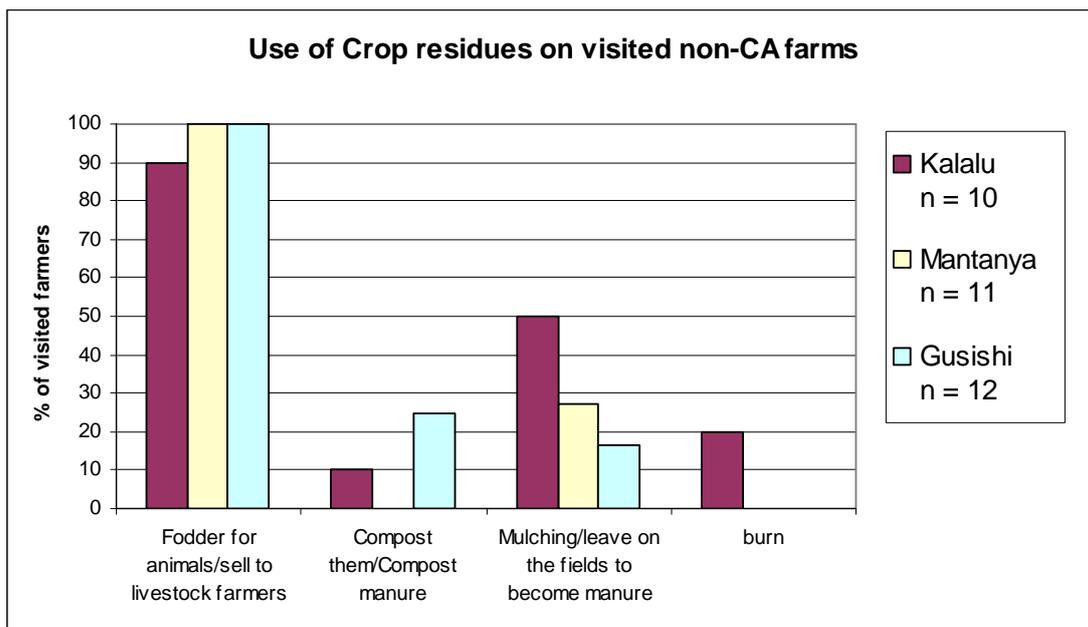
#### **Zero and minimum tillage technologies once applied**

Two of the three farmers said that the technologies they used that time were less labor intensive. One farmer said that he saved a lot of time since he did not mulch the fields anymore. The other farmer said the horticultural crops planted at the time under zt were more time consuming than the crops they planted presently (maize, beans, potatoes).

## 6.2.4 Livestock production

### Zero and minimum tillage technologies not applied

In Kalalu, eight of the ten interrogated farmers were content with their livestock production. The farmer who was discontent said that the breed was not the best and that milk production was low. Five farmers who were content with their livestock production mentioned that they had enough grazing area and crop residues to feed the livestock. Of the four farmers who were discontent about livestock production in Mantanya, three farmers mentioned that they had too small plots to provide fodder for their livestock. They had to get additional fodder from neighboring farms and unsettled plots. One farmer posted that during the dry season livestock would die sometimes because he was not able to provide them enough water and fodder. Four farmers in Mantanya were content with the livestock production. One said that the production was good during the rainy season and two stated that their farm provided enough fodder and the livestock was healthy. Farmers in Gusishi were generally discontent with livestock production. They said that their plots were too small and that milk production was bad. Only one of the twelve farmers said that he had enough fodder on his farm to feed the livestock.



**Figure 18:** Use of crop residues in the three study areas

The collected data show that farmers' satisfaction concerning livestock is different in the three study areas. In Kalalu, eight of the twelve interrogated farmers were content and half of all interrogated farmers said that they had enough fodder on their farm for the livestock. In Mantanya, the numbers of farmers who were content and discontent with livestock production were equivalent. The fact that three quarter of the discontent farmers said that their farms were too small to provide enough fodder for their livestock and that only two of the eleven farmers were able to feed their livestock from their plots shows how important the grazing areas on unsettled land were to these farmers. In Gusishi, livestock was solely fed from the own farm on only one of the twelve visited farms. Following these statements, the highest

pressure on common land for grazing was found in Gusishi, followed by Mantanya and Kalalu. In addition, the pressure in Gusishi was intensified by three factors:

- Observations during the data collection showed that the settlement density was higher than in all other areas.
- The area under crop production of the total area owned was on average more than 10% higher in Gusishi than in the other areas.
- The median of livestock units per household was in Gusishi nearly 0.4 LU higher than in Kalalu.

The average LU per farm was nearly equally high in Mantanya and Gusishi. The fact that only two of the eleven interrogated farmers were able to feed the animals on their farm indicates a high pressure to the unsettled land used as communal grazing areas like in Gusishi. The fodder required by livestock in the three study areas influenced the use of crop residues. Figure 18 shows how farmers in the three study areas used the crop residues. It appears that all the respondents in Mantanya and Gusishi used at least a part of the residues as animal fodder. In Kalalu, only one farmer did not use residues as fodder at all. Even the two farmers who did not have own livestock sold at least a part of their residues to other farmers as animal fodder. The farmer in Mantanya who had no livestock used the part which was not sold as mulch. In Mantanya, only three farmers used a part of their crop residues as mulch. In Gusishi three farmers composted a part of the crop residues and two farmers left them on the fields to become manure. Eight farmers in Kalalu used at least a part of the residual not as fodder. Two farmers sometimes burned a part of the residues. Mr. Padero said they burned the bean residues sometimes to increase soil fertility. Five farmers used the residues as mulch on their fields. Mrs. Wahu described that they placed maize stems on the farm to prevent soil erosion. One farmer in Kalalu was using the residuals to make compost manure.

The fact that in all three areas all beside one farmer used their residues at least partly as animal fodder indicates how scarce the resources for feeding livestock are.

### **Zero and minimum tillage technologies applied**

The only factor where half of the interrogated farmers did not recognize an improvement compared to the technologies they used before was livestock production. They had the opinion that their cultivation techniques did not affect livestock production. One farmer said that the livestock had its own grazing area which was not affected by the technology used to cultivate crops.

The two farmers who started using CA technologies a short time ago were not able to tell if there was a difference between now and before. One of two farmers who were more content with the performance of their livestock said he had some grazing area and also a machine to cut maize cobs into small pieces as fodder for the cows. The second farmer who was more content compared to before planted napier grass on his farm to feed the cows. He also used a portion of the crop residuals as animal fodder.

### **Zero and minimum tillage technologies once applied**

For the factor livestock production, a similar pattern as in Figure 17 is visible. Two of the three farmers said that the change of cultivation techniques did not affect livestock production. One of them said that when she had applied CA they had cultivated a bigger part of their plot and that livestock was grazed outside the farm. At the time the study was carried out, livestock was mainly fed on the farm. Crop residuals and the planted napier grass provided enough fodder.

For one farmer livestock production turned better after having changed back to conventional farming techniques because the residuals were not used as mulch material any longer but instead provided fodder for the animals.

### **6.2.5 Advantages and disadvantages of CA cultivation technologies**

Farmers who were practicing CA on their fields were asked where they saw the advantages compared to other cultivation technologies. The question about the advantages of CA was posed before the question about satisfaction of farmers with CA technologies. Farmers had to think about the advantages themselves. A first look at Figure 19 shows that farmers who were practicing CA in Kalalu and Gusishi mentioned much more different reasons than those in Gusishi.

That CA brought higher yields and preserved soil moisture were the two most mentioned advantages of the technologies. In Mantanya, all farmers mentioned both points; in Kalalu, only one farmer did not mention the better yields and in Gusishi, only one of the two farmers stated that crop production was better under CA.

At least one of the advantages, namely that CA reduces labor costs or that the technology is cheap, was mentioned on six of the eight farms and shows that this point seems to be important to the farmers. Here, for example no farmer mentioned that livestock production was better since CA had been applied.

The eight farmers practicing CA were also asked which disadvantages they faced while practicing CA on their farms. Three farmers (37%) had the opinion that no disadvantages were related to CA technologies. Two of these farmers were from Kalalu and one from Gusishi. One farmer in Mantanya who had started using CA in 2007 stated that he did not know whether there had been any disadvantages so far.

Each of the farmers mentioned one aspect he or she was not content with. Mrs. Wangui from Mantanya pointed out, that CA technologies needed some special skills, especially the application of herbicides. Farmers had to know the effects of the herbicides used, the right time to apply them and so on. Another aspect given by a farmer was also concerning the use of herbicides: Mr. Marete from Gusishi considered some herbicides to be harmful to earth worms. Mr. Thuita from Mantanya did not apply herbicides at all. He slashed the weeds, made some planting holes and mulched the field afterwards. He said the biggest disadvantage to him was fast growing weeds during times of heavy rains. It was very important to him to react quickly and slash the weeds or cut them with a special jembe.

The last disadvantage was posted by a farmer from Kalalu. Mrs. Guantai said that the planter she hired was malfunctioning and seeds were wasted. Sometimes more than one seed was dropped at one time.

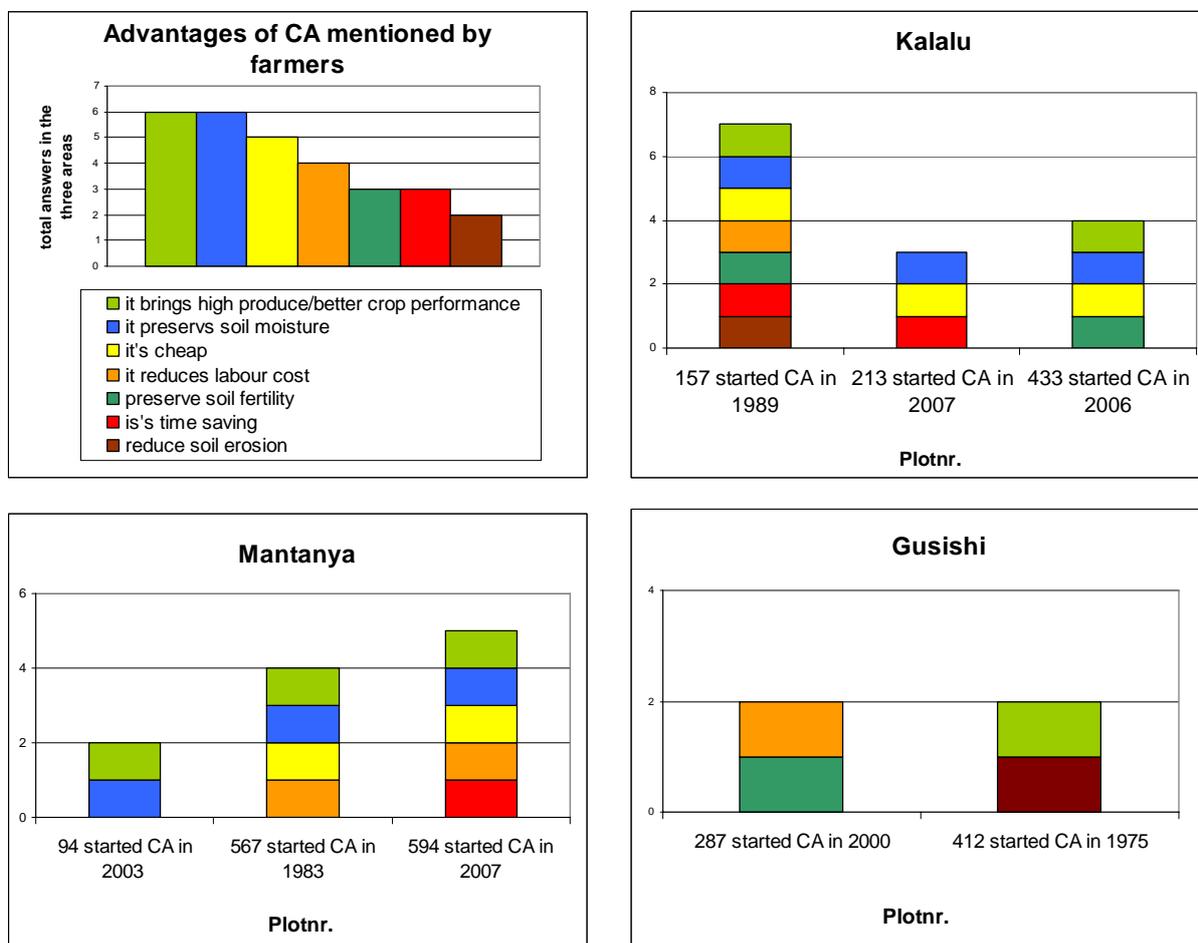


Figure 19: Advantages of CA mentioned by farmers practicing the technologies.

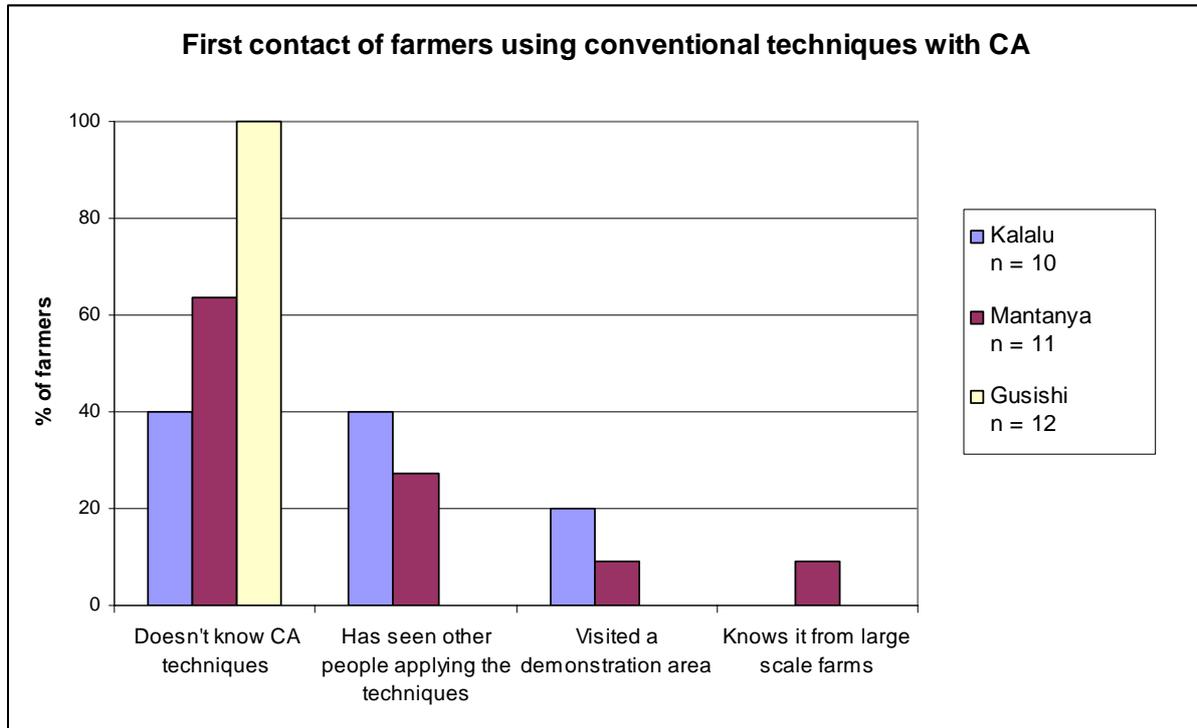
### 6.3 Human factors influencing the decision-making of farmers

For the long interviews, one of the goals was to identify the factors which influenced the decision-making of a farmer about adoption or non-adoption of CA technologies with zt or mt. Human factors such as the social position or reputation of farmers who practiced zt or mt were considered as having an influence on the decision-making of farmers (see section 2.3 and 2.3.1).

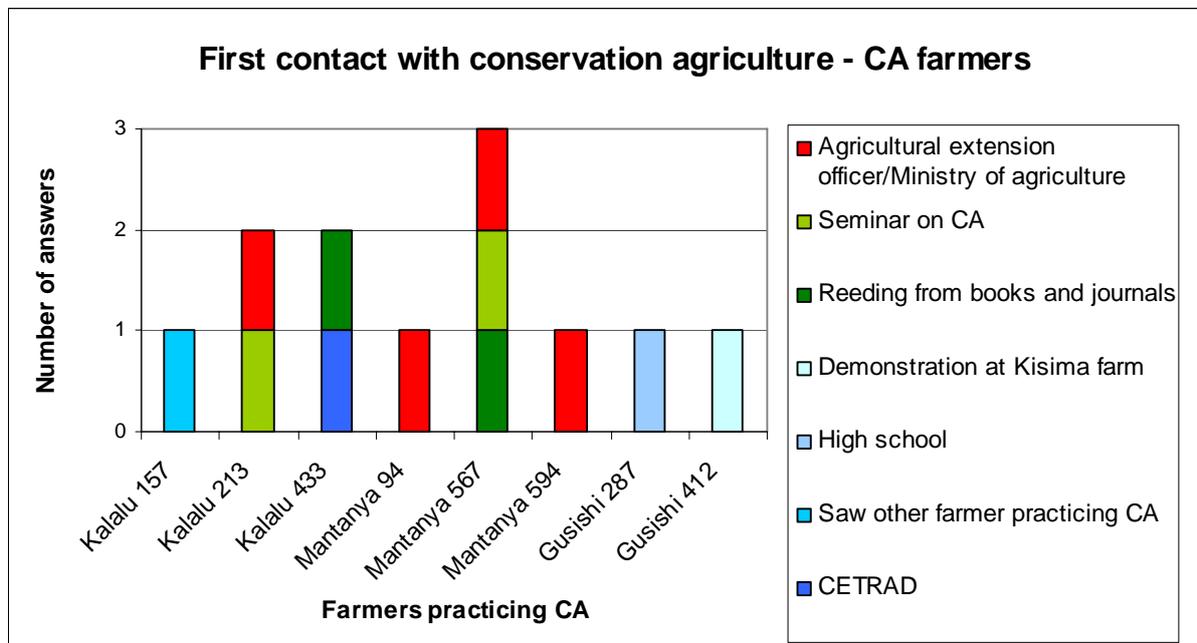
#### 6.3.1 First contact with conservation agriculture

Figure 20-Figure 22 show how the farmers first got in contact with CA technologies. Three quarters of the interrogated farmers in all study areas who were not practicing zt or mt had neither heard something about CA nor did they know a person who applied the technology. In Figure 21, the first contact with CA technologies of farmers who were practicing the technologies are presented. Half of the interrogated farmers declared that their first contact to

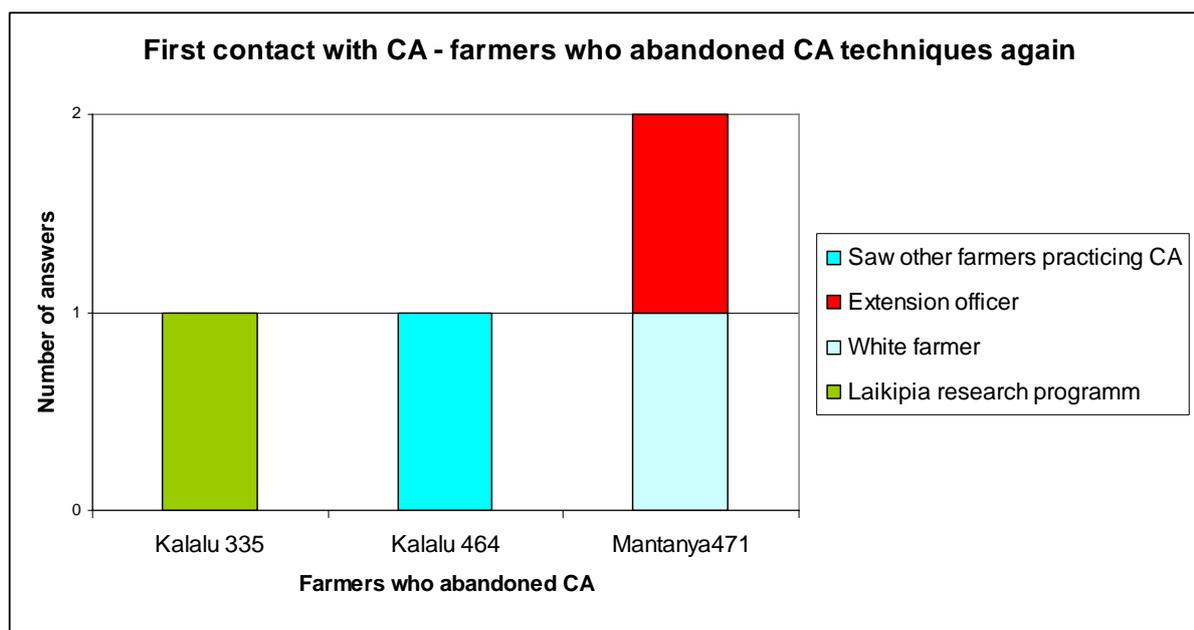
CA was through an agricultural extension officer. The three farmers who abandoned zt and mt technologies again got to know about CA on different ways.



**Figure 20:** First contact with CA of interviewed farmers who were not using zero and minimum tillage technologies.



**Figure 21:** First contact with CA of interviewed CA-farmers.



**Figure 22:** First contact with CA of farmers who abandoned the technologies again.

### Zero and minimum tillage not applied

The interviewees in the three study areas were asked how they got to know about CA. Figure 20 shows the answers given in the three study areas. The same findings as in the short questionnaire are reflected. The most given answer in all three areas was that farmers did not know the technologies. In Gusishi, not a single interviewee of the long questionnaire 'CA not applied' knew something about conservation technologies or a person practicing the technologies.

In Kalalu and Mantanya, four respectively three respondents had seen others applying the technologies on their farms. All persons who gave this answer did not know exactly how to practice CA technologies. They said that they had never been taught how to use these technologies. One farmer in Kalalu noted that farmers who applied the technology used herbicides to kill the weeds. In his belief, herbicides are harmful to the soil and make soils hard. Two farmers said they would like to learn more about the technologies and how to use them.

Two farmers from Kalalu and one from Mantanya visited a demonstration area once. Mr. Kamau from Kalalu learned there how to apply herbicides with modern spraying equipments to avoid problems of drift, minimum- and zt technologies and how to dig trenches with an animal-drawn plow. The demonstration area had been at Kuria Wangondu's home and supported by the MoA. Mr. Kamau thought that CA would be a good technology because it helps to conserve soil moisture, but the herbicides were not affordable to him. Mr. Warui from Mantanya visited a demonstration area which was set up in Mantanya. There, he learned how to apply herbicides and the advantages of crop rotation. The demonstration area was supported by the MoA like in Kalalu. Mr. Warui said he did not apply zt or mt on his farm due to missing support.

One farmer from Mantanya was on a field day on Lory Sessions farm. On this large scale farm, mainly barley and wheat were planted using modern zt equipment. Mr. Session also

supported a demonstration area where crops were grown under the same conditions as it would be possible on a small scale farm.

### **Zero and minimum tillage applied**

Respondents who were practicing CA on their fields were asked how they got to know about CA. Figure 21 illustrates how the first contacts with the technologies were made. The most mentioned first contact is red, the second-most mentioned contacts in green and all those which were mentioned only once are kept in blue.

The interviews showed that half of the farmers were introduced to CA by an agricultural extension officer from the MoA, but there were big differences between the three study areas. None of the farmers in Gusishi mentioned the MoA as a source of knowledge about CA technologies. On the other hand, all three interrogated farmers in Mantanya had contact to an agricultural extension officer and one out of three interviewees in Kalalu got the first information from an extension officer too. The situation in Mantanya was special because the extension officer was also living in Mantanya and the respondents knew him as the first person practicing CA in the area. That all the interviewed CA farmers in Mantanya had contact to the same person who was practicing CA shows that a farmer can take over a role model which is then followed by other farmers.

Two of the eight farmers attended a seminar after they had got the first information by an agricultural extension officer. Both farmers were also organized in a group after they started using CA technologies.

Two farmers stated that they acquired information about new technologies from books and journals about farming. Both of them pointed out that it was very hard to get literature because books were expensive and rare in the region.

One farmer in Kalalu saw other farmers practicing CA which was his first contact with the technologies. After he had understood the advantages and had talked to the farmers who used the technologies, he started to apply CA on his farm too.

At the beginning of the study, it was expected that more farmers got to know about CA like this. Farmers observe their neighbors and if they realize that those using a new technology are more successful, they would also start to adopt the technologies. In reality it seems to be different. In the questionnaire 'CA not applied', seven farmers (63%) of those who knew something about CA had their knowledge from other farmers practicing CA. However, they did not know exactly how it works or they did not trust the herbicides. This shows that in most cases, some additional information would be necessary to encourage more farmers to change their farming technologies and to minimize certain doubts farmers have e.g. concerning herbicides.

One farmer had read something about CA in agriculture books and got more information about the technologies through members of the Syngenta group in Nanyuki. Later, she also visited courses organized by CETRAD and the Syngenta group.

The two farmers who practiced CA in Gusishi got their information in agricultural classes during high school or on a farmer field day organized on the Kisima farm, a large scale farm in the area.

### **Zero and minimum tillage once applied**

The first contact with CA was a different for all three farmers who abandoned the technologies again. Like all farmers in Mantanya who applied CA at the time of interviewing, the farmer who abandoned the technologies again was introduced to CA by an agricultural extension officer. This shows how important the work of extension staff is in that area. The farmer from Mantanya was also invited to the farm of Lory Session in the context of the FFS organized by the Ol Pejeta conservancy. One of the farmers in Kalalu was introduced to CA by the LRP whereas the second farmer in Kalalu saw other people practicing the technologies and started using them on her farm.

### **6.3.2 Known farmers who practice zero and minimum tillage technologies by non CA farmers**

Five farmers in Kalalu and two farmers in Mantanya knew one or more farmers who were practicing zt or mt technologies. In both areas, three farmers who practiced zt and mt technologies were named. In Kalalu, the farmer Mr. Muriuki was mentioned by all respondents. All farmers who knew a CA-farmer did not know about the organization of farmers in a group. They were also asked about the social position and reputation of these farmers. In general, the given answers were consistently positive.

For both questions, the most mentioned answer (four times) was that farmers were in the same social position as they were before and their reputation was good. It was mentioned once that those farmers were respected, well known persons in the area and that people saw them as advisors.

Two respondents said that CA-farmers belonged to a higher social class because they had a lot of money. One farmer in Kalalu said zt farmers charged high prices for their equipment and thereby it was cheaper to hire an ox-plow or dig the field with a jembe. The very same farmers said that these farmers had a bad reputation. Another farmer from Kalalu said that conventional farmers were socially not very close to CA-farmers, even though they were not bad persons. Neither of the two interrogated farmers in Mantanya who knew a farmer practicing zt or mt said something negative about them.

Even though most of the farmers who were using conventional farming technologies did not know about zt or mt technologies (neither did some farmers who were applying those technologies), CA-farmers were seen as reputable community members by the majority of those who knew them.

### **6.3.3 Organization in a CA group and participation on field days or courses**

#### **Zero and minimum tillage applied**

The organization of farmers in a group seems to be conducive in the process of adopting new technologies, as it has been shown in the FAO case study on conservation agriculture introduced in section 1.2.5. Adaption rates were much higher in groups than among the rest of the population. In two of the three visited study areas, groups existed and some farmer participated in one of the group. Gusishi was the only study area where no CA group was known.

Three of the visited CA farmers were organized in a group with other CA farmers. One farmer had been part of a group which split up some years ago. The other four farmers were practicing CA without the support of a group. Two of those four farmers were from Gusishi. Farmers supported each other in these groups. Mrs. Wangui was a member of a CA group which covered Mantanya and some areas around. She said that it was a new group and that farmers did not support each other yet, but that they had the possibility to cheaply hire a tractor for planting. In Kalalu, the groups were already older and well established. Both farmers from this area who were members of one group said that they supported each other with advices on CA and that there was also some financial support. Mr. Karobia said that each member payed 5'000.- KES on a group account twice a year. The money on that account was then used to acquire new equipment and they had a new project to buy grade cows. The goal was to enhance livestock production through by having more productive cows. Mr. Thuita from Mantanya had been member of a former CA group. He had an explanation for the splitting of the group:

*“The group collapsed in 2003 because the lack of knowledge on right herbicides made many people to get heavy losses after using the wrong herbicides.”*

This statement shows how important knowledge is to keep these self-help groups alive and thereby enhance the chance to arouse interest of more and more farmers. Only well-functioning groups with successful farmers can serve as role models and attract interest of other farmers.

Only half of the interviewed CA farmers were members in a group, even though all of them had visited a demonstration area or participated on a course about CA. In courses and on demonstration areas, farmers were able to acquire important know-how about the use of different technologies and to compare the crops on the demonstration areas with those they grew on their farms. Further, on events as courses or field days, farmers came together and had the possibility to exchange their experiences and probably find solutions to problems they faced.

The eight visited CA farmers learned different things in the courses or on demonstration areas. Generally, farmers in Kalalu and Mantanya learned more different technologies than those from Gusishi. One farmer in Mantanya did not answer the question although he had visited a demonstration area.

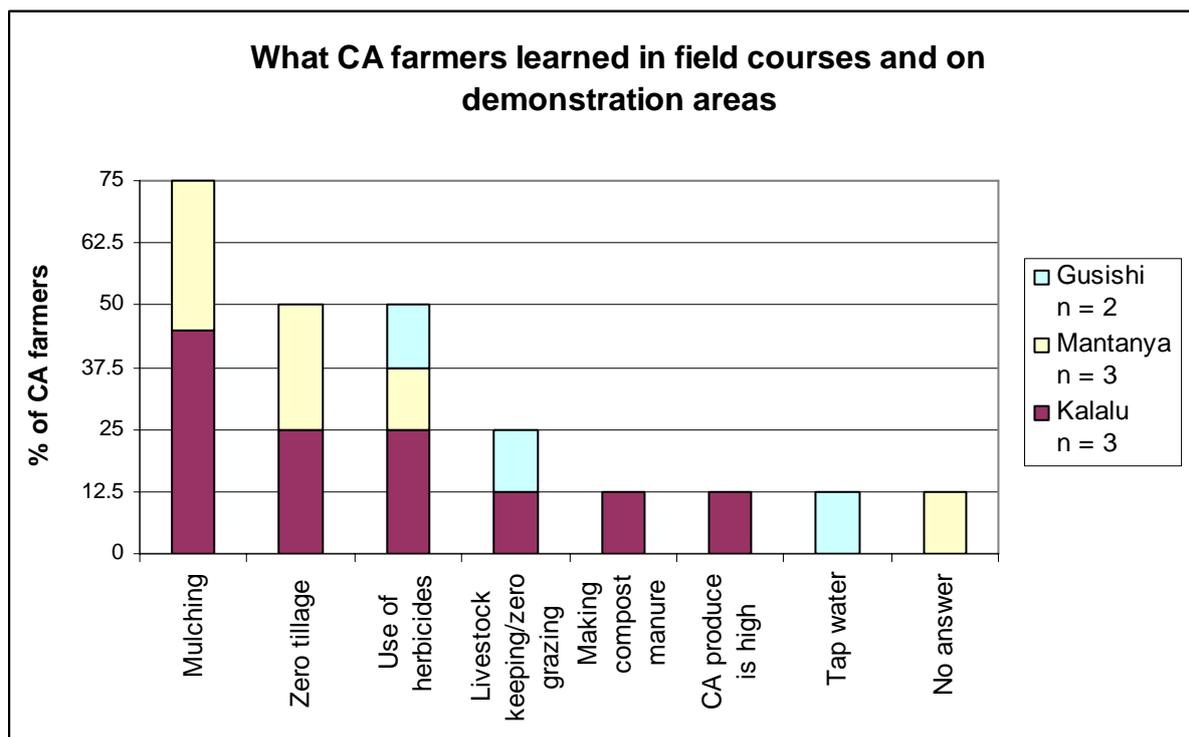
75% of all farmers interviewed with the questionnaire ‘CA applied’ knew mulching technologies from a course or the visit of a demonstration area. These 75% were composed of all three interviewed farmers from Kalalu and the two who answered the question in Mantanya. Half of the interviewed CA farmers also learned how to use zt technologies on one of these two possibilities. The same pattern as above emerged here again: Two out of three farmers from Kalalu and all farmers who answered the question in Mantanya made up the 50% of all interviewed CA farmers. Gusishi did not show up again.

The application of herbicides was learned by two farmers in Kalalu, one in Mantanya and one in Gusishi. This equals 2/3 of the farmers in Kalalu and half of the farmers who answered the question in Mantanya and Gusishi. All the other technologies were not exceeding one positive answer per area.

The question about the technologies farmers learned in such courses or on demonstration areas not only sheds light on the origin of knowledge of the farmers, but indications also suggest how extended the CA networks in the three study areas are. It is known that several organizations were working in Kalalu and Mantanya during the last 20 years with the goal of changing the land use techniques of small-scale farmers. Different demonstration areas were and are still set up by these groups. From Gusishi, it is not known whether some CA promotion took place in the area, but the results of this study suggest that there was no organized group promoting CA.

Knowledge imparted through these two channels is not the same in the three study areas. The list of what CA farmers learned in a course or on a demonstration area was longer in Kalalu and Mantanya than in Gusishi<sup>17</sup>. It seems that farmers in Kalalu and Mantanya had more possibilities to get information about the technologies and their network with organizations and other groups was denser.

The courses or field visits on a demonstration plot were organized by different institutions or large scale farmers. Seven of the eight visited CA farmers knew who had organized the course or run the demonstration areas they visited.



**Figure 23:** Different technologies CA farmers learned during a field course or on a demonstration area.

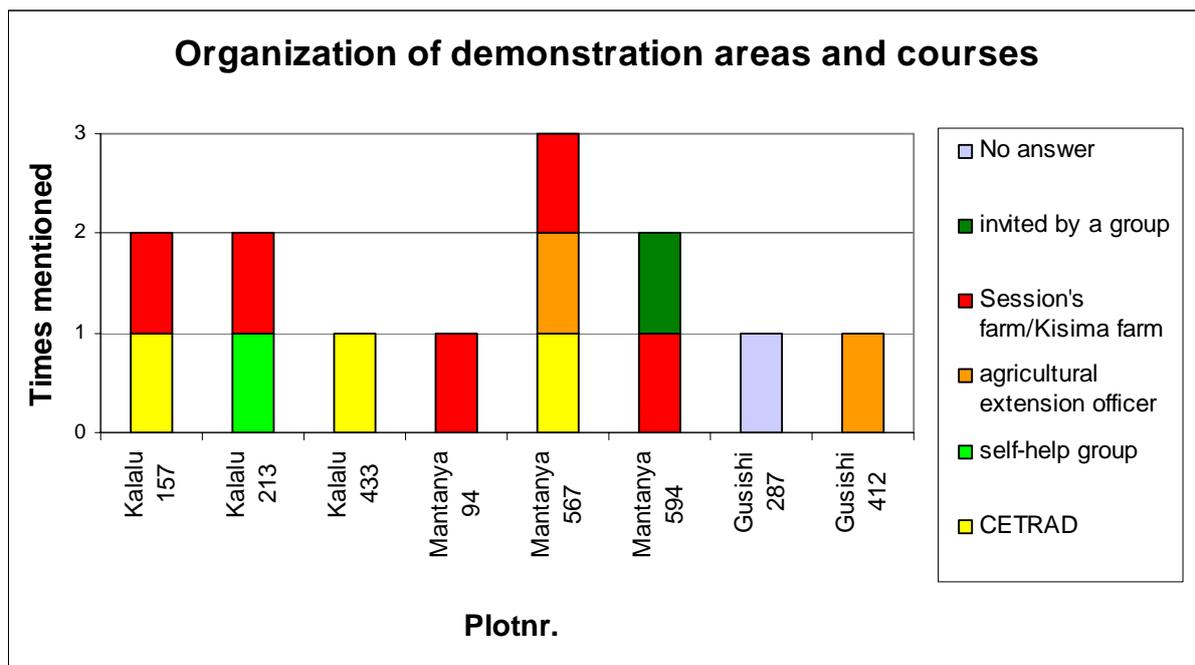
Five of the six CA farmers from Kalalu and Mantanya visited a demonstration area on the large-scale farm of Lory Session or the Kisima farm of family Dyer. On these two large-scale farms, regular CA field days for interested small-scale farmers were arranged. Mr. Session

<sup>17</sup> A detailed figure of the techniques learned by CA farmers in courses or on demonstration areas for each farm is in the attached in the appendix.

had a special demonstration area on his farm, which is cultivated with the same means farmers small-scale farmers can provide on their farms. It was interesting that both farmers from Gusishi had never participated on a field day of the Kisima farm. The farm is located in Meru district and thereby closer to Gusishi than to the other two study areas.

Kalalu was the area which had been supported by the staff of the Syngenta group in Nanyuki. Thus, it was not amazing that two of the three interviewees participated on a course organized by the CETRAD office which was working together with the Syngenta group. The farmer from Mantanya who had attended a course organized by CETRAD was part of the early CA adopters. He started using the technologies in 1983 when they were introduced by the LRP.

Two farmers visited a demonstration area which was maintained by a CA group. The farmer who was practicing CA in Mantanya said that he had also been invited by the group, to join them on a trip to Mr. Sessions' farm and visit the demonstration plots there. CA groups maintained demonstration areas and organized trips to other CA farmers, showing that groups in the two study areas were active and it appears they played an important part in spreading knowledge. Through the contact to other groups, farmers or institutions they keep building a platform for discussion of CA technologies.



**Figure 24:** Organization of demonstration areas and courses by different corporations.

Gusishi was the only area where neither groups nor an organization such as CETRAD had been active. One of the two farmers there did not know any other CA farmer in the whole area and stood on his own using the technologies. The lack of possibilities for exchanging knowledge and experiences was probably one reason why the second farmer in Gusishi believed he was practicing CA on the whole cultivated land he owned, even though he used a plow to prepare the fields for planting potatoes and considered mulching as not always necessary.

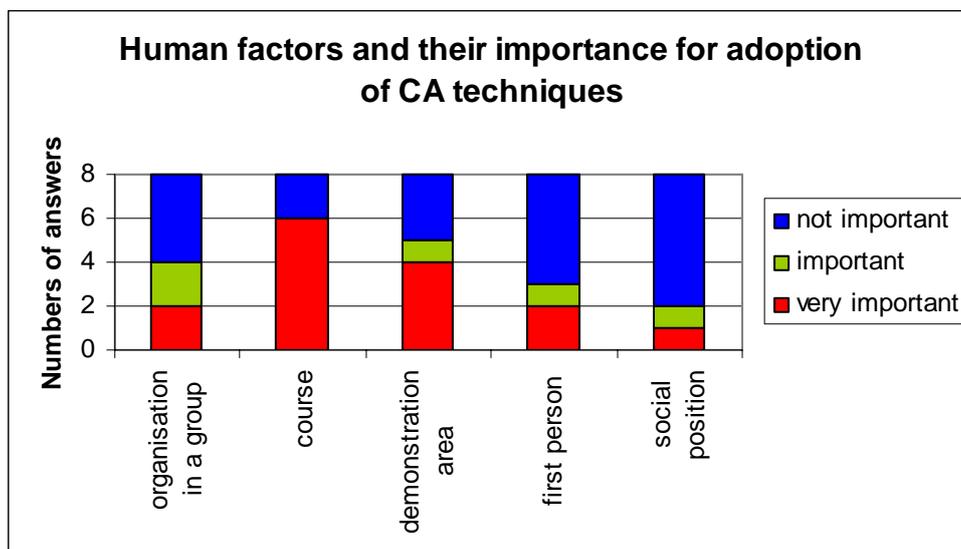
### Zero and minimum tillage once applied

Mrs. Ndungu was the only of the three interrogated farmers who was organized in a group with other farmers during the time she applied CA on her plot. She said they were taught about CA by a white farmer and they had a demonstration on his farm. After that, the group members practiced the technologies on their own farms. They visited each other and discussed the occurring problems together.

The two farmers in Kalalu were not organized in a group. Mr. Kamenju stated that they were taught individually and that they visited the demonstration plot owned by the LRP. Mrs. Gituma who adopted the technology because she saw her neighbors practicing it said that she was never in a group, but she heard of other people who were organized. Mrs. Gituma never participated on a course or visited a demonstration area, but people from the Syngenta group visited her on the farm. They advised her in using the right herbicides.

### 6.3.4 Ranking the human factors in order of importance for adoption of CA technologies including zero and minimum tillage

CA farmers visited during data collection were asked to rank different human factors in order of importance for their decision to adopt CA technologies. They had to choose for each factor if it was not important, important or very important for their decision.



**Figure 25:** The importance of different human factors for the decision of farmers to adopt CA technologies.

It was surprising that half of the eight interviewed CA farmers considered the organization in a group as not important for their decision because e.g. the case study about conservation agriculture in Kenya from the FAO<sup>18</sup> pointed out that adoption of CA technologies is more likely among farmers who were organized in a group. Therefore, three quarter of the CA farmers said that the participation on a course was very important for them and more than half

<sup>18</sup> The summary of this study is found in section 1.2.6

of the farmers said that the visit of a demonstration area was important or very important to them. This might also explain why the organization in a group seems to be not that important. Farmers had the possibility to visit demonstration areas or courses even if they were not members of a group. On these occasions they saw the advantages of conservation technologies, had the possibility to acquire knowledge and were able to talk with other farmers and experts. In this case, these field days or courses replaced the function of a CA-group.

The first person who was practicing CA in the area seemed not to have a big influence on the decision-making of farmers. A closer look at the data shows certainly that half of the respondents considered themselves as being the first person practicing CA in the area and thereby they had nobody as role model to follow. Because of that, the first person practicing was not important to them. A second view at the figure shows that three quarter of the four other farmers consider the first person practicing CA in the area as important or very important. It shows that the decision-making was influenced by farmers who were already practicing CA technologies on their farms.

The factor 'social position of farmers who were practicing CA technologies' did not have a big influence on the decision making of farmers as well. Half of the four farmers who thought the first person who was practicing CA influenced them were also influenced by the social position. Farmers were asked before how they estimated the social position of CA farmers in their area. The answers of 75% of the farmers were positive. The other 25% of interviewed farmers mentioned that the social position was considered as bad by conventional farmers. One interviewee in Mantanya who said CA farmers or in this special case he was lowly esteemed and the people in the area were laughing about him, because the herbicides did not function and the weed was higher than the crops at the time the interview took place. 75% of the farmers said that CA farmers were respected. CA farmers were also regarded as advisors or teachers in the area and two of the farmers mentioned that they were considered as high producers and high income earners.

The evaluation of this ranking shows that farmers who already practiced CA technologies considered the influences from direct or indirect interaction with other farmers as important. Observing other farmers or at least their plots respectively demonstration areas and the success those farmers had, seemed to increase the will of a farmer to adopt the new technologies. The participation on courses and the exchange between farmers there is very important to the interviewees.

#### **6.4 Natural factors influencing the decision-making of farmers**

In this section, the results from questions concerning natural factors and the adoption of CA technologies are discussed. During data collection, it was realized that most of the farmers did not know the technologies and thereby were not able to tell how these factors influenced them. Because of few usable answers concerning the relation between natural factors and non-adoption of CA technologies, a ranking of the factors was not possible.

The answers in the sections ‘zero and minimum tillage not applied’ came from farmers who knew something about CA technologies or who imagined how they would decide after the interviewers had explained the technologies to them.

#### **6.4.1 Rainfall pattern**

##### **Zero and minimum tillage not applied**

One farmer in Kalalu, three in Mantanya and one in Gusishi said that the rainfall attended both technologies the same way. They did not believe that CA farmers had an advantage of their technology. Mr. Muniyiri from Mantanya described it as follows:

*“The rains that fall on our land will have the same effect on the CA and non CA farmer, for evaporation is the same.”*

This was the most often mentioned answer to this question, given by five farmers out of nine who gave a useful answer. It shows that also farmers who already know something about CA because they have visited a demonstration area or know a person who is practicing have major knowledge gaps concerning the technologies.

A farmer from Gusishi said his farm depended on irrigation water and was not depending of rainfalls. One farmer in Mantanya said during the interview that there was enough precipitation for the crops to grow. This answer came unexpectedly, because Mantanya is known as the driest of the three study areas. There was probably a connection between the answer and the rainfalls during the growing season when the interviews took place. According to local people, precipitation in Mantanya was much higher than in normal years.

##### **Zero and minimum tillage applied**

In general, the interviewed CA farmers said that the rainfall pattern influenced their decision. 25% of the eight farmers did not answer the question. The others were aware of the difficult situation concerning the unreliable rainfalls and made the linkage between rainfall, soil moisture and evaporation. Mrs. Muathamani from Mantanya made the following thought concerning the rainfall pattern:

*“The rains are short and not enough for the crop, so I had to look after a way to retain the soil moisture.”*

Mr. Thuita, also from Mantanya, explained how he experiences the rains in the area and why the rainfall pattern influenced his decision to adopt CA technologies:

*“The rains in the area are short but heavy and I had to look for a way of retaining the water in the soils for a long time, to make sure the crops grow well.”*

These two statements show that the short and heavy rains were important for the decision-making of farmers. If these statements are compared with the answers given by conventional farmers in this section, it becomes obvious that latter farmers need more education to understand the negative impacts of plowing or digging the fields as well as the positive influences of mulching or zt and mt technologies. The fact that seven of the nine conventional farmers who answered the question about the rainfall pattern stated that rains had the same influences to all technologies shows the urgency of farmer education.

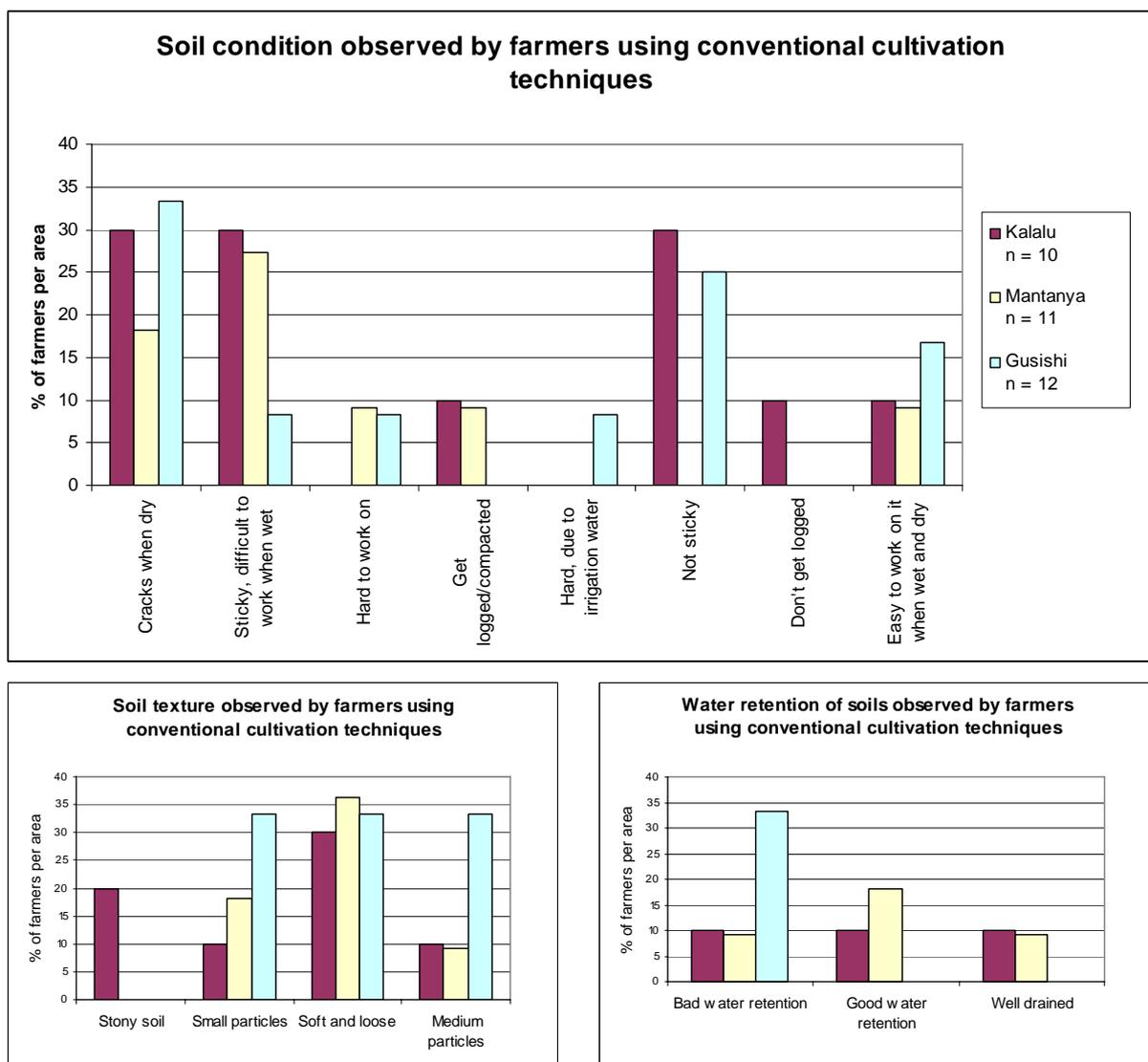
## Zero and minimum tillage once applied

All three farmers who had once applied zt and mt technologies on their farms said the rainfall pattern did not influence their decision to change back to conventional technologies. Only one of them gave an explanation why he changed back. Mr. Kamenju from Kalalu said, as already mentioned before, that he changed back because other farmers were not interested in the demonstration area they had on their farm.

## 6.4.2 Soil conditions and suitability of the soils

### Zero and minimum tillage not applied

As a next natural factor, farmers were asked about the conditions of their soils. Here, all the farmers could give an answer, even if they were not able to tell the relation between soil conditions and their decision how to work soils. On the left hand of Figure 26, the bad properties of soils are listed. The better soil conditions are found on the right side of the figures.



**Figure 26:** Observed soil conditions, soil textures and water storage capacity in the three study areas.

It becomes obvious that farmers in all three areas had problems with the workability of their soils. The categories 'cracks when dry', 'sticky, difficult to work on when wet', 'hard due to irrigation water' and 'hard to work on' all describe soils, which at some stage cause problems to work them.

The four farmers in Gusishi whose soils had bad water retention were all irrigating their fields.

About one third of all interrogated farmers in the three study areas describe their soils as soft and loose. These soils are very vulnerable to soil erosion.

Farmers who were already content with their soils and described them e.g. as well drained with good water retention were less numerous than farmers who remarked some problems. Figure 26 shows that most farmers have some difficulties with the conditions of their soils. For most of the problems the application of CA technologies is likely to make an improvement.

40% of the farmers in all areas were content with the suitability of their soils but there were differences between the three areas. 40% of the visited farmers in Kalalu, 72% in Mantanya and 8% in Gusishi were content. They said they were able to grow all crops on their fields. The factor soil fertility is already discussed in section 6.2.2 and is thus not discussed here.

20% of the farmers mentioned here again, they had infertile soils. That is just half of the farmers who were discontent with their soils as is seen in Figure 15. An explanation for this difference is the way of asking. In the question whether farmers are content with the technology they used, they were asked directly if they were content with the factor soil fertility, whereas this question is more open and farmers were free to mention whatever they find most important.

There were also some new things mentioned. One farmer in Gusishi said that the soils on his farm had a hard pan. To break the hard pan, he had to hire a tractor.

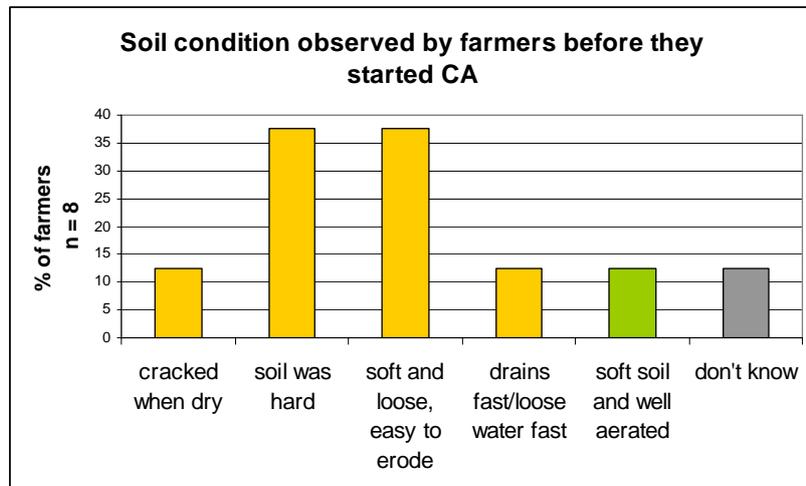
### **Zero and minimum tillage applied**

The eight farmers who used zt and mt technologies on their farms described the condition of their soils before they started using CA on their farms similar to the farmers who did not apply CA (compare Figure 26 and Figure 27). One of the eight farmers said the soils cracked when they were dry.

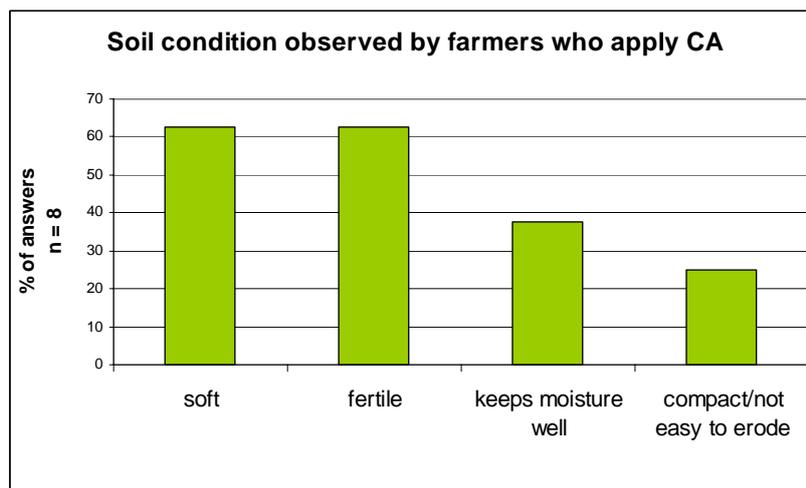
Three interviewees described their soils as hard and difficult to work on. Three others said they were soft and loose what caused problems because the soils were very vulnerable to soil erosion caused by wind or water. One farmer said the soils had lost the water quickly before he used CA and the crops had not enough water to grow well. Only one farmer from Mantanya had been content with the soils before she started using CA. She described the soils as soft and well aerated. One farmer from Kalalu said she did not remark a difference because she did not observe the soil conditions before she started using CA.

All CA farmers beside the farmer, who did not observe the soils before, described that the soil condition improved since they applied CA. Figure 28 shows how farmers observed their soils by the time when the study was carried out. Mr. Thuita from Mantanya who had loose soils, which were very vulnerable to erosion before he used CA, described his soils as compacted and able to keep the soil moisture for a long time, allowing the crops to perform well. Five of

the eight interrogated CA farmers described their soils as fertile due to humus accumulation since they left the crop residuals on the fields<sup>19</sup>.



**Figure 27:** Soil conditions before CA was applied.



**Figure 28:** Soil conditions observed by farmers who applied CA technologies on their farms.

### **Zero and minimum tillage once applied**

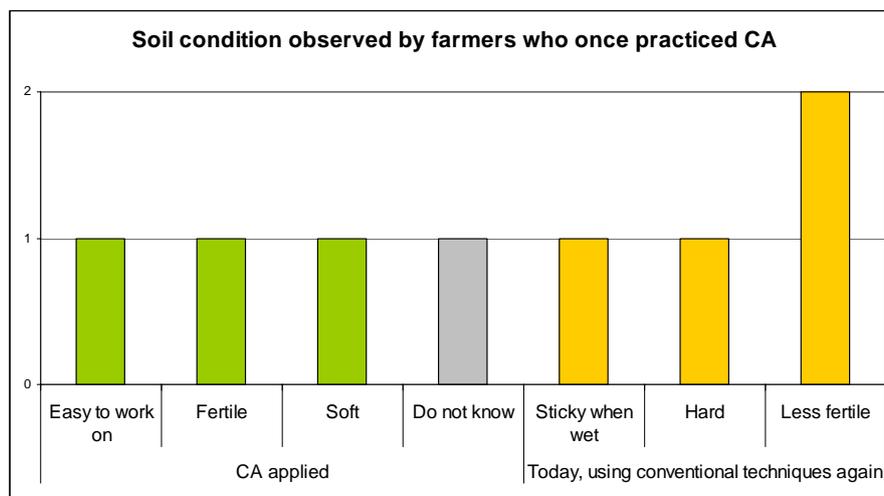
Figure 29 illustrates the soil conditions observed by farmers during the time they had been practicing CA and today. Two of the three farmers who had once practiced zt and mt on their farms made observations similar to those of farmers who practice CA today. They described the soils as soft and easy to work on when they had applied CA. One farmer said the soils had been more fertile during that time because crop residuals had been used as mulch. One farmer said she did not remember the soil conditions when she applied CA.

After the farmers stopped using CA, the positive soil characteristics they described before were lost again. The soils they worked on when the study was carried out were described as sticky when they were wet and hard when they were dry. Thereby, they were difficult to work

<sup>19</sup> See also section 6.2.2 Soil fertility runoff and soil erosion.

on. Two farmers also stated that soils were less fertile than during the time when they had used CA.

The answers given to this question by the three farmer groups (CA, Not CA and once CA) are like a circle. More than 40% of all interviewed farmers who did not apply CA on their plots were discontent with the factors soil erosion, soil fertility and soil moisture<sup>20</sup>. Figure 27 shows that farmers who were applying CA when the study was carried out had the same problems before they started using CA on their farms. They realized an enhancement of soil conditions and the workability since they practiced CA. Farmers who stopped using CA realized that their soils lost the good conditions which were built up during the time when CA was applied.



**Figure 29:** Soil conditions observed by farmers who once practiced CA.

### 6.4.3 Ranking natural factors in order of importance for adoption of CA technologies including zero and minimum tillage

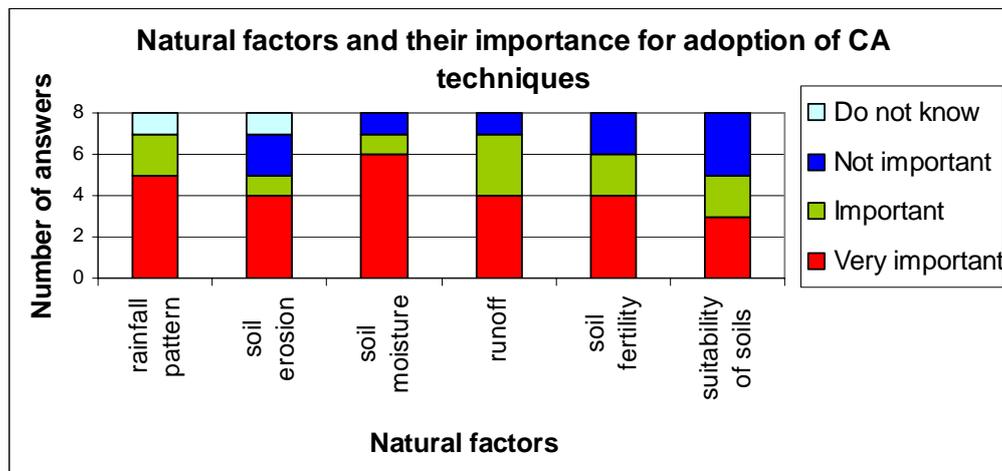
The influence of natural factors on the adoption of CA technologies was constantly high for all factors asked. More than half of the interviewees ranked the different factors as very important or important.

The three factors ‘rainfall pattern’, ‘soil moisture’ and ‘runoff’ were ranked as important or very important by seven of the eight interviewed farmers. Farmers realized the problems on their farms. They knew that the rainfalls were unreliable and heavy as described above. Also, the runoff caused by rain and the fast drying up of the soils after the rain were realized by the farmers.

The interviewees who practiced CA were discontent with the factors they had observed on their plots before they used the technologies and got interested in the new technologies and their advantages. Farmers realized the problems on their farm and were willing to change. This attitude is conducive in the process of adopting a new technology. About 50% of the farmers who were not practicing CA today stated that they were content with the factors

<sup>20</sup> See also Figure 15: Satisfaction of farmers who did not practice zero or minimum tillage technologies with different factors in the three study areas.

‘runoff’ or ‘soil erosion’. As long as they do not see the disadvantages, it is not likely that they change their actions.



**Figure 30:** The importance of natural factors for the decision of farmers to adopt CA technologies.

## 6.5 Available equipment

This section shows which tools were used by the three groups of farmers (CA, Not CA and once CA) and which problems they faced in acquiring the needed equipment. During the interviews, farmers were asked which equipments they needed for cultivation and if they owned or hired them. Information about the available equipment helps to find out which additional tools would be needed by the farmers to implement CA technologies.

### 6.5.1 Equipment owned and hired by the farmers

#### Zero and minimum tillage not applied

The most common tools over all areas were jembes, folk jembes and pangas. All of the interrogated farmers owned at least one jembe. 80% of the farmers in Kalalu and 90% of the farmers in Mantanya and Gusishi owned also a folk jembe. Pangas were owned by all interviewees in Mantanya and 90% of the respondents in the other two areas. Jembes and folk jembes are used for different activities as digging the fields, weeding or harvesting.

18 farmers owned a sprayer to apply herbicides. Five of the interviewees in Kalalu, four in Mantanya and nine of the twelve in Gusishi had a sprayer. Only one farmer in Kalalu participated in a course, where he learned how to apply the herbicides.

In total, 72% of the interrogated farmers in Kalalu and Gusishi used an animal drawn plow to prepare their fields for planting whereas in Mantanya not a single farmer used animal drawn plows. According to the statements of several farmers, the reasons for this unequal distribution were the heavy soils in Mantanya, making it impossible to use animals to prepare land for planting. As showed in Figure 32, a higher percentage of farmers hired a tractor plow to prepare the fields.

A combine harvester is the only machinery which was not owned by at least one of the 33 visited farmers. Only a small percentage of people hired them for harvesting. The four farmers who hired one in Kalalu planted wheat at some stage. For one of them, wheat was the

most important crop. The contractors came around with the machinery during time of harvesting and reap the wheat for the farmers. One of the four farmers who used a combine harvester also stated that he did not know the owner, but that people came around during the time when the equipment was needed during times of harvesting.

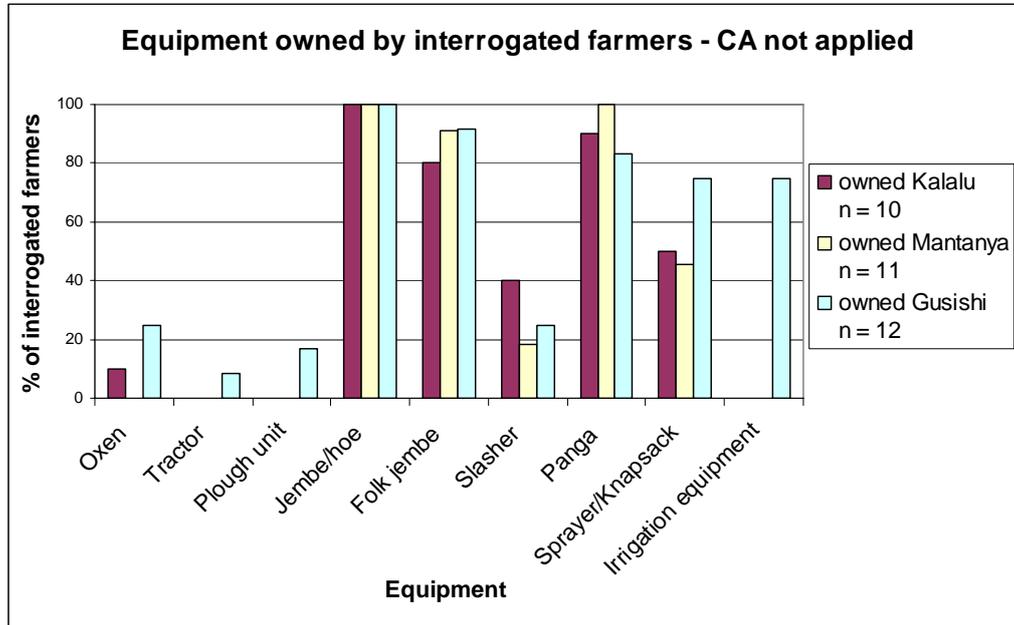


Figure 31: The most important equipments owned by non-CA farmers in the three study areas.

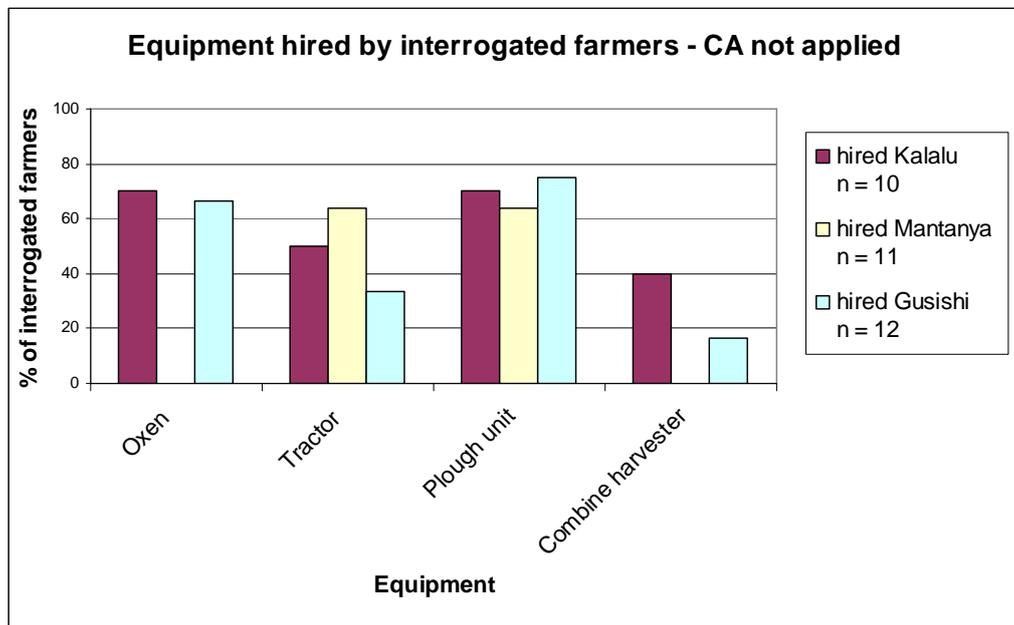
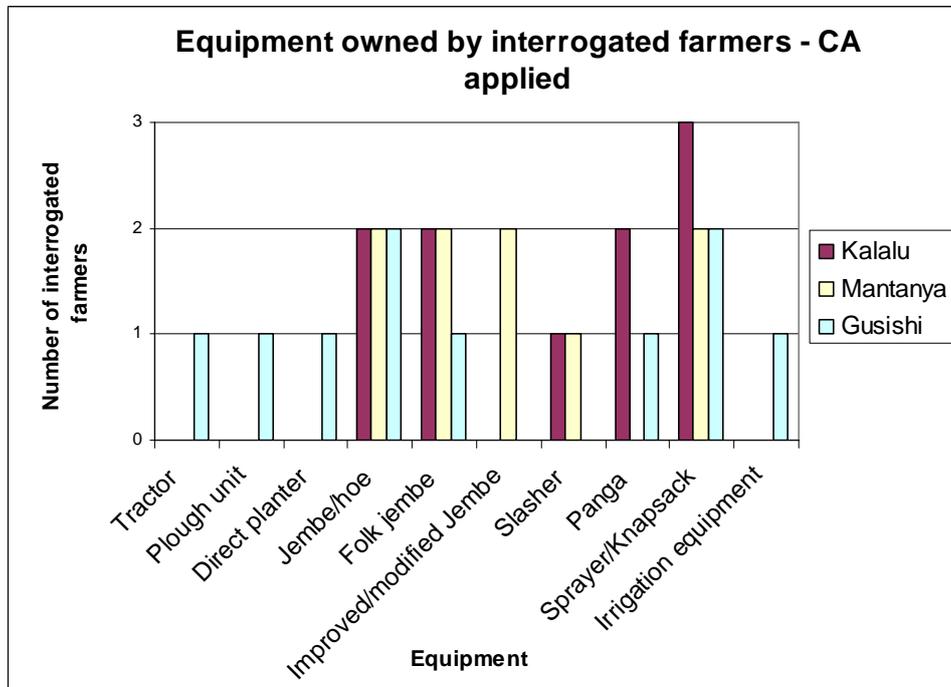


Figure 32: Equipment hired by interrogated non-CA farmers in the three study areas.

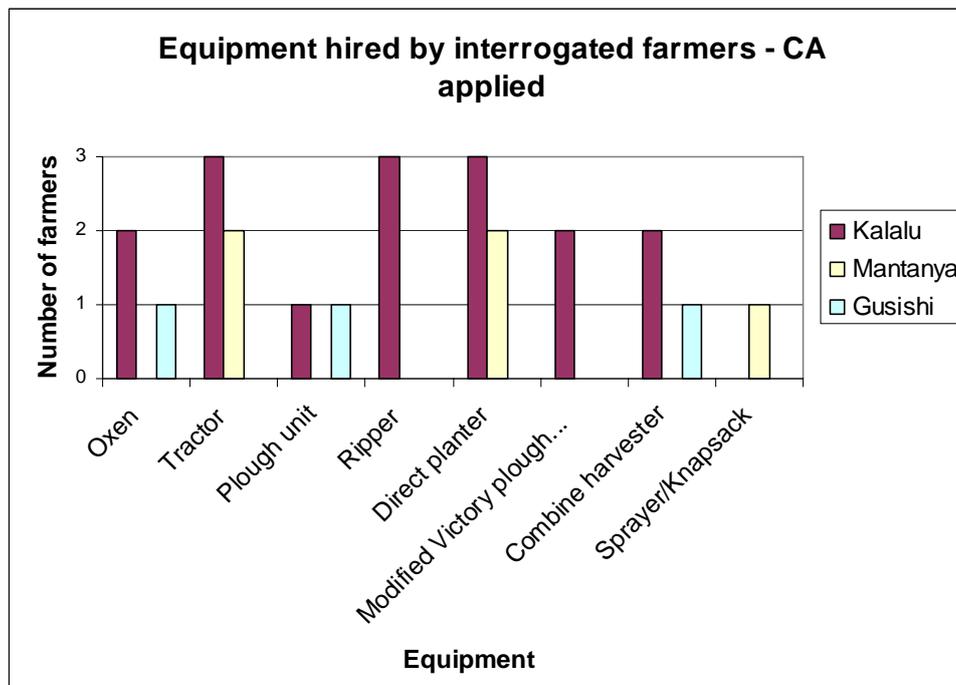
In all areas, farmers owned very simple hand tools to cultivate their fields and about 80% of them hired animal or tractor drawn implements for land preparation and harvesting. The remaining 20% cultivated their land by the use of their hands only. The distribution in the three areas is again unequal. Only on one of the visited farms in Kalalu and on one in Gusishi only the hands were used for cultivation, whereas in Mantanya, four farmers (36%) used their

hands solely. Farmers who cultivated their whole land by hand invested a lot of labor. If they got information about conservation technologies and for example the use of a Jab-planter to reduce labor, interest about the technology might grow.

### Zero and minimum tillage applied



**Figure 33:** The most important equipments owned by CA farmers in the three study areas.



**Figure 34:** Equipment hired by interrogated CA farmers in the three study areas.

Farmers practicing CA used some different tools than farmers who planted their fields using conventional practices. Figure 33 and Figure 34 show the equipment owned and hired by CA farmers in the three study areas. All farmers who used herbicides to kill the weeds on their fields (88% of the total CA farmers) owned a knapsack sprayer. One farmer in Gusishi also owned a sprayer to apply herbicides with his tractor. The farmer from Mantanya who hired a sprayer belonged to a group. A tractor for spraying and planting was provided by the group. All interrogated farmers in Kalalu used a direct planter after spraying the weeds, as did two third of the interviewees in Mantanya and one of two in Gusishi. Two farmers in Kalalu used an animal drawn planter, whereas the other farmers used tractor drawn ones. The two farmers (one from Mantanya and one from Gusishi) who did not use a direct planter, planted by hand. Mr. Thuita from Mantanya described the cultivation of his fields as follows:

*“First I slash the weeds and make planting holes. Then I plant and mulch the crop. The upcoming weeds I scratch with a small, modified jembe. If money is available to purchase herbicides, I use herbicides to kill the weeds.”*

The way how Mr. Thuita cultivated his fields shows that it is possible to practice CA without a lot of additional equipment.

Three of the eight farmers used a plow to cultivate at some stage. One farmer in Gusishi used an oxen drawn plough to make rills for planting. One farmer in Kalalu said he used the plow only for planting potatoes.

A combine harvester was used by three of the farmers. One farmer from Kalalu said that wheat was the most important crop for him. Not a single farmer in Mantanya used a combine harvester by the time the interviews were carried out; but Mr. Muthamy who started using CA technologies in October 2007, planted wheat on his fields and intended to use a combine harvester if the crops would perform well.

In Kalalu and Mantanya, some CA specific implements were used which did not turn up in Gusishi. The modified victory plow beam for example was only used in Kalalu. All farmers in Kalalu used a ripper as well to increase rainwater infiltration after harvesting the crops. In Mantanya, two of the three farmers used a modified jembe to scratch the weeds. A possible explanation for this unequal distribution of implements is that the persons or organizations who introduced the technologies also introduced some specific implements to the farmers.

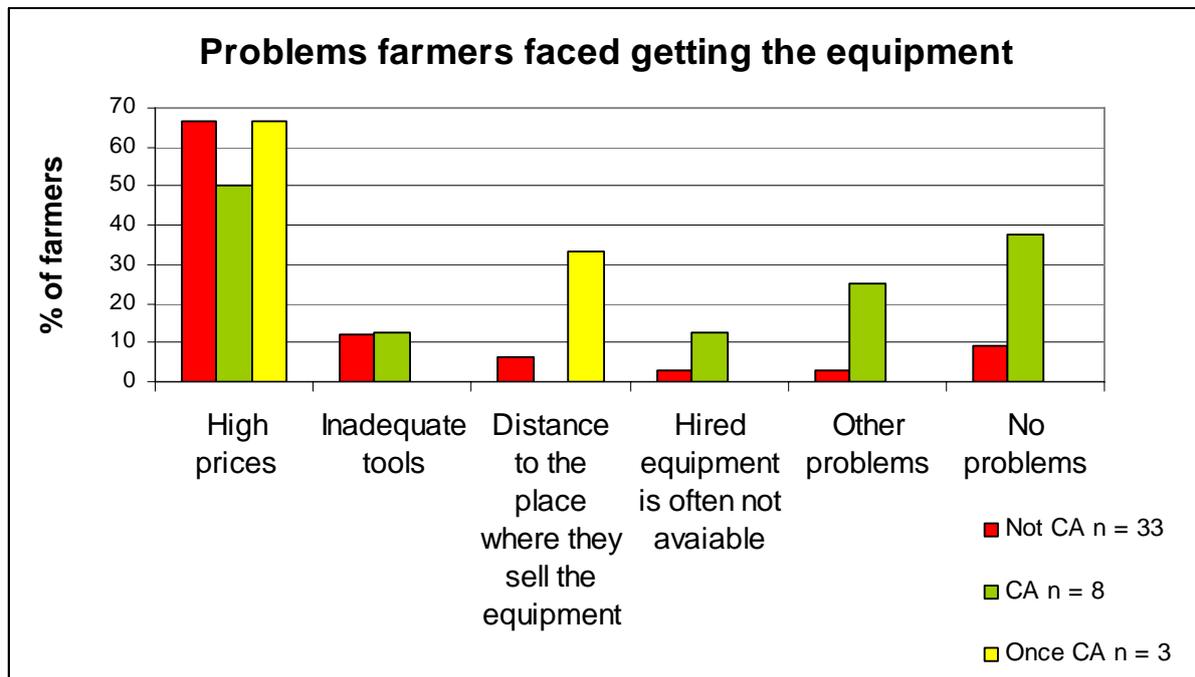
### **Zero and minimum tillage once applied**

Farmers who once applied zt and mt technologies on their farms were asked which tools they used when they applied CA on their fields and which tools they used presently. Only one of the farmers said he had used other equipment while he practiced CA. He used the same modified jembes as CA farmers did in Mantanya. The other two farmers who stopped CA did not mention that they used different tools.

### **6.5.2 Problem in obtaining equipment**

Figure 35 shows the problems farmers faced when they had to acquire new equipment. The figure shows the problems mentioned by the farmers of the three categories: CA applied, not

applied and CA once applied. The high price for equipment is the problem most mentioned by all three groups.



**Figure 35:** Problems farmers faced getting the equipment.

### **Zero and minimum tillage not applied**

One problem faced by more than two third of farmers in the three study areas were the high prices of equipment. Farmers could not afford to buy new equipment or other farm implements as fertilizers or herbicide. 90% or 30 farmers in all areas did not get any support to buy their equipment and maintain it. The remaining 10% got some help or some equipment for free. One farmer in Gusishi helped to build up fanya juus to control erosion. The construction work was guided and organized by a group for soil erosion control. Farmers who helped to construct the fanya juus could keep the equipment afterwards. The farmer in Gusishi got a shovel and a jembe through this group. The two farmers who got some support when they purchased the equipment in Kalalu got some financial help from their family members. In Mantanya, no farmer got any help.

A further problem mentioned by 12% of the farmers is that purchased tools were inadequate. , Imitations of a known and trusted brand were sold in shops sometimes. The imitations are of lower quality and do not last for a long time. This was an observation of one farmer in Gusishi. All the other farmers who mentioned that tools were inadequate just said that the quality was very poor and tools would break quickly.

One respondent in Kalalu and one in Mantanya said that the distances to the places where the equipments were sold was too far and that the way to town took a lot of time. The same interviewee from Kalalu also complained about the availability of equipment to hire. He said that there were not enough tractors, plows and harvesters available at the time when they were needed, leading to a delay in planting or to crops not being harvested in time.

The fact that only 9% of all visited farmers did not face any problems acquiring the equipment they needed reveals a major problem. Farmers do not have enough money to buy the necessary tools and it is to assume that there is also no money to invest in CA equipment. Hence, even if farmers got information about the advantages of CA and the interest in these technologies grew, adoption would probably still be very seldom due to the investments which have to be made at the beginning.

### **Zero and minimum tillage applied**

The problem most mentioned by farmers who do apply CA on their farm was the same as in all groups: The high prices of equipment and the fact that farmers do not have enough money to acquire them. Mrs. Wangui from Mantanya said the biggest problem was that hired equipment is not available by the time needed. She said there would be just one sprayer for the whole group what caused problems every year. Two farmers said the equipments they wanted to buy were not readily available in the shops (other problems in Figure 35) and they had to search them in various places.

Two of the eight farmers got some support for investing in tools. A farmer from Gusishi got two jembes from his father when he started farming on his own. The other farmer is Mrs. Wangui. The group got a sprayer and they had the possibility to hire a cheap tractor for planting. The sprayer was provided by the MoA.

### **Zero and minimum tillage once applied**

The three farmers who once practiced zt or mt faced the same problems as the farmers from the other two categories. The equipment is expensive and the distances to the markets where they are sold is far. One of the three farmers got some financial support when she acquired the equipment she used for CA. It was Mrs. Ndungu from Mantanya. She said that a white farmer supported her with some money to acquire the equipment she needed to practice CA. By the time when the study was carried out, none of the farmers got financial support by anyone.

## **6.6 Activity of the people living on the farm influencing adoption or non-adoption of conservation agriculture**

The family size and thereby indirectly also the labor that is available on a farm are assumed to influence farming practices. CA technologies require less labor than conventional technologies. In the following part, it is analyzed how many of the people living on the farm have some off-farm employment and how many are working only on the farm. The education farmers have is a further aspect which could influence the decision-making.

Table 8 shows the occupation of the people living on the visited farms. It has to be regarded that the three groups of farmers (CA not applied, applied and once applied) have different sizes. It is visible that the total of children and adolescents living on the farm was 10% respectively 15% higher on farms where CA was not applied than on farms where CA was once applied or was applied when the study was carried out. The percentages of people who had an off-farm employment were also higher in the two groups 'CA applied' and 'CA once applied'. More detailed information on the groups is presented in the following part.

	CA not applied 33 visited farms		CA applied 8 visited farms		CA once applied 3 visited farms	
	Number	%	Number	%	Number	%
Number of people living on the visited farms	242	100	34	100	28	100
Adults living on the farm	114	47	21	62	16	57
Not schooling or schooling children and adolescents living on the farm	128	53	13	38	12	43
Adults working on the farm	80	33	15	44	8	29
Adults with a permanent off-farm employment	12	5	4	12	4	14
Adults with a casual off-farm employment	21	6	2	6	1	4

**Table 8:** People living on the farms in all areas and their activities.

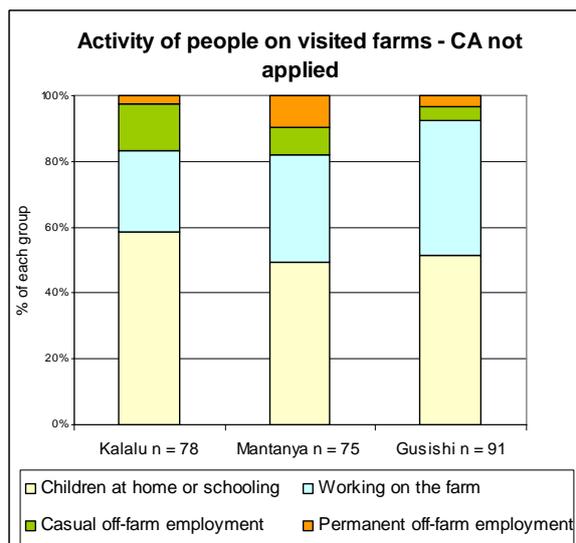
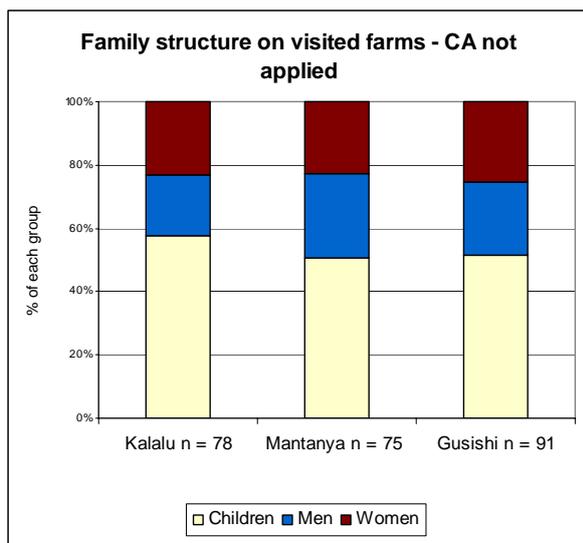
### 6.6.1 Family structure and activity of the people living on the farm

#### Zero- and minimum tillage not applied

244 people lived on the farms in all three study areas that were visited to fill out the long questionnaire ‘CA not applied’. The median of people living on one farm was seven, but the range was between one and 17 persons per farm. The Median of people living on the farm for the three study areas was five in Mantanya, seven in Gusishi and eight in Kalalu. Children made up at least half of the people living on the farm. In Kalalu, nearly 60% of the family members were children.

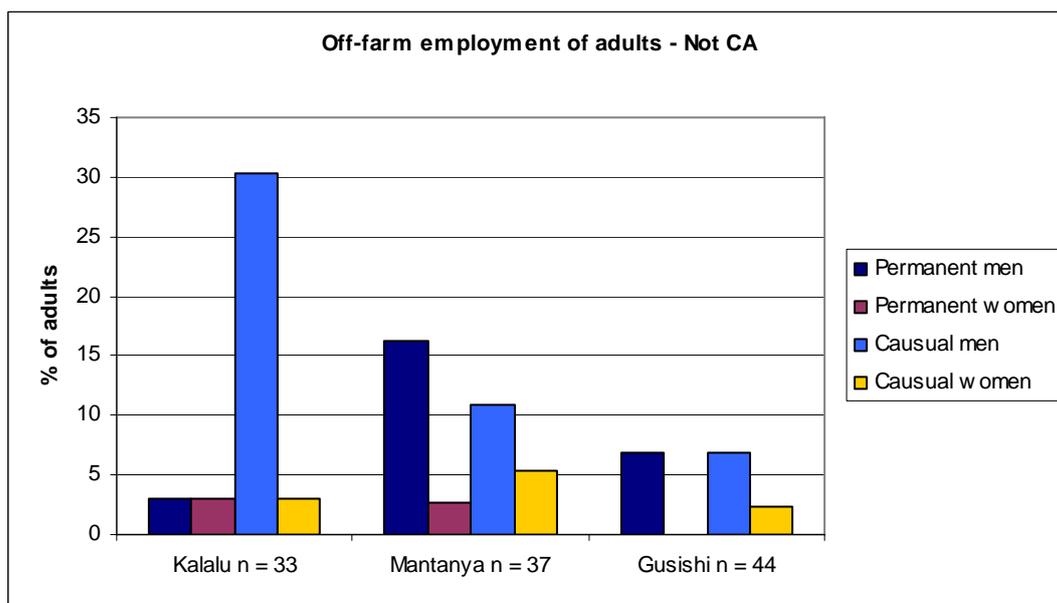
41% to 50% of people living on the farm were adults. In Kalalu and Gusishi, slightly more women (three and two respectively) were living on the farms than men. In Mantanya, it was exactly the other way around; there were three more men living on the visited farms. Adults on the farm were split into three groups: Persons working on the farm and in the household, persons with a casual off-farm employment and those with a permanent off-farm employment. An average of 11% over all three study areas had a permanent off-farm employment and about 18% had a casual off-farm employment. In Kalalu, 17% and in Mantanya, 18% of the adult people living on the visited plots had at least sometimes the possibility to earn money outside the farm. In Gusishi, just 8% of the people had the same possibility. This fact was surprising because Gusishi and Kalalu are both surrounded by large horticultural farms which provided work to the people living in the area.

An interesting fact is that mostly men had an off-farm employment, whereas women normally stayed at home. In the three study areas, six women had an off-farm employment. Figure 38 shows in detail the two groups ‘permanent off-farm employment’ and ‘casual off-farm employment’ from Figure 37.



**Figure 36:** Family structure on farms visited for the questionnaire ‘Not CA’.

**Figure 37:** Activity of people on farms visited for the questionnaire ‘Not CA’.



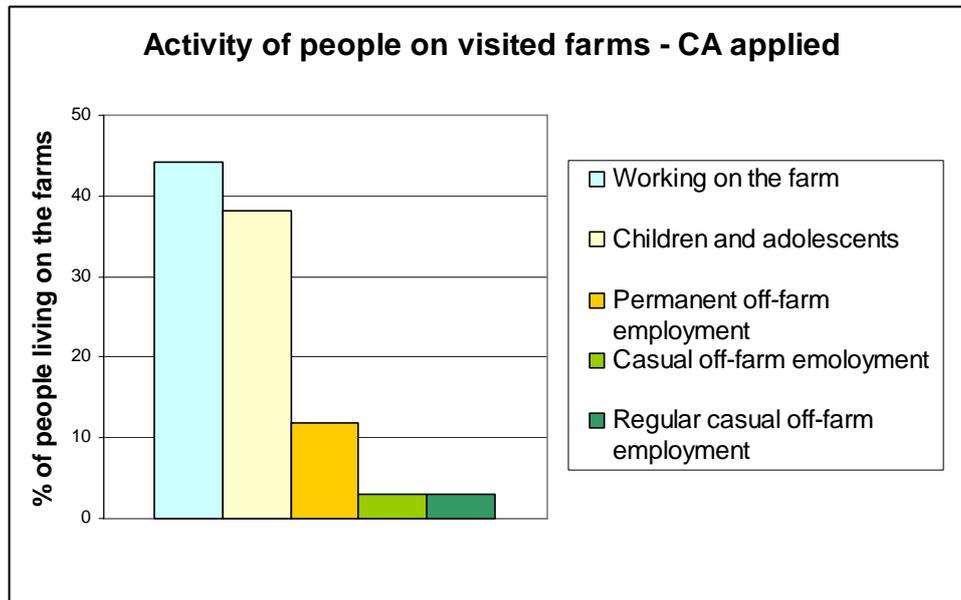
**Figure 38:** Off-farm employment of family members living on non-CA farms

**Zero- and minimum tillage applied**

On average, four people lived on farms where CA was applied. The median of people living on the farm was 3.5 and thereby smaller than the one of farmers who did not apply CA. The fact that less people were living on CA farms could be related to the fact that less labor was available on these farms.

In total, 18% of the adult persons living on the visited CA farms had the possibility to earn some additional money outside the farm. This equals the values of farmers who did not apply CA in Kalalu and Mantanya. Only one of the eight farmers who had an off-farm employment was a woman. Also the relation between farmers who had a permanent employment and those who had a casual one was nearly the same as in the section above. About 11% of the farmers

who did apply CA had a permanent off-farm employment and 6% had a casual off-farm employment.



**Figure 39:** Activity of people on farms visited for the questionnaire ‘CA applied’

Farmers who practiced CA did not only work outside their farm, they did also employ people on their farms. On five of the eight visited farms, at least one person was employed. One farmer in Gusishi employed four people on his farm. On this farm, both adult persons had a fulltime job. They ran a private primary school and Mr. Kabuturu was the headmaster of the school.

Children were living only on half of the visited farms. The owners of these farms were all more than 50 years and their children were already adults. Some of them were still living on the farm but they were working or they had an off-farm employment.

### **Zero- and minimum tillage once applied**

16 adult persons were living on one of the three visited farms where CA had once been applied. 50% of them were female. As already showed in Table 8, five of these persons had an off-farm employment. All of them were men. The tendency towards a higher percentage of men working off-farm was also visible under the other two groups of farmers. In total, only seven of all adult women had an off-farm employment.

### **6.6.2 Education of adult people on the farm**

Most of the adult persons, who finished education, completed or started primary school. Farmers who applied CA on their farm and those who had once applied CA on their farm had a higher education than non-CA farmers. About 30% of the CA farmers and of the farmers who had once applied CA completed secondary school or did training after schooling. One farmer of each group had completed University. Only 14% of the farmers who did not apply CA finished secondary school or had a higher education.

	<b>Not CA n = 114</b>	<b>CA applied n = 21</b>	<b>Once CA n = 16</b>
No formal schooling	7	10	19
Started primary school, but didn't complete	21	5	25
Ended education with primary school certificate	44	48	19
Started secondary, but didn't complete	11	5	0
Ended education with form 4 certificate (O-level)	7	10	13
Ended education with form 6 certificate (A-level)	1	0	0
Informal training after primary or secondary	3	0	6
Formal training after primary or secondary	3	10	0
Diploma training	0	5	6
University and post graduate	0	5	6
Not indicated	3	5	6

**Table 9:** Education level in percentage of all adults living on the visited plots

### **Zero- and minimum tillage not applied**

Not a single person in all three areas did diploma training or attended a university course. In general, the different education levels did not cohere with the kind of off-farm employment a farmer had. One farmer who did not finish primary school had a permanent employment in the private sector, whereas a farmer who did some formal training after school had only a regular casual job.

	<b>Kalalu n = 33</b>	<b>Mantanya n = 37</b>	<b>Gusishi n = 44</b>
No formal schooling	15	0	7
Started primary school, but didn't complete	24	22	18
Ended education with primary school certificate	36	51	43
Started secondary, but didn't complete	12	14	9
Ended education with form 4 certificate (O-level)	6	3	11
Ended education with form 6 certificate (A-level)	0	3	0
Informal training after primary or secondary	0	5	2
Formal training after primary or secondary	0	0	7
Diploma training	0	0	0
University and post graduate	0	0	0
Not indicated	7	2	3

**Table 10:** Education levels of percentages of adults living on the visited farms practicing conventional agriculture.

In general, there was no big difference between the education levels in the three areas; but in Kalalu, not a single farmer on the visited plots had a higher education than a form 4 certificate. In Mantanya, about 8% and in Gusishi, about 9% of the farmers had a better education.

**Zero- and minimum tillage applied**

Three of the four farmers who had a permanent off-farm employment completed school and did a training afterwards or attended a university course. One of the farmers from Kalalu did diploma training after school. The other two farmers were from Gusishi. One of them did some formal training and one graduated at university.

It seems as if farmers with a better education have more chances to get a permanent job, but the sample size is small and it is not possible to generalize. Approximately the same percentage of farmers who did not apply CA also had a permanent employment, even if their education was not that good.

**Zero- and minimum tillage once applied**

All farmers of the group 'CA once applied' who did some training after schooling or attended a university course had a permanent off-farm employment. This fact fortifies the assumption made above, that farmers with a higher education have a better change to get a permanent employment. The problem is again that the sample size is too small to generalize and that farmers who did not apply CA had a lower education-level than the two other sampling groups.

## 7 Conclusions and recommendations

### 7.1 Conclusions on learning theories and decision-making of farmers

- **Passive social learning** is assumed to be the most common way of learning<sup>21</sup>, a fact which is not reflected in the study at hand. Passive social learning occurred in a ‘negative way’: Farmers who did not practice CA, saw how other farmers failed with herbicide applications and remembered it. Social learning in a ‘positive way’ also occurs, but does often not lead to adoption<sup>22</sup>. Farmers see other people practicing CA, but they are not able to understand fully and thus keep practicing the technologies they know. Still, one farmer who was practicing CA mentioned that better crop performance at CA farms arouse his attention in the technology whereon he started collecting additional information about the technologies. These findings lead to the assumption that negative events and failures are remembered better than success.
- **Active social learning** is more efficient than passive social learning. Courses where experts teach novices as well as FFS or CA groups where both farmer to farmer and farmer to advisor discussions take place, are important platforms. This way of knowledge transfer is the most successful, concerning the adoption of CA technologies.
- The study at hand shows that **experimental learning** is a very enduring form of learning but the conclusions drawn by the farmers depended on what they had experienced. Farmers whose CA trial plots performed better than the conventional plots, were more likely to change their cultivation techniques, whereas farmers whose trial plots failed once or several times, because they e.g. used a wrong herbicide, rather refused to adopt CA technologies.

To give farmers the possibility of testing the technologies on their own with additional advice of an experienced farmer or expert would be a very efficient way of creating ‘positive’ experiences and would eventually enhance the probability of adoption of CA technologies. Such trial plots were introduced during the LRP and also the FFS have trial farms. It is important, that these plots are well maintained and interested farmers are actively involved in the discussions and have the possibility to try the technologies on their own. A trial plot alone does not lead to adoption.

### 7.2 Conclusions on goals of the study

In the forefront of the field work, three goals concerning the spread of SWC technologies and especially the spread of zt and mt technologies among small scale farmers in the study areas were defined.

- The first goal, “**Mapping the distribution of SWC technologies, with a special focus on zero and minimum tillage technologies in the study areas**”, was attained. Three different SWC measure types were applied in the study areas: Agronomic, vegetative and

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<sup>21</sup> See section 2.1 Active and passive social learning.

<sup>22</sup> See section 6.3.1 First contact with conservation agriculture.

structural measures. For each of the measures, beside of the structural measures, different SLM technologies were utilized<sup>23</sup>. SLM technologies were widespread in the three study areas. More than 80% of all visited farmers applied at least one of the technologies. The three SWC measure types were used by different farmers. The number of land users applying the different SLM technologies varied greatly.

**Agronomic measures** were used on 28% of all visited farms. Zt and mt technologies belong to this type and were applied on 4% of all visited farms. This result is surprising because at least in Kalalu and Mantanya, where CA technologies were introduced among small scale farmers about 20 years ago, a higher adoption rate would have been assumed. The reasons why only a few farmers used the technologies are discussed later in this section.

**Vegetative measures** were the most often applied measures in the three study areas. 74% of all visited farmers applied one or more vegetative measures on their farm. 88% of those farmers planted trees or shrubs either around the plot or between the crops. This conservation technology used by  $\frac{3}{4}$  of the interrogated farmers was not considered as conservation technology. All beside of two interviewees did not prune the roots of the trees and shrubs they planted, although tree planting and root pruning was introduced on experimental plots. Trees were considered as useful plants, because they provide fire and building wood. 12% of farmers who used vegetative measures, planted not only trees on their plots but also applied contour line planting. This measure were concentrated on the steeper areas and often used in combination with agronomic or structural measures. Farmers planted the grass stripes to slow down runoff and minimize soil erosion. Moreover, the planted napier grass serves as animal fodder. Both types of vegetative measures found in the study area were not only applied owing to SWC, but because the plants grown were useful to the farmers. These fact shows, SWC technologies which fulfill more than one purpose, are used by more farmers than other technologies are.

**Structural measures** were the least spread type observed in the three study areas. 13% of all farmers used this type of measure. All these farmers built fanya juus on their plots to reduce the slope angle and thereby reduce soil erosion. This measurement type was used more often in Gusishi (21%) and Kalalu (7%), where steeper slopes occur than in Mantanya (0.5%). Whether farmers apply the technologies or not is thereby related to slope. The construction and maintenance of fanya juus is time consuming what is most likely one of the reasons why this measure type is applied so little.

- To **“Determine the spatiotemporal pattern of distribution of zero and minimum tillage technologies”** was the second goal of the study. The assumption was that around the places where demonstration areas had been or where farmers are who are contractors for zero and minimum tillage, more farmers would apply CA including zt and mt and technologies would have spread from this starting point over the area through processes of active and passive learning. Non-CA farmers are supposed to get attracted by the technologies their neighbors use, because they harvest higher yields.

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<sup>23</sup> Compare Table 7: Soil and water conservation technologies observed in the study areas.

As illustrated in Figure 5 and Figure 6, Kalalu is the only area where a cluster of farmers who had once practiced CA and of those who were practicing is visible. The accumulation around the former demonstration area<sup>24</sup> seems to confirm the assumption above, but a closer look at the questionnaires shows something different: The two farmers who were practicing CA close to the former demonstration area had started in 2004 and 2007 respectively. Two of the three farmers who had once practiced CA in this area had tried it recently and stopped again, either because they had used the wrong herbicides or the equipment for planting had not been available. The third farmer who stopped had only some theoretical education about CA, but had never attended a seminar or visited a demonstration area. The assumption stated above can be discarded, because the farmers who used CA were practicing the technologies since a short time and the farmers who had stopped did not mention the demonstration area or the LRP. For the other two study areas no pattern can be found at all. Farmers who applied zt and mt were scattered over the whole area and no regularities were found.

Two third of the farmers in Kalalu and Mantanya started using CA technologies on their farms within the last five years. The situation was different in Gusishi: all farmers who applied CA had started before 2000. None of the visited farmers adopted the technologies afterwards. This shows that the small circle of farmers using the technologies stayed constant and no new adopters turned up. This situation is worse than in Kalalu and Mantanya, where adoption is taking place and at least some farmers show interest in the new technologies even though the process of adoption is slow and non-CA farmers are skeptical of the new technologies.

- The third goal of the study was to “**Ascertain the reasons for adoption or non adoption of Conservation Agriculture**”. During data collection for the study at hand, several reasons why farmers do adopt a technology or not were collected. Also farmers who had once practiced CA explained why they changed back to traditional farming technologies. The **reasons for non-adoption** of CA technologies including zt and mt showed the largest range of answers. Even though the range is wide, five<sup>25</sup> of the twelve categories (displayed in Figure 12) can be ascribed at least partly to missing knowledge about the technologies of farmers. Non-CA farmers had wrong assumptions about the technologies e.g. CA is more expensive than the technologies they apply or the belief that crops can not grow without digging the fields first. This finding is supported by interviewed CA farmers who stated that they adopted the technologies because they are cheaper and less labor intensive. The five categories altogether made up between 82% and 95% of all utilizable answers<sup>26</sup> given by the farmers.

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<sup>24</sup> The plot of the farmer who ran the demonstration area is marked in Figure 6: Land use with trees Kalalu.

<sup>25</sup> The first of the five categories was ‘do not know the technique’. Here, knowledge was obviously missing. This reason was followed by ‘money or support not available’, ‘being used to the traditional method/digging is necessary’, ‘do not trust the herbicides/technique’ and ‘not enough labor/equipment is available’. These four reasons were partly ascribed to missing knowledge. To close these knowledge gaps, farmers need more information about the CA and the possibility to get some experiences.

<sup>26</sup> The relations look different in Figure 12, because there is an additional category of all farmers who did not answer the question.

The **reasons for adoption** of CA given by the farmers<sup>27</sup> included economic factors such as crop production, human factors such as labor and natural factors such as soil conditions. All farmers who mentioned more than one reason covered two of these factors. It arises from the two rankings<sup>28</sup> that farmers had realized the problems concerning natural factors before practicing CA, and that the participation at courses and the visits at demonstration areas were very important for the decision-making. The reasons given by the farmers indicate two important elements for the adoption process: First of all, farmers have to be aware of their situation and recognize that runoff, soil erosion, high evaporation losses and other factors reduce the productivity of their farms. Second, farmers have to be informed about the possibilities of CA and experience the advantages of the technologies on their own, for example on field visits.

**Reasons for abandonment** of CA technologies after practicing or testing them were multifarious. Six interviewees mentioned five different reasons. It was not possible to identify one single factor which is very important to hold farmers back from abandoning CA. However, two of the given reasons, namely problems with herbicide application and discontinuation of an extension officer, indicate that contact with a person or a group is important to solve occurring problems. If this support is not available, farmers have no possibility to find a solution and abandonment of CA is more likely.

The analysis of the interviews indicated that three factors have to be fulfilled to **increase the rate of adoption**: First, non-CA farmers have to realize that runoff, soil erosion and high evaporation losses reduce the productivity of their farms. Second, farmers have to be aware of the advantages related to CA technologies. Third, farmers have to be attended and supported during the phase of adoption. The contact to CA experts or skilled CA farmers is important to novices. Occurring problems, e.g. with herbicide application can be discussed with skilled persons thus questions can be solved and failures can be avoided. The study at hand reveals the importance of all three factors: If only one element is missing, adoption of CA technologies is far less likely.

### 7.3 Recommendations for research and development cooperation

During preparation of the study at hand and during field work, it was observed that various organizations and institutions are working parallel in the study areas. The Syngenta group offers courses on CA technologies in collaboration with the CETRAD office and advises farmers on the use of herbicides, the Ol Pejeta Conservancy runs several FFS, the MoA is active with its own extension officers, large scale farmers organize field days, High Schools teach their agricultural classes on CA and the FAO carried out a report on the spread of CA. All these activities take place simultaneously and overlap to a certain degree.

- **All institutions and organizations** running some programs to introduce sustainable agriculture technologies in the area should be specified and a way of collaboration between all involved institutions has to be found. This would enable institutions to work together and to enhance their efficiency. Different programs within the same area could

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<sup>27</sup> See Figure 13.

<sup>28</sup> See Figure 25 and Figure 30.

coalesce. Hence, competent advice of farmers who start using the technologies could be provided to more farmers and probably also over a longer time than nowadays because costs could be reduced. Farmers have to be taught until they are not reliant on advice of experts any more and are thus able to solve upcoming problems within the local group of CA farmers. Trainings and on farm follow ups are important to maintain the skills and enhance awareness of farmers.

- **A contact to interested farmers should be established** (by a person, institution or group) to show them what CA technologies include and how they could be implemented on the farms. During field work, some farmers showed interest in CA technologies and asked for more information and education. Such farmers want to learn something and have realized that they have problems with the technologies they are using. Thus, they are probably willing to change their cultivation technologies after getting the required information about the technologies and assistance with implementation.
- To **promote additional benefits** of SWC technologies would increase the adoption rate. Trees and bushes are common CA measures in the three study areas. Trees are esteemed as useful plants by farmers because they provide fire and building wood. Thus, a possible way of introducing other SWC measures is to show farmers the additional benefits of the measure. Napier grass or cover crops as *Dolichos lablab* are plants with such an additional benefit. The beans of *D.lablab* serve as food and the residues can be used as livestock fodder (FAO, 2008). At the same time, the cover crop reduces evaporation and soil erosion.



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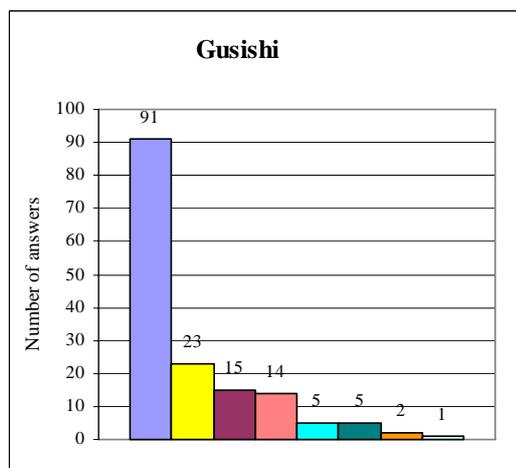
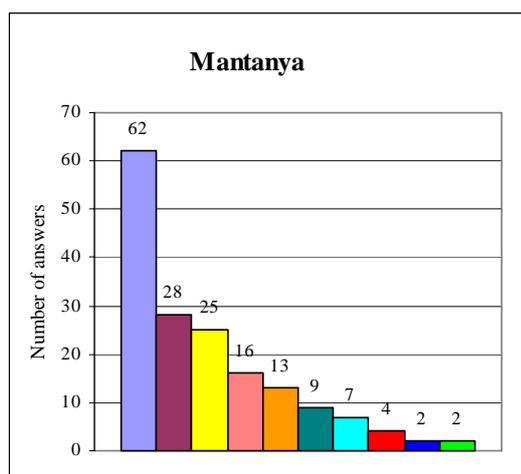
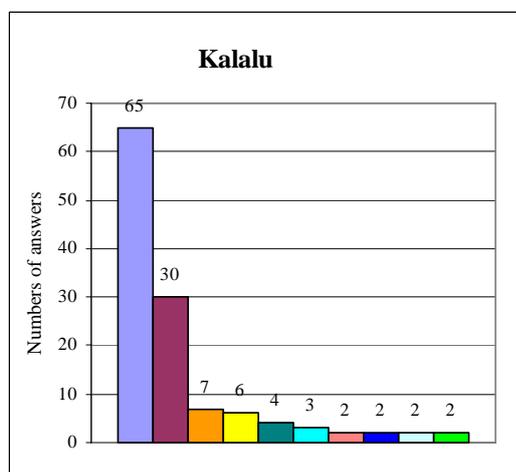
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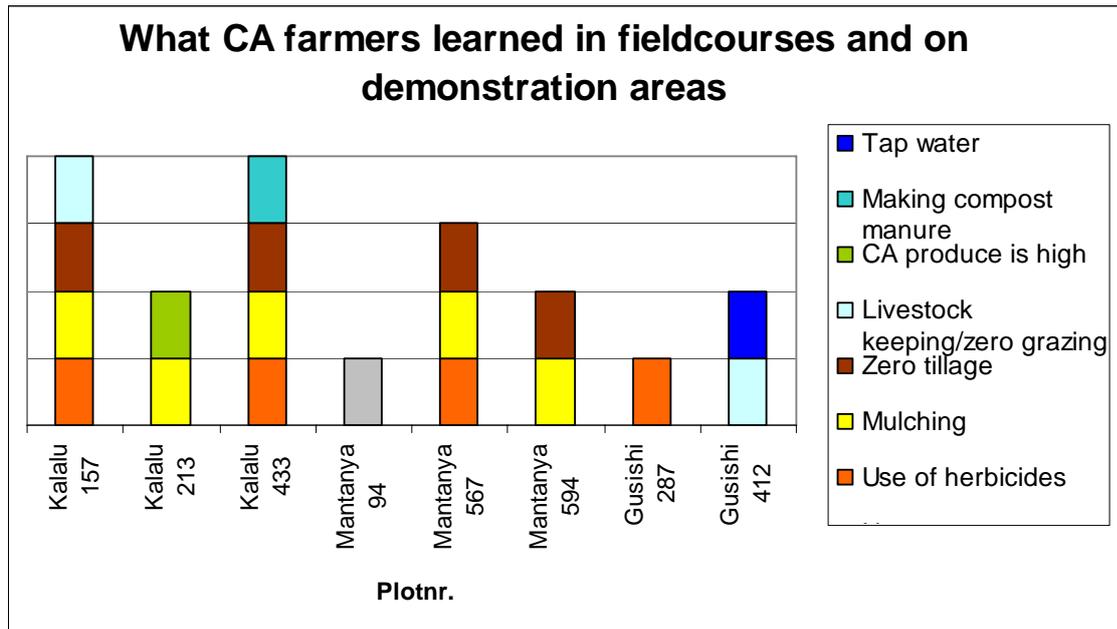
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## Appendix

### Reasons for non-adoption of CA – number of answers given by the farmers





## Questionnaire Study area Plot Nr:

### 1 Questions about the person

- 1.1 Name
- 1.2 Since when are you living here?
- 1.3 Where did you come from?

### 2 Questions about the farm

- 2.1 How big is the land holding (In acres)?
  - 2.1.1 How much of the land holding is crop land?
  - 2.1.2 How much is used for livestock grazing?
    - Controlled
    - Uncontrolled
- 2.2 How much livestock do you keep? (Wiesmann, 1998: 149)
  - Milk cow (1)
  - Other cattle (0.7)
  - Heifers (0.5)
  - Calves (0.25)
  - Sheep and goats (0.1)
  - Other small stock e.g. chicken (0.02)
- 2.3 How many people are living on this farm?
  - 2.3.1 What are their main activities? (How much in each group)
    - No activity: e.g. small children, elderly persons
    - Schooling
    - Working on the farm
    - Working partly on the farm and partly off farm
    - Working off farm
    - Any other (specify)
  - 2.3.2 How many people are depending on the farm?
- 2.4 What are the predominant soils in your farm?
  - Clay red
  - Clay black
  - Clay red basement
  - Any other (specify)
- 2.5 How do you prepare land for planting?
- 2.6 Since when are you working your soils like that?
- 2.7 Is it the same technology as people use at your place of origin?
- 2.8 Do you apply any conservation technologies?
  - 2.8.1 If yes, what type?
  - 2.8.2 If no, why?
- 2.9 On how much of your land are you practicing these technologies? (In acres)
- 2.10 Do you have your own equipment or do you hire it?

### **3 Other people**

#### 3.1 Do you know other people

- Practicing CA?
- Not practicing CA?
- Who may have practiced CA, but have stopped?

## Questionnaire Conservation Agriculture NOT applied

### Information about the person and farm

Name: \_\_\_\_\_ Parcel Nr. \_\_\_\_\_

Living here since \_\_\_\_\_

Place of origin \_\_\_\_\_

Farm size (Landholding) in acres: \_\_\_\_\_

Area under crop production: \_\_\_\_\_

### 1 Questions about the land use technologies

1.1 How do you cultivate your farm?

1.1.1 Which of the following technologies are you using?

Ripping (After harvesting to harvest intermediate rains)

Zero Tillage (Herbicide used before the rains to kill grasses and weeds)

Plough (land is ploughed before the main rains)

Conventional (Preparation is done before the rains with hand hoe or tractor, Plough is deep and soil turned up and down)

Mulching

Others:

1.2 Which crops do you grow on your fields (order of importance)?

1.3 How do you use the crop residues (fodder, burn, mulch)?

1.4 What are in your opinion the advantages of the technologies you apply?

1.5 Are there also some disadvantages?

1.6 Are you content with the following factors on your farm? (1: content – 2: discontent) Why?

1.6.1 Crop production

1.6.2 Soil moisture (Evaporation)

1.6.3 Soil fertility

1.6.4 Livestock production

1.6.5 Runoff

1.6.6 Soil erosion

1.6.7 Labor (more/less/change of peaks compared to other technologies)

1.6.8 Others

### 2 Factors influencing non adoption of CA technologies – Natural factors

2.1 Did the rainfall pattern influence your decision NOT to adopt Conservation Agriculture technologies? Why?

2.2 Did the condition of your soils influence your decision NOT to adopt Conservation Agriculture technologies? Why?

- Rainfall pattern
- Soil erosion

- Soil moisture
- Runoff
- Soil fertility
- Suitability of your soils
- Others:

### **3 Factors influencing non adoption of CA technologies – Human factors**

3.1 Did you get to know about CA technologies? If yes, how?

If no, answer 4.5.1 and then continue with part 5!

3.2 Do you know farmers who are organized in a group and practice CA?

3.3 Did you ever participate in a course in Conservation Agriculture or visit a demonstration area?

If no, continue with question 4.4

3.3.1 What did you learn in this course?

3.3.2 Who organized the course and is supporting the demonstration area?

3.3.3 Did this course or the visit influence your decision on soil/water management? If yes why/how?

3.3.4 Could you describe the condition and texture of your soils?

3.3.5 Have you had problems with the suitability of your soils?

3.4 **Depending on the land!** Is your farm slopy? Are there some problems occurring?

3.5 Could you rank the factors in order of importance for your decision not to adopt CA technologies? (1 very important - 2 important - 3 not important)

3.6 Who was the first person to practice CA technologies in this area?

3.6.1 What do you think of this person or in which social position is this person in the village/area

3.7 How is the social position (reputation) in the community of farmers who are practicing CA?

3.7.1 What are old traditional/cultural farming practices?

3.7.2 Which (technologies/practices) are currently in practice?

3.7.3 How do they influence adoption of CA technologies?

3.8 Could you rank the factors in order of importance for your decision not to apply CA technologies? (1 very important - 2 important - 3 not important)

- Organization in a group (self-help groups)
- Participation on a course in CA
- Visiting a demonstration area
- First person who was practicing CA in the region
- Social position of farmers who are practicing CA

- Cultural practices in crop production

## **4 Factors influencing non adoption of CA technologies – Origin of equipment**

4.1 What types of tools do you use for your work?

Oxen  
Jembe/Hoe  
Folk Jembe  
Ripper  
Shovel  
mattock  
Victory plough  
Plough unit  
Chisel (tindo)  
Tractor  
Combine Harvester  
Drill  
Sprayer  
Others:

4.2 Do you own or hire your equipment?

4.2.1 If you hire it: From whom?

4.2.2 Where do you buy your equipment from?

4.3 Where is the equipment, you are using produced (locally made/ imported)?

4.3.1 If it is imported: From where?

4.4 How much do the tools you own cost?

4.4.1 Which problems did you face getting the equipment?

4.4.2 Did you get some financial support for the initial investments (e.g. for machinery)?

4.4.2 If yes: From whom?

## 5 Questions to the social environment

### 5.1 Household Tree

**Gender**            Square:            Male  
                          Circle:            Female

#### Age

0      0-5  
 1      6-10  
 2      11-15  
 3      16-20  
 4      21-30  
 5      31-40  
 6      41-50  
 7      51-60  
 8      61-70  
 9      > 70

#### Activity/Occupation of all the household members

0 No activity - e.g. small children, elderly persons  
 1 Schooling – Nursery School  
 2 Schooling – Primary School  
 3 Schooling – Secondary School  
 4 Schooling – University  
 5 Schooling – in specific informal training (fundi, tailor)  
 6 Schooling – in specific formal training (polytechnic)  
 7 Schooling – Special schools  
 10 Working on the farm – no other activity  
 11 Working on the farm as well as in the household  
 12 Working partly on the farm and partly off-farm  
 13 Working in the household – no other activity  
 20 Working off-farm – not specific  
 -99 Occupation not indicated

#### Sector (only in off-farm)

First digit – Off-farm level

0 Occasional casual jobs  
 1 Regular casual jobs  
 2 Permanent employment in private Sector  
 3 Permanent employment in Government/parastatal  
 4 Self employed

Second digit – Sector of off-farm

1 Agriculture, ranching, forest  
 2 Domestic and security  
 3 Jua Laki, informal and small enterprise sector  
 4 Production and Repair

- 5 Trade and Transport
- 6 Hotel, entertainment, tourism, services
- 7 Education, health, church
- 8 Civil service
- 9 NGO

**Education Level (for every adult member)**

- 0 No formal schooling
- 1 Started primary school, but did not complete
- 2 Ended education with primary school certificate
- 3 Started secondary, but did not complete
- 4 Ended education with form 4 certificate (O-level)
- 5 Ended education with form 6 certificate (A-level)
- 6 Informal training after primary or secondary (e.g. driving, tailoring)
- 7 Formal training after primary or secondary (e.g. polytechnic)
- 8 Diploma training
- 9 University and post graduate
- 99 Education level not indicated

**Indicate degree of living on the plot (for every member)**

- 0 Stays permanently on the plot
- 1 is leaving the plot during times of casual employment (or similar) – else stay there
- 2 Stays regularly on weekend and in holidays on the plot
- 3 Stays quite often on weekends and in holidays on the plot (ca. every second weekend)
- 4 Stays regularly during leave (holidays) on the plot
- 5 Stays sometimes during leave (holiday) on the plot
- 6 Visits regularly several times a year (also on other occasions than family meetings)
- 7 Visits only or mainly for special family occasions (e.g. Christmas)
- 8 The visits are few and irregular
- 9 May visit occasionally
- 10 Does not visit at all

## Questionnaire Conservation Agriculture applied

### Information about the person and farm

Name: \_\_\_\_\_ Parcel Nr. \_\_\_\_\_

Living here since \_\_\_\_\_

Place of origin \_\_\_\_\_

Farm size (Landholding) in acres: \_\_\_\_\_

Area under crop production: \_\_\_\_\_

### 1 Questions about the land use technologies

1.1 How do you cultivate your farm? \_\_\_\_\_

1.1.1 Which of the following technologies are you using

Ripping (After harvesting to harvest intermediate rains)

Zero Tillage (Herbicide used before the rains to kill grasses and weeds)

Plough (land is ploughed before the main rains)

Conventional (Preparation is done before the rains with hand hoe or tractor, Plough is deep and soil turned up and down)

Mulching

Others:

1.2 Which crops do you grow on your fields (order of importance)?

1.3 How do you use the crop residues (fodder, burn, mulch)?

1.4 Which of the technologies you are using are Conservation technologies?

1.5 Why do you apply these technologies?

1.6 Since when do you apply these technologies?

1.7 On how much of your farm do you apply CA technologies? (In acres)

1.8 What are in your opinion the advantages of the technologies you apply?

1.9 Are there also some disadvantages? If yes, which ones?

1.10 Please match the categories: *1: more/better – 2: equal – 3: less/worse – 4: don't know*, to the following questions. Compare the technology you are now using with the one you used before.

1.10.1 How is the technology you are using influencing **livestock production**? Why?

1.10.2 How is the technology you are using influencing **other factors**? Why?

1.11 Please match the categories: *1: less – 2: equal – 3: more – 4: don't know*, to the following questions. Compare the technology you are now using with the one you used before.

1.11.1 How is the technology you are using influencing **runoff**? Why?

1.11.2 How is the technology you are using influencing **soil erosion**? Why?

1.11.3 How is the technology you are using influencing **labor** (change of peaks)? Why?

1.11.4 How is the technology you are using influencing **other factors**? Why?

## **2 Factors influencing adoption of CA technologies – Natural factors**

- 2.1 Did the rainfall pattern influence your decision to adopt Conservation Agriculture technologies? Why?
- 2.2 Did the condition of your soils influence your decision to adopt Conservation Agriculture technologies? Why?
- 2.2.1 Could you describe the condition and texture of your soils before you started using CA technologies?
- 2.2.2 Could you describe the condition of your soils right now?
- 2.2.3 Have you had problems with the suitability of your soils?
- 2.3 **Depending on the land!** Is your farm slopy? What experiences did you make since you applied CA technologies?
- 2.4 Could you rank the factors in order of importance for your decision? (1 very important - 2 important - 3 not important – 4 don't know)
- Rainfall pattern
  - Soil erosion
  - Soil moisture
  - Runoff
  - Soil fertility
  - Suitability of your soils
  - Others:

## **3 Factors influencing adoption of CA technologies – Human factors**

- 3.1 How did you get to know about CA technologies?
- 3.2 Are you organized in a group with other farmers who are practicing CA?
- 3.2.1 Do you support each other in this group? How?
- 3.3 Did you ever participate in a course in Conservation Agriculture or visit a demonstration area?
- 3.3.1 What did you learn in this course?
- 3.3.2 Who organized the course and is supporting the demonstration area?
- 3.3.3 Did this course or the visit influence your decision on soil/water management? If yes why/how?
- 3.4 Who was the first person to practice CA technologies in this area?
- 3.4.1 What do you think of this person or in which social position is this person in the village/area?
- 3.5 How is the social position (reputation) of farmers in the community who are practicing CA?
- 3.5.1 What are the old traditional/cultural farming practices?
- 3.5.2 Which (technologies/practices) are currently in practice?
- 3.5.3 How do they influence adoption of CA technologies?
- 3.6 Could you rank the factors in order of importance for your decision? (1 very important - 2 important - 3 not important)

- Organization in a group (self-help groups)
- Participation in a course of CA
- Visiting a CA demonstration area
- First person who was practicing CA in the region
- Social position of farmers who are practicing CA
- Cultural practices in crop production

#### **4 Factors influencing adoption of CA technologies – Origin of equipment**

4.1 What types of tools do you use for CA?

Oxen  
 Jembe/Hoe  
 Folk Jembe  
 Ripper  
 Shovel  
 mattock  
 Modified Victory plough beam to rip the soil  
 Plough unit  
 Chisel (tindo)  
 Tractor  
 Combine Harvester  
 Drill  
 Sprayer  
 Others:

4.2 Do you own or hire your equipment?

4.2.1 If you hire it: From whom?

4.2.2 Where do you buy your equipment from?

4.3 Where was the equipment, you are using, produced (locally made/ imported)?

4.3.1 If it is imported: From where?

4.4 How much do the tools you own cost?

4.4.1 Which problems did you face getting the equipment?

4.5 Did you get some financial support for the initial investments (e.g. for machinery)?

4.5.1 If yes: From whom?

#### **5 Questions to the social environment**

See questionnaire 'Conservation agriculture not applied'

## Questionnaire Conservation Agriculture ONCE applied

### Information to the person and farm

Name: \_\_\_\_\_ Parcel Nr. \_\_\_\_\_

First name: \_\_\_\_\_

Living here since \_\_\_\_\_

Place of origin \_\_\_\_\_

Farm size (Landholding) in acres:

Area under crop production:

CA applied from/till:

CA applied on % of the farm.

### 1 Questions about land use technologies

1.1 How do you cultivate your farm?

1.1.1 Which of the following technologies are you using

Ripping (After harvesting to harvest intermediate rains)

Zero Tillage (Herbicide used before the rains to kill grasses and weeds)

Plough (land is ploughed before the main rains)

Conventional (Preparation is done before the rains with hand hoe or tractor, Plough is deep and soil turned up and down)

Mulching

Others:

1.2 Which crops do you grow on your fields (order of importance)?

1.3 How do you use the crop residues (fodder, burn, mulch)?

1.4 What are in your opinion the advantages of the technologies you apply?

1.5 Are there also some disadvantages? If yes, which ones?

1.6 Please match the categories: 1: *more/better* – 2: *equal* – 3: *less/worse* – 4: *don't know*, to the following questions. Compare the technology you are now using with the one you used before.

1.6.1 How is the technology you are using influencing **crop production**? Why?

1.6.2 How is the technology you are using influencing **soil moisture** (Evaporation)? Why?

1.6.3 How is the technology you are using influencing **soil fertility**? Why?

1.6.4 How is the technology you are using influencing **livestock production**? Why?

1.6.5 How is the technology you are using influencing **other factors**? Why?

1.7 Please match the categories: 1: *less* – 2: *equal* – 3: *more* – 4: *don't know*, to the following questions. Compare the technology you are now using with the one you used before.

1.7.1 How is the technology you are using influencing **runoff**? Why?

1.7.2 How is the technology you are using influencing **soil erosion**? Why?

1.7.3 How is the technology you are using influencing **labor** (change of peaks)? Why?

1.7.4 How is the technology you are using influencing **other factors**? Why?

## **2 Factors influencing adoption of CA technologies – Natural factors**

2.1 Did you change back to traditional technologies because of the rainfall pattern?

2.2 Did the condition of your soils influence your decision to change back to traditional technologies? Why?

2.2.1 Could you describe the condition and texture of your soils when using CA technologies?

2.2.2 Could you describe the condition and texture of your soils right now?

2.2.3 Have you had problems with the suitability of your soils?

2.3 **Depending on the land!** Is your farm slopy? What experiences did you make since you stopped CA technologies?

2.4 Could you rank the factors in order of importance for your decision to change back to traditional technologies? (1 very important - 2 important - 3 not important – 4 don't know)

- Rainfall pattern
- Soil erosion
- Soil moisture
- Runoff
- Soil fertility
- Suitability of your soils
- Others:

## **3 Factors influencing adoption of CA technologies – Human factors**

3.1 How did you get to know about CA technologies?

3.2 Were you organized in a group with other farmers who are practicing CA?

3.3 Did you support each other in this group? How?

3.4 Did you ever participate on a course in Conservation Agriculture or visit a demonstration area?

3.4.1 What did you learn in this course?

3.4.2 Who organized the course and is supporting the demonstration area? \_

3.4.3 Did this course or the visit influence your decision how to work soils? If yes why?

3.5 Who was the first person to practice CA technologies in this area?

3.5.1 What do you think of this person or in which social position is this person in the village/area?

3.6 How is the social position (reputation) in the community of farmers who are practicing CA?

3.6.1 What are the old traditional/cultural farming practices?

- 3.6.2 Which (technologies/practices) are currently in practice?
- 3.6.3 How do they influence adoption of CA technologies?
- 3.7 Could you rank the factors in order of importance for your decision to change back to traditional technologies? (1 very important - 2 important - 3 not important)
- Organization in a group (self-help groups)
  - Participation on a course in CA
  - Visiting a demonstration area
  - First person who was practicing CA in the region
  - Social position of farmers who are practicing CA
  - Cultural practices in crop production

#### **4 Factors influencing adoption of CA technologies – Origin of equipment (5.1 – 5.5.1 for the time CA was practiced)**

- 4.1 What types of tools did you need for CA?
- Oxen
  - Jembe/Hoe
  - Folk Jembe
  - Ripper
  - Shovel
  - Mattock
  - Modified Victory plough beam to rip the soil
  - Plough unit
  - Chisel (tindo)
  - Tractor
  - Combine
  - Drill
  - Sprayer
  - Others:
- 4.2 Did you own or hire your equipment?
- 4.2.1 If you hired it: From whom?
- 4.2.2 Where did you buy your equipment from?
- 4.3 Where was the equipment, you were using produced (locally made/imported)?
- 4.3.1 If it was imported: From where?
- 4.4 How much did the tools you owned cost?
- 4.4.1 Which problems did you face getting the equipment?
- 4.5 Did you get some financial support for the initial investments (e.g. for machinery)?
- 4.5.1 If yes: From whom?
- 4.6 What types of tools do you need now?
- Oxen
  - Jembe/Hoe
  - Folk Jembe

Ripper  
Shovel  
mattock  
Modified Victory plough beam to rip the soil  
Plough unit  
Chisel (tindo)  
Tractor  
Combine  
Drill  
Sprayer  
Others:

4.7 Do you own or hire your equipment?

4.7.1 If you hire it: From whom?

4.7.2 Where do you buy your equipment from?

4.8 Where was the equipment, you are using produced (locally made/imported)?

4.8.1 If it is imported: From where?

4.9 How much do the tools you own cost?

4.9.1 Which problems did you face getting the equipment?

4.10 Did you get some financial support for the initial investments (e.g. for machinery)?

4.10.1 If yes: From whom?

## **5 Questions to the social environment**

See questionnaire 'Conservation agriculture not applied'