Graduate Institute of International Development and Applied Economics

WHAT ARE THE IMPACTS OF CONSERVATION AGRICULTURE ON THE LIVELIHOODS OF SMALLHOLDER FARMERS IN ARUSHA REGION, TANZANIA?

Alastair Stewart

Dissertation prepared in partial fulfilment of the requirements for
MSc Agriculture & Development

September 2011

Acknowledgements

I wish to thank all who participated in the research: the members of the Farmer Field Schools, agricultural extension workers, and the staff at SARI, CPAR, WADEC, RECORDA, NANDRA and CAMTEC whom I visited, who made me feel extremely welcome and willingly gave me their valuable time.

I am especially grateful for the help of the following three people without whom this research would not have been possible: Wilfred Mariki (SARI), Maritha Owenya (SARI) and Deogratias Ngotio (CPAR). Their assistance in organising, translating, transporting, explaining and re-explaining was invaluable and contributed hugely to a successful research placement.

I would also like to thank my two tutors at the University of Reading: Prof. Amir Kassam for his assistance in organising the placement, his Conservation Agriculture expertise and for providing inspiration just when it was required and Dr. Alistair Murdoch for his help in developing the research question again and again, his guidance along the way on all dissertation related queries and for pushing me to apply for funding.

Finally, and extremely importantly, I wish to thank the Tropical Agricultural Association and the Mursley School House trust for the funding they awarded me in order to complete the research placement. I feel extremely honoured and privileged to have received funding to complete this research, from which I have gained so much experience and understanding.

Table of Contents

List of Figures and Tables

Abbreviations

ACT	African Conservation Tillage network
CA	Conservation Agriculture
CAMARTEC	Centre for Agricultural Mechanization and Rural Technology
CA-SARD	Conservation Agriculture for Sustainable Agriculture and Rural Development
CCA	Climate Change Adaptation
CPAR	Canadian Physicians for Aid and Relief
FAO	Food and Agriculture Organisation of the United Nations
FFS	Farmer Field School
GDP	Gross Domestic Product
HIV	Human immunodeficiency virus
MDGs	Millennium Development Goals
NGO	Non-governmental organisation
PRA	Participatory Rural Appraisal
RECODA	Research, Community and Organizational Development Associates
SARI	Selian Agricultural Research Institute
SSA	Sub-Saharan Africa
TZS	Tanzania shilling – valued at 1500 to USD 1 in this report
US$	United States dollar
VICOBA	Village Community Bank
VLE	Village Level Enterprise
WADEC	Women's Agriculture Development and Environmental Conservation

Summary

Conservation Agriculture is being adopted by smallholder farmers in Arusha Region, Tanzania as a means of restoring the fertility and productivity of soils which have degraded due to the effects of tillage and erosion. Using the three CA principles of soil cover with organic matter, minimum soil disturbance and diversifying crop rotations the productivity of the land can be improved, which is important for the food security and poverty reduction of the rural poor. This research will investigate how the livelihoods of smallholder farmers have changed since adoption of CA, concentrating specifically on its potential to contribute towards poverty reduction. To measure impacts of livelihood the study uses the concepts of asset accumulation, livelihood diversification, perceptions of vulnerability and the role of networks as areas of focus, taking the form of a livelihood impact assessment. Each of these concepts form the basis of the four objectives on which this dissertation focuses throughout.

Smallholder farmers from Arumeru and Karatu districts of Arusha Region participated in the research, all of whom were members of farmer field school set up in the area to encourage CA adoption. The research consisted of workshops which used participatory and qualitative techniques such as ranking matrixes, seasonal budgets, group surveys and focus groups. Other participants included government extension workers and agronomists, NGO staff and representatives of farming equipment manufacturing companies.

The research found that CA has contributed to the accumulation of assets held by smallholder farmers in areas of natural, social, financial, human and physical capital; has improved the productivity of land with higher output to input ratios; reduced the

necessity to resort to coping strategies as a way of meeting income gaps and increased resilience to shocks and stresses such as periods of drought and low rainfall. Involvement in farmer field schools has been shown to increase smallholder farmers' involvement in networks and interaction with outside parties, and the research has identified the decisions made by outside parties that have successfully generated a facilitating environment for smallholders to adopt CA. Cross-cutting themes that cover all the objectives include the role of livestock in CA systems, accessibility and affordability of CA equipment and impacts on the gender roles within households and on-farm activities.

Word count:

Chapter	**Words**
Introduction	1,477
Literature Review	3,121
Methodology	1,720
Results	868
Discussion	4,662
Conclusion	1,444
Total	**13,292**

Chapter 1 – Introduction

This research project will investigate the impacts of Conservation Agriculture (CA) on the livelihoods of smallholder farmers in the Arusha Region of Tanzania. CA has been promoted in this area by government agricultural programmes, research centres and non-governmental organisations (NGOs) in an attempt to address the problems of declining yields, water stress, soil degradation and erosion. By addressing these issues it is hoped that smallholder farmers can raise production levels, helping them to achieve food security and make the transition from subsistence to semi-commercial farming.

The focus of this research is on the livelihood aspects of CA, attempting to identify how the lives of farmers who have adopted CA approaches have changed. The aim is not to become embroiled in the debate surrounding the agronomic benefits or shortcomings of the three CA principles, a topic that has been well debated and documented in agricultural development literature (Fowler et al, 2001; Friedrich et al, 2008; Kassam et al, 2009; Giller et al, 2009; and Pretty et al, 2011). Although there is still scope for more research on the agronomic aspects of CA (Giller et al, 2011) it is also important to consider the human and social impacts of the technology so that CA can be judged by the effectiveness of its contribution to rural poverty reduction.

1.1. Principles of Conservation Agriculture

Whilst not wanting to become entrenched in the technical aspects of the CA principles it is vital to understand these technicalities to appreciate the reasons for its application and relevance to agriculture in Northern Tanzania and more widely in sub-Saharan Africa (SSA). CA claims to enable sustainable intensification of agriculture by

conserving and enhancing the quality of the soil, leading to higher yields and the protection of the local environment and ecosystem services (Friedrich et al, 2008: p4). CA is based upon three key principles; (1) minimum soil disturbance, (2) permanent organic-matter soil cover and (3) diversified crop rotations.

Conventional tillage methods provide short term benefits for growing crops by loosening the soil, making a seedbed and controlling weeds (Kassam et al, 2009: p293). Over time however, this practice compacts the soil, releases stored carbon into the atmosphere and speeds up the oxidation of organic soil matter (Kassam et al, 2009: p293). The consequences of this are decreased water absorption, soil erosion, loss of soil structure and nutrients, reduced organic soil matter, less biodiversity and ultimately falling crop yields.

A non-tillage approach involves the direct planting of seeds through mulch from previous crops, with as little soil disturbance as possible. By covering the soil with mulch it is protected from the effects of rain and wind erosion and provides a habitat for insects and bacteria which decompose the mulch and incorporate it into the soil (Friedrich et al, 2008: p2). Diversified crop rotation is important for encouraging biodiversity, building up a diverse nutrient base in the soil and for pest management. Firstly, the rotation of crops with different root lengths will mobilise the existing nutrients and the selection of high biomass legumes will fix nitrogen from the atmosphere and enhance the range of nutrients in the soil (Friedrich et al, 2008: p3). Secondly, by changing the available host plants, crop rotations will disrupt the lifecycle of some major pests and diseases that may have been encouraged by the permanent soil cover. These principles are aimed at

enhancing natural biological processes above and below the ground so that the soil becomes potentially self-sustainable (Kassam et al, 2009: p293).

1.2. Role of Conservation Agriculture in Africa

In the specific context of Africa, CA is relevant to addressing the challenges of environmental degradation, climate change and labour shortages that are faced by resource poor farmers who often have less than one hectare of land to support their livelihoods. Evidence from a wide range of African countries in different agro-ecological and socio-economic conditions show increases in soil health and fertility management using CA practices in both small and large-scale farms (Pretty et al, 2011: p15). In Africa, CA has the potential of reversing the current annual 3% decrease in agricultural production due to soil erosion and land degradation by providing more stability in crop production and better ratios of outputs over inputs (FAO, 2009: p15).

CA provides environmental services such as contributing to atmospheric carbon sequestration, preserving biodiversity, managing watersheds and preventing soil erosion (Fowler et al, 2001). Communities and societies can also benefit from the adoption of CA through improved food and water security, more reliable water supplies (Fowler et al, 2001: p2) and protection of ecosystem services (Kassam et al, 2008: p309). In the context of labour constraints due to HIV/AIDS and rural migration to towns and cities, less labour intensive CA systems can leave farmers with more time to dedicate to other activities (FAO, 2009: p16).

Agriculture in SSA accounts for around 65% of full-time employment and between 25-30% of the continent's gross domestic product (GDP), with production trebling between 1960 and 2010 (Pretty et al, 2011: p6).

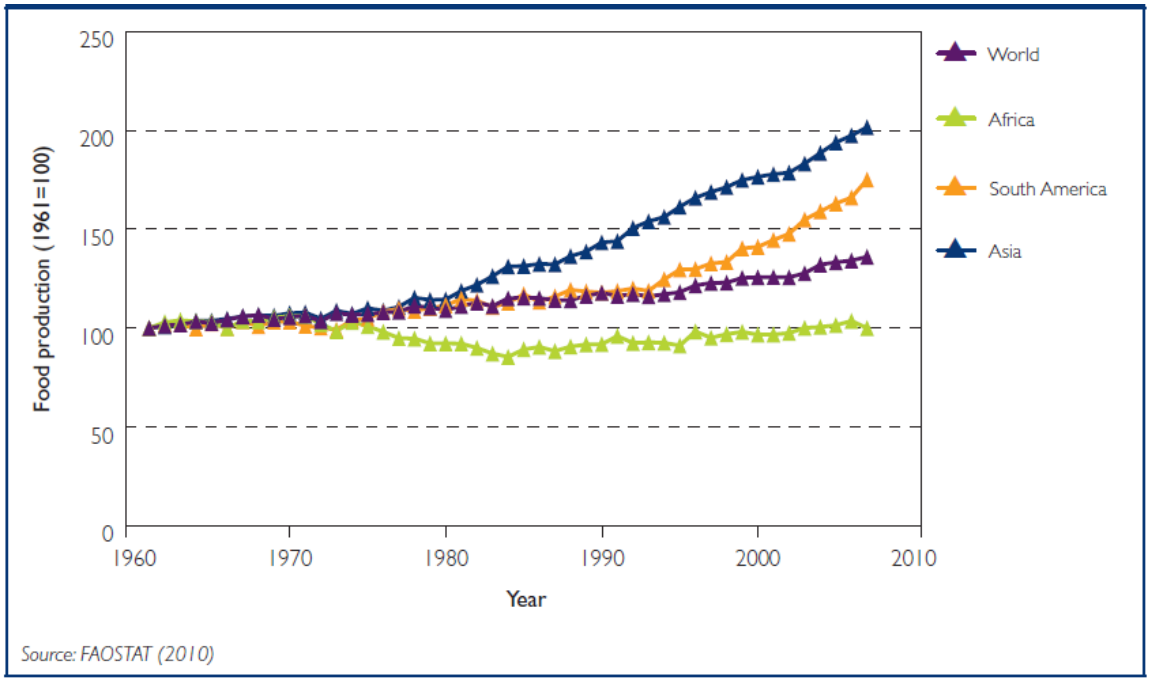

Figure 1 – Changes in per capita net agricultural production (1961-2007)

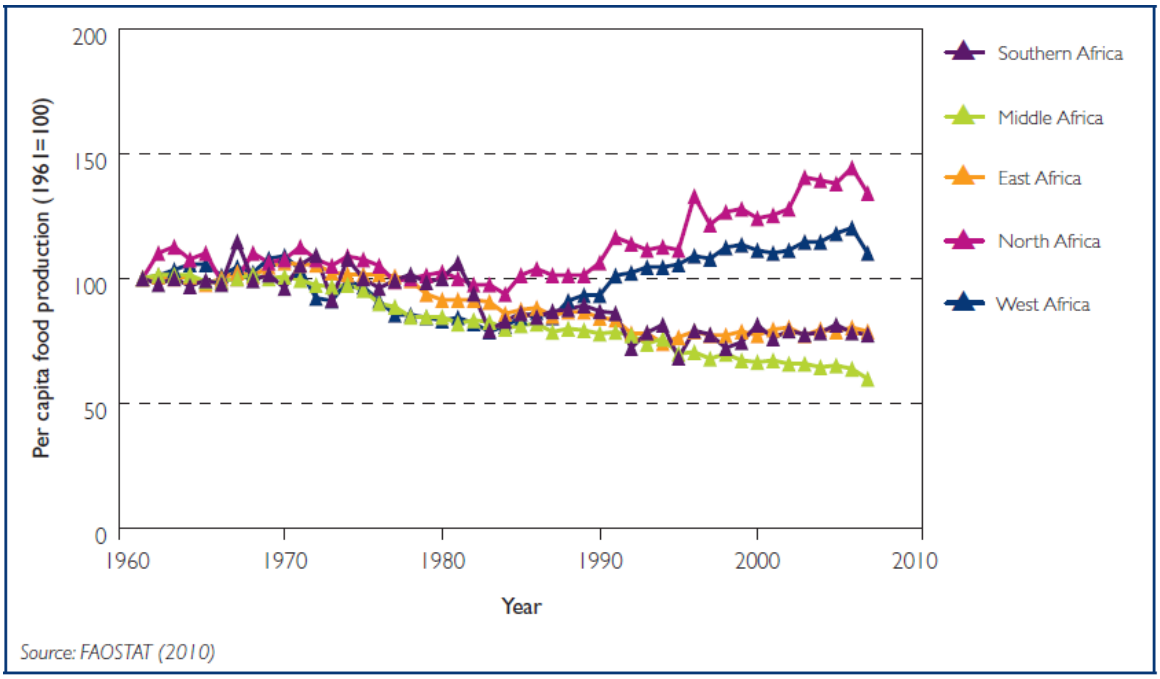

Figure 2 – Africa: changes in per capita net agricultural production (1961-2007)

Source: Pretty et al, 2011.

Despite this increase, Africa lags behind the rest of the world in regards to agricultural production with per capita net agricultural production at the same levels in 2007 as 1961 (Figure 1) and with the southern, central and eastern regions of Africa

witnessing a steady decrease in per capita net agricultural production since the 1970s (Figure 2). Explanation of this per capita decrease in production can be attributed to the reliance on rainfed farming systems, neglect of African agriculture among policymakers and international donors (Diao et al, 2008: p539), lack of processing, marketing and transport infrastructure and lack of access to inputs and credit. It is argued however, that an African Green Revolution should be built upon the lessons learned from Asia over the last 40 years. High input farming systems that depend heavily on chemical fertilizers and pesticides do not maintain the soil's natural fertility and also lead to the generation of resistant pests, leading to ever more increased use of chemical inputs (Rosset, 2000: p4). These methods can increase production and be more profitable but only if the price of crops stay ahead of the costs of petrochemicals and machinery (Rosset, 2000: p4). Even if this is the case, the long term impact of high input farming on ecosystem services can have serious consequences on the ability of land to maintain adequate production levels in the future, raising the necessity for alternative and more sustainable agricultural practices.

Sustainable agricultural intensification can be defined as producing more output from the same area of land while reducing the negative environmental impacts and at the same time increasing contributions to natural capital and the flow of environmental services (Pretty et al, 2011: p7). For producers, sustainable production systems should offer higher productivity and profitability with reduced vulnerability to shocks such as extreme weather conditions (Kassam et al, 2011: p2).

Future global food security relies not only on high production of food but also on accessibility of food and the need to address the destructive effects of current agricultural

production systems on ecosystem services (Foresight, 2011: p42). Sustainable agricultural intensification has become “imperative” (Fowler et al, 2001: p94) and provides an opportunity not only to increase agricultural productivity but also to address problems of environmental degradation and increase resilience to the effects of climate change.

However the win-win rhetoric of strategies for sustainable agriculture, such as CA, agroforestry and organic farming, have been criticised as being more hypothetical than real (Tschakert, 2005: p75) with claims that the synergies of poverty reduction and renewable natural resource conservation “do not naturally emerge” (Barrett et al, 2005: p193). Despite this, Fowler et al (2001: p103) believe the “degradation and loss of Africa’s agricultural resources must be urgently addressed. The adaptation and adoption of CA techniques can reduce and reverse current trends, but these options need to be identified and communicated to resource poor farmers”.

The aim of this research is to investigate the impacts of CA on the livelihoods of smallholder farmers in an area where they have had such options communicated to them; in the hope of gaining a better insight into the potential for CA to accomplish both natural resource conservation and poverty reduction. The objectives of the research are as follows:

- (1) Compare the assets held by smallholder farmers before and after adoption of conservation agriculture practices.
- (2) Identify the livelihood strategies of smallholder farmers practising conservation agriculture.

- (3) Explore smallholder farmers' perceptions of their vulnerability to shocks and stresses and how these perceptions may have changed since adoption of conservation agriculture.
- (4) Investigate the role of institutional structures on the livelihoods of farmers adopting conservation agriculture.

Chapter 2 – Literature Review

To investigate the impacts of CA on the livelihoods of smallholder farmers in Tanzania it is important not only to understand the technicalities and purpose of CA but to comprehend what is meant by the term 'livelihood'. Chambers and Conway (1992: p6) define a livelihood as comprising "the capabilities, assets and activities required for a means of living". The term livelihood is often preceded by 'sustainable' which as Chambers et al (1992: p6) explain as being one which "*can cope with and recover from stress and shocks, maintain or enhance its capabilities and assets, and provide sustainable livelihood opportunities for the next generation...*" Assessing impact on livelihoods therefore must take into consideration the assets owned by an individual, household or community and the activities by which these assets are gained, retained and protected. Assets are both tangible and intangible (Table 1), contribute to a sustainable livelihood when they can be maintained or enhanced and their availability effects the ability of an individual or group to respond to stresses and shocks.

Table 1 – Examples of tangible and intangible assets

ASSETS			
TANGIBLE		INTANGIBLE	
STORES	RESOURCES	CLAIMS	ACCESS
Food stocks Stores of value such as gold and jewellery Cash savings in banks	Land Water Livestock Farm equipment	Demands or appeals for food, loans, work etc. Often made at times of stress or shock	Opportunity to use a service e.g. transport, education, health etc Opportunity to obtain information e.g. extension services, radio, newspapers

Source: Adapted from text in Chambers and Conway, 1992

From the birth of this concept of livelihoods the Sustainable Livelihoods Approach has emerged which measures assets of natural, social, physical, human and financial capital to design development programmes at the community level (Hahn et al, 2009: p75). Bebbington (1999: p2028) states that viable livelihoods have the ability to gain and secure access to resources and opportunities, use such resources and opportunities intelligently, and finally, to gain access "to networks, institutions and relationships" which subsequently increases the successful attainment of both resources and opportunities, highlighting therefore, that networks and relationships may well be the most important factor in securing livelihoods.

Using these concepts of livelihoods, the literature review will now explore four main areas of (1) asset accumulation, (2) livelihood strategies, (3) vulnerability and resilience and (4) the role of networks and institutional structures. Each area will be explored in the context of rural smallholder farmers and although in some instances literature for each of the four areas may not be directly related to CA, the review will combine research from both livelihood and CA literature in an attempt to find evidence that supports or opposes the potential of CA to contribute to poverty reduction.

2.1. Asset Accumulation

Successful asset accumulation, Ellis et al (2003: 1372) claim, is critical for the achievement of rising prosperity over time. Measurement of this accumulation can be aided by the division of assets into the categories of produced (or physical and financial), human, social and natural capital. Bebbington (1999: p2029) describes capital as being the "resources that make livelihood strategies possible, the assets that give people capability and the outputs that make livelihoods meaningful and viable."

The relevance of CA within these capitals is most obvious in the form of natural capital. As Fowler et al (2001: p95) identify, the primary cause of resource loss and environmental degradation on African arable land are the hand hoe and mouldboard plough, responsible for the damaging effects of soil erosion and water loss from runoff. Using evidence from a study by Vogel (1994) in Zimbabwe, Fowler et al (2001: p96) demonstrate the ability of no-till and mulching to reduce soil and water loss (Figure 3).

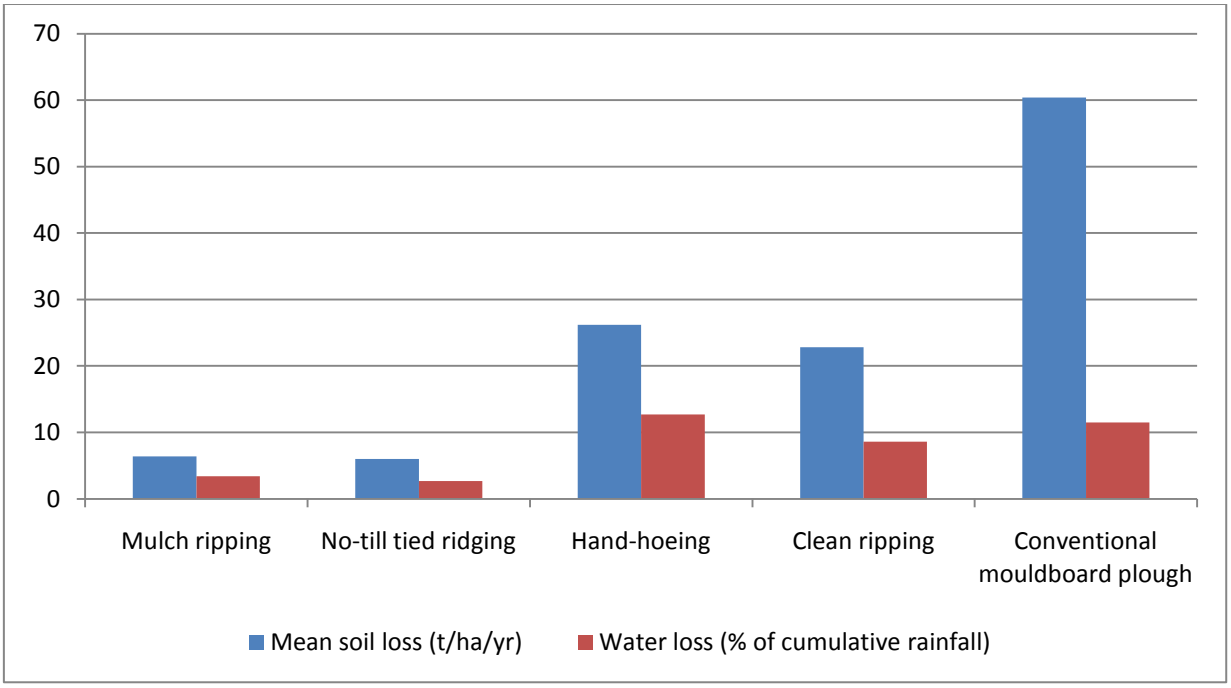

Figure 3 - Comparisons over six seasons of soil and water loss in Zimbabwe

Source: Adapted from data in Fowler et al (2001: p96)

With 24 billion tons of topsoil being lost on an annual basis (globally) and with 70% of the world-wide dry land crop production area degraded (Fowler et al, 2001: p95) soil erosion from conventional tillage has led to the decline of soil fertility with devastating effects for resource poor smallholder farmers who cannot access or afford the inputs necessary to maintain soil fertility and adequate levels of production. Through the application of CA techniques smallholder farmers have the potential to build their

natural capital by improving the fertility and water use efficiency of their soil allowing them to improve yields without the need for large amounts of expensive inputs such as inorganic fertiliser and pesticides (Friedrich et al, 2009: p4). This leads to a low input, high output system which benefits farmers by increasing yields to levels where they can sell surplus crops. This increased yield leads to a higher income which in turn leads to the accumulation of assets such as investment in savings (financial capital), household improvements (physical capital) or education (human capital).

Bebbington (1999: p2034) describes social capital as belonging to "that alarmingly long list of terms in development that are notoriously difficult to define." Words that pervade other efforts at defining social capital include norms, networks, social structures, collective action and individual and community objectives. However social capital is defined, it is becoming widely accepted that it plays a crucial role in the livelihoods of the rural poor. Bebbington (1999: p2034) writes "networks and organisations play a vital role in helping people act to improve their livelihoods, mobilise assets and defend them" whilst Smith et al (2001: p431) in their study of livelihood diversification in Uganda explain that the "most apparent vehicle for livelihood diversification, enhancement and differentiation within the communities were the small informal groups or associations which rely upon norms, objectives, reciprocity and trust to survive."

The spread of CA in the northern zones of Tanzania has been facilitated through the promotion of farmer field schools (FFS) through which groups of 25 to 30 smallholder farmers are trained on CA techniques. The formation of these groups enables farmers to test new techniques on a shared plot of land before transferring the methods back to their own land, and to discuss agricultural and social issues with other group members

(Owenya et al, 2011: p147). The groups are facilitated by village and ward level government extension workers who not only train the farmers on CA techniques but on other topics such as livestock management and HIV prevention. Smith et al (2001: p431) comment that the success of such groups "has been characterised by experience, education and links gained outside of the community context ... benefiting from government, donor and NGO infrastructural investment in the districts." Involvement in CA FFS can therefore lead to the accumulation of social capital amongst the group members, which leads to further access and accumulation of assets.

Human capital or the skills, knowledge and experience owned by an individual or population are important in developing the ability to engage, negotiate, discuss and enhance their potential to be agents of change (Sen, 1997: p1959). Looking back at the division of assets in Table 1, human capital relates to access to education, health and information services. Rigg (2006: 196) claims that the best means of reducing poverty in rural areas is not by supporting smallholder farming but by building the skills of poor people so they "can escape from farming and perhaps, escape from the countryside." Rigg's use of language may seem extreme but his reasoning is confirmed by the importance placed by many smallholder farmers on the need for education for their children, the growing number of young people leaving farming and the ageing farming population in rural areas of developing countries. Whilst ignoring smallholder agriculture is not the answer to poverty reduction there is a growing importance being placed on livelihood diversification.

2.2. Livelihood Strategies

This move away from farming or as Bryceson (2002: p726) labels it 'deagrarianisation' is a "long-term process of occupational adjustment, income-earning reorientation ... and spatial relocation of rural dwellers away from strictly agricultural-based modes of livelihood." Rigg's (2006: p189) belief that it is young people who are "most urgently and fervently" attempting to escape farming is based upon the factors of decline in productivity of smallholder agriculture, environmental degradation, land shortages and the emergence of new opportunities in the non-farm sector (Rigg, 2006: p187).

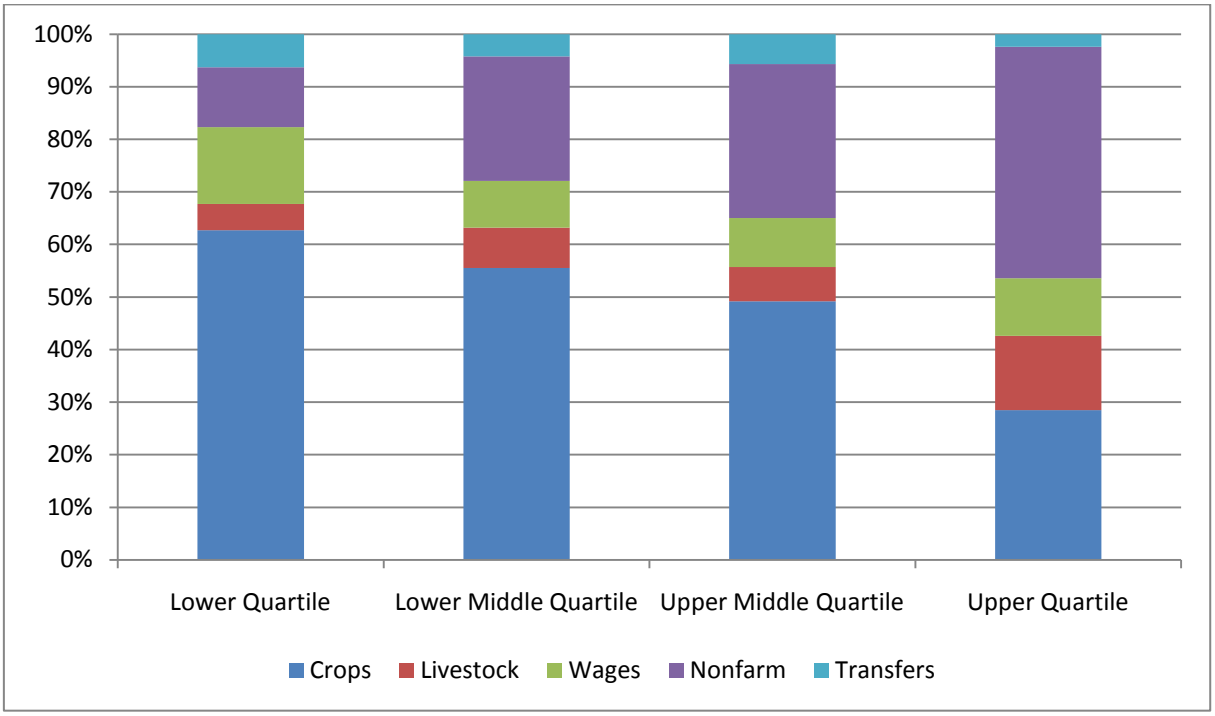

Figure 4 - Income of Tanzanian smallholder farmers by income quartile (% of household incomes)

Source: Adapted from data in Ellis and Mdoe, 2003: p1378

Ellis and Mdoes' (2003: p1379) study of the link between poverty reduction and livelihood strategies of smallholder farmers in Tanzania resulted in them declaring that "becoming better off in rural Tanzania involves becoming less reliant on agriculture within

a diverse livelihood strategy." By splitting data collected from participants into four wealth groups Ellis et al (2003: p1379) found that the relative contribution of crops to income declines across the income ranges with the contribution of livestock and nonfarm income increasing (Figure 4).

However, although households in the upper quartile have an increased contribution from off-farm income, this does not denounce the contribution of agriculture to their livelihood as the combination of crops and livestock in this category makes up 43% of household income compared to 44% from off-farm opportunities. Instead, it is likely that access to worthwhile off-farm opportunities is only possible after developing "a strong farming base on which to build" (Smith et al, 2001: p428) and that an increase in agricultural productivity has the knock on effects of releasing the labour and capital necessary to access other livelihood strategies (Jayne et al, 2010: p1388).

CA can therefore contribute to rural households being able to effectively engage in diverse livelihood strategies in two key ways. Firstly, from raised productivity of agriculture generating the assets required for adding value to primary production (Smith et al, 2001: p428) or investing in education and skills required for off-farm opportunities. Secondly, through the generation of spare time as a result of a less labour-intensive farming system (Owenya et al, 2011: p149), which can then be used for other income generating opportunities.

2.3. Vulnerability and Resilience

As well as accumulation of assets through increased agricultural production and livelihood diversification it is important to ensure that assets are protected once gained and that accumulation of assets is sustainable. Assets can be lost through what Chambers

et al (1992: p6) refer to as stress and shocks. Stresses tend to build over time and can be continuous or cyclical such as rising population pressures, seasonal food shortages and declining soil fertility whereas shocks can be defined as sudden and traumatic events such as extreme weather, thefts and civil unrest (Chambers et al, 1992: p25).

The ability of a community, household or individual to cope with shocks and stresses can be explained using the concepts of vulnerability and resilience. Vulnerability as described by Cannon (2008: p303) "is a characteristic not simply of being human and in a dangerous location, but of being part of a socio-economic system that allocates risk unequally between different social groups." This can result in disproportionate vulnerability amongst those living in poverty, women, children, the elderly and ethnic and religious minorities. As Kelman (2010: p213) states, a "disaster requires much more than a hazard; the disaster requires vulnerability which is a long term process, not a one off event." Resilience therefore is the ability of a group or individual to protect themselves or recover from shocks and stresses. With reference to Chambers et al's (1992) division of assets (Table 1), ownership and access to: food stocks and financial savings (stores), livestock and water (resources), appeals for food and loans (claims), and information and health services (access), all influence a household's ability to be resilient in times of hardship.

The ways in which families respond to shocks and stresses are known as coping strategies which Bryceson (2002: p730) defines as "an involuntary response to disaster or unanticipated failure in major sources of survival." For farming households such strategies can include expanding cultivation, intensifying agriculture, diversifying livelihoods and migrating (Paavola, 2008, p649). Although such strategies may be effective in meeting the

needs of families in periods of stress they can have detrimental impact on a households' ability to secure a livelihood in the future as a result of damaging the local environment through soil erosion and deforestation (Paavola, 2008: p649). In this respect CA provides the potential for a household to improve resilience; in the short-term through reducing the need for families to use coping strategies due to increased and more reliable production and in the long-term by minimizing the negative impacts of agriculture on the environment and protecting ecosystem services hence increasing sustainability of future livelihoods.

In African agriculture, heavy reliance on rain-fed systems increases the risks faced from precipitation changes, highlighting the reality of climate change as a major threat to the livelihoods of smallholder farmers. In Tanzania, temperatures are predicted to rise by 2-4 ^{o}C by the year 2100 with dry seasons likely to be prolonged and availability of water for crops diminished (Paavola, 2008: p647). Hahn et al (2009: p74) predict that by 2050, 350-600 million Africans will be at risk from increased water stress. Through the eradication of tillage, and hence improved soil structure, the infiltration rates and water holding capacity of the soil are improved (Fowler et al, 2001: p95) and reduce the likelihood of water stress during dry periods. This results in CA being a more water efficient system, and increases the resilience of crops by diminishing onset of stress conditions (Friedrich, 2008: p45).

Zero-till also contributes to carbon sequestration by storing it in the soil which presents an opportunity for reversing the greenhouse gas build-up. Whilst this will not be of immediate significance to smallholder farmers in SSA, if adopted on a large-scale CA has the potential to eradicate the damaging effects resulting from the carbon released

into the atmosphere due to tillage. There are also opportunities to combine this carbon sequestration with credit systems such as those seen in Alberta, Canada (Goddard et al, 2009), where farmers are paid as part of a scheme in which companies or governments that exceed their carbon emission allowance can purchase offset credits. There may be scope for such schemes to be rolled out to suit small-scale farmers in SSA, generating another means of income from adoption of zero-till practices.

2.4. Role of Networks and Institutional Structures

Decisions made by smallholder farmers on the production methods they adopt are likely a result of multiple factors, some of which will be influenced by outside parties such as government institutions, NGOs and the private sector. If farmers are to be allowed to adopt new technologies that enhance agricultural production they need a "facilitating environment" (Ellis et al, 2003: p1381). Such an environment however, is precisely what many smallholders lack with Friedrich et al (2008: p29) identifying barriers consisting of a lack of inputs, market access, infrastructure and pro-poor policies which restrict them from adopting new technologies or not benefitting accordingly once the new technology has been adopted. Farmers may be unable to access or afford inputs, such as improved seed varieties, pesticides or equipment, without assistance from the government or NGOs. Even if farmers produce a surplus to be sold, access to markets isn't always guaranteed: the remoteness of many smallholder farmers can provide a barrier as can the costs of entry into agricultural markets. Cadot et al (2006: p20) estimated the costs of entering markets for smallholder farmers in Madagascar as being 124-153% of subsistence farmers' annual production. This highlights the importance attributed to increasing production but also for the need to improve rural transport services,

infrastructure and credit access for smallholder farmers. Policy decisions directly affect the uptake of new technologies such as the choice of messages communicated to farmers through agricultural extension workers. Indirect effects of policy decisions could include financial cutbacks which decrease road maintenance, police protection and other public services leading to further isolation and therefore reduced uptake of improved production technologies and market participation (Barrett, 2007: p311).

Smith et al (2001: p434) note that "responsibility for small enterprise and non-farm livelihood diversification has, by default, been left with NGOs and the private sector. Whilst the NGO sector is making some progress, there are few incentives for private investment in rural areas." Encouraging smallholder access into markets can be facilitated by NGOs or the private sector through the formation of groups, provision of certification costs and business training (Markelova et al, 2009: p5). Friedrich et al (2008: p37) also note that a lack of liaison between governments, the private sector and NGOs often leads to missed opportunities to share expertise and results. For CA to be adopted effectively, and for the benefits of CA to be realised after adoption, decisions made by institutional structures, NGOs and the private sector will need to contribute towards the creation of a facilitating environment for smallholder farmers.

2.5. Summary

The sustainable livelihoods approach to development focuses on the concept of assets and the five capitals: human, financial, physical, natural and social. Accumulation and protection of assets is essential for smallholder farmers if they are to escape poverty. CA offers them an opportunity to increase such assets through building their natural, physical, financial, social and human capital. With accumulation of assets smallholder

farmers can engage in more effective livelihood strategies, enabling them to generate income through post-production processing and off farm opportunities. CA can contribute to this process of livelihood diversification through increases in production and timesaving. As livelihoods diversify, a process of 'deagrarianisation' begins, starting a shift away from agriculture which has the potential to raise household incomes and lift rural families out of the poverty trap. This process, however, is most likely to occur when a household has a stable and profitable agricultural base on which to build.

The concept of vulnerability and resilience to shocks and stresses has been explored, with strategies that smallholder farmers employ in times of hardship being described as coping strategies. These coping strategies, whilst helping a household to meet living costs in difficult periods, often have negative repercussions on future livelihood strategies through unsustainable extraction of natural resources subsequently building pressure on ecosystem services. The issue of climate change also adds to the likelihood of declining yields further straining the ability of farmers to meet food consumption needs and raise an income. CA offers an opportunity for farmers to build their resilience to shocks and stresses through securing higher and more stable yields, more efficient use of rainfall and the protection and sustainability of natural capital.

Finally, the role of networks and institutional structures was assessed with evidence showing how critical the actions of governments, NGOs and the private sector are on influencing decisions made by smallholder farmers. For successful adoption of new production technologies such as CA, smallholder farmers need access to a facilitating environment, which institutional structures are able to create through policies, programmes and investment. Currently, barriers that prevent rural communities from

engaging in new technologies and therefore from escaping poverty include lack of farming inputs, isolation, inadequate markets and ineffective policies. If these barriers remain, farmers may be unable to adopt CA and those who have adopted may be unable to capitalise upon their efforts.

Chapter 3 – Methodology

3.1. Objectives

After exploring the literature on livelihoods and poverty reduction it has become apparent that to research the impacts of CA on the livelihoods of smallholder farmers there will be four areas of focus, these being asset accumulation, livelihood diversification, vulnerability and resilience, and the role of networks and institutional structures. These topics have been used to develop the following objectives:

- (1) Compare the assets held by smallholder farmers before and after adoption of conservation agriculture practices.
- (2) Identify the livelihood strategies of smallholder farmers practising conservation agriculture.
- (3) Explore smallholder farmers' perceptions of their vulnerability to shocks and stresses and how these perceptions may have changed since adoption of conservation agriculture.
- (4) Investigate the role of institutional structures on the livelihoods of farmers adopting conservation agriculture.

3.2. Research Approaches

Before deciding on the methods to gather the data, this chapter will explore the theoretical aspects of research approaches. Development research typically uses a range of approaches which are known as quantitative, qualitative and participatory methods. Quantitative methods are useful for assessing trends and changes on a large scale (Place et al, 2007: p324) and help to quantify impacts which can contribute to monitoring, evaluation and targets. Quantitative methods are often used for producing baseline data

which can be referred to in the future as a way of measuring change and as Mayoux (2008: p116) states, pressures for "quantification [*for development organisations]* have further intensified to demonstrate progress on the Millennium Development Goals" (MDGs). However, Chambers (1994a: 1444) insists that there is no evidence that such surveys have been useful or worth the costs and that they are not only expensive and time consuming, but lack sufficient insight. Qualitative approaches, contrastingly, are more adept at providing insights into power and socio-cultural relationships (Place et al, 2007: p313) such as status and stigma and are aimed at understanding complex realities and processes (Mayoux, 2008: p116). It is possible to use both qualitative and quantitative methods in what is known as combined or mixed methods. Using this approach enables researchers to consolidate the different strengths of the two methods, increases confidence in the findings and helps to disseminate information in different ways (Mayoux, 2008: p116). However, as Place et al (2007: p313) admit, use of combined methods has been rare for researching technology adoption and impacts.

Another approach is participatory research for which advantages include "rapidity and reliability of collecting many types of qualitative and quantitative information" (Mayoux, 2008: p116). However, the main aim of participatory research is to make the research accessible to and inclusive of participants, involving them in the research in an attempt to gather their viewpoints, raise their own understanding of their situation and develop solutions to local development issues. Participatory Rural Appraisal (PRA) has been defined as an "approach for learning about rural life and conditions from, with and by rural people" (Chambers, 1994b: 953) and is billed as being cost-effective, popular with participants and researchers, revealing and empowering (Chambers, 1994a: 1444).

With reference to the objectives of this research it would appear that asset accumulation (objective one) could be best measured through a quantitative approach, however, for human and social capital a more qualitative approach may be necessary to extract opinions that cannot be measured, suggesting the need for combined methods. Investigation of livelihood strategies (objective two) could benefit from a participatory approach as the research for this is likely to be carried out in a group situation, highlighting the need to encourage participation from all members and include them in analysis of the findings. Research into vulnerability and resilience (objective 3) would need a qualitative approach in an attempt to enhance the researcher's understanding of the context and consequences of shocks and stresses, something that may be difficult to achieve with quantitative data. Finally, exploration into the role of networks and institutions is likely to be qualitative or participatory as the aim is to understand how different stakeholders influence each other and to discover complex links and networks.

3.3. Field Placement

To combine the research with first hand field experience, a placement was set up with the Selian Agricultural Research Institute (SARI) in Arusha, Tanzania. SARI has been promoting CA techniques to smallholder farmers since 2003 through the FAO project CA-SARD (Conservation Agriculture – Sustainable Agriculture and Rural Development). The project objective was to improve food security and rural livelihoods and build a foundation for the expansion of conservation agriculture to contribute to sustainable agriculture and rural development. A central aspect of the project was the set up of farmer field schools (FFS) through which CA knowledge and technology could be disseminated. These FFS are groups of 25-30 farmers who joined together to practice CA

techniques on a shared one acre plot of land, enabling them to better understand the process before implementing these measures on their own land.

Table 2 – List of villages and FFS visited for research

District	Village	Farmer Field Schools
Arumeru	- Ekenywa	- Tuamke Tuamke - Kilimapunda
	- Likamba	- Eotulelu
Karatu	- Bassadowish	- Upendo
	- Getamock	- Juhudi - Tumaini - Alehhay - Mshikamano
	- Kilimatembo	- Upendo
	- Kambiasimba	- Tumaini

The research worked with ten FFS from six villages in Arumeru and Karatu districts in the Arusha Region of Tanzania (Table 2). Arumeru and Karatu districts can be divided into three major agroecological zones: the highlands or uplands, midlands and lowlands, ranging from 800 to 1900 metres above sea level with the lowlands receiving approximately 400-700mm annual rainfall (semi-arid) increasing to around 1000mm in the highlands (subhumid) (Shetto et al, 2007: p12). Most smallholder farmers in the region grow maize, beans and pigeon pea, with some farmers able to cultivate rice and wheat and small scale vegetable production. There are also large scale farms growing coffee, vegetables and flowers in fertile highland areas (Shetto, 2007: p12). Soils across the two districts vary in fertility and formation including clay, volcanic ash, and sandy soils. Degradation and erosion of soil has been caused by intensive cropping on hill slopes, the introduction of mechanised agriculture by settlers in the 1960s, continuous cropping, wind erosion and runoff after intensive storms. This has led to a reduction in yields

among smallholder farmers as well as problems with gullies and siltation of water sources.

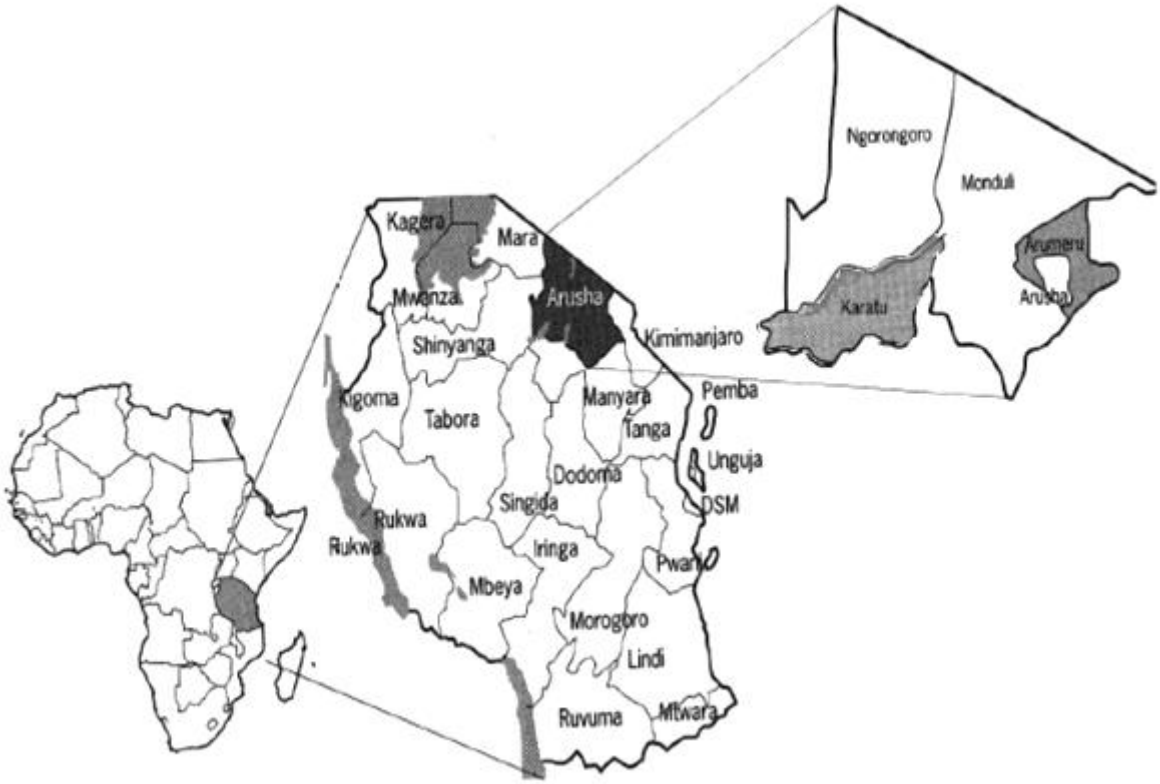

Figure 5 – Map of Tanzania and Arusha Region showing the districts of Karatu and Arumeru.

Source: Shetto et al, 2007.

3.4. Methods and Tools

Participants were selected due to their involvement in a CA FFS, so therefore sampling was non-probability with quota sampling setting a target of 100 smallholder farmer participants with equal proportions of females and males. Group workshops were organised through staff contacts at SARI, CPAR (Canadian Physicians for Aid and Relief), and through village and ward level agricultural extension officers. A workshop consisted of 10 to 15 smallholder farmers who all belonged to the same FFS. When participants were invited to attend, organisers arranged groups that represented the gender and age

make-up of that particular FFS. Workshops were carried out with a co-facilitator who would also translate proceedings. Before any workshop began, participants were informed that the process was voluntary, the reasons for the research and what would happen with the results. A copy of the participant information sheet can be found in appendix A.

Objective 1 – Compare the assets held by smallholder farmers before and after adoption of CA practices. The aim here is to determine if adoption of CA has enabled smallholders to accumulate assets and this will be done using two tools; one participatory and one quantitative. Firstly, the participatory budget will be carried out with a small group of farmers and will investigate the inputs necessary for one acre of CA land for one year. This will cover both the costs and time used for inputs and activities such as land preparation, weeding, fertilisers and seeds. Outputs from one acre of CA land will then be recorded. Farmers will be asked to expand on how these inputs and outputs differ to before they adopted CA techniques. Secondly, a short field survey will be used to collect data on the changes in assets held by farmers since adoption of CA practices. Assets of natural, social, human, physical and financial capital will be covered with simple questions of whether they have increased, decreased or stayed the same e.g. incidence of weeds, interaction with other farmers, child attendance at school, quality of housing and ability to save money. An example of the field survey can be found in appendix B.

Objective 2 – Identify the livelihood strategies of smallholder farmers practising CA. By identifying the livelihood strategies adopted by CA farmers it will be possible to judge whether CA aids or hinders livelihood diversification. A participatory ranking exercise will be used to identify the different strategies CA farmers use to generate

income (i.e. selling surplus produce, working for another farmer, off farm opportunities). From their answers a matrix will be drawn and participants will be asked to mark next to each strategy they personally use, those that generate the majority of their income, and those that they spend most time doing. Participants will then be asked to explain how their livelihood strategies have changed, with the matrix being redrawn to represent their sources of income before CA adoption.

Objective 3 – Explore smallholder farmers' perceptions of their vulnerability to shocks and stresses. The aim of this objective is to better understand how CA can build resilience of smallholder farmers to challenges such as climate change and water stress. For this task a qualitative focus group will be used with questions exploring the challenges that smallholder farmers face, how these challenges affect their livelihood, how they respond to these challenges and whether their response to such challenges has changed since adoption of CA practices.

Objective 4 – Investigate the role of networks and institutional structures on the livelihoods of farmers adopting CA. To understand the importance of networks and relationships for the successful adoption of CA it is not only important to carry out research with smallholder farmers but also with the other institutions involved. A stakeholder analysis will be carried out with SARI staff from the CA-SARD project with the aim of identifying who is involved in the project at local, regional, national and international levels and to identify the extent of cooperation between these stakeholders. The stakeholder analysis will also explore the stakeholders' roles in the promotion of CA and how they plan to be involved, if at all, in the upscaling of CA in the future.

Chapter 4 – Results

The research involved 112 participants in total, of which 100 were farmers from ten different FFS based in six villages in Arumeru and Karatu districts. The 12 participants who were not farmers were all interviewed using the stakeholder analysis matrix. This included six government extension officers (from district, ward and village level), two staff from SARI (Selian Agricultural Research Institute in Arusha), two managers from farming equipment manufacturing companies (CAMTEC in Arusha and NANDRA in Moshi), and two staff from NGOs (CPAR and WADEC).

Table 3 – Breakdown of participants and tools

	Participatory budget	Survey	Ranking Exercise	Focus Group	Interview	Total
Female	1	26	7	18	6	**58**
Male	2	25	5	16	6	**54**
Total	**3**	**51**	**12**	**34**	**12**	**112**

4.1. Objective One

Compare the assets held by smallholder farmers before and after adoption of conservation agriculture practices.

The participatory budget recorded the activities that a CA farmer carried out, how many hours each task took, the costs of inputs and income from outputs. Table 4 shows the monthly totals for each of these categories, showing that one acre of CA land generated US$400 of profit on top of maize that is reserved for family consumption. Table 5 shows the actual participatory budget, from which these results were calculated.

Table 4 – Expenditure and income for one acre of CA land

Month	Hours	Expenditure	Income
Jan	63	-	-
Feb	9	-	-
Mar	8	56,000 (seeds and herbicide)	-
Apr	24	-	-
May	15	-	-
Jun	2	9,000 (pesticide)	-
Jul	5	-	-
Aug	26	34,000 (shelling and bagging maize)	-
Sep		-	-
Oct	72	4,800 (bags for lablab/ pigeon pea)	400,000 (4 bags of pigeon pea)
Nov	36	-	-
Dec	6	-	300,000 (5 bags maize and ½ bag lablab)
Total	266 hours per acre	103,800 Tsh per acre Approx 70 USD	700,000 Tsh per acre Approx 470 USD

N.B. This also generates 10 bags of maize (1 tonne) and 1 bag of lablab (120kg) for family consumption. This was for a family of seven so obviously the amount of maize reserved for consumption and therefore profit made will vary depending not only on yield but on family size.

Table 5 – Participatory budget for one acre of CA land

	Jan	Feb	Mar	Apr	May	Jun
Activities	Ripping Manure Contouring	Manure Ripping Pruning trees to reduce canopy cover at contours - gravalia, cactus.	Seeding maize pigeon pea and lablab. Spraying herbicide	Weeding	Clean and repair contours after rains	Spraying insecticide for lablab and pp
Inputs	Ripping – 3 hours. Manure – 30 hours for 7 tonnes. Contours – 30 hours	Manure, ripping split from Jan. Pruning 9 hours (3 hours x 3 days)	Direct planter (ox drawn) 3 hours/acre. PP + LL 3 hours/ acre combined. Maize hybrid DK803, 3,500 /kg. Need 10kg per acre. PP – 3,000/ kg x 2kg. LL – 1,500/ kg x 2kg. Herbicide – 2hr. 1 litre needed = 12,000. No output	4 persons x 6 hours = 24 hours	5 days x 3 hours = 15 hours	Karate 400ml per acre. 9,000 Tsh. 2 hours/acre
Outputs	No output	No output		No output	No output	No output
Balance	63 hours/acre	9 hours / acre plus overlap from Jan	3+3+2 = 8 hours -56,000 Tsh Seeds and herbicide	24 hours/ acre	15 hours/acre	2 hours/acre -9,000 TSH

	Jul	Aug	Sep	Oct	Nov	Dec
Activities	Contour cleaning Rouging (hand pulling weeds) Observing	Harvest maize. Transport harvest by ox cart. Shelling and bagging maize.	Activities carried over from August	Harvest Pigeon pea and lablab	Threshing	Slashing crop residues Early ripping if rainfall.
Inputs	Contours 3 hrs Rouging – 2 hrs	Harvest 4 persons per day x 5 hours = 20 hours (can go up to 40 depending on yield) Transport – 6 hr. Hire cost for shelling 1,500/bag + cost of bag and twine (800)=2,300/bag		6 person per day (6 hours = 36 hours. PP one harvest, LL one harvest = 72 hr/acre.	6 person/day = 36 hours Bags = 800 x 6 bag (4pp +2 LL) = 4,800 Tsh	1 day/acre = 6 hours
Outputs	No output. Beans and veg on plot not using CA.	15 bags maize (100kg/bag)		PP = 4 bags (120kg/bag) 480kg pp LL 1½ = 180kg.	No output	No output
Balance	5 hours / acre	10 bags kept for family of 7. 26 hours/acre 2,300x 15bags= 34,000 Tsh on shelling and bagging		72 hours/acre	PP sold immediately 100,000 /bag = +400,000. -4,800 on bags 36 hours	6 hours 5xbags maize at 40,000/bag = +200,000 Tsh ½ bag lablab = +100,000.

PP= pigeon pea. LL = lablab

Members of FFS are able to practice and observe CA techniques on a one acre demo plot which is split into five sub plots to help farmers visualise the difference in results and help them decide which techniques to transfer back to their own land. Yield results for each sub-plot are recorded and can be seen in Table 6 with Figure 6 showing what the yields for each of these 1/5 acre plots would represent in terms of tonnes per hectare.

Table 6 – Yield from demo plots (kg)

Yield (kg) from 1/5 acre plot	Getamock	Basodawish (dry area)	Kambiasimba (fertile area)
Maize + lablab + ripping	300	250	574
Maize + pigeon pea + ripping	327	195	484
Maize + lablab	290	120	386
Maize + pigeon pea	180	101	370
Normal farmer practice	150	61	320

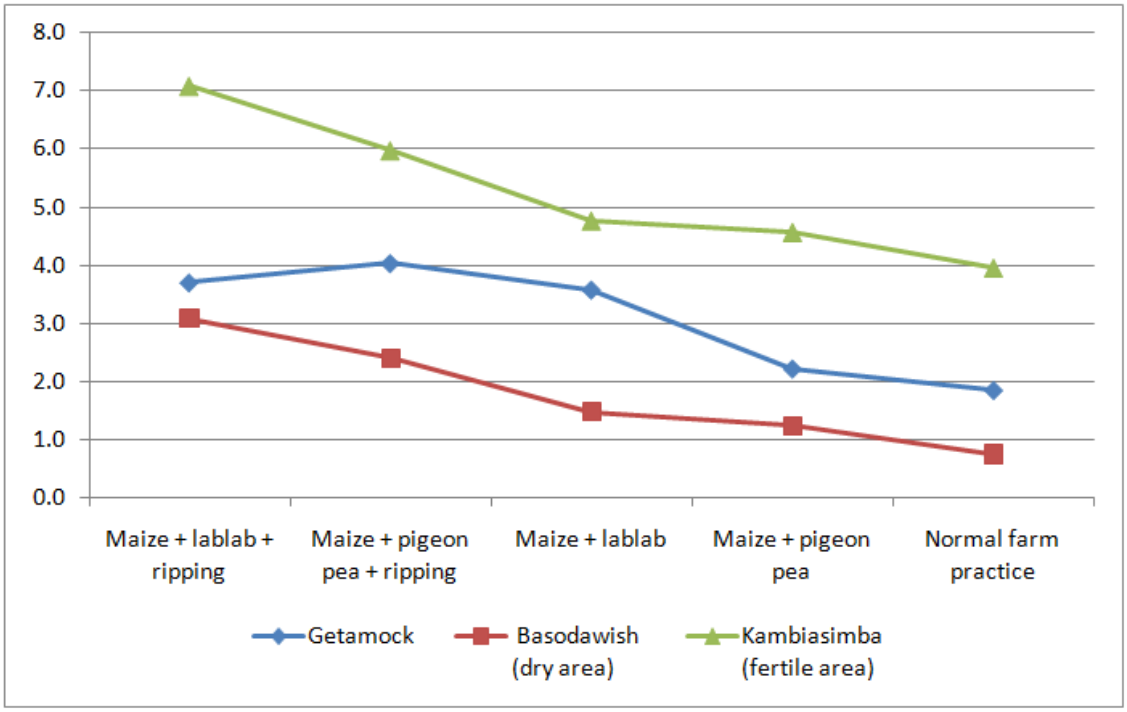

Figure 6 – Demo plot yield equivalent for tonnes per hectare

For objective one, the survey was used to generate information about the accumulation of assets. Participants were asked whether certain assets had decreased, increased, or stayed the same since adoption of CA. Table 7 splits these assets into the five capitals of natural, social, human, physical and financial.

Table 7 – Asset changes since adoption of CA

Capital	Change since CA adoption	Asset
Natural	Increased	-Yield of staple crops -Variety of crops grown -Retention of topsoil -Biological life in soil -Water infiltration into soil -Water retention of soil -Quality of soil -Quality of crops
	Decreased	-Incidence of weeds -Use of pesticide
	No Change	-Quality of drinking water
	Mixed response	-Use of chemical fertilizers -Use of manure -Use of herbicide -Incidence of pests
Social	Increased	-Interaction with other farmers -Involvement in community meetings -Time for other income opportunities -Time for rest or social purposes
Human	Increased	-Access to agricultural extension services -Child attendance at school -Nutrition of family diet
	Decreased	-Family members migrating to towns
Physical	Increased	-Availability of transport -Quality of roads
	Decreased	-Distance to nearest market
	Mixed response	-Quality of grain storage facilities -Quality of housing -Quality of latrines
Financial	Increased	-Ability to afford medicine -Purchase of household goods -Quality of seeds purchased -Access to credit services
	Decreased	-Quantity of livestock

The breakdown of age and gender of the survey participants can be seen in Table 8 and the average size of owned and CA land in Table 9. It is evident from the participants interviewed that about half of all land owned is dedicated to CA.

Table 8 – Age and gender of survey participants

	20-29	30-39	40-49	50-59	60+	Total
Female	2	11	7	4	2	26
Male	2	6	11	1	5	25
Grand Total	4	17	18	5	7	51

Table 9 – Land area owned and dedicated to CA

	Total land owned (acres)	Area of CA land (acres)
Minimum	0.5	0.25
Maximum	12	12
Mean	2.5	1.3
Mode	3	1

4.2. Objective Two

Identify the livelihood strategies of smallholder farmers practising conservation agriculture.

The livelihood strategy ranking exercise was used to discover how farmers were generating their income and whether their livelihood strategies had changed since adoption of CA. Once all strategies had been discussed it was possible to discover which strategies were new, had been increasingly adopted, were maintained, reduced or eliminated all together (Table 10). Figure 7 shows the strategies that generated the most income before and after CA adoption and Figure 8 shows the shift from time spent on arable farming before CA adoption, to livestock farming after CA adoption.

Table 10 – Changes in use of livelihood strategies since CA adoption

Status of strategy	Source of Income	Before CA	Present
New	Maize surplus	0	12
	Lablab beans	0	12
	Selling pigs	0	6
	Selling manure	0	1
Increased	Selling chickens and eggs	3	9
	Using ox for land preparation and transport	2	7
	Selling milk (cow and goat)	3	6
	Selling cows	5	6
	Lentils	1	2
Maintained	Pigeon pea	12	12
	Selling goats/sheep	12	12
	Sunflower	12	12
	Finger millet	12	12
	Selling water	2	2
	Green vegetables	1	1
	Selling donkeys	1	1
	Reselling charcoal	1	1
Reduced	Selling firewood	5	4
	Making and selling rope	2	1
Eliminated	Casual labour	6	0
	Rock breaking for selling gravel	2	0
	Local brew	1	0

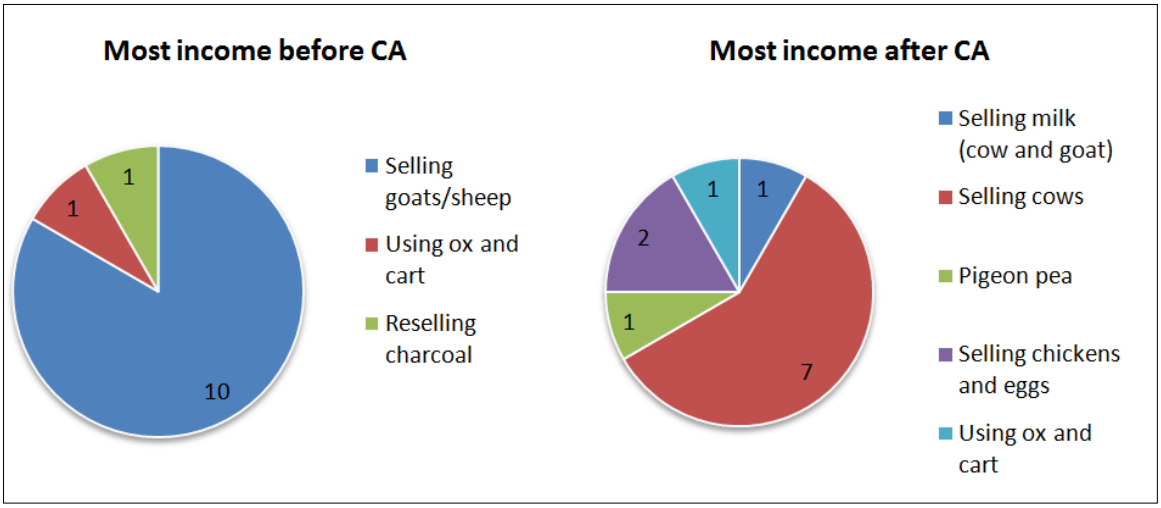

Figure 7 – Change in most profitable income generating strategy since CA adoption

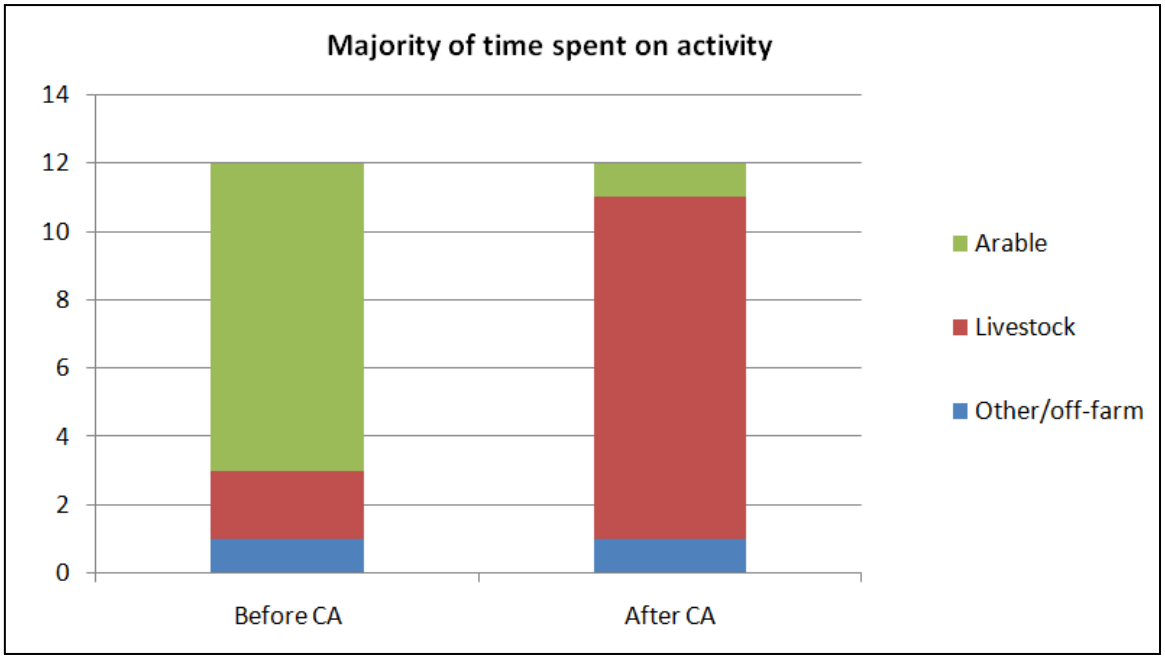

Figure 8 – Majority of time spent on livelihood strategy before and after CA (number of participants)

4.3. Objective Three

Explore smallholder farmers' perceptions of their vulnerability to shocks and stresses and how these perceptions may have changed since adoption of conservation agriculture.

To understand farmers' perceptions of their own vulnerability and resilience to shocks and stresses, the focus group explored what challenges they had faced over the last 40 years, how they coped with these challenges and how their response to such challenges has changed since adoption of CA. Table 11 shows some of the key discussion points that were mentioned during the focus group.

Table 11 – Points discussed in focus group on perceptions of vulnerability

Q1. What challenges, in regards to food production, have you faced over the last forty years?		
Year	Event	Details
1974	Drought and pest outbreak	Livestock died and people ate dead livestock. Walking up to 100km to find food. People migrated with livestock but returned to village without livestock. People ate maize bran which was usually fed to cattle.

1984/85	Drought and pest outbreak	Food relief in the form of yellow maize provided by the US. Food relief was in exchange for work such as road construction, breaking rocks and collecting sand. Following year there was an outbreak of maize grain bore which villagers believe was related to the import of US maize.
1994	Drought	Similar to previous. Food for work schemes. Note decadal recurrence. Farmers mention the issue of climate change as droughts are no longer at ten year intervals.
2000/01	Drought and pest outbreak	People began shifting to towns to look for jobs, especially the young who dropped out of schools and searched for casual labour. Pest outbreak from caterpillars. Government introduced Maize Strategic Grain Reserve which aimed to buy maize from Tanzanian farmers and store for food aid so as to reduce foreign imports in times of low availability.
2009	Drought	Although the village was not too badly affected many Masai came to the area to graze their livestock. This created tension between communities and many of the Masai's livestock died in the area.
2011	Low rainfall and yields	Farmers were reporting reduced yields and expecting that the government would have to distribute food relief in the coming months.

Q2. How did you cope with these challenges?

- Migrate with livestock
- Migrate to towns in search of casual labour
- Sell animals – first chicken, then goats, then cattle
- Food rationing – dependence on government or foreign aid
- Get food or cash loans from wealthier families

Q3. What effect did these challenges have on you and your family?

- Children drop out of school
- Some male heads of household run away from family
- Women are left to care for and feed family
- If someone is sick they are left untreated as medicine cannot be bought
- Sometimes children were abandoned

Q4. Since using CA practices has your response to these challenges changed?

- Even with reduced rainfall, farmers still get yield compared to traditional practice which may get no yield
- Cover crops provide extra food and cash
- Not only change in yield but cost effective – "Even if you produce the same amount of yield you have spent less money doing so."
- Reduced livestock and more biomass makes it easier to feed livestock in periods of drought
- Milk from dairy cattle can be given to children or sold
- Now reserve 3 bags of maize per person for the following year in case of drought
- Village Community Bank gives access to credit

4.4. Objective Four

Investigate the role of institutional structures on the livelihoods of farmers adopting conservation agriculture.

The decisions made by farmers are often influenced by outside parties and the aim of this objective was to identify the stakeholders that are be involved in this decision making process and understand how different stakeholders interact with each other. The stakeholder analysis (Table 12) shows why and how each stakeholder is involved in the adoption and dissemination of CA to farmers, the positive impacts of their involvement and the challenges they have encountered.

Results for the four objectives have been presented in this chapter; however, interpretation of the results has purposely been reserved for the discussion section in an attempt to fairly represent the words of the research participants and restrict personal opinion of the researcher at this stage.

Table 12 – Results from stakeholder analysis matrix

How affected by the problem?				Impacts of the project?	
Stakeholder	**What is the problem being addressed?**	**What is the stakeholder's role in addressing the problem?**	**What are the relationships with other stakeholders?**	**What are the positive impacts of the stakeholder's involvement?**	**What challenges has the stakeholder experienced?**
Agricultural Extension Officers – Village, Ward and District level.	-Low yields due to soil degradation and erosion, infertile soils and insufficient rainfall.	-Setting up FFS with demo plots. -Training farmers on CA practices on demo plot. -Facilitating FFS with 25-30 members. -Training members on other topics such as livestock husbandry, credit schemes, and tree planting.	-SARI researchers – help with monitoring and evaluation and with inputs for farmers. -NGOs – visit their groups to assist with CA knowledge and group facilitation. Training on HIV. -Farmers – organising field days, and facilitation of FFS. -Seed companies – invited to field days.	-Increase in yield -Soil fertility improved -Rainwater use efficiency increased -Many farmers have achieved food security -Changed livestock practices from free grazing to zero grazing. -Many farmers securing extra income for education and health costs.	-Adoption rate has been slow -Not enough implements so not all fields are prepared in time. -Stopping free grazing of livestock. -Getting area of land for demo plot.
CA-SARD Project Facilitators – SARI	-Need national facilitation and coordination of project activities	- Organize and conduct CA and FFS trainings to CA FFS Facilitators -Coordinates day to day activities between the district, CA FFS facilitators and farmers	-Linking CA-SARD project and promoting collaboration amongst the following: • NGOs • Manufacturers • Input suppliers • Extension workers	-Formation of more than 130 CA FFS farmer groups and over 250 CA FFS from NGOs -Farmers have improved their food security by more than 40% in CA	-Farmers need more training in livestock integration into CA. -Government funding to continue promotion of CA is limited

		-Link the CA SARD project to the local NGOs WADEC, CPAR etc and CA Implement manufacturers, input suppliers, and large scale CA farmers.	• Smallholder farmers • Large scale CA farmers	adopted areas, have better income and have improved their livelihoods.	-Capacity building to local CA implements manufacturing is needed.
Information and Extension Manager – SARI	-Awareness of CA technologies	-Collecting and repackaging information in accessible and user friendly formats for multiple audiences. -Dissemination and promotion of CA information through mass media and agricultural shows.	-Media – for message dissemination. -Farmers – targeting materials and collecting feedback for researchers -Policymakers – targeting materials.		
Ministry of Agriculture, Food and Cooperatives – Director of Agro-mechanization	-Lack of National recognition of the CA SARD project Policy makers were not aware of the CA technology in solving farmers problems -Lack of connection of the CA technology to private sector and new NGOs	-Link the CA SARD project to the Ministry of Agriculture and stakeholders including NGOs, private sector, CA manufacturers, input suppliers and large scale CA farmers. -Chairs the project steering committee for the CA SARD project -Coordinate the project activities to the National and district Facilitators		-There is excellent awareness of CA in the Ministry of Agriculture in Tanzania. -There is good coordination of national level, districts and villages about CA. -Policy maker awareness from village level to national level is already taking place.	

		-Links the CA project to the Policy makers (MPs, Regional commissioners, District commissioners, District Development Directors)			
African Conservation Tillage (ACT) network – Executive Secretary	-Lack of linkage of the local CA projects to other similar projects in other countries.	-Links the CA in Africa to other international organizations such as FAO the donor country and ENBRAPA in Brazil from where the cover crops and no-till direct seeding technology is being transferred to Tanzania. -Conducts documentation of CA and sharing of different success stories in Africa. -Conducts monitoring and evaluation during the CA SARD project		-Linkage has been established in the areas of CA technology -Brazilian direct seeding equipment prototypes are now being produced in the country. -There are many new NGOs promoting CA.	-The speed of farmers adopting CA is higher in numbers and faster than the manufacturing of CA implements. -The cost of CA implements is too high for poor resource farmers to afford.
NGOs **(WADEC & CPAR)**	-Low yielding farmer practices contributing to poverty entrenchment.	-Training for farmers on CA practices. -Promote farmer to farmer learning through study visits and workshops.	SARI – Provision of cover crop seeds. SIDO – (Small Industry Development Organisation) Training and loans for small businesses.	-Yield increased from 3 bags/acre to 18-25 bags/acre with 700mm of rain. -Increased community cohesion, learning from	-Purchase of CA tools and implements is an issue. Famers unwilling to use loans to purchase equipment. -Pest problems with lablab

		-Focus on income generation through livelihood diversification and small business opportunities.		each other and breaking gender barriers. -Reduced time and labour is opening up other opportunities for farmers. -Spread of other income generating opportunities such as sunflower oil processing, buying and reselling clothes and chicken rearing. -Farmer groups being set up without assistance from NGO. Training received from farmers who are already in FFS.	-People have started to steal residues from CA plots.
Equipment manufacturers **(NANRA & CAMTEC)**	-Local CA implement manufacturers are needed as imported implements are expensive and take a long time to order.	-Collaborates with the CA project in designing new CA implements. -Manufactured more than 3,000 rippers since the CA SARD project was started in 2004. -Currently producing oxen drawn rippers, hand jab and animal driven direct planters.	-Receive orders from individual farmers, District development projects and NGOs. SARI – follow-up in the performance of CA implements purchased by farmers.	-More than 3,000 rippers, over 400 jab planters and 300 animal drawn direct planters have been manufactured for CA farmers.	-Need more orders from farmers to make manufacturing cost-effective and reduce prices.

Chapter 5 – Discussion

The discussion section starts with an explanation of the limitations of the research and how the tools and methods could be adapted to improve data collection. The results from the previous chapter will then be analysed for each objective, putting them into context of the debates surrounding livelihood and conservation agriculture explored in the literature review.

5.1. Limitations of Research Methodology

There were three main issues with the research methodology, the first being that access to research participants was restricted by time and financial constraints. The initial plan was to be able to complete the participatory budget, survey, ranking matrix and focus group with all the smallholder farmers that participated in the research. However, each tool took approximately three to four hours to complete and the participants had other duties to attend to so it was unreasonable to ask them to stay for longer. Revisiting the villages to continue with the other methods was restricted by the costs for transport and fuel to the remote locations, and when a village was revisited it was difficult to get the same participants involved. This resulted in a mixture of tools being used in different locations, eliminating the opportunity to compare results between FFS. However, it seemed best to let each tool take as long as it needed to complete for reasons of reliability, enjoyment and ethics rather than rushing the participants to complete all methods in one workshop. As Chambers (1994b) writes, principles of participatory research have to do with behaviour and attitudes of researchers, including being self-critically aware, not rushing and helping participants to express themselves in their own way.

The second issue was with the survey as although it was short and simple it still took between twenty to forty minutes to complete with each participant. Often, many participants would turn up at once, so would have been waiting for a long time if the survey was to be done individually. For this reason, the survey was adapted to suit a group situation and delivered more like a focus group but with short questions and answers. This worked well as it gave the participants an opportunity to debate their answers and shed more light on the situation than would have been gleaned from individual surveys. However, collecting the data in this way meant it was not possible to complete statistical analysis with the results as they did not necessarily represent individual views but instead the views of the group as a whole. During the research placement, ACT (African Conservation Tillage Network) and the World Agroforestry Centre were completing a baseline survey with smallholder farmers which took about one to two hours per farmer to complete, with 100 farmers interviewed over a three day period by ten research assistants employed specifically for the task. In this situation, the baseline survey was useful for setting up monitoring and evaluation processes and was possible to complete in the short time with plentiful resources dedicated to the task. However, for this research task, with financial constraints limiting the ability to employ research assistants a survey was not an ideal tool. Chambers (1983: p52) appears familiar with this situation, labelling it 'survey slavery', warning of the demands that are "habitually ignored or underestimated, and the duration of which almost always exceeds that planned."

The final limitation was a lack of access to non-CA farmers. All 100 of the smallholder farmers that participated were members of FFS and had transferred CA practices to at least a part of their land, resulting in a lack of comparison when measuring impact on livelihoods. The research attempted to deal with this by asking farmers to compare their situation to what it was like before they adopted CA. This helped to generate information useful for

investigating the impact of CA on livelihoods but also allowed for discrepancies in that impacts may be a result of a number of interventions and not just the adoption of CA. Comparing the livelihoods of CA and non-CA farmers in similar areas would have allowed for better analysis and may have helped to identify the specific effects of different interventions.

If the research was to be repeated there would be a number of ways to address these limitations. The first way would be to have more money and time with each group of participants to allow completion of all tools including the individual survey. However, with similar financial and time constraints another option would be to reduce the number of tools used and find a method that could address all areas of the research in one go. This would, however be difficult as although the topics of asset accumulation, livelihood diversification, vulnerability and networks are all related, they need separate attention in order to be properly explored.

5.2. Asset Accumulation

Assets can be seen as the "building blocks by which the poor construct their own routes out of poverty" (Ellis et al, 2003: p1372) and accumulation of these assets increases opportunities for poverty reduction. CA offers a number of ways of building the asset base of smallholder farmers and the first is by increasing efficiency of the production system by attempting to reduce inputs and increase outputs.

The participatory budget showed that major expenditure for CA plots included the purchase of seeds[1] and shelling and bagging costs[2]. Pesticides and herbicides were the only

[1] TZS 44,000 per acre (US$30) on maize, lablab and pigeon pea seeds.
[2] TZS 38,400 (US$25) for 15 bags of maize and 6 bags of pigeon pea/lablab.

other expenses[3] bringing the total costs for one acre of CA land to approximately US$70.[4] Outputs included one tonne of maize and 120kg of lablab beans for family consumption plus 500kg maize surplus, 60kg of lablab and 480kg of pigeon pea which are sold, generating approximately US$470. The income generated from one acre of CA land not only depends on yield size, but also on family size and market prices.

The budget calculated that approximately 266 hours per acre per year are needed for CA land and a large portion of this is spent on contouring (which may not be necessary for all farmers), spreading manure, harvesting and threshing. Contrary to the belief that the time saved from the eradication of ploughing in a CA system is spent instead on weeding (Giller et al, 2009: p26), only 26 hours per year per acre (about 10% of total time) is spent on weeding and rouging. There are two main reasons for this, the first being that herbicide use has increased in the early years of CA adoption to make weeding more manageable. The second reason can be explained by the use of adequate crop cover which takes approximately two to three years to achieve. As well as fixing nitrogen, cover crops such as lablab suppress weed growth and reduce the need to spend money on herbicides in the long run.

Claims of CA being a low input high output system are debateable as the amount of inputs used may either decrease or increase depending on the system that the farmer used before. Many of the smallholder farmers applied no inputs except for labour before and are now using improved seeds, herbicide, pesticide and manure whilst others may have reduced the use of inorganic fertilizers, herbicide and pesticide. What is evident from all farmers is that yields have increased and time is being saved, suggesting that the efficiency and

[3] TZS 21,000 (US$14) for 400ml of pesticides and 1 litre of herbicides.

[4] Total costs obviously change depending on the yield, which for the year recorded was 15 bags (1500kg) maize per acre, as it was a fairly dry year. In good rainfall years, the yield increased to up to 25 bags (2500kg) per acre, therefore raising the shelling and bagging costs by Tsh2,300 (US$1.5) per bag.

productivity of the land has increased. Whilst the term low input/high output may be misleading seen as CA systems still require quality inputs, what CA does ensure is a higher output to input ratio than traditional faming systems. One farmer commented that “even if you produced the same amount of yield you would spend less money doing so” which shows that CA can help smallholder farmers to make better use of their resources to build capital.

The group survey investigated changes in the assets held by participants since adoption of CA practices and split these assets into the five capitals of natural, social, human, physical and financial. Smallholder farmers’ perceived that their assets of natural capital had increased due to the eradication of the environmentally damaging effects of tillage. There was a noticeable increase in soil quality identified by the colour change, water retention and increase in biological life which can all be explained by the elimination of tillage, use of manure, crop rotation and application of crop residues (Fowler et al, 2001: p95). Incidence of weeds decreased, supporting the findings from the participatory budget exercise that emphasised the role of herbicide in the early stages of adoption and then of cover crops after a few years.

Bebbington (1999: p2034) believes that social capital plays “a vital role in helping people act to improve their livelihoods, mobilise assets and defend them” and participants of the research believed their social capital had increased since adoption of CA through more involvement in community meetings, increased interaction with other farmers and more time for off farm activities and socialising. The importance of involvement in these social situations became evident when farmers explained how through the FFS they also learned about health issues such as HIV, and discussed concerns such as the necessity to educate their children. Previous barriers to education had been the need for children to look after

livestock, some parents were worried that the school was too far away and some people thought education was not necessary as the children would work on the farm in the future. When these thoughts were shared and discussed in the group many farmers came to the conclusion that when they get old, their children take care of them so it would be a good idea if they are educated so they can earn a better income. This led to an increase in human capital among households as child attendance in schools has increased.

Accumulation of human capital such as education, skills and access to information and health services build the capacity of households to diversify their livelihood strategies and is key to promoting pro-poor growth in rural areas (Rigg, 2006: p194). As well as an increase in child attendance at school, CA farmers also reported an increase in access to agricultural extension officers and a decrease in family members migrating to towns. Participants explained this decrease in migration as being linked to the increase in productivity of land due to CA and therefore people were returning from towns to work on small plots of land. An increase in yield has also led to better nutrition of family diets through increased consumption and more income to spend on other commodities such as vegetables, meat and fish.

Financial capital has improved through an increase in yields enabling farmers to sell surplus crops. Families are now better able to afford medicine and purchase quality seeds. They also have better access to credit services through membership to VICOBA (Village Community Bank) enabling them to draw loans at low interest rates and without having to travel to the nearest town. Many farmers reduced their quantity of livestock, but were keen to communicate that they had increased the quality, often investing in dairy cows. The reduction of livestock is linked to the conflict of crop residue use between animal feed and

mulching (Giller et al, 2009: p25) and whilst some farmers have migrated to keep their large herds, most farmers in FFS have seen the advantages of adopting CA and having a more manageable, sustainable and integrated livestock farming system. The conflict between livestock feed and mulching of residues has been resolved through the enforcement of bylaws that restrict free-grazing (Owenya et al, 2011: p150) and transferring fodder to tethered animals. Due to increased yields under CA systems, more biomass is produced so after the maize harvest farmers cut the stover, leaving about one metre from each plant in the field as residue and taking the rest for animal feed. This results in adequate soil cover and enough feed for livestock.

Physical capital in the form of better quality roads and transport has increased since CA adoption. Although this may not be directly linked to the spread of CA practices, such as the investment in roads by the government, there are links between impacts of CA and the accumulation of physical capital. Some farmers claimed that because of the reduced rainwater runoff from fields as a result of CA, local roads are less eroded than they used to be. Better roads and the ability to purchase mobile phones has led to increased availability of transport services as farmers are now able to phone for motorcycle taxis to come to the village. Due to increased yields some villages are being visited by grain purchasers which means farmers can sell their crops for the same price as they would in the towns but save money on travel costs to markets. Some farmers have improved the quality of their housing, upgrading from mud and thatch to concrete and iron houses with proper windows, making their living standards more comfortable and durable, which reduces the frequency of repairs. Some have also managed to invest in solar panels and biogas which have benefits for households such as less exposure to harmful wood-smoke, access to information through

radios, charging mobile phones at home rather than in the town and completing household tasks more easily after sunset.

There exists a link between each of these capitals, with the accumulation of one asset providing an opportunity to gain another. All assets may not have been gained directly due to the adoption of CA but through the increase in natural capital as a result of the three CA principles and social capital as a result of involvement in the FFS, farmers have gained opportunities to build financial capital and invest in human and physical capital.

5.3. Livelihood Strategies

There exists a debate as to whether the best approach to escape rural poverty is through improving agricultural production of smallholder farmers (Jayne et al, 2010) or by exiting farming altogether and building the skills of the rural poor so they can seek off-farm employment (Rigg, 2006; Bryceson, 2002). Livelihood diversification can be a means for a rural household to increased income, however, involvement in a diverse set of livelihood strategies doesn't necessarily mean a household is earning more income as often such strategies are used as coping mechanisms.

The livelihood strategy ranking matrix explored the strategies that CA farmers used before and after CA adoption. The most notable point was that farmers are now able to sell surplus maize, something that none of them did before CA adoption because yields were too low. The introduction of lablab as a cover crop also generated a new income source as lablab was not previously grown. Other new or increased strategies mostly revolved around livestock including selling cows, pigs, milk, chickens and eggs and this has only been possible because farmers gained income from selling maize, which they invested in livestock. Strategies that were either reduced or eliminated since the adoption of CA included casual

labour, making and selling rope, breaking rocks to sell gravel and making and selling local brew. When asked why they had stopped using such strategies farmers replied that the tasks are so menial that they generate very little income and whereas before they tried everything they could to raise money they no longer needed to do these tasks because they had increased income from crops and livestock.

There is also a notable difference when investigating the strategies that created most income before and after CA adoption. Before CA, 10 out of the 12 farmers involved in the exercise generated most income from selling goats and sheep, whereas after CA adoption this strategy does not feature in the 'most income generated' list. After CA, selling cows featured highly and selling milk, chickens and eggs also featured. These findings support the necessity of building up a good agricultural base before livelihoods can be effectively diversified as "productivity increases in food crops ... release labour and capital... making them available for the production of higher value crops and non-farm activities such as manufacturing and services" (Jayne et al, 2010: p1388). Research into the types of activities farmers spent most time doing also showed significant change with a big shift from arable farming to livestock. This can be attributed to the time saving properties of CA practices which are then spent on livestock duties, leading to better rearing practices and increasing the income generated from livestock.

These results show that a diverse set of livelihood strategies does not necessarily mean that the household is generating more income and that tasks such as rock breaking and casual labour are more than often done as coping strategies. Through adopting CA, farmers have been able to build-up the productivity of their land, enabling them to generate income which is invested in livestock, generating a more substantial income. Once farmers

build up their agricultural production there is scope to invest more widely in human and physical capital which will improve a households chances of accessing off-farm opportunities. However, arguments that insist on ignoring agriculture and instead focus solely on the accumulation of human capital forget that households with no financial or social capital have little chance of obtaining the skills needed to access the more lucrative off-farm opportunities. The first step in 'deagrarianisation' (Bryceson, 2002: p726) should therefore be productive smallholder agriculture. The challenge lies in convincing smallholder farmers to invest in human capital once they accrue the necessary financial and/or social capital.

5.4. Vulnerability and Resilience

Resilience is essential for smallholder farmers to respond to and recover from shocks and stresses and can be accrued through the accumulation and protection of assets. When faced with challenges such as food shortages or extreme weather a household's ability to respond depends on the assets they hold including resources, stores, claims and access (Chamber et al, 1992: p8). As a result of their isolation, poverty and dependence on subsistence agriculture many rural smallholder farmers are vulnerable to shocks and stresses meaning they are unable to support their families in such scenarios.

The focus group explored the farmers' perceptions of their vulnerability and how this may have changed over the last forty years. A factor that came to light was the ten year recurrence of drought in 1974, 1984 and 1994 and farmers noted the frequency of droughts has increased recently, having experienced them in 2000, 2009 and potentially in 2011. This supports findings that smallholder farmers in Tanzania are already experiencing the effects of climate change (Paavola, 2008) and although they previously encountered similar

challenges the frequency has increased, leaving less time for farmers to recover from shocks and building pressure on stores of assets. Farmers felt they were better able to cope with these challenges since adoption of CA due to its water use efficiency. They noticed that even with low rainfall they produced higher yields than farmers using traditional practices, which can be attributed to the improved water infiltration and water holding capacity of the soil, reduced surface evaporation resulting from soil cover and the introduction of ripping which naturally channels rainfall to the crops. Hahn et al (2009: p74) write "a dependence on agriculture and livestock and a lack of irrigation means that African farmers are especially vulnerable to precipitation changes". CA therefore has a central role to play in climate change adaptation (CCA) for agriculture in low rainfall areas as smallholder farmers have demonstrated that whilst using the same land and in the same climate conditions as traditional farming systems, CA makes better use of limited water resources resulting in higher yields.

Another aspect that has improved farmers ability to cope in such situations is their newly adopted approach to livestock management. With the need for residues for crop cover, farmers have reduced their number of livestock and invested in better quality animals which produce more milk. This milk can be sold to raise income or fed to children, helping to improve nutrition in periods of drought. Also, as farmers have reduced their livestock numbers they are better able to take care of and feed them when yields are low, and should the situation be desperate they can extract crop residues from the field to use as feed. Whereas before caring for large numbers of cattle was extremely difficult in periods of drought they now have a more sustainable and integrated farming system which helps to prevent the loss of assets through the death of livestock.

Coping strategies are the involuntary responses to shock and stresses (Bryceson, 2002: p730) and in this research participants explained such strategies included migrating either with livestock or to towns in search of casual labour, selling livestock to generate income, dependence on food aid and seeking food or cash loans from wealthier families. The effects of such strategies often meant that women were left to care for and raise income for the family either because the male heads had migrated or run away. Sick family members are often left untreated and in extreme cases children are left with other families or abandoned at road sides if a family is unable to feed and care for them. Other coping strategies include access to credit through membership of the village community bank and the reserve of three bags of maize per person each year in case of drought the following year; both of which are schemes that have been promoted by agricultural extension workers visiting the FFS. Coping strategies may still be used if necessary but the likelihood of having to resort to these is minimised leading to a reduction in families being split up, women being left solely in charge of the family, children dropping out of school and illness and death of family members and livestock.

5.5. Role of Networks and Institutional Structures

Smallholder farmers face barriers to adopting CA through a lack of access to information, inputs and equipment. Barriers to generating income include inadequate markets, processing technologies and infrastructure. These barriers are often outside of the control of smallholder farmers and therefore they rely upon the decisions made by outside parties, such as the government, NGOs and the private sector for the creation of a "facilitating environment" (Ellis et al, 2003: p1381) in which they can build their asset base and raise standards of living. The stakeholder analysis investigated the network of outside

parties and how the actions of these stakeholders impacted the choices available to smallholder farmers.

A key role for the dissemination of CA techniques is that of the agricultural extension workers. Whether at district, ward or village level, it is their job to initiate the set up of FFS and train farmers on CA techniques on a demo plot, so that farmers can decide what methods to use on their own land. They are also responsible for training farmers on other topics such as livestock husbandry, credit schemes and tree planting and on social issues such as HIV and the importance of education. A major obstacle they encountered in their role was the slow adoption rate of CA outside of FFS which they attribute to the lack of CA equipment and also the challenges surrounding free grazing of livestock and the initial battle to get bylaws imposed which protect fields from wandering livestock (Owenya et al, 2011: p150).

Other government staff involved in the spread of CA include agronomists, researchers and communication staff at research institutes such as SARI. The CA-SARD Facilitators at research institutes are responsible for linking stakeholders and coordinating the national approach for CA adoption. They advise extension workers and farmers on seed varieties and suitable cover crops, liaise with manufacturers for distribution of equipment and gather information from practising farmers on the benefits and constraints of CA. It is the role of the information and extension officer to increase coverage of new technologies such as CA and repackage information in suitable formats for audiences including farmers, NGOs and policymakers. These messages are often disseminated through the mass media (radio and newspapers) and at agricultural shows.

NGOs carry out similar tasks to agricultural officers in respect to training and formation of FFS but also have the capacity to address non-agricultural enterprises such as set up of small businesses. NGOs are keen to mainstream issues of gender and environment into their practices, an area that may not be central to government extension workers' role. From the spread of CA, NGOs have noticed that yields have increased, time is being saved which opens up other opportunities for farmers and there is increased community cohesion as farmers are learning from each other leading to the breakdown of gender barriers. The private sector is involved through the manufacturing and provision of CA equipment such as rippers, direct seeders and hand-jab planters. Heads of local manufacturing companies have been on international visits to witness the production of CA equipment in areas where uptake is high. These companies then produce equipment at the request of agriculture extension staff that place group orders for FFS wishing to purchase the specialist equipment.

The spread of CA in this area is therefore an effect of the concerted efforts made by extension workers, researchers, NGOs and policy makers who are using CA to address issues of soil degradation and erosion to build the productivity of farms in an attempt to achieve food security for smallholder farmers. For members of FFS, CA adoption has been successful but for farmers outside of these groups adoption has been slower than would have been hoped. Stakeholders believe that continued upscaling requires more of the same with more FFS setup and training on CA practices and special topics such as livestock management, micro-credit and HIV.

The two major constraints to CA adoption highlighted by all stakeholders included the crop residue issue and access to equipment. The first of these constraints has been well addressed with bylaws being enforced, livestock herds reduced to manageable levels and a

transfer from free-grazing to zero-grazing practices. The issue of equipment however remains an issue for farmers and although many FFS own some equipment it appears there is still not enough for all farmers to complete timely field preparation. With manufacturing companies in the local areas having the capabilities to make CA equipment it is not the lack of availability that is the problem but instead a question of provision and affordability. With the government and NGOs providing some equipment at the FFS setup phase, many farmers have established a mindset of dependence or what Fowler et al (2001: p103) label 'receiver mentality'. When asked about accumulation of capital farmers were quick to point out the improvements they had been able to make to their homes and the ability to send their children to school, but they were less willing to spend money on CA equipment.

Meeting costs of CA equipment is challenging for a rural household but from the gains it has been proven to produce, expenditure on equipment would soon recoup it costs. There is also scope for farmers to purchase equipment as a FFS group, splitting the costs between members, however, whilst farmers in FFS may be happy to learn techniques together there are less examples of collective action in sharing costs and collaborating on income generating opportunities. This presents a potential area for governments, NGOs and the private sector to train FFS in the future on the opportunities and practicalities of collective action.

Chapter 6 – Conclusion

6.1. Findings from Objectives

CA can contribute to the accumulation of assets which enhances smallholders' potential to build sustainable livelihoods. Through higher output to input ratios and the subsequent improved efficiency of land, smallholders can make better use of limited resources, improve yields and build financial capital through the sale of surplus crops. Natural capital is gained through the application of the three CA principles which reverse the trends of degradation and erosion that have led to reduced yields. Through careful natural resource management and protection of ecosystem services smallholders not only get improved yields but are ensuring their ability to support their livelihoods in the future. Social capital has improved by smallholders' involvement in FFS which build relationships and trust in the community and encourages interaction with outside parties such as agricultural extension workers and NGOs which can then be used to access further opportunities and information. Through the generation of natural, social and financial capital, smallholders are able to invest in human and physical capital such as education for children, improved health through better nutrition and medicine, and household improvements such as more durable walls and roofing and purchase of solar panels.

Under CA, productivity of land is restored reducing the need for smallholders to engage in menial income generating strategies such as casual labour and rock breaking. With the income gains made from higher yields, smallholders are investing in more lucrative livestock practices including dairy cows and chickens. Since CA adoption there has been a shift from the majority of time spent on growing crops to attending to livestock, highlighting the time-saving aspects of CA and the opportunity this creates to raise more income from

livestock. Although livelihood diversification is regarded as a vital strategy for rural development, it should be preceded by an increase in farm productivity as most of the smallholders involved in diverse income strategies generate little income. Instead an increase in agricultural productivity frees up the financial and human capital necessary to access the profitable off-farm opportunities that will make a significant difference to the incomes of rural households.

CA has built the resilience of smallholder farmers to shocks and stresses in two distinct ways. Firstly, due to the increase in productivity they are able to build their asset base which can be drawn upon in times of need. Assets such as food stores, savings, livestock, health services and good relationships with community members enable the rural poor to cope during challenging periods. This reduces the need for households to resort to coping strategies such as migration, selling livestock and requesting high interest loans which have knock-on effects of separated families, sick family members being left untreated and children being abandoned. These effects often have more bearing on women who are left to care for, feed and raise income for the household when the male household heads migrate to find casual labour or abandon the family. Secondly, the improved water use efficiency of CA systems due to better soil structure and ripping means that in periods of low rainfall CA farmers are still able to harvest something, when those using traditional practices have no yields. Climate change poses a serious threat to the livelihoods of smallholder farmers in Tanzania and they are already experiencing more frequent drought conditions. Increased frequency of droughts gives farmers less time to recover their assets to help them through the next shock period, so by adapting farming systems to cope with erratic rainfall conditions CA farmers will be less vulnerable than those using traditional practices.

CA adoption in Arusha Region of Tanzania has been successful because of the efforts of the government, NGOs and international institutions to create a facilitating environment for smallholder farmers. Stakeholders have contributed through dissemination of CA knowledge, loans of cover crop seeds, advice on improved maize varieties and provision of CA equipment. Together the stakeholders were able to overcome a major issue presented by the conflict of crop residue use by training smallholders on livestock management and the implementation and enforcement of bylaws protecting land from grazing. It is now essential that all stakeholders continue to work together to overcome the issues regarding affordability and provision of CA equipment through strategies that encourage farmers to invest in the specialist tools whilst avoiding the receiver mentality that can ensue from subsidy schemes.

The set up of FFS has presented an avenue to disseminate ideas and techniques between farmers and other stakeholders, with regular contact from district, ward and village level extension workers who train farmers on CA practices, livestock management, set up of credit services and heath issues. Outside of FFS, adoption of CA has been slow, representing the necessity for effective communication and visualisation of techniques to encourage uptake.

6.2. Upscaling and Future Strategies

The key to the continued growth in adoption of CA by smallholder farmers in Tanzania lies in the expansion of FFS and their linkages with agricultural extension officers and NGOs. These groups help to develop skills and knowledge through training on agricultural production technologies and are an effective means for delivering wider development messages related to health and livelihood issues. The group scenario also

contributes to greater trust between members, discussion on social issues within the community and a breakdown of gender barriers. Improvements in the yields of FFS members are being noticed by farmers who are not involved in such groups with requests being made for the formation of new groups and in some areas farmers are setting up their own FFS with the assistance and training from members of other groups.

This expansion of the FFS structure will help to spread uptake of CA but there is still more work to be done with FFS that have already been set up. Although CA farmers have shown increases in production and an ability to build their asset base, the research into livelihood strategies suggests that whilst most farmers have reduced the menial tasks they used as coping strategies, they have not as yet diversified into more lucrative off-farm income generating strategies, instead investing their money into livestock production. There is scope for FFS members to build on their production gains by entering into food processing to add value to their produce, which has been done in a few areas with FFS that are linked to more innovative NGOs. Processing can be difficult on an individual basis as costs of equipment and marketing act as a barrier, but with group structures like FFS already set up there is a viable path towards successful market entry for these smallholder farmers. Barrett (2007, p301) writes,

> *"...interventions aimed at facilitating smallholder organisation ... and improving poorer households' access to improved technologies and productive assets are central to stimulating smallholder market participation and escape from semi-subsistence poverty traps..."*

FFS already have their individual identities, a build up of trust within the group and shared experience of working together on the demonstration plots. A transition from FFS being seen

as training groups to village level enterprises (VLE) could be facilitated with training from extension officers, NGOs and the private sector and would enable these groups to become more focussed on effective income strategies. Facilitation is an important part of this process as the facilitators, be they government, NGOs or private sector, "provide information and technical assistance and build the capacity of a group to effectively engage in marketing activities" (Markelova, 2009: p5). In a group situation, costs of specialist CA and processing equipment can be shared and bargaining power with buyers improved.

6.3. Closing Statement

The purpose of this research was to investigate the impacts of CA on the livelihoods of smallholder farmers in Arusha Region of Tanzania, an area which has been the focus of a concerted effort to promote CA as a viable technology for farmers. Through the study of the four objectives it is possible to see that CA has contributed to the accumulation of assets held by smallholder farmers, improved productivity of land, reduced the need to resort to coping strategies, increased resilience to shocks and stresses and increased social capital and involvement in networks. All of these aspects point to the fact that CA has had an overwhelmingly positive impact on the livelihoods of smallholder farmers. However, it is important to state that these improvements are related to an increase of productivity of the farmland and the related rise in yields. The solution to poverty reduction does not end there. Smallholder farmers must be able to capitalise on these gains in production, through access to markets and processing technologies and training on how to set up and run small enterprises.

Barrett (2007: p314) believes that "breaking out of semi-subsistence requires interventions to build up assets, facilitate uptake of technologies ... and the breakdown of

barriers to finance and market access." This research has demonstrated that adoption of CA through the FFS structure builds the assets of farmers and facilitates uptake of technologies. There has been some breakdown of the barriers to finance and market access but it is in these areas where more work is needed for farmers to capitalise on their increases in production.

Appendices

Appendix A – Information and Consent Form

My name is Alastair Stewart and I am currently studying for an MSc in Agriculture and Development at the University of Reading in the UK. I am carrying out research on the impacts of Conservation Agriculture on the livelihoods of smallholder farmers in the Arusha Region of Tanzania, as part of my postgraduate programme. The research is for my final dissertation and so will contribute to my degree.

As part of this research, I invite you to take part in a participatory workshop consisting of a focus group and a budget and ranking exercise as well as a short field survey. You have been selected through your association with SARI to give a broad cross-section of the local farming population. I will take notes of the discussion and may also represent the points made by the group in the form of diagrams for you to comment on.

Participation is entirely voluntary and you may withdraw from the activity at any point. Your identity will not be revealed to anyone other than the interviewer. If at any time after the activity you wish to withdraw a contribution you made to the discussion, you can do so by contacting me (details below) stating the unique participant number at the bottom of this page, the date and location of the activity and a summary of the contribution that you wish to withdraw. An overall summary of the research results will be available by 7th September 2011. If you would like to have a copy of this, please contact myself or Wilfred Mariki, the Senior Agronomist at SARI.

<u>Contact details</u>

Alastair Stewart	University of Reading	a.d.stewart@student.reading.ac.uk
Wilfred Mariki	Selian Agricultural Research Institute (SARI), PO BOX 6024, ARUSHA Tel: (255-027) 3883	

By taking part in the group discussion and completing the survey, you are acknowledging that you understand the terms of participation and that you consent to these terms.

This application has been reviewed according to the procedures specified by the University Research Ethics Committee and has been given a favourable ethical opinion for conduct.

Your participant number is: [ ]

Appendix B

FIELD SURVEY		
1	Participant number	
2	Village	
3	District	
4	Farmer Field School	
5	Gender of respondent	
6	Age	
7	Area of land owned by farmer (acres)	
8	Area of land owned, dedicated to CA (acres)	
9	Years since adoption of CA practices	

In the last _____ (insert answer to Q9) years have you noticed changes in:				
NATURAL CAPITAL		**No change**	**Increased**	**Decreased**
10	Yield of staple crops			
11	Diversity of crops grown			
12	Retention of topsoil			
13	Biological life in soil			
14	Water infiltration into soil			

15	Water retention of soil			
16	Quality of soil			
17	Use of fertilizers			
18	Incidence of weeds			
19	Incidence of pests			
20	Use of pesticide/herbicide			
21	Quality of crops produced			
22	Availability of drinking water			
23	Drinking water quality			
SOCIAL CAPITAL		**No change**	**Increased**	**Decreased**
24	Interaction with other farmers			
25	Involvement in community meetings			
26	Time for off farm activities (for income opportunities)			
27	Time for off farm activities (for social purposes)			
28	Decision making within household			
29	Access to agricultural extension services			
HUMAN CAPITAL		**No change**	**Increased**	**Decreased**
30	Child attendance at school			
31	Calorie content of diet			
32	Nutrition of family diet			
33	Health of family members			
34	Family members migrating to towns			

PHYSICAL CAPITAL		No change	Increased	Decreased
35	Quality of housing			
36	Quality of latrines			
37	Quality of transport services			
38	Quality of roads			
39	Quality of storage facilities			
40	Distance to nearest market to sell/buy goods			
FINANCIAL CAPITAL		**No change**	**Increased**	**Decreased**
41	Ability to afford medicine			
42	Ability to save money			
43	Ability to afford school fees			
44	Purchase of household goods			
45	Quality of seeds purchased			
46	Quantity of livestock			
47	Access to credit services			

END OF SURVEY

Appendix C – Ethical Clearance

Applicant

Signed: A.D. Stewart

Date: 10.05.11

Student's supervisor or staff PI AJMURDOCH

Signed: [illegible]

Date: 16/5/11

Email: a.d.stewart@student.reading.ac.uk (main email address to which ethical clearance decision should be sent) PLEASE MAKE THIS LEGIBLE !

For group projects, names and email addresses of all participating students.

Ethical Approval

Note: The process of obtaining ethical approval does not include an assessment of the scientific merit of the questionnaire. That is the responsibility of the academic supervising your project, or your Principal Investigator.

Status:

Clearance refused	
Clearance granted as presented	✓
Clearance granted subject to revisions suggested	
Referred to University Research Ethics Committee	

Reasons for non-approval (if applicable):

Signature: [illegible] Print Name:

Date: 20/5/11

SAPD Ethical Clearance Submission Form Version 2.0 Last revised September 2010 Page 11

References

Barrett, C. (2007). *Smallholder market participation: Concepts and evidence from eastern and southern Africa.* Food Policy: Issue 22, Pages 299-317.

Barrett, C., Lee, D. and McPeak, J. (2005). *Institutional arrangements for rural poverty reduction and resource conservation*. World Development: Issue 33, Pages 193-197.

Bebbington, A. (1999). *Capitals and Capabilities: A Framework for Analyzing Peasant Viability, Rural Livelihoods and Poverty.* World Development: Issue 27 (12), Pages 2021-2044.

Bryceson, D. (2002). *The scramble in Africa: Reorienting Rural Livelihoods*. World Development: Issue 30 (5), Pages 725-739.

Cadot, O., Dutoit, L. and Olarreaga, M. (2006). *How costly is it for poor farmers to lift themselves out of subsistence?* World Bank Policy Research Working Paper 3881.

Cannon, T. (2008). *Vulnerability and Disasters.* Chapter 6.6 in DESAI & POTTER (Editors) The Companion to Development Studies. Sage: London. Pages 300-305.

Chambers, R. (1994a). *Participatory Rural Appraisal (PRA): Challenges, Potential and Paradigm.* World Development: Issue 22 (10), Pages 1437-1454.

Chambers, R. (1994b). *The Origins and Practice of Participatory Rural Appraisal.* World Development: Issue 22 (7), Pages 953-969.

Chambers, R. (1983). *Rural Development: Putting the last First*. Pearson Education Limited: England.

Chambers, R. and Conway, G.R. (1992). *Sustainable rural livelihoods: practical concepts for the 21st century*. Institute of Development Studies Discussion Paper, December 1991.

Diao, X., Headey, D. and Johnson M. (2008). *Toward a green revolution in Africa: what would it achieve, and what would it require?* Agricultural Economics: Issue 39, Pages 539-550.

Ellis, F. And Mdoe, N. (2003). *Livelihoods and Rural Poverty Reduction in Tanzania.* World Development: Issue 31 (8), Pages 1367-1384.

FAO (2009). *Scaling-up Conservation Agriculture in Africa: Strategy and Approaches*. The FAO Sub regional Office for Eastern Africa.

Foresight (2011). *The Future of Food and Farming: Challenges and Choices for Global Sustainability*. Final Project Report. The Government Office for Science, London.

Fowler, R. and Rockstrom, J. (2001). *Conservation tillage for sustainable agriculture: An agrarian revolution gathers momentum in Africa.* Soil and Tillage Research: Issue 61, Pages 93-107.

Friedrich, T., Kassam, A. and Shaxson, F. (2008). *Conservation Agriculture (CA). Agricultural Technologies for Developing Countries, Annex 2*. European Technology Assessment Group, FAO, Rome.

Goddard, T., Haugen-Kozyra, K. And Ridge, A. (2009). *Alberta: North America's First Compliance Offset Carbon Market.*

http://www.fao.org/ag/ca/Carbon%20Offset%20Consultation/CARBONMEETING/3FULLPAPERSBYCONSULTATIONSPEAKERS/PAPERGODDARD.pdf

Giller, K., Corbeels, M., Nyamangara, J., Triomphe, B., Affholder, F., Scopel, E., and Tittonell, P. (2011). *A research agenda to explore the role of conservation agriculture in African smallholder farming systems.* Field Crops Research: Article in Press, Corrected Proof, Pages 1-5.

Giller, K., Witter, E., Corbeels, M. and Tittonell, P. (2009*).* *Conservation agriculture and smallholder farming in Africa: The heretics' view.* Field Crops Research: Issue 114, Pages 24-34.

Hahn, M., Riederer, A. and Foster, S. (2009). *The Livelihood Vulnerability Index: A pragmatic approach to assessing risks from climate variability and change – A case study in Mozambique.* Global Environmental Change: Issue 19, Pages 74-88.

Jayne, T., Mather, D. and Mghenyi, E. (2010). *Principal Challenges Confronting Smallholder Agriculture in Sub-Saharan Africa.* World Development: Issue 38 (10), Pages 1384-1398.

Kassam, A., Friedrich, T, Shaxson, F. and Pretty, J. (2009). *The spread of Conservation Agriculture: Justification, sustainability and uptake.* International Journal of Agricultural Sustainability*:* Issue 7 (4), Pages 292-320.

Kassam, A., Friedrich, T., Shaxson, F., Reeve, T., Pretty, J. and de Moraes Sá, J.C. (2011). *Sustainable Agricultural Production Systems: Integrating Productivity with Ecosystem Services*. Chapter 3, Sustainable Intensification. FAO, Rome. In Press.

Kelman, I. (2010). *Introduction to climate, disasters and international development.* Journal of International Development: Issue 22, Pages 208-217.

Markelova, H., Meinzen-Dick, R., Hellin, J. and Dohrn, S. (2009). *Collective action for smallholder market access.* Food Policy: Issue 34, Pages 1-7.

Mayoux, L. (2009). *Quantitative, Qualitative or Participatory? Which method, for what and when?* Chapter 13 in DESAI & POTTER (Editors) Doing Development Research. Sage: London. 2009. Pages 115-129.

Owenya, M., Mariki, W., Kienzle, J., Friedrich, T. and Kassam, A. (2011). *Conservation Agriculture in Tanzania: the case of the Mwangaza-B CA farmer field school.* International Journal of Agricultural Sustainability: Issue 9 (1), Pages 145-152.

Paavola, J. (2008). *Livelihoods, vulnerability and adaptation to climate change in Morogoro, Tanzania.* Environmental Science and Policy: Issue 2, Pages 642-654.

Place, F., Adato, M. and Hebink, P. (2007). *Understanding Rural Poverty and Investment in Agriculture: An Assessment of Integrated Quantitative and Qualitative Research In Western Kenya.* World Development: Issue 35(2), Pages312-325.

Pretty, J., Toulmin, C. and Williams, S. (2011). *Sustainable intensification in African agriculture*. International Journal of Agricultural Sustainability: Issue 9, Pages 5-24.

Rigg, J. (2005). Land, Farming, *Livelihoods, and Poverty: Rethinking the Links in the Rural South*. World Development: Issue 34 (1), Pages 180-202.

Rosset, P. (2000). *Lessons from the Green Revolution.*

http://www.soc.iastate.edu/sapp/greenrevolution.pdf

Sen, A. (1997). *Editorial: Human Capital and Human Capability*. World Development: Issue 25 (12), Pages 1959-1961.

Shetto, R. and Owenya, M. Editors. (2007). *Conservation agriculture as practised in Tanzania: three case studies.* FAO: Nairobi.

Smith, D., Gordon, A., Meadows, K. and Zwick, K. (2001). *Livelihood diversification in Uganda: patterns and determinants of change across two rural districts.* Food Policy: Issue 26, Pages 421-435.

Tschakert, P. (2007). *Environmental services and poverty reduction: Options for smallholders in the Sahel.* Agricultural Systems: Issue 94, Pages 75-86.

Vogel, H. (1994). *Conservation tillage in Zimbabwe: evaluation of several techniques for the development of sustainable crop production systems in smallholder farming*. African Studies Series A11. University of Berne, Switzerland.

Bibliography

Borlaug, N. (2007). *Fomenting an African Green Revolution*. Sasakawa Africa Association Annual Report 2005/06, 1-2.

Eriksen, S., Brown, K. and Kelly, M. (2005). *The dynamics of vulnerability: locating coping strategies in Kenya and Tanzania.* The Geographical Journal: Vol. 171, No. 4. Pages 287-305.

FAO (2008). *Investing in sustainable crop intensification: The case for improving soil health.* Plant Production and Protection Division. FAO, Rome.

La Rovere, R. and Dixon, J. *Operational guidelines for assessing the impact of agricultural research on livelihoods.* CIMMYT. http://apps.cimmyt.org/english/docs/manual/ia/contents.htm#contents

Liwenga, E. (2008). *Adaptive livelihood strategies for coping with water scarcity in drylands of central Tanzania.* Physics and Chemistry of the Earth: Issue 33, Pages 775-779.

Mowo, J., Janssen, B., Oenema, O., German, L., Mrema, J. and Shemdoe, R. (2006). *Soil fertility evaluation and management by smallholder farmer communities in northern Tanzania.* Agriculture, Ecosystems and Environment: Issue 116, Pages 47-59.

Ngowi, A., Mbise, T., Ijani, A., London, A., and Ajayi, O. (2007). *Smallholder vegetable farmers in Northern Tanzania: Pesticide use practices, perceptions, cost and health effects.* Crop Protection: Issue 26, Pages 1617-1624.

Quinn, C., Huby, M., Kiwasila, H. and Lovett, J. (2003). *Local perceptions of risk to livelihood in semi-arid Tanzania.* Journal of Environmental Management: Issue 68, Pages 111-119.

Reardon, T. and Vosti, S. (1995). *Links between rural poverty and the environment in developing countries: Asset categories and investment poverty.* World Development: Issue 23 (9), Pages 1495-1506.

Sanchez, P., Denning, G. and Nziguheba, G. (2009). *The African Green Revolution moves forward.* Food Security: Issue 1, Pages 37-44.

Sartorius, K. and Kirsten, J. (2007). *A framework to facilitate institutional arrangements for smallholder supply in developing countries: An agribusiness perspective.* Food Policy: Issue 32, Pages 640-655.

Wiggins, S. and Cromwell, E. (1995). *NGOs and Seed provision to Smallholders in Developing Countries.* World Development: Issue 23 (3), Pages 413-422.