Draft – Strictly Not for Quotation

18th ANNUAL RESEARCH WORKSHOP

Factors Influencing the Adoption of Conservation Agriculture by Smallholder Farmers in Karatu and Kongwa Districts of Tanzania

by

Dr. Simon Lugandu

Final Draft Report GD8

Presented at REPOA's 18th Annual Research Workshop held at the Kunduchi Beach Hotel, Dar es Salaam, Tanzania; April 3-4, 2013

Factors Influencing the Adoption of Conservation Agriculture by Smallholder Farmers in Karatu and Kongwa Districts of Tanzania
by Dr. Simon Lugandu

ABSTRACT

The study was conducted to investigate factors influencing adoption of conservation agriculture farming system among smallholder farmers in Karatu and Kongwa districts in Tanzania. The level of adoption of conservation agriculture, which entails simultaneous implementation of the three conservation agriculture (CA) principles, was found to be implemented by as low as 13% of households, thus disproving the proposition that the majority of smallholder farmers in the study districts have adopted CA. Although the variation in benefits was not statistically different between CA adopters and non adopters, the cost-benefit analysis of maize production revealed that net benefit for non adopters was higher than that of adopters by a small margin of 41,875 Tshs/ha. The factors that significantly affect adoption of CA in the study districts were the size of land owned by the household and the farmer category. To facilitate CA adoption the government and or stakeholders have to strengthen the capacity of extension services; provide farmers with financial, institutional and technical support services; increase sensitisation of the public and private sector to increase investments on CA; launching CA learning and experience sharing interventions for smallholder farmers; and addressing CA knowledge, information and incentives gaps through further research.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ABACO	Agro-ecology based aggradation-conservation agriculture project
ACT	African Conservation Tillage Network
ARI Uyole	Agricultural Research Institute Uyole, Tanzania
ASDP	Agricultural Sector Development Programme
AU	African Union
CA	Conservation Agriculture
CA SARD	Conservation Agriculture for Sustainable Agriculture and Rural Development
CAADP	Comprehensive African Agricultural Development Program
CBO	Community Based Organization
CPAR	Canadian Physician Aid and Relief
CYMMT	International Maize and Wheat Improvement Centre
FAO	Food and Agriculture Organisation of the United Nations
FFS	Farmer Field School
FGDs	Focused Group Discussions (FGDs)
GDP	Gross Domestic Product
HIV/AIDS	Human Immunodeficiency Virus/Acquired Immuno Deficiency Syndrome
IIRR	International Institute of Rural Reconstruction
M&E	Monitoring and Evaluation
MDG	Millennium Development Goal
NEPAD	New Partnership for Africa’s Development
NGO	Non-Governmental Organization
NORAD	Norwegian Agency for Development Cooperation
PRA	Participatory Rural Appraisal
RECODA	Research, Community and Organisational development Associates
RELMA	Regional Land Management Programme
REPOA	Research on Poverty Alleviation
SARI	Selian Agricultural Research Institute, Tanzania
SSA	Sub-Saharan Africa
TPB	Theory of Planned Behaviour
TRA	Theory of Reasoned Action
UNEP	United Nations Environment Programme
URT	United Republic of Tanzania
VICOBA	Village Community Banks
WADEC	Women in Agriculture Development Communities

EXECUTIVE SUMMARY

The study was conducted to investigate factors influencing adoption of conservation agriculture farming system among smallholder farmers in Karatu and Kongwa districts in Tanzania. Data collection was undertaken through household surveys, key informants interviews, and focused group discussions. Both qualitative and quantitative data analysis methods were used. Qualitative information was collected through various techniques such as Participatory Rural Appraisal (PRA), Focus Group Discussions (FGDs), observational method and unstructured interviews. Analytical approach was mainly content analysis technique. Content analysis involved recording the verbal discussions with respondents which was followed by breaking the recorded information into meaningful smallest units of information, subjects and tendencies and presented them as text. Descriptive and inferential statistical analyses were undertaken for quantitative data. Binary logistic regression analysis was adopted to analyse the factors affecting adoption of conservation agriculture and the factors influencing intercropping of trees with food crops. These statistical analyses were aided by Statistical Package for Social Sciences (SPSS Version 17).

The level of adoption of conservation agriculture, which entails simultaneous implementation of the three CA principles, was implemented by as low as 13% of households in both study districts thus disproving the hypothesis that the majority of smallholder farmers in the study districts have adopted conservation agriculture. It was established that adopter and non-adopter farmers differ significantly in terms of household characteristics, mainly on the type of farmer and level of mechanisation employed for farming, marital status, family size and food adequacy in some months of the year. The cost-benefit analysis of maize production revealed that net benefit for non-adopters was higher than that of adopters by 41,875 Tshs/ha Although this difference is not statistically different, it disproves the hypothesis that net benefits per unit area is higher for CA adopters than for non-adopters. The factors that significantly affect adoption of conservation agriculture were found to be land size owned and farmer category, hence confirming the hypothesis that adoption of conservation agriculture technologies by smallholder farmers in Tanzania is significantly affected by household socio-economic and farm characteristics.

To make CA an efficient farming system and facilitate its adoption process there is a need for the government or stakeholders to strengthen the capacity of extension service provision, provide smallholder farmers with financial, institutional and technical support services, increase sensitisation of stakeholders including the public and private sector to increase investments on CA, launching CA learning and experience sharing interventions for smallholder farmers, and addressing CA knowledge and information and incentives gaps through further research.

1.0 INTRODUCTION

1.1 Background

Tanzania has a total area of 945,239 km^2 with a population of 34.5 million people (National Census, 2002). Agriculture is the leading sector of the economy, accounting for about 24.6% of the GDP and 31% of merchandize exports (URT, 2010). Over 80% of its population derive livelihood from agriculture (*ibid*). Food production is the dominant sub-sector in the agriculture sector accounting for about 55% of the agricultural GDP (Larsen et al., 2009). The industrial crops mainly produced for export contribute only 9% of the GDP while the livestock sub sector contributes 32% of the agricultural GDP (URT, 2010). With the increasing population the total demand for food and non food commodities in Tanzania is expected to increase many times. Therefore increased food production is essential to meet the demand of this growing population.

Declining soil fertility, climatic extremes, high costs of inputs and lack of support for diversified income sources are all critical problems and are widely recognized as major factors responsible for declining agricultural productivity and increasing rural poverty (UNEP, 2009). Conventional farming practices such as intensive tillage and burning or removing crop residue often make these problems worse (Shetto *et al.,* 2007). Attaining food security and development goals at the household and national levels requires a shift from conventional to more efficient, sustainable and climate resilient food production practices (FAO, 2010). Sustainable land management including conservation agriculture (CA) holds that promise (ACT, 2008). Conservation agriculture, a three-pronged approach to farming, involving maintenance of permanent soil cover, practicing non-tillage planting methods to reduce soil disturbance, and implementing crop rotations/associations that break pest cycles and introduce nitrogen-fixing leguminous species to help restore soil fertility has shown potential for mitigating and adapting to impacts of climate change (Shetto *et al.,* 2007). Employing CA principles significantly increases and stabilizes crop yields while at the same time preserves the natural resources that are critical for food production (ACT, 2008).

Over the past decade, there has been a growing advocacy on the role of CA in enhancing household food security for poorer farmers in sub-Saharan Africa (SSA) and Asia. Thus, CA can enable attainment of the United Nations' Millennium Development Goal (MDG) on food security (Hobbs, 2007; Hobbs *et al*., 2007). Although there is growing interest in CA technology, its transfer to farmers in SSA is still limited to on-farm and on station demonstration trials (Gowing and Palmer, 2008). This is contrary to the situation in regions such as South America and some parts of Asia where farmers have adopted CA as a farming system (Derpsch, 2005; Twomlow *et al.,* 2006; Rockstrom *et al.,* 2007; Hobbs *et al.,* 2007).

To increase the scale of adoption and impact of innovation, such as conservation agriculture, action must be based on an understanding of the dynamics of adoption and the critical factors that determine whether farmers accept, do not accept, or partially accept innovations (Denning, 2001). Currently there is insufficient understanding of factors (household and farm characteristics) affecting adoption behaviour of conservation agriculture practices in Tanzania, yet better knowledge of how these characteristics of individual farmers and their farming practices affect adoption would help policy makers and researchers in designing more effective technologies that will be tailored to the needs of the farmers. Therefore the objective of this study is to investigate factors influencing conservation agriculture technologies adoption among smallholder farmers in Karatu and Kongwa districts in Tanzania.

1.2 Statement and significance of the research problem

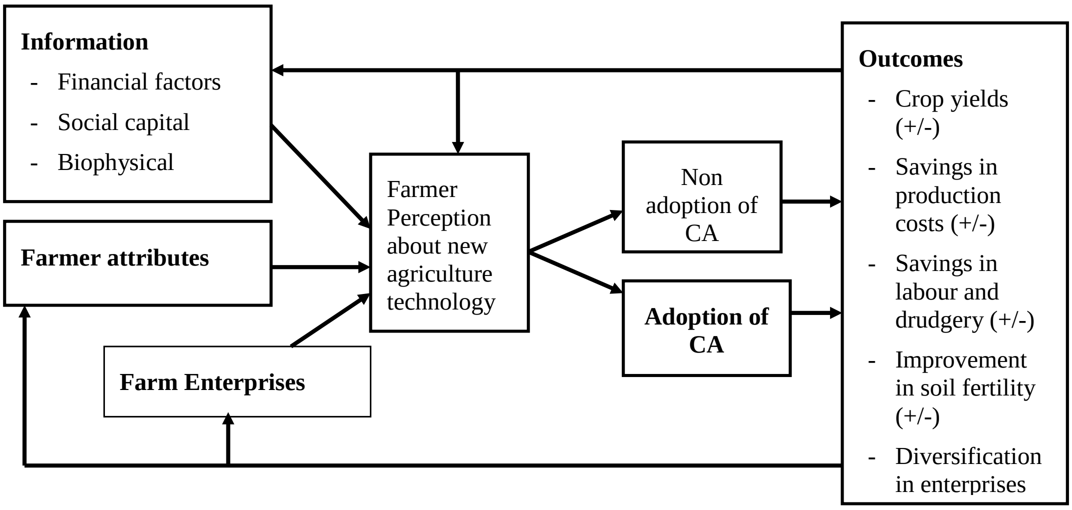
Conservation agriculture is increasingly being promoted as an alternative to address soil degradation resulting from poor agricultural practices. The advantages of conservation agriculture in labour saving, cost effectiveness and sustainable soil fertility and environmental conservation have been well studied and documented, for example, Hensley and Bennie (2003), RELMA (1998), Barron *et al*. (2003), Rockstrom *et al. (*2008), and Enfors (2009). Despite all the known benefits of conservation agriculture scaling up of the technology among smallholder farmers in Tanzania has remained low.

To fully exploit the potential of promoting the scaling up of CA the existing knowledge gaps have to be addressed. Information is lacking on the drivers that have made some countries succeed in scaling up CA, the constraints they face and how they address them, lessons learnt and how to achieve impacts at a greater scale. Despite the demonstrated positive impacts of conservation agriculture, there has been a generally-low adoption rate in Tanzania (Shetto *et al.,* 2007). The reasons for not optimally adopting conservation agriculture have not been fully established (*ibid*). This study intends to raise awareness among stakeholders especially policy makers and implementers on the factors that influence adoption of sustainable land management practices such as conservation agriculture in view of obliging them to design policies and or strategies that enhance adoption of CA and for advancing environmental and developmental goals.

1.3 Conceptual framework

Adoption or non-adoption of CA is a function of farmer's perception about it against other farming practices or technologies. CA is just one of many options available to farmers who are responding to perceived changes in their production environment (FAO, 2001). Farmers who switch to some new farming technique from conventional practice may do so for a variety of reasons and factors. They may detect a more efficient and profitable way to produce, or they may perceive a problem and in seeking solutions arrive at a new practice, such as CA (FAO, 2001; ACT, 2008). In this study adoption or non adoption of CA is influenced by farmers' perception about it, which is in turn affected by the information farmers have about CA, farmer attributes and farm enterprises. Outcomes of adoption or non adoption can as well affect farmers' perception about CA. The conceptual framework for the study is presented in Figure 1.

Figure 1: Conceptual framework



Changes in agriculture policy, social systems, financial incentives and declining natural resource quality is a signal to the farmer that the current pattern of natural resource use may be affected (FAO, 2001; Milder *et al.,* 2011). In Tanzania, in particular, a number of agriculture or related policies and strategies have been developed and introduced for implementation (URT, 2011). They include the sustainable land management practices such as CA. Government credit and extension policies play an important role in influencing a decision of the farmer to adopt CA (Thiombiano & Meshack, 2009). The declining soil fertility, climatic extremes, high costs of inputs and lack of support for diversified income sources influence farmers' choices on which technology to adopt (ACT, 2008). Farmers are likely to adopt CA if the external stimuli are supportive to the technology.

Households make technology choices and decisions about the use of their soil resources under the constraints imposed by their socio-economic attributes and on-farm resources (FAO, 2001). For example, poor land tenure and access to credit, the farmer cannot invest in CA if this requires a large capital outlay. Existing farm enterprises or ongoing economic activities may influence adoption of CA (*Ibid)*. For example adoption of CA can be challenged when livestock keeping is integrated in CA system (ACT, 2008). Some land management practices such as agroforestry do have positive impacts to CA adoption when the trees to be incorporated are perceived by farmers to bring positive benefits such as soil fertilisation or availability of wood based materials for household use (Denning, 2001).

Farmers who have adopted CA enjoy positive benefits resulting from simultaneous application of a set of practices of minimal mechanical soil disturbance, organic soil cover and diversified cropping that can lead to greater and stable yields, better use of production inputs and therefore greater profitability while reducing production costs, enhanced crop, soil and ecosystem health as well as the associated ecosystem services, and improved climate change adaptability and mitigation (Biamah *et al.,* 2000; FAO, 2001; Derpsch, 2005; ACT, 2008; Kassam *et al.,* 2009, Mazvimavi, 2010). Farmers who have not adopted CA may experience negative outcomes. The outcomes of CA adoption feeds back to perception about the CA technology and that it influences further the social economic characteristics of farmers in terms of food production and security, access to information and household livelihood capacity improvement (Krishna *et al.,* 2008).

1.4 Research objectives

The overall objective of this study was to investigate factors influencing conservation agriculture technology adoption among smallholder farmers in Karatu and Kongwa districts so as to create awareness among stakeholders involved in the introduction and up scaling of the technology in Tanzania.

The specific objectives were:

i. To establish adoption level of conservation agriculture practices among smallholder farmers.

ii. To compare crop yields and production costs between conservation agriculture technology and conventional agriculture practices.

iii. To determine household socio-economic and farm characteristics that significantly affect adoption of conservation agriculture technologies by smallholder farmers.

1.5 Hypothesis

This study hypothesised that:

(i) The majority of smallholder farmers in the study districts have adopted all the three CA technology principles.

(ii) Profitability per unit area is higher for CA adopter farmers as compared to non adopters

(iii) Adoption of conservation agriculture technologies by smallholder farmers in Tanzania is significantly affected by household socio-economic and farm characteristics.

2.0 THEORETICAL FRAMEWORK AND LITERATURE REVIEW

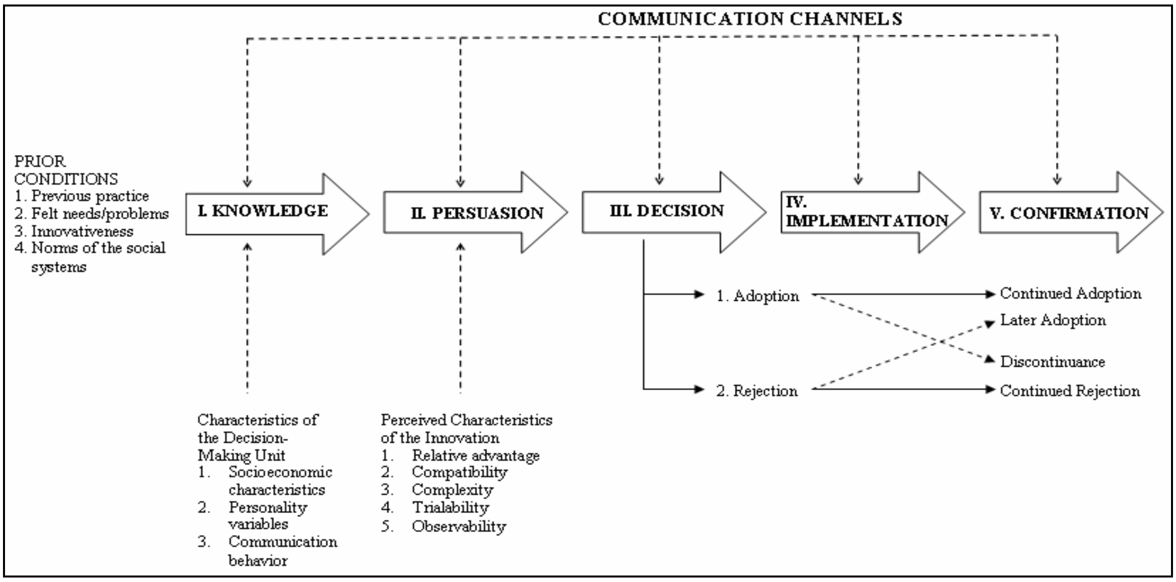
2.1 Innovation adoption theories

Adoption is defined as a decision of full use of an innovation as the best course of action available while the process in which an innovation is communicated through certain channels over time among the members of a social system is known as diffusion (Rogers, 2003). Feder *et al,* (1985) defined adoption as "a mental process an individual passes from first hearing about an innovation to final utilization. Fisher, Norvell *et al.* (2000) explain that diffusion differs from adoption in that it is the process by which new technologies are spread among users whereas adoption is said to be an individual internal decision.

The process of adopting new innovations has been studied for many years, and one of the most popular adoption models, diffusion of innovation theory, is described by Rogers (2003). According to this theory individuals pass through five stages on their way to adopting a new practice or behaviour (Rogers, 2003; Gregor and Jones, 1999). These stages are (i) knowledge whereby a person becomes aware of an innovation and has some idea of how it functions. In this step, an individual learns about the existence of innovation and seeks information about the innovation. "What?," "how?," and "why?" are the critical questions in the knowledge phase, (ii) persuasion stage is when a person forms a favourable or unfavourable attitude toward the innovation after he or she knows about the innovation, (iii) decision whereby a person engages in activities that lead to a choice to adopt or reject the innovation, (iv) implementation - person puts an innovation into use, and (v) confirmation in which a person evaluates the results of an innovation-decision already made and the individual looks for support for his or her decision. A Model of Five Stages in the Innovation-Decision Process is presented in Figure 2.

Since all potential adopters in a social system do not adopt a new product at the same time, adopters can be classified into categories, depending on when they adopt the product. Rogers (2003) classified adopters into five categories namely innovators, early adopters, early majority, late majority, and laggards. The categories are important because they can aid the targeting of new prospects for a new product, assist in developing marketing strategies to penetrate the various adopter categories, and assist in predicting the continued acceptance or rejection of a new product (Mahajan *et al.,* 1990).

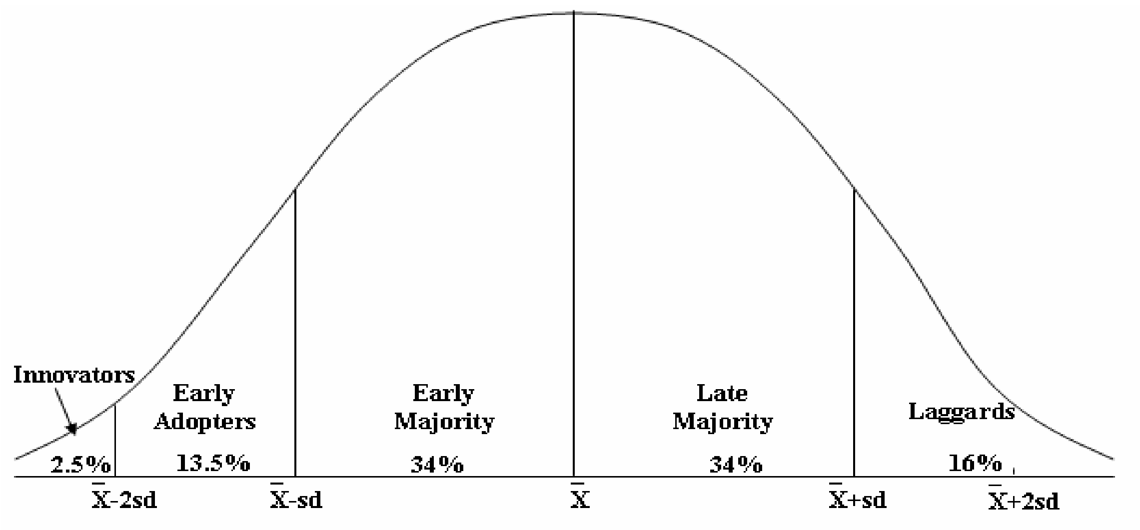
Figure 2: A model of five stages in the innovation-decision process



Source: Everett M. Rogers (2003). Diffusion of Innovations, Fifth Edition. The Free Press.

The distribution of adopters is a normal distribution (Figure 3). For Rogers (2003), innovators were willing to experience new ideas. Thus, they are prepared to cope with unprofitable and unsuccessful innovations, and a certain level of uncertainty about the innovation. Early adopters are more limited with the boundaries of the social system. Since early adopters are more likely to hold leadership roles in the social system, other members come to them to get advice or information about the innovation. As observed by Sahin (2005), leaders play a central role at virtually every stage of the innovation process, from initiation to implementation, particularly in deploying the resources that carry innovation forward. Although the early majority have a good interaction with other members of the social system (Rogers, 2003), they do not have the leadership role that early adopters have (Sahin, 2006). However, their interpersonal networks are still important in the innovation-diffusion process (Sahin, 2006). The late majority includes one-third of all members of the social system who wait until most of their peers adopt the innovation (*ibid*).

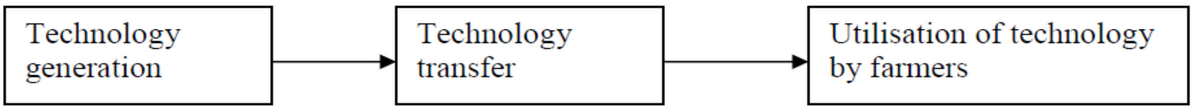
Figure 3: Adopter categorization on the basis of innovativeness



Source: Rogers. (2003).

Although the late majority are sceptical about the innovation and its outcomes, economic necessity and peer pressure may lead them to the adoption of the innovation (Sahin, 2006). Laggards have the traditional view and they are more sceptical about innovations and change agents than the late majority. Because of the limited resources and the lack of awareness-knowledge of innovations, they first want to make sure that an innovation works before they adopt. Within the agriculture sector Rogers (2003) provides a linear model of the diffusion process (Figure 4).

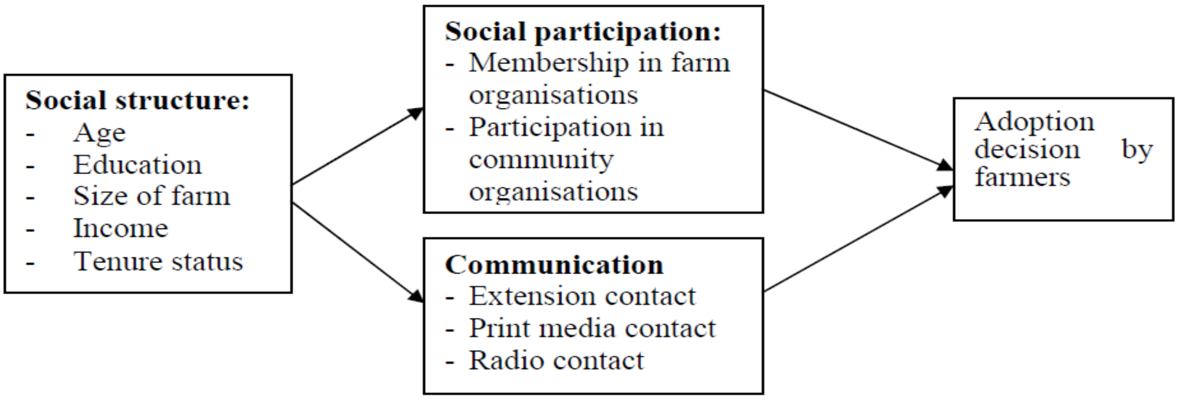
Figure 4: Diffusion as a linear model



Source: Rogers (2003)

Fliegel (1993) and Feder and Umali (1993), proposed a more widely accepted, non-linear approach to the adoption of agricultural innovations as opposed to the Rogers (2003) linear approach. Unlike the linear approach which tends to restrict diffusion to a rational, planned process that relies on institutions such as government departments a non-linear approach views the farmer as a passive individual who responds to random forces related to social participation and communication (Figure 5).

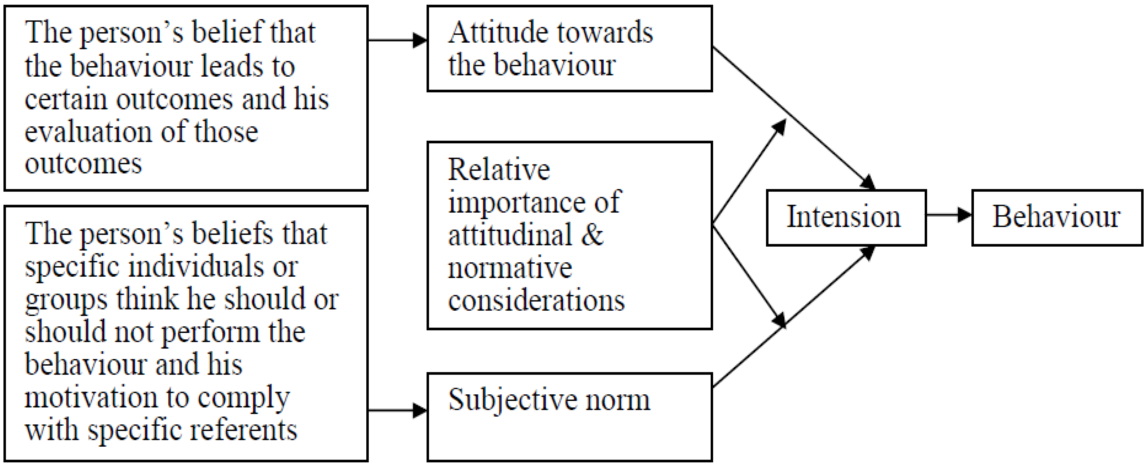
Figure 5: A non-linear approach to the adoption of agricultural innovations



Source: Jackson *et al.* (2006)

The Theory of Reasoned Action (TRA) focuses on behavioural determinants of the individual instead of technological characteristics (Green, 2005). Overview of existing research suggests that the majority of contemporary technology adoption studies are rooted in behavioural intention, which contends that a user's choice to adopt a new technology is a conscious undertaking that can be sufficiently explained and predicted by their behavioural intention (*ibid*). The theory is used to gain deeper insight into how attitudes and beliefs are correlated with individual intentions to perform (Fishbein & Ajzen, 1975). The theory has proven useful in predicting intention to adopt or use a technology. The assumption is that people are, more often than not, rational beings who make systematic use of available information, considering the repercussions of their actions before deciding whether or not to engage in a given behaviour (Ajzen and Fishbein, 1980). Figure 6 depicts a graphical representation of TRA.

Figure 6: Theory of reasoned action

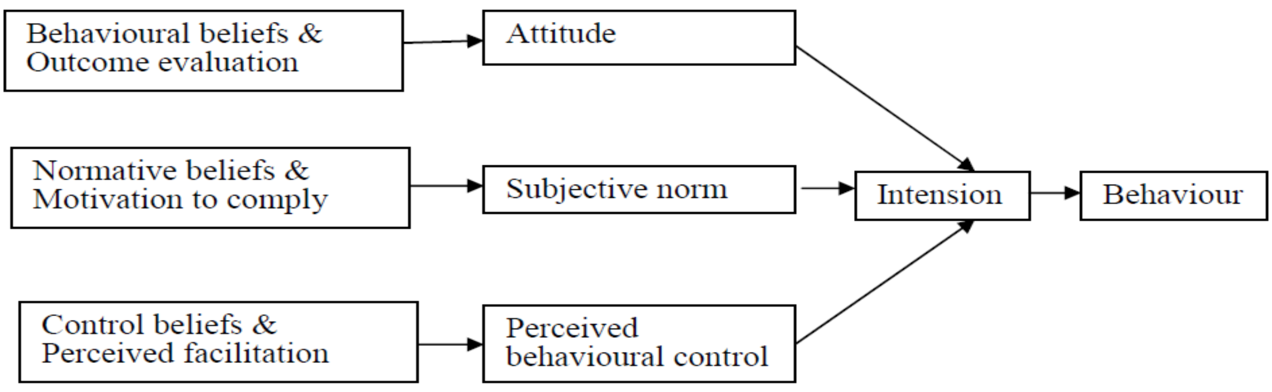


Source: Jackson *et al.* (2006)

TRA proposes that the behavioural intention of an individual to perform (or not perform) a certain target behaviour, is solely and directly responsible for influencing that individual's target behaviour (Marandu *et al.,* 2010). In turn, an individual's behavioural intention is said to be jointly determined by two factors: attitude towards behaviour and subjective norm. Attitude towards behaviour can be described as an individual's subjective forecast of how positive or negative he/she will feel when performing the target behaviour, whereas subjective norm refers to a person's perception of the social pressure exerted upon her to perform or not perform the behaviour being contemplated (Ajzen and Fishbein, 1980). Furthermore, an individual's attitude towards performing the target behaviour is itself determined by his / her beliefs regarding the consequences of performing the target behaviour, as well as the evaluation of these consequences. Likewise, an individual's subjective norm is the by-product of his / her normative beliefs and motivation to comply.

The Theory of Planned Behaviour (TPB) is an extension model of TRA (Jackson *et al.,* 2006). TPB states that attitudes alone are not sufficient to predict behaviour, but that social pressures and the perceived difficulty in carrying out the action are also important. As can be seen from Figure 7, while 'Intention' is still the central construct of the theory, the construct of 'Perceived behavioural control' has been added. This enables the measurement of the extent to which an individual believes the outcomes of behaviour can be controlled (Burton, 2004). The Theory of Planned Behaviour (TPB) extends TRA to account for conditions where individuals do not have complete volitional control over their behaviour (Taylor & Todd, 1995). The inclusion of a third determinant of behavioural intention, perceived behavioural control, is TPB's major point of departure from TRA. This difference results in TPB recognising that not all behaviour may be under an individual's volitional control, with behaviour ranging on a scale from complete control through to total lack of control (Ajzen, 1991).

Figure 7: Theory of planned behaviour



Source: Ajzen (1991)

2.2 Conservation Agriculture

Conservation Agriculture (CA) is an approach to managing agro-ecosystems for improved and sustained productivity, increased profits and food security while preserving and enhancing the resource base and the environment and is characterized by three linked principles, namely (i) continuous minimum mechanical soil disturbance (ii) permanent organic soil cover (iii) diversification of crop species grown in sequences and/or associations (ACT, 2008). CA functions best when all three key features are adequately combined together in the field (Derpsch, 2001). CA experience worldwide, over the past four decades, has demonstrated how the simultaneous application of a set of practices of minimal mechanical soil disturbance, organic soil cover and diversified cropping can lead to greater and stable yields, better use of production inputs and therefore greater profitability while reducing production costs, enhanced crop, soil and ecosystem health as well as the associated ecosystem services, and improved climate change adaptability and mitigation (Kassama *et al.,* 2010). Experience through a number of initiatives (Benites *et al*., 1998; Biamah *et al*., 2000) has shown that the principles of conservation agriculture are feasible in the African environment, but it is important to be mindful of the fact that success in application and adoption will have to conform to the specific local socio-economic and cultural factors in addition to technical parameters.

Minimal disturbance of the soil by tillage reduces land and water pollution and soil erosion, reduces long-term dependency on external inputs, enhances environmental management, improves water quality and water use efficiency, and reduces emissions of greenhouse gases through lessened use of fossil fuels (FAO, 2011). Studies (Mazvimavi *et al.,* 2010; Shetto *et al.,* 2007) indicate that reduced tillage leads to lessened human inputs, in both time and effort. For HIV/AIDS affected regions minimum tillage practices ensure effective labour utilisation. Mixing and rotating of crops has been reported to replenish soil fertility through intercropping with nitrogen-fixing legumes which adds ‘top-dressing fertilizer’ to the soil; enable crops to use the nutrients in the soil more effectively; help to control weeds, diseases and pests by breaking their life cycles through the introduction of a new crop; and reduce the risk of total crop failure in cases of drought and disease outbreaks (ACT, 2008).

Keeping the soil covered is a fundamental principle of CA as cover crops improve the stability of the CA system, not only on the improvement of soil properties but also for their capacity to promote an increased biodiversity in the agro-ecosystem. According to the study conducted by Mazvimavi *et al.* (2010) among smallholder farmers in Zimbabwe farmers seemed knowledgeable about mulching although there were misconceptions that mulching can only be done using crop residues. Generally, there was low production of biomass in smallholder farms which may not allow farmers to meet the 30% mulch cover as a minimum recommendation for conservation agriculture (Giller *et al*., 2009). However, various other materials can also be used as mulch including leaf litter and grass.

A recent study (FAO, 2011) on farm enterprises in Zambia demonstrated that conservation agriculture practices such as CA Planting basins and CA Magoye ripper had generally performed well as compared to conventional draft tillage practices in aspects of revenues, input costs and returns.

The origins and early roots of discovery, inventions and evolution of CA principles and practices are embedded in the farming communities and civil societies in North and South America who, out of necessity, had to respond to the severe erosion and land degradation problems and productivity losses on their agricultural soils due to intensive tillage-based production practices (Kassam *et al.,* 2010). Initially, this occurred in North and South America, and later in other parts of the world such as Australia, and more recently Asia and Africa (*ibid*). Thus CA has largely evolved and spread bottom up, unlike the intensive tillage-based 'Green Revolution' practices whose evolution has largely followed a top down approach with the international and national scientific community setting largely a reductive research agenda and strongly influencing what innovations and technologies can be and are actually delivered to the farmers in the developing nations through a linear research-extension-farmer approach (Derpsch and Friedrich, 2009; Kassam, 2009; and FAO, 2001).

The current status of adoption and spread of CA globally is low particularly in Africa (Table 1). It has been reported that 47.6% of the total global area under CA is in South America, 34.1% in the United States and Canada, 14.7% in Australia and New Zealand and 3.5% in the rest of the world including Europe, Asia and Africa (Kassama *et al.,* 2010). The latter are the developing continents in terms of CA adoption. Despite good and long lasting research in these continents showing positive results for no-tillage systems, CA has experienced only small rates of adoption in Africa.

Table 1: Global area under conservation agriculture

Continent	**Area ("000" hectare)**	**Percent of total**
South America	55,630	47.6
North America	39,981	34.1
Australia & New Zealand	17,162	14.7
Asia	2,630	2.2
Europe	1,150	1.0
Africa	368	0.3
World total	116,921	100

Source: Kassama *et al.,* 2010.

Application of no-tillage has been reported in some countries for example: Ghana 30,000 ha; Kenya 15,000 ha; Morocco 4,000 ha; Mozambique 9,000 ha; Sudan 10,000 ha; Tanzania 6,000 ha; Tunisia 6,000 ha; Zambia 40,000 ha; Zimbabwe 7,500 ha (Kassama *et al.,* 2010). In Africa CA is expected to increase food production while reducing negative effects on the environment and energy costs, and result in the development of locally-adapted technologies consistent with CA principles (FAO 2007; IIRR and ACT, 2005).

In Tanzania, the practice of conservation agriculture is not new as it dates back many years ago when indigenous technologies were used (Shetto *et al*., 2007). Most of these technologies have one or more features that reflect some of the principles of CA (accumulation of residues on soil surface, minimum soil disturbance, crop rotation, seeding on mulch) (McCall, 1994; Reij *et al*., 1996; and Mutunga *et al*., 2001). Mulching, for example, was commonly practiced although it has declined as a result of other competitive use of the crop residues such as feed for livestock, fuel and building materials (Shetto, 2011). Improved fallows consist of deliberate planting of selected fast growing trees or shrub, usually leguminous species to improve the fertility of the soil largely through Biological Nitrogen Fixation (Jama *et al.,* 1998). The Chagga home garden consists of a three storey arrangement, with large trees such as *Albizia and Gravillea* forming the upper most storey, banana and coffee canopies forming the next lower storey and fodder, herbs, and grasses forming the lowest layers (Fernandes *et al.,* 1981). This system provides a continuous ground cover protecting the soil against erosion, and a high degree of nutrient cycling through the accumulated mulch while the trees provide fodder, fuel wood and fruits. Although these traditional farming practices were purposefully done to protect the soil from degradation and improve its productivity the increased problems of deforestation, over-grazing and inappropriate tillage practices exaggerated the problem of soil degradation (Biamah *et al.,* 2000; Jonsson *et al*., 2000; Elwell *et al.,* 2000).

In the wake of declining soil fertility and crop yields a number of institutions started to engage in finding out how the situation could be reversed. FAO, CYMMT and ACT are among the organisation that engaged in promoting of CA in Africa including Tanzania. In the late 1990s, several Agricultural Research Institutions under the Ministry of Agriculture initiated some activities on conservation agriculture. For example, Selian Agricultural Research Institute (SARI) and Agricultural Research Institute Uyole (ARI Uyole) have been undertaking some research activities in conservation agriculture which include promotion of animal drawn rippers and no-till direct seeders by using the Farmer Field School approach and dissemination of conservation agriculture technologies through establishment of both on station and on farm demonstration plots and selling of cover crop seed (*lablab and mucuna*) directly to farmers (Shetto *et al.,* 2007).

Implementation of CA projects also started taking shape in Tanzania in early 2000s (www.act-africa.org, accessed 2012). Conservation Agriculture for Sustainable Agriculture and Rural Development (CA SARD) was a pilot project aimed at empowering small scale farmers and farming communities to adopt conservation agriculture technologies through Farmer Field School (FFS) approaches. It was implemented in six districts of Arumeru, Karatu, Babati, Hanang, Bukoba and Moshi Rural in 2004-2010. The core activities in the CA SARD Project involved the training of farmers to enable them to apply CA practices to the farmer Field School plot and adapt the practices to their local technical and socio economic circumstances. Other areas where the project was implemented were Meru, Mbulu, Same, Kilindi, Mvomero, Kilosa, Njombe, and Singida districts through support of CA SARD. Other projects include the agro-ecology based aggradation -conservation agriculture (ABACO runs from 2011 to 2014 targeting innovations to combat soil degradation and food insecurity in semi-arid Africa. It is being implemented in semiarid areas of East (Kenya, Tanzania) Africa and other parts. There are also a number of nongovernmental organisations that are promoting conservation agriculture in Tanzania among them are Research, Community and Organisational Development Associates (RECODA), Women's Agriculture Development and Environmental Conservation (WADEC), Canadian Physician for Aid and Relief (CPAR) and others (ACT, 2008). Other activities that have been implemented regarding CA are the farmer field days that are jointly organised by ACT and the Ministry of Agriculture Food Security and Cooperatives.

Inadequate or lack of institutional capacity in Tanzania for wide scale adoption and application of profitable and sustainable conservation agricultural practice is one of the weaknesses. URT (2011) highlighted the urgent need to strengthen human and institutional capacity for change and innovation in agriculture. New approaches and innovative initiatives need to be sought in order to address these critical capacity deficiencies.

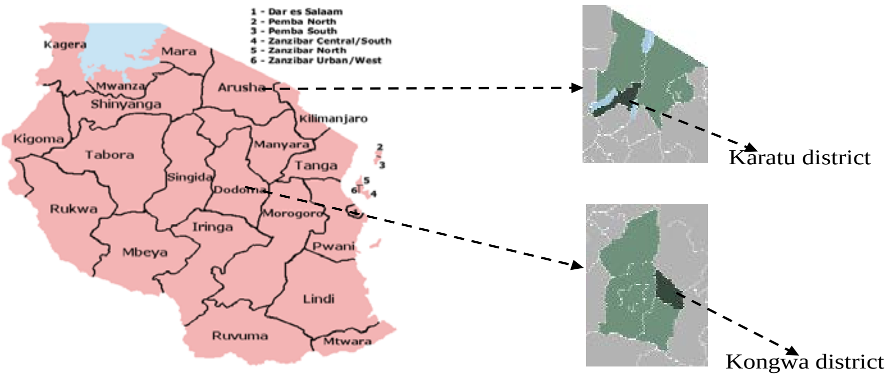
Adoption of Conservation Agriculture (CA) especially by smallholder farmers involves risk of reduced yield among others at an early stage of CA introduction. The government of Tanzania is using macro-economic policy, trade regulations, input subsidies, or education and extension to alter the decision-making environment in which farmers choose one practice over another, for this case conservation agriculture technology (Shetto *et al.,* 2007). It is however very important to note that not all policy instruments have worked in the same way or have given positive results everywhere. Different situations need different policy instruments to make the desired end. Therefore policy research is necessary in the differing socio ecological environment to enable identification of right policy incentives to target beneficiaries and address differentiated needs.

3.0 RESEARCH METHODOLOGY

3.1 The study area

The study was conducted in two districts of Karatu and Kongwa in Arusha and Dodoma region respectively (Figure 8). The study districts are highly vulnerable to land degradation in particular soil compaction, deforestation and environmental degradation. Kongwa and Karatu districts are characterised by semi arid climatic conditions with relatively inadequate but also of high variability in rainfalls. These areas experience prolonged drought which lead to serious food shortages.

Figure 8: Locations of the study sites



3.2 Sampling design

The study used both probability and non-probability sampling methods. Two districts namely Karatu and Kongwa were purposely selected for the study. These districts are highly vulnerable to land degradation in particular soil compaction, deforestation and environmental degradation. Some projects on Conservation Agriculture (CA) were implemented at different times since 2004. At district level 3 villages out of 67 and 45 villages in Karatu and Kongwa respectively were purposely selected based on apparent level of adoption and accessibility. According to Boyd *et al.* (1981) a sample size of at least 5% is recommended. A total of 129 households were randomly sampled in all the study villages.

3.3 Data collection

A combination of methods was employed in collection of socio-economic data. Cross-sectional household surveys involved administration of a questionnaire was employed to collect both qualitative and quantitative information. The data that was collected through the questionnaire included family/household characteristics, farm enterprises and access to and sharing of CA knowledge and information. Focused Group Discussions (FGDs) were carried out with farmer groups to give their views on a number of issues and confirm or cross check the information obtained through other data collection methods. Data obtained through participant observation acted as a check against participants' subjective reporting of what they believe and do. Participant observation was useful for gaining an understanding of the physical, social, cultural, and economic contexts in which study participants live; the relationships among and between people, contexts, ideas, norms, and events; and people's behaviours and activities. Secondary data were collected through review of publications and official reports. Internet search method was also employed to access data stored via websites.

3.4 Data Analysis

Analysis of the level of adoption and the socio-economic profiles of adopters and non-adopters was done using descriptive statistics such as frequencies, mean, and standard deviation. Pearson's Chi-square was used to test if the socioeconomic characteristics between adopter and non adopter farmers were significantly different. The analysis was performed using SPSS statistical software version 17. In order to calculate the adoption level, responses from respondents was taken on the number of conservation agriculture principles being implemented by each farmer. The level of adoption of conservation agriculture was ranked low if a farmer implements only 1 principle, moderate if the farmers implements a combination of 2 principles and high (optimal) adoption if farmer implements all the principles. All respondents undertaking the three principles qualified to the "Adopters" otherwise they were "Non adopters" of CA. Socioeconomic profiles between the adopters and non adopters was compared and statistical differences established. Analysis of profitability of farm operations for adopters (conservation agriculture) and non adopters (conventional agriculture) was carried by calculating the mean revenues and costs for maize crop farm operations using SPSS and spreadsheet software. Maize was chosen since it is one of the main crops promoted for food security in Tanzania.

This study applied logistic regression model to analyse the factors affecting adoption of conservation agriculture. Literature indicate that decision-making process by farmers involved in adopting new technologies can be quantitatively analysed using logistic regression modelling approach (Bekele and Holden, 1998; Adesina *et al.,* 2000; Chaves and Riley, 2001; Ayuk, 1997). The dependent variable "adoption of conservation agriculture" was a binary variable with a value of 1 if the farmer was a "CA adopter" or 0 for "CA Non-adopter". It was conceptualized that when a farmer implements all three CA principles then he or she is regarded as an adopter farmer and is ranked 1, otherwise ranked 0.

The independent variables and the expected relationship with the dependent variable are as follows:

Description	Sign
Age of head of household (years);	+
Gender of head of household (1=Male 0=Female)	+
Education of head of household (1=Never, 2=Primary, 3=Secondary, 4=College, 5=University). Highly educated farmers are more likely to adopt CA than those with lower education levels	+
Farmer category: (1= Small scale hand hoe, 2= Small scale ox-plough, 3=Small scale tractor, 4=Large scale). CA adoption is more likely to happen for large than small-scale farmers	+
Training received and extension service on Conservation Agriculture (1=Yes received, 0=Not received)	+
Subsidy received for agriculture (1=Yes received, 0=Not received)	+
Credit received for agriculture (1=Yes received, 0=Not received)	+
Perception about Conservation agriculture (1= Positive, 0=Negative)	+
Maize yields, kg/ha;	+
Land size of household (Ha)	-
Off farm income: (1=Yes, 0=No)	-
Participation in decision making on CA issues (1=Participate, 0=don't participate)	+

The likelihood of the farmer to be an adopter of conservation agriculture is predicted by odds (Y=1) i.e. the ratio of the probability that Y=1 to the probability that $Y \neq 1$

Odd Y=P(Y=1)/ (1-P(y=1) ……………………………………………………………… (1)

The logit (Y) is given by the natural log of Odds; i.e.

$\ln(p(Y_i = 1)/ (1 - p(Y_i = 1)) = \log \text{Odds} = \text{Logit}(Y)$ ……………..………….………(2)

Which can be expanded to:

$\text{Logit}(Y) = \beta o + \sum \beta 1 X1 + \ldots\ldots + \sum \beta n X n + \text{error}$……………………………..….…….. (3)

Where:

Y_i = Dependent variable, adoption of conservation agriculture; X1,,… Xn = Independent variables; β = Constant; ln = Natural log and p = Probability

4.0 RESULTS AND DISCUSSION

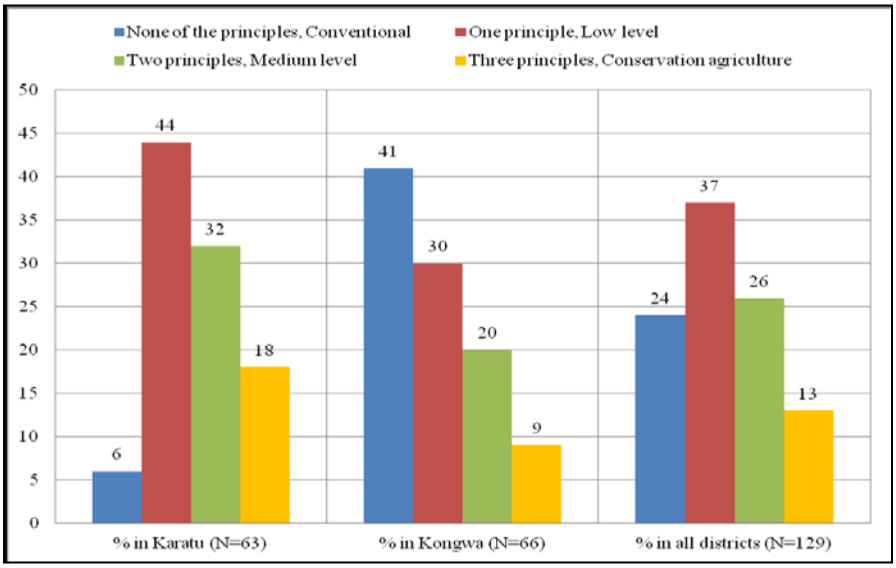
4.1 Level of adoption of CA among farmers in Karatu and Kongwa districts

The level of adoption of conservation agriculture, which entails simultaneous implementation of the three CA principles, was implemented by as low as 13% of households in both study districts. The result disprove the hypothesis that majority of smallholder farmers in the study districts have adopted all the three CA technology principles. This means that 87% of households in the study area are partially implementing the three CA principles or are still practicing conventional farming.

It was observed that 24% of the interviewed households in both districts are practicing conventional or other farming practices, which imply that they don't abide to any of the three CA principles. Kongwa and Karatu districts had 41% and 6% of its households who could be categorised as conventional farmers respectively. This means farmers mostly practice monoculture, do not grow soil cover crops, and use conventional tillage practices in their fields. Conventional farming practices such as intensive tillage and burning or removing crop residue often lead to declining agricultural productivity and increasing rural poverty (Shetto *et al.,* 2007). About 63% of the farmers implement one (low) or a combination of two principles (medium).

The reason for the low level of adoption of CA in the study districts could be that farmers had not been exposed to the farming practice and support services that could promote uptake of the technology. Adoption levels and percentage of implementing households in Karatu and Kongwa district are presented in Figure 9.

Figure 9: Adoption levels of CA in Karatu and Kongwa districts

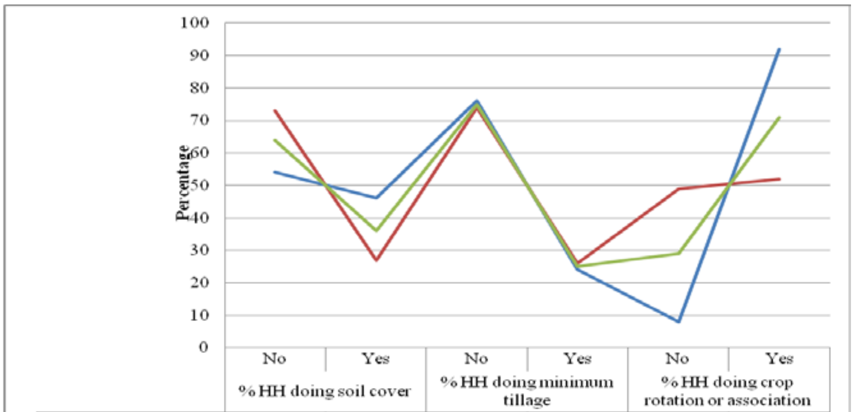


Source: Survey data, 2012

Derpsch (2001) notes that for maximum and sustainable benefits the three principles must be implemented simultaneously. The benefits include reduction in land and water pollution and soil erosion, improving water quality and water use efficiency, and reduction of emissions of greenhouse gases through lessened use of fossil fuels (FAO, 2011). The recent study (FAO, 2011) on farm enterprises in Zambia demonstrated that CA generally performed well as compared to conventional draft tillage practices in aspects of revenues, input costs and returns. CA can also improve soil properties its capacity to promote an increased biodiversity in the agro-ecosystem.

It was further observed that crop rotation principle is practiced by the majority (71%) of farmers in Karatu and Kongwa districts (Figure 10).

Figure 10: Percentage of households (HH) implementing different conservation agriculture principles in Karatu and Kongwa districts



	% HH doing soil cover		% HH doing minimum tillage		% HH doing crop rotation or association	
	No	Yes	No	Yes	No	Yes
Karatu (N=63)	54	46	76	24	8	92
Kongwa (N=66)	73	27	74	26	49	52
All districts (129)	64	36	75	25	29	71

Source: Survey data, 2012

The principles of soil cover and minimum soil disturbance are implemented poorly by 36% and 29% of households respectively in all the districts. The practice of minimum soil disturbance did not differ significantly for farmers in both the two districts. Focus group discussions and observation showed that tillage of the soil is mainly by ploughing and hand hoe. Although farmers do ploughing to improve soil structure and control weed but in the long term destroys soil structure and contribute to declining fertility and organic matter levels. It was evident from the discussions that the availability and technical knowledge of the CA equipments such as the jab planters, direct seeders, sub-soilers, rippers is limited hence becoming difficult for farmers to reduce soil disturbance through tillage practices. There is significant difference in the application of the soil cover and crop rotation principles between the two study districts. Karatu district has got more farmers practicing soil cover and crop rotation/association as compared to those in Kongwa district. It might be there is large number of livestock in Kongwa than in Karatu district. It has been reported

(ACT, 2008; Giller *et al*., 2009) that maintenance of cover crops in livestock keeping areas is difficult hence affecting adoption of CA. Limited studies have been conducted to find solutions for CA and livestock keeping integration.

4.2 Profitability analysis of crop production among adopters and non adopters of CA

Profitability analysis showed that the profit from maize production for non adopters was higher (562,925 Tshs/ha) than that of adopter farmers (521,050 Tshs/ha). Profitability analysis was carried out by computing the difference between reported explicit revenues (in Tanzania shillings) per unit area and the corresponding production cost. These findings disprove the hypothesis that profit per unit area is higher for CA adopter farmers as compared to non adopters. Maize crop was used for comparing the yields and production costs, being one of the main crops used for food among smallholder farmers. It was found that 75% of households interviewed were engaged in maize cultivation. Previous studies on CA portray that crop yields increases when CA was applied (Mazvimavi, 2011). The possible explanation for lesser net benefit for adopter farmers could that the farmers have not fully embraced the CA practices and or soils have not yet regained their fertility. It has been reported in some studies that the first years of CA implementation may be less productive and or more costly than conventional farming or other practices (FAO, 2001). Crop yields and cost of production for maize crop in Karatu and Kongwa districts are presented in (Table 3).

Table 2: Revenue and cost of production for maize among adopters and non adopters in Karatu and Kongwa districts

		Maize Value Tshs/Ha	Costs incurred (Tshs)/Ha	Net profit (Tshs/Ha)
Non adopter	Mean	663,489	100,564	562,925
	Std. Deviation	573,916	95,528	
	Minimum	50,000	22,500	
	Maximum	2,600,000	481,000	
	N	87	87	
Adopter	Mean	630,500	109,450	521,050
	Std. Deviation	507,644	116,838	
	Minimum	60,000	21,000	
	Maximum	1,500,000	330,000	
	N	10	10	
Total (All)	Mean	660,088	101,480	
	Std. Deviation	565,093	97,274	
	Minimum	50,000	21,000	
	Maximum	2,600,000	481,000	
	N	97	97	

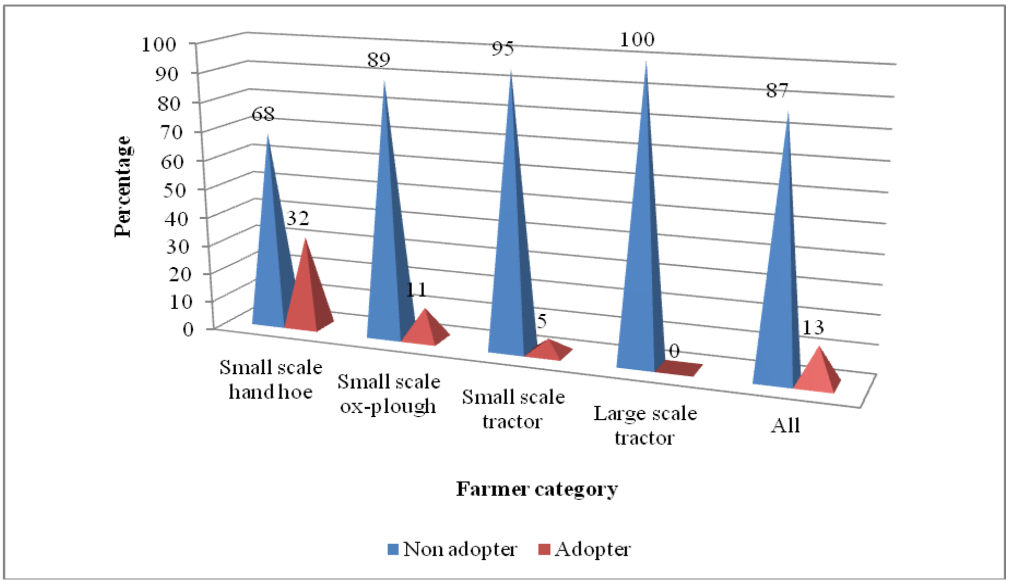
Source: Survey data, 2012

4.3 Household and farm socio-economic characteristics among CA adopter and non adopter farmers

4.3.1 Household characteristics

The study found that CA adopter farmers are mostly hand hoe or ox-plough based farmers while non adopter's category includes farmers who are tractor based. The large scale tractor based farmers were found to have not adopted CA (Figure 11). There was a significant ($p<0.05$) difference between adopter and non adopter farmers in terms of scale and level of mechanization. This suggests that the type or scale of a farmer and level of mechanisation can determine the willingness of a farmer to shift from practicing conventional farming to CA practices.

Figure 11: Percentage of adopters and non-adopters by farmer category



Source: Survey data, 2012

The family size between adopter and non adopter farmers differed significantly ($p=0.05$), with non adopters having a household size of 8 people as opposed to 6 for adopter farmers. This is could imply that the source of labour for the smaller household sizes is limited hence the reason to drift to CA. Increase in population is regarded as one of the reasons that could necessitate uptake of CA since CA is capable of increasing food productivity which in turn fight food insecurity (ACT, 2008). Using household size as a proxy for population size the results obtained contradict with the expectation that households with large number of family members could embrace CA for purpose of improving food security. The family size and analysis of variance in the size of households between adopter and non-adopter farmers is presented in Table 3.

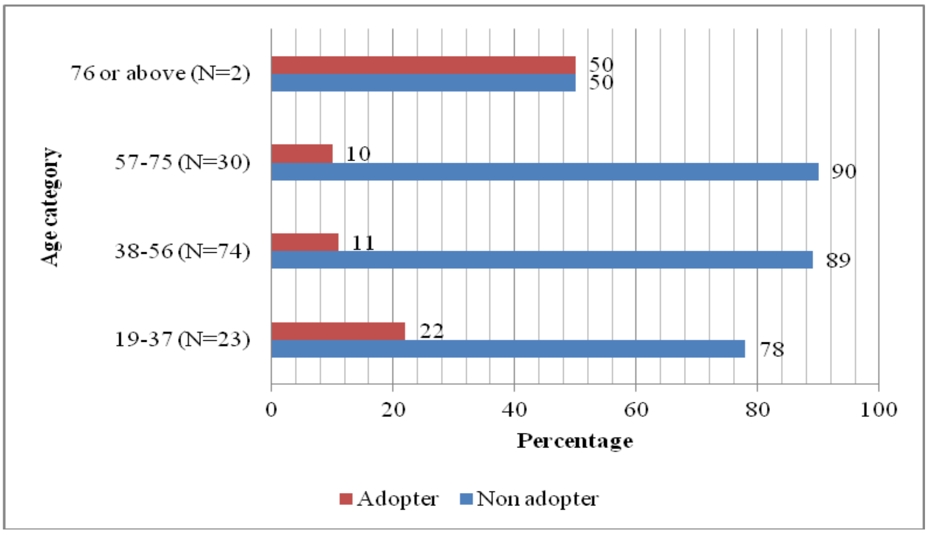
Table 3: Family size of household

	Mean	Std. Deviation	Minimum	Maximum
Non adopter	8.01	3.311	3	22
Adopter	6.35	2.783	2	13
Total	7.79	3.285	2	22

Source: Survey data, 2012

It was also found that young and very old age categories have adopted CA as compared to counterpart middle age categories (Figure 12). Although there was no significant difference among adopter and non adopters across the different age categories it is clear that the youngest and oldest people have adopted CA as opposed to middle age categories. The reason for the situation could be that younger people, in this new information age, have more ability to acquire information about new technology while older people might have accumulated experiences about possible profitable farming systems to adopt (Sonii, 1992). Similar results were reported by Alavalapati *et al.* (1995) in India and Ayuk (1997) in Burkina Faso.

Figure 12: Percentage of adopters and non-adopters of CA by age categories



Source: Survey data, 2012

It has been established that highly educated people have not adopted CA as compared to the rest of the households (Table 4). The reason to these results could be that advancement in formal education is associated with increase in specialisation in technical skills that make farming, including CA, less attractive. According to Matata *et al.* (2008) if majority of farmers can read and write eventually they can follow technical recommendations. For those with complete no formal education it might be that they learn through adult or participatory methods which increases the knowledge to implement CA.

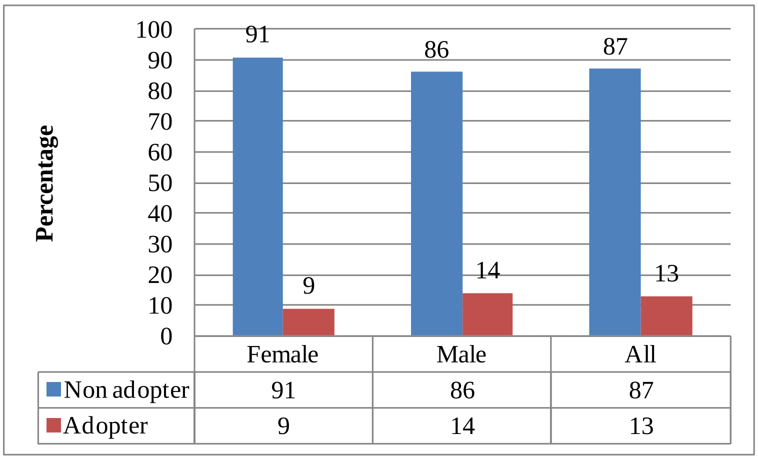
Table 4: Percentage of heads of households by education levels

Education level	Adoption category		Total
	Non adopter	Adopter	
Never (N=18)	83	17	100
Primary (N=96)	88	13	100
Secondary (N=11)	82	18	100
College (N=2)	100	0	100
University (N=2)	100	0	100
Total	87	13	100

Source: Survey data, 2012

Although there is no significant statistical difference between male or female headed households on adoption of CA, the study results in Figure 13 show that more male headed households (14%) have adopted CA as compared to female headed ones (9%).

Figure 13: Percentage of adopter and non-adopter farmers by type of head of households

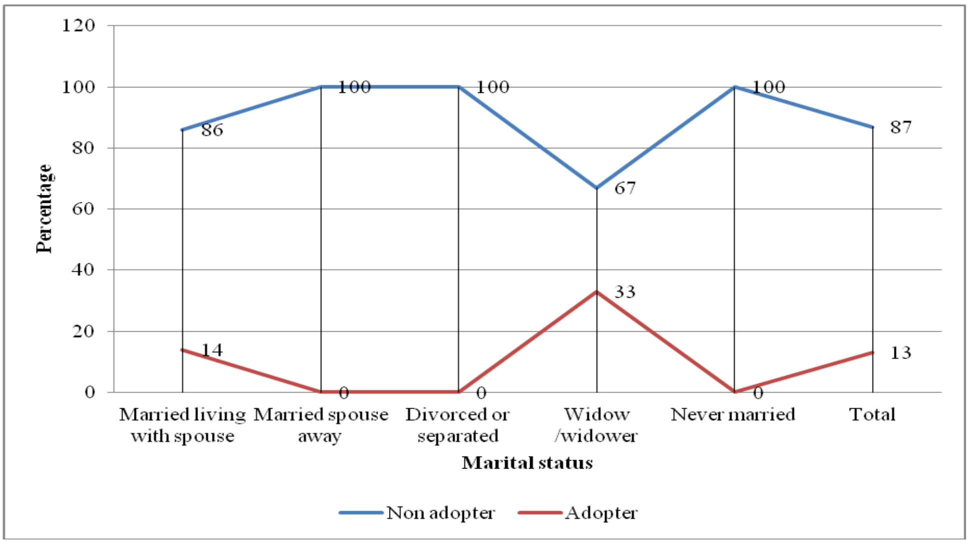


Source: Survey data, 2012

These results suggest that although females are heading households the decision to adopt or not adopt CA lies beyond their wishes implying that others forces influence their decision. Literature on the theory of planned behaviour recognises that not all behaviour may be under an individual's control, with behaviour ranging on a scale from complete control through to total lack of control (Ajzen, 1991). In the African context although female may be leading households but the conservative behaviour about women making decisions is still affected by the extended family settings.

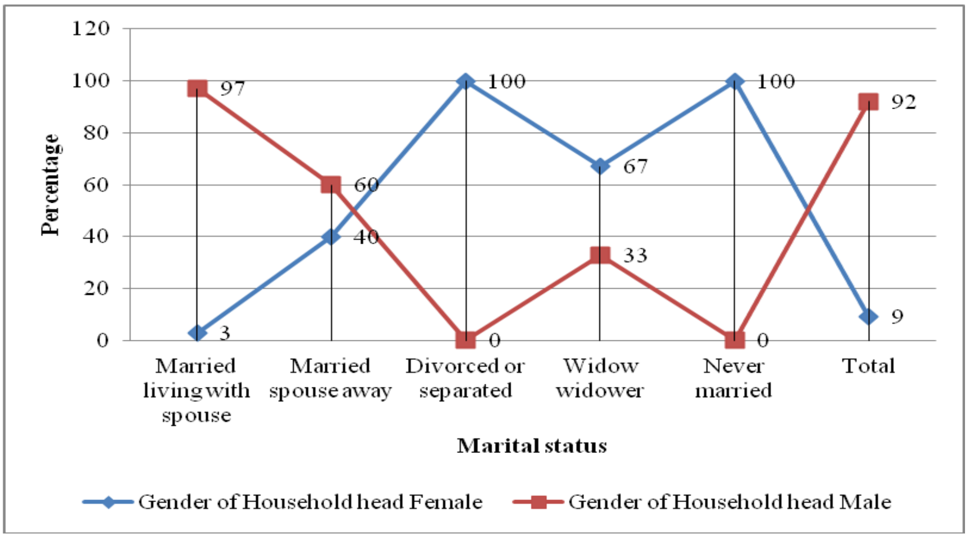
Fourteen percent of households who are married and living with spouses have adopted CA while 33% of widows have done so (Figure 14). None of the married but spouse staying away (working elsewhere or visited relatives for considerable longer period), divorced or separated, widows or widowers are adopters of CA. It is likely that this group might have limited access to land ownership rights, thus not motivated to engage in sustainable land management practices such as CA. In addition this group is mainly dominated by female headed households indicating that decision making for choosing CA as an alternative farming practice may be limited for women (Figure 15).

Figure 14: Percentage of adopter and non-adopter farmers by marital status of headed households



Source: Survey data, 2012

Figure 15: Relationship between marital status and gender for heads of households in the study area



Source: Survey data, 2012

4.3.2 Source and adequacy of food production

There are three sources of food for smallholder farmers in Karatu and Kongwa districts namely own farm, off farm purchase and aid (Table 5). The main source of food for more than 70% of both adopters and non adopters is from own farm. This means households in Karatu and Kongwa districts are dependent on farming activities for their livelihoods. These results imply that sustainable land management practices are required since farming largely contributes to food production among many smallholder farmers. These results however show that large proportion of adopters (40%) experienced shortage of food as compared to non adopters (29%). Shortage of food may be a result of poor production from the fields; the probable reason being that soils under CA may have not regained fertility adequately to bring about positive food production. A number of literatures about land productivity show that in some cases the first years of CA implementation may be less productive as compared to alternative practices (FAO, 2001; ACT, 2008).

Table 5: Percentage of adopter and non adopter households and their sources and situation of food in study area

		Non adopter (N=112)	Adopter (N=17)	Total
Source of food	Own farm	78	74	77
	Off farm purchase	20	24	20
	Aid	2	3	2
	Total	100	100	100
Food situation	Shortage	29	40	31
	No shortage	71	60	69
	Total	100	100	100

Source: Survey data, 2012

4.3.3 Livestock keeping

Majority (78.3%) of all interviewed households in all districts keep livestock such as cattle, goat and sheep. Disaggregated data among households showed that proportion of adopter households who are keeping livestock is larger (82.4%) than non adopters (77.7%). This indicates that livestock keeping is not necessarily a negative intervention for CA farmers, given proper management. Field observation and discussion with farmers indicated that some of the adopters have opted to keep livestock for getting manure that could be applied on their fields to increase soil fertility. It was also found that the proportion of non adopter households who chose not to keep livestock is larger than that of adopters.

4.3.4 Intercropping of subsistence crops with trees

The proportion of CA adopters who were intercropping trees with food crops was 35.3% of adopters as compared to only 30.4% of non adopters. This means that 64.7% and 69.6% of adopters and non adopters respectively do not intercrop trees with food crops respectively. These results suggest that adopters appreciate the role of trees in improving the quality of soils and supplying wood based materials more than their counterpart non adopters. Literature has documented the benefits of trees when intercropped with crops. The benefits accruing from the incorporation of trees in CA include, among others, the gradual build up of the capacity of poor farming communities to access inputs (Sileshi *et al.,* 2008, FAO, 2007b). Some trees contribute to soil physical, chemical and biological improvements that lead to sustainable production systems. Fodder from trees integrated into CA fills an important feeds supply gap, especially during the dry season. Well-fed livestock will provide more milk and meat, and provide much-needed manure; an important component in CA. Fodder from trees will also contribute to minimizing the need for feeding livestock with crop residue and hence allow the much needed organic material to remain as soil cover.

4.3.5 Landholding and land tenure

The average land holding per household was 13.9 ha, with non adopters having largest mean land size (15 ha) as opposed to adopters (6.3 ha) (Table 6). There was a significant difference on mean land sizes between adopter and non adopter farmers. Farmers with smaller landholding sizes are likely to engage in sustainable land husbandry practices that could increase land productivity. Larger sizes of land on the other side entertain a farmer to practice shifting cultivation when fertility of the piece of land is depleted. It is generally accepted that land size can influence the adoption of technology (Putler and Zilberman, 1988; Rahm and Huffman, 1984; Nkonya *et al.*, 1997).

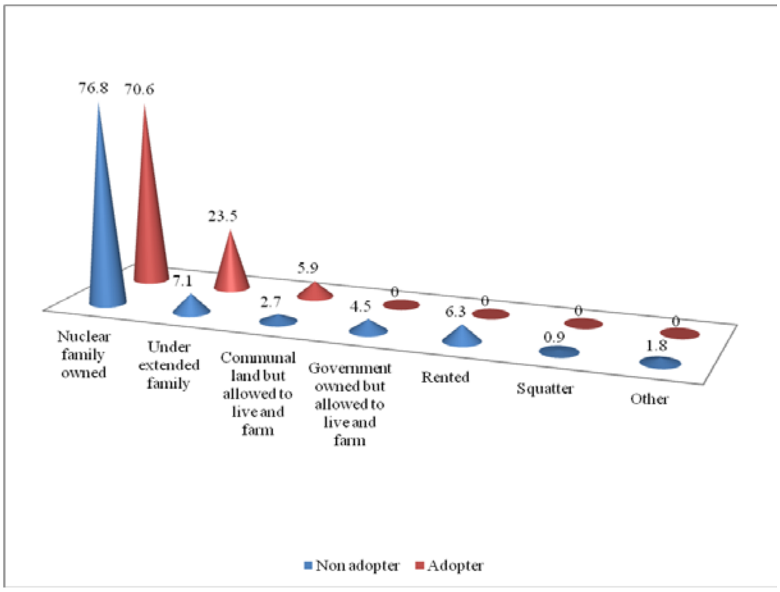
Table 6: Household land size, ha

Adoption category	Mean	Minimum	Maximum	Std. Deviation
Non adopter	15.0	1	85	17.5
Adopter	6.3	1	17	5.3
All	13.9	1	85	16.7

Source: Survey data, 2012.

Nuclear family ownership of land is common for both adopter and non-adopters (Figure 16). However households using rented, borrowed or squatter land did not adopt CA as a farming system. This suggests that security of land tenure affects adoption of land management practices such as conservation agriculture. These results generally suggest that adoption of CA could be influenced by the type of land ownership.

Figure 16: Percentage of households with different types of land ownership in the six study districts

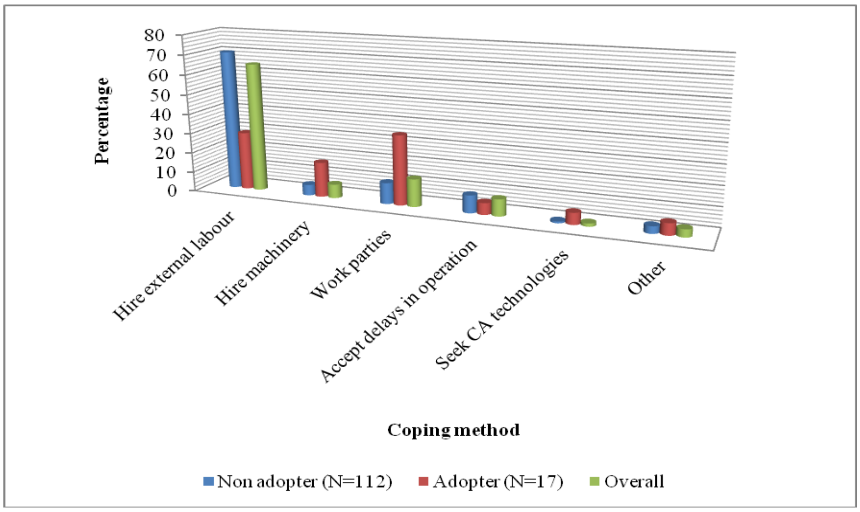


Source: Survey data, 2012

4.3.6 Household sources of labour

The main source of labour for 73.6% of all interviewed households was their families while the rest (26.4%) depended on other sources. In events of labour shortages non adopters (72.3%) hired external labour while adopters (35.3%) chose to go for work parties (Figure 17). The reason for adopters using work parties to deal with labour shortage was probably influenced the Farmer Field Schools (FFS) approach which encourages collective work and sharing on knowledge. Shortage of labour for household and farming activities is among the reasons why CA is promoted.

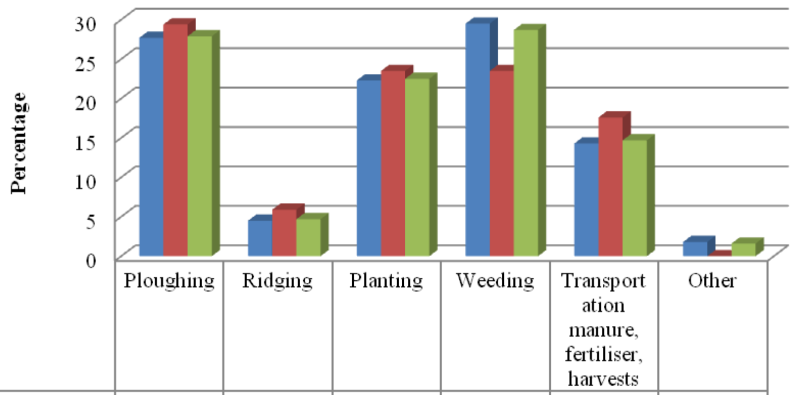
Figure 17: How farmers cope with labour peaks in the study districts



Source: Survey data, 2012

When asked about the labour constraining farm operation households reported that ploughing (27.9%), weeding (28.7%) and planting (22.5%) are the most constraining operations (Figure 18). To reduce the ploughing and planting constraints among farmers in both Karatu and Kongwa districts CA approach using reduced tillage and direct planting equipments may be applied. Gitau *et al.* (2010) noted the need for introduction of CA since labour intensive operations such as ploughing can be eliminated. Weeds can also be well managed when cover crops or mulching for the soil is applied in the field. Some reports (IIRR and ACT, 2005) supports that cover crops suppress the growth of weeds thus reducing labour constraint for weeding. The use of herbicides is normally reasonable before the cover crops or application of mulch improves or increases in the field. Caution should be taken on the type and duration of the herbicides to avoid any unforeseen negative impacts.

Figure 18: Labour constraining farm operations



	Ploughing	Ridging	Planting	Weeding	Transport ation manure, fertiliser, harvests	Other
Non adopter (N=112)	28	5	22	30	14	2
Adopter (N=17)	29	6	24	24	18	0
Overall (129)	28	5	23	29	15	2

Source: Survey data, 2012

Investigation of responsibilities in different farm operations by gender revealed that both female and male undertake farming roles at different proportions (Table 7). Ploughing for example is primarily carried out solely by 51.8% of non adopters while it is only 29.4% for adopters. This means large proportion of adopters (above 70%) plough by engaging women and or both men and women. This indicates that CA may change the roles and responsibilities among men and women in farming activities. Studies by NORAD (2011), for example, pointed that CA has many benefits for women including reduction in labour time as compared to labour invested in conventional agriculture. There is, however, a fair risk that CA results in a shift of labour required from tasks normally performed by men, such as hand tillage or ox-drawn ploughing to hand weeding that is performed mainly by women and children (*ibid*). Without a reallocation of the gender-division of these roles in agricultural production this may lead to an unacceptable increase in the burden of labour on women (Giller *et al.,* 2009).

Table 7: Percentage gender that is primarily responsible for farm operations

Operation	Gender	Adoption category		Total
		Non adopter (N=112)	Adopter (N=17)	
Ploughing	Male	51.8	29.4	48.8
	Female	2.7	5.9	3.1
	Both	45.5	64.7	48.1
Ridging	Male	50.0	29.4	47.3
	Female	0.9	5.9	1.6
	Both	49.1	64.7	51.2
Planting	Male	10.7	17.6	11.6
	Female	10.7	0.0	9.3
	Both	78.6	82.4	79.1
Weeding	Male	8.9	5.9	8.5
	Female	1.8	0.0	1.6
	Both	89.3	94.1	89.9
Transportation	Male	33.9	58.8	37.2
	Female	3.6	0.0	3.1
	Both	62.5	41.2	59.7

Source: Survey data, 2012

4.3.7 Dissemination of CA technology methods

Farmer field schools is the most common approach for dissemination of sustainable land management technologies, including CA, followed by contact farmer, farmer research groups, and champion farmers approaches (Table 8). The efforts by the ministry of agriculture Food Security and Cooperatives and other stakeholders such as NGOs to introduce agriculture projects through FFS might have popularised the approach. In all the approaches used there seem to be a sizeable amount of households who do not know about the approaches. It has been reported by Rogers (2003) that mass communication channels are more effective in creating knowledge of innovations, whereas interpersonal channels are more effective in forming and changing attitudes toward a new idea, and thus in influencing the decision to adopt or reject a new idea. Most individuals evaluate an innovation, not on the basis of scientific research by experts, but through the subjective evaluations of near-peers who have adopted the innovation.

Table 8: Percentage of farmers' appreciating perception about new technology dissemination approaches

Dissemination approach		**Adoption category**		**Total**
		Non adopter (N=112)	Adopter (N=17)	
Farmer Field Schools (FFS)	Don't know	29.5	11.8	27.1
	Yes	47.3	47.1	47.3
	No	23.2	41.2	25.6
Farmer research groups	Don't know	29.5	11.8	27.1
	Yes	33.9	47.1	35.7
	No	36.6	41.2	37.2

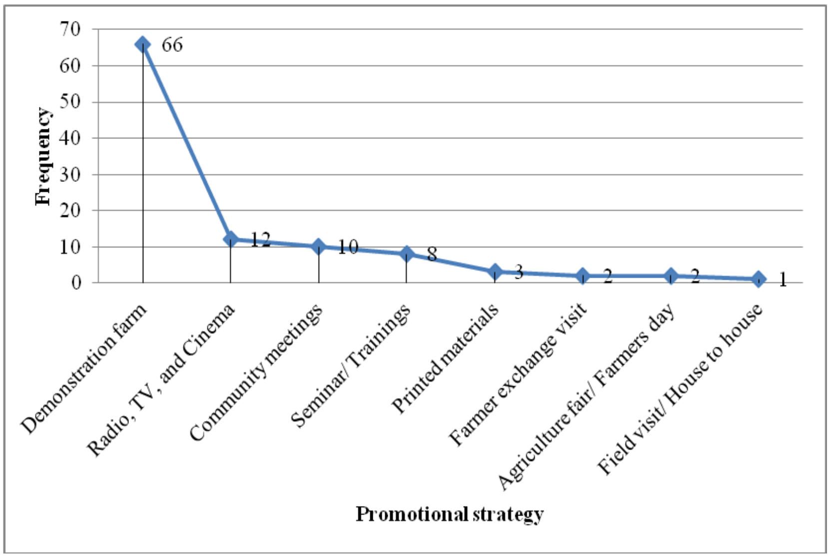
Dissemination approach		Adoption category		Total
		Non adopter (N=112)	Adopter (N=17)	
Contact farmer approach	Don't know	30.4	11.8	27.9
	Yes	39.3	47.1	40.3
	No	30.4	41.2	31.8
Champion farmers	Don't know	30.4	11.8	27.9
	Yes	25.9	23.5	25.6
	No	43.8	64.7	46.5
Other	Don't know	40.2	23.5	38.0
	Yes	7.1	5.9	7.0
	No	52.7	70.6	55.0

Source: Survey data, 2012

4.3.8 Promotional strategies of conservation agriculture technologies

The three most effective promotional strategies for CA in Karatu and Kongwa districts are demonstration farm; radio, TV and cinema; and community meetings (Figure 19). It should, however, be noted that promotional strategies may be different under different conditions and hence assessment of the appropriate strategy to be used must be considered.

Figure 19: Most effective promotional strategies conservation farming technologies

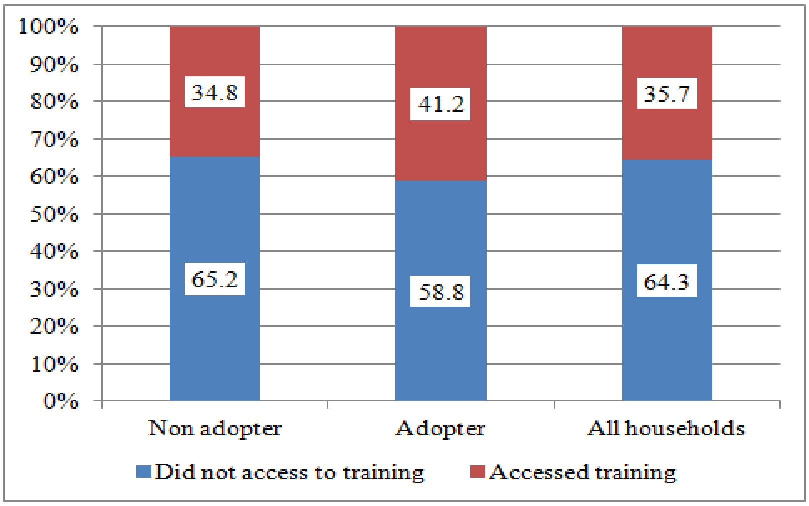


Source: Survey data, 2012

4.3.9 Training and extension resources

The proportion of farmers who had access to conservation agriculture training resources was higher (41.2%) for adopter than non adopter farmers (34.8%). It is reflected that training resources are regarded as important in the improvement of knowledge and skills about conservation agriculture and subsequent facilitating adoption of the same. This argument is also supported by Masvimavi (2011) who informs on the necessity for access to CA extension services by farmers in order to gain knowledge about the technology. Figure 20 depicts the status of access to agriculture training resources among adopter and non-adopter farmers.

Figure 20: Access to conservation agriculture training resources

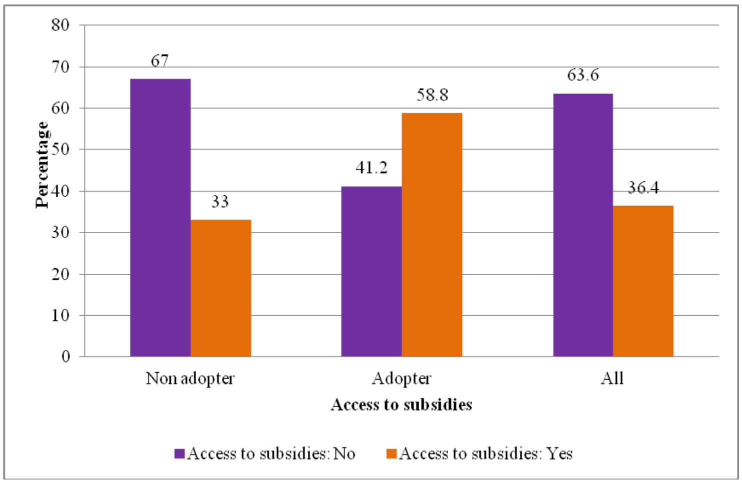


Source: Survey data, 2012

4.3.10 Agriculture subsidies

More than half of adopter farmers (58.8%) received some subsidies as compared to 33% for non-adopter farmers (Figure 21). Subsidies to farmers are likely to reduce the farm operational costs. The reasons for many adopters receiving some subsidies could be that CA or related projects that were carried out in the study districts were providing inputs at reduced rates hence acting as incentive for farmers to start implementing CA. FAO/GIZ (2011) have argued that project provision of CA equipment to resource-poor farmers can lead to a higher adoption rate, but is financially unsustainable for a technical assistance project. However, it could be argued that historical adoption patterns in South America also reveal the need for initial government subsidies (*ibid*). Suitable policies would need to facilitate capital access for farmers and eventually even directly subsidize the cost of the equipment and machinery to reduce the investment risk for early adopters (Kassam *et al*., 2009). This subsidy could be justified as payment for environmental services considering the reduced impact on the environment compared to tillage based farming.

Figure 21: Access to agriculture subsidies

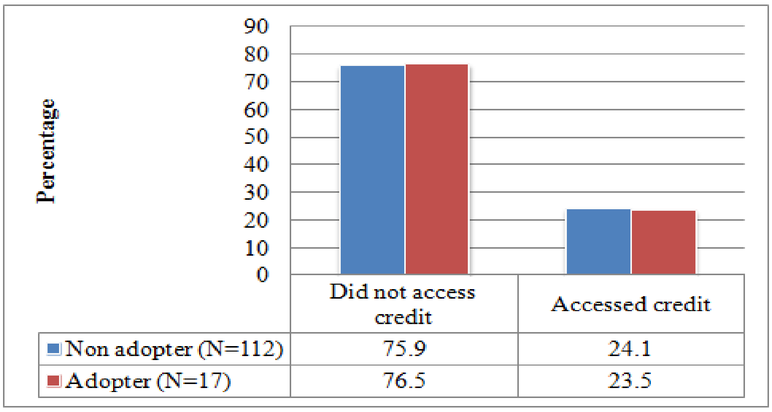


Source: Survey data, 2012

4.3.11 Credit facilities

Less than 25% of both adopter and non adopter farmers had access to credit facilities. Focus Group Discussions with farmers groups indicated that credit is important as capital for accessing goods and services for undertaking CA. The available credits are both informal or formal, whereby informal ones are based on agreement between individuals while the formal one mainly come from the local banking systems such as Village Community Bank (VICOBA.) It has been reported by Amani (2005), however, that availability of formal agricultural credit for production is limited. The main constraint to credit expansion is risk associated with poor credit recovery. Commercial bank lending for agricultural production is extremely limited, and with the collapse of the cooperative unions, farmers find it difficult if not impossible to access some reliable form of formal credit to facilitate purchase of production inputs. Percentages of adopter and non-adopter farmers who reported to access credit in both Karatu and Kongwa districts are presented in Figure 22.

Figure 22: Percentage of adopter and non adopter farmers who reported to access credit in both Karatu and Kongwa districts



Source: Survey data, 2012

Further logistic regression analysis on the factors that influence access to credit in study areas was undertaken whereby it was found that age of the head of households, access to credit information and decision making through social networks assists farmers ability to get credit for their farming activities (Table 9).

Table 9: Determinants of access to credit

Variable	β	S.E.	Wald	df	Sig.	Exp(B)
Age of household head (years)	0.049	0.021	5.446	1	0.02*	1.05
Gender of household head (1=Male, 0=Female)	0.134	0.895	0.022	1	0.881	1.144
Formal education of the household head(1=Never, 2=Primary, 3=Secondary, 4=College, 5=University	0.327	0.345	0.898	1	0.343	1.387
Access to information (Number of source of information – Max 4, Min 1 (FFS, Research group, Champion farmer, Contact farmer)	0.637	0.226	7.924	1	0.005*	1.892
Household land size (ha)	-0.02	0.02	0.994	1	0.319	0.98
Decision making (1= Social networks, 0=Individually)	1.292	0.648	3.974	1	0.046*	3.638
Constant	-6.281	1.589	15.62	1	0	0.002

Dependent variable: Access to credit (1=Access, and 0=No access); *= significant at<0.05
Source: Computation, Survey data, 2012

4.3.12 Perception of farmers about conservation agriculture

Although not all farmers have adopted CA but the majority of them, 71% and 52% of adopter and non adopter farmers respectively, are satisfied with CA. The reasons for positive perception about CA among farmers were related to increases in crop yields and better utilisation of labour and time for farm operations (Table 10). Many authors agree to these reasons (FAO, 2011; Mazvimavi *et al.,* 2010; Shetto *et al.,* 2007; ACT, 2008 and Giller *et al.,* 2009). Lessons from the previous initiatives in Tanzania show that conservation agriculture is one of the most concrete and promising ways of implementing sustainable agriculture in practice especially if controversial issues such as the challenge farmers face in keeping the soil covered, in gaining access to adequate no-tillage seeding equipment, in controlling weeds and on the institutional challenges faced in implementing truly participatory approaches to technology development are addressed (Shetto *et al*., 2007).

Table 10: Reasons for the positive perception of CA

Reason	Rank
More yields	1
Time and labour saving	2
Input saving	3
More soil fertility	4
Less soil erosion	5
More soil water	6

Source: Survey data, 2012

Farmers who switch to some new technique from conventional practice may do so for a variety of reasons. They may detect a more efficient and profitable way to produce, or they may perceive a problem and in seeking solutions arrive at a new practice, such as CA. The problems stimulating the possible change to CA are typically soil degradation, soil erosion or declining crop yields due to deteriorating soil fertility. These views are associated with the traditional model of innovation and the adoption of new technologies in many industries, including agriculture. Some farmers have adopted CA because they found that immediate yield benefits or profits were attractive. In this situation, a clear financial incentive has induced the change in behaviour. However, it may be inappropriate to rely on the classical model as a basis for promoting the adoption of agricultural conservation technologies (for example, no-till). This is because the adoption and diffusion model is based on "voluntarism on the part of the farmer's decision making and the economic gain attached to the new behaviour" (Alene *et al.,* 2000).

Experience and empirical evidence across many countries has shown that the rapid adoption and spread of CA requires a change in commitment and behaviour of all concerned stakeholders (Derpsch, 2008a and b). For the farmers, a mechanism to experiment, learn and adapt is a prerequisite. Adopting CA requires substantial changes not only in practices, but also in mindset. CA contradicts much of conventional farming knowledge and farming traditions. Many farmers are accustomed to thinking of the plough or the hoe as an essential part of agriculture, and may find it difficult to overcome the idea that ploughing is not required for successful planting. It can be particularly difficult to convince farmers to adopt CA if they do not experience strong environmental or economic pressures to change. Conventional agricultural practices may also be tightly woven into local culture and ritual, making such practices even more entrenched. For the policy-makers and institutional leaders, transformation of tillage systems to CA systems requires that they fully understand the large and longer-term economic, social and environmental benefits CA paradigm offers to the producers and the society at large. Further, the transformation calls for a sustained policy and institutional support role that can provide incentives and required services to farmers to adopt CA practices and improve them over time (Friedrich and Kassam, 2009; Friedrich *et al*., 2009).

4.3.13 Off-farm income

The proportion of non-adopters who do not have off farm income activities is higher (41.1%) than that of adopters (29.4%). Therefore 70.6% of CA adopter farmers do have some off farm income generating activities as compared to only 58.9% of non adopter farmers. According to focused group discussions the main off farm activities include small business such as shops and selling of milk, horticulture activities, and tourism service. Other studies have revealed that off-farm incomes affect decision for adoption of technologies. Uncertainties about the profitability (productivity) of new technologies are risky hence preference to off farm activities (Kaguongo *et al.* 1997; Feder & Slade, 1984; Feder *et al.*1985; Kristjanson, 1987).

4.3.14 Social capital

It was found that both adopter and non adopter farmers are members to social networks through at different proportions. It was found that 64.7% of CA adopters and 58% of non CA adopters were members to social networks available in local areas. Farmers' decision about adoption of CA or other agriculture technologies may be facilitated by situation when a farmer is a member in a social network. The project evaluation report confirms that there was a significant interest of farmers joining Farmer Field Schools (FFS) or Village Community Banks (VICOBA), all which enhance access to knowledge and capital for CA uptake and implementation (FAO/GIZ, 2011). The study by Chi (2008) confirms that people association in groups such as extension clubs, farmers' Association, Women's Association and tightly cooperation of Farmers, Administrators, Traders, and Scientist (FATS) stimulate the adoption of agriculture technologies.

4.4 Factors affecting adoption of CA among smallholder farmers

The factors that significantly affect adoption of conservation agriculture were size of the land a farmer owns and the type and category of a farmer, thus confirming the hypothesis that adoption of conservation agriculture technologies by smallholder farmers in Tanzania is significantly affected by household socio-economic and farm characteristics. A multicollinearity diagnosis was undertaken and it was found that there exists no multicollinearity between the independent variables, with acceptable Variance Inflation Factor (VIF) ranging from 1.096 to 2.180. Table 11shows the factors that affect adoption of CA.

Table 11: Factors affecting adoption of conservation agriculture among smallholder farmers in Karatu and Kongwa districts

Independent variable	β	S.E.	Sig.	t-value
Age of head of household (years)	0.041	0.04	0.305	1.0250
Gender of head of household (1=Male 0=Female)	0.75	1.91	0.695	0.3927
Education of head of household (1=Never, 2=Primary, 3=Secondary, 4=College, 5=University)	-1.065	1.163	0.36	-0.9157
Farmer category: (1= Small scale hand hoe, 2= Small scale ox-plough, 3=Small scale tractor, 4=Large scale)	-5.713	2.123	0.007*	-2.6910
Training received and extension service on Conservation Agriculture (1=Yes received, 0=Not received)	-0.776	1.463	0.596	-0.5304
Subsidy received for agriculture (1=Yes received, 0=Not received)	1.817	1.547	0.24	1.1745

Independent variable	β	S.E.	Sig.	t-value
Credit received for agriculture (1=Yes received, 0=Not received)	1.59	1.181	0.178	1.3463
Perception about Conservation agriculture (1= Positive, 0=Negative)	1.94	1.643	0.238	1.1808
Maize yields, kg/ha;	0	0.001	0.433	0.0000
Land size of household (Ha)	-0.297	0.134	0.026*	-2.2164
Off farm income: (1=Yes, 0=No)	-0.75	0.731	0.305	-1.0260
Participation in decision making on CA issues (1=Participate, 0=don't participate)	0.244	1.144	0.831	0.2133
Constant	7.314	4.52	0.106	1.6181

*=significant at <0.05
Source: Survey data computation, 2012
The model summary: Chi-square = 27.540, at sig =0.006;
Nagelkerke R Square = 0.510; Overall Percentage of Classification table = 91.8%.

4.4.1 Farmer scale category

Findings from the study indicated that farmer scale category significantly influences the adoption of CA in Karatu and Kongwa districts. Farmers who are considered as large scale farmers mainly using tractors for their farming operations were less likely to adopt conservation agriculture as compared to the smallholder farmers especially those using hand hoe or ox-plough. The plausible explanation could be that large scale farmers in these districts have heavily invested in conventional tillage equipments such as disc plough drawn by tractors such that shift to tractor based conservation farming equipments may mean to discard the costly currently under use. For the case of farmers considered as smallholder farmers the existence of CA projects (e.g. CA SARD) was instrumental in the procurement and distribution of CA equipments for example jab planters and rippers such that smallholder farmers (hand hoe and oxen) had access to the CA equipments. Local manufacturing companies such as Nandra in Moshi Tanzania are producing a range of CA equipments suitable for smallholder farmers. CA tractor based equipments are not produced by these companies since they claim that there exists no market. Similar results regarding availability of CA equipments have been reported by FAO/Government of German, 2011. It can be concluded than unavailability of appropriate CA equipments for both hand and ox or tractor base can limit farmers from adopting CA. Additionally mechanisms are needed probably by compensating the already existing conventional tractor tillage equipments.

4.4.2 Household land size

The size of the land owned by farmers had a significant influence on the adoption of CA in Karatu and Kongwea district. Farmers with large sizes of land were less likely to adopt CA as compared to ones with smaller sizes of land. The reason which might be contributing to this is the fact that shifting cultivation from one degraded piece of land to another is possible when someone holds a big piece of land. The attraction for CA on smaller pieces of land results from the resulting soil degradation which happens if the land management practices are not sustainable. This is consistent with results by Adeola (2010) who agrees that farmers with small land sizes are likely to adopt new technologies probably for maximum utilization of their small farmlands.

5.0 CONCLUSIONS

Majority of farmers in the study districts still apply conventional farming practices or partially implement the CA principles. Instead of implementing all the three CA principles simultaneously, farmers practiced only one or two principles. This reflects that adoption of conservation agriculture among farmers in Karatu and Kongwa districts is low.

The factors affecting adoption of conservation agriculture are likely to vary greatly and might produce different results over one place to another and time. Analysis of the area specific factors can identify the site specific issues that need be addressed if CA is to be adopted among smallholder farmers.

The economic profit of CA is only a fraction of the factors that influence adoption of CA. Ignoring the inclusion of social and environmental benefits analysis might print a false picture about the benefits of CA technology. Farmers' emphasis on only economic benefits can lead to choice of shorter term benefit technologies that might have negative impacts in the long run. Inadequate considerations of the various benefits in interventions for promotion of CA could affect perception and hence choice of CA farming practices.

6.0 RECOMMENDATIONS

To make CA an efficient farming system and facilitate its adoption process the following preconditions are recommended (i) strengthening extension services by the government and other stakeholders (ii) providing smallholder farmers with financial, institutional and technical support services (iii) stakeholders including the public and private sector be sensitised more on increasing investments on CA (iv) launching CA learning and experience sharing interventions for smallholder farmers

7.0 SUGGESTED FURTHER WORK

CA adoption calls for a range of supporting issues such as increased access to knowledge and information, incentives and the linkage between CA and economics. There is limited knowledge on how these issues may influence CA adoption among smallholder farmers in Tanzania. Further research is therefore recommended on these issues.

REFERENCES

ACT (2008). Linking Production, Livelihoods and Conservation; Proceedings of the Third World Congress on Conservation Agriculture, 3 - 7 October, 2005, Nairobi. African Conservation Tillage Network, Nairobi.

Adeola, R. G. (2010). Influence of Socio-Economic Factors on the Adoption of Soil Conservation Measures in Ibadan/Ibarapa Agricultural Zone of Oyo State. Report and Opinion 2010; 2(7)

Adesina, A, A., Mbila, D., Nkamleu, G, B. and Endaman, D. (2000). Economic analysis of the determinants of adoption of alley farming by farmers in the forest zone of South west Cameroon. Agriculture, Ecosystems and Environment 80:255-265.

Ajzen, I. & Fishbein, M. 1980. Understanding Attitudes and Predicting Social Behavior. Englewood Cliffs, NJ: Prentice Hall.

Ajzen, I. (1991) 'The theory of planned behavior', Organizational Behavior and Human Decision Processes, vol. 50, no. 2, pp. 179-211.

Alavalapati, J.R.R., Luckert, M.K., Gill, O.S. (1995). Adoption of Agroforestry practices: a case study from Andhara Prades, India, Agroforestry system. 32: 1-14

Alene, A. D., Poonyth, D. & Hassan RM. (2000). Determinants of adoption and intensity of use of improved maize varieties in the Central Highlands of Ethiopia: A tobit analysis. Agrekon, 39 (4)

Amani, H.K.R. (2005). Making agriculture impact on Poverty in Tanzania: The case on non-traditional Export crops. Paper Presented at a Policy Dialogue for Accelerating Growth and Poverty Reduction in Tanzania, Held at ESRF, Dar es Salaam, 12th May 2005.

Ayuk, E.T. (1997) Adoption of agroforestry technology. The case of live hedges in the central plateau of Burkina Faso. Agricultural systems 54:189-206.

Barron, J., Rockstrom, J. and Hatibu, N. and Gichuki, F. (2003) Dry spell occurrences and maize yields for two locations in semi-arid East Africa. Agricultural and Forestry Journal. 13:67-72.

Bekele, S. and Holden, S. (1998). Resource degradation and adoption of land conservation technologies in the Ethiopian Highlands. A case study in Andit Tid, North Shewa. Agricultural Economics 18: 233-147.

Benites, J., Chuma, E., Fowler, R., Kienzle, J., Molapong, K., Manu, J., Nyagumbo, I., Steiner, K., van Veenhuizen, R. (Eds.), 1998. Conservation Tillage for Sustainable Agriculture. Proc. from the International Workshop on Conservation Agriculture. Proceedings from an International Workshop. Harare, 22–27 June are, 22 – 27 June 1998. Part I (Workshop Report). Deutschegesells chaft, GTZ, Eschborn, Germany. P59.

Biamah, E.K.; Rockström, J. 2000. Development of sustainable conservation farming systems. In Conservation Tillage for Dryland Farming. Technological Options and Experiences in Eastern and Southern Africa, eds. E.K. Biamah; J. Rockström; G.E.Okwach. RELMA, Workshop Report No. 3: 27-35.

Boyd, H. K., Weslfall, P., and Stasch, S. F. (1981). Marketing research. Text and cases. Illinois. Richard D. Irwin. Inc. 80pp

Burton, R. J. F. (2004), 'Reconceptualising the 'behavioural approach' in agricultural studies: a socio-psychological perspective', Journal of Rural Studies, vol. 20, no. 3, pp. 359-371.

Chaves, B. and Riley, J (2001). Determination of factors influencing integrated pest management adoption in coffee berry borer in Colombian farms. Agriculture, Ecosytems and Environment 87: 159-177

Chi, T. T. N. (2008). Factors affecting technology adoption among rice farmers in The Mekong delta through the lens of the local authorial Managers: an analysis of qualitative data. Omonrice 16: 107-112 (2008)

Chuchu, T.O. (2001). Conservation technologies: the case of river Njoro Watershed, Nakuru district-kenya. A Thesis Submitted to the Graduate School in Partial Fulfilment for the Requirement of the Award of a Master of Science Degree in Agricultural Economics of Egerton University

Denning, L.G. (2001). Realizing the potential of agroforestry. Integrating research and developement to achieve greater impact. Development practice 11 (4) 407-416

Derpsch, R. (2001): Frontiers in Conservation Tillage and Advances in Conservation Practice. In: D.E. Stott, R.H. Mohtar and G.C. Steinhardt (eds). 2001, Sustaining the Global Farm. Selected papers from the 10th International Soil Conservation Organization Meeting held May 24 -29, 1999 at Purdue University and the USDA-ARS National Soil Erosion Research Laboratory, p 248-254

Derpsch, R. (2008a). No-tillage and Conservation Agriculture: A Progress Report. In: No- Till Farming Systems (Goddard, T. *et al*., Eds.), pp. 7-39. WASWC Special Publication No. 3, Bangkok.

Derpsch, R. and Friedrich, T. (2009a). Global Overview of Conservation Agriculture Adoption. Proceedings, Lead Paper, 4th World Congress on Conservation Agriculture, pp. 429-438. 4-7 February 2009, New Delhi, India

Derpsch, R. and Friedrich, T. (2009b). Development and Current Status of No-till Adoption in the World; Proceedings on CD, 18th Triennial Conference of the International Soil Tillage Research Organization (ISTRO), June 15-19, 2009, Izmir, Turkey

Derpsch, R., 2005. The extent of conservation agriculture adoption worldwide: implications and impact. In: Keynote Paper at the 3rd World Congress on Conservation Agriculture. World Agroforestry Center, Nairobi, Kenya.

Derpsch. R. (2008b). Critical Steps in No-till Adoption. In: No-Till Farming Systems (Goddard, T. *et al*., Eds.), pp. 479-495. WASWC Special Publication No. 3, Bangkok.
Elwell, H.; Brunner, E.; Mariki, W. 2000. Recommendations on the adoption of minimum and conservation tillage in Tanzanian. In Conservation Tillage for Dryland Farming. Technological Options and Experiences in Eastern and Southern Africa, eds. E.K. Biamah; J. Rockstrom; G.E. Okwach. RELMA, Workshop Report No.3, 87-95.
Enfors, E. (2009) Traps and Transformations. Exploring the potential of Water Systems Innovations in dryland sub-Saharan Africa. Doctoral Thesis. Stockholm University. Pp 164
FAO (2001). The Economics of Conservation Agriculture. FAO, Rome
FAO (2007). Adaptation to Climate Change in Agriculture, Forestry and Fisheries: Perspectives, Framework and Priorities. Rome, Italy
FAO (2007b). Agriculture and Consumer Protection Department. Rome, Italy Available from http://www.fao.org/ag/ca/
FAO (2008). Proceedings of an International Technical Workshop on Investing in Sustainable Crop Intensification: The case for improving soil health. FAO, Rome, 22-24 July 2008. Integrated Crop Management, Vol. 6. 2008. FAO, Rome.
FAO (2010). “Climate-Smart” Agriculture; Policies, Practices and Financing for Food Security, Adaptation and Mitigation. FAO, Rome
FAO (2011). Socio-economic Analysis of conservation agriculture in Southern Africa
FAO and GIZ (2011). Evaluation of Supporting Conservation Agriculture for Sustainable Agriculture and Rural Development (CA for SARD) Phase II. GCP/RAF/413/GER. Report of the Evaluation Mission, March 2011
Feder G & Slade R. (1984). The acquisition of information and the adoption of the technology. American Jounral of Agricultural Economics 66(3): 312-320.
Feder, G. & O’Mara, G. (1981). Farm size and the diffusion of green revolution technology. Economic Development and Cultural Change 30:59–76.
Feder, G. & Umali, D. L. (1993) 'The adoption of agricultural innovation: a review', Technological Forecasting and Social Change, vol. 43, pp. 215-239.
Feder, G. Just, R. E. and Zilberman, D. 1985 Adoption of agricultural innovations in developing countries: a survey. Economic Development and Cultural Change 33 (2): 255-297.
Fernandes E.C.M, Oktingati, A. and Maghembe, J. (1981). The Chagga homegardens: a multistoried agroforestry cropping system on Mt. Kilimanjaro (Northern Tanzania). Agroforestry Systems 2: 73-86.
Fishbein, M. & Ajzen, I. (1975) Belief, Attitude, Intention and Behavior – An introduction to theory and research, Addison-Wesley Publishing Company, USA.

Fisher, D. K., Norvell, J., Sonka, S. & Nelson, M. J. (2000), 'Understanding technology adoption through system dynamics modelling: implication for agribusiness management', International Food and Agribusiness Management Review, vol. 3, no. 3, pp. 281-296.

Fliegel, F. (1993) Diffusion Research in Rural Sociology, Greenwood, Westport, USA.

Fliegel, F. C. & Kivlin, J. E. (1962) 'Farm practice attributes and adoption rates', Social Forces, vol. 40, no. 4, pp. 364-370.

Friedrich, T., Kassam, A. H. (2009). Adoption of Conservation Agriculture Technologies: Constraints and Opportunities. Invited paper at the IV World Congress on Conservation Agriculture. 4-7 February 2009, New Delhi, India.

Giller, K.E., Witter, E., Corbeels, M., Tittonell, P. (2009). Conservation agriculture and smallholder farming in Africa: The heretics‟ view, Field Crops Research, 114, 23-34.

Gitau, A.N., Kasisira, L.L., Mganilwa, Z.M. (2010). Mechanisation status in the Lake Victoria Basin of East Africa. Australian Journal of Agricultural Engineering. AJAE 1(5) 160-164

Gorddard, B. J. (1992) 'Barriers to the adoption of conservation tillage in Western Australia', in Proceedings of the 7th ISCO conference, Sydney, pp. 391-403.

Goss, K. F. (1979) 'Consequences of diffusion of innovations', Rural Sociology, vol. 44, no. 4, pp. 754-772.

Gowing, J. W., Palmer, M., 2008. Sustainable agricultural development in sub-Saharan Africa: the case for paradigm shift in land husband. Soil Use Mgt. 24 (1), 92–99.

Green, I.F.R. (2005). The Emancipatory Potential of a New Information System and its Effect on Technology Acceptance. Dissertation Submitted in partial fulfilment of the requirements for the degree: M.Com (Informatics) Faculty of Economic and Management Sciences University of Pretoria

Gregor, S., & Jones, K. (1999). Beef producers online: Diffusion theory applied. Information Technology & People, 12(1), 71-85.

Hausman, A. (2005) ‘Innovativeness among small businesses: Theory and propositions for future research’, Industrial Marketing Management, vol.34, no. 8, p. 773.

Hensley, M. and Bennie, A.T.P. (2003). Application of water conservation technologies and their impacts on sustainable dryland agriculture in Sub-Saharan Africa. Proceedings of the symposium and workshop on water conservation technologies for sustainable dryland agriculture in Sub-Saharan Africa. (Edited by Beukes *et al*.). 8-11 April 2003, Bloem Spa Lodge and Conference Centre, Bloemfontein. pp 2-17.

Hobbs, P.R. (2006). Conservation Agriculture: What is it and why is it important for future sustainable food production? Proceedings of an International Workshop on Increasing Wheat Yield Potential. CIMMYT, Obregon, Mexico. March 20-24th 2006. Accepted for publication in 2006.

Hobbs, P.R. (2007). Conservation agriculture, what is it and why is it important for future sustainable food production? J. Agric. Sci. 145, 127–137.

Hobbs, P.R., Sayre, K., Gupta, R. (2007). The role of conservation agriculture in sustainable agriculture. Phil. Trans. R. Soc. B 363, 543–555.

Hofmeyer, G.D. (2005) An investigation of the factors that influence the intention to adopt business to business (B2B) trading exchanges in small businesses in Western Australia, PhD thesis, Curtin University of Technology

IIRR and ACT (2005). Conservation Agriculture. A manual for farmers and extension workers in Africa. International Institute of Rural Reconstruction, Nairobi; African Conservation Tillage Nnetwork, Nairobi

Intrapairot, A. (2000) A study on the adoption and diffusion of information and communication technologies in the banking industry in Thailand using multiple-criteria decision making and system dynamics approaches, PhD thesis, Curtin University of Technology.

Jackson, E.L, Quaddus, M., Islam N. and Stanton, J. (2006). Hybrid Vigour of Behavioural Theories in the Agribusiness Research Domain. Is It Possible? Journal of International Farm Management Vol.3. No.3 - July 2006

Jama, B., Buresh, R. and Place, F.M. (1998). Sesbania Tree Fallows on Phosphorus-Deficient Sites: Maize Yield and Financial Benefit. Agronomy Journal Vol. 90, N0.6. pp 717-726

Jensen, R.A. (1982) 'Adoption and diffusion of an innovation of uncertain probability', Journal of Economic Theory, vol. 27, no. 1, pp. 182-193.

Jensen, R.A. (2001) ‘Strategic intrafirm innovation adoption and diffusion’, Southern Economic Journal, vol. 68, no. 1, pp. 120-133.

Jonsson, L. O., Singish, M. A.; Mbise, S. M. E. 2000. Dry land farming in Tanzania. Experiences from the Land Management Program. In Conservation Tillage for Dryland Farming. Technological Options and Experiences in Eastern and Southern Africa, eds. E.K. Biamah; J. Rockstrom; G.E. Okwach. RELMA, Workshop Report No. 3: 96-113.

Kaguongo, W., Staal, S.J. & Ackello-Ogutu, C. (1997). Risk with intensification of Kenyan smallholder dairying. In: Proceedings of the Poster Paper Presented at XXIII International Conference of Agricultural Economists, 10–16 August, Sacramento, CA.

Kassam, A. H., Friedrich, T. and Derpsch, R. 2010 Conservation Agriculture in the 21st Century: A Paradigm of Sustainable Agriculture. Invited paper at the European Congress on Conservation Agriculture, October 2010, Madrid, Spain

Kassam, A. H., Friedrich, T., Derpsch, R. (2010). Conservation Agriculture in the 21st Century: A Paradigm of Sustainable Agriculture. Invited paper at the European Congress on Conservation Agriculture, October 2010, Madrid, Spain

Kassam, A. H., Friedrich, T., Shaxson, F., Pretty J (2009). The spread of conservation agriculture: Justification, suitability and uptake. International Journal of Agricultural Sustainability 7(4): 1-29

Krishna R. T., Bishal K. S., Ingrid L. P. N., Giridhari S. P. (2008). Determinants of Farmers' Adoption of Improved Soil Conservation Technology in a Middle Mountain Watershed of Central Nepal. Environmental Management (2008) 42:210–222

Kristjanson, P. M. (1987). The role of information and flexibility in small farm decision-making and risk management: evidence from West African semi-arid Tropics. University of Wisconsin, Madison, WI.

Lubwama, F.B. (1999). Socio-economic and gender issues affecting the adoption of conservation tillage practices. In: Kaumbutho P G and Simalenga T E (eds), 1999. Conservation tillage with animal traction. A resource book of the Animal Traction Network for Eastern and Southern Africa (ATNESA). Harare. Zimbabwe. 173p

Larsen, K., Kim, R., Theus, F. (Eds.). (2009). Agribusiness and Innovation Systems in Africa. Washington D.C.: The World Bank.

Lynne, G. D., Casey, C. F., Hodges, A. & Rahmani, M. (1995) 'Conservation technology adoption decisions and the theory of planned behavior', Journal of Economic Psychology, vol. 16, no. 4, pp. 581-598.

Mahajan V., Muller E., Srivastava R.K. (1990). Determination of Adopter Categories by Using Innovation Diffusion Models. Journal of Marketing Research, Vol. 27, No. 1. (Feb., 1990), pp. 37-50.

Marandu, E.E., Nkisang M. and Joseph, H. (2010). Predicting Residential Water Conservation Using the Theory of Reasoned Action. J Communication, 1(2): 87-100 (2010)

Matata, P.Z., Ajayil, O.C., Oduol, P.A. and Agumya, A. (2008). Socio-economic factors influencing adoption of improved fallow practices among smallholder farmers in western Tanzania. International NGO Journal Vol. 3 (4), pp. 068-073

Mazvimavi, K., Ndlovu, P.V., Nyathi, P. and Minde, J. I. (2010). Conservation Agriculture Practices and Adoption by Smallholder Farmers in Zimbabwe. Poster presented at the Joint 3rd African Association of Agricultural Economists (AAAE) and 48th Agricultural Economists Association of South Africa (AEASA) Conference, Cape Town, South Africa, September 19-23, 2010

McCall, M.K., ed. 1994. Indigenous Technical Knowledge (ITK) in farming systems of Eastern Africa: A Bibliography. Bibliographies in Technology and Social Charge series No. 9. Technology and Social Charge Program, Iowa State University Research Foundation.

Milder J. C., Majanen T., Scherr S.J. (2011). Performance and Potential of Conservation Agriculture for Climate Change Adaptation and Mitigation in Sub-Saharan Africa. An assessment of WWF and CARE projects in support of the WWF-CARE Alliance’s Rural Futures Initiative. Final Report February 2011

Mutunga, K., Critchley, W., Lameck, P., Lwakuba, A., Mburu, C. (2001). Farmers’ initiatives in land husbandry. Promising technologies for the drier areas of East Africa. Technical Report No. 27. RELMA, Nairobi.

Nkonya, E., Schroeder, T. and Norman, D. (1997). Factors affecting adoption of improved maize seed and fertilizer in Northern Tanzania. Journal of Agricultural Economics 4: 1-12

NORAD (2011). Report from a fact finding mission: Women, Gender and Conservation Agriculture in Zambia. Norad Report 5/2011 Discussion

Putler, D.S. & Zilberman, D. (1988). Computer use in agriculture: evidence from tulare county, California. American Journal of Agricultural Economics 70:790–802.

Rahm, M. R. and Huffman, W. (1984). The adoption of reduced tillage: the role of human capital and other variables. American Journal of Agricultural Economics 66: 405-413.

Reij, C., Scoones, I., Toulmin, C., eds. (1996). Sustaining the soil. Indigenous soil and water conservation in Africa. London, U.K.: Earthscan.

RELMA (1998). Water harvesting. An Illustrative manual for development of micro-catchment techniques for production in dry areas. Technical Handbook. No. 16. pp345

Rockstrom, J., Hatibu, N., Oweis, T.Y., Wani, S., Barron, J., Bruggeman, A., Farahani, J., Karlberg, L., Qiang, Z., 2007. Managing water in rainfed agriculture. In: CAWMA 2007, Water for Food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture. Earthscan, London (Chapter 8).

Rockström, J., Kaumbutho, P., Mwalley, J., Nzabi, A.W., Temesgen, M., Mawenya, L., Barron, J., Mutua, J., Damgaard-Larsen, S., 2008. Conservation farming strategies in East and Southern Africa: Yields and rain water productivity from on-farm action research. Soil Till. Res. 103, 23-32.

Rogers, E.M. (2003). Diffusion of innovations (5th ed.). New York: Free Press.

Sahin, I. (2005) Understanding faculty adoption of technology using the Learning/adoption trajectory model: a qualitative case study. The Turkish Online Journal of Educational Technology – TOJET January 2005 ISSN: 1303-6521 volume 4 Issue 1 Article 10

Sahin, I. (2006). Detailed review of Rogers' diffusion of innovations theory and educational technology-related studies based on Rogers' Theory The Turkish Online Journal of Educational Technology – TOJET April 2006 ISSN: 1303-6521 volume 5 Issue 2 Article 3

Shetto, R., Owenya, M., eds. (2007). Conservation agriculture as practised in Tanzania: three case studies. Nairobi. African Conservation Tillage Network, Centre de Coopération Internationale de Recherche Agronomique pour le Développement, Food and Agriculture Organization of the United Nations

Shetto R. (2011) Policy analysis and institutional arrangements on conservation agriculture with trees (CAWT) in Tanzania. Conservation agriculture with tree policy analysis report

Sileshi, G., Akinnifesi, F.K., Ajayi, O.C., Place, F. (2008). Meat-analysis of maize yield response to planted fallow and green manure in sub-Saharan Africa. Plant and Soil 307: 1-19.

Taylor, S. & Todd, P. (1995b). Understanding information technology usage: a test of competing models. Information Systems Research, June 1995, vol.6, no.2, pp.144-176.

Thiombiano. L., and M. Meshack. 2009. Scaling-up conservation agriculture in Africa: strategy and approaches. FAO Subregional Office for Eastern Africa, Addis Ababa.

Twomlow, S.J., Steyn, J.T., du Preez, C.C. (2006). Dryland farming in southern Africa. In: Dryland Agriculture 2nd Edition. Agronomy Monograph No. 23. American Society of Agronomy, Madison, Wisconsin. pp. 769–836 (Chapter 19).

UNEP (2009). UNEP Year Book 2009 Makes the Green Economy Case. 25th Session of UNEP's Governing Council/Global Ministerial Environment Forum 16-20 February

URT (2010). The economic survey 2009. The Ministry of Finance and Economic Affairs. KIUTA, Dar es Salaam – Tanzania, June, 2010

URT (2011). Tanzania Agriculture and Food Security Investment Plan (TAFSIP); 2011/12 to 2020/21. Working Paper No. 3. TAFSIP Policy and Institutional Framework

Xu, J. (2003) A study of the factors influencing knowledge management systems diffusion in Australia, PhD thesis, Curtin University of Technology.