

MAKERERE



UNIVERSITY

**USE OF INFORMATION COMMUNICATION TECHNOLOGIES IN
CONSERVATION AGRICULTURE KNOWLEDGE PATHWAYS AMONG
SMALLHOLDER FARMERS IN MACHAKOS AND LAIKIPIA
COUNTIES, KENYA.**

BY

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NOVEMBER, 2019

DECLARATION

I ACHORA, Janet Cox, declare that this dissertation titled **“USE OF INFORMATION COMMUNICATION TECHNOLOGIES IN CONSERVATION AGRICULTURE KNOWLEDGE PATHWAYS AMONG SMALLHOLDER FARMERS IN MACHAKOS AND LAIKIPIA COUNTIES, KENYA”** is my original work and to the best of my knowledge, has never been submitted to any university or institution for any academic award whatsoever.

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DEDICATION

I dedicate this work to my late parents Edward and Celina Cox (RIP).
Thank you for giving me the foundation in life that has led me this far;

And

My children, Douglas and Jordana.

Nieces and nephew Edna, Nancy and Eddie.

.

ACKNOWLEDGEMENT

“He reveals limited portions of his glory in multiple ways. I do not speak nor write on my own authority but through the Father who dwells in me does the works”

Exodus 33:18-23

Every journey has a beginning and an end, as I begin the end of my journey, I go back to how it all began. Mine began with the design of a proposal for the Community Action Research program in response to a call by the Regional Universities Forum for capacity building in Agriculture. This is a story for another day, but deserves mention as I begin to write my appreciation. It may not be possible for me to acknowledge each and every one who has walked this journey with me, but I am forever indebted to each and every one of you in your various capacities, for the support you gave to me.

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LIST OF ACRONYMS

ACT	African Conservation Tillage Network
AGRA	Alliance for a Green Revolution in Africa
AKIS	Agricultural Knowledge and Information Systems
ALIN	Arid Lands Information Network
ASALs	Arid and Semi-arid Lands
ASDP	Agricultural Sector Development Support Program
ASK	Agricultural Shows of Kenya
CA	Conservation Agriculture
CABI	Centre for Agriculture and Biosciences International
CA-SARD	Conservation Agriculture for Sustainable Agriculture and Rural Development
CETRAD	Centre for Training Research and Dissemination of Agricultural Information
COMESA	Common Market for East and Southern Africa
DIT	Diffusion of Innovations Theory
ICTs	Information and Communication Technologies
ITU	International Telecommunications Union
KARLO	Kenya Agricultural Research and Livestock Organization
KEPHIS	Kenya Plant Health Inspectorate Service
KMS	Kenya Meteorological Services
LCIDP	Laikipia County Integrated Development Plan
MCIDP	Machakos County Integrated Development Plan
MoALF	Ministry of Agriculture, Livestock and Fisheries
WSIS	World Summit on the Information Society

ABSTRACT

The low integration of emerging Information Communication Technologies (ICTs) in Agricultural knowledge systems is a challenge to the timely provision of extension services to farmers. The main objective of this study was to analyse the use of ICTs for Conservation Agriculture knowledge among smallholder farmers in Machakos and Laikipia counties, Kenya. While a number of studies have investigated agriculture knowledge sharing systems, limited literature exists on conservation agriculture knowledge sharing systems. This study applied three theoretical frameworks, the knowledge systems framework, the social network theory and diffusion of innovation theory to understand how conservation agriculture knowledge is shared. The overall objective of this study was to examine how ICTs are used to enhance conservation agriculture knowledge sharing among smallholder farmers. Specifically, the study (i) determined the knowledge sources and pathways used for conservation agriculture knowledge sharing (ii) established how Actor positioning affects conservation agriculture knowledge sharing; and (iii) described the use of different ICTs for conservation agriculture knowledge sharing. The study used a mixed methods research design using a cross-sectional household survey, key informant interviews and focus group discussions for data collection. Data were collected from 300 survey respondents, 28 key informants and five focus group discussions. Results indicated that, knowledge pathways were not mutually exclusive, but integrated for optimal conservation agriculture knowledge sharing. The use of ICTs was low and limited to the basic ones. An analysis of the knowledge network indicated that although the network size was 1892, there were only 226 active ties, with a low density of 12%. Measures of centrality indicated that positions of influence were occupied by three actors, the farmer, Laikipia and Machakos counties out of a total of 44 Actors signifying a fragmented network. ICT Actors occupied periphery positions, indicating their minor role in the network. Land under CA, accessibility to communication networks, education and costs associated with the use of ICTs were significant predictors for the use of ICTs for conservation agriculture knowledge. A key output from this study is the Conservation Agriculture ICT knowledge sharing framework, recommended for the integration of emerging ICTs implemented at two levels, in terms of use of ICT tools at the institutional level and integration of ICT capacities of the different institutions involved in the promotion of the conservation agriculture practice.

CHAPTER ONE

GENERAL INTRODUCTION

1.1 Background

Conservation Agriculture (CA) has been practiced for more than three decades and its spread has been a global phenomenon except for Africa (Thorpe & Maestre, 2015). It is defined as a farming approach that fosters natural ecological processes, to increase agricultural yields and sustainability by minimising soil disturbance, maintaining permanent soil cover, and diversifying crop rotations and/ or association (FAO, 2013). Kaluzi, Thierfelder & Hopkins (2017), suggest that land management practices like CA are known to adapt to the negative effects of climate change, sequestering of soil carbon, and reduction of the emission of greenhouse gases, thereby improving the agricultural production systems. However, its knowledge systems are not adequately equipped to support its sustained practice among smallholder farmers (Whitfielder *et al.*, 2014). This is reflected in how the different organisations define it¹, the various ways it is promoted by organisations and the perceptions among farmers and extension staff on the tools and equipment needed for its practice (Ward, Bell, Droppelmann, & Benton, 2018).

Globally by 2015/2016, CA was practiced on approximately 180million hectares of cropland compared to about 12.5% of the total global cropland as estimates show in Figure 1.1. In Africa, CA is practiced on approximately 1.5 million hectares corresponding to 0.8% of global CA cropland area and 1.1% in Africa (Kassam, Friedrich, & Derpsch, 2019).

Although it was initially developed for large scale commercial farms in Argentina and Brazil, much effort has

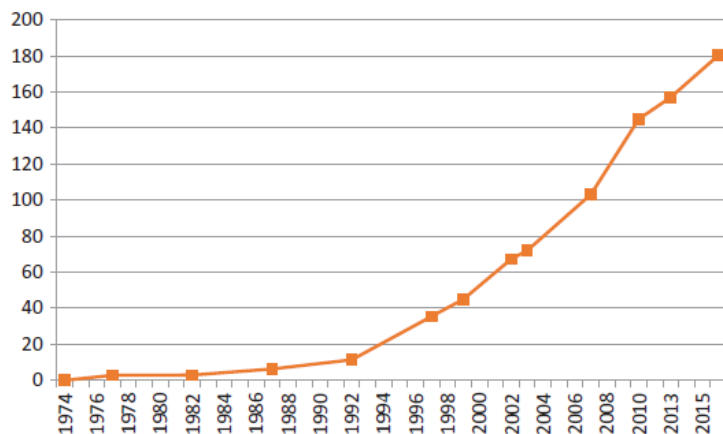


Figure 1.1 Global uptake of Conservation Agriculture in million hectares of cropland.

Source: Kassam, Friedrich & Derpsch, 2019

¹ Different interpretations of CA e.g Farming God's way; organic agriculture; Integrated soil fertility; promotion of only one or two principles (crop rotation or minimum soil disturbance or maintaining permanent soil cover)

gone into adopting CA systems for smallholder farms in developing countries due to declining soil fertility, volatile weather changes and declining crop yields (Ward et al., 2018).

In East Africa, FAO (2013), statistics puts the total area under CA at 33,100 hectares in Kenya, 25,000 hectares in Tanzania and at 10,000 hectares in Sudan. Conservation agriculture statistics for Uganda, Rwanda and Burundi were not readily available at the time of this study. The rate of adoption varies with farm size, with large commercial farms comprising most of the area under CA globally and in parts of Africa. Ndah *et al.*, (2015) attributed the low adoption to external funding mechanisms, deficient infrastructures, small farm sizes, low educational level and the land tenure systems in Kenya. Sani *et al.*, (2014), suggested that the extent to which farmers adopt innovations and the speed by which they do so could be determined by examining how useful they find the sources through which they get information about the innovation.

Kassam *et al.*, (2014) suggest that CA knowledge learning systems are in primary stages and are not well defined among the extension services and the smallholder farming communities. And so, if CA were to be widely adopted and practiced, there has to be an improvement in the approaches used for its knowledge sharing (Thierfelder, Mombeyara, Mango & Rusinamhodzi 2013). Studies by UNDP (2012), revealed that lack of knowledge and skills in CA among field officers and farmers were a major constraint to the adoption of CA. The first African congress on CA held in Zambia 2014, further highlighted that challenges associated with CA adoption were the persistent knowledge gaps, and the uncoordinated efforts on part of the action- research community (Kassam et al., 2019).

The agriculture sector in Kenya is dominated by smallholder farmers in rural areas and accounts for 25% of GDP according to the Kenya National Bureau of Statistics (2017). Farming is largely rain-fed with worsening cycles of drought affecting food production for local consumption (AGRA, 2016). Despite the country's commitment to agriculture in terms of budgetary and policy requirements, the sectoral growth remains below the six percent productivity target and has been declining steadily at 21% since 2015 to date (World Bank, 2017). Kenya is comprised of about 84% arid and semi-arid land and is not suitable for rain-fed farming due to low and erratic rainfall, making only 20% of the country's land suitable for agricultural production (Ibid).

Kenya, Agricultural Sector Development Strategy 2010-2020 recognizes that extension services play a key role in disseminating knowledge, technologies and agricultural information. It also further recognizes that extension services can be improved through better utilization of information and Communication Technologies (ICTs). According to the Kenya National Agricultural Sector Extension Policy-NASEP (2012), the ratio of frontline extension officer to a farmer was approximately 1:1000 compared to the FAO recommended ratio of 1:400. This ratio has continued to decline due to the reduced funding for operations and staff recruitment. To counter this challenge, part of Kenya's vision 2030 calls for a more responsive and demand-driven extension system to harness ICTs and other mass media for improved agricultural information sharing. ICTs play a crucial role in agriculture as broadly illustrated in Figure 1.2.

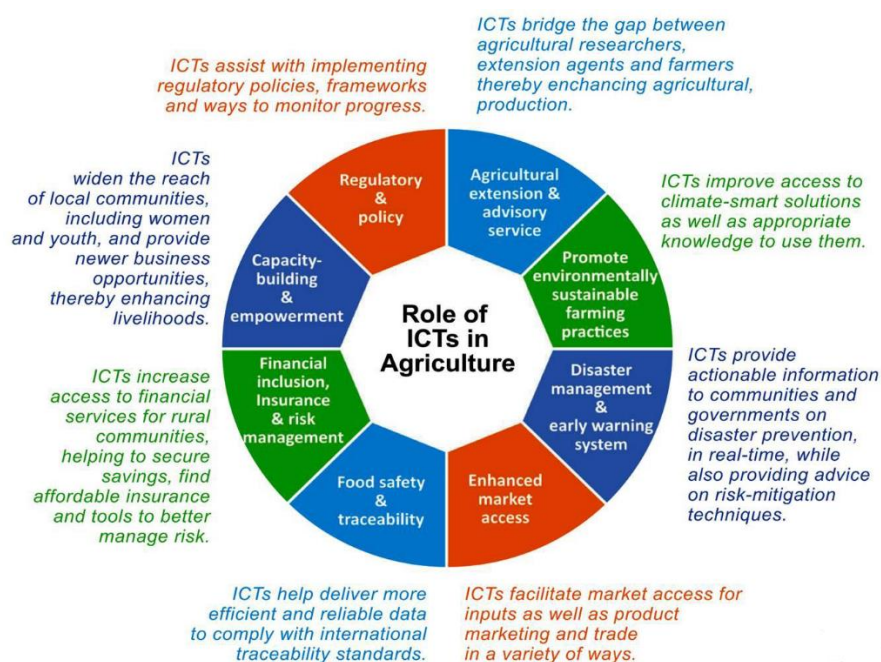


Figure 1.2: E-Agriculture strategy guide.
Source FAO-ITU (2016)

The United Nations 2030 agenda for Sustainable development recognizes the great potential of ICTs and calls for significant increased access by striving to provide universal and affordable access to internet in least developed countries by 2020 (United Nations,2015). ICTs are cross-cutting enablers in the economic and social sectors and play a catalytic role in enabling access and allowing individuals to communicate. The use of ICTs in agriculture is referred to as e-Agriculture and it is one of the outcomes of the Millennium Development Goals (FAO, 2017). Following the

World Summit on the Information Society (WSIS) meetings in 2003 and 2005 respectively, on how ICTs could improve agriculture and contribute to rural development (Mekonnen & Okyere, 2012), significant progress has been made in making ICTs available to farmers, rural communities and fishing communities by providing them with up-to-date and reliable information to improve their livelihoods (FAO, 2015). This has significantly changed the rural landscape of agricultural advisory services, market information, value chains and financial services.

1.2 Context of ICTs for Agriculture in Kenya

Kenya's NASEP outlines several key priorities for integrating ICTs into the extension system (GoK, 2012). These include increasing investment in agricultural information and knowledge systems; encouraging the use of participatory learning approaches and the use of existing informal channels by enhancing the two-way flow of information between advisory services and farmers (ibid). Other key priorities include the motivation of the private sector to set up and operate ICT-based rural information centres. According to Thorpe & Maestre (2015), in developing economies, ICT applications in agriculture have enormous potential in reducing the cost of accessing information by poor smallholder farmers and in the reduction of coordination costs by extension services.

The proliferation of ICTs in agriculture in Kenya is a reflection of the favourable policy environment, that has allowed innovative ICT applications to mushroom (FAO, 2018; Irungu, Mbugua, & Muia, 2015). This is demonstrated by applications like SokoniSMS64 developed by the Kenyan Agricultural Commodities Exchange in partnership with the mobile operator, Safaricom (Keengwe, 2014). This service uses SMS messaging to send details about wholesale prices to farmers so that they are able to negotiate fair prices. Other ICT applications include iCow, a mobile-phone application that allows herders to register each cow, receive individualized text messages on their mobile phones, including advice for veterinary care. Farmers are also able to receive feeding schedules (Baldauf, 2011). The application has a database of experts, and updated market rates for cattle prices (ibid). Another application known as "iShamba" provides SMS tailored services for crops and livestock to farmers based on their location in Kenya. The platform is also used by agri-product suppliers as a direct channel to reach new clients (Manfre & Nordehn, 2013). "Shamba Shape up" is another way agricultural information is disseminated through a farming TV show, prominent for its agriculture broadcasts. Weekly shows are aired throughout the

main cropping season. Each week a selected farm (Shamba) is visited, where current issues and problems facing a host farmer and household are discussed, then solutions and opportunities are identified with the help of experts. While the shows are being aired, the public can call in using telephone and/or text messaging (ACEF & University of Reading, 2014).

1.3 Conservation agriculture knowledge systems in Kenya

Conservation agriculture (CA) knowledge systems are important to study because it is a fairly concept new concept in East Africa with several challenges in its knowledge systems (Gunter, Moore, Eubank, & Tino, 2019). Conservation agriculture has been in practice in Kenya from the 1950s when most farmers embraced elements of CA principles and practices except the tillage techniques (K'Owino, 2010). Common practices included mixed cropping systems with the integration of Agroforestry, residue retention or cover crops. Green manure legumes such as Velvet bean (*Mucuna pruriens*) and sunhemp (*Crotalaria ochroleuca*) were also introduced in smallholder farms for soil fertility improvement (Rockstrom, Kaumbutho, Mwalley & Temesgen, 2003). Most CA efforts in sub-saharan Africa are scattered and disjointed, yet CA requires the involvement of multiple actors working together in a joint and coordinated manner (Kassam et al., 2019).

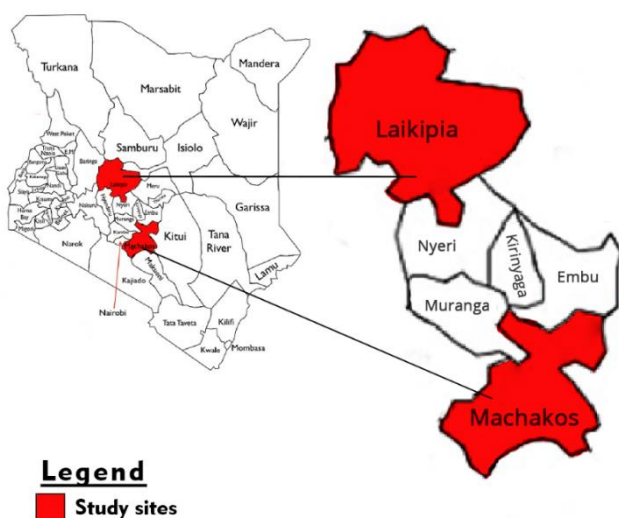
In 2002, when the first CA pilot project was introduced in Kenya, it was supported by the German Government and coordinated by the Food Agricultural Organisation through the Conservation Agriculture for Sustainable Agriculture and Rural Development (CASARD) project. The aim of the project was to promote profitable CA practices by smallholder farmers, and the emphasis was on the simultaneous application of the three CA principles (*minimum soil disturbance, permanent soil cover, and diversifying crop rotations and/ or association*) (FAO, 2008). Other goals of the project were to strengthen the institutional mechanisms, and stimulate knowledge sharing to improve production and productivity (K'Owino, 2010). An impact assessment of the project showed that CA adoption rates by farmers and the diffusion of messages by extension workers were low (Bultemeier, Kotschi, Mansoor & Njuki, *et al.*, 2011).

In Machakos and Laikipia counties, CA is promoted through the use of scientifically validated trials, (farmer learning by doing) and field demonstrations which are supposed to have been instrumental in facilitating and accelerating uptake (Kassam *et al*, 2014). The CA practice in these two counties is that leguminous cover crops like *Dolichos lablab* (hyacinth bean) are

integrated with Maize for the resuscitation of soil fertility and biodiversity (Zaal & Oostendorp, 2002). In some of the CA trials that were done by the African Conservation Agriculture Tillage Network in one of their projects, “CA for Food Security”, the trials were conducted in two sets; the mother field demonstrations with a full set of treatments and baby field demonstrations with one half of the trial sets. This gave farmers a wide range of demonstration sites to participate and learn from. All field demonstration sites were in the farmers’ fields and the research model used was the researcher-designed and farmer-managed type of on-farm experimentation.

Each farmer group was facilitated to choose a lead farmer to host the demonstration site in his or her farm but all aspects of crop management were jointly done by the entire group as a way of facilitating learning by doing. Each Mother field demonstration site had the complete full list of six treatments while Baby field demonstration sites only hosted half of the treatments. The full list of treatments were: T₁= Farmer practice: Conventional ploughing (ox or hand), no residue retained; T₂= Conventional plough practise with fertilizer, no residue retention; T₃= Minimum tillage with no fertilizer and no residue retention; T₄= Minimum tillage with fertilizer and no residue retention; T₅= Minimum tillage, without fertilizer, with residue retention and T₆= Minimum tillage with fertilizer and with residue retention.

Geographically, Machakos County covers an area of 6208.2 km² and is located 66.2 kilometers from Nairobi City. The annual rainfall is unevenly distributed and unreliable and is between 500 mm and 1300 mm. Arid and semi-arid lands represent approximately 80% of the land



and are largely underutilized. Approximately 20% of the land in the high and medium potential area is under agricultural production (Machakos County, 2015). Agriculture is the major source of livelihood, and the major crops grown are maize, beans, wheat, Irish potato, cabbage and tomatoes. The main types of livestock kept include cattle, sheep, goat, camel, donkey, poultry and pigs (Kenya National Bureau of Statistics, 2016).

Figure 1. 3 Map showing the study sites

The average farm sizes for small and large-scale production in the county are 0.756 and 10 hectares respectively. This is a huge decline in the farm sizes, considering that small-scale farms were on average 8.4 hectares in the 1940s and 1.3 hectares in 1997 (Ministry of Agriculture, Livestock and Fisheries (MoALF), 2018). Given that shifting cultivation and fallowing are no longer possible owing to scarcity of land, most farms have continuously and unsustainably been cropped for over 100 years. All-year-round cultivation combined with poor land management practices have led to the depletion of the soil macro and micro nutrients, and acidity has affected yields negatively (ibid).

Laikipia County, covers an area of 9,462 km² and is located 263.6 kilometres from Nairobi City. Laikipia is located on the plateau north west of Mount Kenya and generally has unreliable, inadequate and unevenly distributed rainfall pattern. The County experiences a relief type of rainfall due to its altitude and location. The annual average rainfall varies between 400mm and 750mm though higher annual rainfall totals are observed on the areas bordering the slopes of Mt. Kenya and the Aberdare ranges (Muriithi, 2016). The annual mean temperature ranges between 16° C and 26°C. The high and medium potential farm land constitutes about 21% of the total county's land area while the remaining 79% is low potential and therefore unsuitable for crop farming, although agriculture and livestock are the main sources of livelihood. Seventy-five per cent of total land area is devoted to livestock production, game parks and reserves, leading to overstocking which in turn has resulted into a high rate of soil and environmental degradation. The average farm size for small-scale holders is two acres while for large-scale holders is 20 acres. The ranching community holds an average of 10,000 acres (MoALF, 2018). Several climatic hazards like drought, moisture stress and uncertainty in the onset and duration of seasons have been observed in the county. These hazards pose a growing threat to the agricultural sector and have led to significant crop and livestock production losses and food insecurity (ibid). The yield of most crops has declined by 40 percent over the years, with continued tillage identified as one of the principal causes (Rockstrom, et al., 2003).

1.4 Problem statement

The current knowledge pathways (*farmer field schools, field days, and the farmer- learning by doing approaches*) used to promote conservation agriculture in Laikipia and Machakos counties have not led to envisaged increased uptake of the practice. The cropland under CA has remained small with 0.5ha as the average land size on which it is practised (Kassam et al, 2019). The

sustained practice of CA by smallholder farmers is hindered by the multiple conceptualization of the practice, by the different actors thus affecting its knowledge systems. Kassam et al., (2019) further suggests that the major constraints to the adoption of CA continue to be knowledge about its existence and how to do it. The mindset, inadequate policies, unavailability of appropriate equipment, lack of knowledge on suitable management strategies are other major constraints cited (Ward et al., 2018). The application of ICTs in agriculture is not a new concept, literature states that the use of modern ICTs like mobile enabled web portals, cloud computing and open data are technologies that have not yet been fully conceptualized in agricultural knowledge systems (Janssen *et al.*, 2017).

Despite these advancements in ICTs (FAO, 2014; Subashini & Fernando, 2017) the CA knowledge sharing systems have not taken advantage of this to enhance CA knowledge sharing to smallholder farmers. While Kenya's vision 2030 calls for a more responsive and demand-driven extension system to harness ICTs for increased agricultural knowledge sharing, limited empirical research exists to explain how this has been incorporated in CA given the multitude of knowledge sources, CA actors and available knowledge pathways. This study therefore aims to (i) Determine the knowledge sources and pathways for CA knowledge sharing. (ii) Establish how Actor positioning influences CA knowledge sharing; and (iii) Describe the use of different ICTs for CA knowledge sharing.

1.5 Objectives of the study

The overall objective of this study was to Examine how ICTs are used to enhance CA knowledge sharing among smallholder farmers in Machakos and Laikipia counties. The specific objectives addressed by the empirical chapters in this thesis were to:

1. Determine the knowledge sources and pathways for conservation agriculture knowledge sharing.
2. Establish how Actor positioning influences conservation agriculture knowledge sharing; and
3. Describe the use of different ICTs for conservation agriculture knowledge sharing.

1.6 Significance of the study

Conservation agriculture is an important practice in the face of declining soil fertility, climate variation, dwindling farmland and food insecurity. The majority of CA efforts in Sub Saharan Africa have been scattered and disjointed, yet CA requires the involvement of multiple

actors (Kassam et al., 2019). To bring uniformity in CA, it is important that coordination efforts are strengthened at the CA National Task force to provide overall guidance for CA knowledge sharing. In Kenya, CA initiatives have predominantly addressed problems around water shortages, soil compaction and loss of topsoil through erosion (IFAD, 2016). The use of modified ox-drawn ploughs, shallow ripping are performed after harvest yet these are important activities at the land preparation stage. Supportive practices like growing cover crops and agroforestry that can help to reduce weeds during the dry seasons have not been commonly used (ibid). However, the sustained practice of CA by smallholder farmers is hindered by the multiple conceptualization of the practice by the different actors thus affecting its knowledge systems (Thierfelder et al., 2013; Gunter et al., 2014). Major constraints to the adoption of CA practices continue to be knowledge about the existence of CA and how to do it. The study addresses this gap by analyzing how ICTs could improve the CA knowledge sharing systems.

The study contributes to the body of knowledge on e-Agriculture. It further examines the CA knowledge networks and analyses the information sharing relationships among actors. The study also informs on the types of CA information preferred by farmers and looks at the relationships between the information sources and types of information. It examines the factors that influence the choice of a knowledge source or pathway. ICT models used for agricultural knowledge sharing are analyzed and the models that use ICTs that are most appropriate for smallholders' are highlighted. The findings of this study provide practitioners with a CA ICT knowledge sharing framework that could improve CA knowledge sharing according to the smallholder farmers' context. It is expected that the results of this study will also guide policymakers in the development of policies that guide the standards for CA knowledge sharing.

1.7 Conceptual Framework

A Conservation Agriculture knowledge sharing framework should have in place mechanisms for knowledge creation, knowledge sharing, and retrieval. These may be influenced by factors that affect the choice of a knowledge pathways a farmer may prefer. The conceptual framework (Figure 1.3) is anchored on three theories that guided this study, the Knowledge Systems framework, the Social Network theory and Roger's Diffusion of Innovations theory.

Use of Information Communication Technologies in Conservation Agriculture Knowledge systems

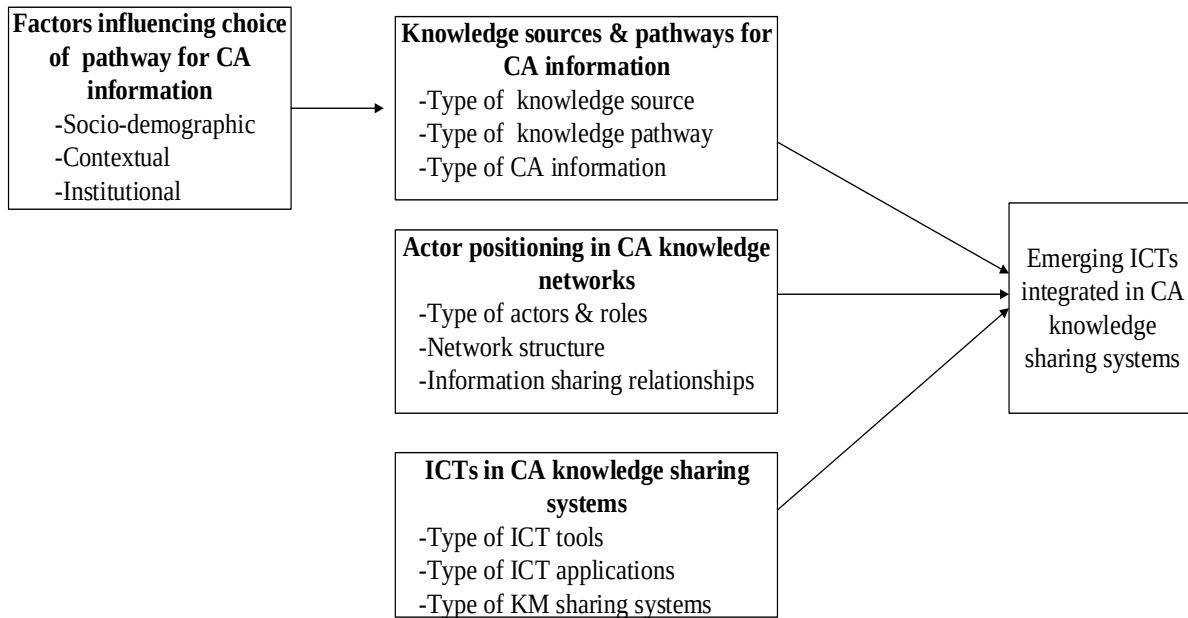


Figure 1.4: Conceptual framework used to analyse the Use of ICTs for conservation agriculture knowledge sharing

The schematic framework presents an overall conceptualization of the study and how the three variables knowledge sources and pathways, Actor positioning and ICTs in CA, relate to the integration of emerging ICTs in CA knowledge sharing systems. The framework shows that the use of ICTs in agricultural knowledge systems is an interaction of various dynamics. The initial analysis of the knowledge sharing system involves examining the types of knowledge sources and pathways used by smallholder farmers for CA, the type of CA information required and the factors that influence their use (objective 1). The Knowledge systems framework, provided the framework for understanding who creates CA knowledge and which pathways farmers' prefer for the different types of CA information.

An examination of the Actors, their roles in the network, and the relationships formed as a result of their information sharing relationships, gave an insight into the network structure (Objective 2). The Social Network Theory(SNT) provided the theoretical underpinning for this objective and was used to understand how institutions operate within a network environment, the relationships and factors influencing these relationships. The SNT is centrally concerned with structured relations among persons who create, disseminate and utilize various types of knowledge (Ramirez, 2013).

The type of ICT tools and applications used in CA knowledge sharing systems were further analysed to show what ICTs are used (objective 3). This objective was analysed using the Rogers diffusion of Innovations Theory. Diffusion of Innovations theory provides a framework for understanding why a user when presented with an innovation will come to perceive it as useful and accept to use or may reject it. The outcome of these various components interacting with each other are expected to contribute to the integration of emerging ICTs in CA knowledge sharing.

1.8 Organisation of the Thesis

This is a manuscript based thesis with five chapters. The first chapter provides an overall introduction and context of the study and sets the foundation for the subsequent empirical chapters. In addition to a common background and context, the introduction chapter presents the overall framing of the study with respect to the research objectives and conceptual framework.

The empirical chapters (Chapter 2 to Chapter 4) are stand-alone and independent. However, cross-references are made in some cases to illustrate the connection of the empirical chapters. Each chapter provides the specific background to the topic drawing on related literature and elaborates the methodology, results and also provides independent conclusions and recommendations. Chapter 5 provides a summary of all the chapters and further highlights the relationships between the chapters.

Chapter two provides an analysis of the different knowledge sources and pathways. It also examines the factors that influence their use. The CA information needs for smallholder farmers are examined and the relationship between the type of information and knowledge sources are investigated.

Chapter three examines the influence the different actors hold in the CA network, their roles and activities. The strength of the network ties and how this influences CA information sharing is further explored using social network analysis.

Chapter four examines the use and application of ICTs in CA knowledge sharing. In this chapter, the study examines the different ICT tools and applications used for CA knowledge sharing. The knowledge sharing models and how they can be enhanced for the effective use of ICTs are explored.

Chapter five summarised the key empirical findings, conclusions, and implications. Recommendations are presented for practice, policy, and further research.

1.9 Key operational definitions and terms

This section presents the various operational definitions and terms that have been adopted and used in the study.

Knowledge:	Mixture of experiences, values, contextual information & expert insights (Dalkir, 2005)
Information:	Refers to structured data within a context that gives it meaning (Demiryurek, 2010)
Agricultural knowledge sources:	Refer to Institutions or individuals who create & provide content or expertise of interest to recipients (Mbanda-Obura et al., 2017).
Knowledge pathways:	Are the approaches through which information is transferred or received (Livondo et al., 2015)
Knowledge sharing:	Refers to the processes of communication, interaction, and coordination of knowledge that help improve productivity, and innovation capacity of stakeholders (Navimipour & Charband, 2016)
Knowledge application:	Refers to the utilization of available knowledge to make decisions and perform tasks through direction and routines (Becerra-Fernandez, & Sabherwal, 2010).
ICTs	Are any devices, tools or applications that permits the exchange or collection of data through interaction (World Bank, 2017)
Agricultural ICT models	Refer to knowledge approaches that apply ICTs in the sharing of agricultural information to farmers (Zhang, Wang, & Duan 2016).

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CHAPTER TWO

AGRICULTURAL KNOWLEDGE SOURCES AND PATHWAYS FOR CONSERVATION AGRICULTURE IN LAIKIPIA AND MACHAKOS COUNTIES- KENYA

Abstract

Conservation agriculture is promoted as one of the few technologies that potentially improve farmer's yields in the long term. However, its knowledge systems are still not well understood among smallholder farmers and extension services. The main objective of this study was to examine how agricultural knowledge sources and pathways are used for conservation agriculture knowledge sharing. The study used data from a cross-sectional survey covering 300 households, twenty-eight key informant interviews, and five focus group discussions. Qualitative data was analysed using content analysis. Frequencies and means were used to summarize the socio-economic characteristics, knowledge sources and pathways. Chi-square tests were used to analyse the relationships between knowledge sources and pathways; knowledge sources and types of information. Binary logistic regression was used to analyse the factors predicting the farmer's choice for use of an ICT for CA information. Results indicate that knowledge sources and pathways were not mutually exclusive, but were integrated for optimal conservation agriculture knowledge sharing. Land under CA, accessibility to communication networks, education level of the farmer and costs associated with the use of ICTs were significant predictors for the choice of an ICT for conservation knowledge sharing.

Key words: Knowledge sharing, Knowledge application, conservation agriculture, Kenya, Sub Saharan Africa.

2.1 Introduction

The use of agricultural knowledge sources and pathways by smallholder farmers is an important factor in the improvement of agricultural production (Mbanda-obura, Isaiah, Amudavi, & Obura, 2017). This is so because as the need for information about new agricultural technologies increases, so should the platforms that farmers use to seek for knowledge. However, limited literature exists to show how conservation agriculture knowledge sources and pathways are integrated for effective knowledge sharing, the type of information preferred by smallholder farmers and the factors that influence their choice for an agricultural knowledge source or pathway.

Agriculture is the main source of livelihood in Kenya and contributes approximately 30% of its gross domestic product. Kenya's rapidly increasing population (39.5 million in 2011 and predicted to increase to 81 million in 2039) has led to the fragmentation of land in high-potential agricultural areas, thereby affecting food production (Food and Agriculture Organisation (FAO), 2017). The FAO (2017), country programming framework for Kenya further states that "farmers who are used to rain-fed farming systems are being pushed into the dryer, more marginal areas", (p.17), resulting in exposure to harsher weather conditions. The country, experiences extreme rainfall, on average, every two years and has increasingly had significant rainfall variability, coupled with an increasing frequency of severe drought. The combination of frequent droughts, high dependence on rain-fed agriculture and high poverty rates among smallholder farmers and pastoralists has made the country vulnerable to the effects of severe weather and at risk for food insecurity (D'Alessandro, Caballero, Lichte & Simpkin, 2015).

To alleviate the severe effects of the changing weather patterns on agricultural production, one of the proposed agricultural options is conservation agriculture (CA), which has been known to mitigate the effects of climate change through improved rainfall infiltration and soil moisture capacity, thus improving crop productivity (Williams et al., 2018). Kaluzi, Thierfelder & Hopkins (2017) define conservation agriculture by the three principles of "minimum soil disturbance, organic soil cover, and diversification of crops grown in sequences or associations" (p.86). Thierfelder et al., (2015) further suggest that these three basic principles should be supported by the use of good agricultural practices for improved agronomic and economic benefits. Several advantages of CA over conventional agriculture (e.g., conserving organic matter and soil moisture, increased soil carbon sequestration, improved soil productivity, reduced erosion) have been well

documented (Mkonda & He, 2017; Muzangwa, Mnkeni, & Chiduza, 2017; Ngwira, Thierfelder, & Lambert, 2013).

As a result of these benefits, CA has been promoted in many sub-Saharan African countries, but its uptake has been slow among smallholder farmers (Ngwira et al., 2013). Thierfelder, Mombeyarara, Mango and Rusinamhodzi, (2013) state that “a critical factor in the integration of CA is the provision of sufficient knowledge to farmers and extension agents on the effects of each component of the CA system on crop productivity, these effects are relatively unknown and little understood ” (p.3). However, Ndah et al. (2012) suggest that "CA adoption rates are low in Africa.... for several reasons that include technical and/or financial support” (p.1). An FAO (2018) evaluation report on CA and good agricultural practices further confirm that "a major factor found as limiting CA and good agricultural practices are the financial capacity of farmers to access inputs and equipment" (p.26). Sani, Boadi, Oladokun & Kalusopa (2014) suggest that the extent to which farmers could adopt innovations and the speed by which they would do so only be determined by examining how useful they find the sources through which they get information.

2.1.1 Promotion of conservation agriculture in Kenya

In Kenya, CA is promoted through the use of scientifically validated trials and field demonstrations, which are supposed to be instrumental in facilitating and accelerating uptake. However, this technology is perceived to be complex, and a management and knowledge-intensive practice (Kassam et al., 2014). This perception of CA among smallholder farmers and extension staff demands a fundamental shift in the way knowledge is transmitted. Muzangwa et al. (2017) also note that CA technology is expensive in terms of equipment and inputs, thus investing in CA appears to compete with the basic needs of farmers (Ndah et al., 2012).

Livondo, Kipkoech, Macharia, & Odwori, (2015) suggest that technologies like CA provide opportunities for small-scale farmers to increase their crop production, improve their soil fertility and increase household incomes, but most farmers and extension agents have been reluctant to adopt it. Some of the other reasons for the reluctance are attributed to the fact that, when CA technologies are introduced to smallholder farmers, they view these as separate packages rather than a single CA package (Ward, Bell, Droppelmann, & Benton, 2018). The major approaches of how CA and its three principles are introduced to farmers is known and significant amounts of research have been done in this area (Mango, Siziba, & Makate, 2017; Moore *et al.*, 2014).

However, CA promotion still faces challenges in having a common definition. The existing knowledge gaps among extension workers and farmers further complicate the practice. This following research questions guided this study.

- 1) What agricultural knowledge sources and pathways are used for CA knowledge sharing?
- 2) What types of CA information do smallholder farmers prefer?
- 3) What factors influence the use of an agricultural knowledge source or pathway?

The study hypotheses were:

- i. there is a significant positive association between knowledge sources and pathways;
- ii. there is a significant positive relationship between knowledge sources and types of CA information;
- iii. Age, education, experience in CA, training in CA, location, land under agricultural production, land under CA are significant predictors for the choice of use of ICTs for CA knowledge.

2.2 Theoretical Framework

Knowledge processes are central to the learning and application of any innovation. The information generated either through research, experience or own knowledge has to be shared and applied for it to have meaning. The Knowledge systems framework was used to explain the dynamics that occur in the sharing of agricultural information and choice of a pathway. The basic concept of the Knowledge systems framework is that knowledge-based processes are carried out by actors who may be individuals or institutions who develop, transfer and apply this knowledge. The knowledge then flows through networks of linked actors who perform several knowledge related functions that link knowledge and know-how with action (McCullough & Matson, 2011).

Van Kerkhoff & Szepak (2010), defines a knowledge system as a "network of actors connected by social relationships. These may be formal or informal relationships that combine knowing, doing and learning to bring about specific actions for sustainable development pg.1". Knowledge systems consider both the processes through which knowledge is created and shared and the flow of such knowledge through personal or institutional relationships (Davila *et al.*, 2016). Therefore, knowledge may be acquired by farmers through multiple pathways that may be

complementary or substitutes to each other (Mittal & Mehar, 2015), however, not all the pathways are considered to be effective (Abdulhamid & Solagberun 2017). The authors in their study on the perceived effectiveness of agricultural extension methods in Kogi state Nigeria, found that not all the methods were considered to be effective by the farmers. They recommended that for effective farmer participation a variety of extension methods should be used (ibid). Khan & Akram (2012), assessed the extension methods used to disseminate new agricultural technologies in Pakistan, they found the extension services in-effective. A study by Mittal & Mehar, (2015) in India, showed that farmers use multiple information sources that may be complementary or substitutes to each other. These studies show that farmers use multiple information sources to meet their information needs.

2.3 Methodology

2.3.1 Description of the study area

The study was conducted in Machakos and Laikipia counties, in five sub-counties and eight wards (villages), as illustrated in Figure 2.2, between March 2015 and October 2016. These counties were purposively selected with the help of County agriculture officers and the extension officers at the sub-county and ward level respectively. The criteria used to select the counties were based on; (i) counties where CA has been piloted in 2002 by FAO (ii) Had more than 3000 smallholder farmers practising CA and counties where the e-Extension program had been rolled out.

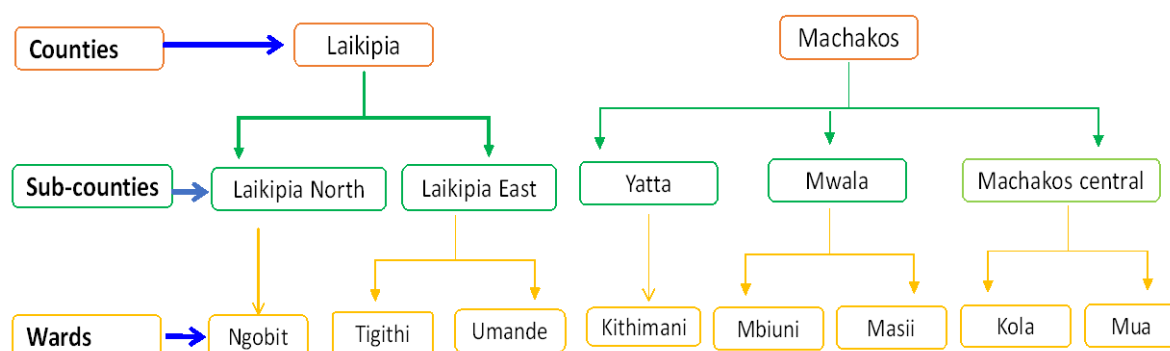


Figure 2.1: Showing the Counties, sub-counties, and wards where the study was conducted

2.3.2 Research design

The study used a mixed methods design, consisting of key informant interviews (KII), Focus Group Discussions (FGDs) and a descriptive cross-sectional survey. This design was suitable because it used a variety of methods thereby allowing for data validation and reliability. Creswell (2012), stipulates that a mixed methods study provides a more complete understanding of a phenomenon under study. He goes further to suggest that results can also be collaborated from different methods.

2.3.3 Population and sampling

Key informants

Participants for the KII were 28 (Table 2.1) and were purposively selected based on the roles they play within the agricultural sector in the county. The selection criteria included; working with farmers in the county; if one was trained in e-extension and one was participating in the e-extension program.

Table 2.1: Summary of category of respondents for key informant interviews

Category of designation	No. of respondents
1. Media personnel	4
2. ICT Authority Officer	1
3. e- extension Co-ordinator	1
4. Director Agricultural information centre	1
5. Monitoring and Evaluation officers	1
6. Chief Agricultural officers	2
7. Extension staff	18
Total	28

Source: KII data, 2015/2016

Focus group discussions

Focus group discussions were used for triangulation and allowed for the seeking of clarification on ambiguous responses. Jamieson and Williams (2003), suggest that focus group methodology is useful for the natural control of data since participants in a group discussion can question, refute or validate each other's responses. FGDs were used because of their ability to stimulate interaction between group members and to gain in-depth data on the ICTs used by farmers for agricultural information, factors that affect use of ICTs and the ICTs farmers have access to, either through ownership or communal access points. Five Focus Group Discussions [FGDs]

consisting of forty- six participants (Table 2.2) were held. The participants for the FGDs ranged between 6-12 and were purposively selected based on their; (i) practice in CA (ii) participation in two or more CA trainings and; (iii) membership in an active² farmer group.

Table 2.2: Summary of respondents for Focus group discussion by wards

Ward	Number of participants
Mua	11
Kithimani	10
Masii	10
Kola	9
Mbuini	6
Total	46

Source: FGD data, 2016

Household survey

According to Neuman (2011), a household survey is most appropriate for exploratory, descriptive or explanatory research. Findings from such a population can be generalised to the entire population. For the household survey, the sample was drawn from a sampling frame comprising a population of 3022 CA practicing farmers in a household, from five sub-counties. We used proportional stratified sampling to select a sample size of 300 respondents (Table 2.3). The unit for stratification were the wards. Stratified sampling ensured unbiased representation and inclusion of all CA farmers. Using the equation by Parsons, (2014) strata sample size was determined using the following formula

$$n_h = (N_h / N) * n$$

where n_h is the sample size for stratum h ,

N_h is the population size for stratum h ,

N is total population size (3022), and

n is total sample size

² Active farmer groups have members hosting CA demonstration sites and have CA equipment (*eg. Jab planters, animal and tractor drawn planters*) that they use to provide planting and weeding services to members.

This technique was employed to ensure that the sample size of each stratum was proportionate to the population of the stratum as shown in Table 2.3.

Table 2.3: Number of respondents for household survey sampled by ward

County	Sub-county	Ward	Total households	Sampled households
Laikipia	Laikipia East	Tigithi	546	55
		Umande	402	40
	Laikipia North	Ngobit	558	55
Machakos	Mwala	Mbiuni	307	30
		Masii	295	30
	Machakos	Kola	310	30
		Mua	308	30
	Yatta	Kithimani	296	30
Total			3022	300

Notes: The analysis is based on N=298, two respondents were dropped due to insufficient data

2.3.4 Data collection methods and tools.

Key Informant Interviews (KII) were conducted using interview guides for ICT and policy actors and extension officers. The interview guide for ICT service providers and institutions (Appendix 2), and the guide for Actors in policy and extension (Appendix 3) collected data on the different extension approaches, the use of ICTs in agricultural extension, the ICTs used in CA, ICT incentives, the factors influencing the use ICTs for agricultural information. In addition, data was collected on CA knowledge pathways and the ICTs used for agricultural information.

Data for the FGDs was collected using an FGD guide. The FGDs captured data on the different approaches smallholder farmers' use to access CA information, type of CA information, and factors that influence a farmer's choice for a knowledge pathway.

Primary data was collected using a semi-structured questionnaire from the sample of 300 respondents. The questionnaire collected data on socio- demographic characteristics, the farmers' agricultural practice, sources and pathways used for knowledge sharing. information smallholder farmers prefer, factors that affect use of knowledge pathways.

Table 2.4: Summary of the Data collection methods and tools

Data collection methods	Tool	Information sources	Sampling method	Data collected
Key informant interviews	Interview guide	28 key informants	Purposive	-Knowledge sources & pathways - Type of CA information -ICT tools & applications used - Factors influencing choice of a source or pathways
Focus group discussion	Focus group discussion guide	5 FGDs (46 farmers in CA groups)	Purposive	- Type of CA information - ICTs used for agric. information -Factors that affect farmer's use of ICTs
Household survey	Semi-structured questionnaire	300	Stratified Purposive	-Household demographics - socio-economic characteristics - Farming systems -CA information needs - knowledge sources & pathways -Factors influencing use of knowledge sources & pathways

Content validity

Content validity refers to how well an instrument includes a representative sample of questions that relate to the content of what is being measured. Content validity is defined as the degree to which an instrument has an appropriate sample of items (Polit & Beck, 2006). To validate the content validity of the survey instrument, the researcher made an extensive literature review relating to ICTs, and agriculture, to be able to develop appropriate instrument content.

Four experts, from different areas of expertise, determined whether the instrument contained clear and appropriate content as deemed necessary to measure the study objectives. Judgment was made based on the relationship between the study objectives and questions in the research instrument, and by knowledge of the normal practices as deemed appropriate by the professionals. Further, the instrument was checked for appropriateness and clarity of questions and instructions. Once the professionals accomplished all the above tasks, revision and modification of the instrument was done. The revised instrument was then re-submitted to the

professionals for re-evaluation after which corrections were made and the final instrument developed (Appendix 1).

Reliability

To test for reliability of the study instruments, a split-half reliability test was conducted to determine the consistency and reliability of the study instrument. Reliability indicates the degree to which a survey instrument is consistent with what it measures. It also refers to the degree to which results obtained by a measurement that can be replicated (Bolarinwa, 2015). To carry out the split-half reliability test, the instrument was administered to ten CA farmers who were randomly selected from the population of farmers who practice CA and were not part of the sample. A sample of 10 respondents was deemed adequate for the reliability test according to recommendations by Drost (2011). A Spearman Brown coefficient of 0.7 was obtained which showed that the instrument was reliable.

2.3.5 Data analysis

Qualitative data from FGDs and KIIs were analysed using content analysis to identify the general patterns and categories emerging from the conversations. These were then used as anecdotal evidence to complement the quantitative data from the survey.

Survey data were analysed using the statistical package for social sciences (SPSS version 23). Frequencies and means were used to describe the farmer and farming system characteristics as well as the types of knowledge sources, pathways and types of CA information shared with the smallholder farmers. The chi-square test of independence was used to test whether the various knowledge sources and pathways; and the knowledge sources and type of CA information shared with the farmer were independent of each other.

A binary logistic model was used to establish the factors that influenced a farmers' choice to use ICTs³ for CA information. The farmers using ICTs for CA information were 69.1 and those who were not using ICTs for CA information were 30.9. The dependent variable in the binary logistic regression model was if a farmer used ICTs for CA information. The binary choice was dummied as 1 if a farmer used ICTs for CA information and 0 for otherwise.

The decision to use ICTs was presumed to be dependent on several factors that included socio-economic, farming system characteristics, relevance of content, access to ICTs, perceived cost of using ICTs to access agriculture information, access to communication networks and training. The selection of the predictor variables included in the model was based on theory and data availability. The model was specified as;

$$P(Y) = \frac{1}{1 + e^{-(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \dots + \beta_n X_n + \mu)}} \dots\dots\dots(1)$$

P(Y) is the probability that a farmer uses ICTs for CA information

X₁ to X₁₁ are independent variables presumed to predict the probability of a farmer using ICTs for CA information

β₀ is the Y-intercept

β₁ to β_n are the coefficients (weights) attached to each of the predictors X₁ to X₁₁

μ is the error term

The above coefficients are only used to show the direction of the relationship between the dependent variable and the specific predictor variable (Deressa *et al.*, 2009). To indicate the magnitude of influence that a specific predictor variable has on the dependent variable, odds ratios are used. An odds ratio of more than one indicates that as the predictor increases, the odds of the outcome occurring increase while a value of less than one shows that as the predictor increases, the odds of the outcome occurring decrease (Deutsch *et al.*, 2010).

$$\text{Odds of using information on timing of onset } Y = \frac{P(Y)}{1 - P(Y)} = \frac{\frac{1}{1 + e^{-Z}}}{1 - \frac{1}{1 + e^{-Z}}} \dots\dots\dots (2)$$

Where $Z = \beta_0 + \beta_2 X_2 + \beta_3 X_3 + \dots + \beta_n X_n + \mu$

The above equation can be simplified by finding the natural logarithm

$$\text{Log}\left[\frac{P(Y)}{1 - P(Y)}\right] = Z = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \dots + \beta_n X_n + \mu \dots\dots\dots (3)$$

For instance, Odds ratio for X₁ = $\frac{\text{Odds of using a knowledge pathway after a unit change in } X_1}{\text{Original odds}}$

The specific predictors that were included in the model, how they were measured and the expectations about their influence on choice of a knowledge pathway are presented in Table 2.5.

Table 2.5: Description of the predictor variables entered into the empirical model

Predictor variable	Description of the variable	Expected sign/relationship
X ₁ = Age	Number of years	+
X ₂ = Education	Number of years of schooling	+
X ₃ = Farming experience	Number of years of CA farming	+
X ₄ = Income options	Number of off-farm income sources	-
X ₅ = Training in CA	Number of years of training	+
X ₆ = Land under agricultural production	Acreage	+
X ₇ = Land under CA	Acreage	+
X ₈ = Costs associated with use of ICTs for CA information ⁴	Dummy 1 if important factor 0 otherwise	-
X ₉ = Access to communication network	Dummy 1 if farmer has access to network 0 otherwise	-
X ₁₀ = Accessibility to ICTs	Dummy 1 if farmer has access to ICTs 0 otherwise	+
X ₁₁ = Relevance of content	1 for relevant, 0 if not relevant	+

2.4 Results and discussion

2.4.1 Socio- economic and demographic characteristics

The study results demonstrate a diversity of socio-demographic variables including sex, age, marital and occupation status to characterize the respondents to this study. Results in Table 2.5 reveal that the larger proportion (62%) of the respondents were female as compared to their male counterparts (38%). Overall the results show that there no significant differences between between the CA farmers in Laikipia and Machakos

⁴ Costs associated with use of ICTs refers to the perceived costs a farmer incurs in buying airtime, data or charging the phone in order to access conservation agriculture information.

Table 2.6: Socio- demographic characteristic of conservation agriculture farmers sampled

Household characteristics	Pooled sample (n=298)	Laikipia (n=150)	Machakos (n=148)
Sex of respondent (%)			
Female	62.1	58.7	66.2
Male	37.9	41.7	33.8
Marital status (%)			
Married	81.9	80.7	83.1
Widowed	14	10.7	12.8
Single	3	6	4.1
Divorced	0.7	1.3	0
Respondent occupation (%)			
Farming	88.3	78.7	96.6
Off-farm income options	11.7	21.3	3.4
Age in years (mean)	53.1	53.7	52.5
Education in years (mean)	9.3	9.2	9.3

Source: Survey data, 2015/2016

The results from the table further show that the age of the respondents had a mean of 53 years, suggesting an aging farming population. The respondents had on average attained an education status of approximately nine years, implying that most of the farmers had completed primary education. Farming was the predominant occupation with 88% of the respondents growing a diversity of crops and keeping livestock. It is therefore evident that the households participating in the study largely obtained their food and income security from agriculture. The findings above should however not underestimate the relatively small portion of respondents (approximately 10%) whose livelihood was supported by other off-farm income activities.

2.4.2 Description of the farming system

Agriculture is a major source of livelihood in the study area and respondents grew and kept a diversity of crops and livestock respectively (table 2.7). Maize and beans were the predominant crops within the farming system with at least 90 % of the respondents growing the crops. Other crops grown on the farm holding included pigeon peas, potatoes, green grams, sorghum, cassava, grown by 15-45% of the respondents. Most of the respondents (86.4 %) kept cattle as the major livestock. Other livestock kept included, poultry(82.1%), goats(65.2%), Sheep(40.2%), donkeys(5.1%) and rabbits(1%).

Table 2.7: Description of the farming system

Description	Total (n=298) % of respondents	Mean
Type of crops grown		
Maize	97.3	-
Beans	87.6	-
Pigeon peas	45.6	-
Potatoes	25.3	-
Green grams	16.8	-
Other	15.6	-
Type of livestock kept		
Cows	86.4	-
Poultry	82.1	-
Goats	65.2	-
Sheep	40.2	-
Donkey	5.1	-
Rabbit	1.0	-
Average land size in acres		
Total land owned	-	5.3
Land under agric. production	-	3.0
Land under CA production	-	1.3

Source: Survey data, 2015/2016 *Total percentages are greater than 100% due to multiple responses.

In such a diverse farming system, land was a crucial resource that was required to promote agricultural production. On average a farmer owned five acres of land out of which three were allocated to agricultural production. Approximately one acre of the agricultural land was utilized under conservation agriculture.

2.4.3 Knowledge Sources used in CA knowledge sharing among smallholder farmers

Knowledge sources in this study were defined as institutions or individuals who create and share agricultural information. This study used the knowledge systems framework to analyse the different ways in which the generators and the end-users of conservation agriculture knowledge shared it amongst themselves. Three major knowledge sources for CA information featured within the study area. Among these, the government extension worker was the dominant source of knowledge as reported by 94% of the respondents implying that government is a credible source of information for smallholder farmers. Isaya *et al.*, (2018) and Sani, Boadi & Kalusopa (2014), also had similar findings and suggested that government extension officers were important sources of agricultural information for smallholders, and were critical in making extension services

effective. Others knowledge sources included NGO extension workers and fellow farmers who provided CA information to over 60% of the respondents. The results concur with Lwoga, Stilwell & Ngulube (2011) who noted that NGOs were important sources of agricultural information for smallholder farmers. Hashemi (2011) also concluded that farmers were more receptive to advice from fellow farmers, and most especially from those who had similar experience in the use a technology.

The results of the study showed that farmers accessed CA information from multiple sources. This result commensurate with findings of Gunter *et al.*, (2016) who noted that information about conservation agriculture is received from multiple sources given the multi-faceted nature of the technology. The sources of information however were not mutually exclusive but rather integrated to effectively deliver appropriate CA knowledge to the user. However, Gunter et al (2016), also noted how multiple source of information were used to convey contradicting messages to the end-user on the same subject. Like one farmer confidently said during a focus group discussion, “.....Most times officers from NGOs such as World Vision, African Conservation Tillage Network (ACT) and FAO come with the government extension officers from the county to conduct trainings, so we get information from both the NGOs and extension officers”. We also receive information on conservation agriculture from the Cereals Board, Kenya Agricultural Research and Livestock Organisation (KARLO) and our fellow farmers” (FGD, Masii Ward, 6th September 2016)

Type of CA information relevant to the farmers’ practice

With the diverse nature of information sources, a wide range of CA information (figure 2.2) was shared with the farmers and this ranged from type of CA equipment to land preparation information. Figure 2.3 shows the relationships between the three major sources of information and the type of information that were shared with the respondents using chi-square estimates.

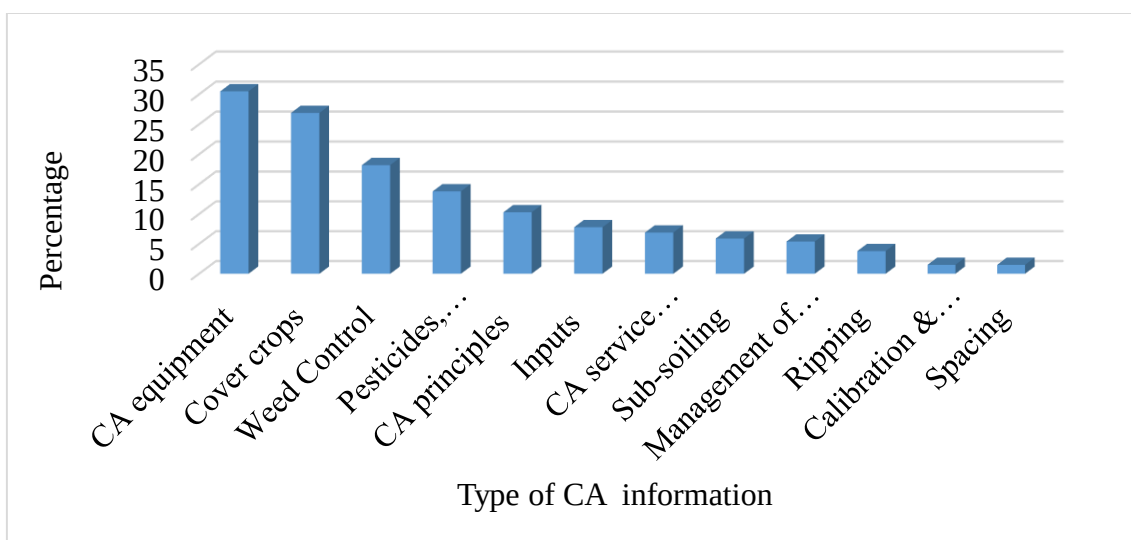


Figure 2.2: Type of CA information relevant to the farmer's information needs

The different types of information were further categorized under six broad categories, (i) Agronomy (ii) CA principles (iii) Trainings on different aspects of CA (iv) New technologies (v) Market Information (vi) Weather information.

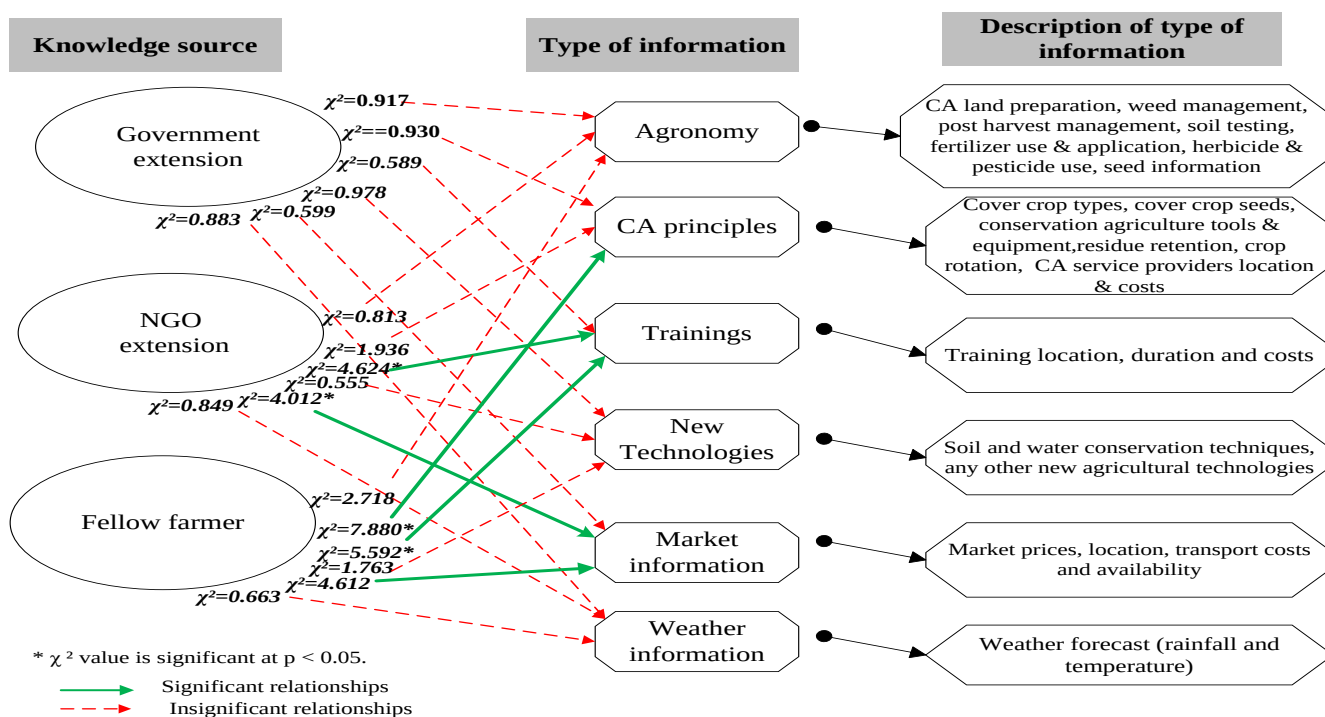


Figure 2.3: The relationship between a knowledge source and type of conservation agricultural information

The chi-square tests of independence show that NGO extension officers usually shared information about training ($\chi^2=4.62$; $p=0.032$) and markets ($\chi^2=4.61$; $p=0.045$) with the farmers. Further, fellow farmers shared information amongst themselves largely on CA principles ($\chi^2=7.88$; $p=0.005$); training ($\chi^2=5.59$; $p=0.018$) and markets ($\chi^2=4.41$; $p=0.001$). The results also indicated that while farmers and the government extension officer would share any type of CA information, the two variables were independent. Although a variety of CA information was shared among the respondents from the different sources, not all information was deemed relevant. These results show that a farmer was likely to use a knowledge source if the type of content was relevant as shown in Table 2.8.

Table 2.8: Farmer's perception of the relevance of CA information shared

Type of information	(perceived relevance of information n=298)	
	Relevant (%)	Not relevant (%)
Agronomy	69.1	30.9
CA principles	64.1	35.9
Training	53.4	46.6
New Technologies	20.8	79.2
Weather information	16.8	83.2
Market information	6.0	94.0

2.4.4 Type of knowledge pathway used for conservation agriculture

Two types of knowledge pathways namely; the conventional and ICT pathways were used to share CA information (see figure 2.5). The main conventional pathways used to disseminate CA information were field days (82%), Farmer Field Schools (25%) and Research centres (20%).

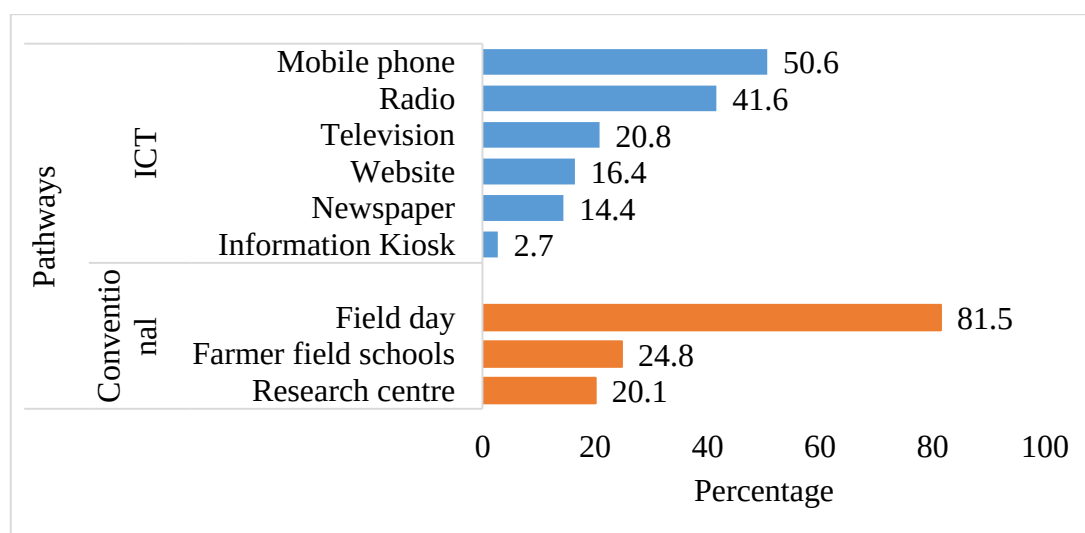


Figure 2.4: Knowledge pathways for conservation agriculture

*Total percentages are greater than 100% due to multiple responses.

Field days were predominantly used by the farmers to access CA information. Field days provided space where farmers interacted with each other and also shared experiences with other stakeholders. Abdulhamid & Solagberun (2017) recognizes the importance of field days as platforms that introduce findings of modern research to increase agricultural production and productivity. Though this was true, results from FGDs and KII noted that using field days to disseminate agricultural information to farmers had shortcoming on timeliness and coverage. Farmer Field Schools (FFS) on the other hand were the least used pathways to relay CA information. Discussion with farmers further indicated that FFS were preserved for a few “favourite” farmers who hosted demonstration plots and discouraged participation of other farmers. FFS were also perceived as time consuming and distant from the farms thus rendering them unpopular pathways. Like the FFS, research centres were not very common pathways for CA information. Results from the FGDs noted that information from the research centres were highly scientific and difficult to interpret. The farmers also complained that the research centres gave them contracts to bulk seeds for CA cover crops, but these were often poorly priced leading to high defaults rates.

ICT pathways were also used to compliment conventional pathways to disseminate CA information. Among the ICT pathways, mobile telephones were the most popularly used tools to share CA information as reported by over 40% of the respondents. Other ICT pathways used included radio, websites information kiosks and newspapers. The results showed that the ICTs were limited to the traditional ICTs. Similar studies by various authors (Norberth *et al.*, 2018; World Bank, 2017; Mtega & Msungu, 2013) show that radio, the mobile phone, and television were still predominant ICTs preferred by smallholder farmers. However, Janssen *et al.*, (2017), critics the predominant use of outdated ICTs that date back to the 1970s through to the 1990s. The author encourages extension services to take advantage of modern ICTs in order to make agricultural knowledge systems more collaborative, flexible and accessible. Though Janssen et al (2017) made the later recommendation, use of modern ICT in the study area was still limited due to; (i) costs associated with the use of ICTs, (ii) access to communication networks, (iii) access ICTs and (iv) training in CA (table 2.9).

Table 2.9: Challenges affecting wide use of ICTs by smallholder farmers

Challenges	Frequency	Percentage (n=298)
Cost of using ICTs	123	41.3
Limited access to comm. networks	166	55.7
Access to ICTs	203	68.1
Training in CA	34	11.4

*Total percentage is greater than 100% due to multiple responses

The relationship between a knowledge pathway and a knowledge source

This section elaborates on the relationship between the knowledge sources and the conventional pathways, and the relationship between the knowledge sources and ICT pathways. Chi-square tests of independence were used to establish the relationships as shown below in Table 2.10

Table 2.10: Relationship between agricultural knowledge sources and pathways

Type of pathway	Govt. Ext.	NGO Ext.	Farmer
Conventional pathway	χ^2	χ^2	χ^2
Farmer field schools	0.225	0.224	48.120**
Field days	0.091	2.758	4.283*
Research centre	0.011	2.029	15.298**
ICT pathways			
Mobile phone	0.550	4.395**	11.970**
Radio	3.530	3.088	42.411**
Television	2.975	22.467**	29.302**
Newspaper	2.322	0.787	5.525*
Website	3.384	11.105**	16.205*
Information Kiosk	0.517	4.411*	2.524

** χ^2 value is significant at $p < 0.01$

* χ^2 value is significant at $p < 0.05$

The chi-square tests of independence show that the government extension as a knowledge source for CA and the use of either pathway were insignificant. This implies that government extension as a knowledge source was independent of both the ICT and conventional pathways. This implied that the two variables were independent of each other (i.e. government extension worker used any pathway that was available to them to deliver agricultural information).

Chi-square tests for the NGO extension as a knowledge source and the conventional pathways were insignificant but were significant for the ICT pathways (mobile phone ($\chi^2=4.375$, $p=0.036$), television ($\chi^2=22.467$, $p<0.01$), website ($\chi^2=11.105$; $p <0.01$) and information kiosk ($\chi^2=4.411$, $p=0.036$). Use of ICT pathways were mainly for experience sharing by CA farmers, awareness, information about trainings, field days and agricultural shows. As one KII stated “.....I use the mobile phone to send information to farmers about trainings and I send technical advice by either calling or through SMS.....” (KII, Ward agricultural officer, Ngobit. 4th April, 2015)

Results from the FGDs also noted that farmers were often hosted on the “Farmers’ television”, and “Nation TV where they shared their farming experience. The implication was that whereas NGOs used the ICT pathways for awareness creation, the conventional pathways were used for the application of CA knowledge. The relationship between the ICT pathways and fellow farmer as a knowledge source were significant for (mobile phone ($\chi^2=11.970$, $p=0.000$), radio ($\chi^2=42.41$, $p=0.001$), television ($\chi^2=29.302$, $p=0.000$) and newspaper ($\chi^2=5.525$, $p=0.019$). This result is rather unexpected given that farmers as sources of information are unlikely to use ICT to share information with other farmers. Like one of the respondent confidently said; “...there are officers in each division with mobile phones, laptops, and modems to enable them to search for information and send to the farmers. The county website is the repository for all agricultural information generated during activities in the field and we use it to disseminate information ...” (KII, e-extension coordinator, Laikipia. 21st April 2015). In the use of conventional pathways, chi-square tests of independence were significant for the farmer as a knowledge source for field days $\chi^2=4.283$, $p=0.038$; farmer field school $\chi^2=48.120$, $p< 0.001$ and research centre $\chi^2=15.29$, $p<0.01$.

2.4.5: Factors that influence a farmer’s choice to use ICTs for CA Information

This section explores the factors that influence a farmer to use ICTs for CA information using a logistic regression. Results in table 2.11, indicate that the likelihood for a farmer to use a ICTs for CA information was dependent on several factors that included socio-demographic, economic or contextual.

Table 2.8: Factors that predict a farmers' choice to use ICTs for CA information

Predictor variables	ICT s		
	B	Sig.	Exp(B)
Age of respondent (Years)	-0.034	0.104	0.967
Education(Years)	-0.223	0.011**	0.877
CA experience (Years)	0.126	0.521	0.882
Training in CA(years)	-0.588	0.485	0.555
Income options (No. of income sources)	0.491	0.375	1.635
Land under agric. Prodn. (ha)	-0.087	0.451	0.917
Land under CA (ha)	0.694	0.007**	2.002
Content relevance (Relevant=1, otherwise 0)	0.437	0.437	1.547
If farmer considers cost associated with use of ICTs important (Yes=1. Otherwise 0)	-3.053	0.032*	0.047
Access to Comm. networks (Yes=1, otherwise 0)	1.665	0.004**	5.285
Constant	1.914	0.195	6.780

-2loglikelihood= 226.890, Cox and Snell R Square=0.068, Nagelkerke R square= 0.097

*p<0.05; **p<0.01

Several factors predicted a farmer's choice to use ICTs for CA information. These ranged from land under CA, accessibility to communication networks, education level of the farmer and costs associated with the use of ICTs. Results indicate that farmers who allocated larger portions of their farmland to CA were approximately two times more likely to use ICTs for CA information. According to Mittal & Mehar (2016), farmers with large land holdings are more likely to obtain information from a variety of sources including modern ICT. Such farmers are likely to explore for new information to mitigate and manage farm risks.

Likewise, proximity to a communication network was likely to increase the use of ICTs for CA information. Similar studies by Muriithi, Horner, & Pemberton, (2016), note that poor telecommunications and electricity infrastructure (such as low bandwidth for basic internet access) are strong deterrents to access and utilization of ICTs for agricultural extension and research. This is supported by Wawire, Wangia & Okello (2017), who suggest that one of the challenges for ICT initiatives is access to telecommunication infrastructure which significantly influence their use for agriculture.

Education of the respondent negatively influenced a farmers' choice for ICTs for CA information. The odds ratio for education shows that an educated farmer was approximately 87.7% less likely to use an ICTs. The results are contrary to literature which points out that education is a main socio-demographic predictor of ICT usage (Neves, Amaro & Fonseca, 2013; Mbanda-obura et al., 2017). Literature also suggests that farmers with higher education status are receptive to agricultural expert advice and are more likely to acquire, interpret and utilise information on improved technology (Musemwa *et al.*, 2013). The results are also contrary to the model, which had predicted a positive relationship for the use of ICTs.

Results further revealed that perceived costs associated with the use of ICTs negatively influenced a farmers' likelihood to use an ICTs for CA information and this was significant at $p=0.032$. The odds ratio for costs associated with the use of ICTs showed that a farmer was 4.7% less likely to use ICTs if they perceived that the cost of operation was high. Kante et al., (2017) found that the high costs of mobile handsets and mobile services negatively affected the use of ICTs for agricultural information. They concluded that high costs of ICT services were a significant barrier to its use for agricultural information.

2.5 Conclusion and recommendation

There were a wide range of knowledge sources used to share CA information to the end-users and this included technical knowledge to support the implementation of the CA principles. But other types of information were shared to complement CA. The wide availability of CA information from various sources implies that the farmer as end-user has a wide resource base to tap into using a combination of knowledge sources.

This indicates that the knowledge sources were not mutually exclusive but rather integrated for the effective delivery of CA information to smallholder farmers. Given that each knowledge source given its existing knowledge base could promote CA independently, though an important factor was not sufficient to effectively cover all the farmer information needs. In this sense, integrated knowledge was considered to be more beneficial to the farmer. This study therefore recommends that information from diverse sources should be packaged as resultant knowledge and be effectively shared to accomplish a task.

Results from the study show case that conservation agriculture knowledge was created by a diversity of actors and shared through various pathways namely; the conventional pathways and ICT based pathways. Though both conventional and ICT based knowledge pathways were used to access and disseminate CA information. The results indicate that multiple and unique factors co-determined farmer's choice to use ICTs. This is clear evidence that the use of the different pathways is contextual and will largely depend on how accessible and familiar that either the information source or the end-users has. It is therefore recommended that CA information sources develop specific CA content and package it with respect to a particular pathways as may be deemed appropriate for easy access and utilization of the CA practices.

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CHAPTER THREE

ACTOR POSITIONING IN CONSERVATION AGRICULTURE KNOWLEDGE NETWORKS IN MACHAKOS AND LAIKIPIA COUNTIES, KENYA.⁵

Abstract

Knowledge networks play a significant role in the transfer of innovations like conservation agriculture. However, one of the key challenges of networks is their unclear structures that lead to fragmentation in knowledge sharing processes. The objective of this study was to establish the Actor positioning and how it affects the conservation agriculture knowledge sharing relationships. Qualitative data from 28 key informant interviews and five focus group discussions were collected and analysed using content analysis. UCINET software was used for the social network analysis and NETDraw software for visualizing the relationships in the CA knowledge network. Results indicated that positions of influence were occupied by only three actors, the farmer, Laikipia and Machakos counties out of 44 actors in the network. ICT actors in the network had a very low level of influence which was reflected by their low centrality measures and periphery positions reflecting the weak use of ICTs. ICT actors were also the low receivers of conservation agriculture information. Although the network size was 1892, there were only 226 active ties, with a low network density of 12%. The few active ties, and only three actors in positions of influence indicated a fragmented network. The study recommends that ICT actors take a more active role to enhance use of ICTs for conservation agriculture knowledge sharing. The results of the existing ties also imply that the network was not operating at its optimal capacity. The latter is indicative of an under-utilization of potential relationships that would otherwise foster access, dissemination and utilization of CA knowledge. Actors in influential positions should play a facilitation role that brings the diverse actors in the network together.

Key words: Innovations, knowledge networks, conservation agriculture, Kenya.

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3.1 Introduction

The agricultural sector plays a major role in the economic development of Africa, contributing a high proportion to the livelihoods of populations involved in agricultural based activities (FAO, 2017). However, the sector is faced with major challenges like low productivity, limited diversification, changing weather patterns and continuous degradation of the environment (Blitzer, Wongtschowski, Hani, & Flink, 2016). As a result, several "sustainable" land practices like Conservation Agriculture (CA) are now promoted as mitigation measures among smallholder farmers in Africa (Ward, Bell, Droppelmann & Benton, 2018). Complex technologies like CA are developed and disseminated by networks of actors. The impact of these networks depend on the assets they command, their learning routines and the socio- economic environment in which they operate (Ekboir 2012). Mlozo-banda et al., (2012) observe that CA entails a qualitative change in agriculture as it engages multiple actors and a farming environment in a long process of social construction and re- construction of both existing, new cropping techniques and institutional actors. Such changes necessitate specific processes of knowledge sharing and learning from experience.

Research shows that innovations require new knowledge bases, with new content and various forms of knowledge and learning processes (Sutherland *et al.*, 2017). Integration of these knowledge bases takes several forms like networks, collaboration between farmers and researchers or through multi-actor knowledge networks. For wider acceptance and adoption of practices like CA, it is important to understand the actors involved, their roles, and information sharing relationships. Borgatti & Hargin (2011), suggest that individuals need to have certain kinds of relationships to utilize each other's knowledge. These relationships influence how new knowledge and innovations spread. Part of the reason for the underutilisation of the CA knowledge systems is attributed to the mushrooming of non-regulated advisory services. This has led to complex open systems which smallholder farmers prefer for their information needs, thus turning their backs to the formal extension systems (Curry, Ingram, Kirwa & Maye, 2012).

In Kenya, CA adoption has been growing among large-scale operators, with minimal growth among smallholder farmers (Milder, Majanen & Scherr, 2011). This is attributed to several factors like the expensive equipment required for CA (Ndah et al., 2015), and limited understanding among farmers of the benefits of the simultaneous application of the three principles (Kassam et al., 2019). Besides, extension services are equally not well equipped with the technical skills of the

practice, access to the knowledge and experience generated is also limited (Cicek *et al.*, 2017). Tata & McNamara (2016), suggest that the use of network agents has the potential to enhance the adoption and dissemination of complex technologies like CA. Knowledge networks have been known to bring together collections of individuals across organizational, spatial and disciplinary boundaries to invent and share information (Pugh, 2013). These sometimes have been referred to as “open” systems where knowledge is harnessed through a platform that provides for learning about new ideas (Aboelmaged, 2018). Being a relatively new production system, CA is still not well understood by a wider section of the farming community (Kassam et al, 2019). Some of the challenges have been attributed to the CA fragmented knowledge systems ((Ward et al., 2018; Gunter et al., 2019).

The research questions this study addresses are;

- 1) Who are the actors in the CA knowledge network & what are their roles?
- 2) How do actors’ positions in the CA knowledge network affect CA knowledge sharing?

3.2 Theoretical framework

This study used the Social Network Theory (SNT) as a framework to understand the structure of the network, the actors and their roles, and how they were positioned to effectively share CA information. Social networks are defined as “a set of linkages among a defined set of persons. The characteristic of these linkages may be used to interpret the social behaviour of the persons involved” (Park, 2011, p.1279). The key concepts of the Social Network theory are (i) the structure of the network, (ii) the flow or distribution of information and (iii) the social interactions, (Borgatti & Foster, 2003). This study applied these three concepts to analyse the characteristics of the CA knowledge network.

Park (2011), suggests that social systems are networks through which resources and information exchange takes place. Chan & Liebowitz (2006), identify four common role players, (i) central connectors as the actors who link most people in an informal network with one another; (ii) boundary spanners who connect an informal network with other parts of the organization or similar networks in other organizations (iii) information brokers as the ones who keep the different sub- groups in the network together and (iv) the peripheral specialists are the ones who provide

expertise to anyone in an informal network. Each of these four role players has a significant role in the network and is critical to the productivity of the network or organization.

Existing studies on the use of SNA have mainly focused on the social and organisational behaviours, and the network influences at different levels of knowledge diffusion (Lucas & Maynes, 2013; Levy & Lubell, 2016). Wood et al. (2014) investigated farmer networking as an interpersonal practice. Their findings suggest that farmers exchange knowledge in densely tied and strongly organized interpersonal networks. These networks decisively shape the communication of agriculture science in ways that limit professional closure and effectively disable the linear transfer of technology (ibid). Hoffman, Lubell & Hills (2015) further argue that knowledge networks are the social infrastructure that support social learning. An individual's ability to engage in social learning activities such as the generation, access and spreading of ideas is either constrained or enabled depending on the structure of the network and the individual's position in that network (ibid). The Social Network theory has been used by several scholars to analyse and study social behaviours, organizational behaviour and how actors relate within these networks (Levy & Lubell, 2016; Mloza-Banda *et al.*, 2015; Gava *et al.*, 2017). Limited literature exists to show the structural relationships in conservation agriculture knowledge networks and how these influence the knowledge sharing among actors, therefore, this study addresses this gap.

3.3 Methodology

3.3.1 Research design and data collection method

The study employed a qualitative research design using key informant interviews and focus group discussions. For the key informant interviews, an interview guide was used to collect data on the actors in the CA network, their roles in CA knowledge sharing and collaborative arrangements. For the focus group discussions, using an interview guide, data was collected on the different information sources farmers use to learn about CA, how CA information is shared, the main information needs and the choice of methods for accessing CA information.

3.3.2 Sample and sampling method

The study sample was composed of 28 KII respondents purposively selected with the aid of the extension officers from Laikipia and Machakos counties. Key respondents for the KII included media personnel, ICT Authority officer, e-extension coordinator, Director of the

Agricultural information resource centre, chief agricultural officers, extension staff, and monitoring and evaluation officers.

For the FGDs, 46 participants were purposively selected with the aid of the extension officers. Members of the FGDs were from five different CA farmer groups and participants ranged between 6-12. The criteria for selection were: (i) being a CA practicing farmer for over two years; (ii) participation in more than two CA trainings and (iii) being an active group member.

3.3.3 Data analysis

Three basic stages were used to analyse the CA knowledge network. The first stage was to establish the individuals and institutions (nodes) that form the knowledge system. The second stage involved analysing the links between the nodes and the third stage was to characterize the nature of relationships between the nodes that were linked. The analysis was done by first drawing the boundaries where CA farmers are located in Machakos and Laikipia counties through the CA farmer lists, identification of links to the potential actors in the network, and definition of the nature of the relationship. This was done to define membership of the network and keep the study within feasible limits.

The second stage of the analysis concentrated on examining the structure of the network and the type of information shared through the various linkages. A relatively high proportion of the arrow heads in the diagrams reflected the centralised position of the actors in the network and a lower proportion reflected periphery actors. The total number of ties or relationships between the actors was analyzed by the reciprocated and unreciprocated ties. A reciprocated or two-way link was when both actors influenced each other. Reciprocal links are more effective and efficient means of network communication, while a one-way reciprocal tie is when one actor is not influenced by another (Lucas & Mayne, 2013).

To analyse the CA knowledge network, UCINET (6.528) was used for the in-degree and out-degree measures, while NetDraw (2.141) was used to visualise the network. Using the excel software, two databases were created, one with information on the nodes (actors) and their attributes and the other with the tie information (the type of CA information exchanged). The tie database was composed of four columns, actor interviewed, actor's name, type of information and

means by which the information was accessed. The attribute database contained the name of the actor and type of actor. The attribute database was composed of the complete list of the CA knowledge actors. Actors with incomplete information in the database had the empty cells filled as no data. The two databases were then combined and saved as .txt formats in excel database and opened in notepad to make the last adjustments before importing into the Netdraw software for visualization and analysis.

Types of information were analysed and coded one to six (Table 3.1). The pathways used to information were also categorized into five and given codes 1-5. Clark (2006) suggests that when using the ties to define qualitative value of relationships, all data must be coded and numbered. To map the social network, four key variables were identified, and these included the actors in the network, their roles, the types of information exchanged and the type of pathways used to exchange information (Table 3.1).

Table 3.1: Type of conservation agriculture Information and means used in knowledge sharing

Type of Information	Code	Types of pathways	Code
Agronomy	1	Conventional (FFS, Field days & research center)	1
CA principles	2	Traditional ICTs (Radio, TV, phones)	2
Trainings on three principles	3	New ICTs (Smart phones, tablets)	3
New Technologies	4	Web- based (mobile enabled websites)	4
Weather Information	5	Mobile applications (Android enabled)	5
Market Information	6		

Source: KII & FGDs, 2016

The type of data used to map the CA knowledge network were: (i) the institution (ii) the type of information exchanged, and (iii) means of exchanging the information. Degree centrality measured the prominence of actors in the network and reflected how influential an actor was in the network, by the amount of information flow controlled. A summary of the network measures used are shown in Table 3.2. A summary of the themes and axial codes generated are shown in Table 3.3.

Table 3.2: Description of key terms used for the social network analysis

Element	Definition
Node	Represents the actors in a network. Actors in this network refer to individuals & institutions participating in CA knowledge sharing.
Line/edge	Represents the tie or relationships between actors in a network.
Socio-gram/Network	Graph consisting of nodes to represent actors and lines to represent ties or relations. It may represent a single relationship or multiple relations.
Network size	Size of the network is determined by $(k*k-1)$ where k is the number of actors.
Network density	number of existing relationships/number of available relationships in the whole network.
Degree centrality	A measure that quantifies how many ties a node has to other nodes in the network. This index is often considered a measure of actor activity.
In- degree	"sinks"" or " receivers of information"
Out-degree	Sum of connections an actor has, by sending out information to other actors

Source: *Hanneman & Riddle, 2005:144; Chan & Liebowitz, 2006*

Table 3.3: Summary of the axial codes and themes generated

SNT Tenet	Themes	Categories
1. Social interactions	Actor roles in the CA network	1.Policy oversight 2.Awareness & CA promotion 3.Provision of land for CA 4. Research in cover crops 5. Sale of inputs & equipment 6.Awareness raising
2. Structure of the Network	Information sharing relationships in CA networks	1. In-degree 2. Out-degree
3. Flow of Information	How CA actors share information	1. Conventional 2. Traditional ICTs 3. New ICTs 4. Web- based applications 5. Mobile applications

Source: KII and FGDs data, 2015/16.

3.4 Results

3.4.1 Actor categories and their roles in the CA knowledge network

Networks provide a framework for understanding how information flows between actors in a social network. The relationships or associations that result from sharing information show how this influences the adoption of an innovation. The CA knowledge network was comprised of six major categories of actors and each of them played a different role (Table 3.4).

Table 3.4: Actors in the CA Knowledge Network, their roles and gaps

Actor Category	Actors	Role in the network	Gaps
Government	MoALF, AIC, KEPHIS, KMS, NDMA, ASDSP, County governments	Policy oversight & coordination of CA activities	Utilization of the CA National taskforce
NGOs	ACT, ALIN, LWF, CABI CARITAS, Syngenta, World vision, Farm concern, FAO	Awareness & promotion of CA activities to other actors	Harmonization of CA promotional activities
Farmer	Farmer	Participation in action research & provision of land for demonstration sites	Integration of CA farmer innovations
Research	KARLO, CETRAD, FAO	Research into cover crops, seeds & multiplication. Soil testing	Technicality of the information for farmer & extension use
Private sector	Ol-Pejeta, KWME, input dealers, CA service providers	Sale of inputs & equipment, CA service provision	Research into CA tools & equipment
ICT Actors	Sauti ya wanachi, Inooro FM, NTV, KBC, ICT authority	Use of ICTs to create awareness on CA	Passive receivers of CA information
Missing actors	<i>Universities, financial institutions & Communities of Practice</i>		Integration of CA into the extension curriculum Credit; mobilization of farmers

Source: KII & FGDs 2015/2016.

The Government actors provided policy oversight and coordination of CA activities. Some of these activities were e- extension, promotion of the dairy, maize and mutton value chains through the agriculture sector development support program. The major role for the NGO actors focused on awareness and promotion of CA activities through field days, trainings and farmer field schools. In the network, farmers provided the land for demonstration plots which were used for field trials and experiments on CA. Other actors included; input suppliers, researchers and the private sector. Some of the Actors missing from the network included Universities, financial institutions as one KII noted, “.....for CA to be successful it must be inclusive and not eliminate some actors like Universities, banks, SACCOs and farmer organisations. There is need for more improvement and more meetings of collaborators. Funds are limited and some collaborator do not engage us in their activities from the start..” (KII, Nanyuki, Laikipia East, April, 2015)

3.4.2 Knowledge sharing relationships with the CA network

Knowledge sharing relationships were reflected by the set of ties that connected actors. In this study, where two actors were sharing CA knowledge with each other, this was referred to as a reciprocated relationship. Where only one actor was sharing CA knowledge to the other, this was an unreciprocated relationship. The social interactions within the CA knowledge network was analyzed in terms of the ties between the actors, and this was used to determine the CA knowledge sharing relationships.

Reciprocated information sharing relationships between Actors in the network

Although there was no formal collaborative framework for CA at the time of this study, there were a number of knowledge sharing relationships among the actors. Results of the sociogram (Figure 3.1) show that the CA knowledge network had 205 reciprocated ties. This reflects the number of active CA knowledge sharing relationships that had both an in-ward and out ward flow of CA information among the different actors.

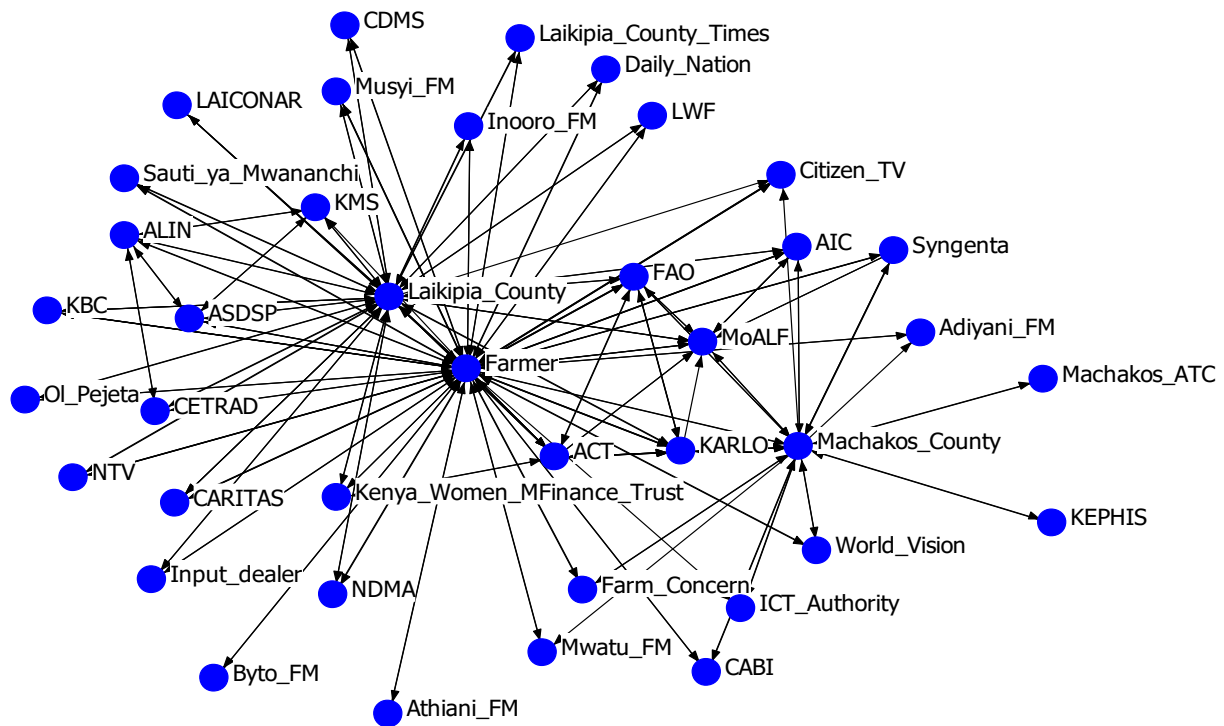


Figure 3.1: Network map showing the reciprocated information sharing relationships between actors in the network.

Some of the knowledge sharing relationships were between the Ministry of Agriculture, Livestock and Fisheries (MoALF) and the Laikipia and Machakos county governments. The Kenya Meteorological Services (KMS), The Arid Lands Information Network (ALIN) and the Agricultural Sector Development Support program (ASDSP) also had formal partnerships (memorandum of understanding) for the dissemination of climate and market information. Laikipia County Times was also collaborating with the ASDSP and the African Conservation Tillage network (ACT) in terms of agricultural information sharing and dissemination although without a formal partnership. The Laikipia and Machakos county governments had collaborative arrangement with almost all the institutions, but it was not clear if all these were formally constituted. Though the various actors were linked through both formal and informal partnership, in the promotion of the CA practice.

Unreciprocated information sharing relationships between actors in the CA knowledge network

There were 19 unreciprocated ties in the CA knowledge network as illustrated in Figure 4.2.

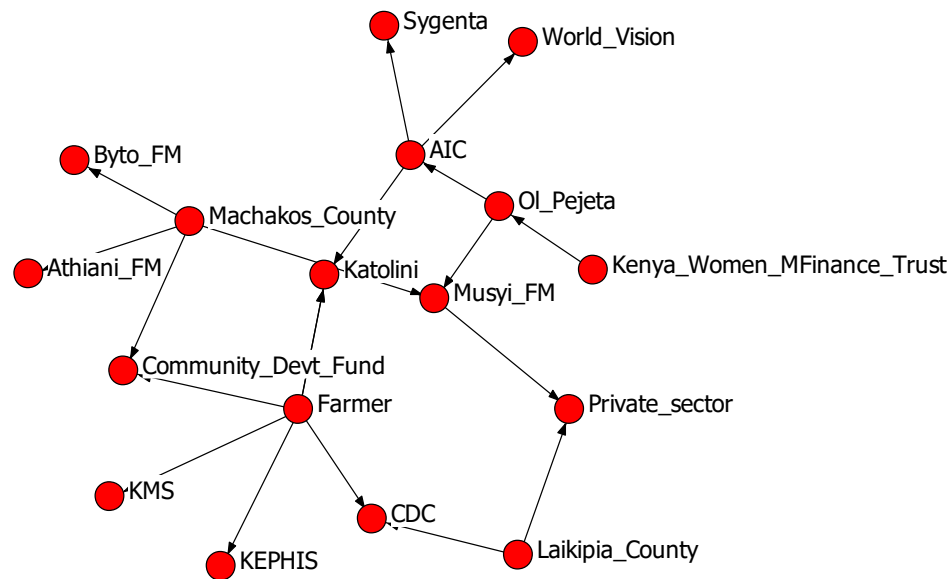


Figure 3.2: Network map showing the unreciprocated information sharing relationships between actors

Although the number of unreciprocated ties seemed to be very few, these actors had the potential to fragment the CA knowledge network and thus lead to the network disintegration. As noted from figure 3.2, there were unreciprocated ties between Musyi FM and Ol pejeta conservatory, a prominent CA actor; and Katolini and the private sector; the Agricultural information centre (AIC) and Katolini, a community based organisation; and Syngenta and World vision among others. With no formal framework for engagement in the promotion of conservation agriculture, institutions had the choice with whom to engage and therefore were not obliged to reciprocate to another actor even if that actor was sharing CA information with them. These results point to a fragile knowledge network and the need to enhance share CA knowledge sharing among the various actors.

3.4.3 The CA knowledge Network structure showing Actors, reciprocated and unreciprocated ties

The CA knowledge network structure was comprised of all the actors with reciprocated and unreciprocated ties. The overall network size was 1892 but the number of existing information sharing relationships was 226 ties with a network density of 12% (Figure 3.3). Levy & Lubell (2016) suggest that knowledge networks have a unique importance in agricultural knowledge systems and are rapidly replacing the linear model of knowledge transfer. The authors further suggest that networks are becoming a domain of specialized knowledge in which both formal and outreach professionals serve as knowledge brokers. Therefore, enhancing the CA knowledge sharing relationships among several actors could potentially improve the knowledge sharing process and network efficiency.

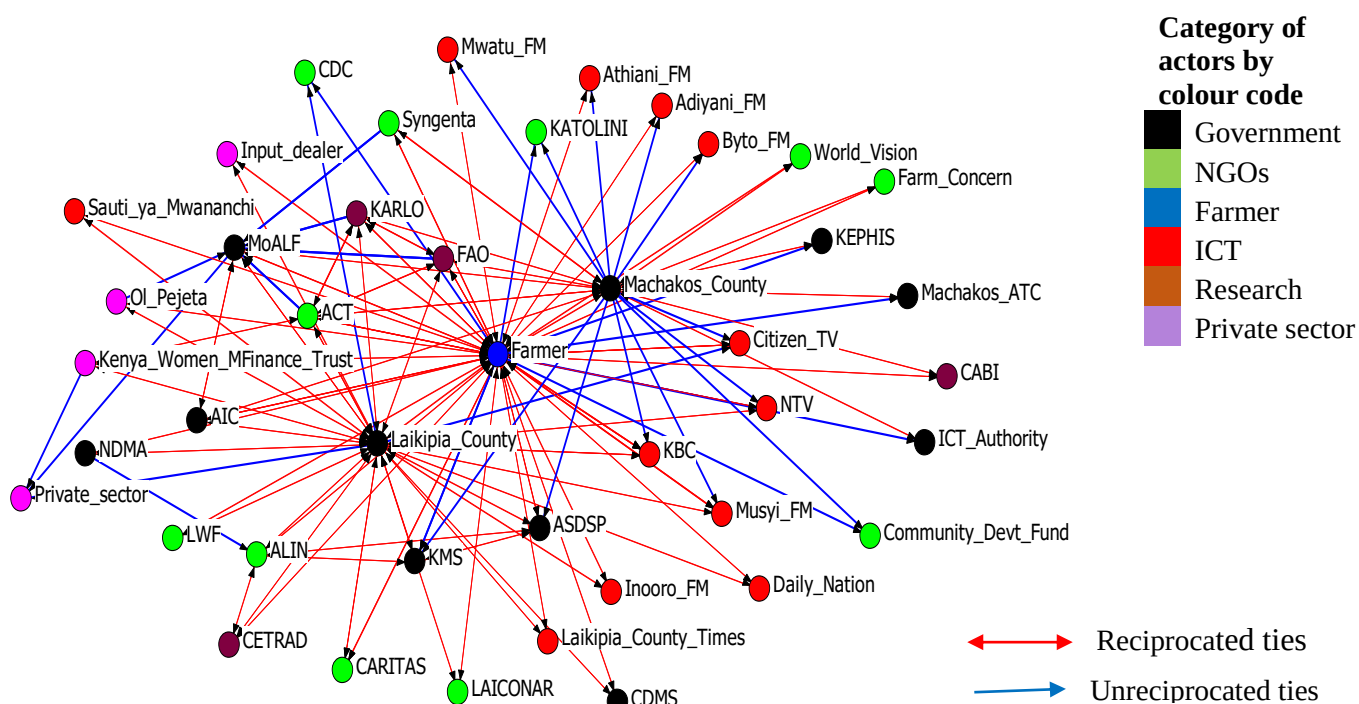


Figure 3.3: The CA network structure showing Actors, the reciprocated and unreciprocated ties

The network was linked by knowledge sharing relationships and the maximum number of possible connections or ties any individual actor had. The relatively high proportion of the arrow heads as illustrated in figure 3.3 pointed towards the farmer, Laikipia and Machakos counties⁶ indicating their prominence in the network. The lower proportion of arrows pointed towards periphery actors like the FM radio stations, the ICT authority and private sector actors. The results show that this network was operating below its optimal level due to the low number of ties (226), the low network density (12%), and only three actors in positions of influence.

As reflected in the findings, the central actors facilitated sharing of CA knowledge to the various actors in the network, through their ties and linkages, but the unreciprocated ties hindered the smooth flow of knowledge sharing. Strong ties and network cohesion are important for the transfer of complex and tacit knowledge (Rieple & Snijders, 2014). Hoffman, Lubell & Hillis (2015) suggest that the ability to access and spread knowledge can be constrained by network bottlenecks as was reflected by the unreciprocated ties in CA knowledge network. For example, in this network, outreach professionals like the extension officers at the county level could get overburdened by too many requests and their quality of work could be compromised thus affecting the knowledge shared out to farmers.

3.5 The degree centrality measures in the CA knowledge network

Degree centrality is a measure of how connected an actor is to the rest of the network and reflects the importance of an actor in a network. The magnitude of the degree centrality also describes the prominence and influence of an actor by the measure of the in-degree and out-degree respectively. In this study, the in-degree and out-degree centrality measures were used to identify actors with the highest number of direct connections, and those who played the most dominant and influential role in the CA network. The results of the centrality measures in Table 3.5 identified three main actors including; the farmer, Laikipia county and Machakos county as the most influential and prominent actors.

⁶ Laikipia and Machakos counties refer to the County agricultural officers and extension workers in the respective counties.

Table 3.5: Descriptive measures of centrality for the CA knowledge network

No.	Actor	In-degree	Out-degree
1	Farmer	82	98
2	Laikipia County	59	66
3	Machakos County	30	57
4	Ministry of Agric. Livestock & Fisheries	20	11
5	African Conservation Tillage Network	14	16
6	Arid Lands Information. Network	14	11
7	Food & Agriculture Organisation	11	16
8	Kenya Agric. Research & Livestock organ.	11	14
9	Agric Sector Dev. support program	11	9
10	Kenya Meteorological services	11	7
11	Agriculture Information Centre	9	11
12	Kenya Women Micro Finance Trust	7	9
13	Centre for Training Research Dissem.	7	7
14	Kenya Broadcasting Corporation	7	5
15	Musyi FM	7	5
16	Nation TV	7	5
17	Private sector foundation	7	2
18	National Drought Management Authority	5	7
19	Ol_Pejeta conservatory	5	7
20	Centre for Agric. & Biosciences Int.	5	7
21	Syngenta	5	7
22	CARITAS	5	5
23	County Meteorological services	5	5
24	World Vision	5	5
25	Farm Concern	5	5
26	Laikipia County Natural Resource Netn.	5	5
27	Lutheran World Federation	5	5
28	Input dealer	5	5
29	Citizen Newspaper	5	5
30	Daily Nation	5	5
31	Laikipia County Times	5	5
32	Inooro FM	5	5
33	Sauti ya Mwananchi	5	5
34	Kenya Plant Health Inspectorate services	5	2
35	Centre for Disease control	5	2
36	Community Development Fund	5	2
37	KATOLINI	5	2
38	Machakos Agricultural Training Centre	5	2

39	ICT Authority	5	2
40	Citizen TV	2	2
41	Adiyani FM	5	2
42	Athiani FM	5	2
43	Byto FM	5	2
44	Mwatu FM	5	2

Source: KII & FGDs 2015/2016.

The positions of influence occupied by only three main actors in the CA knowledge network, indicate that the network structure could easily be disrupted if these central actors closed the network to other actors by limiting the sharing of CA knowledge. Gunter *et al.*, (2016), noted that network influences at the local level play a key role in innovation and technology diffusion. Mloza-Banda *et al*, (2015), however, note that low network influences lead to breakdowns in institutional frameworks. Actors with high centrality have a great potential to be aware of other actor's expertise and can spread information rapidly because they are well connected. This is supported by Gava *et al*, (2017), who established that influential actors in a farm biogas knowledge network, enabled quick diffusion of information because of their central positions. Consequently, the three central actors in the CA knowledge network (the farmer, Laikipia and Machakos counties) have the potential to enhance CA knowledge sharing through their social capital. Gunter, Moore, Eubank & Tino (2016), noted that network influences at the local and regional level played a key role in innovation and technology diffusion. Networks support multiple knowledge processes in the diffusion of new technologies and low network activities slow down knowledge sharing.

While the farmer, Machakos and Laikipia counties were the most central actors, there were other prominent actors like FAO, MoALF, ACT, KARLO and ALIN who had the technical expertise on CA and were therefore important actors. Sutherland *et al.*, (2017), had similar findings and noted that diversified knowledge is exchanged and distributed through decentralised networks among a range of actors. Networks become important because they are social entities through which actors in their relationships influence how knowledge flows. The least degree centrality positions were occupied by the ICT actors including the ICT authority, the FM radios and the Nation TV (Kenya Broadcasting Corporation (KBC)). The network analysis shows that ICT actors were sitting at the periphery of the network and yet the use of ICTs has an enormous potential to reduce the cost of accessing information by poor smallholder farmers and to reduce costs in coordination by extension services. This implies that ICTs were not being used efficiently to broker

and share CA knowledge within the network. Nonetheless, Aboelmaged (2018), argues that actors with low centrality measures can fragment the network, but at the same time are important because they can link actors who would otherwise not be connected.

3.6 Conclusion and recommendation

Using the Social Network theory, this study was designed to describe the actors, their roles and positioning of in the CA knowledge network and how this affects CA knowledge sharing. The results of the study show that a wide range of actors performing different roles existed in the network. The major actors in the network were the government counties and farmers who largely performed technical support, co-ordination and implementation roles. The dominance of these actors crowded out the influence of other actors such as the FM radio stations, Citizen TV and the ICT authority who seemingly played other complementary roles to enhance the adoption of the CA practice. The position of the ICT actors at the peripheral of the network renders them from playing an active role in CA knowledge sharing. This is rather disappointing given that ICTs are known to remove several barriers that affect knowledge sharing. The study therefore urges that ICT actors could take more active roles in the sharing and communication of CA knowledge as this will enhance the timely and consequently use of this knowledge by smallholder farmers.

The CA knowledge networks portrays a fragmented network where actors are not effectively sharing CA knowledge. With a network density of only 12%, it is evident that weak linkages existed among the different actor categories within the CA knowledge network. The results of the existing ties also imply that the network was not operating at its optimal capacity. The latter is indicative of an under-utilization of potential relationships that would otherwise foster access, dissemination and utilization of CA knowledge.

Engagement of diverse actors in CA knowledge network shows the importance of sharing knowledge of the CA practice. The diverse nature of actors and the respective roles they play bring on board new opportunities to increase the diffusion and uptake of the different CA principles. While this is true, the actors in CA network have not tapped into each other strength and expertise which in turn impedes the timeliness and efficient utilization of the available CA knowledge. There is therefore need to strengthen interaction and sharing of knowledge among the different actors. This calls for the building of multi-actor platforms where physical or virtual space is availed to the different actors to play their role. In the addition, the actors in the influential position should play a facilitation role that brings the diverse actors together.

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CHAPTER FOUR

ICT ENABLED AGRICULTURAL MODELS FOR CONSERVATION AGRICULTURE KNOWLEDGE SHARING IN LAIKIPIA AND MACHAKOS, KENYA⁷

Abstract

For the effective utilization of ICTs in conservation knowledge sharing, it is essential to explore how they are integrated into agricultural knowledge systems. This study examined the use of ICTs for conservation agriculture knowledge sharing among smallholder farmers. Qualitative data from 28 key informant interviews and five focus group discussions were collected and analysed using content analysis. Results indicate Agricultural knowledge sharing takes many forms as demonstrated by the different actors using a variety of ICTs and applications to share agricultural information. This was also demonstrated by the use of the government and NGO ICT knowledge sharing models. It was also clear that the use of ICTs for CA information was very weak. Although the government knowledge sharing model had a robust ICT infrastructure, the NGO model reflected an increased use of advanced mobile applications using the internet, interactive voice response and unstructured supplementary service data. The study recommends that, if ICTs are to be effectively used, an integrated flexible model that takes advantage of the government ICT infrastructure and the advanced ICTs used by NGOs is proposed to enhance CA knowledge sharing. This would enable more smallholder farmers to be reached by extension services.

Key words: ICTs, Agricultural knowledge systems, Conservation Agriculture, Kenya, Sub-Saharan Africa.

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4.1 Introduction

In the past thirty years, several scholars have established the relevance of ICTs in improving the quality and speed of delivery of agricultural extension services (Carmody et al., 2015; Kaloxylou et al., 2013). Sometimes integration of ICTs in agriculture is known as e-agriculture, since new technologies and applications are in constant evolution (Food and Agriculture Organisation, 2014). The application of ICTs in agriculture is not a new concept, literature states that the use of modern ICTs like mobile enabled web portals, cloud computing and open data are technologies that have not yet been fully conceptualized in agricultural knowledge systems (Janssen *et al.*, 2017). Several authors who cite challenges in using ICTs among smallholder farmers are silent on how new ICT technologies and applications improve knowledge sharing of practices like Conservation Agriculture (CA) (Duncombe 2016; Sylvester, 2013). Faced with worsening cycles of drought affecting food production for local consumption, smallholder farmers are becoming more innovative on how they gain knowledge to sustain their agricultural practices. This chapter addresses this gap by analysing how new ICTs and applications are integrated for CA knowledge sharing.

This study argues that innovations like CA spread through social systems which use different communication channels to create awareness and share knowledge on the practice. This influences how and at what rate the innovation may be adopted. Roger's diffusion of innovation theory states that, the innovation, communication channels, time, and a social system influence the spread of a new idea. As will be explained later each of these processes represent how knowledge sharing occurs in a system.

Conservation agriculture knowledge systems are important to study because it is a fairly concept new concept in East Africa with several challenges in its knowledge systems (Gunter, Moore, Eubank, & Tino, 2019). In Kenya, the agriculture sector is dominated by smallholder farmers in rural areas and accounts for 25% of GDP according to the Kenya National Bureau of statistics (2017). Farming is rain-fed, despite the country's commitment to agriculture, the sectoral growth remains below the six percent target and has been declining steadily at 21% since 2015 (World Bank, 2017). Conservation agriculture is proposed as a production system that has the potential to deliver both on sustainability and intensification. It's three principles of minimum or

no tillage, soil cover and crop rotation are widely applicable across a range of farming system (Kassam, Friedrich, & Derpsch, 2019). Thierfelder, Mombeyarara, Mango, & Rusinamhodzi, (2013) note that, if CA is to be widely adopted and practiced, its knowledge sharing practices have to be improved.

Most CA efforts in sub-saharan Africa have are scattered and disjointed, yet CA requires the involvement of multiple actors working together in a joint and coordinated manner (Kassam et al., 2019). The sustained practice of CA by smallholder farmers is hindered by the multiple conceptualization of the practice, by the different actors thus affecting its knowledge systems. Kassam et al., (2019) further suggest that major constraints to the adoption of CA continue to be knowledge about its existence and how to do it. The mindset, inadequate policies, unavailability of appropriate equipment, lack of knowledge on suitable management strategies are other major constraints.

Rogers (2003) diffusion of innovation theory, provided the analytical framework to understand innovation, communication channels and social systems in CA agricultural knowledge practices. In this study, the context under which integration of new ICTs in CA knowledge systems takes place was the innovation. Knowledge and information are used interchangeably even though knowledge refers to the flows of communication and agricultural information moving across multiple actors. And information is the content generated through CA action research activities and farmer's experiences. Kameswari, Kishore & Vinita (2011) argue that the major causes attributed to the low adoption of CA are the costs of infrastructure, telecommunications and access to farming communities. The generic nature of "public good" agricultural information perceived to be easily available through conventional means is another cause.

The applicability of ICT in agriculture has been well researched (Mirembe, Obaa & Ebanyat, 2016; Enwelu *et al.*, 2017) and its importance in improving agriculture in developing countries (Ajani, 2014; Uwandu *et al.*, 2018). However, there is limited documented evidence of how effectively ICTs are used in agricultural knowledge systems for conservation agriculture. This study addresses the following research questions;

- 1) What ICT tools and applications are used for CA knowledge sharing?

- 2) How has the agriculture knowledge sharing systems used ICTs for CA information?

4.2 Theoretical framework

This study used Roger's diffusion of innovations theory as a framework to understand how ICTs are used and applied in the conservation agriculture knowledge systems. The Diffusion of Innovations theory seeks to explain how, why and at what rate new ideas and technology spread through cultures. It has four main elements that influence the spread of a new idea, the innovation, communication channels, time, and a social system (Rogers, 2003). These elements work in conjunction with one another.

4.2.1 The innovation

Innovations are embedded in innovation systems and one of its functions is knowledge development and diffusion through networks (Hekkert *et al*, 2007). Agricultural innovation is the process where individuals or organisations bring new or existing products into use for the first time in a specific context to increase effectiveness, competitiveness and resilience to shocks (Food and Agriculture Organization of the United Nations, 2018). Studies show that CA knowledge systems face challenges of efficiently delivering information to smallholder farmers (Kassam *et al.*, 2019; Moore *et al.*, 2014). Conservation agriculture is also perceived not to fit well with memorised knowledge because of its principles of adaptation, which require that knowledge grows and evolves within the context where it is applied (Moore *et al.*, 2014).

The integration of new ICTs in the CA knowledge sharing process is expected to make the flow of CA information more efficient. Assefa, Alemneh, and Rorissa, (2014), suggest that these new ICTs have to be understood before integration in agricultural knowledge systems in developing economies. The integration of new ICTs can be complicated depending on the social systems in which they are introduced. Such complications include the low levels of digital literacy among smallholder farmers and issues related to sustainability (FAO, 2018). Duncombe (2016) argues that adoption of ICTs in agriculture is a complex process more so, where each member of the community has their own agricultural information needs and bias. Therefore, the context under which innovations like the use of new ICTs for CA knowledge sharing are introduced need to be critically understood to be able to determine the communication channels to use.

4.2.2 Communication channels

The concept of agricultural communication is not new and studies show that it aims at communicating agricultural technology, to bring about a desired behavioural change in farmers and improved production (Age *et al.*, 2013; Vignare, 2013). Rogers (2003) suggests that communication is “a process in which participants create and share information to reach a mutual understanding” (p. 5). Etyang *et al.*, (2014), broadly categorizes communication channels into two; localite where channels are traditional and messages are conveyed over short distances, and within the boundary of the target group. Or, communication channels may be cosmopolite, where the sources of information may be from outside the system even though it may involve face to face interactions. Such channels, the author further elaborates includes farmer field schools, on-farm demonstrations and agricultural shows.

Jowi (2018), proposes that communication channels may be unidirectional for channels that are disseminative or multidirectional for channels that are communicative. We recognise that extension services use various communication channels to facilitate the flow of information, and are influenced by various factors, like physical distance and logistical challenges. Aldosari, Al Shunaifi, Ullah, Muddassir, & Noor, (2019) suggest that, these are some of the major impediments between farmers and extension staff, and suggest the use of ICTs to overcome some of these barriers.

Wulystan and Mpho (2018) argue that emerging new ICTs that enable instant feedback are more likely to facilitate effective agricultural knowledge flows. On the contrary Jowi (2018), argues that contemporary societies view new ICTs as intrusive, irksome and distractive. Mirembe *et al.*, (2016) suggest that if farmers are to use ICTs, emphasis should be placed on ICT models that cater to their information needs and suggest use of audio visuals. Similarly, Mittal & Mehar, (2016) note that ICT-based models serve as complementary dissemination mechanisms for extension services and cannot be used in isolation. If such models are to meet smallholder farmer’s information needs, they have to be dynamic and corresponding to the farmer ever changing information priorities. Therefore, in the CA farming social systems, we expect to observe diverse use of communication channels.

4.2.3 Social systems

The agricultural social system starts from the actors, their actions and roles in an agricultural system (Janker, Mann, & Rist, 2019), these systems have no boundaries and are

influenced by factors that may be political, by market forces and the farming systems. Rogers (2003) defines a social system as “a set of interrelated units engaged in joint problem solving to accomplish a common goal” (p. 23). Since the diffusion of innovations takes place in the social system, are influenced by the structure of the social system. Such systems have communication structures that facilitate or impede the decision to adopt an innovation. Aerni et al., (2015) argue that social systems are difficult to define because they comprise of interrelationships between individuals, groups, communities and institutions. Such groupings define the structure of the social system, within which information and ideas spread. How actors in such social system share information gives an insight into their knowledge sharing habits, perceptions and belief. This may be used to determine what type of communication channels to use, when to use them, and what type of farming information to disseminate.

4.2.4 Time

Time is a key factor in the decision-making process, innovativeness and an innovation’s rate of adoption. In the innovation-decision process, an individual seeks information through several stages of knowledge, persuasion, decision, implementation (adoption) and confirmation (Perkins, 2011), to reduce uncertainty about the usefulness of the innovation. Decision stages result in the adoption or rejection of the idea (Rogers, 2003). The time smallholder farmers take to decide on when and how they will use ICTs for CA information is unpredictable. Therefore, time was outside the scope of this study and was not utilised in the design and analysis of results.

4.3 Methodology

4.3.1 Research design

The study applied a qualitative research design using Key Informant Interviews(KII) and Focus Group Discussions (FGDs) to describe the ICTs and applications used for conservation agriculture knowledge sharing in Machakos and Laikipia counties. According to Baxter & Jack (2008), a qualitative research design allows for multiple facets of the phenomenon to be studied and understood. It is an approach to research that facilitates the exploration of a phenomenon within its context using a variety of data sources.

4.3.2 Study population and data collection

The study population consisted of twenty-eight key informants and forty-six FGD participants. Key informants were purposively selected based on their roles in CA knowledge sharing in their respective counties. Key respondents for the KII included media personnel, ICT Authority officer, e-extension coordinator, Director of the Agricultural information centre, chief agricultural officers, extension staff, and monitoring and evaluation officers.

Two interview guides were used to collect KII data. The guide for actors in policy and extension was used to collect data on the ICTs used to disseminate agricultural information, how ICTs are integrated with other dissemination methods, the context under which ICTs are used, advantages and limitations of using ICTs (Appendix 2).

The interview guide for ICT service providers and institutions was used to collect data on the type of ICT tools used, type of agricultural information, the costs incurred in using ICT tools and institutional collaborative arrangements (Appendix 3). KIIs are used for obtaining an in-depth understanding. They were also used to understand the type of ICT applications used by the actors involved in CA promotion.

4.3.3 Focus Group discussions

Forty- six participants belonging to five different CA farmer groups were purposively selected from five wards for participation in focus group discussions. Participants for each FGD ranged between 6-12 and the criteria for selection were: (i) a CA practicing farmer for over two years; (ii) participation in more than two CA trainings and (iii) an active group member. FGDs were used because of their ability to stimulate interaction between group members and to gain in-depth data (Jamieson & Williams, 2003). FGDs captured data on what ICTs farmers use, what access farmers have to ICTs, who use ICTs to share CA information, and the type of CA information.

4.3.4 Data analysis

Data were analysed using thematic and content analysis using the method by Schutt, (2011). Merriam & Tisdell (2015) suggest that a qualitative research approach produces narrative data and text that comes in many forms. Content analysis was used for identification, analyzing, organizing, describing, and reporting themes found within a data set. The analysis approach was suitable for

the study because it enabled the researcher to identify patterns and themes as tentative answers to the research questions from oral narratives. Codes were derived from the field notes using the inductive approach as suggested by Merriam & Tisdell (2015) by attaching meaning to individual narratives basing on the researcher's perception and experience. The steps followed included (1) conducting the interviews and transcribing the data (2) familiarizing myself with the data through reading and re-reading the text (3) generating initial codes by displaying coded data (4) searching for and reviewing themes and (5) defining and naming themes. To bring meaning to the words, one has to identify the themes and patterns and organise them into coherent categories. The themes generated through FGDs and KIIs are summarized in (Table 4.1)

Table 4.1: Thematic and axial categories from the KIIs and FGDs data.

DIT Tenet	Themes	Axial codes/categories
1. Social systems	Type of agricultural knowledge sharing systems	1. Government 2. NGO
2.Communication channels	Type of ICT tools used Type of applications used	1. Basic ICT tools 2. Smart mobile tools 3. Web based tools 4. Social media 5. Interactive voice response 6. Mobile enabled websites 7. Android enabled agric. 8. applications

Source: KII & FGD data 2015/2016

4.4 Results and Discussion

4.4.1 ICT Communication channels used in conservation agriculture knowledge sharing

According to Rogers, when an individual learns about an innovation, they seek information about the innovation and they ask questions about the “What”, “how” and “why” The information they seek should be relevant, timely and packaged in the right way (Sahin, 2006). This forms part of communication which is an important process for farmers to understand an innovation. To achieve this, communication channels are used. Table 4.2 shows the difference actor categories, the ICT tool and applications and who was using to share information

Table 4.2: ICT tools and applications used for agricultural knowledge sharing

Actor Categories	What ICT tools	Type of application	Who uses to share information
Government Extension agents	Radio	e-extension	MoALF, Laikipia & Machakos extension officers.
	Mobile phone	Social media	
	Television		
	Tablets	e-subsidy –register farmers for fertiliser	MoALF & Machakos extension officers.
	Laptops/desktops		
NGOs	Radio	Soko-pepe (Virtual market)	Arid Lands Information Network & partners.
	Mobile phone		
	Television		
	Tablets	Tangaza pesa (Payment platform)	Arid Lands Information Network & partners.
	Laptops/desktop computers		
		Plantwise	CABI & Extension
		Ishamba	SNV & Extension
		Websites, social media	World Vision , ACT, CARITAS
Farmers	Mobile phone	SMS , phone calls	Farmers, extension officers (<i>Government & NGOs</i>)
	Radio		
	TV	Radio & TV shows	
Researchers	Radio , TV,	Radio & TV shows, websites	Researchers, NGO & extension
	Mobile phones		
ICT service providers	Radio, TV, mobile phone & computers	Radio & TV shows, websites	Radio (Innooro, Sauti ya Mwananchi Radio) Citizen TV, Laikipia county times.

Source: KII & FGD data 2015/2016

4.4.2: Types of Knowledge sharing models

Government knowledge sharing model

The public domain was represented by the government knowledge sharing model. Here, the ICT applications consisted of the e-extension and e-subsidy programs initiated in 2013 and

2016 respectively by the Ministry of Agriculture, Livestock and fisheries (MoALF). These were implemented in Laikipia and Machakos counties and the type of agricultural information shared was general as illustrated in Figure 4.1

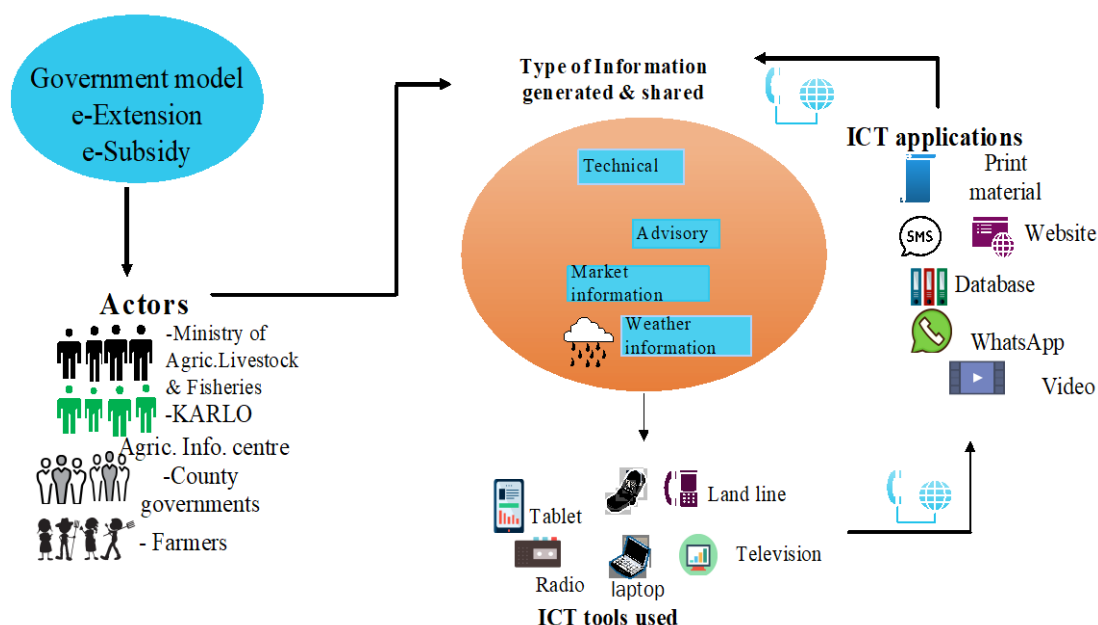


Figure 4.1: Government ICT model used for agricultural Knowledge sharing

In this model, an e-extension officer generated databases that were used to update farmers on inputs, weather, diseases and pests. Extension officers were equipped with ICT tools like laptops, modems and mobile phones to enable them to search from online agricultural sources. They were then expected to disseminate this information using SMS, phone calls, farmer visits, exhibitions and the information desks placed at the county and ward levels. The main collaborating partners to this system included the National Farmers Information Service (NAFIS), Kenya Seed company, Infonet Biovision and Kilimo whose websites were used as information sources.

The e-fertilizer subsidy program, the second application under this model, was rolled out in 2016 in both mobile and web-based ICT applications. This program was mainly based on data and SMS to manage the issuance, redemption and reconciliation of vouchers given to farmers. It also had databases of targeted farmers and agro-traders which were utilized to allocate fertilizers to farmers, verify and vet farmer profiles.

Findings from this model show that support to implement knowledge sharing is from multiple actors. These come from the central government, local county governments, the NGOs

and farmers. Laptops and tablets were used in documentation of farmer's activities, capturing data into databases and smartphones were used to communicate and capture pictures from the farmers' fields. One of the respondents stated that '*...I have been trained to send information and queries from the field, for example, I take photos of diseased crops and send to my extension officer for feedback. Use of this system is very effective as it enables faster interaction with the farmers and they get fast responses at lower costs...*' KII, Crops Officer Laikipia County, 27th April 2015).

The advantage of this model was that it allowed easy access to information through the extension officers. Since it was running on a government budget, services were offered "freely" to farmers. This model also made use of interactive communication tools. The assistant agricultural officer, Kola ward, Machakos in his view of the system stated that, '*... We use laptops and tablets to register farmers for the e-subsidy fertilisers and we use the mobile phones for the description of the plant diseases and pests and give recommendations to the farmers on the appropriate chemicals to use...*' (KII, 5th September, 2016).

However, respondents from the FGDs said that although this was a good mechanism of receiving information, they could not afford smartphones, lacked skills and sometimes faced challenges with the costs of SMS. Lack of power to charge their phones at home and network problems in some areas that were far from the town centres were some of the other challenges cited.

From the analysis, the advantage of this model is that its robust ICT structure made use of the traditional ICTs that most farmers owned. It was implemented by government extension officers placed throughout the counties and financed by a government budget. The disadvantages were in the use of traditional ICTs which limited the repackaging of information. The sustainability of this model was also subject to government funding both at the central and local levels. Zhang *et al.* (2015) suggest that government-led mechanisms are the most suitable for low income farmers in developing economies as free services are often offered by government and allow access to information. From the results, it is noted that government had a robust ICT extension structure that enabled information to reach farmers at the village level.

Mangombe and Sabiiti (2013) also had similar findings and noted that, even though the private sector has a growing role in agricultural knowledge generation, research and development, the public sector will continue to generate knowledge, information and technologies for the poor.

This is because poor farmers are usually unable to meet the costs associated with private sector participation in the agricultural knowledge systems.

The NGO knowledge sharing model

The NGO model (Figure 4.2) though still in infant stages offered CA information that was crucial to the effectiveness of the knowledge system. The model was also deemed suitable in areas where farmers had adopted the technology and knew their information needs. In this model the ICT applications included “*Soko pepe*” (Kiswahili word for “virtual market”) and “*Tangaza Pesa*” mobile phone-based payment solution initiated by Arid Lands Information Network (ALIN). “Plantwise” another ICT application was implemented by the Centre for Agriculture and Biosciences International (CABI) through the plant clinics on market days, farmers were able to interact with the system.

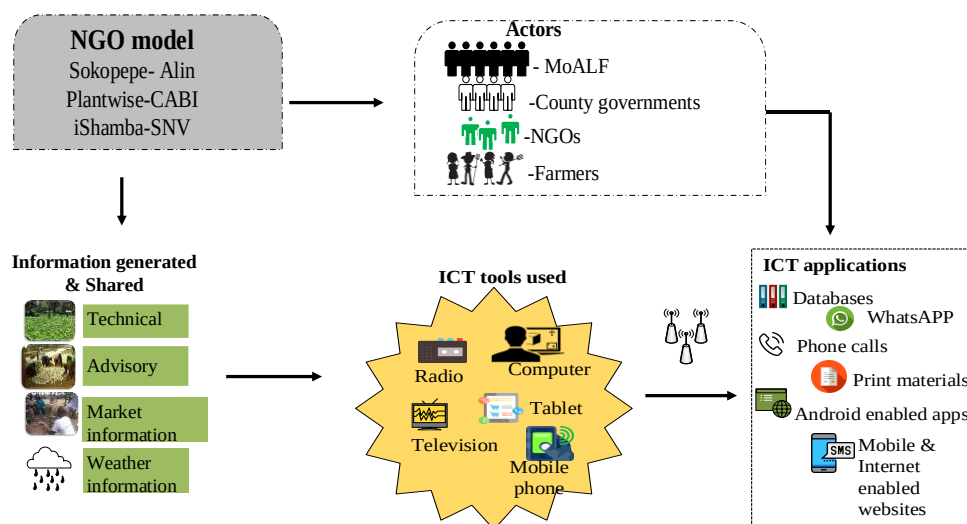


Figure 4.2: NGO ICT model used for agricultural knowledge sharing

“iShamba” an SMS mobile-based system was implemented by SNV. This system was comprised of an SMS and call centre based mobile application from which farmers received information on market prices, weather, crops and livestock every week.

The model was driven by the need to provide custom-tailored information to specific segments of farmers. Farmers contributed to the costs of receiving the information through the use of Short Messaging Service (SMS), Interactive Voice Response (IVR) and Unstructured

Supplementary Service Data⁸ (USSD) technologies. However, costs related to provision of information were subsidised by the NGOs who paid fees to the telecommunications service providers. A similar study by Perrier, DeRenzi, and Anderson (2015) noted that the use of USSD for improved data collection allowed for immediate validation. The menu systems also eliminate the need for using complicated syntaxes to fit as much information as possible in a single SMS.

An example of this model was demonstrated through one of the partnerships where the Arid Lands Information Network was collaborating with the Kenya Meteorological services and the Agricultural sector development program. Arid Lands Information Network shared information on behalf of the partners through its ICT platforms, “Sokopepe” and the community information kiosks “the Marifas” that were placed in different parts of the county.

In Machakos county, a key respondent stated that ‘...*In this collaboration (between Machakos county and CABI) extension staff have been trained as plant doctors to diagnose plant health problems presented by individual farmers during the plant clinic days. Farmers are given prescription and recommendations on site or through their phones when they call in...*’ (KII, Machakos, 14th August, 2016).

The advantages of this model were that it had interactive communication tools and it also incorporated the use of GPS technologies that could be used to provide location-related information services. The model was also composed of online communities suggesting that there was active user interaction. The other advantages included the provision of quality and diversified content to meet the farmer’s information needs.

The main disadvantage of this model was that knowledge sharing was limited to farmers in their project areas. Other limitations were in the time required for the maintenance of services. It also required advanced IT skills and was only accessible to users who could afford the service. This model worked well if there was adequate communication infrastructure, smart devices and a well-established IT infrastructure and personnel. Referring to the disadvantages of this model, some FGD respondents stated that,

⁸ USSD is a protocol defined within the GSM standard as a session-based protocol like the Interactive voice response that supports the exchange of text data, like SMS. Common uses of USSD is the interaction with telecom carrier such as buying airtime or subscribing to information services.

‘...We get CA information through NGOs like the World Vision, FAO, African Conservation Tillage Network during field days and training in the farmer field schools. Sometimes these NGOs air radio programs on Adiyani FM or on Musyi FM, where we are invited to talk about our farming experiences... but if you want to know the price of maize in the market from “sokopepe”, the SMS costs are high’. (FGD, Mbiuni Ward, 8th September 2016).

During the key informant interviews, respondents suggested that the incentive the county governments could provide for them to easily use ICTs, was to negotiate the cost of SMS for agricultural information with telecommunication providers. Text messages were considered ideal for smallholder farmers because when one received it, it could be stored on the phone and read at one’s convenience. Other incentives suggested were the easing of licensing procedures for ICT agriculture-related businesses.

Sanga, Kalungwizi and Msuya, (2013) suggest that any extension model that includes the use of ICTs is far much better than any other models of agricultural extension services. The authors give examples of models like the NGO extension model, private extension model and national public extension models that have successfully used ICTs to disseminate information to farmers. The NGO ICT model demonstrated that ICT applications in agriculture information systems were developing at a rapid pace. This was through the use of advanced mobile technologies in most of the online platforms used. According to Assefa *et al.*, (2014), in any knowledge diffusion model, the communication channels play a central role. Users must take advantage of the existing relevant and appropriate ICTs to prioritise, interpret and apply information. Mirembe, *et al.*, (2016) suggest that ICT- based models have to be anchored on ICT platforms, these act as repositories for information and provide tools for collaboration and interaction with farmers as a result there is increased use of services.

Community knowledge sharing model

The third knowledge sharing system was the community ICT model composed of farmer groups and individual farmers. In this model, the farmers used traditional ICT to share CA agronomy information. The social structure of the farming systems was organised along the CA farmer groups where knowledge sharing was at interpersonal level, during field days, in the farmer field schools

and during exhibitions. This structure was composed of the lead or model farmers who hosted the CA demonstration fields and other members of the group who transferred the learning from the demonstration fields to practice in their fields. Zhang et al, (2016) suggest that community information models are important for rural agriculture information dissemination. The community model in this study was loosely organised and used interpersonal communication. The main ICT tool in use in the CA small holder farming communities was the basic mobile phone to receive information on trainings and field days. This model provided the context within which the government and NGOs knowledge sharing models operated. In farming communities where such models work, the local communities organise, finance and facilitate knowledge sharing activities as stated in similar studies (Assefa *et al.*, 2014).

The three models suggest that no any one model can work in isolation. Whilst the government model had the e- extension infrastructure that could be used to share agriculture information up to the village level, but CA information shared was negligible. The NGO model had integrated the use of new ICTs and was majorly sharing CA information but its outreach was minimal. For effective outreach, it would have to make use of the government e-extension infrastructure.

From the results, for the effective utilisation of ICTs in CA knowledge sharing systems, a flexible model taking advantage of the government ICT infrastructure and advanced ICTs used by NGOs is proposed. This would enable more smallholder farmers to be reached by extension services. This proposed model (Figure 4.3), integrates the NGO model with the government model as this would enable integration of CA information into Agricultural knowledge systems.

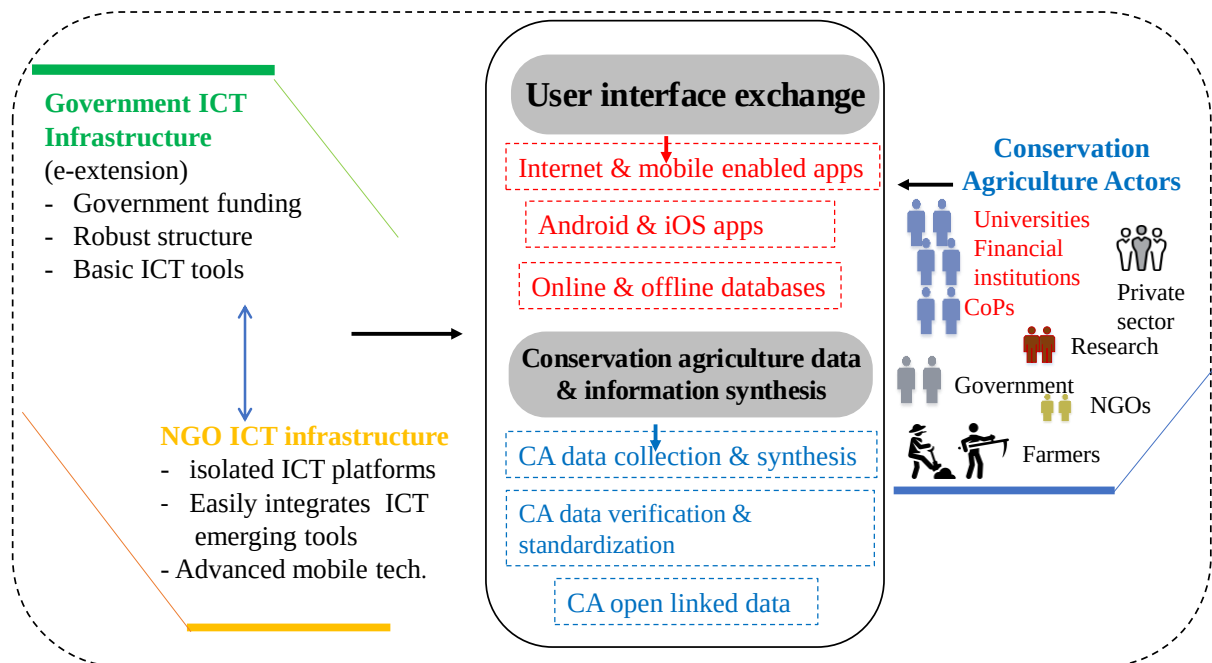


Figure 4.3: An integrated ICT conservation agriculture knowledge sharing

The integrated model has five main sections, (i) Government ICT infrastructure that is anchored on the e-extension structure and supported by a government budget. This section of the model integrates the use of ICTs in extension services. (ii) NGO ICT infrastructure is comprised of isolated ICT platforms and makes use of advanced mobile technologies needed for integration of emerging new technologies in agriculture knowledge systems. (iii) the user interface Apps. provide the domain within which to use new ICTs, (iv) data and information synthesis domain provides the option for use of an open data system where CA information can be centrally collated and lastly the (v) actors who determine how emerging ICTs can be used in CA knowledge sharing.

4.5 Conclusion and recommendations

The study was designed to analyse the ICT tools and applications used for CA knowledge sharing. It was evident that agricultural knowledge sharing takes many forms as demonstrated by the different models. The use of ICTs in the different models were also at different levels. However, the government ICT model demonstrated a robust e-extension program that had well established structures up the village level. Even though the NGO model was using advanced mobile and web based ICT technologies, these were individual and at organisational level. The government and

NGO knowledge sharing models were two separate entities each having its own unique ICT infrastructure that could be leveraged for CA information sharing

Agricultural knowledge sharing takes many forms as demonstrated by the different actors using a variety of ICTs and applications to share agricultural information. It was also clear that the use of ICTs for CA information was very weak as this was limited to a few NGOs who lacked the robust ICT infrastructure required for an effective ICT knowledge sharing strategy. The community model provided the context within ICTs would be used by the farming communities. But this also required that there was ownership of ICTs at the farmer level and some basic skills for effective knowledge sharing. The ICT tools used for knowledge sharing were limited to the basic tools like radio, mobile phones and television expect for the ones used by the NGO actors. The study recommends that for effective utilisation of ICTs for CA knowledge sharing, several factors have to be taken into consideration, the ICT infrastructure in place, the type of information shared and the ICT readiness of the users in terms of access to ICT tools and facilities.

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CHAPTER FIVE

GENERAL DISCUSSION OF RESEARCH FINDINGS, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

Although the use of ICT applications in agriculture have developed significantly in Kenya, its use in the knowledge systems for specific innovations like Conservation Agriculture and how it influences information sharing and application is low. The objective of this study was to analyse the effective use of ICTs in conservation agriculture knowledge sharing and application among smallholder farmers in Machakos and Laikipia counties. Specifically the study sought to (i) determine the knowledge sources and pathways in conservation agriculture knowledge sharing and the factors that influence their use (ii) Establish Actor positioning and how it affects information sharing in the conservation agriculture knowledge network and (iii) Analyse the use of ICTs in conservation agriculture knowledge sharing. This chapter provides a summary of the findings, general conclusions and recommendations for practice, policy and future research.

Agricultural knowledge and Information systems play an important part in the agricultural transformation process. Research shows that any ICT intervention that improves livelihoods of rural smallholder farmers is likely to have a significant impact on enhancing agricultural production (Mugwisi, *et al.*, 2015). The results of this study shows that use of ICTs was low in the conservation agriculture knowledge systems. ICTs actors were at the periphery of the knowledge network, indicating their limited role in sharing conservation agriculture information.

5.2 Overview and General discussion of Research Findings

Actors in the CA knowledge network control how and what type CA knowledge flows in and out of the network. This flow of CA knowledge determines how farmers become aware of innovations. Results in chapter two, showed that government extension, NGO extension and fellow farmers were key knowledge sources for conservation agriculture knowledge. The pathways used for CA knowledge sharing were limited to the traditional ones and basic ICTs were used.

The priority information needs for the respondents in this study were on agronomy specifically on weed management which is a persistent challenge in the first three seasons of production practising conservation agriculture. Other pertinent agronomic information needs were on land preparation, herbicide use and application, pest and disease management. The second priority information needs were on the three principles, specifically on cover crops types, procurement of seeds, access to conservation agriculture tools and equipment for planting, weeding and harvesting and accessibility to conservation agriculture service providers.

The results in chapter two, show that one of the challenges of conservation agriculture knowledge sharing are the variuos definitions and how the three principles are applied. As a result farmers receive conflicting messages. Whitfield *et al.*, (2014) concur that international institutions and local NGOs have different interpretations of conservation agriculture and deliver conflicting messages to farmers.

The study also shows that there are various factors that influence a farmer's choice to ICTs for CA information. These include land under CA, accessibility to communication networks, education level of the farmer and costs associated with the use of ICTs. This study is aware that there are various other factors, that may affect smallholder farmers' use of ICTs for Conservation agriculture and recommends this as a research gap that needs further exploration. Similar studies by Churchird, Sasaki & Abe (2017) and Razmerita, Kirchner & Nielsen (2016), show that factors that influence use of agricultural information, are positively associated in some cases and are negatively associated in others cases. Vaiknoras *et al.*, (2015), notes that promotion of technologies should be context specific than being fitted to people of a certain profile.

In my analysis of the conservation agriculture knowledge network six main categories of Actors were identified. These included, Government, NGOs, Farmer, Research, ICT, and the Private sector (Chapter 3). Positions of prominence and influence were occupied by the county governments and the farmer. ICT actors were periphery actors indicating the low influence they had in network. The information sharing relationships were also notably weak as indicated by the low network density and the fact that there only three main prominent actors. The social processes were demonstrated by the density of reciprocated and unreciprocated ties demonstrating the level of interactions and information sharing. The overall network structure indicated that it was

underutilised resulting in weak information sharing relationships. Similar findings by Gunter *et al.*, (2016), noted that networks play an important role in knowledge exchange and have been used to identify local agricultural knowledge hubs, and network structures for effective diffusion of technologies.

The findings in Chapter four, showed that agriculture information sharing took place at three levels, government, NGO and community. Although traditional ICTs were used in the government ICT model, the infrastructure was robust and had the capacity to reach farmers at the village level, which was not the case with the other models. The results showed that the NGO knowledge sharing model had advanced mobile technologies but information was shared at individual NGO level targeting specific groups of farmers. An integration of the two systems would enable a more efficient use of ICTs and faster flow of conservation agriculture information to farmers. Similar finding by Lin *et al.*, (2017), suggest that ICT systems in agriculture have improved significantly and are used in many aspects of agricultural development. These systems are in precision farming, mobile applications and provide platforms for collaboration between researchers and farmers.

Overall, the results show that although there is integration of ICTs in agricultural knowledge systems, its utilization is still very low. The findings show that ICTs have not been optimally integrated in agriculture knowledge systems for conservation agriculture knowledge sharing.

From the analysis of the knowledge sources and pathways while advanced mobile technologies are increasingly integrated in the overall agricultural knowledge systems, The results of this study show that the e-extension system focused on sharing general agricultural information. Existing literature shows that where ICTs have been integrated in agricultural extension, awareness and knowledge of the technologies have increased (World bank, 2017).

5.3 General conclusions

It is evident from this study that; the Agricultural knowledge systems are not optimally utilized for conservation agriculture sharing. This is demonstrated by the weak information sharing relationships in the conservation agriculture knowledge network. The use of the different

knowledge source and pathways reflected that farmers required different types of information from multiple sources. However, the sources used for sharing conservation agriculture information were limited to the conventional ones and for the ICTs to radio, basic mobile phones and television. This points to a need for integration of advanced ICT applications to enable effectiveness and efficiency in conservation agriculture knowledge sharing.

In the structure of the conservation agriculture knowledge network, only three actors in positions of influence led to more fragmentation of the network thereby affecting the efficiency of the network. Social networks support multiple knowledge sharing processes by enabling faster diffusion of information through actor interactions, therefore if there are few actors in positions of influence, it means diffusion of information is slow. Since knowledge networks are increasingly taking over the role of formal systems and enabling complex knowledge systems like that of conservation agriculture to function within the overall framework of agriculture knowledge systems, such networks should be strengthened through policy and budgetary support.

Integration of ICTs in the conservation agriculture knowledge systems requires that supportive infrastructure is in place. The presence of the ICT Authority department at Machakos county indicated some level of e-readiness. With the improvement of infrastructure like roads and electricity in the counties, establishment of cyber-cafes becomes easier thereby making accessibility to ICTs by farming communities easier as services are drawn nearer in rural areas. Conservation agriculture is a technology that is deemed to be complex due to its infant knowledge system, the integration of ICTs could address this complexity.

Overall, the study concludes that a conservation agriculture knowledge sharing framework that guides how knowledge should be collated, verified and disseminated to smallholder farmers is embraced. This could further be reinforced by having a standardization unit comprised of research institutions and universities to synthesize and standardize the packaging and information shared by the various stakeholders.

Lastly the use of ICTs in the promotion of agricultural technologies increases awareness and uptake of technologies through improvement of the knowledge sharing processes. ICTs are enablers in any knowledge sharing process, integration of traditional and new emerging ICTs in

the agriculture knowledge systems would improve the awareness of innovations like conservation agriculture.

5.4 Recommendation for Practitioners, Research and Policy

The following recommendations are suggested based on the key findings.

Practitioners

From the results above, it is evident that farmers use multiple information sources and pathways to share conservation agriculture knowledge. It is recommended that for effective delivery of conservation agriculture information, there is a need for the integration of agricultural knowledge sources and the various pathways used by extension services.

There is a need for ICT actors to take on a more active role to enhance conservation agriculture knowledge sharing by facilitating access to timely and accurate information for smallholder farmers. The gradual integration of the emerging ICT technologies like open data, crowdsourcing and use of USSD technologies is recommended. Actors in influential positions should play a facilitation role that brings together all the actors, to enable active interaction and sharing of conservation agriculture knowledge.

Policy

It is important to have a CA knowledge sharing framework at the county level, that integrates the use of traditional ICTs with the conventional methods of sharing agricultural information. Traditional ICTs are still the predominantly used by smallholder farmers. There is a need to strengthen the co-financing and multi-stakeholder frameworks proposed for conservation agriculture promotion at the county level. This is a good step towards inclusion of actors that would have otherwise been isolated. Collaborations among the stakeholders need to be formalised. Overall, the results and recommendations proposed above point towards a need for the integration and use of ICT pathways in conservation knowledge systems.

5.5 Contribution to Research

This research contributes to the existing literature by providing an integrated ICT conservation agriculture knowledge sharing framework. Most of the available e-agriculture frameworks focus on the ICT tools and/or mixture of ICT technologies and not on the knowledge sharing models that lead to effective use of ICTs in agricultural knowledge sharing. This research

attempts to fill this gap by generating a framework that provides for an articulation of agricultural knowledge sharing models that integrate ICTs.

This research also contributes to the body of knowledge on agricultural innovation systems in the area of Agricultural knowledge systems and adoption of new technologies. A key output from this study is the proposed Conservation Agriculture ICT knowledge sharing framework, recommended for the integration of emerging ICT technologies which can be implemented at two levels. In terms of the use of ICT tool and integration of the ICT capacities of the different institutions. Although the concept of conservation agriculture and its adoption has been widely researched, this is one of the very few studies that investigates how ICTs are utilized in agricultural knowledge systems.

5.6 Areas for further research

Further research is needed to understand how smallholder farmers utilize the emerging ICT technologies for their agricultural information needs. This will require understanding the smart devices owned and used for agricultural information at the farmer level. This would provide useful insight at the design level for e-Agricultural knowledge sharing systems. The study also indicated that central actors in the CA knowledge network were very few and this results in the disintegration of the network and a disruption in the knowledge flows. Future research should focus on understanding how knowledge networks can actively sustain actor engagement in diffusion of new technologies. Such studies should also analyse how central actors and actors in brokerage roles create new network links for more dynamic network structures, resulting in optimal knowledge sharing. Although the results indicate that use of ICTs in agricultural knowledge systems is increasing, additional research is needed to understand the factors that influence sustained use of ICTs by smallholder farmers for agricultural information. Such studies should aim at establishing whether increased use of ICTs for agricultural knowledge is a reflection of effective e-Agriculture knowledge systems.

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APPENDICES

Appendix 1: Household survey instrument

Questionnaire No: _____ Date: _____

Enumerator Name: _____

Bio Data:

1. Respondent No: _____

2. Sub county _____ Ward _____

(Please circle the appropriate number for sub -county and division respectively)

Sub-county	Ward
1. Machakos	1. Kalama
2. Mwala	2. Machakos central
3. Yatta	3. Mwala
4. Lakiapia East	4. Yathui
5. Lakiapia North	5. Katangi
	6. Kithimani
	7. Yatta
	8. Mukogondo East
	9. Umande
	10. Tigithi
	11. Ngobit

3. Name of respondent: (optional) _____

4. Telephone no. of respondent (optional) _____

5. Gender of respondent: (Please circle the appropriate)

1. Male 2. Female

6. Age of respondent (please write in years): _____

7. Marital status of respondent (Please circle appropriate box)

1.Married [] 2.Widow [] 3 Widower [] 4. Female headed []

5. Separated [] 6. Child headed []

8. What is the highest level of education you have attained? (Respondent to give level of education and please compute in years of schooling)

9. What is your main occupation? (Please circle only one)

1. Farming []

2. Agro pastoralist []
 3. CA Service provider []
 4. Government employee []
 5. Self –employed [] Indicate trade _____
 6. Other (specify) _____

10. What is the main occupation of the household head?
(If not respondent, please write occupation in the space below)

General Agricultural Practice

11. What are the three most important crops you have grown since last season?
(Please circle the three most important)

Categories		Crops			
1. Cereals	Maize []	Wheat []	Millet []	Rice []	
2. Grain legumes	Dry beans []	Pigeon peas []	Green grams []	Dolichos []	
3. Roots and Tubers	Potatoes []	Sweet potatoes []	Cassava []	Arrow roots []	
4. Fodder	Silage []	Hay []	Fodder trees []		
5. Horticultural					
4. Others (specify)					

12. What type of farming do you practice?
(Please circle the three most important)

1. Conventional []
2. Conservation Agriculture []
3. Organic []
4. Others (specify)

13. How much land does this household currently own? *(Record land size as given – total ownership)*

14. How did you acquire this land? *(Please write in the space below and record size)*

15. How much of this land is under agricultural production? *(Record size as given)*

16. How much of the land is under Conservation Agriculture farming? *(Record Land size as given)*
(Skip this question for non- CA adopters)

17. What type of Livestock do you own?

(Please circle only the three most important and indicate number of each, rank in order of importance)

(1- very important 2- important 3- not important)

1. Cows []
2. Sheep []
3. Goats []
4. Donkey []
5. Poultry []
6. Others specify _____

18. What is the most important use of your livestock on the farm?

(Please circle only three and ask the farmer to rank in order of importance)

(1- very important 2- important 3- not important)

1. Ploughing []
2. Planting []
3. Ripping []
4. Weeding []
5. Source of manure []
6. Other (specify) _____

Conservation Agriculture farming practice

19. How did you learn about Conservation Agriculture?

(Please circle only three and ask the farmer to rank in order of importance)

(1- very important 2- important 3- not important)

1. Farmer Field schools []
2. Fellow farmer(s) []
3. Government extension services []
4. NGOs []
5. Research Centre []
6. Trainings/ workshops []
7. Exhibitions []
8. Field days
9. ICTs (1.radios 2. sms 3. websites, 4. social media)
10. Others (specify) _____

20. How has each of the methods below been useful to you in learning more about CA?

(Skip for non- CA adopter, proceed to 20 A)

20:A How has each of these methods been useful to you in your farming practice?

Farmer Field Schools: _____

Fellow Farmers: _____
 Government Extension workers: _____
 NGOs: _____
 Trainings: _____
 Research Centres: _____
 Field day _____
 Website: _____
 Radio: _____
 SMS: _____
 Others: _____

21. What challenges have you faced while using each of these methods to learn about CA?
(Skip for non- CA adopter, proceed to 21: A)

21:A What challenges have you faced while using each of these methods in your farming?

Farmer Field Schools: _____
 Fellow Farmers: _____
 Government Extension workers: _____
 NGOs: _____
 Trainings: _____
 Research centres: _____
 Field days: _____
 Website: _____
 Radio: _____
 Sms: _____
 Others: _____

22. How have these methods influenced your decision to practice CA? **(Skip for non-CA adopter)**

Information Communication Technology Use

23. Have you been accessing CA information through any of the following ICTs? **(Skip for non-CA adopter, proceed to 23 A)**

(Please circle only three and ask the farmer to rank in order of importance)

23 A: Have you been accessing agricultural information through any of the following ICTs?

(Please circle only three and ask the farmer to rank in order of importance)

(1- very important 2- important 3- not important)

- | | |
|------------------------|-----|
| 1. Radio | [] |
| 2. TV | [] |
| 3. Mobile phone (sms) | [] |
| 4. Information kiosk | [] |
| 5. Newspapers | [] |

6. Other (specify) _____

24. Which one do you find most appropriate to use? *(please circle only one)*

- | | |
|----------------------|-------|
| 1. TVs | [] |
| 2. Radios | [] |
| 3. Mobile telephones | [] |
| 4. Websites | [] |
| 5. Community centres | [] |
| 6. Others (specify) | _____ |

25. Which ICT is most affordable for you to use in accessing CA information *(Circle and rank the three most affordable)* **(Skip for non- CA adopter, proceed to 25:A)**

(1- Most affordable; 2- affordable; 3- not affordable)

25:A. Which ICT is most affordable for you to use in accessing agricultural information *(Circle and rank the three most affordable)*

(1- Most affordable; 2- affordable; 3- not affordable)

- | | |
|----------------------|-------|
| 1. TVs | [] |
| 2. Radios (handsets) | [] |
| 3. Community radios | [] |
| 4. Mobile telephones | [] |
| 5. Websites | [] |
| 6. Community centres | [] |
| 7. Others (specify) | _____ |

28. What challenges do you find in using ICTs to access CA information? **(Skip for non- CA adopter, proceed to 28:A)**

(Please circle only three and ask the farmer to rank in order of importance)

(1- very important 2- important 3- not important)

28:A. What challenges do you find in using ICTs to access agricultural information?

(Please circle only three and ask the farmer to rank in order of importance)

(1- very important 2- important 3- not important)

- | | |
|--------------------------------|-------|
| 1. Lack of skills | [] |
| 2. Lack of training | [] |
| 3. High costs | [] |
| 4. I do not own | [] |
| 5. No network (infrastructure) | [] |
| 6. No accessibility | [] |
| 7. Others (specify) | _____ |

29. What would you suggest is the best ICT for accessing CA information? **(Skip for non- CA adopter, proceed to 29:A)**

29:A. What would you suggest is the best ICT for accessing agricultural information?

Social Economic factors

30. How do the roles that you perform at the household level affect your use of ICTs to access CA information? (***Skip for non- CA adopter, proceed to 30:A***)

30:A. How do the roles that you perform at the household level affect your use of ICTs to access agricultural information?

31. Who owns the different ICT tools that you have in the household?

1. Radio_____
2. Mobile phone_____
3. TV_____
4. Computer Pc_____
5. Laptop_____
6. Other_____

32. How do you pay for the cost of accessing CA information using any of the ICTs above? (***Skip for non- CA adopter, proceed to 32:A***)

32:A. How do you pay for the cost of accessing Agricultural information using any of the ICTs above?

Impact

33. Why did you decide to take up the CA practice? (***Skip for non- CA adopter, proceed to Q.35***)
(Please circle only one)

- | | |
|-----------------------------|-------|
| 1. Other farmers practicing | [] |
| 2. Government promotion | [] |
| 3. NGO promotion | [] |
| 4. Better yields | [] |
| 5. Better soils | [] |
| 6. More income | |
| 7. Others (specify) | _____ |

34. What are the main changes that have occurred since you started practicing CA?

1. Yields _____
2. Income _____
3. Labour saving _____
4. Soils _____
5. Others (specify) _____

35. What challenges do you face with the CA farming practice? (***Skip for non- CA adopter,***

proceed to Q.35:A)

(Please circle only three and ask the farmer to rank in order of importance)

(1- very important 2– important 3- not important)

35 A:. What challenges do you face in your farming practice?

(Please circle only three and ask the farmer to rank in order of importance)

(1- very important 2– important 3- not important)

- | | |
|--|-----|
| 1. Limited access to inputs | [] |
| 2. Limited access to equipment | [] |
| 3. Limited access to service provision | [] |
| 4. Where to find CA information | [] |
| 5. Access to Markets | [] |
| 6. Others (specify) _____ | |

36. What are your main information needs on conservation agriculture? (***Skip for non- CA adopter, proceed to Q 37)***)

37. What are your main information needs in the traditional farming methods?

38. What would you suggest is the best way to get CA Information? (***Skip for non- CA adopter, proceed to Q 38:A)***)

38:A. What would you suggest is the best way to get agricultural Information?

Thank you for taking time to respond to these questions.

Appendix 2: Key Informant Interview Guide- ICT service providers/Institutions

Process: Introduction and building rapporteur

Seeking consent:

The purpose of this interview is understand how ICTs are used in the dissemination of conservation agriculture practice among small holder farmers. Anything that we discuss will be used solely for the purpose of this study and nothing will be recorded without your consent.

Your participation in this interview is completely voluntary.

Are you willing to be interviewed?

Do you have any questions before we begin?

Date:

County: _____ Sub-county: _____

Division: _____ Village/ Name of organization _____

Respondent Designation: _____ Name: (optional) _____

Gender: 1- M 2- F

Name of Interviewer: _____

Guiding questions

Section 1: ICT Applications in Agricultural information

1. What kind of information sharing activities does your institution engage in?

2. What ICT tool(s) do you use to provide agriculture information?

3. What type of agricultural information do you disseminate using this ICT tool(s)?

4. How is each of the tools used to disseminate information?

5. How do you use each of this tool(s) at each stage of the dissemination process below?

(Ask at each of these stages and tick appropriate)

a) At the awareness/ comprehension of the agricultural message?

b) At the skills level?

c) Is it to reinforce what message is being conveyed?

d) Is it at the implementation stage of the message being conveyed?

e) Or is it used when farmers come to give testimonies of how they used and benefited from the use of the tool?

Other useful comments _____

6. How do you use the ICT tool(s) with the traditional methods of dissemination?

7. How do you raise awareness to farmers and other users (*researchers, extension workers, NGOs* of the existence of these tool(s)?

8. How would you describe the use of this tool(s) among women farmers in comparison to the male farmers? (*ask for explanations on appropriateness, ease of use, skills, costs and time*)

9. What type of training have you been able to give the farmers to effectively use these tool(s) for information access?

10. What experience would you like to share on the use of this tool(s) in the provision of agricultural information to small holder farmers? (*ask for effectiveness, farmers response, policy support*)

Section 2: Social factors

11. Which is the most common means of communication between households? (i.e *how is information exchanged between households?*)

(**Note the differences in communication means among the different households*)

12. How would you describe the use of this tool(s) at the household level? (i.e *does a particular HH member dominate its use?*)

(**Note the differences in the use of the tools within the household and between the different genders*)

Section 3: Economic factors

13. As an organization, what kinds of costs do you incur for farmers to be able to use this tool? (*i.e what kind of arrangements have to be in place*)

14. How do you share the costs of using this ICT tool(s) between you and the farmer?

15. From your experience, are farmers able to meet the costs associated with the use of this tool(s)? (i.e costs in terms of finance, telecommunication infrastructure, time, location, complexity of the tool)

Section 4: Institutional Arrangements

16. Which institutions do you collaborate with in the provision of agricultural information?

17. What are the institutional arrangements in place that enable you to collaborate effectively?

*(*Note the nature of the collaboration)*

18. What role does each of these institutions play?

19. What challenges have you faced with such arrangements?

Section 5: Impact on farmer's knowledge

20. Since farmers started using this tool(s) to access information, what changes do you see in their Practice? (* Note the production/yield levels)

21. In what ways would you attribute the changes in farmers practice to the use of this tool(s)?

Thank for taking time to response to these questions.

Appendix 3: Key Informant Interview Guide- Policy and extension staff

Consent

The purpose of this interview is to understand how ICTs are used in the dissemination of conservation agriculture practice among small holder farmers. Anything that we discuss will be used solely for the purpose of this study and nothing will be recorded without your consent.

Your participation in this interview is completely voluntary. Are you willing to be interviewed?

Do you have any questions before we begin?

Date: _____

County: _____ Sub-county: _____

Division: _____ Village/ Organization _____

Respondent _____ Designation: _____ Name: _____ (optional)

Telephone no. (Optional) _____

Gender: 1- M 2- F

Name of Interviewer: _____

ICT use in agricultural information dissemination

1. In what ways is the county government supporting farmers to get information on agricultural technologies?

2. Could you explain the main approaches the county government uses to disseminate agricultural information to farmers?

3. Which are the common ICTs used to disseminate agricultural information to farmers? (**ICTs include; TVs, radio, mobile phones and web – based technologies like websites, social media*)

4. Would you explain how these ICTs are used in each of the dissemination approaches?
(Approaches e.g trainings, FFS, model farmers etc)

5. How are the ICT tools used in CA knowledge dissemination?

6. In the county, what agricultural programs are aired on Radio?

7. In what context do any of these radio programs address conservation agriculture?

- a) Farming Practice addressing the three principles:
- b) Service provision (*hand, animal or tractor*)
- c) Inputs (seeds, implements etc)
- d) Other

8. How does the community participate in the agricultural radio talk-shows that focus on conservation Agriculture?

9. In what ways are farmers involved in the conservation agriculture radio talk-shows? (*in planning, as speakers etc.*)

10. What approach is taken to reach the farmers who cannot listen in during the radio talk- show time?

11. How have listening clubs been used to enhance farmer access to CA information?

12. In what ways have information kiosks been able to provide CA information in the county?

13. To whom do the information kiosks belong (*private owned or public or both*)

(note their evolution, management)*

14. What was the main objective of setting them up?

(note the services they provide, the target groups, frequency, outreach)*

15. How do the service providers get the farmers to use the services?

*(*Note the incentives in place for farmers to use the services)*

16. In what ways has the mobile phone been used in the dissemination of conservation agriculture information?

17. Could you explain any specific agricultural mobile phone based information service that farmers use in this county?

18. Who provides the mobile phone based agricultural information service?

19. What experiences would you like to share on the use of mobile phones in agricultural information provision?

20. What would you suggest are some of the advantages that ICTs play in improving agricultural knowledge dissemination to small holder farmers?

21. What are some of the limitations in the use of the ICT tools discussed above in the agricultural dissemination process?

Institutional and Social factors

22. What incentives has the county government put in place to encourage people to set up cyber cafes, telephone kiosks or local radio stations? (*ask for kind of tax incentives, free space etc*)

23. To what extent have these incentives been taken advantage of by ICT service providers?

24. How is the nature of the collaborative arrangements between institutions in the provision of conservation agriculture information?

25. What challenges does your institution face in these collaborative arrangements?

26. How do you address such challenges?

Impact

27. Of the various dissemination approaches we have discussed, how would you describe the impact on the farmer's CA knowledge?

28. Could you give any examples to illustrate this?

29. What important changes have you seen in the farmer's practice as a result of accessing CA knowledge?

30. What other views would you like to share on how best conservation agriculture information dissemination could be improved using ICTs?

Thank you for taking time to respond to these questions

Appendix 4: Focus Group Discussion Guide

Process: Introduction session and setting of FGD

- a) Record date and location of the FGD (general setting)
- b) Opening remarks and introductions
- c) Explain purpose of the FGD
- d) Seek consent (*read consent form*) to conduct the discussion and assure participants of confidentiality.
- d) Be observant to capture non-verbal expressions

Tool

County: _____

Sub-county: _____ Division: _____

Village: _____ Farmer Group: (optional) _____

No. Male: _____ No. Female: _____

Date: _____

1. What are the different ways in which you get Agriculture information?

- a. *Have the group members generate a list of all the different ways in which they get Agricultural information?*

2. How do you get Conservation Agriculture (CA) information?

- (a) *Have the group members generate a list of all the different ways in which they get CA information?*

Prompts:

- Have you listed all the methods? (eg FFS, Trainings, Lead farmers, radio, TV, sms, Information kiosks, Governments, NGOs, fellow farmers)

- (b) *Using the Communication mapping exercise, for each identified method*

- a) What kind of information is got from each method?
- b) What is the source of this method?
- c) What kind of ICT is used in each of these methods? *(if conventional method of dissemination)*
- d) What are the advantages of each method?
- e) What are the challenges of each method?
- f) How easy is it for women to access CA knowledge using this method?
- g) How easy is it for men to access CA knowledge using this method?
- h) Which is the most preferred channel of getting CA information? By men? by women?
- i) To what extent does the source of information influence the farmer's decisions to take up the CA practice?

3. What are the social factors influencing the use of ICTs?

- (a) *Engage group members in a discussion on social factors and first generate list of ICTs at household and community level*

Prompts:

- a) Who owns the different ICT assets at the household level?
- b) Who owns the different ICT assets at the community level?
- c) Who makes the decision on the use of the different ICT tools at the household level?
- d) Who makes the decision at the community level?
- e) Can the tools be used by all members of the household equally?
- f) What challenges do farmers face in the use of ICTs to access CA information?

4. What are the economic factors influencing the use of the ICTs?

- (a) *Engage group members in a discussion to generate ideas of what possible economic factors could affect the use of ICTs in accessing information.*

(Economic factors include, income; costs of ICTs; airtime costs; proportion of income for other household needs viz a vis ICT costs)

Prompts

- a) Who buys the different ICTs in the household?
- b) Who buys them at the community level?
- c) Who makes the decision to buy these tools at the household level?
- d) Are any of the tools used to access agricultural information?
- e) Who pays the costs associated with accessing information using these tools?
- f) What proportion of the household income can be used to finance use of ICTs?

5. What changes have taken place in your farming practices as a result of accessing CA knowledge?

a) Using an agricultural timeline, engage the participants in recording the changes that have taken place in the farmers practice since they started accessing CA knowledge

Prompts

- a) When did the farmers learn about Conservation agriculture?
- b) From whom did they learn about conservation agriculture? (list the sources)
- c) How did the farmers learn of these sources?
- d) What are the main changes that have occurred since they started practicing CA?(*changes may include production techniques, change in type of equipment, in marketing, change in enterprise*)

Then for each change ask

- a) When was the change introduced to the farmer's practice?
- b) Why did the farmer make this change?
- c) How did it spread to other farmers?
- d) Were there any modifications made to how the farming practice was being done?
- e) What have been the advantages as a result of the change in practice?
- f) What have been the challenges associated with this change?
- g) What are the farmers' main knowledge needs relating to the CA practice?
- h) Which is the most effective method for accessing CA knowledge ?

Closing statement

Thank you all for your time and your valuable feedback. The purpose of this discussion was to find ways in which we can improve CA knowledge dissemination at the farmers' level.

Does anyone have anything else to add or any final questions?

Appendix 5: Introduction and Informed consent form**(i) Introduction and purpose of the study**

My names are Achora, Janet Cox a PhD student of Agriculture and Rural Innovation in the Department of Extension and Innovation Studies, School of Agricultural Sciences, College of Agricultural and Environmental Sciences, Makerere University. The objective of this study is to

understand how smallholder farmers get information for conservation agriculture and what ICT tools and applications they use. The study covers two counties, Machakos and Laikipia counties.

I will mainly be consulting smallholder farmers engaged in conservation agriculture, organisations promoting conservation agriculture and agricultural staff at the counties who work with the farmers and organisations. I do this through interviews and a household survey. There are no monetary gains for participating in this research but refreshment will be provided during the interview process. This information may not benefit you directly but it will be used to improve the process of how conservation agriculture knowledge is shared and applied.

(ii) Associated risks and rights to with draw

There will be no risks involve for participation in this research and you a free refuse to participate or withdraw from the research at any time. Your refusal to participate or withdrawal of consent will not affect your relationship with Makerere University, Machakos or Laikipia counties or result a loss of benefits from the organisations which provide you with inputs.

(iii) Feedback of the study results

I will share the results with the communities in the study site and in various stakeholders meetings or workshops and with Makerere University. In addition, the results will be available in written form as PhD Dissertation and journal publications. I will provide reports in case you request for it.

(iv) Consent and contact

Do you have any questions that you would like to ask?

Are there any things you would like me to explain again or say more about?

Do you agree to participate in the interview?

1) Yes (Thank the person(s) and continue with the interview)

2) No (Thank the person and close the discussion)

Contact details:

In case you have any other questions about this study later, you can contact:

Achora, Janet Cox

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School of Agricultural Sciences, College of Agricultural and Environmental Sciences,
Makerere University,
P.O Box 7062, Kampala Uganda
Tel: 0726224950/+256782866495
Email: jalonyo@gmail.co

Appendix 6: Contingency table for relationships between knowledge source and type of information

Knowledge source	Information type											
	CA				New				Market		Weather	
	Agronomy		information		Training		technologies		information		information	
	1	0	1	0	1	0	1	0	1	0	1	0
Government extension												
Use	191	88	179	100	150	129	58	221	17	262	4	275
Do not use	15	4	12	7	9	10	4	15	1	18	0	19
NGO extension												
Use	145	66	130	81	121	90	42	169	9	202	2	209
Do not use	61	26	61	26	38	49	20	67	9	78	2	85
Fellow farmer												
Use	118	62	104	76	106	74	42	138	9	171	2	178
Do not use	88	30	87	31	53	65	20	98	9	109	2	116

Appendix 7: Node and Tie data used for social network analysis

*Node data.

"ID"	"Type of actor"
Arid Land Information Network (ALIN)	NGO
CARITAS	NGO
African Conservation Tillage Network (ACT)	NGO
Lutheran World Federation	NGO
Laikipia County Natural Resources Network (LAICONAR)	NGO
Food and Agriculture Organisation (FAO)	INGO
Centre for Disease Control & prevention (CDC)	Government
Centre for Training Research Dissemination (CETRAD)	Research
Kenya Agric. Research & Livestock Organisation (KARLO)	Research
National Drought Management Authority (NDMA)	Government
Agriculture Information Centre (AIC)	Training
Kenya Meteorological Services (KMS)	Government
Agric. Sector Development Support Program (ASDSP)	Government
County Meteorological Services (CDMS)	Government

Ministry of Agric. Livestock & Fisheries (MoALF)	Policy
Laikipia_County	Policy
Ol_Pejeta Conservatory	Private_sector
Input_dealer	Private_sector
Laikipia_County_Times	Newspaper
Daily_Nation	Newspaper
Inooro_FM	Radio
Sauti_ya_Mwananchi	Radio
Musyi_FM	Radio
Kenya Broadcasting Corporation (KBC)	Television
Kenya_Women_MFinance_Trust	Microfinance
Farmer	Research
Machakos_County	Policy
Kenya Plant Health Inspectorate Service (KEPHIS)	Government
ICT_Authority	Policy
Machakos_Agriculture Training Centre	Training centre
Mwatu_FM	Radio
Athiani_FM	Radio
Musyi_FM	Radio
Byto_FM	Radio
Adiyani_FM	Radio
Citizen	Television
Nation TV	Television
Centre for Agric. & Bioscience Information (CABI)	Research
Syngenta	Research
Farm_Concern	NGO
World_Vision	NGO
Community_Devt_Fund	NGO
KATOLINI	NGO

*Tie data.

"from"	"to"	"Information"	"Means"
Inooro_FM	Farmer	1	2
Musyi_FM	Farmer	1	2
Sauti_ya_Mwananchi	Farmer	1	2
Citizen_TV	Farmer	1	2
NTV	Farmer	1	2
KBC	Farmer	1	2
Inooro_FM	Laikipia_County	1	2
Musyi_FM	Laikipia_County	1	2
Sauti_ya_Mwananchi	Laikipia_County	1	2
Citizen	Laikipia_County	1	2
NTV	Laikipia_County	1	2
KBC	Laikipia_County	1	2
ACT	Laikipia_County	2	1
ACT	Farmer	2	1
ACT	KARLO	2	2
ACT	FAO	2	2

ACT	Kenya_WMF	2	2
LWF	Farmer	2	1
LWF	Laikipia_County	2	2
LAICONAR	Farmer	3	1
LAICONAR	Laikipia_County	3	2
Ol_Pejeta	Laikipia_County	2	2
Ol_Pejeta	MoALF	2	2
Ol_Pejeta	Farmer	2	1
CARITAS	Farmer	2	1
CARITAS	Laikipia_County	2	2
FAO	Farmer	2	2
FAO	Laikipia_County	1	2
FAO	KARLO	1	2
FAO	ACT	2	2
FAO	MoALF	1	2
KARLO	Farmer	1	1
KARLO	ACT	2	2
KARLO	Laikipia_County	1	2
KARLO	FAO	1	2
KARLO	MoALF	1	2
ASDSP	Farmer	1	1
ASDSP	Laikipia_County	1	2
ASDSP	ALIN	1	2
ASDSP	KMS	5	4
ALIN	Farmer	2	4
ALIN	Laikipia_County	2	2
ALIN	KMS	5	4
ALIN	ASDSP	5	2
ALIN	CETRAD	2	2
KMS	Laikipia_County	5	2
KMS	ALIN	5	2
KMS	ASDSP	5	2
NDMA	ALIN	5	2
NDMA	Laikipia_County	5	2
NDMA	Farmer	5	2
CDMS	Farmer	5	2
CDMS	Laikipia_County	5	2
MOALF	Farmer	1	1
MOALF	Laikipia_County	1	2
MOALF	Private_sector	7	2
Kenya WMF	Private_sector	7	2
Kenya_WMF	ACT	3	2
Kenya_WMF	Farmer	3	2
Kenya_WMF	Laikipia_County	3	2
Farmer	ALIN	1	1
Farmer	CARITAS	1	1
Farmer	ACT	1	1
Farmer	LWF	1	1

Farmer	LAICONAR	1	1
Farmer	CARITAS	1	1
Farmer	FAO	1	1
Farmer	CDC	1	1
Farmer	CETRAD	1	1
Farmer	KARLO	1	1
Farmer	NDMA	1	1
Farmer	AIC	1	1
Farmer	KMS	1	1
Farmer	ASDSP	1	1
Farmer	CDMS	1	1
Farmer	MoALF	1	1
Farmer	Laikipia_County	1	1
Farmer	Ol_Pejeta	1	1
Farmer	Input_dealer	1	1
Farmer	Laikipia County Times	1	1
Farmer	Daily_Nation	1	1
Farmer	Inooro_FM	1	1
Farmer	Sauti_ya_Mwananchi	1	1
Farmer	Musyi_FM	1	1
Farmer	KBC	1	1
Farmer	Kenya WMF	1	1
Farmer	Farmer	1	1
Farmer	NTV	1	1
Farmer	Citizen_TV	1	1
Farmer	KBC	1	1
Input_dealer	Farmer	2	1
Input_dealer	Laikipia_County	2	3
CETRAD	Laikipia_County	2	3
CETRAD	Farmer	2	4
CETRAD	ALIN	2	4
AIC	Farmer	1	2
AIC	Laikipia_County	1	2
AIC	MoALF	1	2
Laikipia_County_Times	Farmer	1	2
Laikipia_County_Times	Laikipia_County	1	2
Daily_Nation	Farmer	1	2
Daily_Nation	Laikipia_County	1	2
Laikipia_County	ACT	1	2
Laikipia_County	Private_sector	1	2
Laikipia_County	MoALF	1	2
Laikipia_County	ALIN	1	2
Laikipia_County	CARITAS	1	2
Laikipia_County	ACT	1	2
Laikipia_County	LWF	1	2
Laikipia_County	LAICONAR	1	2
Laikipia_County	CARITAS	1	2
Laikipia_County	FAO	1	2

Laikipia_County	CDC	1	2
Laikipia_County	CETRAD	1	2
Laikipia_County	KARLO	1	2
Laikipia_County	NDMA	1	2
Laikipia_County	AIC	1	2
Laikipia_County	KMS	1	2
Laikipia_County	ASDSP	1	2
Laikipia_County	CDMS	1	2
Laikipia_County	MoALF	1	2
Laikipia_County	Ol_Pejeta	1	2
Laikipia_County	Input_dealer	1	2
Laikipia_County	Laikipia_County_Times	1	2
Laikipia_County	Daily_Nation	1	2
Laikipia_County	Inooro_FM	1	2
Laikipia_County	Sauti_ya_Mwananchi	1	2
Laikipia_County	Musyi_FM	1	2
Laikipia_County	KBC	1	2
Laikipia_County	Kenya_WMF	1	2
Laikipia_County	Farmer	1	2
Laikipia_County	NTV	1	2
Laikipia_County	Citizen	1	2
Laikipia_County	KBC	1	2
MoALF	Machakos_County	1	2
MoALF	AIC	1	2
KEPHIS	Machakos_County	7	2
ICT_Authority	Machakos_County	7	2
Machakos_ATC	Machakos_County	3	2
AIC	Machakos_County	1	2
AIC	MoALF	1	2
AIC	Farmer	1	2
Mwatu_FM	Farmer	1	2
Athiani_FM	Farmer	1	2
Musyi_FM	Farmer	1	2
Byto_FM	Farmer	1	2
Adiyani_FM	Farmer	1	2
Citizen	Farmer	1	2
NTV	Farmer	1	2
KBC	Farmer	1	2
KARLO	Farmer	1	1
KARLO	MoALF	1	2
KARLO	Machakos_County	1	2
ACT	Farmer	2	1
ACT	MoALF	2	2
ACT	Machakos_County	2	2
ACT	KARLO	2	1
FAO	Farmer	2	1
FAO	MoALF	7	2
FAO	Machakos_County	7	2

FAO	ACT	2	1
FAO	KARLO	1	2
CABI	Farmer	1	1
CABI	MoALF	7	2
CABI	Machakos_County	1	2
Syngenta	Farmer	1	1
Syngenta	MoALF	7	2
Syngenta	Machakos_County	1	2
ACT	KARLO	1	2
ACT	MoALF	7	2
ACT	Farmer	1	1
ACT	Machakos_County	2	2
Syngenta	Farmer	1	1
Syngenta	Machakos_County	7	2
Syngenta	MoALF	7	2
Farm_Concern	Farmer	1	1
Farm_Concern	Machakos_County	7	2
World_Vision	Farmer	1	1
World_Vision	Machakos_County	1	2
Farmer	MoALF	1	1
Farmer	Machakos_County	1	1
Farmer	KEPHIS	1	1
Farmer	KMS	1	1
Farmer	ASDSP	1	1
Farmer	ICT_Authority	1	1
Farmer	Machakos_ATC	1	1
Farmer	AIC	1	1
Farmer	Mwatu_FM	1	1
Farmer	Athiani_FM	1	1
Farmer	Musyi_FM	1	1
Farmer	Byto_FM	1	1
Farmer	Adiyani_FM	1	1
Farmer	Citizen_TV	1	1
Farmer	NTV	1	1
Farmer	KBC	1	1
Farmer	KARLO	1	1
Farmer	Farmer	1	1
Farmer	FAO	1	1
Farmer	CABI	1	1
Farmer	Syngenta	1	1
Farmer	ACT	1	1
Farmer	Farm_Concern	1	1
Farmer	World_Vision	1	1
Farmer	Community_Devt_Fund1	1	1
Farmer	KATOLINI	1	1
Machakos_County	MoALF	1	1
Machakos_County	KEPHIS	1	1
Machakos_County	KMS	1	1

Machakos_County	ASDSP	1	2
Machakos_County	ICT_Authority	1	2
Machakos_County	Machakos_ATC	1	2
Machakos_County	AIC	1	2
Machakos_County	Mwatu_FM	1	2
Machakos_County	Athiani_FM	1	2
Machakos_County	Musyi_FM	1	2
Machakos_County	Byto_FM	2	2
Machakos_County	Adiyani_FM	1	2
Machakos_County	Citizen	1	2
Machakos_County	NTV	1	2
Machakos_County	KBC	1	2
Machakos_County	KARLO	1	2
Machakos_County	Farmer	1	1
Machakos_County	FAO	1	2
Machakos_County	CABI	1	2