ENVIRONMENTAL FACTORS INFLUENCING WOMEN SMALL SCALE FARMERS' ADOPTION OF CONSERVATION AGRICULTURE IN NAKURU COUNTY, KENYA

MICHURA ELIUD GARRY

A THESIS SUBMITTED TO THE INSTITUTE OF POST GRADUATE STUDIES AND RESEARCH IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF DOCTOR OF PHILOSOPHY IN ENVIRONMENTAL SCIENCE OF

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DECLARATION

"This thesis is my original work and to the best of my knowledge has not been presented to this university or any other university for the award of a degree."

Signature_____ Date _____

MICHURA ELIUD GARRY

GDE/M/1066/9/10

RECOMMENDATIONS

To the institute of Postgraduate Studies and Research;

This Thesis entitled" Environmental Factors Influencing women Small Scale Farmers' Adoption of Conservation Agriculture in Nakuru County, Kenya" written by Eliud Garry Michura is presented to the Institute of Postgraduate Studies and Research of Kabarak University . We have reviewed the Thesis and recommended it to be accepted in partial fulfillment of the requirements for the degree of **DOCTOR OF PHILOSOPHY IN ENVIRONMENTAL SCIENCE**

Signature 1. _____ Date _____

PROFESSOR JACKSON JOHN KITETU

Department of Environmental Science, Kabarak University

Signature 2. _____ Date _____

DR. PAUL MAKENZI

Department of Environmental Science, Egerton University

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DEDICATION

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ABSTRACT

This research examines four environmental factors influencing women farmers' adoption of conservation agriculture (CA) in Nakuru County, Kenya. About 30% of environmental problems in the world, and particularly in the study area emanate from poor agricultural practices. CA is currently being promoted as a better practice than the conventional farming methods because CA has been found to result in optimum agricultural production. In addition to resulting in better agricultural yields, CA protects the environment. The level of environmental degradation in the study area is high, resulting in food insecurity and biodiversity loss. Women small scale farmers' participation in agriculture is 70% of all the farming activities in the area and therefore, women are most affected by environmental changes. Food insecurity and biodiversity loss can be solved through adoption of CA practices which are rare in the study area, especially among women small scale farmers. The farmers have claimed that, CA adoption is not prevalent due to some environmental factors. This claim was inadequately substantiated. The research sampled three sites: Naivasha, Rongai and Njoro which were selected purposefully due to different ecological characteristics. Three hundred and ninety women farmers were randomly selected from a target population of 120, 000 women farmers of which, 130 were selected from each of three Sub Counties. The study uses the descriptive survey research design. Structured questionnaires, interview schedule, personal observation and focus group discussion were used to collect data, which included secondary information. Statistical Package for Social Sciences (SPSS version 20) computer system was used in the data processing and analysis. Descriptive statistics; frequency distributions, means, proportions, percentages and inferential statistics; Chi-square, ANOVA, and post hoc analysis at alpha value = 0.05 level were employed to test four hypotheses. The findings rejected the four null hypotheses of the specific objectives and concluded that extension methods, climate change, land use changes and knowledge of environment significantly influenced women farmers' adoption of CA. The study concludes that CA adoption uptake is low, government policy on extension methods is not well structured, self-help women groups are significantly effective, ICT and video sharing are more effective methods of passing information on best farming practices, but they are rarely used. The following are the recommendations: the use of schools, markets, religious centers for training and the establishing of weather stations in schools. It is hoped that policy and decision makers will use the results of the study to develop land and agricultural policies, provide incentives to promote women small-scale farmers, use new emerging technologies such as ICT, videos and smart phones as well as restructure involvement of self-help women groups to speed up adoption of CA in order to realize food security and conservation of the environment in Nakuru County and in Kenya.

Key words; Adoption, Agriculture, Conservation, Environmental factors, Small-scale farmers.

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LIST OF ABBREVIATION

NCPD	National Council of Population and Development
LPC	Landscape production and Conservation
CA	Conservation Agriculture
EA	Eco Agriculture
NCR	Nakuru County Report
SSA	Africa South of Sahara
FAO	Food Agricultural Organization
UNDP	United Nations Development Programme
IFOAM	International Forum for Organic Agriculture Movement
PELUM	Participatory Ecological Land Use Management
CGIA	Consultative Group on International Agricultural Research
AASR	Africa Agriculture Status Report
WFP	World Food Programme
FGD	Focus group discussions
SHWG	Self Help Women Groups
KARLO	Kenya Agricultural Research and Livestock Organization
NEPAD	New Partnership for African Development
ICT	Information Communication Technology
NGOs	Non-Governmental Organizations
UN	United Nations
UNWW	United Nations Women Watch
ASDS	Agricultural Sector Development Strategy

MTIP	Medium Term Implementation Plan
CAADP	Comprehensive Africa Agriculture Programme
SRA	Strategy for Revitalizing Agriculture
UNCCC	United Nations Framework Convention for Climate Change
NEMA	National Environmental Management Authority
ICRAF	International Centre For Agro forestry
PA	Protected Areas
CAA	Conservation Agriculture Adoption
FGDs	Focus Group Discussions
SPSS	Statistical Package for Social Sciences
ANOVA	Analysis of Variance
ADC	Agricultural Development Corporation
MOALF	Ministry of Agriculture Livestock and Fisheries
ACK	Anglican Church of Kenya
IPM	Integrated Pest Management
GEPA	Gilgil Environmental Protection

OPERATIONAL DEFINITION OF TERMS

Conservation Agriculture (CA): Conservation agriculture is a holistic practice and employs all modern technologies that enhance the quality and ecological function and production of food with biodiversity conservation in mind. Conservation agriculture is based on three principles; No tillage or minimal soil disturbance, permanent soil cover, and cropping rotation/mixing. CA results in maximizing yields and protecting biodiversity.

Conservation Techniques (Practices): Conservation techniques are many and varied depending on the ecological set up of the environment, social, economic and physical characteristics of the farmers. Some examples include; ripping, crop rotation, mixed farming, mulching agro forestry, terracing, crop diversification, dry crop farming, among others.

Small scale farmers: These are farmers who own small farm lands and put them under intensive farming. The average small scale farms vary but range between less than one acre and less than twenty acres.

Women farmers: In this study, these are women who take part and are fully involved in farming to feed their families. They may own land, borrow or rent for purposes of growing food crops. They can be women who use CA, conventional agriculture or both. They are small-scale farmers who are, in one way or the other, influenced by CA adoption factors.

Laggards: These are women farmers who have not adopted any CA practices in the study area.

Tillage/Conventional Agriculture: This refers to industrial agriculture that is a highly simplified ecosystem in which high productivity depends on a few improved high-yielding crop varieties and a heavy reliance on agrochemical inputs (e.g., fertilizers, pesticides) and fossil fuels. It results into tremendous increase in food production over the past 50 years, although this achievement comes

with heavy environmental costs. Adverse effects of modern agriculture include loss of biodiversity and associated traditional knowledge that communities share about it, pest resistance, soil and water pollution, soil loss (along with soil fertility) and increased greenhouse gas emissions (Alcade et al, 2015).

Adoption: CA is an application of modern agricultural technologies meant to improve production while concurrently protecting and enhancing the land resources on which production depends. Application of CA promotes the concept of optimizing yields and profits while ensuring provision of local and global environmental benefits and services. Zero tillage, along with other soil conservation practices, is the cornerstone of CA. CA is a process that involves five stages namely; knowledge, persuasion, decision, implementation and confirmation in the use of an innovation (Rodgers, 1962).

Rate of adoption: This is the relative speed with which an innovation is adopted by agricultural system especially the small-scale farmers. Adoption is measured by the length of time required for a certain percentage of the members of a social system to take up an innovation (Rodgers, 1962).

Adopters: In this study, adopters are women who have taken initiative to practice conservation agriculture.

Non-Adopters: In this study, these are women farmers practicing conventional agriculture only.

Incomplete-adopters: This term has been used to refer to farmers who practiced both CA and conventional agriculture.

Landscape: A 'landscape' is a socio-ecological system that consists of a mosaic of natural and/or human-modified ecosystems, with a characteristic configuration of topography, vegetation, land use, and settlements which is influenced by the ecological, historical, economic and cultural processes and activities of the area. The mix of land cover and use types (landscape composition)

usually includes agricultural lands, native vegetation, and human dwellings, villages and/or urban areas (Shame &S cherr, 2012).

Climate Change: This may refer to a change in average weather conditions, or in the time variation of weather around longer-term average conditions such as temperature, rainfall, wind and humidity. (Webster dictionary)

Land use change: This is a condition where land is used for another activity apart from what it was used for before. (Webster dictionary)

Extension Methods: These are services offered to farmers to improve their farming techniques and increase food production.

Environmental Knowledge: This has been used to refer to information about biodiversity structure, functions and management as well as the protection of other non-bio resource.

Eco agriculture (EA) : The word eco agriculture was coined by McNeely and Scherr (2012) in the report *Common Ground, Common Future* , which laid the foundations for an integrated approach to landscape management that seeks to simultaneously enhance human livelihoods and well-being, improve agricultural production, and conserve biodiversity and ecosystem health.

Biodiversity: This is the richness of species. An ecological set up can hold large numbers of different plants and animals (high biodiversity) or some may have few different species (low biodiversity. In this study climate change, land use change and environmental knowledge of farmers are all likely to affect biodiversity (Shamer and Scherr, 2012).

Benfferoni Test: This is a statistical inference logic based on rejecting the null hypotheses if the likelihood of the observed data under the null hypotheses is low. The problem of multiplicity arises from the fact that as we increase the number of hypotheses being tested, we also increase the

likelihood of a rare event, and therefore, the likelihood of incorrectly rejecting a null hypothesis (i.e., make a Type I error) (Webster dictionary).

Tillage: This has been used in this study to refer to complete tilling of land. This affects soil stability, soil moisture and kills soil living organisms helpful in biogeochemical cycles. Tillage contributes to reduction of biodiversity, poor soil which require increased application of fertilizers and is thus expensive in terms of equipment costs. (Webstar dictionary)

Mixed cropping: This refers to planting of more than one crop in one piece of land or keeping of livestock and growing crops. It is a good practice where the farms are small and there is need to maximize production.

Crop rotation: This is the growing of one crop on a piece of land for one season and alternating it with a different crop in the next season. It helps in maintaining soil fertility, reducing crop infections and consequently maximizing yields.

Minimal Soil Disturbance: This is the use of the ripping method or avoiding tilling of land to conserve the soil (Webster dictionary)

CHAPTER ONE

INTRODUCTION

1.1 Background Information

The current global environmental degradation is as a result of inappropriate technological advances such as seen in agricultural activities resulting in climate change, soil erosion, deforestation, loss of biodiversity, waste disposal and pollution among others (Kahimba, F.C. Mutabazi K.D., Tumbo,S.D.,Masuki, K.F. and Mbungu W.B. 2014). Literature reveals that, conventional agriculture contributes 30% of the environmental damage although it leads in world food production and economy (Theodor et al, 2015).

New innovations in developing countries face new and increasingly complex challenges hindering farmers from maximizing their food production (Ngwira, F.H. Johnsen, J.B. Aune, M. Mekuria, and C. Thierfelder 2014). Poverty, low food production and loss of biological resources are major problems facing those working towards global development today, especially in developing countries. There is urgent need for new mechanisms to foster diffusion of innovation and to strengthen ways of disseminating information to agricultural stakeholders with a view to empowering smallholder farmers and other vulnerable groups facing food insecurity (Saya, 2011).

Several studies have observed that, conservation agriculture (CA) is becoming a better option in mitigating environmental degradation and contributing significantly towards increasing food production and protecting the environment. The study has revealed that in South America, Zambia, Burkina Faso, Malawi and parts of Kenya, conservation agriculture (CA) seem to be a better option for mitigating environmental problems and increasing food production (Kassam and Derpsch, 2012). Conservation agriculture provides a set of principles guiding the implementation of sustainable agriculture while minimizing environmental degradation

because the practice relies on three basic principles the first of which is minimum soil disturbance, or if possible no tillage at all; secondly soil cover being permanently left intact where possible and thirdly crop rotation. Other studies established that, conservation agriculture (CA), which is sustainable agriculture, is being promoted to overcome many of the problems associated with conventional agriculture (Kingiri and Nderitu, 2014).

Africa Agricultural Status Report (2014) indicated that, there is very little documentation on sustainable farming practices in Africa. In Africa South of Sahara, only a mere 0.3% of no-tillage is being practiced, mostly by smallholder farmers. It has been found that smallholder farmers lack agricultural assets and they continue using hand tools, have limited access to new information, and lack agricultural sector support (Kimani, N. J., Macharia, K. N., Nicholas M. S., Lentunyoi M., John, W. and Ikonye, N. 2015). Researchers have found that CA has the potential to increase smallholder farms' resilience to rainfall variability and droughts as well as temperature changes. CA can also address soil degradation, and increase food production in an efficient, productive, and profitable manner (Ngwira, *et al*, 2014). On the other hand, CA as a new technology has been found to be more beneficial both in maximizing food production and protecting the environment, but adoption of CA worldwide is low.

The global spread of CA adoption and its application on arable land is still very small. By the year 2010, conservation agriculture practices had provided benefits for 10.39 million farmers and their families on roughly 12.75 million hectares of land. South America leads with 46%, North America 32%, Australia 24%, Europe 14%, Asia 5%, and Africa is less than 1% area under CA. This means that CA adoption in Africa is very low and several studies indicate that environmental factors are the major causes for the low CA adoption (Alcade, C. S., Enock, G. A.D. Orou, G.G. and Adam, A. 2015). Further research studies have established that, there are

environmental factors contributing to CA adoption in Africa by farmers particularly by women smallholders (Kimani, *et al*, 2015). Environmental factors such as climate change, land use changes, extension methods have significant impact on agricultural production and biodiversity in the study area, especially among women smallholder farmers.

In Sub-Saharan Africa, subsistence agriculture is most vulnerable to the effects of environmental degradation and climate change since lack of economic resources restricts access to alternative livelihoods (Seline S. M., Delia, C., Oluyede C. Ajayi, G., W. Sileshi and Maarten N. 2014). The main cause of climate change is the conversion of forests into farmlands which has been exacerbated by pollution from human activities. The study has found that sub-Saharan Africa faces a rapid increase in human population growth which has resulted in more intensive agriculture and land use pressures which further contribute to land degradation. Climate change and land use changes, induced by human activities and other degrading factors are contributing to limited food production in the world (Caroline *et al*, 2015). Research findings indicate that extension services play a significant part in the adoption of CA. Extension services provide farmers with practical knowledge and equip them with the ability to interpret climate information and agronomic conditions of soil and crop needs (Kingiri and Nderitu, 2014).

In Malawi, conservation agriculture technology is being used and it is yielding good results and could potentially alleviate food insecurity among Malawi's smallholder farmers (Nyangah, 2012). In another study it was noted that conservation agriculture is becoming important as an alternative to conventional cropping practices in Algeria as it increases crop yields and conserves soil resources (Ferrah, 2014).

Theories and frameworks for the adoption of agricultural innovations emphasize the role of extrinsic and intrinsic factors affecting the adoption of CA. Also affecting adoption of CA is the external environment in the decision-making process. The uptake of agricultural technologies is a complex process influenced by both extrinsic (external environmental factors such as soil, water, climate, nature of land among others) and intrinsic (attitude, knowledge, perception, culture among others) variables, and recommend that future studies aiming to understand the adoption process of conservation agriculture innovations and its adoption in Africa South of Sahara should take into account both sets of variables (Akudugu, M. A., Guo, E. and Dadzie, S. K., 2012).

Previous studies have shown that, although there was great potential of agricultural innovations, the innovations uptake by smallholder farmers in Africa seems to be slow (Pretty, J., Toulmin, C., and Williams, S., 2011). It was further found that, technology uptake in adoption of conservation agriculture can be influenced by many factors, such as environmental, social, cultural and economic domains (Kamani, *et al*, 2015). In the study area, women smallholder farmers are much more affected by climate change, land use changes, extension methods and other socioeconomic factors which need to be investigated as reported by Nakuru County government (NCR, 2014)

Research has established that, Kenya's economic growth and its sustainability depend heavily on agricultural production which provides employment for 80% of the population and 70% of materials for agro-based industrial production as some studies have shown (Yatich, et al, 2009). Globally, women who are the major players (70%) in agriculture are mostly affected by environmental degradation which has led to food insecurity and biodiversity loss. Women in Sub- Saharan Africa are heavily affected by environmental factors because they are the main

producers of food and good environmental stewards. It has been observed that 80% of farmers practice small-scale production and out of this, over 70% of small scale farmers are women (Kimani, *et al*, 2015). Similar views are held that, women playa very important role in conservation agriculture although majority of women have problems of land tenure and this affects them a lot in their attempt to feed their families. Food security and environmental conservation heavily depends on women and taking care of women smallholders is taking care of the entire environment (Kyte, 2013).Literature reveals that in Kenya, women are important producers of food but their efforts are frustrated by harsh climatic conditions such as climate variability, land use changes and extension methods. There is little information about women small scale farmers and the environmental factors influencing their adoption of CA to increase food production in Kenya. This calls for more research aimed at shedding light on how climatic variations, land use changes and extension methods affect women farmers (Muna and Muriuki, 2013).

The destruction of major forests and the swelling human population in Kenya, pollution, subdivision of farmlands into small plots for settlements and business premises, have all played a part in altering the environment. These alterations take the form of rising temperatures, rainfall variations and droughts which all impact negatively on farming activities and loss of biodiversity. Most parts of Kenya which used to be farming areas are no longer producing food as is expected. Some parts of Nakuru such as Molo, Elburgon, Njoro and Olengoruone were areas of large-scale farming and wheat, maize, potatoes and dairy industry but now are settlements with farmers owning small farms. Major land use changes have occurred in many study sites such as Naivasha, once known for wildlife, but is now urbanized and supporting a few industries (NCR, 2014). Extensive forest cover, watersheds and wildlife resources in the Mau complex, have now been reduced and converted to settlements and other economic uses.

Also the Mau complex destruction has resulted in climate change which is a major factor affecting low production of food (FAO, 2014).The climate change, extension methods and land use changes are some of the factors affecting adoption of CA as is being claimed by agricultural stakeholders including farmers. Women small scale are most affected (NCR, 2014).

Ineffective extension methods based mostly on conventional practices are serious obstacles to food production in Nakuru County because farmers need to have the knowledge of the effects of these environmental factors and knowledge of the environmental dynamics in order to achieve sustainable agricultural production. Majority of women farmers have abandoned farming and are employed in other sectors other than agriculture because there are unclear policies on extension services to support farmers in new technologies. CA adoption requires input of extension services and the interpretation of climate change as well as knowledge of necessary mitigation measures (AjayiO.C.Akinnifesi F.K. Sileshi G. and W. Kanjipite, 2009) Today; CA is known to improve farmers' ability to deal with negative effects of climate change through improved rain use efficiency which leads to increase in yields under rain-fed agriculture. In addition, agro forestry provides benefits to the environment by providing various ecosystem services (Agevi, 2015).

Conservation agriculture has been successful and there are few examples where CA has been found to offer better farming technology than conventional farming methods in terms in maximizing food production and protecting the environment. A good example is Cheptebo AIC Rural Development Project in Keiyo valley which uses purely organic farming known as "Farming Gods Way". Another success story is found in the Amish community in Pennsylvania USA, where farming is traditional and it produces more food which is healthy

and nutritious. In these areas, there is very minimal use of industrial or convention agriculture (Kitetu, 2014)

In summary, Nakuru County faces numerous environmental problems more specifically food production and biodiversity loss. Because of the destruction of Mau forest adjacent to the study area, climate change is being experienced more and is affecting the farmers by reducing their farm production (Were and Singh, 2013). Increased population has led to subdivision of farmlands into small plots which have become less efficient in producing food to feed households. Besides, most (65%) arable land has been converted into other economic uses (Mubea and Menz, 2014). Agricultural extension methods have not been effective in supporting farmers in realizing their goals in food production. In addition; women farmers are more knowledgeable about environmental conditions than men. In conclusion, women small scale farmers are prone to the effects of environmental factors (climate change, land use changes, extension methods and knowledge of environment) because they influence farmers' uptake of CA (NCR, 2014).

1.2 Statement of the Problem

Conservation agriculture adoption in Nakuru County is low. The farmers and stakeholders claim that low uptake of CA is contributed by certain environmental factors which have caused low agricultural production and loss of biodiversity in the study area. Women small scale farmers are more affected than men because 70% of farm production is by women. Conventional agriculture has contributed nearly 30% of environmental degradation such as climate change, pollution, and acidification of rain, diseases and soil loss. To overcome these environmental problems, conservation agriculture (CA) has become beneficial as an alternative in maximizing yields and conserving the environment. CA uptake is gaining momentum in other countries but it is low in developing countries, especially those located in Africa South

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of Sahara. In the study area, climate change, land use changes, extension methods and knowledge of the environment have been identified as the main causes of low uptake of CA. Women are more affected by these environmental factors, specifically small scale farmers. There is inadequate information or agricultural documentation explaining why CA adoption is low in the study area, particularly among women small scale farmers. Due to the research gaps, the researcher had a strong case for carrying out the study to confirm these claims.

1.3 Broad Objective

The main objective of this study is to examine the influence of environmental factors on adoption of conservation agriculture among women small scale farmers in Nakuru County, Kenya.

1.3.1 Specific Objectives

The four environmental factors being examined are guided by the following specific objectives:

i. To find out the influence of women farmers' knowledge of climate change on adoption of conservation agriculture practices in Nakuru County.

ii. To assess the influence of land use changes on women farmers' adoption of conservation agriculture practices in Nakuru County.

iii. To describe the influence of extension methods on adoption of conservation agriculture among women farmers' in Nakuru County.

iv. To explain the influence of environmental knowledge on adoption of conservation agriculture among women farmers in Nakuru County.

1.4 Hypotheses

The research was guided by the following null hypotheses;

Ho_i: There is no statistical significant influence of knowledge of climate change on adoption of conservation agriculture by women farmers in Nakuru County.

Ho_{ii}:   There is no statistical significant influence of land use changes on women farmers' adoption of conservation agriculture in Nakuru County.

Ho_{iii}:   There is no statistical significant influence of extension methods on adoption of conservation agriculture by women farmers in Nakuru County.

Ho_{iv}:   There is no statistical significant influence of environmental knowledge on women farmers' adoption of conservation agriculture in Nakuru County.

1.5 Significance of the Study

Several researchers have identified gaps that could be addressed to ensure positive adoption of sustainable conservation agricultural systems. Various stakeholders such as students, researchers as well as governments and other interested parties such as environmentalists, agriculturalists, and NGOs, will use the research results as a reference point to guide in development of mechanisms that respond to identified barriers to adoption of CA. This is important because agriculture researchers will draw more interest and expand the research to help solve issues bordering on agricultural and ecological land use practices (Pelum, 2013).Women are the managers in smallholder farms and they are producers in conservation agriculture; therefore, having the knowledge of how CA can be adopted and promoted will increase their food production and income for their families. Finding solutions to the problem of the failure to adopt conservation agriculture by small scale women farmers in Nakuru County will ensure a sustainable society and maintain biodiversity.

1.6 Scope of the Study

The study focused on women farmers' adoption of conservation agriculture as influenced by environmental factors. The study covered women farmers in Nakuru County. Men farmers have not been included because small scale farming in the County is mainly by women. The agricultural production sector especially small scale is predominantly women. Adoption of conservation agriculture is influenced by a wide range of factors but in this study climate change, land use changes, extension methods and knowledge of environment were examined as they influence women farmers' adoption of CA. The women involved in the study were small scale farmers. Other environmental factors were not examined because of time and high cost of research that would be beyond the researcher's reach. Climate change and land use changes have significantly affected small scale farmers in the study area and have reduced food yields. Detailed agronomic and soil sciences and their effects on food production are not covered in this study as they are costly in terms of time.

1.7 Assumptions of the Study

The researcher made the following assumptions;

The women form farmer cooperatives which offer avenues for the sale of their produce and also help the farmers to obtain credits to improve their production. That, the level of education, farm size and age of the farmers, is not the same and influences their adoption of CA. That the women are aware of their environment and hence easily adopt CA practices. That, women farmers targeted for study owned land or hired land for conservation agriculture. That the government has well-structured agricultural extension services.

1.8. Limitation of the Study

The research was not able to get enough finding to cover most part of Kenya. This is the reason why the study concentrated in Nakuru County. 18% of the women farmers interviewed had low education level and their understanding of the questionnaire was low. The researcher took

more time to train the respondents in order to provide appropriate responses required to fulfill the goal of the study. The researcher was a man, and therefore interactions with women farmers were done through self-help women groups and church leaders.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter reviews the literature of the work done on environmental factors influencing women small-scale farmers' adoption of conservation agriculture (CA). The environmental factors influencing women adoption of conservation agriculture examined here were: extent of knowledge on climate change, land use changes, extension methods and knowledge of environment. It also captures previous findings of other authors in international journals, books, media materials and other people's ideas on conservation agriculture. The literature discussed some relevant theory of diffusion, policies, Laws, concepts and approaches regarding the study. The policies, Laws and other principles of agriculture, climate change, land tenure and environmental management are important in this study for they form the foundation on which conservation agriculture and its adoption could be understood. Furthermore, farmers realize their goals in maximizing their food production and at the same time manage their environment for sustainability of life for all living organisms.

2.2 The Concept of Conservation Agriculture (CA)

Several studies show that, conservation agriculture (CA) is becoming a very important agricultural practice among farmers and it is increasingly being promoted as one of the options for addressing food insecurity and protection of biodiversity (Muna M. W., Njenga, W. N.and Muriuki, J. N., 2013). What is conservation agriculture? It is a set of cropping practices designed to sustain high crop yields without depleting water, soil fertility and protection of biodiversity. Conservation agriculture has been in existence for nearly five decades and has spread widely, but its adoption has lagged in countries where most small-scale farming is practiced (Caroline, *et al*, 2014). CA focuses on three principles such as minimum soil

disturbance (zero tillage/minimal tillage, permanent organic soil covers with crops or residues; and establishing crop rotation (Nyangah, 2012)

Some studies posit that, conservation agriculture is claimed to offer several benefits which include increased soil organic matter, improvements in water retention, reduction of the risk of crop failure, increased and stabilized yields, reduction in soil erosion, improvement in soil structure, protecting wild life resources, reduced pests and diseases, reduced weed germination and increased productivity (Derpsch, *et al*, 2011).Marongwe, L.S., K. Kwazira, M. Jenrich, C. Thierfelder, A. Kassam, and T. Friedrich, (2011) found that CA improves agronomic quality of soil. It was observed in a research carried in some parts of developing countries that CA may be useful in conservation of resources. Its ability to serve the worlds increasing human population must be examined carefully (FAO, 2011). Despite these claimed benefits, the area under CA is still small and adoption rates in most parts of the world are low.

2.3 History of conservation Agriculture

It is only recently that conventional farming (tillage) was realized as the main contributor to loss of soil fertility and poor environmental health. The tillage system of farming has contributed to immense damage to the environment and human health. The concept of reducing tillage and keeping soil covered came up recently in the USA and the term conservation tillage was coined to reflect such practices aimed at soil protection (Kassam, *et al*, 2010). No tillage or minimal tillage, had not reached USA until 1960s. In the early 1970s no-tillage farming reached Brazil where farmers together with scientists improved the technology into the system which today is called CA. No-tillage and mulching were also available in West Africa until 1970s (Ajayi, *et al*, 2009). It took some 20 years before CA reached significant adoption levels in South America and elsewhere. During CA adoption period, farm equipment and agronomic practices in no-tillage systems were improved and developed to optimize the performance of

crops, machinery and field operations. This process is still far from being over as the creativity of farmers and researchers is still producing improvements to the benefits of the system, the soil and the farmer. It was noted that there is need for more research on CA and its adoption in Africa. Also worth investigating are the factors that influence its adoption by farmers (Kaman *et al*, 2015). Other studies noted that, from the early 1990s CA began to spread exponentially and this led to the revolution in agriculture in southern Brazil, Argentina and Paraguay (WFP, 2009). It has been noted that during the 1990's CA development increasingly attracted attention from other parts of the world including international research organizations such as FAO, CIRAD and some CGIAR centers (UNDP, 2012).

Research has found that all crops can grow under CA and that CA is being increasingly practiced all over the world. The improvement of conservation tillage and no-tillage practices within an integrated farming concept led to increased adoption even by industrialized countries, after the end of the millennium particularly in Canada, Australia, Spain and Finland (Fitzerald, 2014). The main barriers to adoption of CA practices are believed to include knowledge on how to do it, attitude (tradition, prejudice), inadequate policies, commodity based subsidies and direct farm payments. Others were found to be unavailability of appropriate equipment, machines, suitable herbicides to facilitate weed and vegetation management, especially for large scale farms in developing countries, climate variability and effective extension services, which have far reaching implications in developing countries (Lugandu, 2013).

2.4 Global Area under Conservation Agriculture

The world total arable land used for CA is approximately 106 million hectares (8%) (Ebanyat, *et, al*, 2013). Still, this is a relatively small percentage of land under cultivation. Most cropland under CA is in South America, the United States, China, India and a few countries in Africa (Derpsch, *et al*, 2011). Africa's total contribution is only 0.4% of the total global area

(470,100hectares). This is a small area compared to other countries. In South America, the area under CA is 44%, North America 32%, Australia 24% and Asia 4%.CA practices are essential for soil and water conservation, building and maintaining healthier soils, sustainable optimal production and maintenance of a rich agro biodiversity. They are also important as a response to climate change (Nyangah, 2012). With increased climate change, farmers need to be knowledgeable about the best farming practices that respond to these environmental dynamics, women farmers in particular.

Adoption of CA in most parts of Africa is low with not more than one percent of cropped land on the continent under CA (Kyte, 2013). The diffusion of CA across Africa South of Sahara is constrained by several challenges: institutional, economic, social, historical, environmental and political. One factor impeding extensive adoption of CA is that the practice is generally knowledge intensive, presupposing farmer understanding of soil nutrient cycles, causal affects between erosion and soil fertility, and the role of cover crops or residues in evapo-transpiration (McNair, 2012).

WFP, (2009) asserts that in Africa South of Sahara, about a third of the population lives in extreme poverty due to low food production. Most small scale farmers depend on rain-fed agriculture as their main source of income with the agricultural sector employing over three-quarters of the labour force. Women contribute between 60% and 70% of agricultural food production and in the study area, women small scale farmers contribute to over 75% in food production (NCR, 2015). Most agricultural production is by poor farmers especially women, who depend on agriculture and natural resources as source of food and income (WFP, 2009). The contribution of women to food security is very important and therefore, there is need for farmers to access proper and relevant agricultural information that would enable them improve

their food production. It is critical to encourage farmers particularly women to adopt CA practices which lead to increased yields and at the same time conserve environment (Pelum, 2013)

2.5 The Area under CA Globally

The percentage areas of arable land under CA practices are indicated below,

1	South America	45%
2	North America	32%
3	Australia	14%
4	Asia	4%.
5	Russia and Ukraine	3%
6	Europe	1%
7	Africa South of Sahara, only about v	<1 %

(Source: Pelum, 2013)

It was observed in another study that, improvement of conservation tillage and no-tillage practices within an integrated farming concept such as CA also led to increased adoption of CA, even in industrialized countries after the end of the millennium, particularly in Canada, Australia, Spain and Finland (Lugandu, 2013). The study further observed that, the main barriers to the adoption of CA practices continue to be: knowledge on how to do it (know how), mindset (tradition, prejudice), inadequate policies, for example, commodity based subsidies, direct farm payments, unavailability of appropriate equipment and machines (many countries of the world), and of suitable herbicides to facilitate weed and vegetation management (especially for large scale farms in developing countries), climate variability and effective

extension services which affects the developing countries (Lugandu, 2013). Studies on knowledge of climate change in the study area are few (Etwire, *et al,* 2014) and land use changes which has reduced farm land size has also not been studied(Mubea and Benz, 2014).

2.6 Adoption in Sub-Saharan Africa

New innovations are being developed in Sub-Saharan Africa and are being used to develop supply-chains for producing CA equipment aimed at small holders. Similarly, participatory learning approaches such as those based on the principles of farmer field schools (FFS) are being promoted to strengthen farmers' understanding of the principles underlying CA and how these can be adapted to local situations. CA is now beginning to spread to Sub-Saharan Africa region, particularly in eastern and southern Africa (Pelum, 2013).

Building on indigenous and scientific knowledge and equipment design from Latin America, and more recently, with collaboration from China, Bangladesh and Australia, farmers in at least 14 African countries(Kenya, Uganda, Tanzania, Sudan, Swaziland, Lesotho, Malawi, Madagascar, Mozambique, South Africa, Zambia, Zimbabwe, Ghana and Burkina Faso) now use CA(Shames and Scherr, 2013). CA has also been incorporated into the regional agricultural policies by NEPAD (New Partnership for Africa's Development). In specific context of Africa with resource-poor farmers, CA systems are relevant for addressing the challenges of climate change, high-energy costs, environmental degradation, and labor shortages. So far, the area under CA is small, but there is a steady growing movement already involving more than 400,000 small-scale farmers in the region for a total area of nearly 1 Million ha. (UNDP, 2012).

2.7 Reasons for Conservation Agriculture

The main reasons for adoption of CA can be summarized as better farm economy; flexible technical possibilities for sowing; fertilizer application and weed control; yield increases and greater yield stability; soil protection against water and wind erosion; greater nutrient-

efficiency; and better water economy in dry land areas (Ongugo, *et al,* 2014). No-till and cover crops are used between rows of perennial crops such as olives, nuts and grapes. CA can be used for winter crops, and for traditional rotations with legumes, sunflower and canola, and in field crops under irrigation where CA can help optimize irrigation system management to conserve water, energy and soil quality reduce salinity problems and to increase fertilizer use efficiency (Etweri, P.M., Al-Hassan M.R., Kuwornu, K. M. J. and Owusu,O. Y. 2013).   At the landscape level, CA enables several environmental services be harnessed at a larger scale, particularly Carbon sequestration, cleaner water resources, drastically reduced erosion and runoff, and enhanced biodiversity. Overall, CA as an alternative paradigm for sustainable production intensification offers a number of benefits to the producers, the society and the environment that are not possible to obtain with tillage agriculture. CA is not only climate-smart. It is smart in many other ways. This means that CA is a solution to environment degradation (Pelum, 2013).

2.8 Impact of agriculture on biodiversity

Most of the human environments on Earth (60%) is under agriculture and accounts for about 70% of human freshwater use. Agriculture depends directly and profoundly on healthy ecosystems, for nutrient rich soil, water flows, pollination, and genetic diversity that can increase the long-term viability of common crop species. Agriculture can have severe negative impacts on biodiversity through land-clearing, introduction of non-native species, excessive water use, habitat conversion, and soil and water contamination. It can also be possible to have biodiversity value in cultivated landscapes, for example by planting native species and preserving some of the natural aspects of an area (UNDP, 2012).

2.9 Stakeholders Participation in CA

Environmental factors play key roles in determining what steps can be taken to overcome these factors so that farmers can be able to benefit from the hard work and balance the cost of input

with output. Efforts to assist environmental managers such as farmers, grazers, forest owners, conservation managers, and private industry, to adopt new and more sustainable farming and resource management practice such as CA are under way. CA practices are designed and implemented through collaborative action to address challenges and opportunities that cannot be solved by one group acting alone (Ongugo, *et al*, 2014). Other studies in Uganda, Malawi, and Zambia have found that the key to success in CA management practices is the application and improvement of methods for communication, negotiation and conflict management among stakeholders that help them move away from entrenched positions toward common interests (Nyangah, 2014). In Africa South of Sahara, CA requires environmental dialogue to facilitate cross-agencies in planning, knowledge sharing, and programming, develop policies reflecting locally crafted land use rules. Land use, climate change, extension methods and environmental policies can play key roles in supporting farmers particularly women small scale farmers to increase agricultural productivity. Other factors such as norms, community by-laws and land tenure arrangements, can be instituted to reduce conflict and encourage synergies among multiple activities in environmental productivity (FAO, 2012)

2.10 Successful Agro ecological Efforts

The study found that, Dimbangombe, Zimbabwe which was an important communally grazing area and valuable wildlife habitats in the Hwange and Zambezi National Parks have been mismanaged. This has resulted in degraded environment with reduced water supply and local biodiversity (Louise and Scherr, 2011). It was further noted that new innovations such as introducing rotational grazing system for the livestock to help mimic natural land and less-intense grazing patterns to manage the environment, there was change. In just two years, the fields had vastly more forage and ground cover, water retention had improved, and the area's major river was flowing again. The grazing changes increased livestock production and helped previously starving animals regain their health (Louise and Scherr, 2011)

The study conducted in Kijabe by Kijabe Environmental Volunteers of Lari, Kenya, indicated that farmers increase their food production and at the same time increase biodiversity by growing more trees and protecting watersheds. This observation of tree shed increase is a sure way of mitigating climate change. The Kijabe area has established forest with increase in wildlife. The farmers are also benefitting from healthier soils, higher crop yields, well-fed livestock, and new markets. The incentives from managing environment well has made farmers to diversify their livestock by keeping rabbits, chickens, goats, and cattle, and gathering manure to compost with crop residues to improve soil fertility. The Kijabe community has benefitted a lot by adopting CA. The CA practices are promising higher yields and at the same time the environment is under conservation (Milder J. C., Majanen, T. and Scherr S.J. 2013).

In another study conducted in Kericho, it was observed that, the members of smallholder tea cooperatives have established 8,000 hectares of tea plantations using sustainable agriculture practices such as mulching, intercropping, and constructing drainage systems similar to naturally occurring ecosystems. The farmers have increased the levels of organic matter in the soil and improved water conservation. This is conservation agriculture under practice. The farmers have also been able to increase their production without using insecticides or fungicides in their tea fields. Unilever Company is motivating farmers by publicizing the farmers' efforts to promote environmental health through CA practice which has made farmers to realize10 to15 percent increase in revenues because they are able to sell their tea as a sustainable product (Were and Singh, 2013).

2.11 Role of Women in Conservation Agriculture

The global statistics show that 70% of farmers in developing countries are women in small-scale farming. A case study in Nyando basin indicates that, a total of 1,170 households belong

to farmer groups and out of these, 70 to 85 per cent of the active members are women (CGIAR, 2013). The study found that, women face more economic and social constraints than men. Women account for 60 to 80% of smallholder farmers and produce 90% of food in Africa and about half of all food worldwide. Interestingly, only 15% of landholders are women and they receive less than 10% of credit and 7% of extension services. It was found that policies that address gender inequalities could conservatively, increase yields on women's farms by 2.5% to 4% (Kyte, 2013). Women, especially small holders, are important in food and nutrition security at sustainable levels. Women therefore need to be empowered through policies such as extension services that can help them to grow and achieve food production. There is need to find out what affects women most in their efforts to produce food for their families especially in the study area where women are the main food producers. In the study area, little is known about how climate change, land use systems, extension methods and environmental knowledge impact on women. Studies also indicate that most of the developing countries such as Mozambique, women and girls are directly involved in the small scale farming and households' activities but benefit less from it, yet they comprise 90% of the work force in agriculture. Nearly all women are involved in subsistence farming with very few in commercial farming (Hart, A., C. Planicka, L. Gross and L. E. Buck, 2014). The factors that have contributed to this include low level of literacy among women, access to extension services, climate change, information on adoption practices, capitol and ultimately the social and cultural issues at community level (Hart et al, 2014)

2.12 Environmental Factors Influencing Women Small Scale Farmers Adoption of CA

Having considered conservation agriculture practices, the study discusses four environmental factors influencing women farmers' adoption of conservation agriculture in Nakuru County and the gaps that exist which prompted the researcher to undertake the study. Literature review

focuses on climate change, land use changes, extension methods and knowledge of environment.

2.12.1 Knowledge of climate change and Influence on Adoption of Conservation Agriculture

Knowledge of climate change by women farmers on adoption of CA is very important to any farming conditions and success in food production because climate plays a very important role in land productivity all over (Ogungo, *et al*, 2014). Climate change is defined as variations in weather elements observed for a long time. Any change in weather patterns observed for several years is termed as climate change. Climate change may be attributed to many environmental factors mainly anthropogenic. The degree of vulnerability of the agricultural sector to climate variability and change is a factor of a range of local environment and human operations. A research conducted in Uganda found that over 90% of the farmers interviewed had perceived change in rainfall pattern, dating as far back as five to 10 years. Out of that, only 19% of the farmers indicated that the rainfall situation in the reference season was desirable, with the majority indicating a non-desirable situation (Kansiime, M. K., Wambungu S. K. and Ashisanya, C. A., 2014). There is a significant association between smallholder farmers' perceptions of extreme climatic events and adoption of adaptation technologies. Decisions to adopt adaptation technologies generally depend on farmers' perception of the variability in the climatic condition. In the African setting, CA systems are relevant for addressing the challenges of climate change, high-energy costs, environmental degradation, and labour shortages (Kansiime, *et al*., 2014).

Rainfall regime and degree of temperature in an ecological zone as elements of climate are important factors determining agricultural production. Any changes occurring in temperatures

and rainfall patterns can cause serious repercussions to farmers who depend on farming as their source of livelihood. Farmers' knowledge on climate change is very important and can lead to finding ways of arresting any negative condition that may work against their food production. Women in most countries are aware of such climatic variation (Saya, 2011). Most women small scale farmers are knowledgeable about temperature and rainfall variability that affect their agricultural production. Women in the study area are believed to be knowledgeable on environment. A study conducted in Kinangop, Kenya has also confirmed these findings. Climate change and land use changes are affecting food production in most parts of the developing world (Muna and Muriuki, 2013). In response to climate change, farmers are forced to develop new farming techniques to overcome the hazards. Several coping strategies are available to farmers and it is important that they respond and adopt such practices. Some of the practices under CA are examined in this study. It has been established that farmers who understand climate change respond by planting different crops in the farm, shift from crops to livestock, increasing tree cover, using irrigation, migrating to other sites, increasing water conservation, crop rotation, using organic manure, varying planting dates and mulching (Louise & Sarah, 2011). In developing countries particularly in rural areas, farmers are left to decide on how they could respond to variations in weather. The reason for this is that there are no clear policies on agriculture geared towards supporting farmers especially in small scale production. It is also observed that women farmers' small scale holders are facing more challenges than men farmers in their efforts to feed their families through agriculture, but little study on women small scale farmers is available in Kenya to support this claim.

As the concerns about environmental degradation and climate change mounts, the possibility of eco-friendly, locally adapted agriculture is sparking widespread innovation in Africa and worldwide. Evidence indicates that conservation agriculture (CA) can feed a large portion of

the world while simultaneously addressing problems such as environmental degradation, livelihood insecurity, and poverty (Louise & Sarah, 2011). There is no evidence of any research carried out in Nakuru County targeting women farmers' population regarding their deep knowledge on climate change and its impacts on agricultural practices (NCR, 2014). Food production has gone very low, new pests and diseases have become resistant to chemical controlled applications and the crops are being infected which lowers the yields leading to hunger and poverty in the study area. Application of more pesticides and insecticides to keep off pest and disease are yielding very little results and the impact on this is destruction of soil fertility by use of heavy chemicals (NCR, 2014). Being aware of climate change is different from having a deep knowledge of climate change and using that knowledge to change ways of farming practices. Responding to climate change by adapting new techniques in farming help farmers to cope with climate change, improve food production, and conserve the environment to reduce further damage and poverty (UNDP, 2012

It is not clear to what extent the women are knowledgeable of the climate change in the study area. Farmers in other parts of the world particularly in developing countries, employ coping strategies to overcome effect of climate change. Climate change as a factor may not necessarily influence adoption of CA but it may affect adoption in combination with other factors, a study which is lacking in Nakuru County (Etwire *et al*, 2013).In rural areas, traditional knowledge helps farmers to adopt adaptation techniques under extreme climate. In the study area the population is a mix and there is no particular cultural knowledge being employed hence the need to study how the farmers from different cultural backgrounds respond to climate variability based on their knowledge of climate change. Nakuru County is a settlement region and being one of the hotbeds for agriculture for a long time, environmental dynamics have occurred and resulted in food loses. There is need to know what farmers are facing and how

their efforts in farming could be supported. Climate change or combination of other factors might be affecting farmers in small scale who are not well equipped enough to fight against the odds of climate change (NCR, 2014).

2.12.2 Land Use changes and Influence on Adoption of Conservation Agriculture

Land is a very important and valuable resource for any economic production. If it is planned, managed and used well according to its capability, it satisfies the needs of human and other biodiversity sustainably. United Sates of America classify land into various potential uses such as arable land for agriculture, range lands, conservation areas, forest land, and wetlands, industrial and mining among others (Ongong'a and Sweta, 2014).) Land use change is defined as simply a process where a particular land in use can be converted into a different use. Subjecting land to different uses is driven by several factors that are socio-cultural, political, economic and ecological.

Land use affects land cover and changes in land cover affect land use (Ongong'a and Sweta, 2014). Changes in land cover by land use do not necessarily imply a degradation of the land. However, many shifting land use patterns, driven by a variety of social causes, result in land cover changes that affect biodiversity and food production. Land use change also affects the ecosystem services. Agricultural activities, industries and other economic functions release a lot of carbon related substances that end up polluting the environment (Were and Singh, 2013). Natural resources in Sub-Saharan Africa (SSA) continue to diminish due to increasing population pressure on limited land. Natural forests and communal grazing areas have been declining and converted to crop fields (Meybeck and Place, 2014). Deforestation is a major concern, as it is a major cause for greenhouse gas emission in developing countries (Caroline, ET, al, 2015). Soil fertility continues to be degraded in many places due to the intensification of farming systems without replenishment of sufficient amounts of nutrients, which threatens

the sustainable development of agriculture in SSA (Meybeck and Place 2014). But other studies have established that there are signs of natural resource restoration from more trees naturally regenerated or planted by farmers. Land ownership rights and land tenure security are major determinants of land use, investments in the land to improve it, and increase food production. Where individualized rights are established on agricultural land, farmers invest in longer-term improvements, including tree planting, crop rotations, manure, and soil conservation (Keijiro and Place, 2014)

Studies have established that there is a downward trend in food production in Kenya due to a combination of factors such as drop in yield per hectare, subdivision of agricultural land and weak support from stake holders on food security (Kimani, *et al*, 2009). According to the findings of a national research on the change in land use and food security in Kenya 2014; predictions from the future, changes in land use in the country could pose a major threat in food security in the future (Nyangah, 2012). There is increasing pressure on agricultural land due to population growth, changes in climate, infrastructure developments such as real estate and competing profitability of different economic activities, which could have critical effect on food security as there is evidence of reduction on the acreage under food production in some parts of the country. In Nakuru County low food production and loss of biological resources are threatened (Keijiro and Place, 2014). A research study in Kisii County Keumbu study site revealed that Kisii County is facing rapid reduction of arable land and the food situation is deteriorating. The agricultural land fragmentations, high population increase and urbanization have led to decrease of agricultural land, food production and biodiversity, an effect which has left the rural livelihoods food insecure. The world grain stock has dwindled to dangerously low levels, highlighting the fragility of food supplies in a world where the population is expected

to rise (Ogechi and Hunja, 2014). In urban fringe in Nairobi, more land is converted into real estate hence reducing food production and cash crops for export (Thuo, 2008).

Land use change has serious implications on farmers and their agricultural production especially when the farmlands are reducing and becoming smaller and smaller resulting in low yield output. Within the context of land use changes and low food production, farmers are forced to look for ways of coping with the tragedy of reduced farm size. Smallholder famers maximize their production by changing from conventional farming to conservation agriculture with promising returns. Land use policy, land tenure and land rights affect both men and women but women farmers in small scale farming are more adversely affected because they are the majority managing food production (Ogechi and Hunja, 2014).

Nakuru County the study area has been known for its high potential agricultural production and dairy industry flourished while large plantations of wheat, maize, potatoes covering thousands of acres of land were the part of the environment. Some of the well-known farmers include Lord Delamere, Lord Egerton of Tuttons, Barclay, and Nightingale among others (NCR report, 2014). With Kenya having achieved its independence, agriculture landscape changed. Large farms were sold to cooperative societies and individuals who converted land to settlements and other economic production. The late 1980s saw a big change when the land buying companies sold large tracts of land to individual private owners. This led to subdivision of farmlands into small farms. With the increase of population, Nakuru County became a major settlement area for people from all parts of the country. NCR Report (2014) further noted that from 1990s up to the present time, land fragmentation has taken a toll. Large farms subdivided into small unproductive plots for other economic uses. The area under food production has significantly reduced and food availability is threatened.

Mubea and Menz (2014 studied land use changes in Nakuru county and posit that reduction of farm lands, encroachment of Mau forest, climate change, pollution, soil erosion, and changes of land use from farming to other economic activities have further complicated the scenario of food insecurity and loss of biodiversity. The study observed that, if this trend continues without check, the whole region will suffer greatly and sustainability question will arise. Farmers in Nakuru County have been severely affected more than any other sector. Women farmers are the most affected lot in the study area since agricultural production depends on women who produce 70% of the food in the area. Pre- research study carried out in November 2014 and Nakuru County report of 2015 indicate that land use change from arable to other uses has far-reaching implications on women who are mainly small scale farmers. Since farmlands are reducing in size and new other land productions are on the increase, the women's livelihood are threatened, and they are now seeking alternative income sources like working in flower farms, industries and trade. With the hazards of climate change and ineffective extension methods, food production is at risk (NCR, 2014).

Mubea and Menz, (2014) have indicated that, women are changing from farming to other economic activities in the study area in order to diversify their production function. Working in the new economic activities such as flower farms, industries and horticulture, mainly found in Naivasha, Njoro, Rongai, Molo and Subukia, would help them out of serious food yield fall due to climate change and reduced farmlands. Most women working in flower farms and industries are being exploited. The owners of such companies pay them less while at the same time they work for long hours, and they are exposed to diseases due to heavy chemical applications. Because of the highlighted problems women farmers are facing environmental dynamics (NCR, 2014). The researcher was prompted to carry out research to examine how land use changes in combination with other factors in this study have influenced women

farmers' adoption of CA. No information is available on small scale women farmers and what influence them to adopt CA practices in Nakuru County. The study area is potential for research having the fact that, it faces rapid land use change.

The findings of this research would be beneficial to policy makers, decision makers and to the women farmers in order to have the knowledge how they can diversify their income to solve food production problems in their communities.

2.12.3 Extension Methods and the Influence on Adoption of Conservation Agriculture

Conventional agricultural practices employing extension methods (extension agents and government subsidies, field days, demonstration among others) were very effective and farmers were able to produce sustainable food (Nduru, 2011). In the recent past and current situation, the extension services, have not been effective. The reasons could be the absence of agricultural subsidies, the increase in farmers' population and decrease in extension agents (Nduru, 2011). Extension methods exhibit several approaches used in any production activity such as agriculture. The main objective of such extended methods is that, they improve efficiency and effectiveness of a function and leads to high productivity, quality and quantity of products. In agricultural sector extension services are necessary and farmers are known to perform well, motivated and adopt any innovation presented to them (Pelum, 2013). Pelum (2013) further observed that, extension methods equip farmers with relevant and appropriate information they can use to enhance their skills. The extension methods used for conventional practices could be employed to speed up adoption of conservation agriculture. Extension service is an important source of information on climate change, land use changes, farmer knowledge on production function as well as adoption of CA. Farmers who have contact with extension agents are more likely to be aware of climate change and available adaptation options, and subsequently adopt these options (Etwire *et al*, 2013).

Improvement of agricultural productivity among smallholder farmers is a goal for tropical agricultural research to solve poor soil fertility. Researchers have developed agro forestry technologies including improved fallows and biomass transfer to address these problems. Levels of adoption of agro forestry practices are low and impacts on smallholder farmers' livelihood negligible (Vigyan and Kempinski, 2014). The study has shown that trialing of agro forestry technologies is generally low, 44.9 percent of farmers trialed improved fallow technology and 21.4 percent trialed biomass transfers. There seems to be a reason for this: the work of extension officers need to be established and farmer training be improved especially in agro forestry, and farmer visits. The farmers who implemented agro forestry practices had more retention than those who did not try to implement agro forestry (Vigyan and Kempinski, 2014)

In agricultural system there is lack of linkage between farmers and other sectors regarding agricultural production. Specifically, agricultural service providers and other community agents are significantly supportive of conventional modern farming than CA. This gap therefore need further research to make CA adoption uptake more profitable (Moore, K. M., Jennifer N. Lamb, Dominic Ngosia, Sikuku, Dennis S. Ashilenje, Rita Laker-Ojok and Jay Norton (2014)).

Effective extension system had unintended effects on adoption of CA. Some informants explained that some farmers were discouraged by the frequent change of agricultural extension staff. It was further observed that, farmers get discouraged in attending CA training because the successor field officer was not as good as the predecessor. This could have had negative effect on CA adoption (Nyangah, 2012).

In Nakuru County, although there have been reduced farm size and land use changes for agriculture, extension methods geared to motivate farmers to take up CA practices is a challenge(NCR, 2014). Another study found that, the reason for this is that, the farmers have increased tremendously and yet poor government policy on enhancing farmers to increase agricultural production is not clear and often lacking (Nduru, 2011). Lack of well-structured extension services may be lacking in the study area and no research has been done to establish if extension methods were contributing to women farmers adoption of CA (Wall P. C, Thierfelder, C, Ngwira, A, Govaerts, B, Nyagumbo and Baudron, F., 2013). This research assumed that there are other modern extension methods farmers could use to improve their skills in CA practices in order to boost food production and conserve environment for sustainability of life. Lack of evidence on how extension methods influenced women farmers' adoption of CA ignited the need to illuminate the same, with a view to promoting CA practices as a way of coping with climate change, land use changes and other problems farmers face. Extension methods discussed include, women to women contact, demonstrations, field visits, chief Barazas, agricultural shows, field days, TV and Radio, NGOs training schedules and ICT.

**2.14.4 Environmental Knowledge and its Influence on Adoption of Conservation
Agriculture**

The study found that, knowledge on environmental functions for a farmer is vital (Pelum, 2013). A farmer who has the knowledge of the environment stands a better chance in succeeding in agricultural production and conservation of the natural resources which play an important role in controlling his/ her activities. Conservation agriculture requires farmers to understand changes in their environments (Wall, et al, 2013). Conservation agriculture is more knowledge intensive than traditional low input systems. This is partly because it is new, but also because of the need for the farmer to understand the basis of the system and so have to

adopt it to his or her particular conditions, the need in most instances for chemical weed control, and the need for good farm and crop management. Smallholder farmers are often poorly linked to knowledge systems external to the community. Overcoming this barrier and increasing the knowledge base of the smallholder farmers in Africa is probably the biggest hurdle to overcome in achieving widespread adoption of conservation agriculture in the continent (Seline *et al*, 2014). Success will not only depend on enhancing the knowledge of conservation agriculture adoption among researchers but focusing more on the farmers. Extension agents are very important in the knowledge flow and the farmer is the target of change towards food production and environmental quality. It will also require the development of local innovation systems incorporating agents representing as many as possible of the principal components of the local agricultural value chains using their own comparative advantages and information networks to remove bottlenecks to farm productivity (Wall *et al*, 2013).

Other studies indicate that, women have learnt the importance of biodiversity and the farmers experiment with varieties of other plants in their farms. They also increase animal species number for wealth purposes. Greater inclusion of indigenous communities and indigenous women further validates the significance of women knowledge on environment (UN Women Watch, 2009). It is well documented that, women possess wealth of biodiversity knowledge and hence, are good stewards of the environment. Drivers of farmers' knowledge of agro biodiversity management and analysis of how farmers' knowledge and their current farming contexts may guide future farming systems in Benin are critical in food production. It was found that, farmer's knowledge of agro biodiversity management correlated with the involvement in integrated crop-livestock-tree and agro forestry systems (Alcade, *et al*., 2015).

County Government of Nakuru County Report (2015) established that, women in the region are being equipped with relevant knowledge and skills to enhance their leadership and organizational capabilities to be achieved, and now these women are drivers of their own social and economic transformation.) There is a lot of land degradation in Nakuru County due to deforestation, pollution from industries, accumulated wastes, poor agricultural methods that pose as threats to sustainability of the environment in the study area. Women have good knowledge of the environment and would avoid situations where they ignorantly destroy biodiversity by agricultural practices. No available research in Nakuru County to establish to what extent women farmers are knowledgeable about environmental dynamics and the need to conserve nature and increase their food production (Louise and Scherr, 2011). Due to lack of information on the study area, the researcher felt there is need to build a body of knowledge by filling the gaps on the study subject by finding out the extent of women farmers' knowledge on their environment. The following items were selected for study; enlightenment on soil erosion control measures, minimal tillage, soil conservation strategies, practice of agro forestry, soil control measures, crop rotation, protection of wetlands, protection of wild life, enlightenment to increase forest cover, benefits of using manure, need for environmental conservation. The information gathered will be helpful to the women farmers improve their knowledge by avoiding practices leading to destruction of the environment and increasing food production. The government would also be informed to make policies on empowering famers to adopt CA, which is claimed to be environmental friendly through creating sustainable communities (Louise and Scherr, 2011).

2.13 Laws, Policies and Acts governing Land, Agriculture and Environment

For the understanding of this study, it is paramount to have knowledge on the Laws and policies and guidelines, which form important statements and principles in managing and controlling

environmental resource regarding their exploitation and use. They also prevent human for any misuse, abuse or overuse of resources such as minerals, water, forests, land, soil, wildlife, air among others. They also assist in proper planning and economizing resources for the present and future use and for the wellbeing of all biodiversity (Mubea and Menz, 2014). Nakuru County is rich in resources and it is the responsibility of Kenya government and the Nakuru County government to safe guard the proper use of resources and to ensure that they benefit all human beings, animals, and plants on which they depend. Agriculture is one of the many human activities that may either destroy resources or enhance them. Agriculture uses land, which contains soil and minerals for growing of crops and hosting various living organisms. Wise use of land by protecting and planning for its use is paramount (NCR, 2015). Good agricultural practices for example conservation agriculture will serve as increasing food production and conserving biodiversity.

2.13.1 Land in Kenya: Ownership, Policy, Laws, Tenure and Reforms

With the enactment of the new Constitution and the adoption of the National Land Policy, most of the problems associated with land will begin to be resolved. The new Constitution (Chapter 5 Sections 60 – 68) classifies land into public, private and community and points out that all land in Kenya belongs to the people collectively as a nation, communities and individuals. The Cabinet and Kenya Parliament approved the new land policy, which recognizes land not just as a commodity for trade, but also as a principal source of livelihood. This will correct the injustices against women, children and minority groups. The policy plans to stop hoarding of land or speculation by introducing taxes to discourage ownership of idle land (New Constitution, 2010)).

The land policy also gives the State power to regulate private land. A classic example is the 117-year old Married Women's Property Act of 1882 targeted for repeal to pave way for a

more responsive and modern matrimonial Act sympathetic to spouses whose contribution to the matrimonial property cannot be quantified. The current law, which was borrowed from out dated British statutes, discriminates against women while the courts have been inconsistent over disinheritance of women and widows (Ongong'a and Sweta, 2014).

The new Kenya law will protect the rights of widows, widowers and divorcees by providing the right to co-own matrimonial property. The law will further curb the sale of family land without the involvement of spouses. To correct historical injustices, the land policy seeks to go as far back as 1895 when Kenya became a colony under the British. Pastoralists will benefit from the repeal of the Group Representatives Act so that individual rights are recognised yet ensure they maintain their unique land use (Ongo'nga and Sweta, 2013). If women are allowed legally to own land, it will boost their morale in food production since the majority of farm managers are women.

2.13.2 Food Insecurity Associated with Poor Land use Policies

Today, some 89 % of the households in Kenya are living on less than three hectares, while 47 per cent lives on farms of less than 0.6 hectares and only 10 per cent of the holdings, or 575,000 households, are above three hectares," he says. One cause of food insecurity that has received little attention yet it determines how much of Kenya has remained productive is the fact that the land use system adopted since independence borders on anarchy (Muchemi, 2015). In many parts of the country, any individual can do whatever they wish with land, simply because they hold titles to it. "Land use system is in a state of confusion," says Dr Isaac Mwangi, a senior lecturer at the University of Nairobi's Department of Urban and Regional Planning. Dr Mwangi attributes this to lack of an "overarching" policy Muchemi (2015). Unless decisive actions to come up with a national land use policy are made, Kenyans can surely expect to be etching closer to crunch time," he argues. The country, he says, is itching to attain a 50 per cent level

of urbanisation without a discernible national land use plan or how to manage the many and diversified needs of millions of people living in such a concentrated manner. It is argued Kenya is yet to develop an agricultural land use master plan with a zoning system that would set aside and preserve exclusive areas for food production. A national land use policy embeds a "philosophy of how land and natural resources ought to be exploited (Muchemi (2015)

2.13.3 Conversion of Agricultural lands to other Economic Uses

To get a better glimpse of how much Kenyans have recklessly destroyed the ability of arable land to meet food needs for millions, Dr Mwangi (in Muchemi, 2015) cites the vast areas between Limuru Road from the Northern Bypass junction in Nairobi to Limuru Town, and from Turi to Muchorwi in Molo, Nakuru County. He also cites areas between Kisumu and Kakamega towns and from Kisii to Rongo. Reckless dispersal of rural settlements largely undermines and erodes the capacity to produce food," he says (Muchemi, 2015).

2.13.4 Kenya National Strategies and Policies in Support of the Agriculture

In June 2008 Kenya adopted the Kenya Vision 2030 as a new blue print for Kenya's development. The Kenya Vision 2030 is the road map for the Kenya's economic and social development in the next two decades. It aims at transforming Kenya into "a newly industrializing, middle income country providing a high quality of life to all its citizens in a clean and secure environment". In the Vision, agriculture is identified as a key sector in achieving the envisaged annual economic growth rate. This shall be achieved through transformation of smallholder agriculture from subsistence to an innovative, commercially oriented and modern agricultural sector.

Kenya Vision 2030 was followed by the revision of the Strategy for Revitalizing Agriculture (SRA,2004-2014), this revision led to development of the Agriculture Sector Development

Strategy (ASDS, 2010-2020) that foresees a food secure and prosperous nation by 2020 and aims at achieving a paradigm shift from subsistence, to agriculture as business. Its launch by President Mwai Kibaki provided the ground for the government to launch the formulation of the ASDS and Medium Term Implementation Plan (MTIP) jointly with the CAADP compact1.However, the ASDS has two additional thematic areas (six in total), and namely, "the Legal, Regulatory and Institutional Reforms, thematic area (that) endeavours to create an enabling environment

2.13.5 Kenya Policy on Climate Change

Kenya's economy is highly dependent on the natural resource base, making it highly vulnerable to climate variability and change. This is exhibited through rising temperatures, and changing rainfall patterns resulting in increased frequency and intensity of extreme weather events such as droughts and flooding hence threatening sustainability of the country's development. In its fulfilment of safeguarding sustainable development, the Government of Kenya has developed this National Climate Change Framework Policy to provide a clear and concise articulation of overall response priorities to climate variability and change. Kenya has shown commitment to protect the climate system for the benefit of the present and future generations by supporting the United Nations Framework Convention on Climate Change (UNFCCC) process; ratifying the Kyoto Protocol in 2005; and contributing to continental and regional climate change initiatives. Further, the country's Constitution has set out a legal commitment to attain ecologically sustainable development; hence providing a basis to address the challenge of climate change while striving to attain its development goals through the Kenya Vision 2030.

The Policy's focus on the inter link between sustainable national development and climate change is critical because climate change adversely impacts key sectors that are important to the economy and society: Environment, Water and Forestry; Agriculture, Livestock and

Fisheries; Trade; Extractive industries; Energy; Physical Infrastructure; Tourism and Health (Ogungo, *et al*, 2014)).

2.13.6 Climate Change Policy 2014

This Policy was developed to facilitate a coordinated, coherent and effective response to the local, national and global challenges and opportunities that climate change presents. This will be achieved through the adoption of a mainstreaming approach that ensures integration of climate change considerations into the development planning process, budgeting, and implementation in all sectors and at all levels of government. This Policy therefore aims to enhance adaptive capacity and build resilience to climate variability and change, while promoting low carbon development (Ogungo *et al,* 2014)

2.13.7 Environmental Laws and Regulations in Kenya2003

Kenya has been touted as the 'Land of Splendor', with a rich historical background, great diversity of physical features, pleasant climate, diverse people, and magnificent wilderness areas (Mwenda and Kibutu, 2012). More recently, new constitution is a model for environmental progress in the region following enactment of a new constitution, which contains specific measures for environment. Any constitution functions to guarantee basic human rights and to provide guiding principles for the country, and by entrenching environmental rights and principles in the new constitution, Kenya signals unwavering environmental commitment. Environmental protection is the sole responsibility for NEMA and NEMA must approve any human activity such as agricultural development if it may result into potential negative impacts. Farming activities, which affect land quality, should have permit to do any project (Mwenda and Kibutu, 2012).

On the other hand, Kenya faces a dilemma presented to all countries in their quest for development: ensuring that development is sustainable. Unfortunately, Kenya's economic growth has been associated with environmental degradation and pollution, including declining

forest area; decreased wetlands; falling wildlife numbers; water and land shortage; rapid depletion of renewable and non-renewable natural resources; increased use of toxic chemicals; and discharge of waste and effluent into water, soil and air. Other significant threats to the environment arise from poverty, overpopulation, climate change, political insecurity, pollution and unregulated bio prospecting. For that reason, Kenya is making efforts to restore its name by working to safeguard its environment (Mwenda and Kibutu, 2012).

The new law states that, No licensing authority under any law in force in Kenya shall issue a license for any project for which an environmental impact assessment is required under the Act. Unless the applicant produces to the licensing authority a license of environmental impact assessment issued by the Authority under these Regulations. Regulation 4 (3) states that "No licensing authority under any law in force in Kenya shall issue a trading, commercial or development permit or license for any micro project activity likely to have cumulative significant negative environmental impact before it ensures that a strategic environmental plan encompassing mitigation measures and approved by the Authority is in place"(Mwenda and Kibutu, 2012)

2.13.8 NEMA (EMCA 1999) on Environmental Management

It guides co-ordination at various levels which are responsible for the preparation of the action plans which contain an analysis of the natural resources with an indication of change in their distribution and quantity over time, analytical profile of various uses and value of the natural resources and also recommend appropriate legal and fiscal incentives that may be used to encourage the business community to incorporate environmental requirements into their planning for national development, methods of building national awareness through environmental education. The Act also sets out operational guidelines for the planning and

management of the environment and natural resources. This also assists in the preparation of environmental action plans which cut across the country; national to district environmental action plans. These plans are prepared by the national environment management authority through the district environmental officers (Ooko, 2010).

2.13.9 Wetlands Regulations 2009

These Regulations prohibit a production of any loud, unreasonable, unnecessary or unusual noise, which annoys, disturbs, injures or endangers the comfort, repose, health or safety of others and the environment. The regulations empower the District Environment Committee to co-ordinate, monitor and advise on all aspects of wetland resource management within the district.

2.13.10 Water Quality Regulations 2010

The water quality regulations 2010 are vital in our environmental wellbeing. The water quality includes protection of sources of water for domestic use, water for industrial use, effluent discharge and water for agricultural use. These Regulations outline quality standards for sources of domestic water, quality monitoring for sources of domestic water, standards for effluent discharge into the environment, monitoring guide for discharge into the environment and standards for effluent discharge into public sewers.

2.13.11 Waste Management Regulations 2012

These Regulations apply to all categories of waste.

These include Industrial wastes; Hazardous and toxic wastes; Pesticides and toxic substances; Biomedical wastes; radioactive substances. These regulations outline requirements for handling, storing, transporting, and treatment/ disposal of all waste categories. Disposal of waste is by NEMA licensed company.

2.14 Theoretical Framework

2. 14.1 Conservation Agriculture Approach

With high precision methods in CA practices, experts in CA are helping farmers increase yields with fewer inputs and less pollution. The research input and farmer innovation adoption are placing farmers at a higher level of food production and conservation of resources (Pelum, 2013). Conservation agriculture, based on ecological management of soil, water, plants, micro-organisms and animals, and using a much wider range of agricultural biodiversity, has been shown to increase agricultural yields, improve livelihoods, and benefit the environment in a wide range of contexts. Many sustainable farming systems incorporate advanced modern technology, while others are based on ancient tradition and deep local knowledge; some incorporate both. It has been observed that, International research centers, like the World Agro forestry Centre (ICRAF) and Biodiversity International, and many national programs, are helping to build an understanding of the scientific principles and processes underlying these systems, and ways to improve their management (Pelum, 2013). Farmers are now beginning to link with other partners and adopting CA practices. Such agro ecological systems include conservation agriculture, agro forestry, evergreen agriculture, holistic range management, integrated pest management, and various systems that combine crop and livestock production, among others (Nyangah, 2012).

Kimani, *et al*, (2015) found that, in some parts of Kenya, conservation agriculture practices increased crop yields to 60% due to CA adoption. The study found that, in Malawi agro forestry has raised maize yields by 280 percent while increasing supply of fuel wood, mitigating climate change and sustaining hundreds of native plant species. Integrated crop-livestock systems have increased farm productivity and income by 100 percent in Zimbabwe. Dry crop farming has increased yields of millet and groundnut by as much as 195 percent in

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Senegal, while improving water conditions and carbon reduction (Kansiime, *et al*, 2014)). Study conducted at AIC Cheptebo Rural Project reveal that CA plays a very significant role in conservation of biodiversity and increasing food security, Besides, the technology used such as organic farming, mulching, crop rotation and less use of industrial fertilizers and no tillage have resulted in healthy and nutritious food (Kitetu, 2014). A another study conducted in USA among the Amish community confirmed the findings and that, CA is very beneficial and sustainable (Michura, 2016)

2.14.2. Innovation Diffusion Theory

Adoption is a decision or feeling to use or implement an innovation as the best course of action available. The process in which an innovation is communicated through certain channels over time among the members of a social system is known as diffusion (Rogers, 2003). The process of adopting innovations has been widely studied, and most popular adoption models, diffusion of innovation theory has been described by Akudugu, *et, al* (2012). For farmers to adopt an innovation, an   individual passes through five stages on their way to adopting a new practice or behavior (Rogers, 2003). Other studies also show that the stages are: knowledge whereby a person becomes aware of an innovation and has some idea of how it functions; persuasion stage when a person forms a favorable or unfavorable attitude toward the innovation after he or she knows about the innovation; decision whereby a person engages in activities that lead to a choice to adopt or reject the innovation; implementation where a person puts an innovation into use, and confirmation in which a person evaluates the results of an innovation- where decision is already made and the individual looks for support (Lugandu, 2013). For such new innovations to be realized by farmers and for adoption to take place, agricultural extension methods must be effective and farmers must be trained in all areas of the adoption process. Adoption of conservation agriculture by farmers may be influenced by extrinsic and intrinsic factors that may have serious implications in food production and environmental protection.

The study area has agricultural potential and 70% of farmers are women in small scale. Knowledge in adoption processes are crucial in aiding farmers to adopt CA resulting in maximizing their food production and controlling and preventing biodiversity loss.

2.14.3 Decision-Making in Adoption Practices

Studies have shown that, there is a broad range of literature regarding decision-making processes. The expected utility theory of Daniel Bernoulli predicts that the decision-maker chooses between risky and uncertain prospects by comparing the expected utility values of their outcomes to maximize profit (Seline, *et al*, 2014). Rogers (2003) described how innovations are adopted over time in his 'diffusion of innovations' theory. An innovation can be an idea, or concept, or technical information or an actual practice perceived as new by the individual. The study conducted by Rogers noted that, five characteristics determine the rate of adoption of the innovation: the relative advantage, compatibility, complexity, implementation and observation (Rogers, 2003). The decision to adopt an innovation consists of five stages: knowledge, persuasion, decision, implementation and confirmation. The innovativeness of an individual determines when the individual adopts the innovation. There are five adopter categories: innovators, early adopters, early majority, late majority and laggards. The adoption process is likely to be affected by receiver variables (intrinsic characteristics) and the perceived need for the innovation (Seline, *et al*, 2014). Diffusion of innovation theory is important and it helps to understand the adoption process (Akudugu, *et, al*, 2012)

An innovation adoption requires farmers to link with knowledge owners. The initial adopter of an innovation can share with other non- adopters and this can make non adopters understand and have the will to adopt.

2.15 Decision-making: An analytical Framework

Studies have established that technology uptake is a complex nonlinear process influenced by multiple factors. The use of a single theory in analyzing decision-making could not provide a full picture of the adoption process. A comprehensive framework taking into account the interaction of various factors in decision-making is needed (Seline, *et al*, 2014). An analytical framework which encompasses both extrinsic and intrinsic factors to technology uptake and highlights the interaction of both in decision-making on the application and adaptation of agricultural innovations has been presented (Etwire, *et al*, 2014).

Figure 2.1: Adoption Process
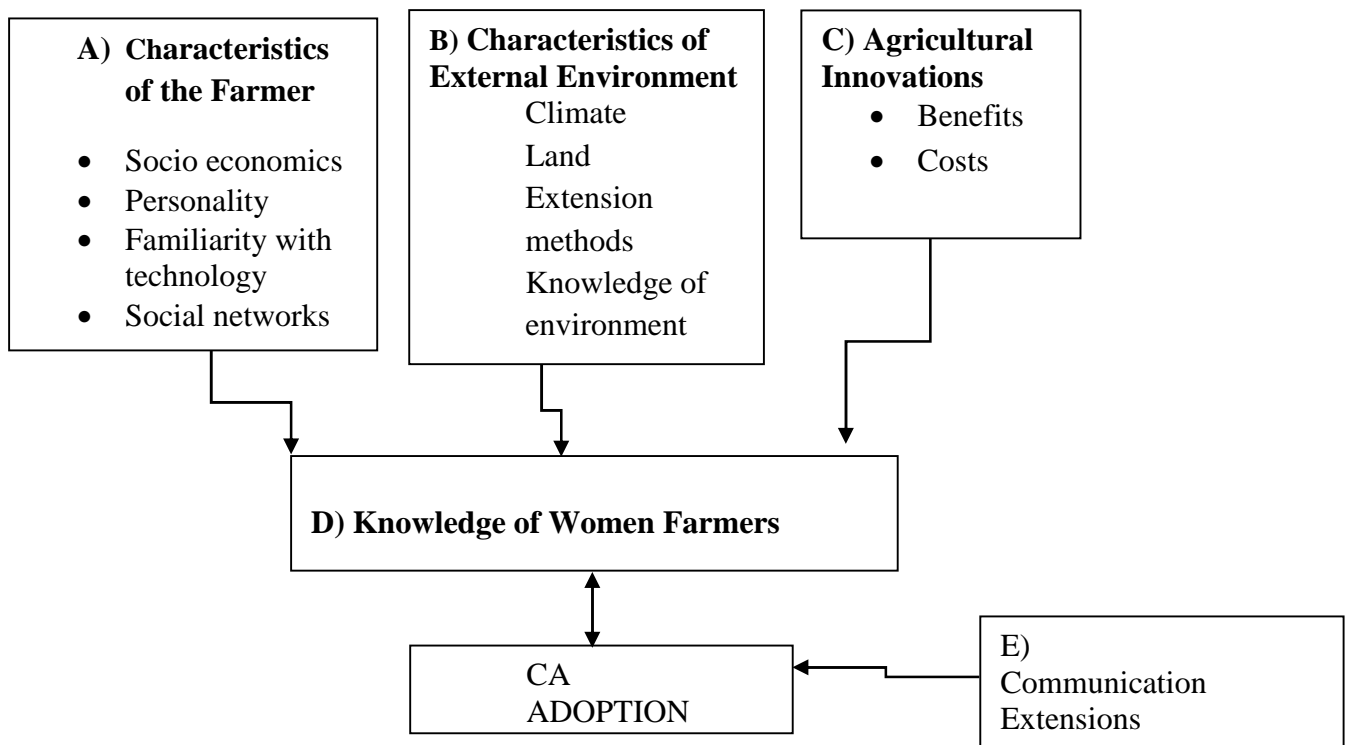
(Source: *(*Seline, *et al,* 2014*)*

2.16 Land Degradation, Conservation adoption practices and Food Production

There is need for appropriate development of agricultural policies that yield results and make farmers more motivated and willing to invest in farming. Knowledge dissemination will not be sufficient because knowledge and attitudes alone do not always translate into actual practice.

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There is; therefore, need to support services for farmers by digging deeper into the root causes of poor land management and understanding of factors affecting or constraining farmers' management practices. More appropriate research is needed to address this knowledge gap. This is interdisciplinary research which integrates local knowledge and perspectives (Taryn, 2014)

2.17 Conceptual Framework: Environmental Factors' Influence on CA Adoption

The conceptual frame work is founded on diffusion theory of adoption by Rogers, in 2003 which explains how an innovation to be adopted has to go through stages which in turn is influenced by intrinsic and extrinsic factors. In this study, four environmental factors (climate change, land use changes, extension methods and knowledge of environment) that influence adoption of CA by women small scale farmers are investigated. If the adoption of CA by farmers is high, agricultural production and biodiversity would be high and if the adoption of CA is low, there would be low agricultural production and loss of biodiversity.

Figure: 2.2: Conceptual Framework

Independent Variables   **Intervening Variables**   **Dependent Variable**
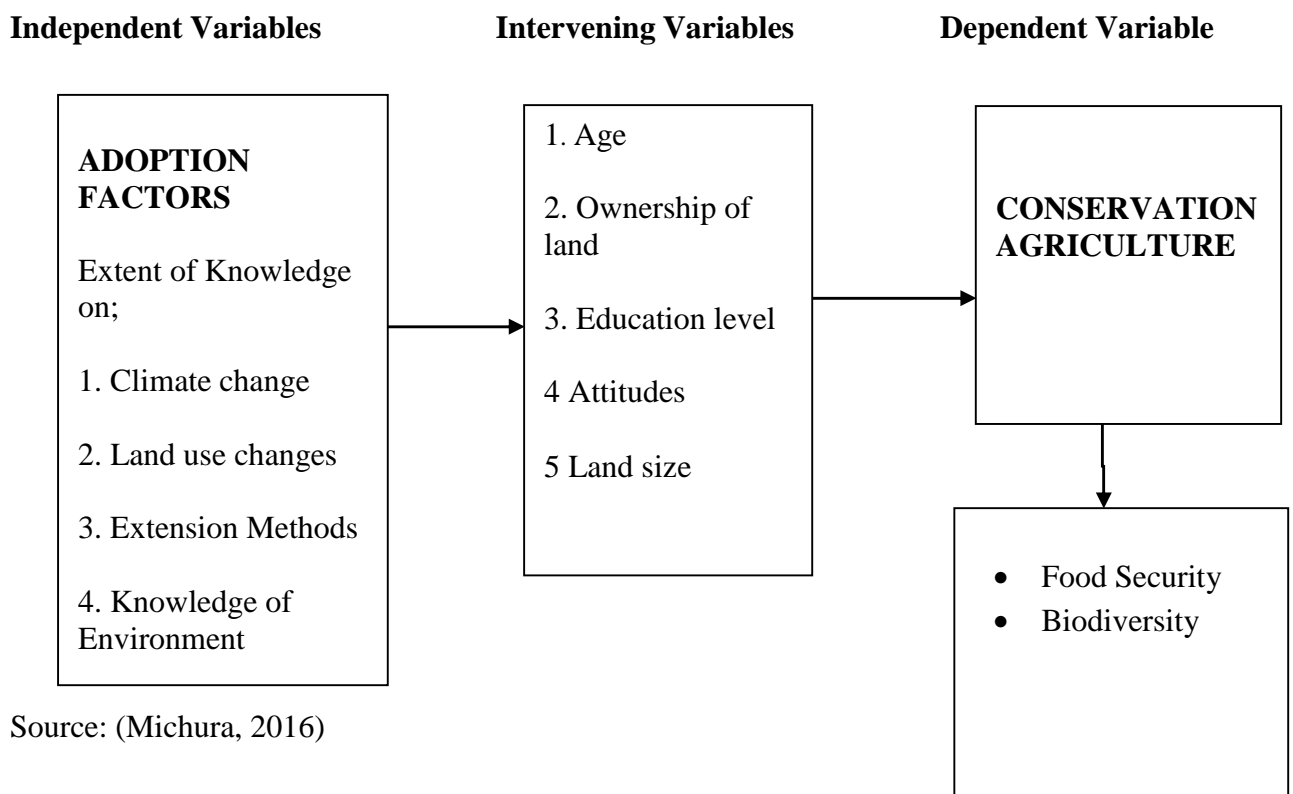
Source: (Michura, 2016)

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2.18 Relationships between the Variables

Climate Change: When women farmers have deep knowledge on variability of climate change, they would make informed choices and adopt technologies that would enable them to be sustainable in food production. The better the climate change knowledge, the more the rate of CA adoption.

Land use changes: Women farmers who have better knowledge on the effect of land use changes especially where farmlands are converted to other uses, the more they adopt CA because conventional agriculture does not solve food insecurity.

Extension Methods: Farmers rely on the support of extension methods to help them overcome agricultural problems that affect their food production. The more the effectiveness of extension methods, the greater is the CA adoption.

Knowledge of environment: Farmers who have better understanding of the environment such as importance of mulching, soil erosion control, increased tree cover, and use of organic manure are more likely to adopt CA to increase food production and biodiversity.

Dependent Variable: Conservation Agriculture adoption depends on farmers exposure to the four independent factors and is measured in terms of degree of increase such as low, moderate and high food production; low, moderate and high biodiversity in the study area.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter three of the research study covers the methodology which was used to study the environmental factors that influence women small scale farmers' adoption of conservation agriculture in Nakuru County. The research design and procedure, sample population, sampling procedure, sample size, reliability, validity of the tools, instrumentation, data collection methods and data analysis procedures are described.

3.2 Research Design

The research study employed descriptive survey design. The descriptive survey design was the best for this study as the study has specific objectives that it aims to answer. The specific objectives form the framework for the adoption of CA. The study described the variables under study as they are without manipulation. The major purpose of the descriptive survey design is the description of the state of events as it exists without manipulation of variables (Ker linger, 2005) Descriptive research is not only restricted to fact finding but may often results in formulation of important principles. The descriptive survey was preferred in this study for it allows for the study of what influences women farmers to adopt conservation agriculture. It also enables the analysis of different variables as well as giving room for the researcher to describe adoption of innovations and technologies in agricultural production and environmental management in Nakuru County Kenya.

3.3 Study Area

Figure 3.1 shows the map of Nakuru County. The study was carried out in Nakuru County which is agro-ecologically and culturally diverse. The county, a former white highland, is

characterized by fast population growth rate. The research study was conducted in three Sub Counties out of eleven counties in Nakuru namely Naivasha, Njoro and Rongai. The population at the time of research was approximately 1.7 million people, living in 5,000 square kilometers in the central part of the country (NCR, 2013). The number of women small holder farmers in the county is approximately 120,000. Nakuru area is rich in history and nearly all communities in Kenya settle here dating back more than 3,000 years. The rural population is estimated at 65%, with the remaining 35% living in towns and urban centers. There are about 400,000 households, 25% of which are female headed. Nakuru County is a region of agricultural importance. In more recent past: 1980s, the people living here have diversified their economy. There are several geographical features in the County such as Lake Nakuru, Naivasha, and Elementaita with excellent sites for tourism.

The altitude is 1850m above sea level and the average temperatures are moderate in Molo but hotter in Naivasha. The County experience diverse ecological conditions varying (NCR, 2013). There are two seasons: the long rains from March to August, and short rains from October to December. The Average rainfall is 850mm.

The soils are fertile sandy loam and volcanic suitable for agriculture which contributes 48% of income. Rural self-employment contributes 8%, wage employment 19%, urban self-employment 23% and other sectors 2%). Average farm size has reduced from large plantations on extensive farms to small scale farms. Because of the loss of farms to other economic activities, small farms are no longer suitable for conventional agriculture, hence, conservation agriculture is being promoted to maximize crop yields and sustain the fertility of soil. The main food crops produced include maize, beans, Irish potatoes and wheat. The types of fruits and vegetables grown are tomatoes, peas, carrots, onions, French beans, citrus, peaches, apples, cabbages, strawberries, asparagus and leeks. Most of these grow in Bahati, Olenguruone,

Nakuru Municipality, Gilgil and Mbogo-ini Divisions. There are three canning factories: Kokoto, Njoro Canners and Kabazi Canners. Tea is produced in Olenguruone and Bahati Divisions. Pyrethrum is a natural product for insecticide and the County is one of the most important production areas in the world though production has considerably fallen. Recently, there have been land use changes from arable farming and livestock keeping to horticulture and flower farming for export. Most of the cut flower farming is mainly concentrated in Naivasha, Njoro, Rongai and Molo in Nakuru County (NCR, 2014). Livestock keeping is now tending to be in small scale and Zero- grazing practice because grazing lands have been converted into other uses. There is a high rate of unemployment, low family income, poor housing conditions, poor access to basic facilities, and disempowerment, just to mention a few of the major challenges of the study area. The study area experiences a number of environmental problems such as soil erosion, pollution, deforestation, climate change, increased human settlements, biodiversity loss, food insecurity and poverty. Naivasha is semi-arid with dry climatic conditions and a relatively inadequate and high variability in rainfalls. It experiences prolonged drought sometimes, leading to serious food shortages. Naivasha, Njoro and Rongai in Nakuru County were selected due to varied ecological characteristic (NCR, 2014).
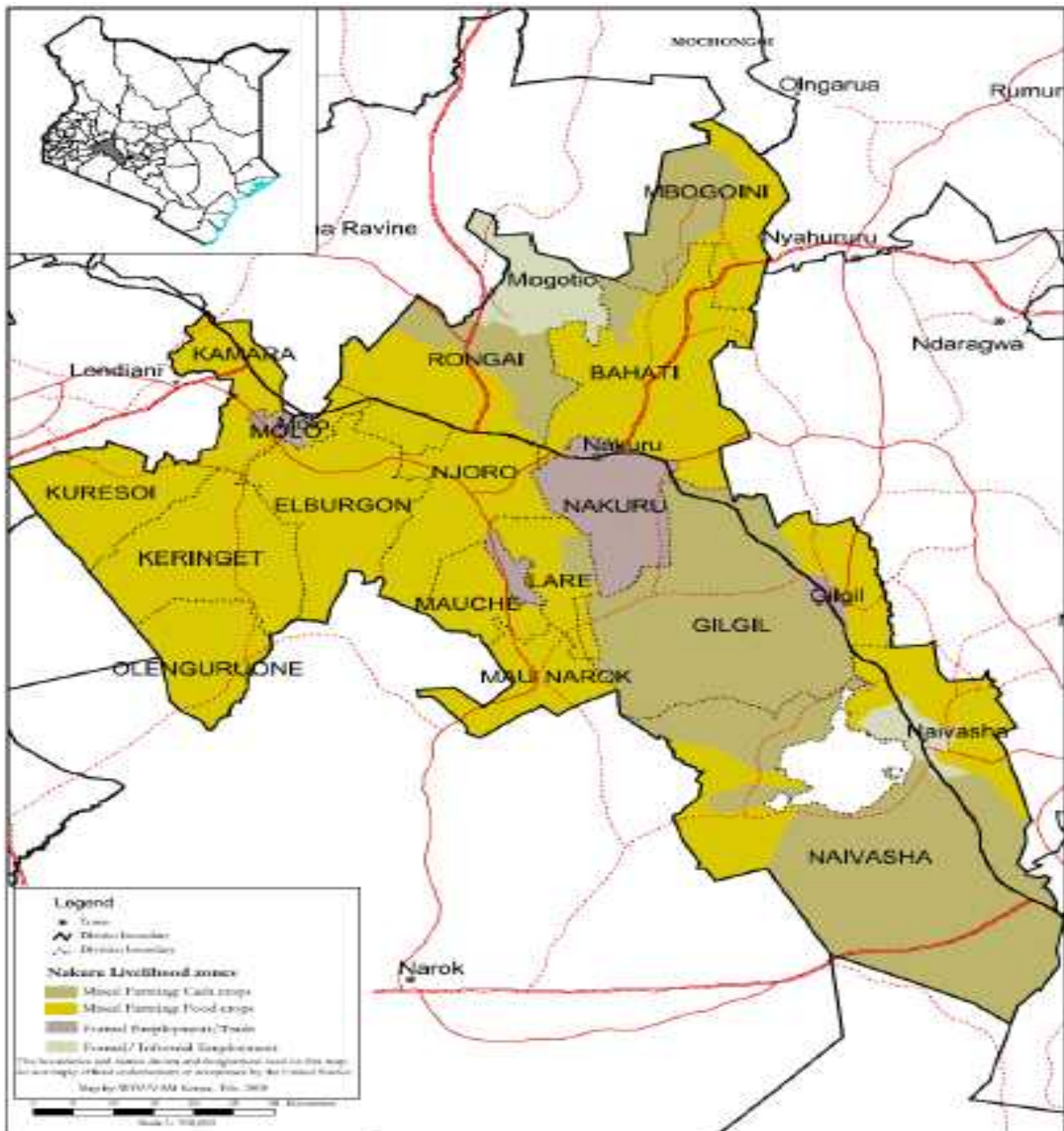
Figure 3.1.: Nakuru County Map (Source; NRC2013)

3.4 Population Sampling Technique and Sample Size

The population of Nakuru County at the time of research was approximately 1.7 million people

at the time of study according to estimated statistics (Kenya Population Analysis Report, 2014).

The population of each sub-county selected was; Njoro 195,253, Rongai 155,745 and

Naivasha269, 632. The target population, women small scale farmers was estimated at 120,000. Out of the target population, a sample size of 390 women farmers' was elected for interviews. To arrive at the sample size, the researcher used a modified table of population sampling (Appendix3) (Crecy and Morgan, 1970). The confidence level was set at 95% (alpha = 0.05). The study used purposive sampling to pick on the 3 sub counties out of 11 namely; Naivasha, Rongai and Njoro. The sub counties exhibit different ecological characteristics and are highly vulnerable to land degradation particularly, soil erosion, climate change, human settlements, industrial pollution, deforestation and land use changes. Of the 390 women farmers, 130 came from each sub county by simple random selection. The 390 sampled from the target farmers population of 120,000 was proportionate and would take care of the sampling errors and provide a level of accuracy and confidence level of 95%. The Table 3.1 shows the distribution of respondents in each sampling unit selected through purposive sampling. The respondents were picked from both churches and self-help groups present in the sub counties. Lists from nine churches and nine self -help groups were used to pick the small scale women farmers using simple random selection. From this a certain number of respondents from each study station were determined, forming 130 respondents from each sub county.

Table 3.1Shows the sampling of respondents at the three study sites

Njoro study site			
Churches		Self- help Groups	Total
AIC Njoro	30	Kamungei	12	
SDA Njoro	27	Setkobor	18	
ACK Egerton	25	Ogilgei	18	
			130

Rongai study site				
Catholic	24	Suumak	15	
AGC Ngata	31	Baraka	16	
AIC Morop	27	Kiptinend	17	
				130
Naivasha study site				
Catholic Aberdare	30	Karagita	14	
Full Gospel Gilgil	28	Gilgilia	17	
Deliverance Naiva	26	Malewa	17	
				130

The Focus group discussions and interview schedule comprised of 5 agricultural extension agents, 3Women self-help groups(Ogilgei in Njoro, Karagita Naivasha and , 3 NGOs (Seeds of Gold, PATFID, and Farming System of Kenya)and 3 officers from the Ministry of Agriculture at three sub counties; Njoro, Naivasha, and Rongai selected from the three Sub-counties. The self -help groups in this study consisted of only women who were small scale farmers. The questionnaire was administered by the researcher with the assistance of three trained enumerators from each sub county drawn from agricultural field officers (see appendix 1).

3.5 Data Collection and Instruments

The researcher obtained the approval and research permit from NACOSTI. The research permit was presented to the Ministry of agriculture Nakuru County as permission was sought to conduct research within the county. The researcher proceeded to the field and reported to the department of agriculture in the three sub-counties Njoro, Rongai and Naivasha where the

study was being conducted. The three agricultural officers introduced the research to the women self-help groups, and churches where the samples were drawn. The selected self-help groups and churches provided the respondents who formed the study target population. The researcher administered the questionnaire with the help of two trained research assistants. Data was collected by use of custom made structured questionnaires, interview schedules and personal observation guides. The questionnaires (appendix1) were used to collect data from the key respondents. Personal observation technique was used to confirm ideas that the respondents had given in the questionnaires and for the researcher to get firsthand information on the type of agricultural practices being undertaken in the study area. It also supplemented the information gathered from the respondents. Interview guides included structured (close ended) and unstructured (open ended). This was essential since it allowed for face to face interactions between the researcher and the respondent in the course of oral discussions. The questions had the several response options hence respondents were able to identify with the preferred response accordingly.

During the tour, the researcher made observations and asked questions using the guide and recorded responses from the respondents. The technique was helpful in clarifying the answers given. The researcher spent forty five minutes in administering questionnaire for each respondent in average while others took at least one hour. The results were check-listed using other information analyzed from literature review and recorded farming practices. The data collected through the questionnaire addressed four specific objectives in the study namely women farmers' knowledge of climate change, effect of land use change among women farmers, effectiveness of extension methods and environmental knowledge among women farmers in Nakuru County. Focused Group Discussions (FGDs) views were used to confirm or cross check the information obtained through other data collection methods. Data obtained through participant observation acted as a check against participants' subjective reporting of

what they believe and do. Participant observation was useful for gaining an understanding of the physical, social, cultural, and economic contexts in which study participants live. Secondary data was included in the study from publications and official reports. Information from websites was useful to enrich the data.

3.6 Validity and Reliability

The instrument was subjected to the right questions in terms of accuracy and meaningfulness based on research results (Mugenda and Mugenda, 2003).

Piloting was used in this study to measure the reliability of the instrument employing split half method. This method was used because it has a major advantage of eliminating chance error caused by varying test conditions. Cronbach's alpha Coefficient of 0.80 was used to estimate the reliability of the instrument. Different collection methods were used to ensure reliability and validity of the instruments. After piloting, the tools were refined and the ambiguous and the unclear questions were excluded in the final questionnaire. This was done after the researcher had discussed with the university academic supervisors. After testing the collection tools and determining their reliability and validity the researcher administered questionnaires to the small scale women farmers. The women farmers selected for the pilot study and the focus group persons were not included in the main study. To select for the sample size, Self-help groups and churches were used and selected by snow ball method. Interview schedules targeting women farmers were administered to self-help groups and church leaders. Three focus group discussions were held in the three sub counties chosen purposively. To improve on the reliability of the research instruments, a pilot study was conducted in Rongai, one of the sub counties of Nakuru County. The researcher practically toured the respondent's farm together with the respondents to make use of the tools concurrently. My university supervisors went through researchers' instrumentation to ensure that they were valid.

3.7 Data Analysis

Data collected was analyzed according to the objectives. The collected data was coded, cleaned and finally entered in a computer system using Statistical Package for Social Sciences (SPSS version 20). The target population units analyzed in this study were women farmers (adopters, incomplete adopters and non-adopters) in Nakuru County.

The quantitative data collected was tabulated and analyzed according to their frequency and percentages. The data was analyzed according to the hypotheses stated in the research study. Qualitative analysis involved measure of central tendency (Cross tabulations, proportions, means and percentages). Chi- Square was used because the data were categorical and showing if there would be any relationships between the variables. ANOVA model was used to determine the statistical significance of the means at $p < 0.05$ level and whether to reject or accept null hypotheses. *Post hoc* tests were used to test if the mean differences really existed. Qualitative data was analyzed by determination of patterns and trends from the open ended test items and interviews from respondents. The analyzed data were then presented in tables, graphs and charts.

3.8 Operationalization of Variables

Table 3.2: Operationalization of Variables

Specific Objectives	Independent Variables	Dependent Variables	Analysis	Output
1.To investigate the influence of knowledge of climate change among women farmers' adoption of conservation agriculture practices.	Knowledge on climate change	Conservation Agriculture	Crosstabs Chi- square ANOVAs Bonferroni test	Increase in Food Production Biodiversity Increase

2. To assess the effect of land use changes on women framers' adoption of conservation agriculture practices.	Awareness of Land use changes	Conservation Agriculture	Crosstabs Chi- square ANOVAs Bonferroni test	Increase in Food Production Biodiversity Increase
3.To describe the effectiveness of extension methods among women farmers adoption of Conservation agriculture.	Effectiveness of Extension Methods	Conservation Agriculture	Crosstabs Chi- square Anova Bonferroni test	Increase in Food Production Biodiversity Increase
4.To analyze the influence of environmental knowledge Among women farmers adoption of conservation agriculture practices.	Environmental Knowledge	Conservation Agriculture Adoption	Crosstabs Chi- square Anova Bonferroni test	Food Production Biodiversity Increase

Table 3.2 above explains the indicators that were measured to test the hypotheses in the study. The variables used to show how each of them influence women small-scale farmers' adoption of conservation agriculture.

SR	Specific Objectives	Items measured
1	To investigate the influence of knowledge of climate change among women farmers' adoption of conservation agriculture practices	1.Awareness of temperature patterns
		2. Knowledge of rainfall variability
		3. Awareness of droughts and influence
		4. Decision to vary planting dates
		5. Decision to plant different crops
		6. Shifting of crops to livestock
		7. To increase tree/shed
		8. Decision to intensify use of irrigation
		9. Migration to other sites
		10. increase water conservation
2	To assess the effect of land use changes on women framers' adoption of conservation agriculture practices.	1 Land policies on forest cover
		2 Construction/ Building cover
		3 Urban expansion
		4 Reduction in grazing land
		5 Increased economic activities industries
		6 Mixed farming
		7 Settlement encroachment
		8 Mining

3	To establish the effectiveness of extension methods among women farmers adoption of conservation agriculture practices	1 Women to women exchange information
		2 Extension agents
		3 Support of NGOs
		4 Farming materials
		5 Radio/ TV agro-program
		6 Farmers field days
		7 Agricultural shows
		8 Exposure to seminars/ workshops
		9 Chief Barasa
		10 Watching agricultural related materials
4	To establish the influence of environmental knowledge among women farmers' adoption of conservation agriculture practices.	1 Soil control measures
		2 Minimal tillage
		3 Practice of agro forestry
		4 Crop rotation
		5 Protecting wetlands
		6 Protecting wild life
		7 Increase of forest cover
		8 Benefits of using manure

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter covers the presentation on data analysis as well as findings of the study on environmental factors influencing women farmers' adoption of conservation agriculture (CA) in Nakuru County. The results are presented in tables and figures which are discussed and conclusions made on each hypotheses tested.

4.2 Demographic Characteristics of the Respondents

The characteristics of the respondents covered include age, income levels, level of education, farm size, household size and ownership of agricultural farms. The decision to adopt or not to adopt conservation agricultural practices by women farmers could be influenced by socio-economic factors. In the research study, there were farmers who fully adopted CA (adopters), farmers who adopted CA and at the same time practiced conventional (incomplete adopters) and farmers who did not adopt CA but practiced conventional farming only (non-adopters).

4.3 Respondents Age, Education Level, Size of Farm, Type of Farm and Ownership of Farm.

The findings indicate that, out of 360 women small scale farmers in the study, 54 farmers practiced CA, 204 practiced conventional farming and 387 practiced both CA and conventional farming. The decision by women farmers to adopt CA or not to adopt depended on many factors, some of which have been discussed in this study. They include knowledge of climate change, land use changes, extension methods and environmental knowledge. The socio-economic characteristics of the respondents were analyzed to give the background of women farmers and provide in-depth information supporting the factors under investigation.

The Figure 4.1 shows the age distribution of the respondents in the study (See table T1 appendix 4).
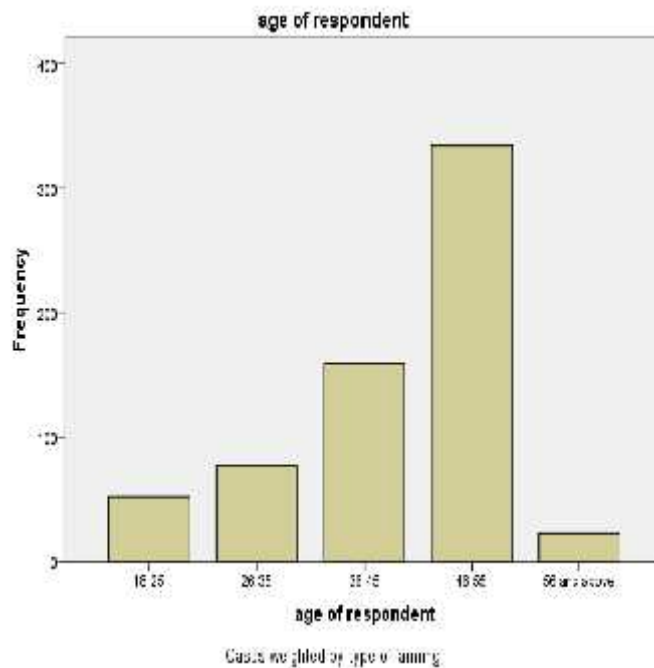
Figure 4.1 shows the age of respondents

The research sought information on the age distribution of the respondents. The findings are presented in figure 4.1. The results indicate that, the age range, 52(14.4%) of respondents were between 18 and 25 years, 50(13.9%) ranged between 26 and 35 years, 53(14.75) were between 36 and 45 years, 182(50.6%) were between 46 and 55 years, the rest 23 (6.4) had their age above 56 years. The findings show that, majority of the respondents 247(68.6%) are below 50 years. The farmer's age is important because the young farmers are knowledge and innovative than old farmers. Young farmers are likely to take any innovation that improves their occupation such as adoption of CA practices. Nyangah (2012) established that, age plays a very important role in CA uptake. The uptake of conservation agriculture (CA) by young women farmers is likely to be higher than the respondents who are older in age. In an interview with old farmers, it emerged that old people find it risky to venture into a new technology which farmers have not seen results of; therefore, uptake of CA becomes a challenge even if

there are problems with conventional farming. A sixty five year old farmer explained that a good field is supposed to be *"clean and cleared of crop residues..."* a view contrary to the CA principle of permanent soil cover. Not all CA practices fall within the domain of good agronomic practices from some farmer's perspective. From interview schedule some of the old respondents, non- adopters felt that conventional agriculture is the in thing and described; *how farming has been done even by our fore- fathers from childhood this(conventional agriculture) is how we have been farming; tillage is how farming should be done; you cannot get rich through CA but through tillage.*
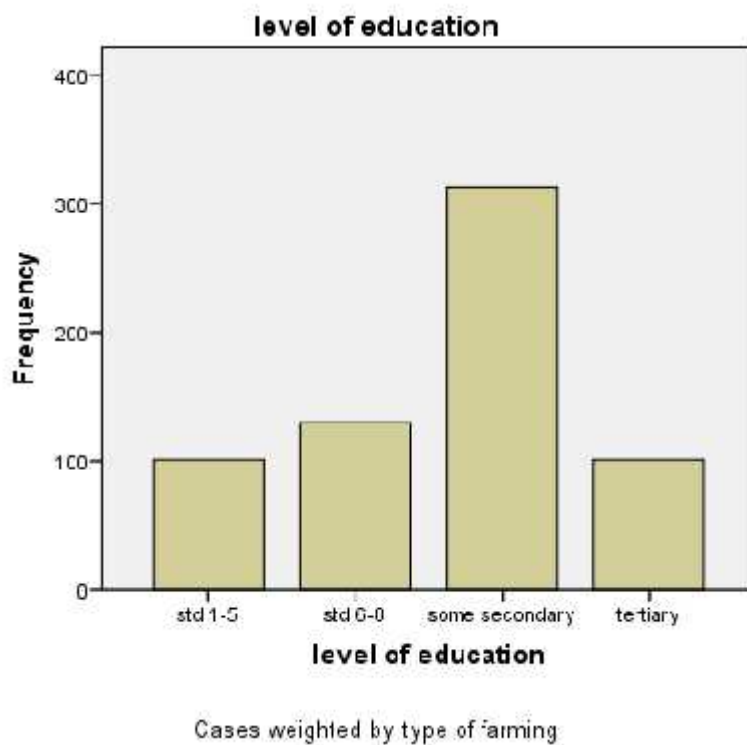
Figure 4.2 Shows education level of respondents

The research sought information on the level of education distribution of the respondents. The findings are presented in figure 4.2. 132(36%) respondents had obtained primary education, 153(42.9. %) secondary education and 75(20.8%) tertiary education. Over 228(62.8%) respondents had obtained secondary school level and tertiary education. Education is a

backbone for innovations. Farmers with higher education level are likely to learn and be trained in new farming techniques compared with low level educated farmers. Most farmers who adopted CA in the study were more educated. Education influences the uptake of conservation agriculture. Education standing is an advantage in responding to climate change, and other environmental factors likely to influence agricultural productivity in the study area (Muna and Muriuki, 2013).
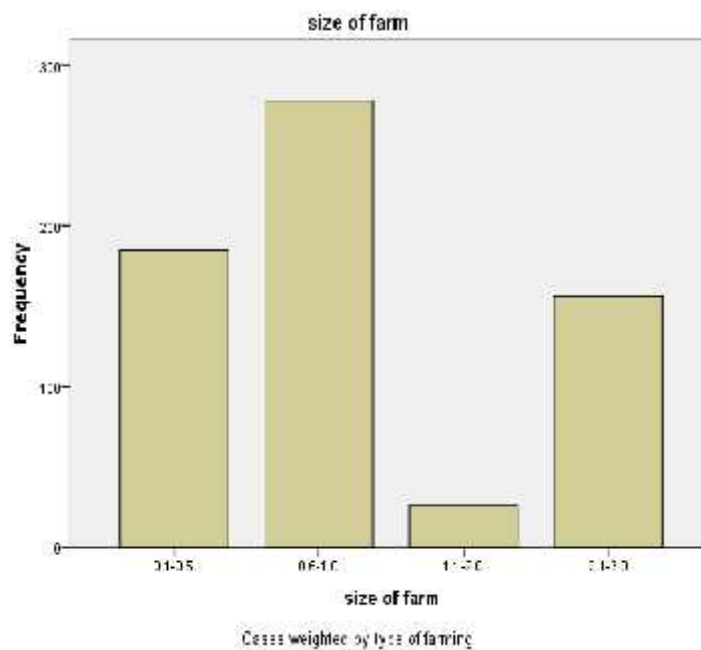
Figure 4.3 Graph showing size of farms

The findings in Figure 4.3 show that, 284 (78.9%) of respondents had farms less than 2 ha and 76 (21.1%) had more than 3.6 ha. Most respondents in the study area generally have small farms, which qualifies them as small-scale holders. A small scale farmer is defined as one whose scale of operation is too small to attract the provision of the services he/she needs to be able to significantly increase his/her productivity. In the study areas like Ngata, Ogilgei, Njoro, Molo, Elburgon, Rongai, Solai, Subukia and Naivasha sub urban peripheries, small farms are likely to affect food production. It is important to know the respondents' size of farms because the size of farms affects the type of farming practices, which should be employed. The

reduction of land size for agriculture can be a factor likely to contribute to adoption of CA in the study area. Kimani *et al* (2015) claimed that, CA practices yield many benefits to farmers with reasonably smaller farms. Ogechi and Hunja (2014) found that Kisii population is growing and fragmentation of land into small sizes has led to intensive agriculture. Thuku (2015) noted the negative impacts of fragmentation of farm lands at the urban periphery of Nairobi due to conversion of rich agricultural lands into urban settlements.
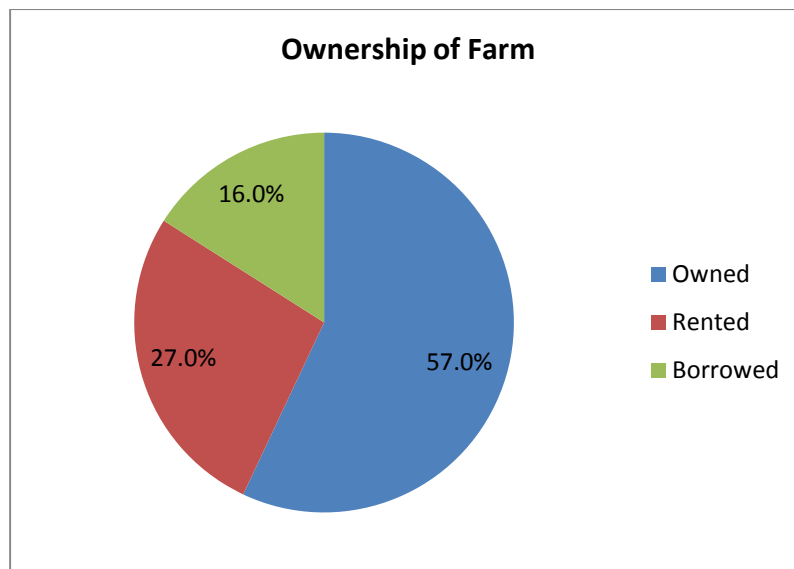
Ownership of Farm

Figure 4.4 Chart showing ownership of farms

The findings in Figure 4.4 indicate that 204 (56.7%) of respondents owned land while 27.7% rented and 16.9 % borrowed or used family land. It can be concluded that over 50% of respondents own land or use family land. Results give information that 54 (100%) of the farmers practicing CA own or use family land. Information from focus group discussion indicates that farmers practicing CA are influenced by the ownership and therefore, most of the CA adopters have their own farms or use family land. Tenure of land is considered a very important factor in CA adoption. Focus group discussion said that 40% of women farmers who do not practice CA have rented or borrowed farms. Respondents who own land have the

freedom to use land without any condition and are able to practice agro- forestry, crop rotation

mixed farming and use organic farming to maximize their production while those who rent or

borrow have restrictions. The owner of the farm may not allow a borrower or tenant to plant

trees. Farmers who practice CA on government or private forest establishments are allowed to

use them to practice agro forestry or Shamba system until the forests form canopy. This finding

is consistent with Asienga (2012), who found that landownership and land rights are

determinants of improvement in farm production in arid and semi-arid zones.
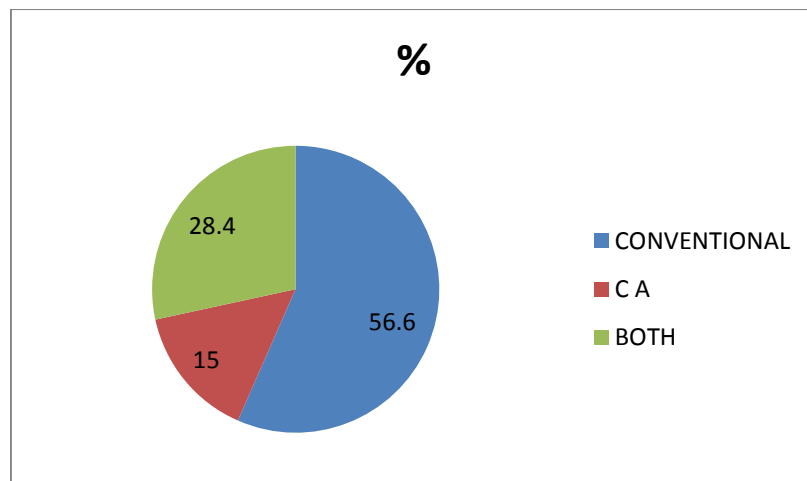
Figure 4.5: Type of farming by respondents

The Figure 4.5 shows that, the number of farmers who practiced CA was very small and those

who practiced both were more than 56.6%. The findings indicate that in Nakuru County only

15% practice CA. The uptake of CA in the study area is very low. The reasons why farmers

chose two methods of practice is that if one method fails due to environmental effects, the other

method is hoped to succeed.

4.4: Household Size

The focus group discussion established that, composition of members of the women farmers

households ranged between two and nine with mean of four members per household. Working

on the mean, households with fewer members had farm size larger and households with many

members had smaller farms. The reason for this is that, if households have many members, the farms would be subdivided according to the number of members. But personal observations indicate that although it is true that household with many members have small farms, this is not always the case. Some households with many members were found to have bigger farms than households with fewer members.

4.5 Selected Environmental Factors Analyzed in the Study.

The second part of data analysis deals with the main four objectives of the study; knowledge on climate change, land use changes, extension methods and knowledge of the environment as they influenced women farmers' adoption of conservation agriculture (CA). The results of the study revealed that out of 390 respondents given interviews only 360 were able to respond and hence were analyzed. The rest of the 30 did not respond fully and hence were not analyzed. The findings show three groups of farmers emerged; adopters (farmers practicing conservation agriculture only), incomplete adopters (farmers practicing both or CA and conventional) and non- adopters (practice only conventional)

4.5.1. Knowledge of Climate Change and its Influence on Women Farmers' Adoption of Conservation Agriculture

Ho1: Knowledge of climate change has no significant influence on women small scale famers' adoption of CA.

Kenya's economy is highly dependent on the natural resource base, making it highly vulnerable to climate variability and change. This is exhibited through rising temperatures, and changing rainfall patterns resulting in increased frequency and intensity of extreme weather events such as droughts and flooding hence threatening sustainability of the country's development. Agricultural production depends very much on climate. Climate control plant growth, health, and yields received. Any variations in climatic elements will affect crops significantly. Farmers

therefore have to develop strategies to cope with weather changes. In this study ten indicators were analysed.

List of the ten climate change variables measured in the study include the following;

1. Knowledge on changes of temperature patterns

2. Knowledge on rainfall patterns

3. Frequency of droughts

4. Decision to varying planting dates

5. Decision to plant different crops

6. Switching crops to livestock

7. Increase tree/ shed

8. Intensify use of irrigations

9. Migrating to different sites

10. Increase water conservation

The first objective of the study sought to determine whether knowledge on climate change has any statistical significant influence on women farmers' adoption of CA. To determine this, women farmers were asked to indicate the extent at which their knowledge on climate change influence their adoption of CA. The cases were weighted in terms of frequencies based on the type of farming practiced before cross-tabulation was carried out. Analysis was done on each question item and thereafter a combination of all the items was analyzed to give the overall relationship.

Awareness of changes in temperature patterns and its influence on CA adoption was analyzed. Farmers who are aware of changes in temperature are better equipped in handling harsh environments than farmers who have little or no knowledge. Temperatures affect the growth

of crops and any change in temperature affect the production function. CA knowledge helps

farmers to overcome variations in temperatures ranging between 3 and 4 ºC (Lugandu, 2013)

The first item sought to determine the influence of the respondent awareness on the changes in

temperature patterns on adoption of CA. The results of cross-tabulation are presented in Table

4.1.

Table 4.1: Cross tabulation awareness of temperature patterns

Type of farming	my awareness on the changes in temperature patterns has influenced my adoption of CA			
	to a little extent	undecided	to great extent	to a very great extent
Conventional	0	126	26	52
	.0%	61.8%	12.7%	25.5%
CA	0	2	52	0
	.0%	3.7%	96.3%	.0%
Both	78	0	228	81
	20.2%	.0%	58.9%	20.9%

The results in Table 4.1 indicate that to a great extent, knowledge on temperature variations

influenced women farmers adoption of CA. 52 (96.3%) of the women farmers were adopters,

228 (58.9%) were incomplete adopters and 78 (38.2%) were non-adopters. This suggests that

the extent of awareness of temperature patterns influence farmers' adoption of CA. Focus

group discussions felt that non adopters could likely be affected by other factors such as age,

education level, and size of farm among other factors. Temperature variations affect crop

production. Other farmers felt that just being aware of climate change is not enough. Weather

information and transmission to farmers through extension services can be helpful and make

women farmers have the adaptability. Nearly 80% of key informants (women self- help group

leaders) indicated that CA compared to conventional is safer and cushion any risks due to

changes in temperatures. Knowledge of variations in temperatures is very important to a farmer because temperature has direct impact on crops. Change in temperature from normal to extreme may lead to new pests and diseases that may be hard to control. The Table 4.2 is as secondary information from Meteorological department in Kenya regarding weather variability in Nakuru County. The evidence confirms that climate change is a reality (Lugandu, 2013).

Table 4.2 Showing temperature changes between 1980 and 2013

Year	Temperature (Celsius)
1980	17.6
1985	18.7
1990	18.0
1995	19.5
2000	22.3
2005	20
2010	23
2013	23.8

Source: (Lugandu, 2013)

To determine the extent of the relationship between temperature changes awareness and adoption of CA, Chi-square test was run. The results are presented in Table 4.3

Table 4.3: Chi-Square Test Results

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	419.701(a)	6	.000
Likelihood Ratio	487.600	6	.000
Linear-by-Linear Association	3.890	1	.049

a 0 cells (.0%) have expected count less than 5. The minimum expected count is 6.53.

From the result in Table 4.3 the Chi-square test statistic, $\chi^2(6, N = 360) = 419.70$ $p< .05$, indicates that there is a significant relationship between farmers' awareness on temperature pattern and their adoption of CA. Awareness of women farmers to temperature variation influence them to adopt CA. Most small- scale women farmers are knowledgeable about temperature and rainfall variability and their impacts on agricultural production (Saya, 2011). Women farmers who did not adopt CA could have been due to other factors.

The second item rainfall variations influence CA adoption was analyzed. Agriculture depends more on rainfall. Any variations in rainfall affect the crop yields. Changes in rainfall either too much of it or too little of it can put farmers into great risk as in Table 4.4. Water aids mineral ions in uptake from the soil by crops through a solution which water provides. Transpiration rate must balance with water being absorbed.

Table 4.4 Rainfall changes between 1980 and 2013

Year	Rainfall (mm)
1980	762.3
1985	1137.2
1990	1064.4
1995	928.6
2000	670.8
2013	725

Source: (Lugandu, 2013)

The second item sought to determine the influence of the respondent awareness on the rainfall patterns on adoption of CA. The results of cross-tabulation are presented in Table 4.5

Table 4.5: Crosstab on patterns of rainfall influence on CA adoption

type of farming	my observation on the patterns of rainfall has influenced my adoption of CA			
	to a little extent	undecided	to great extent	to a very great extent
Conventional	26	52	49	77
	12.7%	25.5%	24.0%	37.7%
CA	2	0	42	10
	3.7%	.0%	77.8%	18.5%
Both	81	156	81	69
	20.9%	40.3%	20.9%	17.8%

The results in Table 4.5 indicate that 42 (77.8%) adopters, 81(20.9%) incomplete adopters and 77 (37.7%) non- adopters of CA to a great extent were aware of rainfall patterns and its influence on adoption of CA practices. The same trend seen with temperature patterns is observed with rainfall patterns. It can be concluded that, CA adopters were knowledgeable about changes in rainfall and were influenced to CA adopt practices.

To determine the relationship between the awareness of rainfall patterns and adoption of CA, chi-square test was run. The results are presented in Table 4.6.

Table 4.6: Chi-Square Test Results

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	173.129(a)	6	.000
Likelihood Ratio	167.135	6	.000
Linear-by-Linear Association	37.240	1	.000

a 0 cells (.0%) have expected count less than 5. The minimum expected count is 8.96.

From the results in Table 4.6, the Chi-square test statistic, $\chi^2(6, N = 360) = 173.129$ $p< .05$, indicates that there was a relationship between awareness of rainfall patterns and adoption of CA. To a great extent, rainfall variations awareness influenced women farmers' adoption of CA. Extreme climatic variations particularly rainfall have strong influence on small-scale farmers in the study area. The source of water for crops growth and development is soil water which also useful in dissolving mineral ions taken up by plants through solution. Little rainfall to a farmer is disastrous and too much of it, may burn the crops destroying the yields. The result of this study is supported by the findings of (Saya, 2011) who observed the same trend with women farmers in Burkina Faso West Africa where the amount of yields was affected and the farmers get less yields. Besides, higher temperatures and rainfall may result in new pests and diseases that could be difficult to control or treat. .

The knowledge on frequency in occurrence of drought and influence on CA adoption was analyzed. Since most of the women farmers in the study area depend very much on rain fed agriculture, frequent droughts affect the crop production. Drought resistant crops are better adapted to climatic changes and are found to be better alternative. Mulching and crop residues left in the fields help to conserve water during the dry weather (Seline *et al*, 2014).

The research also sought the knowledge of the respondents on the influence of frequency of drought on adoption of CA. The results are presented in Table 4.7.

Table 4.7: Crosstab frequency of drought occurrence influence on CA adoption

Type of farming	the frequency in the occurrence of drought has influenced my adoption of CA				
	to no extent	to a little extent	Undecided	to great extent	to a very great extent
Conventional	24	56	26	72	26
	11.8%	27.5%	12.7%	35.3%	12.7%
CA	0	4	0	8	42
	0.0%	7.4%	.0%	14.8%	77.8%
Both	0	0	81	228	78
	.0%	.0%	20.9%	58.9%	20.2%

The cross-tabulation results in Table 4.7 showed that (77.8%) adopters, 228(58.9 %) incomplete adopters and. 72(35.3%) of non-adopters were influenced to a great extent by occurrences of drought. Drought is a serious environmental problem and farmers are severely affected by droughts which often cause great loss on crops and livestock. Old farmers may not want to change from their traditional practice to new innovations even though they are faced with harsh environments which require change of techniques in farming to avoid losses.

To determine the relationship between frequency of occurrence of drought and adoption of CA, Chi-square test was run. The results are presented in Table 4.8.

Table 4.8: Chi-Square Test Results

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	354.004(a)	8	.000
Likelihood Ratio	350.640	8	.000
Linear-by-Linear Association	85.237	1	.000

a 2 cells (13.3%) have expected count less than 5. The minimum expected count is 2.01.

The Chi-square test statistic, $\chi^2(8, N = 360) = 354.004$ $p < .05$ from Table 4.8 indicate that there is a significant relationship between farmers adoption of CA and frequency of occurrence of drought. To respond to drought conditions, majority of respondents were growing drought resistant crops such as millet, sorghum, cassava, cow peas and the keeping of goats. The focus group discussion asserted that, frequency of drought occurrence is high and affects women famers. 80% of the members in the groups voiced that drought resistant crops are reliable and are less affected by harsh climatic changes. Many farmers living in marginal ecological zones practice dry farming and plant drought resistant crops to avert drought hazards (Caroline, *et al*, 2015).

The knowledge of climate change and influence on decision to vary planting dates, influence on CA adoption was analyzed. The crop planting date is important to a farmer and must be

observed accurately. Any lateness or early planting may affect the crops and results in losses. It is a low-cost agricultural management strategy aiming to alleviate crop water stress can contribute to enhance agricultural decision-making, particularly as a climate change adaptation strategy. In the tropical regions, rising temperatures and changes in rainfall patterns, including increased seasonal and inter annual rainfall variability, can directly cause yield reduction for most of the food crops and, therefore, reduce food production. Varying of planting dates is important to respond to the climate change for small- scale farmers for maximum yields (Waongo and Kunstmann, 2015).

The research also sought the perceptions of the respondent on the influence of changes in climate on decision to vary planting dates as part of adoption of CA. The results are presented in Table 4.9.

Table 4.9: Cross tabulation. Decision to vary planting dates influence CA adoption

type of farming	changes in climate has influenced my decision to vary my planting dates			
	to a little extent	Undecided	to great extent	to a very great extent
Conventional	46	80	52	26
	22.5%	39.2%	25.5%	12.7%
CA	3	2	47	0
	5.6%	3.7%	90.7%	.0%
Both	81	81	147	78
	20.9%	20.9%	38.0%	20.2%

The results in Table 4.9 indicate that 52(90.7%) adopters, 147(38%) incomplete adopters 78(38.2%) non-adopters to a great extent were aware that climate change influences their decision to vary planting dates. Women farmers who were adopters may have been influenced by age and education to vary the planting dates. Many farmers may not have the knowledge of weather and its effects thus do not have the exact timing of planting every year.

To determine the relationship between frequency of climate change occurrence and varying planting dates, Chi-square test was run. The results are presented in Table 4.10.

Table 4.10: Chi-Square Test Results

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	109.579(a)	6	.000
Likelihood Ratio	120.159	6	.000
Linear-by-Linear Association	9.342	1	.002

a 0 cells (.0%) have expected count less than 5. The minimum expected count is 8.71.

The findings in Table 4.10 indicate that there is a significant relationship between farmers varying planting dates and their experience of changes in climate (χ^2(6, $N = 360$) = 109.579 $p<$ .05). Awareness of climate change by women farmers influenced them to vary planting dates to respond to timing of rains to prevent losses and enhance productivity. Cases of women farmers who did not adopt CA may be influenced by other factors such as age, education level, size of farms or lack of knowledge on climate change. It was also observed from the focus group discussion that farmers are pessimistic with weatherman broadcast because most of the time weather changes are not accurate, so they do not act on the information. Again the extension services are not adequate enough to advice farmers especially women small scale holders on the best time to prepare the land.

The knowledge of farmers on climate change and influence on planting different crops influence on CA was analyzed. Different crop species have different temperature optima as well as different sensitivities to CO_2 and Ozone. One useful distinction is between crops that originated in temperate environments such as wheat and barley, versus crops from tropical environments, such as cassava (*Manihot esculenta*) and sorghum (*Sorghum bicolor*). A recent synthesis of the literature (Hatfield, et al, 2011*)* identified optimal season average temperature of 15°C for wheat, 18°C for maize, 22°C for soybean, 23°C for rice and bean (*Phaseolus*

vulgaris), and 25°C for cotton (*Gossypol hirsute*) and sorghum. (For some crops, report a range, from which we take the lowest value.) An important distinction for CO_2 sensitivity is between C_4 grains (least responsive), C_3 grains (more responsive), and root and tuber crops (most responsive). Farmers are also likely to change these practices in response to climate change, for instance by sowing different crops or varieties, changing the timing of field operations, or expanding irrigation, and the socioeconomic capacity to make these adaptive changes will differ by region (Hatfield *et al,.* 2011).

The study also determined the extent to which knowledge on climate change influence farmers' decision to plant different types of crops. The results are presented in Table 4.11.

Table 4.11: Cross tabulation on climate change and decision to plant different crops

	changes in climate has influenced my decision to plant different types of crops			
type of farming	to a little extent	undecided	to great extent	to a very great extent
Conventional	0	126	26	52
	.0%	61.8%	12.7%	25.5%
CA	6	4	42	0
	11.1%	7.4%	81.5%	.0%
Both	78	0	228	81
	20.2%	.0%	58.9%	20.9%

The results in Table 4.11 show that the 42 (81.5%) adopters, 228 (58.95) incomplete adopters and 52(25.5%) non-adopters were influenced to a great extent by their knowledge on changes in climate to plant different types of crops. Farmers who planted different crops were to a great extent, influenced by awareness of climate change.

To determine whether there was a significant relationship between the knowledge on climate change and planting of different crops, a Chi-square test was run. The results are presented in Table 4.12

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Table 4.12: Chi-Square Test Results

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	419.701(a)	6	.000
Likelihood Ratio	487.600	6	.000
Linear-by-Linear Association	3.890	1	.049

a 0 cells (.0%) have expected count less than 5. The minimum expected count is 6.53.

The Chi-square test statistic,χ^2(6, N = 360) = 419.701 p< .05, as depicted in Table 4.12 indicates that there is significant relationship between farmers planting of different crops and their experience in climate change. The Interview schedule with stakeholders, 60% indicated that, planting of different crops or crop diversification by women farmers is perhaps one of the coping or survival strategies to avoid losses when the extreme harsh weather conditions are experienced. From personal observation, many farmers had planted more than three crops in their small farms. This shows that they are aware of the dangers of relying on one crop type.

Changes in climate and influence on decision to switch from crops to livestock, influence on CA adoption was analyzed. Switching from crop to livestock is one of the coping strategies farmers practice to reduce losses incurred during climate changes. Livestock keeping is less sensitive to variations in rainfall and temperatures. Majority of farmers take their livestock for grazing into the forest where it is wetter and plenty of grass while other farmers can afford storing hey to be used during dry season.

The influence of changes in climate on farmers' decision to switch from crop to livestock production was also determined. The findings are presented in Table 4.13.

Table 4.13: Cross tabulation on climate change and decision to switch from crop to

Livestock

| type of farming | changes in climate has influenced my decision to switch from crop to livestock production | | | |
	to a little extent	undecided	to great extent	to a very great extent
Conventional	26	52	49	77
	12.7%	25.5%	24.0%	37.7%
CA	0	8	34	10
	.0%	14.8%	66.7%	18.5%
Both	81	156	81	69
	20.9%	40.3%	20.9%	17.8%

The results in Table 4.13 show that the 34(66.7%) adopters, 150 (38.7%) incomplete adopters and 126 (61.7%) no adopters were to a great extent were influenced by their knowledge on changes in climate to switch from crop to livestock production. Non-adopters were aware of climate change but did not adopt CA. Women farmers who were influenced by knowledge of climate change moderately adopted CA.

To determine whether there was a significant relationship between the knowledge on climate change and switching from crop to livestock production, a Chi-square test was run. The results are presented in Table 4.14.

Table 4.14: Chi-Square Test Results

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	173.129(a)	6	.000
Likelihood Ratio	167.135	6	.000
N of Valid Cases	645		

a 0 cells (.0%) have expected count less than 5. The minimum expected count is 8.96

The Chi-square test statistic, $\chi^2(6, N = 360) = 173.129$ $p < .05$, from the results in Table 4.14 indicate that there was significant relationship between farmers switching from crop to livestock production and their experience of changes in climate. From interview, 55% of farmers argued that, there was less risk in keeping livestock. In focus group discussion, it was also noted that livestock keeping can take in the form of zero grazing. During the wet rainy season hay and fodder is grown and stored which the animals can feed on during drought. This is one of the coping strategies to drought impacts on farming in the study area.

Decision to increase tree/shed planting influence CA adoption was analyzed. Maximizing carbon sequestration while meeting multiple needs–by planting a combination of trees and other plants mitigates climate change. Increasing tree shed results in carbon reduction, reduced temperature and increase in rainfall. Tree shades also attract rainfall as the findings confirmed (UNDP, 2012).

The extent to which changes in climate influence farmers' decision to increase tree/shed planting was also determined. The findings are presented in cross tabulation in Table 4.15.

Table 4.15: Cross tabulation on decision to increase tree/shed planting

type of farming	changes in climate has influenced my decision to increase tree/shed planting				
	To no extent	to a little extent	undecided	to great extent	to a very great extent
Conventional	24	56	26	72	26
	11.8%	27.5%	12.7%	35.3%	12.7%
CA	0	12	0	0.	40
	.0%	22.2%	.0%	.0%	77.8%
Both	0	0	81	228	78
	.0%	.0%	20.9%	58.9%	20.2%

The findings in Table 4.15 indicate that, 40 (77.8%) adopters, 228(58.9%) incomplete adopters and 102 (48%) non-adopters to a very great extent were aware of climate change. CA adopters were influenced to adopt CA by increasing tree/shed planting as a result of their knowledge on climate change. Non-adopters were aware of climate change to a great extent but did not adopt increase in tree/ shed planting.

To determine whether there was a significant relationship between the knowledge on climate change and the farmers' choice to increase tree/shed planting, a Chi-square test was run. The results are presented in Table 4.16.

Table 4.16: Chi-Square Test Results

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	354.004(a)	8	.000
Likelihood Ratio	350.640	8	.000
Linear-by-Linear Association	85.237	1	.000

a 2 cells (13.3%) have expected count less than 5. The minimum expected count is 2.01.

The Chi-square test statistic, $\chi^2(8, N = 360) = 354.004$ $p < .05$, showed that there is a significant relationship between farmers' choice to increase tree/shed planting and their knowledge of changes in climate. Interviews with the farmers indicated that planting of trees in the area is recommended as part of overcoming climatic change. The planting of varieties of tree species provide farmers with different ecosystem services such as climate regulations, biogeochemical cycles, livestock feeds, prevention of soil erosion, pollination increase, construction materials, cooling, purification of air, wind speed protection fuel wood and organic manure, water conservation, human food and medicinal products. UNDP (2012) confirmed and established that planting more trees increase biodiversity and help in mitigating environmental hazards in

the area. Farmers with small plots are challenged and indicated that even though they want to increase tree cover, they are limited by the small farms they own and also land tenure presents a big problem. This finding was not supported by another finding (Fredrich and Kassam, 2011) who found that, small plots may not be suitable for tree/shed increase.

Climate change and decision to intensify use of irrigation influence on CA was analyzed. Irrigation increases the regional moisture flux, which in turn modify the convective available potential energy. This causes a reduction in the surface temperature and leads to a modified regional circulation pattern and changes in meso-scale precipitation. These agricultural changes, including irrigation, modify the convection and rain patterns. These regional changes in land use need to be considered in improved weather forecasting as well as multi-decadal climate variability and change assessments (UNDP, 2012).

The influence of changes in climate on farmers' decision to intensify the use of irrigation was also determined. The findings are presented in Table 4.17.

Table 4.17: Cross tabulation on climate change on intensification of irrigation

	Changes in climate has influenced my decision to intensify the use of irrigation		
type of farming	to a little extent	undecided	to great extent
Conventional	56	76	72
	27.5%	37.3%	35.3%
CA	7	0	45
	12.95%	.0%	87.05%
Both	81	150	156
	20.9%	38.8%	40.3%

The findings in Table 4.17 indicate that 45(87.0%) adopters, 156 (40.3%) incomplete adopters and 72 (35.3%) non-adopters to a great extent were aware that intensification of the use of

irrigation. CA adopters were influenced to adopt CA while non-adopters failed to adopt CA. The farmers, who did not adopt CA by intensification of the use of irrigation method, could be facing other challenges. In Nakuru county water supply is a big problem especially in drier zones such as Naivasha and Rongai sub counties. Water taps in rural settings and some urban periphery are dry most of the time. Water may be enough for domestic use and not irrigation. From the interviews, drilling of water in Nakuru is quite expensive due to the low water table. Water is also scarce making irrigation a challenge especially to small scale farmers.

To determine whether there was a significant relationship between the knowledge on climate change and the farmers' choice to intensify the use of irrigation, a Chi-square test was run. The results are presented in Table 4.18.

Table 4.18: Chi-Square Test Results

	Value	Df	Asymp. Sig.(2-sided)
Pearson Chi-Square	70.826(a)	4	.000
Likelihood Ratio	84.860	4	.000
Linear-by-Linear Association	1.110	1	.292

a 0 cells (.0%) have expected count less than 5. The minimum expected count is 11.64.

The Chi-square test statistic, $\chi^2(4, N = 360) = 70.826$ $p< .05$, suggest that there is a significant relationship between farmers' choice of using irrigation as a result of their knowledge in changes in climate and adoption of CA. The study show strong relationship emphasizing the increased use of water and less reliance of rain fed farming. The focus group discussions and interview schedule asserted that there are few rivers in Nakuru County and to drill a bore hole is quite expensive for small scale farmer. The Nakuru County report on development strategies 2014 shows that, the water table for Nakuru region is very low and in most cases drilling depth can be up to 200metres which confirms this finding.

Climate change and its influence on migration on other sites, influence CA adoption was analyzed. Droughts, unpredictable weather, and fluctuation in rainfall regimes are the causes of people migrating to other areas as a way of coping with changes in climate. During droughts or lack of rainfall, farmers move to cooler and wetter areas such as forests and highlands. The influence of changes in climate on farmers to migrate to different site for cultivation was also determined. The findings are presented in Table 4.19.

Table 4.19: Cross tabulation on climate change and migration to other sites

	changes in climate has influenced my decision to migrate to different site for cultivation		
type of farming	To no extent	to a little extent	To a great extent
Conventional	30	75	99
	14.7%	36.8%	48.5%
CA	12	0	40
	26.0%	.0%	74.0%
Both	81	228	78
	20.9%	58.9%	20.2%

The findings in Table 4.19 indicate that 40(74%) adopters, 78(20.2%) incomplete adopters, and 99(48.5%) non adopters to a great extent, were aware of migrating to different site for cultivation. CA adopters were influenced to adopt CA. Non-adopters were not influenced to adopt CA. This means that, other factors may have contributed to their non-responses.

To determine whether there was a significant relationship between the knowledge on climate change and the farmers' migration to different site for cultivation, a Chi-square test was run. The results are presented in Table 4.20.

Table 4.20: Chi-Square Test Results

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	226.611(a)	4	.000
Likelihood Ratio	212.736	4	.000
Linear-by-Linear Association	19.874	1	.000

a 0 cells (.0%) have expected count less than 5. The minimum expected count is 13.81.

The Chi-square test statistic, $\chi^2(4, N = 360) = 226.611$ $p < .05$, suggest that there is a significant relationship between farmers' decision to migrate to different site for cultivation and changes in climate. From the focus group discussions, 40% felt that farmers migrate to other sites when there are extreme changes in weather but 60% said this was not important.

Climate change and decision to increase water conservation influence on CA adoption was analyzed. As the climate changes, conservation practices have the potential to help in achieving maximum sustainable levels of food production, which will be essential to efforts to feed the world's growing population. Good policies/practices for water and other resources conservation will contribute to positive impacts on air, soil, and water quality; soil productivity; and efforts towards achieving and/or maintaining food security. These good policies/practices will contribute to climate change mitigation and adaptation. Poor policies/practices for air, soil, and water conservation (or a lack of policies/practices) will contribute to negative impacts on air, soil, and water quality; soil productivity; and efforts toward achieving and/or maintaining food security. Women small scale farmers in the study area need to have the knowledge of water conservation in order to improve food production. Water conservation is important because it improves crop production (Hatfield, *et al,* 2011).

The influence of changes in climate on farmers' decision to increase water conservation practices was also analyzed. The findings are presented in Table 4.21.

Table 4.21: Cross tabulation decision to increase water conservation

	Changes in climate has influenced my decision to increase water conservation practices			
type of farming	to a little extent	undecided	To great extent	to a very great extent
Conventional	0	26	154	24
	.0%	12.7%	75.5%	11.8%
CA	0	2	52	0
	.0%	3.7%	96.3%	.0%
Both	147	162	0	78
	38.0%	41.9%	.0%	20.2%

The findings in Table 4.21 indicate that 52 (96.3%) farmers who adopted CA were more likely to increase water conservation practices as a result of their knowledge in changes in climate, 78 (20.2%) of the incomplete adopters to a great extent either increase water conservation or did not as influenced by climate change. 168 (87.3%) of non-adopters were aware of climate change but they did not increase water conservation. Changes in climate influence water conservation practice in the farms (Seline, *et al*, 2014). Majority of adopters in the study area were therefore aware of the importance of water conservation practices. Similar information was recorded with focus group discussions and interview schedules where 76% of the farmers' were aware that water conservation help improve soil quality, air quality and increase crop yields. Majority of adopters have planted cover crops, practicing Shamba farming system and reduced tillage.

To determine whether there was a significant relationship between the knowledge on climate change and the farmers' decision to increase water conservation practices, a Chi-square test was run. The results are presented in Table 4.22.

Table 4.22: Chi-square Test Results

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	523.972(a)	6	.000
Likelihood Ratio	598.231	6	.000
Linear-by-Linear Association	119.765	1	.000

a 0 cells (.0%) have expected count less than 5. The minimum expected count is 8.54.

The Chi-square test statistic, $\chi^2(6, N = 360) = 523.972$ $p < .05$, suggest that there is a significant relationship between farmers' decision to increase water conservation practices and changes in climate. Water conservation practices are adoption technologies in CA ensuring permanent soil moisture retention by planting cover crops, tree planting to attracting rainfall, mulching to preserve soil moisture and use of organic manure for maximum crop production.

Effect of Overall Awareness of Climate Change and Influence on CA adoption was analyzed. The overall means on the Influence of overall knowledge on climatic change on adoption of CA was determined. The means are presented in Table 4.23

Table 4.23: Overall Means on Climate Change variables

Type of farming	N	Mean	Std. Deviation	Std. Error
Conventional	204	3.3897	.25178	.01763
CA	27	3.7704	.15396	.02963
Both	129	3.4093	.27935	.02460
Total	360	3.4253	.27414	.01445

The results in Table 4.23 indicate that farmers who are knowledgeable about climatic changes are more likely to adopt CA practices. The mean for CA 3.77 was higher than no-adopters and incomplete adopters indicating that climate change influence farmers to adopt CA.

However to determine whether there was a significant difference in the means, ANOVA was carried out. The results are presented in Table 4.24.

Table 4.24: ANOVA Test of overall multiple means of knowledge on climatic change

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	3.506	2	1.753	26.664	.000
Within Groups	23.474	357	.066		
Total	26.980	359			

The results in Table 4.24 showed that F statistics 26.664 indicate that, there was significant difference ($p< .05$) in the means of the three groups of farmers. Thus the null hypothesis which stated that there is no statistical significance relationship between climate change and influence on CA adoption by farmers was rejected. This implies that there is a relationship between the farmers' knowledge on climate change and their adoption of CA practices and the majority of CA adopters to a great extent were aware of climate change and that is why they accepted to take up CA practices to cope with the climate change.

To determine where the differences existed, a *post-hoc* analysis was carried out using Bonferroni test. The results are presented in Table 4.25.

Dependent Variable: Influence of overall knowledge on climatic change on adoption of CA

Table 4.25 Bonferroni Test of differences in overall means on climate change

(I) type of farming	(J) type of farming	Mean Difference (I-J)	Std. Error	Sig.
Conventional	CA	-.38066(*)	.05251	.000
	Both	-.01960	.02884	1.000
CA	Conventional	.38066(*)	.05251	.000
	Both	.36107(*)	.05427	.000
Both	Conventional	.01960	.02884	1.000
	CA	-.36107(*)	.05427	.000

* The mean difference is significant at the .05 level.

The results presented in Table 4.25 show that there is significant difference in the means between the means of group of farmers who adopted the use of CA and the other two groups .38066 and .36107 respectively. The mean difference between the group of farmers who use conventional practices and those who use both the conventional and CA practices however was not significant. The F test and Bonferroni analysis shows that women farmers were influenced to a great extent by climate change.

The figure 4.6 shows that, the ten items tested and rated from the highest to the least according to the awareness of women farmers' adoption of CA. Temperature variations (96.3% and water conservation (92.6%) scored higher than the other indicators. This means that women farmers were more aware of temperature variations and conservation of water and this influenced them to adopt CA. Switching from crop to livestock (55%) was the lowest and this means that women farmers were less influenced by switching from crops to livestock on CA adoption.
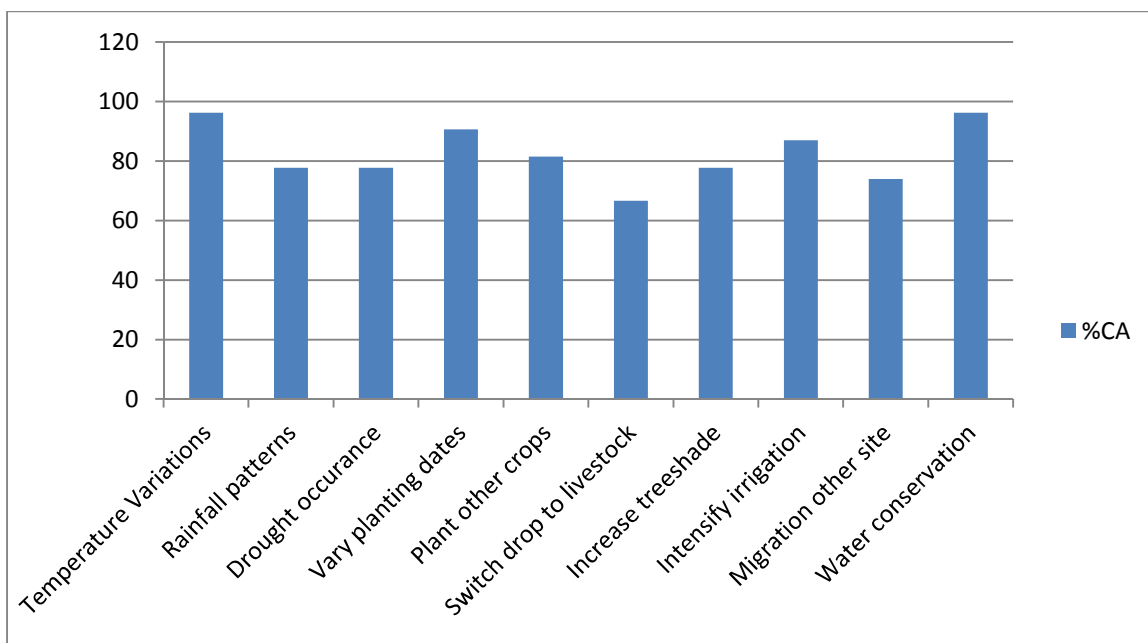
Figure 4.6: Showing respondents mean awareness of the indicators of climate change.

Climate change is a motivator and induces innovation. It was also observed that climate change has a lot of challenges which can only be mitigated by small scale smart agriculture (Ndambiri,

et al, 2011). Women often have a strong body of knowledge and expertise that can be used in climate change mitigation, disaster reduction and adaptation strategies. Furthermore, women's responsibilities in households and communities, as stewards of natural and household resources, positions them well to contribute to livelihood strategies adapted to changing environmental realities. On the other hand women are more vulnerable to the effects of climate change primarily as they constitute the majority of the world's poor and are more dependent for their livelihood on natural resources that are threatened by climate change. Furthermore, they face social, economic and political barriers that limit their coping capacity. The land tenure, small farm size, agricultural policies, political influence and cultural factors may act negatively against women success in food production and poverty eradication as they are hit by climate change (UNDP, 2012)

Climate change has serious ramifications in four dimensions of food security: food availability, food accessibility, food utilization and food systems stability. Women are often excluded from decision-making on access to and the use of land and resources critical to their livelihoods (Muna and Muriuki, 2013). It is therefore imperative that, respect and support rights of rural women are ensured in regards to food security, non-discriminatory access to resources, and equitable participation in decision-making processes. Women small scale farmers in North Kinangop where climate invariability and change had a lot of effect on agricultural production which was highly under rain fed (Muna and Muriuki, 2013).The effect of climate change was causing losses in agribusiness environment in Kinangop where a lot of horticultural activities are taking place. More frequent and more intense, extreme weather cause adverse immediate impacts on food production, food distribution infrastructure, livelihood, assets and opportunities in both rural and urban areas.

Women farmers have access to information about climate change through farm extension services. Farmers with access to information were more likely to perceive climate change than farmers without access to information (Nyangah, 2012). The same famers were also more likely to adapt to climate change compared to their counterparts who do not have access to climate change information. There was negative relationship between knowledge in climate change and adoption of climate related technologies in Ethiopia. Whether women farmers are aware of climate change or not there is decrease in the likelihood of adoption of drought related technologies (Etwire, *et al,* 2013).

Tree planting within and along the farm boundaries and homesteads have a lot of advantages. The focus group noted that, community based approach and the new county government are making efforts to ensure that more trees are established to increase forest cover which will reverse the negative effects of climate change such as global warming, acid rainfall, drought, species extinction, habitat loss among others. The results of interview schedule showed that 85% believed in planting of more trees to mitigate the effects of drastic weather changes.

The extent to which farmers are aware of climate change is not consistent, and the link between knowledge on climate change and action, is often not well defined. Farmers adopt a range of strategies from financial responses, to agricultural changes, to religious and cultural strategies, to the use of local and wider support networks (Harmer and Rahman, 2014). However, whether these actions are adoption or coping strategies is debatable. Response to climate change has both spatial and temporal dimensions. In another study, it was asserted that a host of socio-economic factors (e.g. lack of resources, gender or cultural identities) influence adoption strategies. Finally, these adoption strategies can be seen as nested within broadly defined livelihood strategies. Climate change affect a range of farming activities and knowledge on

climate change and farmers' response is very vital (Pelum, 2013). There is a significant association between smallholder farmers' perceptions of extreme climatic events and adoption of adaptation technologies (Kansiime, 2014). Rainfall is measured using rain gauge apparatus which is one of the instruments in a weather station. Any time it rains, rain water is collected in a bottle and is transferred into a measuring cylinder which is marked in millimeters. This is done for a long period of time in months and years. Temperature is measured with thermometer which is marked in degree Celsius. Any variations in the two elements in a given set time can be interpreted as changes in climate. Farmers do not have these instruments to measure rainfall or temperature variations but rely on the weatherman (Kansiime, 2014). The findings of the study show that climate change has a greater impact on farming and women farmers to adopt any farming type are influenced by it. Temperature variations, conservation of water and rainfall patterns influence women farmers more than other elements tested in the study.

4.5.2 Land use Changes and Influence on Adoption of Conservation Agriculture.

Land is a factor of economic, social and ecological production. Land use is the way human allocates land to a particular usage. How the land is used depends on several factors such as demand, fertility, availability, climate, relief, latitude, altitude, soil formation and PH, among others. Nine indicators of land use changes variable, have been analyzed and discussed (Asienga, 2012).

The second objective of the study sought to determine how land use changes influence farmers' adoption of CA. To realize this objective, specific land use changes were rated against the women adoption of CA before the overall effect was determined. The effects were measured in a 4-point Likert scale ranging from no extent to a great extent.

The following is the list of land use change variables measured in the study;

1. Changes on land use policies
2. Land use change from farmland to roads

3. Land use change from farmland to urban growth

4. Reduction in farm size

5. Farmlands changed to industrial estate

6. Farmland converted to mining sites and quarrying

7. Farmlands converted to settlements villages

8. Farmlands used for mixed farming from plantations

Changes on land policies on forest cover influencing adoption of CA were analyzed. Forest and land use policies across African countries have historically passed through two types of governance: Under traditional systems controlled by families, traditional leaders and communities. Decisions regarding land allocation, redistribution and protection were the responsibilities of local leaders. Evidence from many case studies in Sudan suggests that integrated forest management where communities have access rights to forestlands and are involved in management, is a key factor favoring the restoration of forest carbon stocks. These projects provide examples of a collaborative system for the rehabilitation and use of the forest land property based on defined and acceptable criteria for land cultivation by the local people and for renewal of the forest crop (IUCN, 2004).

The first item sought to determine the influence of Changes on policies on forest cover on adoption of CA. The results of cross-tabulation are presented in Table 4.26.

Table 4.26: Cross tabulation on changes in land policies on forest cover and CA Adoption.

type of farming	Changes in land policies on forest cover has influence my adoption of CA			
	to a little extent	Undecided	to great extent	to a very great extent
Conventional	0	126	26	52
	.0%	61.8%	12.7%	25.5%
CA	0	2	52	0
	.0%	3.7%	96.3%	.0%
Both	78	0	228	81
	20.2%	.0%	58.9%	20.9%

The findings in Table 4.26 indicate that farmers who adopted CA were influenced by changes in land policies on forest cover. 52 (96.3%) adopters to a great extent were aware and adopted CA, 228(58.9%) incomplete adopters to a great extent were aware but practiced both CA and conventional, while 78(38.2%) non-adopters were aware to a great extent but did not adopt CA. This means that women farmers who adopted CA were greatly influenced by land use policy on forest cover increase. Forest cover increase is one of the practices of CA and any policies developed by the government should encourage farmers to protect the environment and avert climatic changes. Large acres of forest land have been converted to farm lands due to population pressure resulting to the demand for settlements, cultivation and expansion of other economic activities in the area. The government through development officers and forestry department should develop policy plan for encouraging people to plant more trees to increase forest cover and this will lead to protection of the environment and avert effects of climate change, global warming and acid rainfall (NCR report, 2014).

Plate 1a Forest and Tea- Elburgon forest 2000(GPS 00° 35' 00'' S, 35° 41' 00'' E)

Plate 1b Farming replacing forest (Source: Alison Jones &Denita Delimont2016)
(GPS 00° 35' 00'' S, 35° 41' 00'' E)

The aerial photograph 1a shows dense forest cover at the background which has been encroached by farming as seen in Plate 1b. Plate 1b shows part of the forest has been converted into farmlands and settlement. The aerial photographs are evidence to confirm that, the study area has undergone land use changes and this has been confirmed (Mubea and Menz, 2014). To determine whether there was a significant relationship between changes on land policies on forest cover and adoption of CA, a Chi-square test was run. The results are presented in Table 4.27.

Table 4.27: Chi-Square Test Results

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	419.701(a)	6	.000
Likelihood Ratio	487.600	6	.000
Linear-by-Linear Association	3.890	1	.049

a 0 cells (.0%) have expected count less than 5. The minimum expected count is 6.53.

The Chi-square test statistic, $\chi^2(6, N = 360) = 419.701$ $p < .05$, suggest that there is a significant relationship between farmers' knowledge on changes on policies on forest cover and adoption of CA. It was observed that, most farms in the study site are small and establishing agro forestry is quite challenging. Women farmers are encouraged to plant trees in their farms. Those who

rent farms may not grow trees but are more interested in benefits from the farms. Land owners with large farms are likely to practice agro forestry (Kimani, *et al*, 2015)

Land use change from farm to road construction and its influence on CA adoption was analyzed. The study also sought to determine the relationship between road construction as land use change and adoption of CA. The results are presented in Table 4.28.

The continued expansion of human population and demand for land has reduced large farms to small farms and human settlements have given way in creating many feeder roads or access roads. As a result of this, impact on food production in the study area has been reducing (Thuo and Maina, 2013).

Table 4.28: Cross tabulation land use change on road construction and influence on CA Adoption.

	Use of the land in road construction has influenced my adoption of CA			
type of farming	to a little extent	Undecided	to great extent	to a very great extent
Conventional	26	52	49	77
	12.7%	25.5%	24.0%	37.7%
CA	0	0	36	16
	.0%	.0%	70.4%	29.6%
Both	81	156	81	69
	20.9%	40.3%	20.9%	17.8%

The finding in Table 4.28 indicate that, 36 (74.6%) adopters, 81(20.9%) incomplete adopters and 77(37.7%) non-adopters, to a great extent were knowledgeable about changes of land use by road construction. The women farmers who adopted CA to a great extent were influenced by knowledge on road construction to adopt CA and women non-adopters to a great extent were aware but failed to adopt. Women farmers in this study site experience loss of arable land to road construction through many feeder roads as land is fragmented into small farm plots but the loss of farmland was moderately significant in influencing women farmers adoption.

To determine whether there was a significant relationship between the use of land for road construction and adoption of CA, a Chi-square test was run. The results are presented in Table 4.29.

Table 4.29: Chi-Square Test Results

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	173.129(a)	6	.000
Likelihood Ratio	167.135	6	.000
Linear-by-Linear Association	37.240	1	.000

a 0 cells (.0%) have expected count less than 5. The minimum expected count is 8.96.

The Chi-square test statistic, $\chi^2(6, N = 360) = 173.129$ $p < .05$, suggest that there is a significant relationship between use of land for road construction and adoption of CA among the farmers. The more the roads are constructed the less the land area under farming. To overcome this challenge, women prefer to practice CA which is intensive and give better results in yields than conventional farming. The increased settlements and subdivision of farms into small plots to create access roads have eaten quiet considerably the farm lands in the study area. The research did not establish the amount of land that has been converted into increased access roads therefore research need to be conducted.

The growth in urban centers and their influence on CA adoption was analyzed. Land use changes due to population growth and conversion of farmlands to other economic uses have serious implications on food production especially the small-scale farmers who depend on food growing as their livelihoods. The influence of growth in urban centers on the adoption of CA was also determined. The findings are presented in Table 4.30.

Table 4.30: Cross tabulation on growth of urban and influence on CA adoption

type of farming	Growth in urban centers has influenced my adoption of CA				
	to no extent	to a little extent	undecided	to great extent	to a very great extent
Conventional	24	56	26	72	26
	11.8%	27.5%	12.7%	35.3%	12.7%
CA	0	2	0	0	52
	.0%	3.7%	.0%	.0%	96.3%
Both	0	0	81	228	78
	.0%	.0%	20.9%	58.9%	20.2%

The cross-tabulation results in Table 4.30 showed that 52(96.3%) adopters, 228(58.9%) incomplete adopters and 98(48%) non adopters to a great extent were aware of urban expansion influence on CA adoption. This means that, women farmers who adopted CA were to a great extent influenced by urban growth to adopt CA and those women farmers who did not adopt CA were aware of urban expansion but failed to adopt CA. Urban growth therefore influenced women farmers' adopters. The study concludes that, the women farmers are affected by increased urban growth which is encroaching into farm lands. Due to the conversion of farm lands to urban growth, the farms are becoming less productive and polluted. Due to this scenario, women farmers are adopting CA practices which encourage zero grazing, vegetable growing, poultry keeping, bee keeping, fish pond and fruit farming. Similar observation was made in a research conducted in Nairobi urban periphery, where productive arable lands have been subdivided into small plots for development of real estate around Limuru (Thuo and Maina, 2013).

To determine the relationship between growth in urban centers and adoption of CA a Chi-square test was run. The results are presented in Table 4.31.

Table 4.31: Chi-Square Test Results

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	354.004(a)	8	.000
Likelihood Ratio	350.640	8	.000
Linear-by-Linear Association	85.237	1	.000

a 2 cells (13.3%) have expected count less than 5. The minimum expected count is 2.01.

The Chi-square test statistic, $\chi^2(6, N = 360) = 354.004$ $p< .05$, suggest that there is a significant relationship between growth in urban centers and farmers' adoption of CA. The growth of urban has acted as stimulator for farmers to engage in diversification of crops and livestock keeping (Ogechi and Hunja, 2014). This enabled the farmers to meet the food supply demand to the population living in urban centers by concentrating on intensive horticulture, zero grazing and poultry keeping. Forest land clearance in favor of urban settlement is impacting on climate change, loss of habitat for forest animals, loss of species, migration of forest wildlife and drought. This observation was strongly supported by informants interviewed and they felt that, it is disappointing to see rich arable land being converted to urban environment. There is need to determine the rate and amount of arable land being converted to other economic uses.

Plate 2a Farmland Nakuru before1980 (GPS 0.3031° S, 36.0800° E)

Plate2bAn Estate in Nakuru Urban growth 2016

Source: (Rosemary Maresi: Nakuru County News 2016) GPS 0.3031° S, 36.0800° E

Plate 2a and 2b show how arable land around Nakuru town has been converted to estates for human settlements. This explains how there is food insecurity in the County. The county used to produce more food because the farms were large and productive before 1980s.

Plate 3a shows the intact forest before deforestation to create land for farming and settlements. Thick forest cover helps to reduce Co2 concentration in the air, attracts rainfall, a habit and acts as windbreaks and protects soil from erosion.

Plate 3a Mau Forest Olenguroune before 1990 (GPS0°25'0'' S and 35°49'60'' *E)*

Plate 3b Olengoruone forest encroachment by farmers-GPS 0°25'0" S and 35°49'60" _E_

(Rosemary Maresi Nakuru County News (2016)

Plate 3b is showing how farmers are encroaching into forest land reducing forest cover. Although the farmers need to grow food but this action may lead to environmental degradation. The farm size reduction and influence on CA adoption was analyzed. When farms become too small, the yields become low in production. Small farms lose their value of production and in order to intensify its use, farmers carry out CA as a way of compensation in increasing their food production (Ogechi and Hunja, 2014).

The study also determined the extent to which reduction in farm size has influenced adoption of CA. The findings are presented in Table 4.32.

Table 4.32: Cross tabulation on farm size reduction and CA adoption

	Reduction in farm size has influenced my adoption of CA			
type of farming	to a little extent	undecided	to great extent	to a very great extent
Conventional	46	80	52	26
	22.5%	39.2%	25.5%	12.7%
CA	0	2	50	2
	.0%	3.7%	92.6%	3.7%
Both	81	81	147	78
	20.9%	20.9%	38.0%	20.2%

The findings in Table 4.32 show that 50 (92.6%) farmers who adopted CA were influenced to a greater extent by reduction in farm size. 225 (58.2%) incomplete adopters to a great extent were aware but practiced both CA and conventional, and 78(38.2%) non-adopters were to a great extent aware of reduction of farm lands but failed to adopt CA.

To determine the extent of the relationship, a Chi-square test was run. The results are presented in Table 4.33.

Table 4.33 Chi-Square Test Results

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	109.579(a)	6	.000
Likelihood Ratio	120.159	6	.000
Linear-by-Linear Association	9.342	1	.002

a 0 cells (.0%) have expected count less than 5. The minimum expected count is 8.71.

The findings in Table 4.33 show that there is a significant relationship between reduction in farm size and farmers' adoption of CA, $\chi^2(6, N = 360) = 354.004\ p < .05$. It can be concluded that farm size affects CA adoption.

The reduction in grazing land and influence on CA adoption was analyzed. The extent to which reduction in grazing land, influence farmers' adoption of CA was also determined. The results are presented in Table 4.34.

Increased diversification of economic activities and settlements are reducing the grazing area. There is no longer free grazing hence livestock keepers adopt new ways of farming either zero grazing, or change to crop or horticulture farming (Mubea and Menz, 2014)

Table 4.34: Cross tabulation on reduction of grazing land on CA adoption

type of farming	Reduction in grazing land has influenced my adoption of CA			
	to a little extent	undecided	to great extent	to a very great extent
Conventional	0	126	26	52
	.0%	61.8%	12.7%	25.5%
CA	0	2	48	4
	.0%	3.7%	88.9%	7.4%
Both	78	0	228	81
	20.2%	.0%	58.9%	20.9%

The results in Table 4.34 indicate that 48 (88.9%) of adopters, 228(58.9%) incomplete adopters and 52(25.5%) non adopters to a great extent were aware of reduction in grazing land influence on CA adoption. Women farmers who adopted CA were influenced by reduction of grazing land and non-adopters to a great extent were aware of reduction in grazing land but failed to adopt CA.

To determine whether the relationship was significant, Chi-square test was run. The results are presented in Table 4.35

Table 4.35: Chi Square Test Results

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	419.701(a)	6	.000
Likelihood Ratio	487.600	6	.000
Linear-by-Linear Association	3.890	1	.049

a 0 cells (.0%) have expected count less than 5. The minimum expected count is 6.53.

The findings in Table 4.35 show that there is a significant relationship between reduction in grazing land and farmers' adoption of CA, $\chi^2(6, N = 360) = 419.701$ $p < .05$.

The study found that, women farmers have been affected by decrease in grazing land. This scenario has affected livestock keepers. Interviews conducted with key leaders 70% asserted

that, for the last fifteen years, there has been rapid land use change from agriculture production to other economic developments. Since grazing requires large tracts of land the reduction in land size and land use changes have forced the farmers to change and adopt CA practices. Were and Singh, (2013) confirm this finding that, because of reduced grazing land, farmers keep animals through Zero grazing which is a form of CA practice.

The Growth of Industries and Influence on CA Adoption was analyzed. Nakuru County has in the last two decades increased its industrial growth. More land is being allocated for industries such as mining, timber, floriculture, dairy, grain storage and transport.

To determine the influence of growth of industries on adoption of CA, the results are presented in Table 4.36.

Table 4.36: Cross tabulation on growth of industries and influence on CA adoption

| type of farming | Growth of industries has influenced my adoption of CA | | | |
	to a little extent	undecided	to great extent	to a very great extent
Conventional	26	52	49	77
	12.7%	25.5%	24.0%	37.7%
CA	8	4	40	2
	14.8%	7.4%	74.1%	3.7%
Both	81	156	81	69
	20.9%	40.3%	20.9%	17.8%

The findings in Table 4.36 indicate that growth of industries is more likely to influence women farmers' adoption of CA. 40 (74.1%) adopters, 150 (38.6%) incomplete adopters and 128 (61.7%) non-adopters to a great extent were aware of growth of industries influence on adoption of CA. Women farmers adopters were to a great extent influenced and non-adopters were aware of growth in industries but failed to adopt CA. Incomplete adopters practiced both CA and conventional.

To determine whether the relationship was significant, Chi-square test was run. The results are presented in Table 4.37.

Table 4.37: Chi-Square Test Results

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	173.129(a)	6	.000
Likelihood Ratio	167.135	6	.000
Linear-by-Linear Association	37.240	1	.000

a 0 cells (.0%) have expected count less than 5. The minimum expected count is 8.96.

The findings in Table 4.37 show that there is a significant relationship between growth of industries and farmers' adoption of CA, $\chi^2(6, N = 360) = 173.129$ $p< .05$. This suggests that probably more land in the study area is being converted to industrial activities. Increase in industrial establishment not only reduces land area but the consequence of industrial growth is pollution which is likely to impact negatively on farm activities. The farmers' awareness of this has influenced their actions to adopt CA practices which reduce risk from pollution effects on crops and livestock production. How pollution from industries such as flowers are affecting farmland.

Plate 4a before Farmland Elburgon1980 (GPS 0.2983° S, 35.8035° E)

Plate 4b after; Farmland converted to timber factory Elburgon 2014

(GPS 0.2983° S, 35.8035° E)

Plates 4a and 4b indicate how industrial growth has occurred at the expense of the farm land in Elburgon Nakuru County. Plate 4a was a farmland which has been replaced by timber industries in Plate 4b. This conversion of land use has negative implications on farming. Intensification of mining activities influence on CA adoption was analyzed.

Increased mining activities may result in the loss of available arable land for cultivation and contamination of soil. This contributes to loss of soil fertility especially the top soil which has been affected by waste from mining factories. Practicing soil improvement practices such as crop rotation, application of manure and mulching are adaptive ways of increasing the fertility of soil hence increase in food production (Kimani, *et al*, 2015).

The study also determined the extent to which intensification of mining activities influenced adoption of CA. the results are presented in Table 4.38.

Table 4.38: Cross tabulation on intensification of mining on CA adoption.

	intensification of mining activities have influenced my adoption of CA				
Type of farming	to no extent	to a little extent	undecided	to great extent	to a very great extent
Conventional	24	56	26	72	26
	11.8%	27.5%	12.7%	35.3%	12.7%
CA	0	11	0	0	41
	.0%	20.35%	.0%	.0%	79.65%
Both	0	0	81	228	78
	.0%	.0%	20.9%	58.9%	20.2%

The findings in Table 4.38 showed that farmers who adopted CA were influenced to a great extent by intensification of mining activities in the area. 41(79.65%) adopters, 228 (58.9%) incomplete adopters and 72 (35.3%) non-adopters were aware of intensification of mining influenced to a great extent to adopt CA. Women farmers adopters were aware of intensification of mining and non-adopters were aware to a great extent influence of mining but failed to adopt CA.

Chi-square test was run to determine whether the relationship was significant. The results are presented in Table 4.39.

Table 4.39 Chi-Square Test Results

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	354.004(a)	8	.000
Likelihood Ratio	350.640	8	.000
Linear-by-Linear Association	85.237	1	.000

a2 cells (13.3%) have expected count less than 5. The minimum expected count is 2.01.

The findings in Table 4.39 show that there is a significant relationship between intensification of mining and farmers' adoption of CA, $\chi^2(8, N = 360) = 354.004$ $p< .05$. The mining activities include stone block mining and removing gravel for road construction. Such activities degrade the land making it nonproductive for agriculture; perhaps this is what drives women farmers to practice CA. It was observed that there many quarry works near Naivasha, Kananga, Bahati, Kokoto impacting on the environment and farming activities. The research did not address how the impact of quarry works is impacting on farming and the environmental health.

The association between changes in settlements and adoption of CA by farmers was also determined. A cross tabulation on the extent of influence is presented in Table 4.40.

Changes in settlements and influence on CA adoption were analyzed. There has been increased movement of people from other places to the study area which has resulted in pressure on resource use together with farmlands fragmented into small plots that no longer viable for farming. Increase in human settlement has also caused pollution of the environment such as soil due to heavy use of inorganic fertilizer which contributes to soil infertility (NRC, 2014).

Table 4.40: Cross tabulation on settlements influence on CA adoption

| type of farming | changes in settlement has influenced my adoption of CA | | |
	to a little extent	Undecided	to great extent
Conventional	56	76	72
	27.5%	37.3%	35.3%
CA	2	8	42
	3.7%	14.8%	81.5%
Both	81	150	156
	20.9%	38.8%	40.3%

The findings in Table 4.40 showed that 42(81.5%) adopters, of the respondents practicing CA indicated that changes in settlement influenced their adoption of CA, 156 (40.3%) incomplete adopters and 72 (35.3%) non-adopters to great extent were aware of changes in settlements influence adoption of CA. Women farmers adopters to a great extent were aware of changes in settlements and women farmers non-adopters were aware to a great extent but failed to adopt CA. This suggests that there is an association between the changes in settlements and adoption of CA by women farmers. Much of the arable land in the study area has been replaced with settlements. 90% of groups interviewed confirmed the findings, which has been supported by (Were and Singh, 2013).

To determine whether the relationship is significant Chi-square test was run. The results are presented in Table 4.41.

Table 4.41: Chi square Test Results

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	70.826(a)	4	.000
Likelihood Ratio	84.860	4	.000
Linear-by-Linear Association	1.110	1	.292

a 0 cells (.0%) have expected count less than 5. The minimum expected count is 11.64.

The findings in Table 4.41 show that there is a significant relationship between changes in settlement and farmers' adoption of CA, $\chi^2(4, N = 360) = 70.826$ $p< .05$.

In the study area, there has been increased rate of settlement and the land area under farming has been significantly reduced affecting farming. Reduced land area has influenced women farmers to adopt CA.

The study observed that, the population in Nakuru County is growing very fast and big farm lands have been subdivided and converted into small plots for constructing residential houses both in urban and rural settings. The influx of population, land fragmentation and degradation are threats to food security not only in the communities living here but the whole of Kenya.

The small interviews conducted with community leaders expressed the seriousness of land degradation as a result of population pressure (Were and Singh, 2013) Interview of informants and stakeholders found that increased settlements have reduced farms to the extent that they are no longer productive. Expected yields are very low and poverty has increased. In households with large members and small farms, the subdivision has further reduced the size to very small units which are less productive. Ogechi and Hunja (2014) found similar situation in Keumbu, Kisii where most of the productive farms have been settled and crop yields over the years have gone down. More enlightenment is needed to find out the extent of urban and rural settlements on food production in the area

Plate 5 Kimende Naivasha Sub division of land (GPS 0.7172° S, 36.4310° E)

(Source: Pauline Kairu Daily Nation, July 2014

The Plate 5 shows the subdivision of land for settlements at Kimende along Naivasha Nairobi highway. The influx of human population in the study area has put pressure on land. Large farms have been subdivided and sold into plots for residential houses and commercial activities. Women farmers have been affected and food production and biodiversity are threatened. Land use change to mixed farming and its influence on CA adoption was analyzed. Mixed farming is one of the practices used in areas where the soil is exhausted or need improvement or where the farms are small to maximize production.

The extent to which practice of mixed farming influenced farmers' adoption of CA was also determined. The results are presented in Table 4.42.

Table 4.42: Cross tabulation on mixed farming and influence on CA adoption

type of farming	practice of mixed farming has influenced my adoption of CA				
	to no extent	to a little extent	undecided	to great extent	to a very great extent
Conventional	24	56	26	72	26
	11.8%	27.5%	12.7%	35.3%	12.7%
CA	0	2	0	2	52
	.0%	3.7%	.0%	3.7%	92.6%
Both	0	0	81	228	78
	.0%	.0%	20.9%	58.9%	20.2%

The findings in Table 4.42 majority 52(92.6%) adopters, 78(20.2%) of the incomplete adopters and 72(35.3%) to a great extent were aware of practicing mixed farming and influence on CA adoption. Women farmers' adopters and non-adopters to a great extent were aware that knowledge on mixed farming influence CA adoption but non-adopters failed to adopt CA. Mixed farming is a way of maximizing the use of land for small scale farmers hence influence adoption of CA. This suggests that there is an association between farmers' practice of mixed farming and adoption of CA practices. Under CA approach, mixed farming is very promising particularly when there are weather variations.

To determine whether the relationship is significant, Chi-square test was run. The results are presented in Table 4.43.

Table 4.43:Chi-Square Test Results

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	226.611(a)	4	.000
Likelihood Ratio	212.736	4	.000
Linear-by-Linear Association	19.874	1	.000

a 0 cells (.0%) have expected count less than 5. The minimum expected count is 13.81.

The findings in Table 4.43 show that there is a significant relationship between farmers' practice of mixed farming and adoption of CA practices, $\chi^2(4, N = 360) = 70.826 \, p < .05$. Focus group discussions argued that growing of more than one single crop and at the same time keeping livestock has advantages for small farms. It also generates animal manure that can be used to increase soil fertility which is a better option instead of using inorganic fertilizer which degrades the soil. The focus group indicated that, CA is a sure way of improving crop yield and maintaining soil fertility. Mixed farming is very ideal in maintaining good quality soil and shielding farmers from losses incurred if it was a single crop.

The overall mean score on the 10 items measuring effect of overall change in land use on adoption of CA was determined. The summary of means is presented in Table 4.44

Table 4.44: Multiple means of overall effect of land use changes

	N	Mean	Std. Deviation	Std. Error
Conventional	204	3.3230	.31089	.02177
CA	27	3.8519	.19245	.03704
Both	129	3.4522	.39313	.03461
Total	360	3.4090	.36340	.01915

The results in Table 4.44 indicate that changes in land use are more likely to influence farmers to adopt CA practices.

However, to determine whether there was a significant difference in the means, ANOVA was carried out. The results are presented in Table 4.45.

Table 4.45: ANOVA Test of overall effect of means in land use changes

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	7.045	2	3.523	31.155	.000
Within Groups	40.365	357	.113		
Total	47.411	359			

The results in Table 4.45 showed that there is a significant difference in the means, $F_{(2,357)}$ =31.155, $p< .05$. Thus the null hypothesis which stated that, there is no statistical significance difference between land use changes and influence on CA adoption by women farmers was rejected. This implies that there is a relationship between changes in land use and their adoption of CA practices.

To determine where the differences existed, *post-hoc* analysis was carried out using Bonferroni test. The results are presented in Table 4.46.

Table 4.46: Bonferroni Test on mean differences in land use changes

(I) type of farming	(J) type of farming	Mean Difference (I-J)	Std. Error	Sig.
Conventional	CA	-.52887(*)	.06886	.000
	Both	-.12921(*)	.03783	.002
CA	Conventional	.52887(*)	.06886	.000
	Both	.39966(*)	.07116	.000
both	Conventional	.12921(*)	.03783	.002
	CA	-.39966(*)	.07116	.000

* The mean difference is significant at the .05 level.

The results in Table 4.46 indicate that differences existed in all the groups. The difference however was in favor of the women farmers who practice CA as indicated by their overall higher mean. The study has alluded that, land use changes have influenced women farmers to adopt CA.
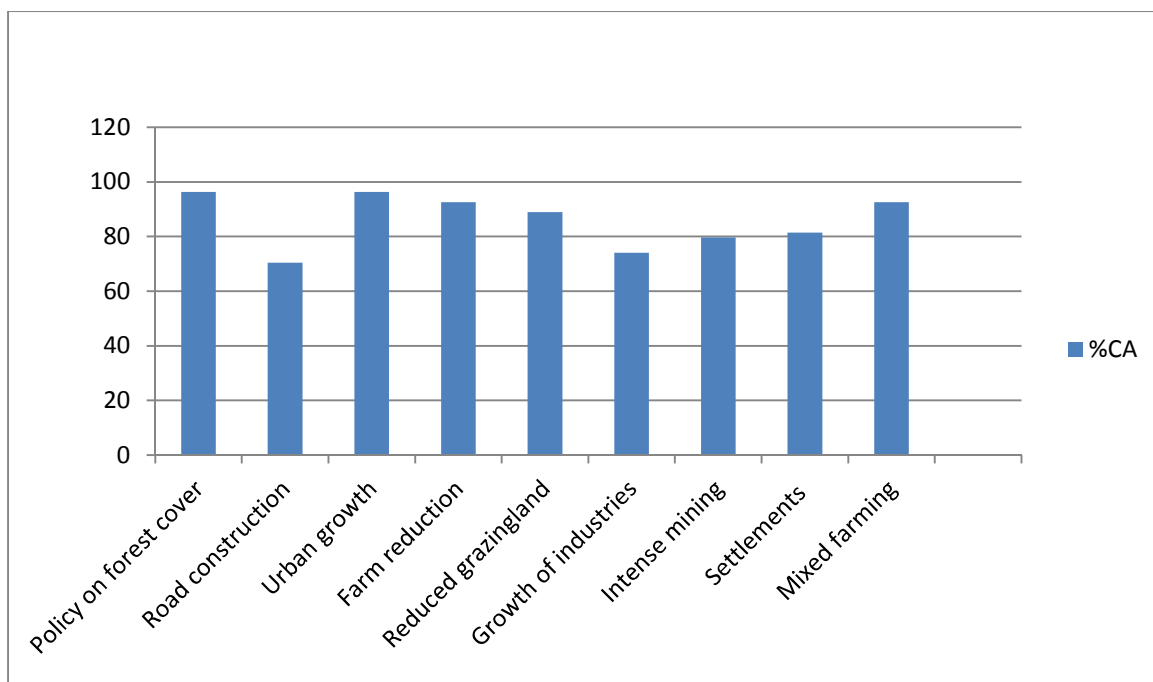
The Fig 4.7 shows the women farmers response to the indicators measured

The results in figure 4.7 show that, land policy on forest cover, urban growth and mixed farming were the highest (96%, 95%, 92% respectively) in score and road construction was the least score (74%). These results mean that, forest policy, mixed farming and urban growth influenced famers to adopt CA because, the farm land were becoming small hence need to develop innovations to increase food production and biodiversity.

The conversion of farmlands to other uses has greatly reduced food crop production resulting to hunger and poverty. During the interviews, it was observed that 65% of farmers are affected. From interview schedule, nearly 50 % of agricultural land in the study area has been hiked out for settlements, construction, mining, flower farming and several urban satellites. Results from the interviews and focus group discussions provided in depth information on the effects of land use change and its influence on women farmers in adopting CA. Over 73 % respondents interviewed also indicated that before 1990, the study area was under extensive agricultural production. Farming was conventional large scale. After 1990s rapid land transformation took place as a result of land policy changes coupled with political influence. This led to increased

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settlements and environmental degradation. More land was also being subdivided and sold to private developers who prefer establishing other economic activities other than farming. Women farmers being the majority of the population in the agricultural sector were mostly and negatively affected. Most flowers and horticulture industry survive because they are grown under drip irrigation and in green houses. The interviewee indicated that large organizations in the study area are trying to address local problems and coping with the climate changes in order to reduce poverty. It was noted from focus groups discussions that, a number of international and private companies in the study have not addressed issues of the local communities and how land use changes are affecting their lifestyles particularly women farmers whose families depend mainly on farm products. The focus group discussion results show that farmers choices to change the use of land and ability to adopt CA practices depends on land rights, government policies, market price and house hold needs.

Aerial, oblique photographs and landscape satellite images have been used in this study to analyze land use changes in the study between 1970 and 2016. Some of the evidences from the satellite images, oblique photos are presented below:

Plate 6a Before-Farmland Egerton Njoro 2000 (GPS 0°22'11.0''S, 35°55'58.0''E)

Plate6b: farmland converted to commercial buildingAfter-EgertonSaccoNjoro-Building2015 (GPS 0°22'11.0''S, 35°55'58.0''E)

Plate 7a: Wildlife grazing land Naivasha –NRB road 1980 (GPS 0.7172° S, 36.4310° E)

Plate 7b After: An Estate along Nrb -Naivasha road

(www.shutterstock.com)2014 (GPS 0.7172° S, 36.4310° E)

Plate 8a: Sobea farming area 20000° 16' 59.99'' N, 36° 04' 0.01'' E

Plate 8b: Farm converted to estate. Sobea Estate 2015 (GPS 0° 16' 59.99'' N, 36° 04'

0.01'' E) Source: Boniface Thuku (Standard Newspaper July 2015)

Land ownership rights and land tenure security are known to be major determinants of land use, investments in the land improvement, and intensification of farming. Where individualized rights are established on agricultural land, farmers invest in longer-term improvements, including tree planting, crop rotations, manure application and soil conservation (Keijiro and Place, 2014).

In dry regions of Kenya, it was found that investment in fencing improves farm production by 70% because farmers can only spend extra cost if they own land (Asienga, 2012). Several factors have been used to explain land use decisions including soil quality, farm size, farm labour, level of household education, farming experience, land tenure among others (Ebanyat

et al, 2013). No consistent effects of these independent variables were usually observed in terms of relationships between land use and household characteristics. Studies in Amazon by Mubea and Menz (2014) showed that land allocation to crops varied between farm types and reflect differences in farmer's production objectives like for domestic consumption or cash. The study showed that private policy on forests has increased forestation. Not all land is under use. These finding concur with other studies where the uses of land depends on many factors; availability of labor, and capital, and access to different natural resources (Mubea and Menz, 2014). More information is lacking on how farmers objectives in production function and settlement levels influence choice in nature of agricultural practices.

Integration of Landsat and ALOS PALSAR have been used to give good results on land use changes that have taken place in Nakuru County since 1970s. Approximately 20 km2 of farm land has since changed to urban land-use indicating rapid urban growth. Land-use information is very important to determine how best land can be productive and used according to its potential which in essence translates to good environmental management (NCR, 2014).Urban expansion has swallowed best arable land for agricultural production. This is seen in Ngata areas of Nakuru County. This growth of urban has pushed women farmers to adopt CA practices in order to maximize their production function (NCR, 2014). A similar study in Kisii County Keumbu confirms the same trend of land conversion. Ogechi and Hunja (2014) found that Kisii County has undergone high rate of land use / cover changes which in turn has affected food production significantly. Fragmentations of fertile arable land, high population increase and urbanization have reduced food production in the area and loss of biodiversity. The world grain stock has dwindled to dangerously low levels, highlighting the fragility of food supplies in a world where the population is expected to rise (UNDP, 2013)

The study also found that, in Limuru, there is high level of rural agricultural land being converted to urban settlements, industries and commercial activities. Productive land for coffee and tea is being converted commercial estates (Meybeck and Place, 2014). This rapid of land utilization of nonagricultural activities is the cause for farmers shifting and embracing innovations and changing their cropping style to engage in food production requiring small land and under intensive agricultural practice such as zero grazing, poultry keeping and horticultural crops. As change in farming system is happening the need for large tracts of land for crop production is becoming unnecessary (Ogechi and Hunja, 2014).

In the study area respondents were asked; what forces drive them to change their production and use land differently. 80 % said that land use change is caused by population pressure, political influence, frequent droughts, land tribal clashes, warmer temperatures, pest invasions, market price fluctuations and economy. Another interview question was, how do you cope with the climate change? The response was diversifying crop production, zero grazing practice and intercropping which are CA practices. A part from population growth, land use change was driven by interactions of political instability that increased insecurity; collapse of input and output markets, weakened land management and extension service delivery institutions (Thuo, 2008). In response to these external shocks resulting from episodes of political instability, smallholders have diversified their farming practice from millet and cotton to production of cassava, now the dominant crop for food security and cash, and rice for cash and other legumes like groundnuts.

It was found out from Focus group discussion that, most of the land in Molo was originally, under forest cover for a long time. Currently nearly 60 % of the forest land has been cleared and replaced with farming and settlements. In comparing Conventional agriculture and CA most farmers said CA practices give higher yield compared to conventional, more

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environmental friendly and less time consuming. CA is less expensive because the cost of inorganic fertilizer and tilling are extremely high. Another question was- What are the reasons for farmers changing to CA methods? The answers varied. Others said agricultural policies and cost of conventional practices, 86%, said no support from government subsidy, 95 %, ineffectiveness of extension services, 75 %, high rate of migration to the study area reducing land size, 84 % reduction in grazing land. Key leaders were interviewed and asked; what CA technologies they have employed in their farms to cope with food insecurity and poverty? The answers were; mixed cropping, use of organic manure, growing of more of resistant crops such as millet, sorghum, sweet potatoes, maize, vegetables for market purposes, cassava, cow pea among others.

This study observed that the Nakuru County unique in that nearly over 40 different communities live here who practice different cultures. The traditional land policies on how land should be used do not apply. The land is open for any use and, that is why land use change and individual decision on how to use the land play a very significant role. In other studies, traditionally, land was owned collectively by the community, clan, lineage, or extended family under customary land tenure systems in Africa South of Sahara, but this has been evolving towards individualized tenure (Ndambiri *et al*, 2011).

4.5.2.1 Discussions of Secondary Data

Several changes in land use have occurred between 1990 and 2015.Aerial photographs and satellite imagery kept in various offices in the Ministry of planning and development, Ministry of agriculture, Forestry department, Mining and Geology indicate that the study area has undergone major changes in land use. The amount of land or land areas under various uses can now be observed and determined.

Another study conducted by Mubea and Menz (2012) used integration of Landsat and ALOS PALSAR and gave good results compared to when ALOS PAL- SAR was classified alone. Land-use information is useful for the comprehensive land-use planning and an integrated management of resources to ensure sustainability of land and to achieve social Equity, economic efficiency and environmental sustainability. Mubea and Menz (2012) made an extensive study on land cover changes occurrence between 1973 and 2011and the findings are shown in satellite images plates 9 (a, b, c). Observations were made on changes in six land covers; Forest shrub land, Cropland, Water bodies, Grasslands, Built uplands and Bare lands. Their study confirms the findings of this study and can be concluded that, land use change has been rapid and are the contributors of the climate change, global warming and soil erosion in the study area. This scenario has resulted in small farms and thus influenced farmers to adopt CA.

Plate 9a,b,c,d respectively show Images of land use from 1990 to 2014.

Plate 9 (a -1990, b- 2000, c- 2010& d- 2014) show the classified images of 1990, 2000, 2010 and 2014 were key tools in the monitoring of land use/cover transfers in the Eastern Mau Complex and also within the identified hotspots. The Overall Kappa of 0.7405 revealed that only about 74% of the whole classification was in agreement with the reference data used for the assessment leaving the remaining 26% to chance. Kappa at this level is considered Moderate (NCR, 2014)

Plate 9a Land use 1990
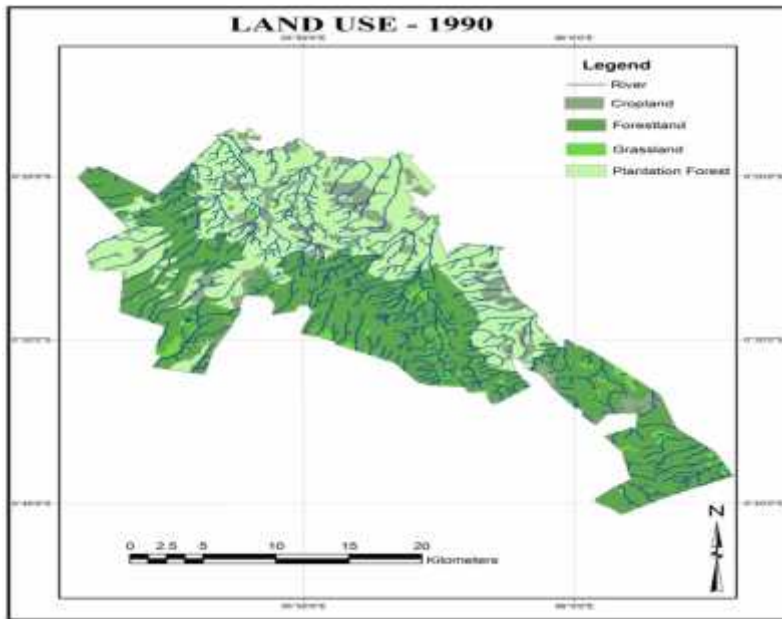
Plate 9b Land use 2000
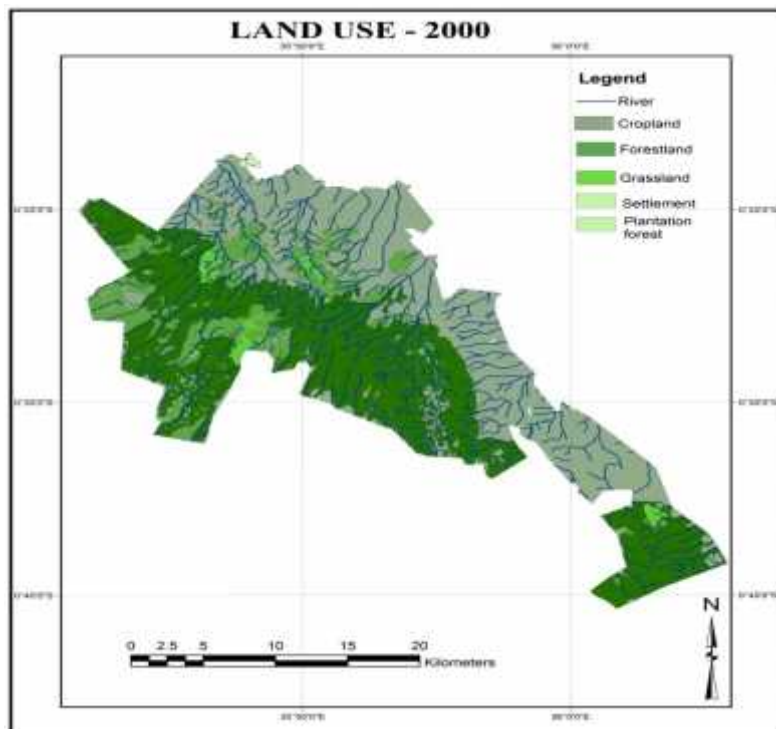
Plate. 9c Land use 2010
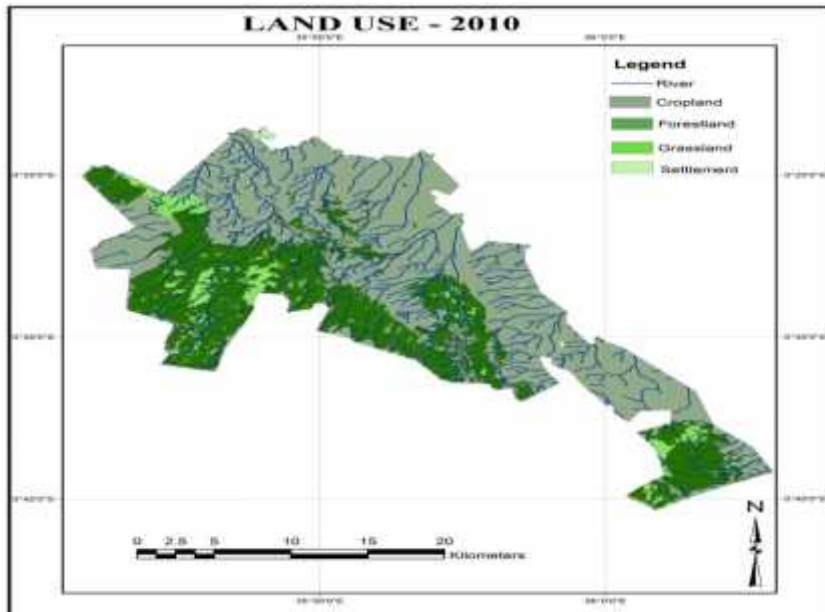
Plate 9d Land use 2014

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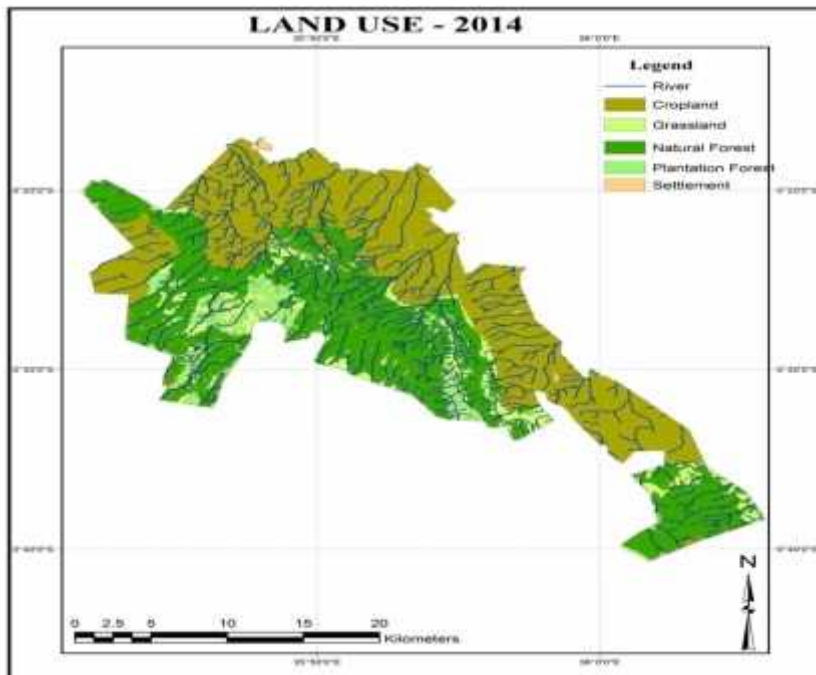
Table 4.47: Land use Changes in Hectares and Percentage Change

Year	1990		2000		2010		2014	
Land cover/use	Area (Ha)	% change	Area (Ha)	% change	Area (Ha)	% change	Area (Ha)	% change
Cropland	5779	8.77	26297	39.89	33548	50.89	30363	46.06
Grassland	31226	47.37	29503	44.76	6845	10.38	6535	9.91
Natural Forest	3324	5.04	2067	3.14	22923	34.77	26244	39.81
Plantation forest	25592	38.82	7888	11.97	2423	3.68	2608	3.96
Settlement	-	-	166	0.25	182	0.28	171	0.26

The Table 4.47 explains percentage changes that have occurred between 1990 and 2014

The table 4.47 shows land use changes which have been replaced such as forests, croplands and grasslands converted to settlements and other economic activities.
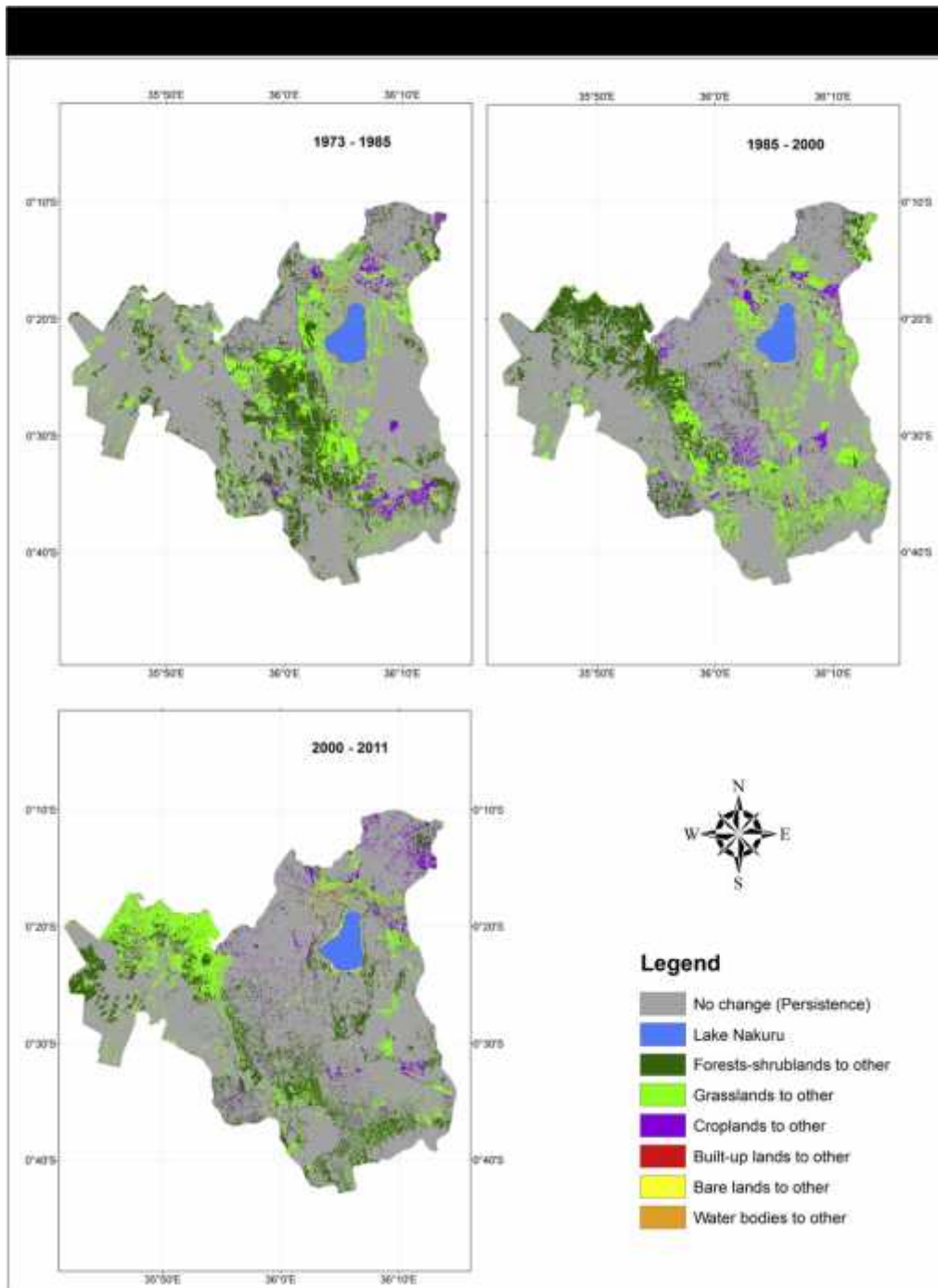
Plate 10 images showing the spatial distribution of the land cover changes in Eastern Mau forest reserve and Lake Nakuru drainage basin from 1973 to 2011Source: (Mubea and Menz 2014) and (NCR, 2014)

The plate 10 with three images taken at different time one; 1973- 1985; two 1985-2000 and third 2000 to 2011 indicating magnitude of land use changes in Eastern Mau. The map shows

how forests-shrub lands dominated in 1973, 1985 and 2000 covering about 1067 km2, 893 km2 and 797 km2 respectively, but overtaken by croplands (953 km2) in 2011. Unproductive lands occupied the least area that varied between 2 km2 and 7 km2 during this period. There was significant decrease of forests/ shrub lands and grasslands at the annual average rates of 1% each, whereas croplands increased by 660 km2 and 24 km2 at the annual rates of 6% and16% respectively. The secondary showed the importance of Mau catchment as one of the largest five forests in East Africa as water catchment and carbon sink and its effect on the study area regarding climate change. Lake Nakuru drainage basin in the recent years has drastically changed from a sparsely populated area to densely populated and high volume of vegetation to less vegetation.

4.5.3 Objective 3: Influence of Extension Methods on Adoption of CA

Farmers like any other profession need guidance so that skills in employing farming practices results in high yield according to the farmers' satisfaction and also maintain environmental health. In the early years farming was guided by extension services where the Ministry of agriculture employed trained agricultural officers who were always in contact with farmers, advising them on land utility, soil conditions, pest management application of chemicals timing of planting season and, harvesting and storage (Nakuru County Report , 2014). With CA practices, it is expected that extension methods play important role in farming production. The following list is extension method variables analysed in this study;

1. Education women to women contact

2. Extension agents effectiveness

3. NGOs training and support

4. Information from chief Barazas

5. Agricultural materials

6. Use of Radios

7. Field days

8. Visit agricultural shows

9. TV- Watching agricultural programs

10. Exposures to seminars

The third objective of the study sought to determine effectiveness of extension methods in enhancing farmers' adoption of CA. To realize this objective, specific aspect relating to extension methods were rated against the women adoption of CA before the overall effect was determined. The effects were measured in a 4-point Likert scale ranging from no extent to a great extent.

Education through women to women contact influence on CA adoption. It is perceived that, women to women farmers contact, yields better result than any other contacts. Women farmers believe and take action when other women farmers who are well conversant with the new farming techniques being introduced to them influence them.

The first item sought to determine the influence of education through women to women farmers contact on adoption of CA. The results of cross-tabulation are presented in Table 4.48.

Table 4.48: Cross tabulation on influence of education through women to women and influence on CA adoption

	my education through women to women farmers contact has influenced my adoption of CA			
type of farming	to a little extent	undecided	to great extent	to a very great extent
Conventional	0	26	154	24
	.0%	12.7%	75.5%	11.8%
CA	0	2	2	50
	.0%	3.7%	3.7%	92.6%
Both	147	162	0	78
	38.0%	41.9%	.0%	20.2%

The findings in Table 4.48 showed that majority 50 (92.6%) adopters, 78 (20.2%) incomplete adopters and 154 (75.5%. non-adopters to a great extent were aware that education through women to women contacts influence adoption of CA. women farmers adopters were influenced to adopt but non-adopters failed to adopt CA. This suggests that women to women farmers contact are effective in enhancing farmers' adoption of CA. Farmers will always listen to other farmers regarding new technology in farming.

Chi-square test was run to determine whether the relationship was significant. The results are presented in Table 4.49.

Table 4.49: Chi-Square Test Results

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	523.972(a)	6	.000
Likelihood Ratio	598.231	6	.000
Linear-by-Linear Association	119.765	1	.000

a 0 cells (.0%) have expected count less than 5. The minimum expected count is 8.54.

The findings in Table 4.49 show that there is a significant relationship between education through women to women farmers contact and farmers' adoption of CA, $\chi^2(6, N = 360) = 523.972$ $p< .05$. The Bio-data showed that most of the women farmers in the study were educated; thus passing information on the best practice to sustain agricultural production is easy. Most of the women involved in the study were also young and thus are likely to be flexible in moving around and willing to accept new ideas that can improve their livelihood. Education is a tool for farmers understanding of the problems and finding ways to solve agricultural problems the face (Moore et al, 2014).

Interaction with extension agents' influence on CA adoption was analyzed. In any farming system, extension methods are very useful in creating awareness to farmers and for any innovation to be adopted. Extension agents need to be knowledgeable so that they can advise

farmers on the best practices and how they can improve on their farming techniques in order to multiply their food production.

The extent to which interactions with extension agents influenced farmers' adoption of CA was also analyzed. The results are presented in Table 4.50.

Table 4.50: Cross tabulation on extension agents and influence on CA adoption

	My interactions with extension agents has influenced my adoption of CA			
type of farming	to no extent	to a little extent	undecided	to great extent
Conventional	24	30	101	49
	11.8%	14.7%	49.5%	24.0%
CA	0	20	0	32
	.0%	33.3%	.0%	66.7%
Both	0	78	69	240
	.0%	20.2%	17.8%	62.0%

The findings in Table 4.50 show that majority 32 (66.7%) adopters, 240 (62.7%) incomplete adopters and 49 (24%) non adopters to a great extent were aware of extension agents influence on CA adoption, women farmers adopters were influenced to a great extent but non-adopters failed to adopt CA. This means that, women farmers who adopted CA were to a great extent influenced by extension agents. With the low number of respondents registering their involvement with the extension agents for non-adopters and mixed adopters, it means that extension agents are not felt much by the farmers but for CA adopters' interaction of extension agents influenced them to adopt.

Chi-square test was run to determine whether the relationship was significant. The results are presented in Table 4.51.

Table 4.51:Chi-Square Tests

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	234.328(a)	6	.000
Likelihood Ratio	250.906	6	.000
Linear-by-Linear Association	60.356	1	.000

a1 cells (8.3%) have expected count less than 5. The minimum expected count is 2.01.

The findings in Table 4.51 show that there is a significant relationship between interactions of farmers with extension agents and their adoption of CA, $\chi^2(6, N = 360) = 234.328$ $p < .05$.

The findings show that, effective extension agents are important in giving farmers new techniques on CA. Interviews with key informant and women leaders, there seemed to be few extension officers and most of the officers are not conversant with CA technologies. The number of farmers has increased and the number of extension agents has remained low to meet and interact with farmers. There is a fundamental gap between the perspectives framing the knowledge of farmers and those of the service sector/community agents with respect to agricultural production norms and practices (Moore *et al*, 2014. Having an effective extension system had unintended effects on adoption of CA.

Support of NGOs through training and seminars influence on CA adoption was analyzed. NGOs play very important role in advising farmers on the best farming practices. NGOs may support farmers in a number of ways such as equipping them with knowledge, skills, funding, supplying agricultural materials, and other relevant information on protecting their crops from damage during growth and after harvest (Vigyan & Kempinski, 2014).

The extent to which support of NGOs through training influenced farmers' adoption of CA was also determined. The results are presented in Table 4.52.

Table 4.52 Cross tabulation on NGO's support influence on CA adoption

	support of NGOs through training has influenced my adoption of CA			
type of farming	to no extent	to a little extent	undecided	to great extent
Conventional	0	131	50	23
	.0%	64.2%	24.5%	11.3%
CA	2	2	0	50
	3.7%	3.7%	0%	92.6%
Both	78	78	0	231
	20.2%	20.2%	.0%	59.7%

The findings in Table 4.52 showed that farmers who adopted CA were influenced to a great extent by support received from NGOs through training. 50(92.6%) adopters, 231(59.7%) incomplete adopters and 23 (11.3%) non-adopters were aware to a great extent of NGOs training influence on CA adoption. Women adopters were to a great extent aware that NGOs training influenced them but non-adopters were aware but failed to adopt CA.

Chi-square test was run to determine whether the relationship was significant. The results are presented in Table 4.53.

Table 4.53: Chi-Square Test Results

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	556.530(a)	6	.000
Likelihood Ratio	584.408	6	.000
Linear-by-Linear Association	60.250	1	.000

a0 cells (.0%) have expected count less than 5. The minimum expected count is 8.46.

The findings in Table 4.53 show that there is a significant relationship between NGOs training in farmers' adoption of CA, $\chi^2(6, N = 360) = 556.530\ p < .05$. From in-depth interviews, farmers who did not adopt or were not decided to adopt CA felt that NGOs conduct their workshops far from them in expensive hotels and this limits them from attending. These are some of the

barriers to CA adoption by farmers especially women who may not be having time to attend trainings far from their homes. Otherwise, farmers who have time for NGOs training support gain a lot and are motivated to adopt CA. Training of small scale farmers is vital in agricultural food production (Vigyan & Kempinski, 2014).

Sharing of information through chief Barazas influence on CA adoption was analyzed.

At location level, Chief Barazas have become very important in disseminating agricultural information to farmers. During Barazas, agricultural experts on CA adoption may be invited to speak on the subject of CA adoption and women farmers have access to any information they need. This becomes useful avenue for farmers to learn new techniques and how to implement such practices (Vigyan & Kempinski, 2014).

The extent to which sharing of farming information during chief Barazas and influence farmers' adoption of CA was also determined. The results are presented in Table 4.54.

Table 4.54: Cross tabulation on sharing information chief Baraza influence on CA adoption

type of farming	Sharing of farming information during chief barazas has influenced my adoption of CA			
	to a little extent	undecided	to great extent	to a very great extent
Conventional	0	126	26	52
	.0%	61.8%	12.7%	25.5%
CA	0	2	46	4
	.0%	3.7%	88.9%	7.4%
Both	78	0	228	81
	20.2%	.0%	58.9%	20.9%

The findings in Table 65 showed that farmers who adopted CA were influenced to a great extent by sharing of farming information during chief Baraza's. 46 (88.9%) adopters to a great extent practiced CA because they received information during chief Baraza's by CA experts. Only 81(20.9%) incomplete adopters who practice CA and conventional were influenced to a

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great extent by Chief Baraza's meetings to adopt CA while 52 (25%) non-adopters were aware of Chief Baraza's but failed to adopt CA. Failure to adopt a practice could be due to other factors outside this study. The adopters of CA were influenced by the environmental factors studied. Chief Baraza's are powerful tools for disseminating information to the farmers about environmental changes and the importance of uptake of CA in order to cope and increase food production.

Chi-square test was run to determine whether the relationship was significant. The results are presented in Table 4.55.

Table 4.55: Chi Square Test Results

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	419.701(a)	6	.000
Likelihood Ratio	487.600	6	.000
Linear-by-Linear Association	3.890	1	.049

a0 cells (.0%) have expected count less than 5. The minimum expected count is 6.53.

The findings in Table 4.55 show that there is a significant relationship between Sharing of farming information during chief Barazas and farmers' adoption of CA, $\chi^2(6, N = 360) = 419.701\ p < .05$. This suggests that one of the most effective means of disseminating information to the farmers is through chief Baraza. It is in this Barazas that the communities learn new information. Barazas provide good atmosphere for experts on CA practices to interact with farmers.

Reading of agricultural related materials influence on CA adoption was analyzed.

Farmers who are exposed to reading agricultural information is believed to be more relevant and are equipped with tools for farming and makes them less reliable in being spoon-fed. They are expected to adopt CA techniques due to the knowledge they obtain from agricultural literature.

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The extent to which reading of agricultural related materials in newspapers and magazines influence farmers' adoption of CA was also determined. The results are presented in Table 4.56.

Table 4.56 Cross tabulation on reading agricultural related materials influence on CA adoption

	reading of agricultural related materials in newspapers and magazines has influenced my adoption of CA			
type of farming	to a little extent	Undecided	to great extent	to a very great extent
Conventional	26	52	49	77
	12.7%	25.5%	24.0%	37.7%
CA	0	6	46	2
	.0%	11.1%	85.2%	3.7%
both	81	156	81	69
	20.9%	40.3%	20.9%	17.8%

The findings in Table 4.56 showed that most 46(85.2%) adopters of the farmers who adopted CA were influenced to a great extent by reading of agricultural related materials in newspapers and magazines. 69(17.8%) of both farmers practicing CA and conventional practices were influenced to a great extent by reading agricultural related materials while 77 (37.7%) non-adopters were aware of influence but did not adopt. This suggests that reading of materials related to agriculture influence women to adopt CA practices. This result indicate that some of the women in this category were either less educated or the agricultural reading materials needed to be interpreted to them.

Chi-square test was run to determine whether the relationship was significant. The results are presented in Table 4.57.

Table 4.57:Chi-Square Tests Results

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	173.129(a)	6	.000
Likelihood Ratio	167.135	6	.000
Linear-by-Linear Association	37.240	1	.000

a0 cells (.0%) have expected count less than 5. The minimum expected count is 8.96.

The findings in Table 4.57 show that there is a significant relationship between farmers reading information from newspapers and magazines and farmers' adoption of CA,χ^2(6, $N = 360$) = 173.129 $p <$ .05. Most of the respondents have been to school, they are more likely to read literature regarding CA adoption and make decisions to adopt or not to adopt. Education statistics indicate that 52 CA adopters had good education and hence could read agricultural materials. Education therefore, influences CA adoption.

The importance of radio programme and influence on CA adoption was analyzed.

Farmers, who listen to radios frequently, are believed to be exposed to new technologies. Majority of women farmers compared to men farmers are poor listeners to radio programme unless the programmers are interesting to them or have been advised by the extension.

The extent to which listening to agricultural programme in radios, influence farmers' adoption of CA was also determined. The results are presented in Table 4.58.

Table 4.58: Cross tabulation on radio programme influence on CA adoption

	listening to agricultural programs in radios has influenced my adoption of CA				
type of farming	To no extent	to a little extent	undecided	to great extent	to a very great extent
Conventional	24	56	26	72	26
	11.8%	27.5%	12.7%	35.3%	12.7%
CA	0	2	11	0	41
	.0%	3.7%	20.35%	.0%	75.95%
Both	0	0	81	228	78
	.0%	.0%	20.9%	58.9%	20.2%

The findings in Table 4.58 showed that 41(75.95%) of the farmers who adopted CA were influenced to a great extent through listening to agricultural programme in radios, 78(20.2%) incomplete adopters listen to radio programme on CA but practiced both while 26 (12.7%) non adopters to a great extent were aware of listening to radios but failed to adopt CA. Farmers can learn CA practices through radio program because nearly every farmer own at least a radio.

Chi-square test was run to determine whether the relationship was significant. The results are presented in Table 4.59.

Table 4.59: Chi Square Results

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	354.004(a)	8	.000
Likelihood Ratio	350.640	8	.000
Linear-by-Linear Association	85.237	1	.000

a 2 cells (13.3%) have expected count less than 5. The minimum expected count is 2.01.

The findings in Table 4.59 show that there is a significant relationship between listening to radio and its influence on adoption of CA, $\chi^2(8, N = 360) = 354.004$ $p< .05$. Radio play important role in society because information received can change peoples' behavior which can help them take up CA practices. Not all women farmers listen to radios. Some of the farmers may not have radios or it could be that radio programme on CA is aired at the wrong time when women are busy with other household chores. That could be the reason why some farmers are not adopting CA.

Watching agricultural related programme on, TV influence CA adoption was analyzed.

TV is a very powerful tool for dissemination. Farmers who watch television programme airing agricultural techniques are better knowledgeable than farmers who don't watch special programme on TV and tend to embrace CA techniques.

The extent to which watching agricultural related programme on TV, influence farmers' adoption of CA was also determined. The results are presented in Table 4.60.

Table 4.60: Cross tabulation on watching agricultural TV programmes influence on CA adoption

| type of farming | watching agricultural related programme on TV has influenced my adoption of CA | | | |
	to a little extent	undecided	to great extent	to a very great extent
Conventional	46	80	52	26
	22.5%	39.2%	25.5%	12.7%
CA	3	15	36	0
	5.55%	27.75%	66.7%	.0%
Both	81	81	147	78
	20.9%	20.9%	38.0%	20.2%

The findings in Table 4.60 showed that 36 (66.7%) of farmers who adopted CA were influenced to a great extent by watching agricultural related programme on television and 78(20.2%) of farmers both practicing CA and conventional farming to a great extent were influenced by TV related CA programme while 26 (12.7%) non-adopters failed to adopt CA even when they were aware through TV broadcast.

Chi-square test was run to determine whether the relationship was significant. The results are presented in Table 4.61.

Table 4.61: Chi Square Results

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	109.579(a)	6	.000
Likelihood Ratio	120.159	6	.000
Linear-by-Linear Association	9.342	1	.002

a 0 cells (.0%) have expected count less than 5. The minimum expected count is 8.71.

The findings in Table 4.61show that there is a significant relationship between changes in settlement and farmers' adoption of CA,χ^2(6, N = 360) = 109.579p< .05.

Not many farmers own TV in rural areas and therefore TV may not have strong impacts on influencing farmers to adopt CA. From the findings, TV significantly influences farmers' decision to adopt CA. From focus group discussion, farmers want real demonstration and an expert on CA to be present as they watch TV programme so that some issues arising could be clarified and emphasis made.

The participation in field Days influence on CA adoption was analyzed. Field days are very important in training farmers. Farmers see the results physically; they get excited and want to copy what they have seen other successful farmers do. CA techniques need farmers' knowledge and skills, which they can acquire through filed day visits (Etwire, *et al*, 2013).

The extent to which participation in agricultural field days, influence farmers' adoption of CA was also determined. The results are presented in Table 4.62.

Table 4.62: Cross tabulation on participation in field days influence on CA adoption

type of farming	participating in agricultural field days has influenced my adoption of CA			
	to a little extent	Undecided	to great extent	to a very great extent
Conventional	0	126	26	52
	.0%	61.8%	12.7%	25.5%
CA	3	2	43	6
	5-55%	3.7%	79.55%	11.1%
Both	78	0	228	81
	20.2%	.0%	58.9%	20.9%

The findings in Table 4.62 showed that 43 (79.5%) adopters, 228 (58.9%) incomplete adopters and 52(25.5%) non-adopters failed to adopt CA although they were aware of participating in agricultural field days. Women farmers' adopters were influenced to adopt CA by participating

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in agricultural field days. The results show that field days are powerful extension service that farmers can be motivated to follow the practice of other farmers who have succeeded.

Chi-square test was run to determine whether the relationship was significant. The results are presented in Table 4.63.

Table 4.63: Chi-Square Test Results

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	419.701(a)	6	.000
Likelihood Ratio	487.600	6	.000
Linear-by-Linear Association	3.890	1	.049

a 0 cells (.0%) have expected count less than 5. The minimum expected count is 6.53.

The findings in Table 4.63 show that there is a significant relationship between changes in settlement and farmers' adoption of CA, $\chi^2(6, N = 360) = 419.701$ $p< .05$. Agricultural field days help farmers to observe practical methods employed in CA practices and the yields that are produced which provide them with a satisfactory and convincing environment to accelerate their thinking and making decisions from what they have practically learnt. Etwire *et al*, (2013) confirmed this finding that extension service such as field days is important source of information on climate change as well as adoption options.

Visiting agricultural shows and its, influence, on CA adoption was analyzed. Agricultural shows are often used as demonstration farms with high success in the farming skills. Attending such shows is motivating and farmers would always want to implement what they have learnt from agricultural shows. Shows are therefore eye openers and improve farmers' skills (Vigyan & Kempinski, 2014).

The extent to which farmers visit to agricultural shows influence their adoption of CA was also analyzed. The results are presented in Table 4.64.

Table 4.64: Cross tabulation on visiting agricultural shows influence on CA adoption

	Visiting agricultural shows has influenced my adoption of CA			
type of farming	to a little extent	Undecided	to great extent	to a very great extent
Conventional	26	52	49	77
	12.7%	25.5%	24.0%	37.7%
CA	0	7	43	4
	.0%	12.95%	79.65%	7.4%
Both	81	156	81	69
	20.9%	40.3%	20.9%	17.8%

The findings in Table 4.64 showed that 43(79.65%) adopters, 69 (17.8%) incomplete adopters and 77 (37.7%) non -adopters were aware of visiting agricultural shows influence on adoption of CA to a great extent. Women farmers' adopters were influenced and adopted CA while non-adopters failed to adopt CA. This suggests that there is need to encourage farmers to visit agricultural shows as a way of exposing them to CA practices.

Chi-square test was run to determine whether the relationship was significant. The results are presented in Table 4.65.

Table 4.65: Chi Square Test Results

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	173.129(a)	6	.000
Likelihood Ratio	167.135	6	.000
Linear-by-Linear Association	37.240	1	.000

a0 cells (.0%) have expected count less than 5. The minimum expected count is 8.96.

The findings in Table 4.65 show that there is a significant relationship between farmers' Visit to agricultural shows and farmers' adoption of CA, $\chi^2(6, N = 360) = 173.129 \ p < .05$.

Those who did not adopt CA after visiting agricultural shows were had other reasons not to adopt. These could be old age, not willing to take a risk or did not care.

Agricultural shows bring farmers from different farming regions with diverse farming systems and outcomes which the farmers need to learn and pick important information relevant to them regarding their ecological set up. Farmers are motivated when they visit the agricultural shows. Etwire, *et al*, (2013) confirmed this finding that agricultural shows visit is part of extension service and is important source of information and attitude change towards adoption options.

Exposure to seminars and training influencing CA adoption was analyzed. Farmers attending several seminars are more exposed and pick up relevant information on farming and are at ease with improving on the best techniques to increase their production. Seminars and training equip farmers with the knowledge in new farming techniques and how to cope with adverse environmental problems affecting farming. CA practice requires skills which the farmers can obtain by attending seminars and training (Nduru, 2011).

The extent to which farmers 'exposure to seminars and training influence farmers' adoption of CA was also determined. The results are presented in Table 4.66.

Table 4.66 Cross tabulation on exposure to seminars and training influence on CA

	Exposure to seminars and training has influenced my adoption of CA				
type of farming	To no extent	to a little extent	undecided	to great extent	to a very great extent
Conventional	24	56	26	72	26
	11.8%	27.5%	12.7%	35.3%	12.7%
CA	0	10	0	17	27
	.0%	18.5%	.0%	31.45%	50.05%
Both	0	0	81	228	78
	.0%	.0%	20.9%	58.9%	20.2%

adoption

The findings in Table 4.66 showed that majority 27(50.9%) adopters, 228 (58.9%) incomplete adopters and 26 (12.7%) non-adopters to a great extent were aware of exposure to seminars

and training influence on adoption of CA. Women farmers adopters were influenced and adopted CA while non-adopters failed to adopt CA. This means that, exposure to seminars and training influence women farmers adopt CA practices. Seminars and training are important in order to gain skills in developing and implementing new technologies in agriculture. Chi-square test was run to determine whether the relationship was significant. The results are presented in Table 4.67.

Table 4.67: Chi square Test Results

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	354.004(a)	8	.000
Likelihood Ratio	350.640	8	.000
Linear-by-Linear Association	85.237	1	.000

a2 cells (13.3%) have expected count less than 5. The minimum expected count is 2.01.

The findings in Table 4.67 show that there is a significant relationship between attending seminars and training and influence on farmers' adoption of CA, $\chi^2(8, N = 360) = 354.004$ $p<$ .05. Attending seminars and training are powerful tools in acquiring new information and how you can use that information to cope with business activities. Farmers are advantaged when they attend seminars and take training courses to improve their skills in farming and also to change methods of practicing. The results are indicating that majority of farmers taking up CA have attended seminars and training. Those who are slow to take CA or have not adopted may be so due to attitude or only attended once.

The overall mean score on the 10 items measuring effect of overall effect of extension method on adoption of CA was determined. The summary of overall means is presented in Table 4.68.

Table 4.68: Overall mean effects of extension methods on CA adoption

	N	Mean	Std. Deviation
Conventional	204	3.3809	.29906
CA	27	3.8704	.15396
Both	129	3.4132	.17338
Total	360	3.4292	.28118

The results in Table 4.68 indicate that extension methods used are more likely to influence farmers to adopt CA practices.

However to determine whether there was a significant difference in the means, ANOVA was carried out. The results are presented in Table 4.69.

Table 4.69: ANOVA Test: overall effect of extension method on adoption of CA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	5.764	2	2.882	45.490	.000
Within Groups	22.619	357	.063		
Total	28.384	359			

The results in Table 4.69 showed that there is a significant difference in the means, $F_{(2,359)} = 45.490$, $p < .05$. Thus the null hypothesis which stated that there is no statistical significance between extension methods and influence on women farmers' adoption of CA was rejected. This implies that there is a relationship between extension method used and farmers' adoption of CA practices.

To determine where the differences existed, *post-hoc* analysis was carried out using Bonferroni test. The results are presented in Table 4.70.

Table 4.70: Bonferroni Test of differences in overall means

(I) type of farming	(J) type of farming	Mean Difference (I-J)	Std. Error	Sig.
Conventional	CA	-.48949(*)	.05155	.000
	Both	-.03230	.02832	.764
CA	Conventional	.48949(*)	.05155	.000
	Both	.45719(*)	.05327	.000
both	Conventional	.03230	.02832	.764
	CA	-.45719(*)	.05327	.000

* *The mean difference is significant at the .05 level.*

The findings in Table 4.70 indicate that there is in means differences existed between farmers who adopted CA and conventional as well those who practice both conventional and CA practices. Effectiveness of extension methods is statistically significant and influence women farmers' adoption of CA.
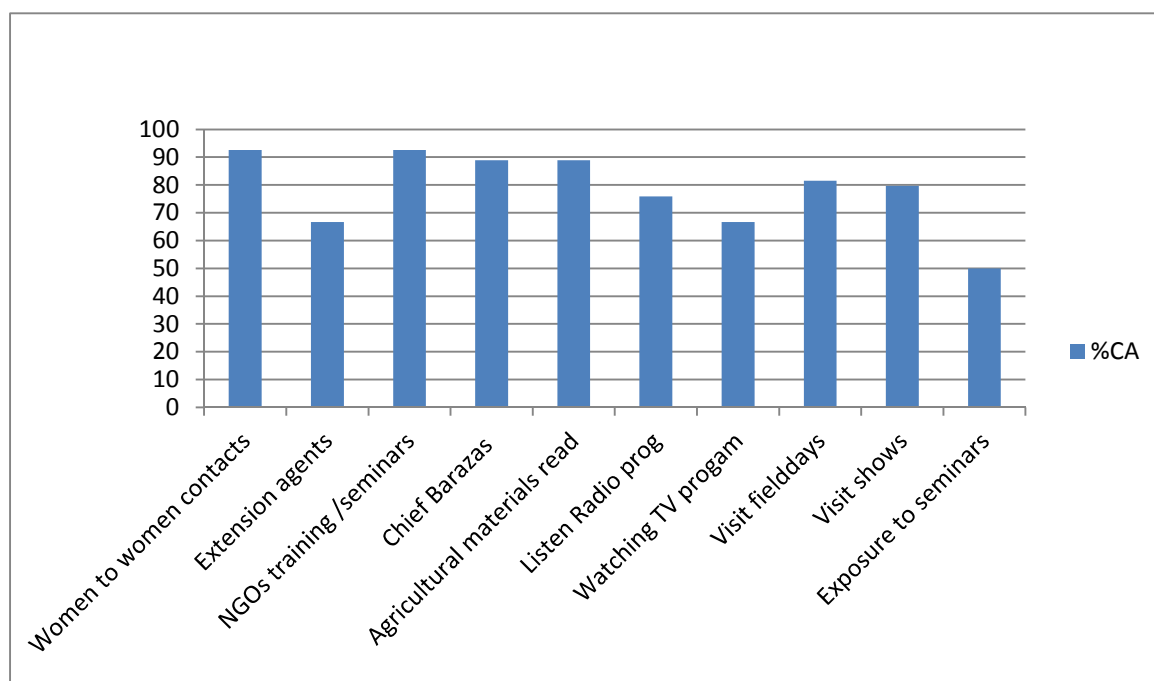
The figure 4.8 show indicators tested and women farmers' responses

Figure 4.8 show that women to women contacts, NGOs training were most effective 92% and extension agents and exposure to seminars were least effective in women farmers in response to CA practices (50%).

Farmers in the study area to some extent are aware of extension methods and it is important to note that, farmers respond well when they understand the merits and demerits of an innovation. Extension services are effective only if specific targets are identified and appropriate techniques in a achieving the results are effectively employed. Most of the extension methods mainly target men farmers and their design of implementation ignores women issues. This is a valid observation made during interviews and is a barrier to CA adoption by women. Being aware of environmental changes and effectiveness of extension methods are not enough, but how these extension methods are practiced can add value to the farmers. Stakeholders participation and decision making process involving farmers is important in realizing CA adoption. Having a good field officer and/or lead farmer usually made people follow what they were taught. In rural areas, farmers usually rely on other farmers for information (Pelum, 2013). 90% of the farmers often depend on the key leaders input in any new technology in the community. The key leaders indicated positive impacts on any change being introduced to a particular group. 89% of key leaders and informants interviewed said that women normally rely on women groups or what their leaders say. 45% of the focus group discussions said that only 48% of women act on information from the media such as TV, Radio or newspaper. Most women get information and implement such information through women self-help groups. Therefore women self- help groups are very powerful agents of disseminating information or new technology. From in depth information women are not like men because they do not have time to read agricultural materials or watch TV or listen to radio. Women mostly act on what they see and what happen in other women counterparts. Further research is needed on the influence of women self- help group in adoption of CA technologies. The uptake of CA

technology through extension methods depend on the socio economic characteristics of women famers. In this study majority of women are moderately educated, young in age and have own small farms which make them an added advantage in adopting CA practices.

From the findings, over 80% adopters and non- adopters are exposed to more than one extension methods. From the in depth interviews, it was observed that although farmers acknowledge the extension methods services, the services were not regular and unplanned. The extension services although powerful in transforming knowledge in CA adoption, there is agent need to increase the number, and they should be well trained and knowledgeable in handling farmers in the field.

Extension service is an important source of information on climate change as well as adoption options hence farmers who have contact with extension agents are more likely to be aware of climate change and available adaptation options, and subsequently adopt these options(Pelum, 2013). The study further observed that farmer to farmer extension is powerful and gives positive influence on the adoption of adaptation technologies in response to climate change which translates to adoption of CA. The effects of interactions on information and learning have always been successful among the farming groups. Accumulation of experience and learning, induce farmers to adopt innovations. Farmers access information through various sources and mechanisms, such as visits by extension agents, participation in training activities, and exposure to mass media. Based on their summary of empirical studies considering the effects of risk and uncertainty on adoption hypothesize that exposure to appropriate information through a range of communication channels reduces subjective uncertainty (Etwire, *et al*, 2013). The consequent reduced uncertainty, should lead to increased adoption, assuming all other factors remain unchanged. Indeed, abundant empirical evidence shows that farmers get involved in diverse learning processes, either by experimenting in their own plots

before full adoption (learning by doing) or by actively or passively taking (Ebanyat, *et al*, 2013).

Although there is a strong association between extension methods and their influence on farmers' adoption of CA, the problem is the gap between famers and community agents regarding structuring of knowledge of farmers (Ebanyat, *et al*, 2013). These findings have confirmed that there is a fundamental gap between the perspectives framing the knowledge of farmers and those of the service sector/community agents with respect to agricultural production norms and practices. Specifically, agricultural service providers and other community agents are significantly more supportive of conventional modern farming than farmers, and significantly less supportive of mixed crop and livestock farming; however, farmer perspectives also vary across sites. This gap therefore need further research to make CA adoption uptake more profitable (Etwire, *et al*, 2013).

Farmers get discouraged after attending CA training because the successor field officer was not as good as the predecessor. This could have had negative effect on CA adoption. Most training and demonstrations are conducted on chiefs and headmen's farms in the promotion of CA and this discourage women farmers who view the practice as discriminating against them. Why don't they do demonstrations in our farms they asked? It was observed that, a number of lead farmers specifically men, occupied some leadership positions like village headman, chairperson for some local organization, and church leaders (Nyangah, 2012). Some of the agricultural extension staff also explained that some farmers adopted CA because they saw a chief or village headman or lead farmer practicing CA successfully. A few cases where local leadership was less supportive towards CA were also observed. In one of these areas, lead farmers confessed that it was quite difficult to mobilize farmers for CA trainings because most of the farmers seemed to follow the opinion of their local significant persons. These results show that adoption of new innovation takes place in a social context as farmers learn by

observing what others were doing. This is consistent with the social learning theory (Bandura, 1977) postulating that, people also learn from each other both in formal and informal ways through observation and influence of significant persons in society.

4.5.4 Objective 4: Influence of Environmental Knowledge

Environment is very dynamic and any lack of knowledge present itself and manifest in the way a farmer handles it. The environment can be made sustainable or unsustainable. A farmer needs to have a deep understanding of rhythms of nature in order to remain productive. Farming with sound knowledge of the environment leads to better yield and management of other adverse factors that may affect farming input and output. Knowledge on conservation of natural resources such as wise use of soil to maintain its fertility, protecting wildlife for ecosystem function and understanding the need to increase forest cover is essential for every farmer. In this objective, ten indicators were tested, analyzed and discussed.

The fourth objective of the study sought to determine whether there is a significant relationship between environmental knowledge and farmers' adoption of CA. To realize this objective, specific aspect relating to environmental knowledge were rated against the adoption of CA by farmers before the overall effect was determined. The items were weighted in terms of frequencies before cross-tabulation was carried out. Analysis was done on each question item and thereafter a combination of all the items was analyzed to give the overall relationship.

The following in the list are variables analyzed in this study;

1. Soil control measures

2. Knowledge on land conservation

3. Agro forestry importance

4. Benefits of minimum tillage

5. Protection of wetlands

6. Increase in forest cover

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7. Benefits using manure

8. Need for environmental conservation

9. Environmental conservation

10. Crop rotation

Enlightenment on soil control measures influence on CA adoption was analyzed. Measures that lead to maintenance of fertile soil are very crucial for achieving maximum yields. Famers therefore should have good knowledge in soil control measures. It is believed that CA is one of the ways in which the fertility of soil is guaranteed in the study area prone to loss of soil by conventional agriculture (Tangcalagan et al, 2014).

The first item sought to determine the influence farmers' enlightenment on soil control measures on adoption of CA. The results of cross-tabulation are presented in Table 4.71

Table 4.71: Cross tabulation on enlightenment on soil control influence on CA adoption

	My enlightenment on soil control measures has influenced my adoption of CA		
type of farming	to a little extent	undecided	to great extent
Conventional	56	76	72
	27.5%	37.3%	35.3%
CA	2	18	34
	3.7%	33.3%	63%
both	81	150	156
	20.9%	38.8%	40.3%

The results in Table 4.71 indicate that farmers who were enlightened on soil control measures are more likely to adopt CA. This is reflected by the large proportion 34(63%) of farmers practicing CA who reported that the enlightenment influenced them to a great extent while 156(40.3%) of farmers practicing both CA and conventional farming were influenced to a greater extent to adopt CA while 72 (35.3%) non-adopters were aware of soil control but did

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not adopt CA. Nakuru County is experiencing high rate of soil erosion. This is due to the impacts of deforestation, poor farming techniques and quarrying activities. One of the problems facing the study area is the high rate of soil erosion resulting to loss of top fertile soil leading to poor agricultural yields. This finding is in agreement with the study conducted on Land Management systems (Taryn, 2014)

To determine the significance of the relationship between farmers' enlightenment on soil control measures and adoption of CA, Chi-square test was run. The results are presented in Table 4.72.

Table 4.72: Chi-Square Test Results

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	70.826(a)	4	.000
Likelihood Ratio	84.860	4	.000
Linear-by-Linear Association	1.110	1	.292

a 0 cells (.0%) have expected count less than 5. The minimum expected count is 11.64.

The Chi-square test statistic, $\chi^2(4, N = 360) = 70.826$ $p < .05$, suggest that there is a relationship between enlightenment on soil control measures and farmers' adoption of CA. This suggests that there is need to enhance farmers' enlightenment on soil conservation measures to increase their uptake of CA practices. Soil erosion measures by permanent soil cover, mulching, application of organic manure and tree cover are some of the CA practices developed to control soil erosion.

Most farmers are enlightened and some are practicing the techniques while a few were found to be lacking information. Soil erosion removes top fertile soil leaving farm unproductive. To increase crop yields, farmers must practice soil control measures.

The knowledge on soil conservation strategies influence on CA adoption was analyzed.

Farmers who have good knowledge of soil conservation for continued maximum yields are knowledgeable of soil conservation strategies such as permanent soil cover, crop rotation, mixed cropping, mulching, controlled soil erosion among others which help in soil fertility and production function (Kimani, *et al*, 2015).

The research also sought the perceptions of the respondent on the influence of farmers' Understanding on land conservation strategies on adoption of CA. The results are presented in Table 4.73.

Table 4.73: Cross tabulation on knowledge on soil conservation influence on CA adoption

	Understanding on soil conservation strategies has influenced my adoption of CA		
type of farming	to a little extent	Undecided	to great extent
Conventional	56	76	72
	27.5%	37.3%	35.3%
CA	2	4	48
	3.7%	7.4%	88.9%
Both	81	150	156
	20.9%	38.8%	40.3%

The results in Table 4.73 indicate that, farmers' understanding of land conservation strategies is likely to influence them to adopt CA. This is reflected by the large proportion 48 (88.9%) of CA farmers who reported that the understanding of soil conservation strategies influenced them to a great extent while 156 (40.3%) of incomplete adopters practiced both systems and 76(35.3%) non adopters to a greater extent were aware of soil conservation influence but failed to adopt CA.

To determine the relationship between farmers' understanding on soil conservation strategies and adoption of CA, Chi-square test was run. The results are presented in Table 4.74.

Table 4.74: Chi-Square Test Results

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	226.611(a)	4	.000
Likelihood Ratio	212.736	4	.000
Linear-by-Linear Association	19.874	1	.000

a 0 cells (.0%) have expected count less than 5. The minimum expected count is 13.81.

The chi-square test statistic, $\chi^2(6, N = 360) = 226.611$ $p < .05$, suggest that there is a relationship between understanding soil conservation measures and adoption of CA. It can be concluded that, soil conservation measures understanding by women farmers is positive due to women farmers characteristics such as good education, age and ownership of land. Soil conservation measures are the approaches of CA where maximum use of farms are recommended because of the small farm size. Women in general are knowledgeable of their environment and are stewards of natural resources. Women are naturally good stewards of the environment use resources wisely (Kimani, *et al*, 2015).

The knowledge on benefits of minimum tillage influence on CA adoption was analyzed. Tillage practice of farming leads to exhaustion of soil and renders it unproductive after sometime. Minimal tillage is recommended as a way of preserving the fertility of soil and less disturbance of soil organisms found to useful in soil aeration and decomposition of decayed matter. Small -scale farmers maintains good soil by no tillage or minimal tillage (Seline, *et al,* 2014).

The research also sought the perceptions of the respondent on the influence of farmers' understanding on benefits of minimum tillage on adoption of CA. The results are presented in Table 4.75.

Table 4.75: Cross tabulation on knowledge on minimum tillage influence on CA adoption

	My understanding on benefits of minimum tillage has influenced my adoption of CA			
type of farming	to a little extent	Undecided	to great extent	to a very great extent
Conventional	0	26	154	24
	.0%	12.7%	75.5%	11.8%
CA	0	0	2	52
	.0%	.0%	3.7%	96.3%
Both	147	162	0	78
	38.0%	41.9%	.0%	20.2%

The result in Table 4.75 indicates that farmers' understanding on benefits of minimum tillage is likely to influence them to adopt CA. This is reflected by the large proportion 52(96.3%) of farmers who reported that the understanding of minimal tillage influenced them to a great extent. A small 78 (20.2%) of the farmers practicing both CA and conventional were influenced to a greater extent by knowledge do adopt CA while 154 (75%) non adopters have the knowledge on minimal tillage but did not adopt CA. Many farmers fill that tilling is only way to prepare the land for planting and if the land is not ploughed weeds will compete with the crops resulting to loss of yields.

To determine the relationship between farmers' understanding on benefits of minimum tillage and adoption of CA, chi-square test was run. The results are presented in Table 4.76.

Table 4.76: Chi Square Test Results

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	523.972(a)	6	.000
Likelihood Ratio	598.231	6	.000
Linear-by-Linear Association	119.765	1	.000

a 0 cells (.0%) have expected count less than 5. The minimum expected count is 8.54.

The chi-square test statistic, $\chi^2(6, N = 360) = 523.972$ $p < .05$, suggest that there is a relationship between farmers' understanding on benefits of minimum tillage and adoption of CA. Land tillage is destructive to the soil living organisms which are part and parcel of soil fertility improvement. The soil moisture is also preserved by non-tillage or minimal tillage. Minimal tillage or non-tillage is the main business and core of CA practices because non tillage results in high yields and protecting environment and increase biodiversity.

Knowledge on practice of agro forestry influence on CA adoption was analyzed. Agro forestry is a form of CA practice that tends to maximize crop production especially where the farms are small. The farmers practice growing of crops and at the same time tender trees in their farms and the trees provide moisture, shade and manure from decayed fallen leaves. Trees also protect crops from wind effects (Seline, *et al*, 2014).

The research also sought the perceptions of the respondent on the influence of Knowledge on practice of agro forestry on adoption of CA. The results are presented in Table 4.77.

Table 4.77: Cross tabulation on knowledge on practice of agro forestry influence on CA adoption

	Knowledge on practice of agro forestry has influenced my adoption of CA			
type of farming	to no extent	to a little extent	undecided	to great extent
Conventional	0	131	50	23
	.0%	64.2%	24.5%	11.3%
CA	2	2	50	0
	3.7%	3.7%	92.6%	.0%
Both	231	78	0	78
	59.7%	20.2%	.0%	20.2%

The results in Table 4.77 indicated that farmers Knowledge on practice of agro forestry is likely to influence them to adopt CA. This is reflected by the large proportion 50 (92.6%) adopters who reported that the knowledge influenced them to a great extent while 78 (20.2%) incomplete adopters' women farmers practicing both CA and conventional farming were influenced to a great extent to practice agro forestry while 50 (24.5%) non adopters were aware but did not adopt CA.

To determine the relationship between Knowledge on practice of agro forestry and adoption of CA, chi-square test was run. The results are presented in Table 4.78.

Table 4.78: Chi-Square Test Results

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	556.530(a)	6	.000
Likelihood Ratio	584.408	6	.000
Linear-by-Linear Association	60.250	1	.000

a0 cells (.0%) have expected count less than 5. The minimum expected count is 8.46.

The chi-square test statistic, $\chi^2(6, N = 360) = 556.530$ $p < .05$, suggest that there is a relationship between Knowledge on practice of agro forestry and adoption of CA. Women farmers grow trees for various reasons which include fuel source, protection against soil erosion, shed and for enhancing soil fertility through decomposition of litter. Most of the tree species planted on the farms varies a great deal with ecological factors. Agro forestry also increases biodiversity and lead to permanent soil cover, attraction of rainfall, purifying the environment; prevent desertification, drought and habitat for wild life. Farmers who practice agro forestry have more benefits than those who practice conventional farming (Seline, *et al*, 2014). Those who did not adopt CA could be having very small farms. Agro-forestry is so important that the health of the environment depends on how much vegetation is present in an ecosystem to make it function sustainably. It has been observed that, levels of adoption of agro forestry practices are low and impacts on smallholder farmers' livelihood negligible (Vigyan & Kempinski, 2013).

Knowledge on the importance of crop rotation influence on CA adoption was analyzed.

Crop rotation is normally recommended for farmers who have small farms. The practice ensures that fertility of soil is maintained. Crop rotation also helps to protect crops from diseases. A farmer grows maize in one growing season and in the next season; beans or any other leguminous crop is planted. This method will also ensure that nutrients taken up by maize are replaced by the second crop hence preserving soil fertility.

The research also sought the perceptions of the respondent on the influence of Knowledge on the importance of crop rotation on adoption of CA. The results are presented in Table 4.79.

Table 4.79: Cross tabulation on knowledge on importance of crop rotation on CA adoption

	Knowledge on the importance of crop rotation has influenced my adoption of CA			
type of farming	to a little extent	Undecided	to great extent	to a very great extent
Conventional	0	126	26	52
	.0%	61.8%	12.7%	25.5%
CA	0	2	52	0
	.0%	3.7%	96.3%	.0%
Both	78	0	228	81
	20.2%	.0%	58.9%	20.9%

The results in Table 4.79 indicated that farmers' knowledge on the importance of crop rotation is likely to influence them to adopt CA. This is reflected by the large proportion 52(96.3%) of farmers who reported that knowledge on the importance of crop rotation influenced them to a great extent. 228(58.9%) of incomplete adopters practice to a great extent practice CA while 52 (25.5%) non-adopters did not adopt CA yet they had the knowledge to a great extent.

To determine the relationship between the Knowledge on crop rotation and adoption of CA, chi-square test was run. The results are presented in Table 4.80.

Table 4.80: Chi-Square Test Results

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	419.701(a)	6	.000
Likelihood Ratio	487.600	6	.000
Linear-by-Linear Association	3.890	1	.049

a0 cells (.0%) have expected count less than 5. The minimum expected count is 6.53.

The chi-square test statistic, $\chi^2(6, N = 360) = 419.701$ $p < .05$, suggest that there is a relationship between Knowledge on the importance of crop rotation and adoption of CA. To keep the land fertile and diseases attacking the crops, crop rotation is one of the practices highly valuable to farmers. Crop rotation will result in less use of fertilizers and pesticides.

Knowledge on the need to protect wetlands influence on CA adoption was analyzed. Wetlands are prone to misuse and yet they are important in any ecosystem functions such as water conservation and soil quality. Watersheds are also sources of river waters which feed the lakes and eventually run into oceans.

The research also sought the perceptions of the respondent on the influence of Knowledge on the need to protect wet land on adoption of CA. The results are presented in Table 4.81.

Table 4.81: Cross tabulation knowledge on the need to protect wetlands influence on CA adoption.

type of farming	Knowledge on the need to protect wet lands has influenced my adoption of CA			
	to a little extent	Undecided	to great extent	to a very great extent
Conventional	26	52	49	77
	12.7%	25.5%	24.0%	37.7%
CA	0	0	52	2
	.0%	.0%	96.3%	3.7%
Both	81	156	81	69
	20.9%	40.3%	20.9%	17.8%

The results in Table 4.81 indicate that, farmers' knowledge on the need to protect wetlands is likely to influence adopt of CA. This is reflected by the large proportion 52(96.3%) adopters women farmers who reported that the knowledge on protecting the wetlands to a great extent, influenced them while 69 (17.8%) incomplete adopters practiced both CA and conventional to a great extent while 77 (37.7%) non adopters did not adopt but were aware of protecting the wetlands influence.

To determine the relationship between the Knowledge on the need to protect wet land and adoption of CA, chi-square test was run. The results are presented in Table 4.82.

Table 4.82: Chi-Square Test Results

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	173.129(a)	6	.000
Likelihood Ratio	167.135	6	.000
Linear-by-Linear Association	37.240	1	.000

a 0 cells (.0%) have expected count less than 5. The minimum expected count is 8.96.

The chi-square test statistic, $\chi^2(6, N = 360) = 173.129$ $p < .05$, suggest that there is a relationship between Knowledge on the need to protect wet land and adoption of CA. Destruction of Mau

forest close to the study area has contributed to several negative environmental effects such as climate change, pollution, loss of habitats and migration of forest species. Farmers in the study area have been affected by clearance of part of the forest which has caused droughts and intermittent rainfall causing low crop yields. Drying of rivers has led to loss of aquatic life and lack of water for domestic use and livestock in the lower river regions. To mitigate the deforestation effect, farmers are learning to protect wetland areas by avoiding human activities and conserving the wetlands.

Knowledge on wildlife increase and influence on CA adoption was analyzed. Wildlife presence is important in biodiversity increase and their waste can manure the soil to increase fertility. The research also sought the perceptions of the respondent on the influence of understanding on the need to protect wild life species to increase biodiversity on adoption of CA. The results are presented in Table 4.83.

Table 4.83: Cross tabulation knowledge on wildlife increase influence on CA adoption

type of farming	To no extent	To a little extent	Undecided	To great extent	To very great extent
Conventional	24	56	26	72	26
	11.8%	27.5%	12.7%	35.3%	12.7%
CA	0	2	0	0	52
	.0%	3.7%	.0%	.0%	96.3%
Both	0	0	81	228	78
	.0%	.0%	20.9%	58.9%	20.2%

The results in Table 4.83 indicated that farmers' understanding on the need to protect wild life species to increase biodiversity is likely to influence them adopt CA. This is reflected by the large proportion 52(96.3%) of farmers who reported that the understanding of protecting

wildlife influenced them to a great extent. 78(20.2%) of incomplete adopters were aware of the

importance of wildlife to create a rich ecosystem, while 26(12.5%) non-adopters were little

aware of the need to protect wildlife.

To determine the relationship between understanding on the need to protect wild life species

to increase biodiversity and farmers' adoption of CA, chi-square test was run. The results are

presented in Table 4.84.

Table 4.84: Chi-Square Test Results

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	354.004(a)	8	.000
Likelihood Ratio	350.640	8	.000
Linear-by-Linear Association	85.237	1	.000

a 2 cells (13.3%) have expected count less than 5. The minimum expected count is 2.01.

The chi-square test statistic, $\chi^2(8, N = 360) = 173.129\ p < .05$, suggest that there is a relationship

between understanding on the need to protect wildlife species and farmers' adoption of CA.

Majority of farmers reported that protection of wildlife is important. Natural plants provide

flowers which produce nectar for honey, insects such as bees provide crop pollination which

increase yields in their farms. The point worth noting is that, it is not possible to keep wildlife

in small farms especially big species of animals unless a farmer has a big farm. This contradicts

findings of Caroline *et al*, (2015) who established that, small scale farmers can grow crops and

keep wildlife for ecosystem services.

The knowledge on need to increase forest cover influence on CA adoption was analyzed.

Forest cover has many functions such as attraction of rainfall, regulation of climate, reduction

of carbon in the atmosphere, protecting crops from strong wind; increases foil fertility, control

soil erosion among others. Growing of trees is therefore part of the CA practices. Farmers can maximize their produce by use of agro-forestry techniques (Wall, *et al*, 2013).

The research also sought the perceptions of the respondent on the influence of enlightenment on the need to increase forest cover to increase rainfall on adoption of CA. The results are presented in Table 4.85.

Table 4.85: Cross tabulation knowledge on need to increase forest cover influence on CA adoption

| type of farming | My enlightenment on the need to increase forest cover to increase rainfall has influenced my adoption of CA | | | |
	to a little extent	Undecided	to great extent	to a very great extent
Conventional	46	80	52	26
	22.5%	39.2%	25.5%	12.7%
CA	0	2	42	10
	.0%	3.7%	77.8%	18.5%
Both	81	81	147	78
	20.9%	20.9%	38.0%	20.2%

The results in Table 4.85 indicate that farmers' enlightenment on the need to increase forest cover to increase rainfall is likely to influence them to adopt and influence them to a great extent. This is reflected by the high proportion 42(77.8%) of respondents who indicted that knowledge on forest cover influenced them to a great extent to adopt CA practices. 78(20.2%) of the farmers practicing both CA and conventional farming to a great extent, felt the need to increase forest cover as part of CA while 26 (12.7%) non adopters did not adopt CA and yet they were aware of forest cover importance.

To determine the relationship between enlightenment on the need to increase forest cover to increase rainfall and adoption of CA, chi-square test was run. The results are presented in Table 4.86.

Table 4.86:Chi-Square Test Results

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	109.579(a)	6	.000
Likelihood Ratio	120.159	6	.000
Linear-by-Linear Association	9.342	1	.002

a0 cells (.0%) have expected count less than 5. The minimum expected count is 8.71.

The chi-square test statistic, $\chi^2(6, N = 360) = 109.579$ $p < .05$, suggest that there is a relationship between farmers' enlightenment on the need to increase forest cover to increase rainfall and adoption of CA. The study area is close to Mau forest an ecosystem that provides services to the farmers. Due to continued destruction of the Mau forest the local weather patterns have changed drastically and have had bad impacts on the farmers. To recover from the effects of destruction of the forest and its indirect impact on the farming, the farmers are being enlightened to plant tree crops in order to increase rainfall and other ecosystem functions. Increased industries, flower farming and settlements in the study area, high level of pollution are experienced. Increase in forest cover will counteract the negative impacts of human activities in the area. Wall, *et al*(2013) alludes that increase in forest cover actually helps farmers to increase their production, because forest regulate climate.

The knowledge on benefits of using manure influence on CA adoption was analyzed.

Use of animal waste and decomposed litter are the best in soil fertility maintenance. Animal manure is not harmful to the soil and soil organisms, which increase the soil fertility, provide best nutrients to the crops. Manure usage is one of the CA practices and therefore farmers who have the knowledge of it benefit more (Seline *et al*, 2014).

The research also sought the perceptions of the respondent on the influence of understanding on the benefits of using manure to enhance soil fertility on adoption of CA. The results are presented in Table 4.87.

Table 4.87: Cross tabulation knowledge on benefits of using manure influence on CA adoption

	My understanding on the benefits of using manure to enhance soil fertility has influenced my adoption of CA			
type of farming	to no extent	to a little extent	undecided	to great extent
Conventional	0	131	50	23
	.0%	64.2%	24.5%	11.3%
CA	0	2	24	28
	.0%	3.7%	44.4%	51.9%
both	231	78	0	78
	59.7%	20.2%	.0%	20.2%

The results in Table 4.87 indicated that farmers who have knowledge on benefits of using manure are likely to adopt CA. This is reflected by the half proportion 28 (51.9%) of farmers who reported that the understanding of the benefits influenced them to a great extent. 78 (20.2%) both practiced CA and conventional farming to a greater extent while 50 (24%) non-adopters did not adopt CA. Farmers are changing from inorganic fertilizer to organic fertilizer which has provide healthy soil.

To determine the relationship between understanding on the benefits of using manure to enhance soil fertility and adoption of CA, chi-square test was run. The results are presented in Table 4.88.

Table 4.88: Chi Square Test Results

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	556.530(a)	6	.000
Likelihood Ratio	584.408	6	.000
Linear-by-Linear Association	60.250	1	.000

a0 cells (.0%) have expected count less than 5. The minimum expected count is 8.46.

The chi-square test statistic, $\chi^2(6, N = 360) = 556.530$ $p < .05$, suggest that there is a relationship between understanding on the benefits of using manure to enhance soil fertility and adoption of CA. Organic manure is known to protect soil fertility, it is environmental friendly. Manure costs less and is obtained locally from farmers who practice mixed farming. Majority of farmers want to cut the cost of fertilizer and also prevent environmental pollution that comes with applying inorganic fertilizer ending up contaminating water and soil hence disease spread and loss of edaphic and aquatic life. CA benefits farmers through soil and water protection, spending less on cost of production and less time spent in farm activities.

The knowledge on environmental conservation influence on CA adoption was analyzed. Farmers' deep knowledge in environmental conservation helps them to maximize their farm production and at the sometime protect biodiversity and the maintaining the good health of the environment. Farmers must relate the importance of biodiversity and their food production function. For example, presences of insects are important in crop pollination, which lead to more fruits and seeds formation (Seline *et al*, 2014).

The research also sought the perceptions of the respondent on the influence of Knowledge on the need for environmental conservation on adoption of CA. The results are presented in Table 4.89

Table 4.89: Cross tabulation on knowledge on environmental conservation influence on CA adoption

	Knowledge on the need for environmental conservation has influenced my adoption of CA			
type of farming	to a little extent	Undecided	to great extent	to a very great extent
Conventional	0	126	26	52
	.0%	61.8%	12.7%	25.5%
CA	0	10	40	4
	.0%	18.5%	74.1%	7.4%
both	78	0	228	81
	20.2%	.0%	58.9%	20.9%

The results in Table 4.89 indicated that farmers' Knowledge on the need for environmental conservation is likely to influence them adopt CA. This is reflected by the large proportion 40 (74.1%) of farmers who reported that the knowledge influenced them to a great extent. 81(20.9%) of farmers who practice both CA and conventional were to a great extent influenced by conservation while 52 (25.5%) non adopters did not adopt CA but were knowledgeable.

To determine the relationship between Knowledge on the need for environmental conservation and adoption of CA, Chi-square test was run. The results are presented in Table 4.90.

Table 4.90: Chi- Square Test Results

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	419.701(a)	6	.000
Likelihood Ratio	487.600	6	.000
Linear-by-Linear Association	3.890	1	.049

a 0 cells (.0%) have expected count less than 5. The minimum expected count is 6.53.

The Chi-square test statistic, $\chi^2(6, N = 360) = 419.701$ $p < .05$, suggest that there is a relationship between Knowledge on the environment conservation and adoption of CA. CA focuses on

environmental conservation through environmental friendly practices such as minimum soil disturbances, enhancing and maintaining soil moisture, biodiversity increase and maximum yields. The knowledge of farmers is therefore crucial in managing environment for sustainable production. The farmers reap benefits and are able to support their families. Protecting the environment means reducing poverty. UNDP, (2012) asserted that environmental conservation need to be given priority and women are sensitive to environmental resources hence protect it.

The overall means on the Influence of overall effect of environmental knowledge on adoption of CA was determined. The means are presented in Table 4.91.

Table 4.91: Overall Mean Effects of environmental knowledge on adoption of CA

	N	Mean	Std. Deviation	Std. Error
Conventional	204	3.1873	.23891	.01673
CA	27	3.4704	.15396	.02963
Both	129	3.0357	.31888	.02808
Total	360	3.1542	.28885	.01522

The results in Table 4.91 indicate that farmers who are knowledgeable about environmental issues are more likely to adopt CA practices. This is indicated by the high mean (3.47) among farmers practicing CA compared to the other two groups. However to determine whether there was a significant difference in the means, ANOVA was carried out. The results are presented in Table 4.92.

Table 4.92: ANOVA Test. Overall Effect of Environmental Knowledge on Adoption of CA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	4.735	2	2.367	33.511	.000
Within Groups	25.219	357	.071		
Total	29.954	359			

The results in Table 4.92 showed that there was significant difference ($p< .05$) in the means of the three groups of farmers. Thus the null hypothesis which stated that there is no statistical significant difference between environmental knowledge and influence on farmers' adoption of CA was rejected. This implies that there is a relationship between the farmers' knowledge on environmental issues and their adoption of CA practices.

To determine where the differences existed, *post-hoc* analysis was carried out using Bonferroni test. The results are presented in Table 4.93.

Table 4.93: Bonferroni Test Differences in the Means.

(I) type of farming	(J) type of farming	Mean Difference (I-J)	Std. Error	Sig.
Conventional	CA	-.28312(*)	.05443	.000
	Both	.15160(*)	.02990	.000
CA	Conventional	.28312(*)	.05443	.000
	Both	.43471(*)	.05625	.000
Both	Conventional	-.15160(*)	.02990	.000
	CA	-.43471(*)	.05625	.000

* *The mean difference is significant at the .05 level.*

The results have shown that, environmental knowledge to a great extent influence women farmers' adoption of CA. The null hypothesis which stated that there is no significant influence of knowledge of the environment on women farmers adoption of CA has been rejected and Environmental knowledge to a great extent influence women farmers adopt CA practices.

The figure 8 indicate that out of the indicators measured and tested minimum tillage crop rotation protection of wetlands wildlife scored the highest while manure benefits scored the lowest. The percentages responses to CA of all the indicators are above 50% meaning they all influence women farmers adopt of CA.
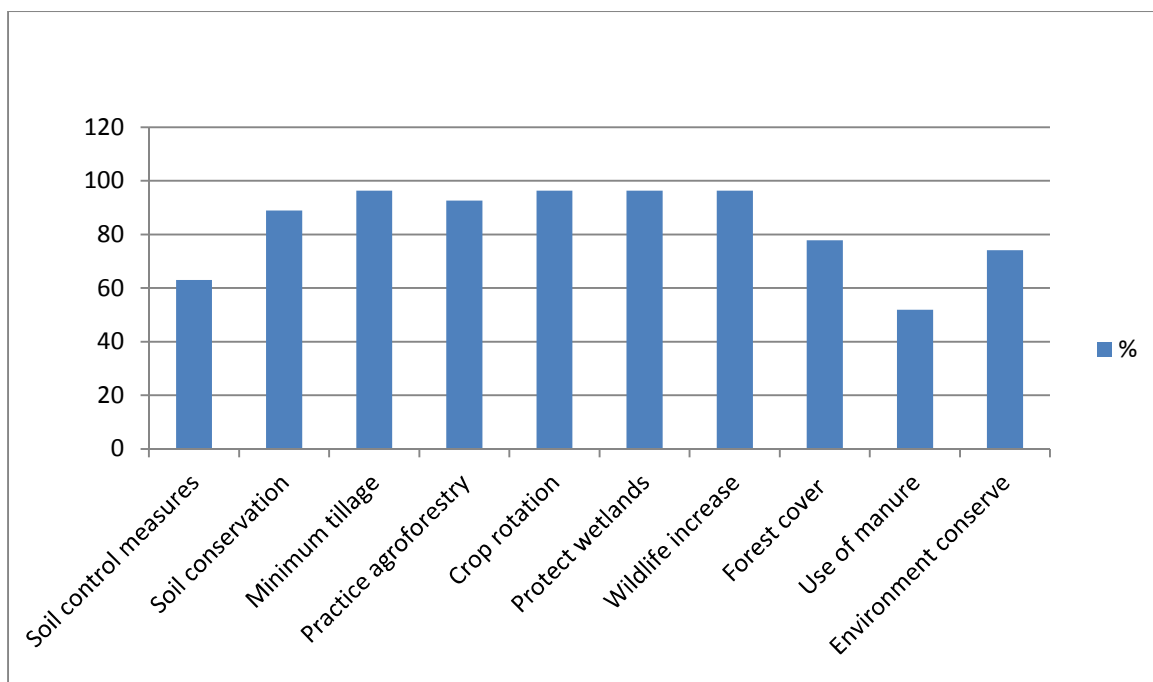
The figure 4.9 shows percentage results of women response to indicators of knowledge of environment.

The figure 4.9 show that minimum tillage crop rotation and wildlife increase scored the highest while soil control measures and use of manure were least regarding women knowledge of the environment.
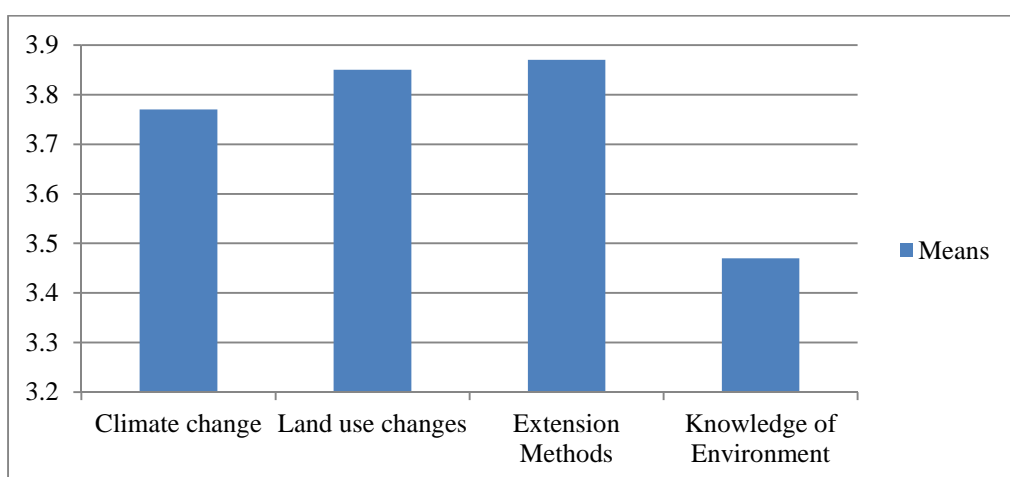
Fig 4.10 Overall Means of all the Variables Measured

The results in Figure 4.10 show the variable and the mean scores. Extension methods influenced women farmers the most in adoption of CA. Extension methods followed by land use changes to a great extent influence women farmers adoption of CA. Knowledge of the environment scored the lowest, meaning it influences the women farmers but was not as strong us the others.

CA practices focus on best ways of increasing food production and protecting the environment. It is imperative for farmers to have deep knowledge on ecosystem functions so that they are able to practice farming methods which add value to the environment. Women are known to have deep ethno indigenous knowledge on the environment and are good managers of the environment. If women are given training on CA technologies they would do better than men farmers.

Table 4.94 Results of Hypotheses Testing of the Objectives of the Study

(P < 0.05 level)

The results in Table 4.94 indicate that, the four environmental factors analyzed in the study were all statistically significant and the four null hypotheses were rejected at $p < 0.05$. It is concluded that the four environmental factors influence women small scale farmers' adoption of conservation agriculture.

4.6 Descriptive Analysis. Interview Schedule and Focus Group Discussions

The descriptive analysis was done from the responses from the members of the Focus group discussions and interview schedules from three selected study sites in Nakuru County namely Njoro, Rongai and Naivasha sub counties. The results are presented in Tables (See Appendix 5)

The number of farmers in each self-help groups in each site was 13 in Njoro, 11 in Rongai and 12 in Naivasha. The responses from the three groups interviewed were recorded. The responses

were voted and the mean responses were determined. The following were the environmental factors analyzed.

Ho	Null Hypotheses	Test	Rejection or Acceptance
1	Knowledge of climate change has no statistical significant influence on women farmers adoption of conservation agriculture	Chi-Square ANOVA Bonferroni Test	Rejected
2	The extent of land use changes has no statistical significant influence on women farmers adoption of conservation agriculture	Chi-Square ANOVA Bonferroni Test	Rejected
3	The effectiveness of extension methods has no statistical significant influence on women farmers on adoption of conservation agriculture	Chi-Square ANOVA Bonferroni Test	Rejected
4	Knowledge on environmental conservation has no statistical significant influence on women farmers on adoption of conservation agriculture	Chi-Square ANOVA Bonferroni Test	Rejected

Climate Change

The mean Yes response for Rongai 8.66 was higher than the other two for Njoro 8.34 and Naivasha 8.45. Women farmers in Rongai are aware of climate change and are able to adopt CA in order to cope.

Land use changes

The mean response for YES in Njoro was 8.13, in Rongai it was 7.26 and in Naivasha was 6.66. This means that the land use changes were more in Njoro than Rongai and Naivasha. There are more farmers in Njoro than the rest of the two sites. Njoro is a farming area and is cooler with high rainfall and fertile soil.

Extension Methods

The mean responses for YES in Njoro was 6.92, in Rongai was 7.53 and Naivasha was 7.0. This means that factors of extension methods were influencing farmers more in Rongai than in Njoro and Naivasha.

Environmental knowledge

The mean response for YES in Njoro was 7.43, in Rongai, 7.25 and in Naivasha 7.00. This means that factors of environmental knowledge were influencing farmers more in Njoro than in Rongai and Naivasha respectively.

Adoption of CA

Figure 15 shows that mean response for YES in Njoro was 8.81, in Rongai it was 8.27 and in Naivasha it was 7.27. This means that factors influencing farmers adoption of CA was to a great extent was higher in Njoro than in Rongai and Naivasha. Since Njoro is a farming zone, there are more farmers influenced by Climate change land use changes, extension methods and knowledge of environment. Climate change and land use changes influence women farmers to a greater extent than extension methods and knowledge of the environment.

The overall results from the Focus group discussions shows that women farmers who practice CA are to a great extent are knowledgeable of the climate change, land use changes, extension methods and environmental knowledge as the drivers to adoption of CA. Climate change is the leading factor in influencing women farmers to adopt CA.

Figure 4.11. Overall Means Yes Response for three Study Sites
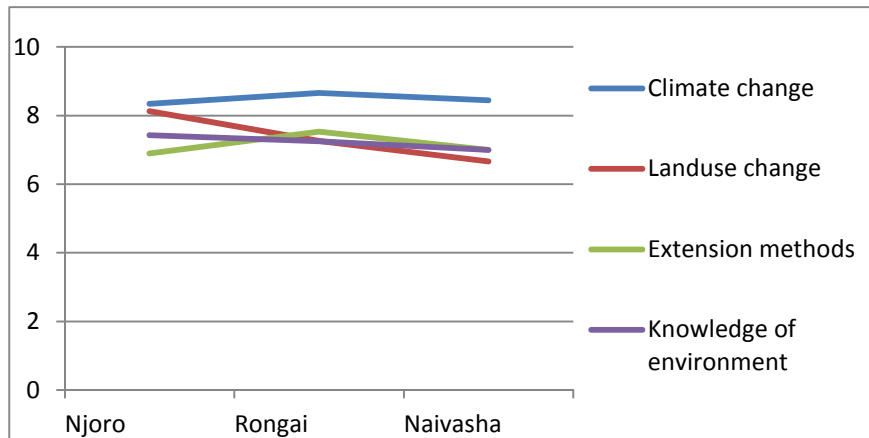
Figure 4.11 indicate the overall means for Yes responses for Njoro, Rongai and Naivasha. Climate change was more significant followed by land use changes, extension methods and lastly knowledge of the environment. In general, women farmers who practice CA are to a great extent aware of environmental factors under study and hence have higher level of adoption than those who do not practice CA.

4.6.1 Rongai Sub County Research Findings from Stakeholders

The interview results indicate that, there are 33, 434 women farmers. Out of the 20 women farmers interviewed, 50% of them practiced conventional farming, 15% CA and 35% practiced both CA and Conventional. Most farmers have heard about CA as one of the promising practices to overcome climate change hazards but are reluctant to embrace it fully therefore this explains why CA uptake in Rongai is low. The reasons could be several; attitude to change to a new technology. Farmers are used to their traditional methods and are not convinced if CA works and its benefits; two, lack of specialized equipment. CA requires special equipment which they do not have; three, conflicts between livestock keeping and growing of crops. Farmers would like to practice livestock and crop farming, four decisions making in the family. Most women farmers would want CA adoption but they are hindered by their husbands who believe in conventional practice as a way of getting income. The fifth one is ownership. Most

women do not own land which affects them not to practice CA. For CA practice, land tenure is important.

It was also observed that, farmers are aware of climate change and for them to cope with it, they are now venturing into drought resistant crops such as sweet potatoes, cassava, Doritos (black beans introduced by Seeds of Gold, Egerton University and KALRO Njoro), millet, sorghum, finger millet among others. It was noted that of all the farmers in Rongai, very few have adopted CA, the rest of the farmers have not fully adopted CA. In 2009 census, the total population of farmers was 142, 127 out of which 71,914 were males and 70,213 were females. The farming family was 33,707 and women farmers 18,700. Out of the women farmers, about 5% fully adopted CA, 50% partially adopted and 45% used conventional method. The farmers to some extent were aware of indicators of climate change such as Necrotic lethal virus which attacks maize and *Tuta obsoluta* which attacks tomatoes (NRC, 2015)

It was observed that land use changes have occurred since 1970s and most rapidly in the early 1990s. Rongai has been a white settler's home where large farms and extensive farming has been taking place. Conventional farming practiced involved growing of a single crop using machinery and industrial fertilizers. Places like Ngata, Ogilgei and Salgaa used to be under ADC farms after the white settlers. Wheat and livestock keeping such as dairy and sheep were reared and pyrethrum plantations dominated the practice. From 1980s land tenure policy changed and land buying companies bought ADC farms from the government and subdivided them into smaller private holdings. There was slow influx of human settlement. Extensive large scale farms reduced to small scale intensive farms for growing different crops which became more prominent. In 1990s, there was rapid increase in human settlements. More people from all parts of Kenya began to acquire land and settle in the study area and took up other economic

activities other than farming. Businesses developed and farming became challenging and with the farms getting smaller, small scale intensive farming became more intense. The current situation is that much farm land is now used for urban expansion, human settlements, flower farming horticulture, industries road constructions. Limited farm area and high population pressure has changed the region into a more urban. Much of the vegetation has been cleared affecting wildlife presence. Some species of plants and animals have disappeared from the area. Land use as has been observed, has changed significantly. This information is also supported by Nakuru County Report (NRC, 2014; Mubea and Menz, 2014)

It was found that, in the whole of Rongai Sub County, only 3 extension officers are available and the ratio of extension agents to famers is 1:1350. The extension officers are too small to serve farmers effectively and that is why many farmers are not taking up CA. It was also observed that the extension agents provide general technical advice to any farmer and are not trained specifically to train farmers on CA practices. Although there were good relations between agents and farmers, few women farmers are reached due to male dominance. The extension agents do not have structured programme on farmers' visits. The agents only visit when they have money for transport and women farmers are discouraged by the agents' responses because they ask farmers to support them financially in order to visit. This makes it hard to convince famers to change to CA.

Farmers 'self-help groups training were found to be most effective and since women form the majority of the self- help groups, it can be the most effective CA adoption method. The extension agents now use self- help women groups to train farmers on farming techniques but CA is partly addressed in the training. This makes it less effective in CA adoption. There is need therefore to sensitize farmers and have specific and qualified extension agents dealing

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with CA. SHG is a good avenue for introducing a new technology if the extension agents programme is designed to address CA and not conventional.

Seminars and training as observed, take place in different organized venues such as churches, schools, shopping centers, chief Baraza and local hotels which they found to some extent effective in bringing farmers together for knowledge gain. Some key informants voiced that, such trainings and seminars can only be effective when self-help women groups are addressed together with men because in most cases men are the decision makers on what agricultural practice can be carried out. The theme of training should also be tailored towards CA promotion. When the training is general, farmers take time to understand the differences between the two practices. Schools and religious institutes have not been effectively used and agricultural teachers have been left out of the programme. Schools can be good learning centers for new innovations. Students and teachers can be effective means of disseminating CA information. Farmers will always take an innovation if it comes from the school. Seminars held in religious places are not well presented and little time allocated. There is little information posted in the villages addressing CA practices, climate change and the impacts of land use changes affecting farmers directly and how they can cope with such changes in the environment.

Stakeholders play important role in any innovations being introduced to farmers. There are several NGOs and government ministries working with the farmers specifically self-help groups which they have found to be very significant in reaching out to farmers and also an entry point. The problem is that such training and seminars are structured programme which address general methods in agriculture and not specific to CA adoption. Some of the organizations working in the study area are KARLO, Egerton University, MOARLF, and

World vision, Friends of Mau Forest, Farming system of Kenya, Churches like ACK, Catholic, PATFID and Plant Clinics. These organizations are able to help farmers but little CA is addressed. There is only one NGO specifically addressing CA adoption and that is PATFID which works with programme and duration. Once their time is over they leave and train the extension agents to follow up with farmers.

ICT was observed as one of the effective methods in reaching out farmers and creating awareness. It was noted that a few farmers with internet access use them to get information through Google search engine. They found ICT useful and any information which was not clear, they would approach agricultural officers to explain. It was suggested that if all farmers are exposed to ICT services their farming skills will improve because they can compare their input and output with other farmers across the country or in other countries practicing CA fully. This will give farmers motivation and inspire them towards working for changes in agriculture and in responding to environmental dynamics that affect their produce. It was observed that only 5% of the farmers use ICT of which women farmers using ICT is 1.7%. There is need to motivate and encourage farmers to use internet information. E- Extension is a new method designated to capture information and relay it to headquarters Nairobi for analysis and action. The three staff in the sub county is responsible for collecting data and sending it to Nairobi through internet. The analyzed information is sent back with action plan back to the sub county for implementation.

It was also noted that most of the women farmers are educated and younger hence have to some extent have environmental knowledge. They are aware of the importance of planting trees, use of manure to protect soil and increase fertility, mulching, to conserve water, crop rotation to maintain soil fertility, ripping to have little effect on soil structures and soil organisms which

are helpful in soil fertility, growing of drought resistant crops to cope with climate change. Wildlife conservation is a problem because, most farmers have small farms less than 3 acres which are cleared and used for intensive crop growing.

The group discussions suggested the following; empowerment of women farmers through SHG, design structured projects for CA adoption so that women can be taken step by step and continuous follow up, need to have some demonstration farms on CA and women are taken through practically how they can convert from conventional practice to CA, allow more duration of training for at least 3 to 4 seasons so that farmers observe the benefits of CA and how it is useful in tackling environmental hazards. The trained women farmers will become the agents of CA adoption. 90% of women use cell phones for farming and this method can be structured and used for sensitizing farmers and consultations.

4.6.2 Njoro Sub County Research Findings from Stakeholders

The researcher also held several interview schedules with key informants, agricultural officers at Njoro Sub County office with field officers, NGOs representative and key community leaders. The team was led by Environment and Land Development Officer Njoro. The interviews were held to determine environmental factors influencing women small scale farmers' adoption of conservation agriculture (CA).The selected environmental factors examine were; climate change, land use changes, extension methods and environmental knowledge.

 In Njoro study area, there are 35, 012 households with 28,791 farm families. Female farmers are approximately 16,590 and male farmers are 12,201. The number of extension agricultural Officers (Field staff) in the whole sub county are 27 and out of this, 4 are more of CA experts and the rest are general agriculture experts. CA in this area is mainly managed by donors who

directly deal with field staff. The donors do not operate through the county offices. Therefore the agricultural officers at the sub county headquarters have no direct control although field officers are employees of the ministry of Agriculture.

The CA uptake in Njoro is very low and it was noted that there are reasons for its slow uptake: CA takes time to realize its benefits because the natural processes taking place can be realized over time. CA involves decomposition of plants and animal remains to form manure. Soil fertility restoration takes time. For one to realize the benefits, a farmer needs to be patient and wait for over 3 years. Farmers are not patient they expect quick returns. The donor funding lasts for a short duration. After the time is over they leave and stop the funding. When the farmers realize this, they are stuck and revert to the old practice (conventional). The farmers who have remained as adopters are patient and benefit for yield increase. One farmer adopter had her yield increased from 10 bags to 16 bags per acre for only 3 years practice. The study found that, the other reason is that, the donors hold information and not willing to share with the ministry or any other stakeholders. This makes CA secretive and some of the barriers affecting CA adoption.

Conservation agriculture common in the study area are; Farmers use of soil manure (animal and plant) compost, application of controlled herbicides to kill weeds reducing soil disturbances, agro forestry promotion, crop rotation and growing of cover crops such as legumes to conserve moisture.

Climate Change Influence on Women Farmers' Adoption of CA was analyzed.

The farmers here have to a great extent had the knowledge of climate change. It was noted that farmers' knowledge of the climate change is rated as 60%. The researcher asked if they know evidence of climate change and the following were the responses; changes in cropping time,

variations in the amount of rainfall, temperature variations, frequent droughts, sometimes rainfall is just too much like in 2010, farmers are no longer predicting weather, strange incidents of pests such as army worms white flies, and aphids, reduced flow in streams and drying. Out of the 60% farmers having knowledge of climate change, only less than 20% act, others are waiting for nature to take its own course; others do not have funds to act. It was observed that farmers no longer believe in weatherman reports because, they don't work as accurate as is reported. A good example is the recent announcement that Elnino will come with lots of rain as from last October. So far nothing has happened.

The farmers also acknowledged that climate change affects their farm yields greatly. When rainfall reduces there is crop failure and too much rain also cause soil erosion and burn the crops. The farmers were asked how they cope with climate change. The responses were; diversification of crops moving from single cropping like conventional to mixed cropping (grains planted with legumes), growing of short season crops, water harvesting measures such as dams and water pans constructions. Dams in large scale farming and water pans in small scale, growing of drought resistant crops as practiced in Lari and Naishi areas of Njoro to cope with weather changes, increase tree cover to moderate micro climate, green house farming to increase yields.

Land Use Changes and Influence on Women Farmers' Adoption of CA was analyzed.
Njoro in the past 30 years has experienced rapid land use changes particularly in the last 20 years from extensive large scale farming to intensive small scale farming and other economic activities which have dominated the whole landscape. Former large ADC farms have been converted into settlements, cash crop to subsistence. Large dairy farms to small scale zero grazing units except a few areas with large scale farming. From single cropping to multi or

diversified cropping systems. The population expansion has put great pressure on land from large arable farms to small plots of farm that can no longer support agriculture and solve food scarcity in the area.

From 1970s to mid-1980s, the land was under wheat and dairy keeping. From 1980s to 1990s major sub division of farmlands into small farms for settlements, urban expansion, industries and road constructions as dominant economic activities. Cash crop replaced by subsistence crops, large scale to small scale. Increase in women involvement in subsistence farming. Forest encroachment and deforestation leading to clearing land for settlements and cultivation. From 1990s to date- high population growth demand for land for settlements and cultivation, increased small scale subsistence farming, emergence of flower and horticultural farming. Further subdivision of land is making it almost impossible to produce enough food for the growing population. To overcome the problems there is now more emphasis to conserve soil due to its fertility loss by over cultivation, pollution and soil erosion. Agro forestry establishment increase, need to increase tree cover, and the need to change from conventional to CA. CA is thought to be the solution to environmental problems facing the area. CA is also recommended for mitigation of climate change, land use changes and government support through extension services and subsidies. The study also noted that, the impacts of land use changes as; low food production, peoples livelihood not certain, increase of vulnerable persons that need support, farmers abandoning Shambas to take up employment in new economic set ups such as trade, flower and horticultural, timber and other sorted industries, increase in crime rate.

Extension Methods Influence on Women Farmers Adoption of CA was analyzed.

The study found that from the interview schedules that extension method is the backbone of agriculture. Weak or ineffective extension services have led to poor food production in the

area. There was 27 field staff only against many farmers in the area. Out of this, only four staff were CA knowledgeable the rest provide general agricultural technologies. Self-help groups approach was found to be most effective to engage farmers in new innovations. The extension staff finds it easy to reach out to many farmers within a short time unlike targeting individual farmers. It is also act as entry point for NGOs and donors who want to support farmers adopt CA and other conventional practices. It was observed that SHGs is 75% effective and stands out to be method commonly used. If farmers organize themselves in groups, they understand one another and training becomes simple and less expensive. Adoption of CA by women farmers is a challenge because of the limited number of field staff knowledgeable about CA technologies. Generally, the degree of field staff involvement with farmers is 60% for conventional and 35% for CA. Women farmers to some extent are aware of CA and the role played by the field staff but in most cases do not want to adopt CA practices.

Other extension methods are used and vary in their effectiveness in the spread of CA technologies; Exhibitions and agricultural shows are useful because farmers are able to exchange knowledge about farming techniques with other farmers from other regions. Exhibitions and shows are general and not specific to CA and contribute to 65%. The disadvantage is that not all farmers attend such functions. Field days are effective and more farmers attend. It is less costly, it is productive and farmers have practical experiences. This was rated as 55% effective. Media such as TV/ Radio are used to access information to some extent.

ICT as a method of reaching farmers is becoming appreciated by farmers especially those who have access to ICT facilities and are educated. ICT was found to be emerging as the most effective way farmers can get information without waiting for field staff. Any problem can be

solved immediately by just using search engines like Google. The limitation is that farmers must be in areas where they can receive internet services. Internet services are also expensive to acquire. Mobile phones are also emerging as powerful tool in accessing information. The advantage of phones is that 95% of farmers have phones and daily communicate with field officers and also get information from the internet. Computer programmes are used by farmers to keep records, process and analyze data at their homes and offices particularly large and medium scale farmers. They suggested that, there is need to lower the cost of ICT services to help farmers increase their produce.

Training and seminars are less effective because they only target field staff and few farmers who have time to attend. Besides that, such functions are held in expensive hotels and far from their homes. Women are busy in other household chores and hardly find time to attend. Trainings and seminars are 10% effective. Chief Barazas are effective to a great extent, but only when field staff is given time to talk about issues affecting farmers. Many farmers attend the Barazas because they address many other social issues and in the process farmers are sensitized on new innovations such as CA. The study suggested that, seminars and training should be held in schools, religious institutions and market places nearer to the farmers.

The study also recommended the use of school teachers and students as avenue for effective communication to reach out to farmers. Formation and revival of 4K clubs, Young Farmers club, Wildlife clubs, and Environmental clubs are vital in the CA adoption. Farmer field schools are effective to a great extent. Farmers are trained on technology enterprise through full cycle up to 3 years from production to marketing the produce. Farmers learn by observations. It is like a laboratory research and farmers are willing to adopt the method.

The knowledge of the environment influence on CA adoption was analyzed.

The study found that, farmers especially women are aware of environmental conservation and sustainability. 80% of the women farmers practice conservation of the environment. The role of field staff help farmers continuously on; soil conservation, riparian protection to maintain quality and quantity of flow of rivers for caring for aquatic life and human consumption, safe handling of pesticides, safe disposal of pesticide containers, HIV/Aids / STS, drug and substance abuse, lifestyle diseases, gender issues, soil fertility management, agro forestry. It was noted that whether farmers practice CA or not, but they have some moderate information. The NGOS who help farmers in this study area are; Africa Conservation Tillage Network Sustain Net – mainly for CA, FAO – sponsor some CA projects, Seeds of Gold Egerton University, KALRO formerly KARI.

It was found that farmers face some problems such as access to financial resources, access to income from farming activities- they grow crops produce but their men pocket everything- women being overworked with many household activities besides farming such as fetching of fuel wood, water, food for the family care of children, reproductive role, pregnancy, lactation; decision making at household level and little time is left to attend seminars and training.

The study also found that the reason CA is beneficial to CA adopters is because conventional farming is slowly coming down due to land use changes, reduction of farm lands and climate change impacts as well as due to promotional for IPM (Integrated pest management) where chemicals are used as last resort to control pests and natural methods are recommended. CA controls and manages soil fertility; it involves less use of chemicals and inorganic fertilizers; CA conserves soil moisture, soil structure and allows natural processes to maintain soil fertility. In conclusion, the focus group suggested that,

- There is need for documentation as evidence for advancement of CA.

- Donors should be advised to avail information to farmers and government offices regarding CA practices.

- CA is sustainable and is likely to solve food insecurity.

4.6.3 Naivasha Sub County Research Findings from Stakeholders

Naivasha sub-county is in a dry ecological zone as compared with other parts of Nauru County. It receives rainfall between 900 mm and 600 mm a year. Temperatures are high ranging between 23 and 30 compared to other study sites in Nauru County. It is mainly made of grass and bush vegetation. Naivasha is known as pastoral land for livestock grazing and wild life area (part of range land) and is covered with Lake Naivasha which is fresh water in the middle. Several conservancies are found here.

The interview was conducted to find out the influence of climate change, land use changes, extension methods and knowledge of environment and how they influence adoption of CA by women farmers.

The schedule was organized by one of the agricultural officers at KALRO Naivasha and guided by the researcher. The results indicate that Naivasha region in the study area has undergone changes in land use and experienced climate change. Most of the farmers here are small scale. Much of the land to the north and west of Naivasha is under individuals who practice large scale flower farming. In the north of the lake the area is dedicated to wildlife conservation. Delamere farm which is a large extensive land has nearly 70% under conservancy. There are also private individuals who dedicate their lives into conserving the natural environments. In these areas, little disturbance or conversion of land into settlements and other economic activities is minimal.

To the south and west area of Naivasha are large flower farms occupying thousands of acres, with flowers grown in green houses. The study found that the lake has been severely polluted and reduced fish population. Pollution is affecting the community around the lake who depend on fish for their livelihood. The pastoral grazing land and livestock grazing have been converted into urban expansion and business hubs. To the south of Naivasha is Olkaria, Geothermal power project which has taken much of the rangeland and restricted pastoral grazing and completely transformed the landscape. The Masaai who are pastoralist have their land taken over and used for power generation restricting them and reducing their grazing area. The study found that, 65% of small scale farmers are women, out of which 16% practice conservation agriculture. It was reported that, to a great extent, women are aware of climate change and the effects of reduction in land size and the conversion of land into other uses. The farmers experience the harsh ecological environment which affects them greatly and therefore many of the farmers adopt a mixture of CA and conventional methods. The adverse climatic variations, reduced water in the area affect farming in the area and in order to cope with dryness of the area, most farmers harvest and store water in water pans. To the south of Naivasha on the higher ground along the Naivasha Nairobi highway, the farms have been subdivided into very small parcels with more of vegetable and maize farming. Around the Longonot region to Mai Mahihu, the land is less cultivated. Along the southern part of the lake, the farms have been converted into large tracks of flower farms. 25% of the women farmers have abandoned farming practice for employment in the farms which they believe is better than dry farming.

Due to its ecological zone and the conversion of land into other economic use and the challenging climate, many farmers are now practicing eco- friendly farming which results in improved yields and conserves the soil. A lot of quarry industry at the west region of the study area, are impacting negatively on farmers by making the soil exposed to erosion or leaving the

quarry sites infertile for farming. Between Naivasha and Kinungi, the free wildlife and livestock grazing zone have now been converted by 60% into peri-urban development. Real estate, industries and business complex have since replaced the range land. This rapid change of land use has affected women farmers and wildlife presence. At Karagita, the farmlands and grazing area is now under pressure of subdivisions with surging human population for settlements and business parks. The farmers at Karagita particularly women have found farming is becoming unprofitable and challenging hence they have taken up other income generating activities such as working in the flower farms.

The study noted that, there are several extension methods such as agricultural officers who work with the farmers assisting adopt eco-friendly farming. Some of the famers who have practiced CA now use their homes as models and assist other farmers to adopt CA after they have been trained and seen what their neighbors' do. About 13% of the farmers are now using ICT to get information on better farming practice. The use of internet and mobile phones and computer software related programmes are being used to assist the farmers in their efforts to better their farming skills.

One of the farmers indicated that the Seeds of Gold from Egerton University is helping farmers to adopt cheaper and more environmental friendly farming. The finding showed that Naivasha has been faced with numerous challenges some of which include; declining of the water levels due to the destruction of its hydrological systems and increased turbidity as a result of excessive discharge of the agricultural impurities among others. It was noted that farmers in the upper catchment area characterized with high sloppy farms have continued to practice conservation agriculture in efforts to promote the long-term existence of the lake Naivasha. Horticultural practices have increased in the area and women are involved in the production. But the large

farms are not belonging to women small scale farmers but, are owned by large multi companies. Women are only used as laborers and are paid peanuts.

It was also observed that increase of human population over the years has led to sizable loss of biodiversity and significantly shrunk the available natural resource base, thereby endangering the lives of humans, livestock and wildlife. Some of the sentiments from farmers were supported by the National Environmental Management Authority compliance officer who noted that, the Zebras and antelopes that used to roam along the Naivasha - Nairobi highway and which were always visible to travellers had disappeared. The disappearance of wildlife along Nakuru Nairobi road is due to several changes in land use and human population growth. Wild animals are threatened by human encroachment into their habitats and are shy from noise and any disturbance.

One of the NEMA official voiced that they are facing the challenge of how to manage the progressive encroachment of humans on wildlife habitation. People are using wildlife areas for human habitation, creating an avenue for human-wildlife conflict. In many cases, the animals simply go away," she said. She said the source of human population influx from outside to settle here and human reproductive activities is increasing.

In promoting, CA, one farmer said Naivasha is dry and farmers here have adopted new farming techniques that will not only guarantee them improved harvests but also transform the environment in a good way. He continued to say that in Gilgil, a group of 32 farmers are being trained on sustainable eco-agriculture practices on a 10 acre model farm established for that purpose with the support of Imarisha Naivasha and the Gilgil Environmental Protection and Advocacy Project (GEPA). The Mbegi Weru farmers group was noted as having a vision for their landscape. Their vision is to turn the dry semi-arid land into a lush verdant land with enough food for humans and animals. They said that the word Weru is Kikuyu for a desert, and

the dry, dusty plains that the farmers inhabit have traditionally been unsuitable for any meaningful form of agriculture apart from nomadic pastoralism. It was found out that group farming is very strong in this area in order to cope with environmental changes such as climate change and land use changes. Farmers in farming groups do a forestation to solve climate change. The forestation project has been extended to the surrounding community and each individual farmer is being encouraged to plant some trees on their farms.

The study found that Gilgil and Ndabibi are very dry, hot and dusty. The Ndabibi Environmental Conservation Centre is a farm that trains other farmers on smart eco-friendly farming practices (CA). The study also found that much of the rangelands and crop farms have been converted into flower farms and flower farming has become one of the land use system. It was found out that, there are major challenges facing flower farming around Lake Naivasha regarding agricultural sustainability, health risks, social accountability, and environmental conservation. One problem is the excessive water abstraction – the flower farms have continuously been in conflict with local communities like the Masaai's who have accused the farms of obstructing water for their livestock. There is also the destruction of riparian areas by farming because they use intensive pesticides, and when swept into the lake puts the lake's biodiversity at risk. There has also been significant reduction of fish population in Lake Naivasha.

The farmers explained that, the area is more of a semi-desert, with scanty vegetation and is often very windy, that is why they intercrop horticultural crops with maize because their stalks act as wind-breakers. The farmers plant vegetables such as water melon. Water pans are constructed to store water for use in irrigation. The farmers also keep livestock herd such both Sabinal and Boron cattle. Within some of the farms visited, zero-grazing unit which has both

Ayrshire and Friesian cows are kept by some farmers. Farmers do intercropping maize with crops such as cabbages and melons would be ideal, especially in open and windy areas. Farmers who intercrop watermelons with maize, however, need to add nitrogen fertilizer to their crops as the two would compete for this particular nutrient thus causing a deficiency. Farmers are trained to be careful in the excessive use of pesticides and fertilizers that affect the soil and pollute the water.

In summary, Naivasha has been affected by harsh climate, experience climate change and land use changes that have influenced farming and especially adoption of CA. Majority of farmers are women with small and medium size farms. The extension methods mostly effective are demonstration and training farmers by farmers who have developed CA models. ICT and mobile use are gaining prominence in the usefulness of accessing information on the best practices in farming. Only about 3% of the farmers use ICT services especially adopter of CA.

The study also observed a new technology, which was developed by Access Agriculture an NGO based in Nairobi started two years ago in reaching out farmers in the country. The new technology uses video filming and sharing videos with farming community as way of spreading new information on farming and the main objective is to show the famers agricultural practices done in other parts of the world in order to motivate and provide practical skills in improving production in agricultural sector. The technology is getting acceptance by farmers worldwide as one of the most effective method of extension services.

4.7 Synthesis of the Problems Found in Nakuru County

The study has identified several problems facing women small scale farmers in Nakuru County. Conservation agriculture adoption was found to be low and only 15% of small scale farmers practice CA and 85% of the farmers either adopt CA partially or not practicing at all.

The four environmental factors studied were influencing CA significantly out of which, extension methods was more influential with mean of 3.87 and knowledge of environment with a mean of 3.40. Shifting to modern agriculture practices such as CA, which involves drip irrigation, requires investment that small-scale farmers don't easily get access to. Inadequacy of knowledge both to the CA practice and environmental of the importance and contribution of biodiversity when it comes to specific and delicate products such as herbs.

Ineffective technical support and supervision contribute significantly to the low food production in the county.

It is argued that, access to finance, knowledge of the environment, climate change, extension methods and markets are not necessarily a guarantee of success: a new whole mentality must be adopted. The first shift has to be towards openness to what is new and innovative: new produce, new ways to approach farming practices and a new dedication that perseveres even when things don't reach the expectations from the beginning.

For CA benefits to be realized, big goals cannot be achieved in short periods. A farmer who really wants to build a long-term, sustainable and safe wealth for their family requires planning, rationalization, and the capacity to see beyond the immediate future. CA takes from three to four years to be realized.

Most small scale farmers interviewed were in farmers' cooperatives which is an avenue to successful farming brought about through knowledge sharing. Self-help groups, church groups and farmer professional groups are very useful in farmers' uptake of new innovations and implementing them in a manner recommended by agricultural experts.

Despite the efforts made by farmers in trying to spur food production, with the population pressure on land increasing and the cultural practice of dividing the family possessions among the sons are still rampant in the study area. The study also learnt that, the problems do not end there for the smallholder. The smallholder farmers have been losing more and more of his or her land to middle class people for other development agendas since the 1990s. Insight information (82%) from interviews indicate that, mostly urban professionals and business people who own between five and 100 hectares of land now control more land than the large-scale farmers in Nakuru county which is a reflection of Kenya.

Many farmers 67% were found to lack the practical education required to undertake a successful farming business, the kind a smallholder neighbor has acquired from years of beating or manipulating the elements, bacteria, insects, birds and village thieves.

CHAPTER FIVE:

SUMMARY, CONCLUSIONS AND RECCOMMENDATIONS

5.1 Introduction

This chapter deals with the findings of the study of the four hypotheses tested and includes summary, conclusions, recommendations and suggestions for further studies.

The research study established that there is low uptake of CA in Nakuru County by small scale women farmers. Out of the 360 women farmers interviewed only 54 (15%) fully adopted CA, at least practising more than three methods of CA, 204 (556.5%) did not adopt CA and the rest 28.5%) partially adopted CA. The majority of the women farmers were to some extent aware of the climate change, land use changes, extension methods and knowledge of the environment. This means that apart from the four specific objectives investigated to a great extent influence women farmers. For non -adopters, there could be other factors that keep women farmers from adopting CA.

It was also established that there is a shift from farming to other occupations by women farmers. Due to environmental and socio economic factors facing the women farmers in the county, more women are being employed in large flower farms and other economic activities. The reason for this is that climate change and land use changes are frustrating women efforts in food production and also to care for their families. It was noted that families with large households have further subdivided their farms into smaller units for their children and hence farms are no longer productive in food production. Food production in the study area has gone down as a result of climate change, land use changes and poor structuring and support of extension methods and government policy on agricultural production in the county.

The research established that, Self-help women groups have become very important extension method in adoption of CA. It was also found that ICT and smart phones are becoming more important in the rural farming and many farmers get any information they want through internet using computers and smart phones but this extension method has not picked up well for farmers who are unable to operate the gargets due to low education and old age. Some farmers did not even have smart phones and cannot reach internet or use computer programmes to help them maximize their production.

The research establishes that Access Agriculture, one of the agricultural NGOs, is using filming, recording and Videos to share and show farmers what other farmers from other parts of the world are doing, their successes and challenges on CA adoption. The farmers learn quickly from video sharing and this motivates them to adopt CA as others have done and are successful. More light needs to be shed on the impacts of Video show sharing with farmers.

Majority of women farmers in the study area were to a great extent aware of their environment and acted according to their understanding of environmental issues.
Climate change is real and many women farmers needed to have weather stations close to them especially in schools, and chief centres for accessibility and quick information access by community leaders. There is need to have information in the villages and agricultural experts to create awareness on weather changes and how to respond as far as farming is concerned.

Self- help women groups are very powerful in adoption of a new technology. SHWGs are powerful tools and a point of entry into the farming communities. Many NGOs and stakeholders are now beginning to disseminate information through self-help groups. Self-help group as an extension method takes the shortest time to reach large populations of farmers

instead of individual farmer contacts. Farmers have also formed farmers' cooperatives for financial support, advice and as a means of information sharing.

5.2. Summary of the Research Study Findings

Ho₁; Hypothesis one: Knowledge of climate change has no influence on women farmers' adoption of conservation agriculture. This null hypothesis was rejected @ $p < 0.05$ alpha and it was found that, knowledge of climate change significantly influences women farmers' adoption of conservation agriculture in Nakuru County. The objective number one had ten elements measured. All the items tested gave positive results which ranged between 96.3% and 66.7% for the adopters. The overall mean scores for the ten items showed influence on women farmers' adoption of conservation agriculture. Awareness of changes in temperature patterns and increase in water conservation scored 96.3% being the highest followed by decision to vary the planting dates as influential. Switching from crop to livestock was least in influencing women farmers with a score of 66.7% for adopters. Farmers who adopted CA fully were influenced by awareness of climate change. From Focus group discussions in Njoro, the women farmers were more aware of climate change and were most influenced by climate change compared to Rongai and Naivasha. Njoro study site is more agriculturally favourable and any change of climate affects them most.

The overall mean of awareness of climate change was, CA adopters 3.77, non-adopters, 3.38 and incomplete adaptors 3.4. This means that the mean of CA adoption was higher hence Climate change influenced women farmers' adoption of CA. The reason why non-adopters did not adopt CA could be age, education level, size of farms and equipment costs among others. Climate change affects women farmers and CA adopters have increased their food production and increasing biodiversity as the findings revealed. There is need to find out why some women farmers never adopted CA yet they were to some extent aware of the climate change.

Ho2; Land use changes does not influence women farmers adoption of CA. Nine items (indicators) were measured. This null hypothesis was rejected @ p< 0.05 alpha and it was found that, land use changes significantly influences women farmers' adoption of conservation agriculture in Nakuru County.

The objective number two had nine elements measured. All the items tested gave positive results which ranged between 96.3% and 70.4% for the adopters. The overall mean scores for the ten items showed that they all influence women farmers to adopt conservation agriculture. Land policy on forest cover and growth of urban scored 96.3% being the highest followed by farm size reduction and mixed farming practice 92.6% for adopters. Road construction and growth of industries scored lowest, 74.% and 70.4% respectively. Farmers who adopted CA fully were influenced by land use changes. From Focus group discussions, Njoro, the study site the women farmers were generally influenced by land use changes in Nakuru County. All the study sites indicated that land use change is very significant and has affected the arable land which subsequently has led to low food production and loss of biodiversity.

The overall mean awareness of climate change was, CA adopters 3.85, non-adopters, 3.32 and incomplete adaptors 3.45. This explains that mean of CA was higher in CA adopters hence Land use change influence women farmers adoption of CA. There could be other reasons why non-adopters did not adopt CA; could be age, education level size, of farms, equipment costs among others. Land use change has significantly affected women farmers in their effort to increase food production through CA practices. CA adopters are quite knowledgeable of land use changes and find an alternative in maximizing their yields through CA.

Ho₃: Extension methods does not influence women farmers adoption of conservation agriculture

This objective had ten items measured. This null hypothesis was rejected @ $p < 0.05$ alpha and it was found that, awareness of extension methods significantly influences women farmers' adoption of conservation agriculture in Nakuru County.

The objective number three had nine elements measured. All the items tested gave positive results which ranged between 92.6% and 50.05 % for the full adopters. The overall mean scores for the ten items showed that they all influence women farmers to adopt conservation agriculture. Awareness of women to women contacts and NGOs training scored the highest and were most influential on adoption of CA by women farmers. The least influential for adopters was exposure to seminars with 50.05% followed by watching TV programme. In the rural setting very few farmers have TV and seminars are held away from the farms and generally expensive limiting the women farmers attending. For any innovation regarding farming techniques, women to women contacts provide a better extension method in CA adoption. Farmers who adopted CA fully were influenced by extension methods. From Focus group discussions, Njoro, the study sites the women farmers were generally influenced by extension methods. All the study sites indicated that extension method is very significant and has affected the arable land which subsequently has led to low food production and loss of biodiversity.

The overall mean awareness of climate change was, CA adopters 3.87, non-adopters, 3.38 and incomplete adaptors 3.41. This explains that mean of CA was higher in CA adopters hence extension methods influence women farmers adoption of CA. There could be other reasons why non-adopters did not adopt CA; could be age, education level size, of farms, equipment costs among others. Extension methods are very significant in agricultural practices because

they promote farmers' awareness and employ the right techniques in agricultural services such as women to women contacts, training by agricultural experts and NGOs support. Other methods like Internet access, smart phones, knowledge in ICT, establishment of weather stations in schools and interpretations are important.

Ho4: Knowledge of the environment does not influence women farmers' adoption of CA

This objective had ten items measured. This null hypothesis was rejected @ $p < 0.05$ alpha and it was found that, knowledge of the environment significantly influences women farmers' adoption of conservation agriculture in Nakuru County. The objective number four had ten elements measured. All the items tested gave positive results which ranged between 96.3% and 51.9 % for the CA adopters. The overall mean scores for the nine items showed that they all influence women farmers to adopt conservation agriculture. Knowledge on minimum tillage, wild life increase and need to protect scored the highest 96.3 % and were most influential on adoption of CA by women farmers. The least influential for CA adopters was benefits of using manure. Women normally are careful in using environmental resources. Women are able to protect biodiversity. Minimal tillage is very significant in keeping the soil fertile and less interference with soil organisms which help to maintain soil fertility for a long time. Generally, women are known to have knowledge about environment. It is not clear if woman's knowledge of the environment helps them in farming practice. For any innovation regarding farming techniques, women to women contacts provide a better extension method in CA adoption. Farmers who adopted CA fully were influenced by Knowledge of the environment. Focus group discussions also voiced that the women farmers were generally influenced by knowledge of the environment.

The overall mean awareness of climate change was, CA adopters 3.47, non-adopters, 3.18 and incomplete adaptors 3.03. This explains that the mean of CA was higher in CA adopters hence extension methods influence women farmers adoption of CA. There could be other reasons why non-adopters did not adopt CA; could be age, education level size, of farms, equipment costs among others. Knowledge of the environment is very vital in the understanding of environmental dynamics which affect farmers daily.

5.3 Conclusions

The study established that the four environmental factors (climate change, land use changes, extension methods and knowledge of environment) examined, significantly influenced women small scale farmers' adoption of conservation agriculture. The four null hypotheses presented for testing were all rejected at alpha value $p < 0.05$. Of the four factors, extension methods influenced women farmers the most, followed by awareness of climate change and the least was knowledge of the environment as far as adoption of CA was concerned. Age, education level and size of farms also influenced farmers adopting CA. The low rate of adoption in Nakuru County by women farmers is therefore attributed to the four examined environmental factors. The study also provides explanation that, women farmers who did not adopt CA may have been influenced by other factors other than the ones under study. It was observed that generally the adoption of conservation agriculture was very low in Nakuru County. 15% of the farmers sampled fully adopted conservation agriculture and the rest did not adopt or tried both systems for their own security reasons. Through discussions and interview schedules, women farmers adopters embraced CA because; it maintains soil fertility for a long time, prevent and control pollution, use minimal pesticides and herbicides, safe from food diseases got from crops when chemicals are used a lot, costs less, mitigate climate change, increase biodiversity and conserve indigenous plants and animals that provide various ecosystem services.

To a great extent majority of women farmers in Nakuru County were aware of climate change, land use changes and extension methods but only a small number practiced CA. The study found that Knowledge of the environment to a great extent influenced women farmers on adopting CA and that women farmers protect the environment for a number of reasons one of which is to conserve wildlife, which in turn aids in pollination leading to high yields hence food security. Wild life interacts with human in many ways: honey production, medicinal products, industrial products, animal manure for soil fertility and increase in rate of decomposition. CA encourages food diversification which is advantageous over single crop production as practiced in conventional farming. The focus group discussion voiced that there is need to restructure extension agents' policies and create awareness through ICT, film video shows, use of religious programme to strengthen information dissemination since about 70% of the religious functions are women and any new information received from the church is taken seriously. Mobile smart phones and self -help groups are emerging as important methods of learning and transmitting information relevant to the famer in order to enhance farm production.

5.4 Recommendations

From the information and findings of the study which indicated that environmental factors investigated in the study significantly influence small scale women farmers' adoption of conservation agriculture, the following recommendations were made,

1. The Ministry of agriculture needs to restructure agricultural relevant policies to speed up CA adoption.
2. The government needs to look for ways of ensuring sharing of research materials in support of farmers for effective CA adoption.

3. The need to establishment weather stations in all community schools and students and staff be empowered to transmit information to local farmers.

4. Need for effective use of religious meetings to sensitize and educate farmers on CA practices and to provide climate change information.

5. The need to share videos among stakeholders as one of the emerging effective communication technology in speeding up adoption of CA by women farmers in all farming groups.

5.5 Suggestions for Further Research Study

The following are the research areas which have been identified for further studies,

1. The influence of self-help women groups small scale farmers on adoption rate of conservation agriculture.

2. The impact of filming and videos show on women small scale farmers' adoption of conservation agriculture in Nakuru County.

3. Assessing the cost and effectiveness of smart phones on dissemination of information and speeding up adoption rate in rural women farmers.

4. Determining the importance of establishing ICT training facilities in local schools as access to conservation agriculture adoption.

5. Establishing how effective religious services are as information conduit to promote conservation agriculture in Nakuru County.

6. Assessing how religious meetings, training and Sunday services can be a conduit of effective dissemination of new CA technologies for women farmers to improve their food production since 80% of the religious activities involve women

7. How using filming, uploading videos and sharing with women farmers would enhance conservation agriculture adoption.

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APPENDIXES

APPENDIX 1: WOMEN FARMERS QUESTIONNAIRE

Dear Respondent,

I am a PhD candidate at Kabarak University currently carrying out a field research. The focus of the questionnaire is Environmental Factors Influencing Women Farmers Adoption of Conservation Agriculture in Nauru County. By sharing your experiences, you will contribute to our effort to document and share lessons learned from landscape-scale to support food production, ecosystem conservation, and rural livelihoods. The results of this study will contribute to a strategic, action and advocacy program to expand the use of sustainable eco agriculture (CA) approaches among women farmers and Kenya at large. Do not write your name on the questionnaire please since all the responses are confidential and will only be used for the purpose of the research.

Yours faithfully,

MichuraEliud Garry

Researcher.

Part A. Women Farmers

Please provide the following basic information about yourself and your role in conservation agriculture.

1. Sub County --------------------------------

Age: [1] 18-25 [2] 26-35[3] 36-45 [4] 46-55[5] 56 and above.

2 .Level of education [1] No formal education [2] STD 1- Std 5[3] STD 6- STD 8 [4] Some

secondary education [5] Some tertiary education

3. Size of the farm (Acres) [1] 0.1-0.5 [2] 0.6-1.0[3] 1.1-2.0 [4] 2.1-3.0[5] >3.06a.

4. Land ownership [1] Own land [2] Renting [3] Borrowed [4] Others specify_____

5. Type of land ownership [1] Customary land [2] Private/ Leasehold land [3] Public land.

6. Indicate type of farming system you practice a) CA b) Conventional c) Both

7. Why practice CA? a) Less costly b) land area small c) land area big c) Mitigate the effects

of climate change d) Land use has changed e) CA extension methods available f) have

knowledge in CA e) Has no knowledge in CA f) Conventional agriculture not good for soil

fertility g) Conserves soil moisture h) protects soil nutrients

Objective 1: Influence of climate change on adoption of conservation agriculture

1 a) The following are climate change indicators. Show which ones influenced you to adopt to

CA practices. Tick the appropriate ones.

	Variables	Little extent	undecided	To a great extent	To very great extent
1	Knowledge on changes of temperature patterns				
2	Knowledge on rainfall patterns				
3	Frequency of droughts				
4	Decision to varying planting dates				
5	Decision to plant different crops				
6	Switching crops to livestock				
7	Increase tree/ shed				
8	Intensify use of irrigations				
9	Migrating to different sites				
10	Increase water conservation				

b) Farmers experience climate change as it affects their adoption of CA. By how much do the following adoption practices help you in overcoming the effect of climate change.

c) To what extent do you agree with the following practices under CA as a means to mitigate climate change?

d) CA adoption has enabled me to cope with climate change in the following areas of practice

Climate change adaptation	Yes	No	I don't know
Ability to adapt to insect pests			
Ability to prevent soil erosion			
Ability to improve lower yields			
Ability to adapt to crop damage and avoid crop failure			

e) Women farmers experience with climate change using conventional farming

Experience	Yes	No	I don't know
Insect pests more frequent			
Soil erosion increase			
Lower yields			
Crop damage and even crop failure			
Loss of wild plants			
Animal migration and loss			

Objective 2: Influence of land use change on women farmers adoption of CA

a) To what extent have the following factors on land use change affected the adoption of CA in your area?

Land use	Little extent	Undecided	To a great extent	To a very great extent
Land policy on Forest cover				
Road construction				
Industry				
Settlements				
Urban development				
Farm size reduction				
Floriculture				
Grazing land				
Mining				

b) Land use changes and influence on women farmers adoption of CA. Fill in appropriately

Land use 1970	1980	1990	2000	2015
Forest cover				
Pasture				
Cash crop				
Dry cropping				
Settlements				
Mixed farming				
Bare soil				
Urban development				

c) To what amount has the land use changed

Land use	Highly Increased	Increased	None at all	Decreased	Idon'tknow
Forest cover					
Pasture					
Cash crop					
Dry cropping					
Settlements					
Mixed farming					
Bare soil					
Urban development					

Objective 3: Influence of extension methods on CA adoption practices

a) Rate the effectiveness of participatory extension methods you have experienced on CA adoption

Method	Very effective	Effective	Undecided	Less effective	Not effective
Women to women farmers contact					
Interaction with extension agents					
NGOs training					
Visiting agricultural shows					
Radio Programme					
TV Program					
Chief Baraza					
Field demonstration days					

Reading agri related materials		215			
Attending Seminars and training					

Objective 4: Influence of environmental knowledge on CA adoption practices

a) Indicate the extent to which your knowledge on the environment affected your adoption of CA

CA Practices	Great extent	Some extent	undecided	Small extent	No extent
Wild life protection increase biodiversity					
Use of organic manure increase yield					
Minimal tillage preserves moisture and fertility of soil					
Protect wet land for water quality and quantity					
Agro forestry conserves / manages trees					
Crop rotation maintains soil fertility and increase yields					
Increase forest cover					
Crop diversification					
Enlightenment on soil control measures					

AGRICULTURAL OFFICERS, INFORMANTS AND COMMUNITY LEADERS (MEN AND WOMEN)

Factors influencing women farmers adoption of conservation Agriculture in Nakuru County

A 1)   Approximately how many women small scale farmers in Nakuru County -------

        i)   Number practicing CA ---------------- ; Both CA and Conventional --------------------

        In Naivasha, ---------------, Molo ---------------- Nakuru --------------------

        ii)   Give reasons why WF practice CA? --

----

        iii)   Name the CA practices common in the area ----------------------------,-----

--------------------, -------------------------------, -------------------------------

2)   Which of the practices of CA are most preferred and why?

B   1) Do WFs have any knowledge about climate change? To what extent is their knowledge?

2)   How does knowledge on climate change by WF contribute to food production and to what degree?

3)   What are the effects of climate change on farming? How are WF cope respond towards   climate change

4)   In what ways are the WF made aware of knowledge about climate change and its impacts on farming?

5)   If the knowledge of climate change is not adequate, what are the possible ways of helping WF to strengthen their knowledge?

6)   What kind of activities are the WF engaged in to cope with climate change.

C   1)   List some of the extension methods employed by women in the area

2)   Rate the extension methods in order of their effectiveness.

3)   What are likely to be the main hindrance to extension methods?

4)   Are the women really knowledgeable about extension methods? To what extent

is the knowledge?

5)   Are there other extension methods would you recommend and why?

6)   Are there information in the villages regarding climate change, extension

methods and CA

practices?

7)   Explain how farmers get information on CA practices and why they practice it.

8)   Do you get feedback from WF about a particular extension method and how is

that helpful in

helping WF to improve their yields and conserve their environment.

9)   Explain how the land use changes have occurred since 1990

10)   What has caused the land use changes, the impacts of land use changes on

farmers and the

response of land use changes by WF.

11)   Which 3 areas hare most affected by land use changes in Nakuru County.

D)   1)   Why do you think having knowledge of the environment is important for WF

2)   To what extent is WF knowledge on the environment?

3)   Describe and explain some of the environmental knowledge practices carried

out by WF?

4)   Will environmental knowledge on environmental conservation and

management helpful to tackle some of the environmental problems such as

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drought, climate change, diseases, that affect community lifestyles in regard of food production? If yes explain

5)   What are the contributions of other stakeholders such as government leaders, NGOs, Scientists, agriculturalists, Weather man, politicians, agricultural teachers and any other in promoting CA? Identify areas in which they can be helpful

6) Are new technologies such as ICT, TV, Radio, Internet, County magazines and News pares creating awareness on the importance of CA being used and to what extent.

APPENDIX 2: BONFERRONI I TEST

The Bonferroni correction is based on the idea that if an experimenter is testing m hypotheses, then one way of maintaining the family wise error rate (FWER) is to test each individual hypothesis at a statistical significance level of times what it would be if only one hypothesis were tested.

So, if the desired significance level for the whole family of tests should be (at most) α, then the Bonferroni correction would test each individual hypothesis at a significance level of α/m. For example, if a trial is testing eight hypotheses with a desired $\alpha = 0.05$, then the Bonferroni correction would test each individual hypothesis at $\alpha = 0.05/8 = 0.00625$.

Statistically significant simply means that a given result is unlikely to have occurred by chance assuming the null hypothesis is actually correct (i.e., no difference among groups, no effect of treatment, no relation among variables)

Let $H_1, \cdots, H_m$ be a family of hypotheses and $p_1, \cdots, p_m$ the corresponding p-values. Let I_0 be the (unknown) subset of the true null hypotheses, having m_0 members.

The family wise error rate is the probability of rejecting at least one of the members in I_0; that is, to make one or more type I error. The Bonferroni Correction states that choosing all $p_i \leq \dfrac{\alpha}{m}$ will control the $FWER \leq \alpha$. The proof follows from Boole's inequality:

$$FWER = Pr\left\{\bigcup_{I_o}\left(p_i \leq \frac{\alpha}{m}\right)\right\} \leq \sum_{I_o}\left\{Pr\left(p_i \leq \frac{\alpha}{m}\right)\right\} \leq m_0\frac{\alpha}{m} \leq m\frac{\alpha}{m} = \alpha$$

This result does not require that the tests be independent.

We have used the fact that $\sum_{i=1}^{n} \frac{\alpha}{n} = \alpha$, but the correction can be generalized and applied to any $\sum_{i=1}^{n} a_i = \alpha$, as long as the weights are defined prior to the test.

Confidence intervals.Bonferroni correction can be used to adjust confidence intervals. If we are forming m confidence intervals, and wish to have overall confidence level of $1 - \alpha$, then adjusting each individual confidence interval to the level of $1 - \frac{\alpha}{m}$ will be the analog confidence interval correction.

APPENDIX 3: SAMPLE SIZE DETERMINATION

Required Sample Size†

Population Size	Confidence = 95%				Confidence = 99%			
	Margin of Error				Margin of Error			
	5.0%	3.5%	2.5%	1.0%	5.0%	3.5%	2.5%	1.0%
10	10	10	10	10	10	10	10	10
20	19	20	20	20	19	20	20	20
30	28	29	29	30	29	29	30	30
50	44	47	48	50	47	48	49	50
75	63	69	72	74	67	71	73	75
100	80	89	94	99	87	93	96	99
150	108	126	137	148	122	135	142	149
200	132	160	177	196	154	174	186	198
250	152	190	215	244	182	211	229	246
300	169	217	251	291	207	246	270	295
400	196	265	318	384	250	309	348	391
500	217	306	377	475	285	365	421	485
600	234	340	432	565	315	416	490	579
700	248	370	481	653	341	462	554	672
800	260	396	526	739	363	503	615	763
1,000	278	440	606	906	399	575	727	943
1,200	291	474	674	1067	427	636	827	1119
1,500	306	515	759	1297	460	712	959	1376
2,000	322	563	869	1655	498	808	1141	1785
2,500	333	597	952	1984	524	879	1288	2173
3,500	346	641	1068	2565	558	977	1510	2890
5,000	357	678	1176	3288	586	1066	1734	3842
7,500	365	710	1275	4211	610	1147	1960	5165
10,000	370	727	1332	4899	622	1193	2098	6239
25,000	378	760	1448	6939	646	1285	2399	9972
50,000	381	772	1491	8056	655	1318	2520	12455
75,000	382	776	1506	8514	658	1330	2563	13583
100,000	383	778	1513	8762	659	1336	2585	14227
250,000	384	782	1527	9248	662	1347	2626	15555
500,000	384	783	1532	9423	663	1350	2640	16055
1,000,000	384	783	1534	9512	663	1352	2647	16317
2,500,000	384	784	1536	9567	663	1353	2651	16478
10,000,000	384	784	1536	9594	663	1354	2653	16560
100,000,000	384	784	1537	9603	663	1354	2654	16584
300,000,000	384	784	1537	9603	663	1354	2654	16586

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$$n = \frac{Z^2 \times p\,(1-p)}{M^2}$$

Where:

n   =   Sample Size for infinite population

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Z   = Z value (e.g. 1.96 for 95% confidence level)

P   = population proportion (expressed as decimal) (assumed to be 0.5 (50%)

M = Margin of Error at 5% (0.05)

Source: Krejcie& Morgan (1970)

APPENDIX 4: SOCIO ECONOMIC CHARACTERISTICS TABLES

T1: Age of Respondents

	Frequency	Percent	Valid Percent	Cumulative Percent
18-25	52	14.4	14.4	14.4
26-35	50	13.9	13.9	28.3
36-45	53	14.7	14.7	43.1
46-55	182	50.6	50.6	93.6
56 and above	23	6.4	6.4	100.0
Total	360	100.0	100.0	

T2: Level of education

	Frequency	Percent	Valid Percent
std 1-5	54	15.0	15.0
std 6-8	78	21.7	21.7
some secondary	153	42.5	42.5
Tertiary	75	20.8	20.8
Total	360	100.0	100.0

T3: Size of Farms

Size of farm (ha)	Frequency	Percent
< 1.0	79	21.9
1.0-2.5	179	49.7
2.6- 3.5	26	7.2
>3.6	76	21.1
Total	360	100.0

T4: Type of Ownership

		Frequency	Percent	Valid Percent
Valid	Own	204	57	57
	Rent		27	27
	Borrowed		16	16

T5: Type of Farming

	Frequency	Percent
Conventional agriculture	204	56.6
Conservation agriculture	54	15
both	102	28.4
Total	360	100.0

APPENDIX 5: RESULTS OF FOCUS GROUPS DISCUSSIONS

Variables	Questions	Frequency of Responses Yes and No					
		Njoro (13)		Rongai (12)		Naivasha (11)	
		Y	N	Y	N	Y	N
Climate change	Climate has changed significantly since 1970s	12	1	11	1	9	2
	Temperatures now are hotter than ever before- global warming	10	3	8	4	7	4
	Temperature variations are common (high, low at times) in this place	9	4	9	3	8	3
	Rainfall patterns have changed considerably – rainfall no longer predictable.	10	3	9	3	7	4
	Our seasons of planting have changed due to weather changes a greatly	11	2	12	0	10	1
	Droughts are too common and unpredictable unlike before	12	1	11	1	9	2
	We plant drought resistant crops due to rainfall variations	9	4	7	5	6	5
	New diseases due to changes in weather patterns warmer To	8	5	6	6	7	4
	Climate the same ever since. No change.	5	8	4	8	6	5
	Many rivers here have dried up others have reduced in volume flow	12	1	9	3	7	4
	Some animal species that used to be here in large numbers reduced or disappeared – No longer seen.	7	6	8	4	8	3
	We don't rely on weatherman because the information not accurate or we are not aware.	11	2	10	2	9	2
	Mean response of Climate change	8.34	1.64	8.66	1.3	8.45	1.55
Land use change	Free grazing land conversion to settlements- Rate is high	8	5	7	5	10	1
	Grazing land converted to flower farms. more flowers grown	6	7	7	5	8	3
	Settlements encroaching productive farm lands	9	4	9	3	8	3
	Forests areas replaced by cultivated fields	7	6	7	4	7	4

	Some farms introducing planted forests to replace natural once	6	7	6	6	7	4
	Mining and quarry taking up some productive farm lands	5	8	6	6	8	3
	High rate of greenhouse flower farms increasing	8	5	7	5	9	2
	Construction roads reducing farm lands	7	6	7	5	5	6
	Large ADC farms sub dived and sold to private and developed to urban	10	3	9	2	5	6
	Single cropping like wheat/ maize /pyrethrum replaced with subsistence crops such as potatoes, vegetables, maize,	11	2	8	4	7	4
	Large farm reduced to small farms	9	4	9	2	6	5
	Extensive livestock farming to intensive small scale	8	5	7	5	6	5
	Single cropping to mixed farming	9	4	8	4	9	2
	Coffee and Tea farms replaced by subsistence farming	8	5	4	8	3	8
	Pyrethrum plants uprooted and horticulture and zero grazing done	11	2	8	4	2	9
	Mean responses for Land use changes	8.13	1.87	7.26	2.74	6.66	3.24

Extension Methods	Extension agents are few and not in contact with farmers	7	6	7	5	8	3
	Extension agents not knowledgeable of CA practices	6	7	7	5	7	4
	ICT can be effective but foreign to farmers	9	4	9	3	7	4
	Need to establish ICT for information -farmers are educated	6	7	6	6	6	5
	Self help women groups very effective but less used	8	5	9	4	8	3
	Women to women groups most effective	10	3	10	2	9	2
	Extension agents rarely contact women but men farmers	9	4	9	3	7	4
	Seminars/ workshops are effective to some class of farmers	5	8	6	6	6	5
	Seminars /training can be effective at if held within reach to women farmers	7	6	7	5	7	4
	Extension services be established in schools for our children inform us about CA and environmental changes and how to respond- benefits	8	5	9	3	8	3
	Women are too busy to attend seminars /training far from home especially in expensive hotels	7	6	7	5	6	5
	Field days/ agricultural shows are moderately effective	4	9	5	7	5	6
	There is need to have weather stations in our schools to help us monitor changes on climate so that we respond	8	5	8	4	8	3
	Mean response of extension methods	6.92	3.03	7.53	3.75	7.0	3.0
Environmental knowledge	Women are very knowledgeable of environment	11	2	9	3	9	2
	Farmers plant trees due to many functions of plants	8	5	8	4	7	4
	We have planted many trees to conserve soil, moisture and attract rain	7	6	7	6	8	3
	With small farms agro forestry practice is best solution	7	6	6	6	7	4
	Mulching is used to preserve moisture	6	7	7	5	6	5
	Mixed farming is healthy to soil	7	6	7	5	8	3

	Plants are useful in pollination, food, and habitats	9	4	8	4	7	4
	We keep some Wild life for many reasons	5	7	6	6	4	7
	Farms too small to keep wildlife	7	6	7	5	8	3
	Farms too small to preserve natural forests	7	6	8	4	7	4
	Plant cover best soil erosion control	11	2	9	3	9	2
	There is effective interactions between plants and wildlife	4	9	6	6	4	7
	Ploughing the soil destroy its fertility and kill soil organisms	8	5	7	5	8	3
	Ripping is the best way to conserve soil	8	5	6	6	7	4
	Increase plant cover filter the air and reduce pollution	6	7	8	4	7	4
	Increase plant cover reduce desertification and mitigates drought	7	6	7	5	6	5
	Mean response for environmental Knowledge	7.43	2.65	7.25	3.75	7.0	3.0

Variable	Questions	Njoro		Rongai		Naivasha
		Yes	No	Yes	No	Yes
Adoption of CA	Climate change is the greatest influence on making us adopt CA	8	5	9	4	8
	Reduction of farming area to small size is better with CA practices	9	4	9	3	7
	Majority of CA adopters are influenced by effective extension methods	10	3	9	3	8
	Land use changes has influenced farmers to adopt CA	10	3	8	4	8
	CA adoption require knowledge of the environment such as soil conservation	7	6	7	5	6
	Farmers can only adopt CA if they are knowledgeable about rainfall and temperature variability	9	4	9	3	8
	Crop rotation, mixed farming and no tillage are practiced due to small farm size, climate change and effective extension methods	9	4	10	2	9
	There are other reasons why we adopt CA	5	7	6	6	5
	Self help women groups have the combined power to effectively influence farmers adopt CA	11	2	9	3	7
	Stakeholders are very significant in CA adoption such as NGOs	9	4	8	4	8
	Establishing ICT services and holding seminars close to farmers will increase rate of CA adoption.	10	3	9	3	7
	Mean response of Adoption of CA	8.81	1.19	8.27	1.73	7.27

APPENDIX 6: RESEARCH PERMITS

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION

Telephone: +254-20-2213471,
2241349, 310371, 2219420
Fax +254-20-318245, 318249
Email: secretary@nacosti.go.ke
Website www.nacosti.go.ke
When replying please quote

9th Floor, Utalii House
Uhuru Highway
P.O. Box 30623-00100
NAIROBI KENYA

Ref. No.

Date

4th March, 2015

NACOSTI/P/15/8611/4856

Eliud Garry Michura
Kabarak University
Private Bag - 20157
KABARAK.

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on "*Environmental factors influencing women farmers adoption of conservation agriculture, Nakuru County,*" I am pleased to inform you that you have been authorized to undertake research in **Nakuru County** for a period ending **31st August, 2015**.

You are advised to report to **the County Commissioner and the County Director of Education, Nakuru County** before embarking on the research project.

On completion of the research, you are required to submit **two hard copies and one soft copy in pdf** of the research report/thesis to our office.

DR. S. K. LANGAT, OGW
FOR: DIRECTOR GENERAL/CEO

Copy to:

The County Commissioner
Nakuru County.

The County Director of Education
Nakuru County.

National Commission for Science, Technology and Innovation is ISO 9001: 2008 Certified

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APPENDIX 7: ACADEMIC PUBLICATIONS

KABARAK UNIVERSITY

Certificate of Participation

This is to certify that

Eliud Michura

Successfully Presented a paper titled
"Research Perspectives in Restoration of Watershed Ecosystems under a Changing Climate:Success, Opportunities and Challenges"

in the 5th Annual Kabarak International Research Conference held on 14th – 17th July 2015

Conference Theme

Research, Innovation For Sustainable Development and a Secure World

Registrar
(Academic & Research)

Deputy Vice Chancellor
(Academic & Research)

REPUBLIC OF KENYA

Ministry of Education
Science and Technology

The Ofri International Training Center
המרכז הבינלאומי ע"ש ע"ש ספרי—חשתה"ב

STATE OF ISRAEL

Ministry of Foreign Affairs

Certificate of Participation

This is to certify that

Eliud Garry Michura

Has successfully completed on small holder Workshop on

Education for Sustainable Development

Held at KESMI—ParklandsNairobi from 27th to 30th July, 2015

And in recognition thereof is awarded this certificate.

Dr. Richard Belio Kipsang
Principal Secretary
Ministry of Education
Kenya

H.E Yahel Vilan
Ambassador
State of Israel

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Original Research Article

Evaluating Sharing Videos; An Innovation to Improve Smallholder Farmers Achieve Agricultural Sustainability in the 21st Century

Eliud Garry Michura

Abstract

Kabarak University

Email: mican1990@yahoo.com

This paper evaluates sharing videos as new innovation for improving smallholder farmers to achieve agricultural sustainability in the 21st century. Individualized training is costly, but technology enables us to disseminate information quickly and at a low cost. Of course, whether that information will be read, used, or even misunderstood is not easily tractable. The world food production to feed ever growing human population is an uphill task in a rapidly changing environment and farmers face serious environmental challenges. Agricultural extension agents to meet farmers needs have not been effective and farming has not become attractive to the youth either. There is need to find new ways to sustain agricultural production by smallholders and involvement of youth. New innovations through communication technology are now helping farmers to realize their dreams. Communication is a very powerful tool to cause change and effective use of it can yield maximum results in food production. One such communication tool which has been innovated is training video sharing by Access Agriculture. The video sharing is gaining prominence in aiding extension services and helping smallholder farmers understand the problems they face and action taken. Millions of farmers all over the world have expressed positive outcomes from sharing training videos. There is more to be done because there are challenges that go with the sharing of videos and affect farmer perception and attitude. Young people are becoming interested in farming after watching such attractive (sexy) videos targeted farming as a good occupation.

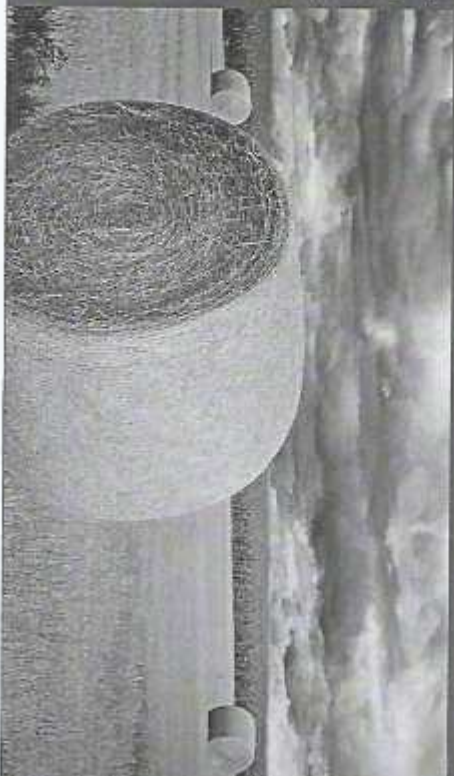Keywords: Innovations, Smallholder farmers, Sustainability, Videos

INTRODUCTION

The majority of the rural poor in Africa depend on smallholder farming as a livelihood strategy. Smallholder farming thus rarely, exceeds levels of subsistence production because many of them lack agricultural inputs and appropriate technology. Improving smallholder farming systems has a direct impact on agricultural

This book contains research articles on my work on reinventing sustainable environment beyond 21st century. It contains several research papers and articles that you will find challenging but providing solutions in protecting human life and other biological resources. Having taught in various high schools and universities in the field of environmental management and conservation, it is paramount to realize that human and other biological species have only one Earth to live in. Human activities can either sustain the Earth or destroy it. Reinventing agriculture in the 21st century will promise the earth's sustainability.

Currently, Eliud Garry Michura is a lecture of environmental science at Kabarak University, Kenya. Eliud, previously taught at Egerton University since 1995 and served in the position of Dean of students both in Egerton university and Kabarak University for 20 years. I have also taught in high school for fifteen years.

Michura

Reinventing Sustainable Environment

Reinventing Sustainable Environment Beyond 21st Centuary

Eliud Michura

KABARAK UNIVERSITY

INSTITUTE OF POSTGRADUATE STUDIES, QUALITY ASSURANCE AND RESEARCH

DOCTOR OF PHILOSOPHY

QUALIFYING EXAMINATION PROVISIONAL TRANSCRIPT

ACADEMIC YEAR: 2010/2011

NAME: MICHURA ELIUD GARRY   REG. NO: GDE/M/1066/9/10

EXAMINATION:
Qualifying examination overall grade (General paper, Specialization, Research Methods and Oral examination).

GRADE: A   PASS

RECOMMENDATION:
The Candidate has been approved to proceed with Thesis Proposal Writing and Research.

DIRECTOR
(POSTGRADUATE STUDIES)

REGISTRAR
(ACADEMIC & RESEARCH)

(0-49%=F; 50-59%=C; 60-69%=B; 70-100%=A)

RECOMMENDATIONS

To the institute of Postgraduate Studies and Research; This Thesis entitled" Environmental Factors Influencing women Small Scale Farmers' Adoption of Conservation Agriculture in Nakuru County, Kenya" written by Eliud Garry Michura is presented to the Institute of Postgraduate Studies and Research of Kabarak University . We have reviewed the Thesis and recommended it to be accepted in partial fulfillment of the requirements for the degree of DOCTOR OF PHILOSOPHY IN ENVIRONMENTAL SCIENCE

Signature 1. _____ Date 10TH OCTOBER 2016

PROFESSOR JACKSON JOHN KITETU

Department of Environmental Science, Kabarak University

Signature 2. _____ Date 11th October, 2016

DR. PAUL MAKENZI

Department of Environmental Science, Egerton University