WOMEN PARTICIPATION IN AGROFORESTRY TECHNOLOGIES ENHANCES CLIMATE CHANGE ADAPTATION IN NGUUMO AND MAKINDU LOCATIONS, MAKINDU SUB COUNTY, MAKUENI COUNTY, KENYA

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DECLARATION

I understand that plagiarism is an offence and I therefore declare that this thesis is my original work and has not been presented to any other institution for any other award.

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DEDICATION

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ACRONYMS AND ABBREVIATIONS

CCAFS	Climate change Agriculture and Food Security
CGIAR	Consultative Group on International Research
CIMMYT	International maize and Wheat Improvement Centre
CSA	Climate Smart Agriculture
FAO	Food and Agricultural Organisation
FHHS	Female Headed Household
IAASTD	International Assessment of Agricultural Knowledge, Science and Technology for Development
IFAD	International Fund for Agricultural Development
ILO	International Labour Organization
KEFRI	Kenya Forest Research Institute
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UNIFEM	United Nations Development Fund for Women
UNO	United Nations Organization
USA	United States of America

DEFINATION OF TERMS

Adoption- denotes decision to make full use of an innovation or technology as the best course of action (Rogers, 2003).

Agroforestry- is the growing of trees together with crops, pasture and/or livestock on the same plot (Lwakuba *et al.*, 2003).

Agroforestry technology- a farming system that integrates trees, forage, livestock and other components in combination with new conservation technologies such as contour hedge rows, alley cropping and enrich fallows (Schroth and Sinclair, 2003).

Climate change adaptation- is the process of adjusting to the ecological system, social or economic towards climate change impacts (UNFCCC, 2011).

Extension service- refers to education and learning activities organised for farmers on application of new and existing scientific knowledge in order to boost productivity (World Bank, 2010)

Gender – refers to the social functions and roles of men and women which is shaped by the environment we have (Indriatmoko, 2007).

Women's Empowerment- is a process where women individually and collectively become aware of how power relations operate in their lives and gain the self-confidence and strength to challenge gender inequalities at the household, community, national, regional and international levels (UNIFEM, 1997)

ABSTRACT

Agroforestry presents a promising option to sustainable agricultural productivity by providing a buffer to climate variability through permanent tree cover and varied ecological niches. Thus, agroforestry can be used as a strategy to adapt to climate change and variability challenges for smallholder farmers. Success of this strategy in adapting to climate change calls for active participation of men and women in agroforestry technologies. This study aimed to establish roles women play in adapting to agroforestry technologies for climate change and variability in Makindu and Nguumo locations, Makindu sub county, Makueni County. Specific objectives were; (i) To establish the agroforestry technologies women practiced in Makindu and Nguumo locations to counteract climate change and variability effects (ii) To examine the extend of women empowerment in and accessibility to these technologies and their adoption in the same locations (iii) To determine the role played by agroforestry technologies to the livelihoods of women in Makindu and Nguumo locations. A cross-sectional survey research design was used to collect data using semi-structured questionnaires. The study focused on Makindu and Nguumo locations. Using coefficient of variation method, a sample size of 109 households were randomly selected from a sampling frame of 11,571 households in both locations. In Nguumo location 54 households, Makindu location 55 households were sampled. Out of 109 questionnaires, 107 were returned for analysis. Both descriptive and inferential statistics were used. The results revealed that females were more active and leading in practising most the agroforestry technologies in both locations. Females in Makindu scored 55.8% in both hortisilvipastoral and hortipastoral (highest), males scored 44.2% in both (lowest). In Nguumo, females scored 54.7%, in agrisilviculture, males 45.3%. A chi-square test of independence calculated comparing frequency of agroforestry technologies applied and gender in both locations showed a significant interaction, (X^2 (10) = 119.1, $p < 0.05$) hence women were more involved in agroforestry technologies application. However, women face challenges in adoption of agroforestry technologies. Factors with major effects in Nguumo and Makindu locations respectively were; lack of basic education 20.8% and 18.5%, women are not decision makers 17.1% and 16.7%, socio-cultural factors 15.1% and 16.7% but the effects were higher in Nguumo location than Makindu location. The study established the need to enhance women capacity in making decisions, accessing resources equitably and benefitting from agroforestry development initiatives. It was concluded that it is very critical to empower women to enable them adopt the agroforestry technologies.

CHAPTER ONE: INTRODUCTION

1.1 Background of the Study

The lives of many people have been affected by climate change, more so the poor people of third world countries. These are the same people whose livelihoods and food security is adversely exposed by socio-economic impacts, HIV and other health problems (Badege *et al*., (2013) reported that food insecurity, population growth and other unfavourable socioeconomic factors make farm families in developing countries more vulnerable to the consequences of climate change. Therefore, adaptation to climate change has become an important issue. Actually, women could be more vulnerable to climate change than men. Studies show that women are more vulnerable to climate impacts more than men because they lack the requisite to adapt to climate change and variability (Rodenberg, 2009). This may be because of their greater dependence on natural resources for livelihoods and their responsibility for obtaining food, water and fuel for the household.

In Africa climate models predict warmer temperatures, increasing severity and frequency of droughts and other extreme weather events and decreasing rainfall among other (Alley *et al.,* 2007). This means increasing risks to the poor smallholder farming communities whose coping strategy is limited by the lack of investment capital and knowhow of the new adaptive practices. Furthermore, their reliant of rain-fed agriculture making increases their vulnerability (Thomson *et al.*, 2010). These changes pose serious threats to food security in an area that is already constrained by high population growth, diminishing family land and deteriorating soil fertility levels. Furthermore, issues relating to water availability are placing additional pressures on the region's ability to meet growing demands for food production. Efforts to adapt and mitigate these climate change and variability impacts are necessary in order to provide long term remedies to the effects of climate change which are likely to worsen.

In many rural smallholder farming systems, women play significant roles in the food production activities like ensuring a family's food security, conservation and selection of seeds of different crops (IUCN/ UNDP/GGCA, 2009); Civil Society Forum for Climate Justice, 2011). Unfortunately, it has been established that women farming communities are more vulnerable to climate change impacts than their male counterparts. This is because they lack the knowledge to adapt to climate change (Rodenberg, 2009) their greater dependence on natural resources like water, land (soil), trees, rainfall, vegetation, for livelihoods and their responsibility in obtaining food, water and fuel for the household (Scapa 1988; Wangila *et al.*, 1999; Gladwin *et al*., 2001). Therefore, it is necessary to find ways to fully integrate gender participation in order to sustainably increase agricultural productivity and resilience of these female farmers that will support the achievement of food-security. Agroforestry has been widely acknowledged and proposed as a potential strategy for helping subsistence farmers reduce their vulnerability to climate change (Thorlakson, 2011; Thornton and Lipper, 2013). However, agroforestry technologies are not gender-specific, their success in climate change adaptation calls for active participation of women farming communities.

The concept of gender in this study was not about women alone but both men and women participation in agroforestry technologies in the society in order to come up with strategies that challenge gender imbalance in agroforestry technologies, practices and their adoption. It laid more emphasis on women and examined their participation relative to men while highlighting gender discrepancies so that strategies to challenge gender imbalances are put in place. This aimed to encourage that women be given opportunities to be able to make decisions, access resources equitably, hold positions and benefit from development initiatives such as agroforestry by educating them. Particular emphasis was laid on women, who despite being much involved in farming and their willingness to participate in agroforestry, remain disadvantaged in the agricultural sector due to cultural and social-economic and factors.

Agroforestry is defined as deliberate interaction of woody species with agricultural crops and or/pasture on the same land unit resulting in interactions between components, thus, the growing of trees together with crops, pasture and/or livestock on the same plot (Young, 1989; Lwakuba *et al.*, 2003; Schroth and Sinclair, 2003). Agroforestry project is therefore a set of activities where trees and food crops with or without livestock keeping are practiced in the same piece of land to achieve defined objectives. The farmer who practices agroforestry often maximizes on the returns from the land at their disposal with or without the use of sophisticated technology. Here, land is not only utilized sustainably but also environmental conservation interests are taken into consideration especially where environmental degradation is rampant leading to soil erosion, loss of vegetation cover, loss of soil fertility, reduced food production, high temperatures, recurrent drought, loss of biodiversity among others (Charles *et al*., 2013). These are also some of the major climate challenges in Makindu and Nguumo locations. There is also an element of inter-dependency between different components of agroforestry where trees provide a source of fire wood, timber for domestic and commercial use, fodder for livestock that provides milk and meat for domestic as well as commercial use.

Agroforestry diversifies agricultural production especially under current climate scenarios by offering the potential to develop synergies between efforts to adapt to climate change and efforts to help vulnerable farmers to adapt to the negative consequences of climate change (Verchot *et al., 2*007). Thus, agroforestry is widely acknowledged as an important component in responding to the twin challenges of poverty, environmental degradation and adaptation to climate change (Carsan *et al.,* 2014). It provides innovative practices that enhance food production while contributing to climate change adaptation (Dawson *et al*., 2013; Galhena *et al*., 2013a; Gebrehiwot *et al.,* 2016). This is through enhanced carbon sequestration, increasing soil fertility; holding the soil together by their roots thereby reducing soil erosion and consequently mitigating the impact of environmental degradation (Syampungani *et al*., 2010). Thus, it strengthens the agricultural system's ability to adapt to the negative impacts of the changing environmental conditions while improving food productivity (Barbhuiya *et al.,* 2016). The trees also enhance and supplement the global environmental conservation efforts in addition to contributing to the realization of ten per cent tree cover recommended by the United Nations organization (UNO). Verchot *et al*, (2005), reports that one of the strengths of agroforestry systems is that they can significantly contribute to mitigation and adaptation to climate change and variability because it can contribute to an increased tropical farming systems which help to withstand and recover from changes in climate change and variability like frequency of extreme weather conditions (McCabe, 2013).

Kenya is strongly committed to integrated natural resources management approaches out of the realization that more timber is already being harvested from farms and forests. This reinforces the practice of domestication and cultivation of trees and shrubs on farms making agroforestry an increasingly attractive option for the future. The Kenya constitution (2010) has emphasized on the need for the country to work towards attaining and maintaining a 10% tree cover. According to the immediate former director of Kenya Forestry Service (Mbungua, Daily Nation of 14th November 2014), there is reliable data which confirms that as at 2010 Kenya's forestry cover was 6.99% of Kenya's land area.

Mugo (2015, June 5) Daily nation pp. 13, concurs with statistics from the Kenya forestry service in 2013 which indicated that the country's forest cover had risen from a low level of 1.7% in 2002 to 6.99% placing the country on the path towards attaining the united nations recommended cover of 10%.With full gender participation where women are equally involved as men, agroforestry technologies and practices have the potential to produce benefits for farmers in Makindu and Nguumo locations. It can also provide opportunities for climate change adaptation while promoting sustainable production that enhances agro-ecosystem diversity and resilience in the area. Thus, it is a win-win solution to the seemingly difficult impacts of climate change like decreasing rainfall, warmer temperatures, low food production and increasing severity and frequency of extreme weather events (Alley *et al*., 2007; Syampungani *et al*., 2010)).

1.2 Statement of research problem

Majority of the inhabitants of the area rely on rain-fed agriculture, this makes them susceptible to the shocks of climate change (Pinto *et al.,* 2012). Agriculture is the main occupation of the inhabitants of Makindu and Nguumo locations. The changes in the pattern and quantity of rainfall and other associated weather characteristics such as high temperature, strong wind and relative humidity over the years has impacted the lives of farming communities in this region (Laube *et al*., 2011). Climate change in this area has been manifested in recurrent drought, high temperatures, very low and unreliable rainfalls, poor/low crop yields, inadequate forage and water for livestock, famine that have threatened lives of people and livestock. These climate variability and associated soil degradation issues have exuberated the challenges of food insecurity and pasture production through lowering crop yields (Thomson *et al.*, 2010). The problem is aggravated by the increasing population that demands more food and more land to settle hence forest degradation.

According to Rotenberg, (2009) climate change impacts have not been gender neutral, women in the study area have been found to be most vulnerable part to the impacts of climate change Women in both locations are vulnerable to climate change impacts because of the position and gender roles that have been attached to them. For example, they play significant roles e.g. vending for family food, addition to the family income by farming and collecting water and/or firewood for the family (Civil Society Forum for Climate Justice, 2011).

In spite of these, women in the study area are unable to voice their specific requirements due to cultural, socio-economic and institutional factors. These include access to resources, land tenure systems, customs and taboos, household decision making, labour, education and extension visits and lack of appropriate technology (Gray & Kevane, 2008; Peterman *et al.*, 2010 & Meinzen-Dick *et al.*, 2010). Women are confined at the lower end of the value chain. This actually is a limitation in controlling returns of the productive process and their potential role of playing as agents of adapting to climate through use of agroforestry technologies can provide solutions for enhanced food production in the face of climate change. The study intends to fill the gap by presenting a synthesis of the involvement of women in various agroforestry technologies.

1.3 Objective of the study

1.3.1 General objective

To assess the role played by women in adopting agroforestry technology strategies to counter climate change and variability in Makindu and Nguumo locations, Makindu sub county, Makueni County, Kenya.

1.3.2 Specific objectives

1. To determine the types of agroforestry strategies practiced by women in Makindu and Nguumo locations to adapt to the effects of climate change and variability.D

2. To examine the influence of women empowerment in adoption of agroforestry technologies in adapting to climate change and variability.

3. To establish the benefits of agroforestry technologies on the livelihoods of women.

1.4 Research questions

1. Which are the agroforestry technologies used by women in Makindu and Nguumo locations to adapt to the effects of climate change and variability
2. Does women empowerment influence their adoption of agroforestry strategies to climate change and variability?
3. What is the importance of the agroforestry technologies used in the livelihoods of women?

1.5 Significance of the study

- The County and national governments can use the findings to enact policies tailored at building gender balance of farmers involved in agroforestry as an income generating activity which enhances the realization of the ten per cent tree cover.
- Farmers will benefit through better support enhanced by a partnership between them, county and national governments through the use of the findings of the study.
- Other researchers could also build on the findings of the current research on their future research.

1.6 Assumptions of the study

- Relevant institutions, authorities and respondents will be ready, willing, honesty and cooperative in providing reliable information.
- Females are more involved in agroforestry more than males.
- The Government, Non-governmental institutions and the community are key in women empowerment when it comes to adoption of agroforestry as a climate change adaptation strategy.

1.7 Scope of the study

The study covered Nguumo and Makindu locations of Makindu sub-county in Kibwezi West Constituency, Makueni County, Kenya. The study was broadly designed to examine the role of Women in the use agroforestry technologies as an adaption to climate change and variability in Makindu sub-county. The respondents were both men and women drawn from small scale farmers of Nguumo and Makindu locations.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This chapter is divided into sub topics to aid in understanding the views of other authors regarding women and agroforestry technologies as an adaptation tool to climate change. The first sub topic deals with approaches of agroforestry, globally, regionally and in Kenya followed by the agroforestry technologies commonly practiced by women farmers. The role of agroforestry technologies in adapting to climate change is then discussed followed by agricultural performance under agroforestry systems/technologies. Finally, the chapter is concluded by a broad discussion on women roles in agroforestry strategies in adapting to climate change and variability.

2.2 Approach of agroforestry

2.2.1 Global approach

Agroforestry is a global practice. Several reports on Climate Change and its effect from Guatemala indicate that the rural area of the Guatemala dry corridor is most affected by droughts and families are likely to be exposed to crops losses, shortage of food and water (Bouroncle *et al.*, 2015; United Nations, 2018). Guatemala government provided emergency food aid and promoted the adaptation through agricultural practices/technologies that would reduce the impact of drought (Sain *et al.*, 2017).

Tyler and Miller (1996) reports that in the United State of America farmers have been reducing soil losses through a combination of conservation tillage. These include agroforestry or alley cropping, a form of intercropping where several crops are planted together in strips or alleys between trees and shrubs which can provide fruit or fuel wood. Trees provide shade which reduce water loss through evaporation. Trees and shrubs also act as wind breaks; alley crops protect livestock from temperature extremes and a source of timber and poles. In UK, Hammer (2012) reports that despite the fact that farmers are enthusiastic about the practice of agroforestry; there are still a handful of farms deliberately practicing it. In Australia, Nubergl *et al.* (2009) reports that agroforestry represents a significant proportion of Australia's native forest.

2.2.2 Regional approach

In Ethiopia there has been recent transition of the agroforestry home garden to commercial production of new cash crops, like khat (*Catha edulis*) which is a farming strategy used by smallholder farmers to address demographic, market and socio-economic changes (Gebrehiwot, 2013; Gebrehiwot *et al.*, 2016). Scroth and Sinclair (2003) reports that farmers in southern Africa practice agroforestry by planting legume trees along with crops to regenerate their soils and provide substitute for mineral nitrogen fertilizers which are needed by plants but which are too expensive for them. According to Asare (2004) agroforestry has been practiced in Ghana for many years to enhance sustainable development through the national agroforestry policy of 1986, which initiated national programs to support agroforestry through research, training and extension.

In Uganda Musukwe and Mbalule (2001) reports that agroforestry is widely practiced. It has been identified as a land use approach which ensures the sustainability of the production base. According to Kabboggoza and Eilu (2008) the University of Makerere offers a Master of Science Degree in agro- forestry where the link between agriculture and forestry is strongly built with agroforestry entrepreneurship and environmental conservation for sustainable agriculture being emphasized.

2.2.3 Approach in Kenya

The forestry and agroforestry issues in Kenya are handled by the Kenya Forestry Service which has offices in most of the counties and sub- counties in the country. The service runs a free seed program whose research is aimed at developing different agroforestry technologies as well as species of woody plants for different agro ecological zones of the country. According to Murigi (2015) a good example of tree species which is a product of KEFRI's robust research activities is the disease-resistant bamboo species which is high yielding, fast maturing.(takes 3-5 years to mature) and can be grown in arid and semi-arid areas.

In Kapsaret-kenya farmers who enjoy higher levels of food security are more inclined in agroforestry (Jerneck and Olsson, 2014). Therefore agroforestry practices play a positive role in food security (Colfer *et al*., 2008; Arnold *et al*., 2011; Vinceti *et al*., 2013). Cultural perceptions, policy restrictions on tree felling on their own land, attitudes of farmers and their willingness to grow trees on their farms contributes to declining tree cover (Meijer *et al,*. 2015).

2.3 Agroforestry systems commonly practiced by women farmers

Agroforestry represents a wide diversity in application and practice. The technologies are in different categories depending on the problems being addressed for example countering winds, low rainfall, harmful insects and the overall economic constraints and objectives (labour and other input costs, yield requirements). According to International Council for Research in agroforestry (ICRAF, 2015) agroforestry technologies include:

2.3.1 Agrisilviculture system

Here, tree species grow in the farmlands where they are managed together with food crops. A good example is where poplar *(Populus deltoids)* and wheat *(Triticum aestivum)* are grown together or white teak *(Gmelinaabrorea)* mixture with paddy rice *(Oryza sativa)*. This system actually solves the problem of food shortage, fuel wood and conserve soil moisture, also ameliorate the harsh climatic condition. This system solves the problem of wood fuel, timber and conserves soil moisture (Gichuki *et al.*, 2000 and Lwakuba *et al.*, 2003 and ICRAF, 2013).

Farmers in Upper East Region of Ghana integrate cereals such as finger millet barley, bread wheat and maize because such crops have good yield when combined with the trees like *Croton macrostachys, Acacia abyssinica and Cordia Africana* are among the trees found on farm lands (Gebrehiwot (2004), Jamala *et al*. (2013)).

2.3.2 Silvipastoral system

The silvo-pastoral practices as wood pastures have been practised in Iberian Peninsula and Europe (Reisner *et al*., 2007; Garrido *et al.*, 2017b) provide an example of a highily utilised agroforestry practice where pasture trees grow together with tree species such as, mulberry *(Morus Alba)* and marvel grass *(Dichanthium annulatum)* or lebbeck *(Albizia lebbeck)* and Dinanath grass *(Pennisetum pedicellatum)*. The trees species could be used to produce timber alone or for in other uses like fuel or even fodder. Grass/legumes mixtures can be simultaneously grown along with tree species on the same piece of land. These combinations helps in soil conservation while soil moisture and fertility status. It also provides fodder for livestock, fences around the grazing land, provides shade and fruits (Scroth and Sinclair, 2003).

2.3.3 Agrisilvipastoral system

In this technology, agricultural and forest trees are simultaneously managed in the same piece of land where farmers also rear animals. A good example is wheat *(Triticum aestivum)*, poplar tree *(Populus deltoids)* and marvel grass *(Dichanthium annulatum)* it provides fodder, mulch and fuel wood at the same time (Nair, 1983). This is done to obtain fodder and firewood usually carried out by farmers to ensure that agroforestry systems generates the needed benefits (Nair, 1993; Agidie *et al*., 2013). The practices reduce the amount of area that will be covered by shade from the trees and create enough space for farmers to plant other crops on the same piece land

2.3.4 Agrihortisilviculture system (trees + fruit trees + crops)

Here, agricultural crops, fruit producing trees and timber producing trees/fuel wood are grown in the same piece of land. These species produce food grains, fruits, timber and fuel wood. Example is wheat *(Triticum aestivum)*, mulberry *(Morus Alba)* and sissoo *(Dalbergia sissoo)*.It improves food security and reduces poverty). The most common food crops species include cereals like *Zea mays*, Sorghum bicolor, finger millet (*Eleusine coracana*). (Meinzen-Dick *et al.*, 2010) According Badege *et al*. (2013), this practice may include Wood perennials, crops and animals are integrated in this system in order take advantage of the interaction among them.

2.3.5 Silvihorticulture system

Here, timber producing trees are grown with fruit producing trees. Example is where lebbeck *(Albizia lebbeck)* and mulberry *(Morus Alba)* are grown in the same plot. This system is extremely helpful in soil conservation especially in improving the soil structure, increasing the nutrient status of the soil and reducing soil erosion. Multipurpose trees on farmlands (MTF) refer to the deliberate integration of woody components in annual croplands, which is the case in almost all observed farmlands in the study area. In this systems, the primary purpose is the production of annual food crops for consumption and/or selling, whereas the uses of woody plant species are as non-food goods like fuel, fodder, timber and services like live fences for protection and demarcation, soil fertility enhancement, shade (Nair *et al.*, 1984).

2.3.6 Agrihorticulture system

This refers to multiple combinations of trees, fruit trees and vegetables. The aim is to produce both agricultural crops and fruits by growing crops and fruit trees together with vegetables. Example is where apple *(Malus pumila)* and wheat *(Triticum aestivum) are grown in the same unit*. Vegetables like kales, brinjals are grown together with mango or orange trees (1983a; Nair, 1984).

Trees may be planted on the boundary, hedges, or trees and shrubs planted in thick bushes around farms and mainly play the role of fences and aesthetics. Examples of such trees include *Lantana camara, Cupressus lusistanica* and *Croton.* This technology also helps in soil erosion control, protection of cultivated fields against destruction and fuel wood.

2.3.7 Hortisilvipastoral system

Here, fruit trees, forest trees and pasture grasses are grown and managed together to produce fruit, fodder, fuel and timber (Dhiman, 2012). Most popular niches for trees is in or bordering on cropland, near homestead, in woodlots or on boundaries and that farmers manage for subsistence and commercial production of building materials (Poles and timber), fruits and fuel wood. Most farmers also acknowledged the fact that it saves them the costs of buying barbed wires and poles for fencing off their farms. Tree species mostly observed for use in this technology included, Acacia nilotica *Grevillea robusta, Croton megalocarpus, Cupressus lusitanica* and *Acacia Spp, Azadirachta indica, leucaena leucocephala*. Tengnas (1994) observed that in small scale Farming areas, boundary planting reduces wind speed and that trees on boundaries can meet most of a family's need for firewood. Fruit trees included, *Carica papaya, Mangifera indica*, bananas *and citrus spp.* Fodder tress included *Sesbania Sesban, Leucaena leucocephala, Calliandra calothyrsus and* Napier grass. (Kerkhof, 1990) who noted that farmers in Rwanda who planted and used *L. leucocephala* and *C.calothyrsus* for fodder in home gardens increased their milk production and dung for manure, which further led to improved crop production and household Income.

2.3.8 Hortipastoral system

Here fruit trees are grown to produce fruits together with pasture grasses for fodder production. A good example is mulberry *(Morus Alba)* and Dinanath grass *(Pennisetum pedicellatum)*. For example in extensive areas of New Zealand where *Pinus radiata* is grown on grazed pasture (Fernades *et al.,* 1984). Also In the UK in the 1960s, for example Bryant and May Ltd (manufacturers of matches) encouraged farmers to grow poplars in rows in arable fields. More common still is for trees to be incorporated in a distinct part of an enterprise as, for example, on a proportion of grazing land on an upland farm such that a sheltered environment is created where grass growth commences early in the spring (Fonzen *et al.*, 1984).

2.3.9 Agripasture system

Here is where crops and pasture grasses grow together for the production of food and fodder. An example is a mixture of wheat *(Triticum aestivum)* and annual meadow grass *(Poa annua).* Wood trees are grown together with agriculture crops and pasture all three species types are interlinked with each other to enhance food production and income generation. Arable crops are grown to provide food eatables, trees provide fodder to animals. (Scroth and Sinclair, 2003).

2.3.10 Silviapiculture system (integrating crops and trees with maintaining honey bee)

This is a system involving bee rearing along tree growing on the same piece of agricultural land. For instance, white teak *(Gmelina arborea)* and bee *(Apis spp*.). (GOK, 2005).Trees provide flowers which are source of nectar for the bees. Bees are important as a source of income to farmers, carry out cross pollination to crops (vegetable seeds, deciduous fruit, sub-tropical fruit, melons, berries, oilseed crops, nuts, cucurbits, beans) and this improves on crop quality and quality (Wulandari, 2012). Also crucial in providing thousands of jobs and food security. Due to its natural sweetness and chemical properties, it is preferred over processed sugars and other sweeteners used in baking, beverages and foods. In medicine, honey is used as a sweetening agent for children’s drugs and the treatment of sore throat, cough, hay fever and burns. It is also used to produce cleansers, lotions and creams in the cosmetic industry and used as a nutritional supplement for children, athletes and people suffering from diabetes.

Other applications of honey are in animal production (it is an ingredient in animal feed and used to increase milk production in dairy cows). Also used in chemical industries where it is used to produce mice and rat repellent compounds.

2.4 Role of agroforestry technologies in adapting to climate change

There is substantial evidence of smallholder/subsistence farmers turning to agroforestry as a means of adapting to the impacts of climate change & Sinclair, 2003: Asare, 2004; Hammer, 2012). A study from the CGIAR research program on climate change, agriculture and food security (CCAFS) (ICRAF, 2015) that surveyed over 700 households in East Africa showed that at least 50% of those household had begun planting trees like *sesbania sesban* and *leucaenia leucosephala* on terraces. The trees ameliorate the effects of climate change by helping to stabilize soil erosion, improving water conservation, soil quality and providing fruits, oil, fodder and medicinal product, raw materials for craft and income (ICRAF, 1992; GEF, 2002). Agroforestry was one of the most widely adopted adaptation strategies in the study.

Depending upon the application, impacts of agroforestry can generally include: reduction of poverty through increased production of wood and other tree products for home consumptions and sale This improves the wellbeing and livelihood of small holder farmers (Tholatkson, 2011; Scherr *et al.,* 2012; Thomton and Lipper, 2013). It also contributes to food security by restoring soil fertility for food crops, cleaner water through reduced nutrient and soil runoff (Smith, 2010). It will also increase food security by producing fruits, nuts and edible oils while reducing deforestation and the pressure on woodlands to provide farm-grown fuel wood, reducing or eliminating the need for toxic chemicals (insecticides, herbicides) through more diverse farm outputs. (Tewari, 2008). Also provides improved human nutrition, helps in situations where people have limited access to medicines and leads to sustained productive land use .hence improved crop production. (Shackleton *et al*., 2011; FAO, 2012) This enhances soil organic matter and biological nitrogen fixation by legumes (Young, 1997). The trees can also facilitate efficient nutrient cycling than mono-cultures while enriching the soil with nutrients and organic matter, while improving soil structural properties which support good crop/pasture growth. Through water tapping and prevention of nutrient leaching, trees help recover nutrients, conserve soil moisture and improve soil organic matter.

Agroforestry therefore provides several opportunities for climate change adaptation and potential to promote sustainable production that enhances agro- ecosystem diversity and resilience, space for medicinal plants, increased crop stability (Verchot *et al.*, 2005). Agroforestry is a multifunctional land–use approach that balances production of commodities such as food, fuel, feed, and fibre with non-commodity outputs like environmental protection and landscape amenities (Smith *et al*., 2012).

2.5 Agricultural performance under agroforestry technologies/systems

Verchot (2008); Scroth and Sinclair (2003) reports that agroforestry provide a means for diversifying production systems and increasing the resilience of smallholder farming systems. Verchot (2008) further proposes that agroforestry as a form of sustainable land use and survival strategy for smallholder farming systems. This is because agroforestry is a means for diversifying production systems and increasing resilience of smallholder farming systems. Young (1989) reports that agroforestry systems may provide solutions to the dilemma implied by existence of high erosion hazard leading to sustained productive land use. This is because agroforestry permits arable cropping on slopping land coupled with adequate soil conservation. This has made it possible for cultivation to be extended to land with slopes of 25 degrees and above. According to Mithika (2011), when farmland begins to grow scarce, people begin to farm on marginal lands including slopes and areas of thin soil. This practice encourages soil erosion but can be controlled by planting trees on the slopes. Schroth and Sinclair (2003) also concur with Mithika that field and farm boundaries can be used for tree planting in areas with poor soils, rocky site, and steep slopes. Musukwe and Mbalule (2001) reported that alley cropping which entails growing food crops between hedgerows of planted shrubs and trees is suitable in highland areas with steep slopes where hedgerows can be established to check water and soil run off. The trees. It also provides green manure.

Muturi (1992) reports that agroforestry has the potential for increasing productivity, profitability and diversity of production from the farmer’s land. It offers the possibility of household access to building materials, medicine and fodder for livestock. It can also lead to sustained productivity of the natural resource base by enhancing the general improvement of the environment. Gichuki *et al.* (2000) builds on those views that areas with rocky sites and steep slopes can be used for tree planting as they hold the soil and reduce erosion Lwakuba *et al.* (2003) take the position that tree planting along the contours on sloping land is a soil conservation measure.

According to International Research in Agroforestry (ICRAF, 2015), agroforestry has potential to improve soil fertility hence improved crop production. These enhances nutrient cycling and increases the organic matter in the soil and its biological activity such as nitrogen fixation by legume trees on farm than mono-culture systems and enrich the soil with nutrients and organic matter, while improving soil structural properties which support good crop/pasture growth. Through water tapping and prevention of nutrient leaching, trees help recover nutrients, conserve soil moisture and improve soil organic matter. Verchot *et al*. (2005) reports that agroforestry provides several opportunities for climate change adaptation and potential to promote sustainable production that enhances agro- ecosystem diversity and resilience. Such opportunities include provision of firewood, timber for domestic and commercial use, and source of fodder for livestock which provides the farmer with milk and meat for domestic as well as commercial use. Trees also contribute to sustainable soil management by reducing soil erosion risks. Tress also help to minimize the risks of crop failure by selling trees compensate themselves should they suffer crop failure.

2.6 Women and agroforestry technologies in climate change adaptation

2.6.1 Role of women in agroforestry technologies

Donors, policy makers and development practitioners point out the critical role of gender plays in development programs since Beijing women conference (Doss 2001; IFAD, 2003; World Bank, 2007; IFPRI, 2007; Meinzen-Dick *et al*,. 2010; Quisumbing and Pandolfelli, 2010; Peterman *et al*., 2010). Gender inequalities in critical areas involved in ownership and access to resources, education, land tenure systems, extension and social factors contribute to higher poverty levels and lower agricultural productivity (Waithanji *et al*., 2013). Because women play insignificant roles in society and family, they are not usually included in discussing and decision-making processes in relation to climate change or any other issue.

Their limited accessibility of information and resources (such as land and credit) further impend them from developing their maximum capacities in agriculture in spite of the crucial role they play in food security.

Furthermore, the gender-related biasness in regard to the value and usefulness of local knowledge disadvantages women. They feel ignored, not taken seriously and overlooked when they trying to make their contributions and share their knowledge (Tripathi, *et al*., 2012). They are mostly considered as "homemakers" rather than true farmers, and thus not capable of producing and sharing valuable farming knowledge. Their knowledge and practices are often viewed as 'primitive', unscientific and a hindrance to development. Similarly, men believe the usefulness of local knowledge if it is validated by science or agricultural extension officers. After this, it is considered acceptable and appropriate for adoption (Brettell and Sargent, 1993).

2.6.2 Why focus on women and agroforestry technologies

Women in Asia, Africa and Latin America play an important role in agricultural productivity according to (Boserup, 1970). Boserup, used research data from these countries to bring out the position women play in the socio-economic lives of their communities. African women and girls are the main collectors of fuel wood (Sunderland *et al*., 2014). Women walk many hours, mostly under highly perilous conditions, to access resources especially in areas affected by deforestation and climate change (WFP, 2012). Women are the ones who plant and manage agroforestry trees and shrubs in the farms and also play crucial roles in providing livestock with these tree-based fodder (Franzel and Wambugu, 2007).More studies; Fortman, 1985; Rocheleau, 1985; Haddad *et al.,* 1997; Quisambing, 1996; Gladwin *et al.,* 2001; Quisambing and Pandolfelli, 2010 and Peterman *et al.,* 2010 highlight on the importance of focusing on agroforestry and women as they play key roles in most production systems. However, women contribution to food security face great obstacles, they contribute substantially in production but they're systemically excluded from benefits associated with technological change. If women are given the same access to resources as men (labour, farm inputs, education), food production will be enhanced. Despite the role women play, their contribution to agriculture is largely ignored by policy makers (FAO, 2015).

Also Women farmers are an integral part of agroforestry because they are often the ones who manage trees more so at the early stages of their establishment (Kiptot & Franzel, 2012; Kiptot *et al.* 2014). They are also known as the principal holders of knowledge who manage the traditional home gardens. They constitute 60% of the practitioners' innovative agroforestry strategies that include production of dairy fodder and domestication of indigenous fruit trees. Therefore, the knowledge women have about trees and tree genetic diversity, and their roles as both suppliers and users of tree germplasm and genetic resources make them critical agents in scaling up agroforestry practices to improve livelihoods (FAO and IFAD, World Bank, 2009).

Secondly, agroforestry is a farming system where perennial trees, annual crops are deliberately grown on the land together with livestock. In this farming system women are responsible for providing most of the labour. For example, Maarse (1995) reports that women in smallholder dairy farms of central Kenya provide most of the labour like, cutting grass, manure application, feeding animals, milking and even selling milk.

Thirdly focus on women and the adoption of agroforestry practices is also important because agroforestry is one of the most common systems of production throughout the continent of Africa (Zomer *et al.*, 2009), and women farmers are frequently responsible for managing trees and other agricultural crops. Women do most of the work during the initial stages of tree establishment like planting, weeding and watering. Epaphra, (2001); Gerhardt and Nemarundwe, (2006) reported that 60% of women in Tanzania were responsible for managing tree species while in Zimbabwe 80% were responsible watering young seedlings. This was confirmed by Franzel *et al*.,(2002), Nyeko *et al*., (2004) who reported that 89% of women out 91% households in Embu, Kenya and over 80% households in Uganda women were responsible for managing *calliandra* fodder respectively. In west Africa and some parts of South Africa, women are the ones involved in collecting indigenous fruits (Campbell, 1987; Schreckenberg, 2004; Kalaba *et al.*, 2009). Despite providing critical roles, their decision making power in households has been limited to by-products of men's trees. They are left to manage subsistence crops that have low returns on labour and those that involving less advanced technologies (Rocheleau and Edmunds, 1997; Chikoko, (2002).

Since agroforestry is a low-cost system that requires minimal inputs, it offers a diversity of products and services such as food, fruits, fodder, and timber while enhancing soil fertility. It also offers many opportunities to women that include increased incomes and sustainable livelihoods. This is because women mostly cannot afford to adopt high cost technologies because of their cash constraints. Purchasing of fuel, fodder fruits is mostly for women who in most cases lack the financial ability but annual crops provide fodder and a few fruits, example fodder shrubs in East Africa (Wambugu *et al*., 2001). More so due to rural urban migration of men, women were reported to assume leadership roles. For example, Female-headed households (FHHs) comprise 30% of the rural smallholder households in Malawi (Gladwin *et al*., 2001), over 50% of the same in western Kenya and Zimbabwe (Skapa,1988; Wangila *et al.*, 1999). A study by Nhemachena and Hassan (2007) argues that female-headed households are the most likely to adopt the climate change adaptation strategies when exposed to such information.

2.6.3 Challenges faced by women in adoption of Agroforestry technologies

This focuses on the areas where women are disadvantaged making it difficult for them to actively participate in agroforestry practices like men. Earlier studies provide such areas to include land and tree tenure, house decision making, access to financial resources, access to labour, access to education, extension visits, lack of appropriate technology, customs and taboos .gender, land ownership and women empowerment in agriculture.

Land and tree tenure

Many women have limited control over land and property rights. In Sub-Saharan Africa, women only have rights to use and access land through men, especially in customary land tenure systems (Farnworth *et al*. 2013), while only 3 percent of women own a title deed in Kenya (GoK, 2008), hence positioning women at the periphery of crop production decisions (Skinner, 2011). Unequal rights to land not only limit women's ability to access credit, but also restrict their decisions on land use that are necessary to adapt to climate change. Also according to Esther Mwangi, a research on land rights at Harvard University, men are never ready to allow women decide on land matters even though they are key to productivity yet the land is out of their domain (Kimani, 2012). They tend to have land use rights that don't translate to ownership or property control rights.

In rural areas of South Asia, Africa, the Caribbean and Latin America, women have access to land but only a few own it or have control over land. This was exemplified by Kameri-Mbote (2005) who indicated that male household heads in are the main controllers of land in Africa where also Carpano, (2010) reported the same for Tanzania, Ngoga, (2012) in Rwanda reported that just a small proportion of house and land titles were possessed by women (UN, 2010). This is the same case that manifests in most rural areas in South Asia though here if they do the properties are smaller with less value than those owned by men (Rao 2011). In Africa, women's rights to own land is limited with only a few exceptional cases like the Ibo of southern Nigeria, where women own economic trees like palm oil in the farm land as a reward from their husbands for their ability to bear children (Nwonwu, 1996). The reason is because land tenure systems grant rights to own and dispose land to adult males who inherit it from their fathers (Place, 1994). In these patrilineal societies, women's rights are linked through the ties to their husbands (Gray and Kevane, 2008).
Women rights to own land may cease to exist upon widowhood, divorce or failure to have a son especially where women do not possess inheritance rights. In such cases, land is transferred from a deceased man to his brother or nephew in accordance with the decision of their clansn (Quisumbing *et al.,* 2001). This is true in Makindu and Nguumo locations (study area) because land is regarded as a man's property and title deeds are secured with man's name and details. Also women have no rights to make full decisions on what to do on the land before they consult their husbands to give their consent.

The right to own and use trees is referred to as tree tenure. There may be different rights among women and men to this depending on the benefits from their harvesting, sale or use. Men usually have the overall authority as pertains to the use of tree products considered to have high returns while women's rights may be restricted to collection and use of fruits but not allowed to harvest fuel wood of high value timber trees such as *Markhamia lutea* and *Albizia* spp (Bradley, 1991). The Akamba community of Eastern Kenya, Rocheleau and Edmunds (1997) allow women to plant trees while felling of the trees is purely am male's domain, while women use and access fodder, fibre, fuel wood, mulch and fruits. The male dominate the use of tree products such as logs, charcoal, timber, large branches and poles. The women's access to land and its tenure has affected the decisions made for example adoption of technology, the types of plants and crops to grow and community efforts aimed at preserving natural resources (Alderman *et al.* 2003).

Household decision-making

Gender based decision-making often linked to intra- household resource allocation determines the response of adopting agroforestry technologies by both women and men. The available evidence suggests that women's decision making power in households is limited to by-products of men's trees, crops that have low returns on labour and those involving less advanced technologies (Rocheleau and Edmunds, 1997; Abbas, 1997; Chikoko, 2002). Women normally are engaged in providing labour for male controlled fields (Abbas, 1997). Chavangi (1994), established that the understanding among the Luhya community of western Kenya is that the husband who is the head of the household, had overall control of all household resources and therefore everything in the household is viewed as belonging to him. On the other hand, the wife is expected to seek the opinion of her husband and his consent before executing any plans that may result in any changes in the distribution of household's tree resources example the pruning of trees to use as mulch or fodder (David 1998). Men's decision making input in purchase and disposal of assets is higher in comparison to their spouses which is either very little, or none at all (Waithanji *et al*., 2013)

Male heads of households are the main decision makers on matters of tree planting among the Akamba community of Eastern Kenya (Muok *et al.,* 1998). As regards decisions making on harvesting of tree products, Chikoko (2002) reports that women's decision power in Malawi is part of the tree dependent. Their influence on harvesting decisions diminishes while that of men increases as decisions move from twigs to the trunk. According to Martini *et al,* (2014) in South and Southeast Sulawesi, men have better access to extension services and consequently greater knowledge and skills; hence greater responsibility for decision-making.

Access to financial resources

Gender inequality also persists in livestock ownership and control of income where men own and control income from large livestock —cattle and draft livestock, whereas women own small livestock such as poultry, goats and sheep. (Njuki and Sanginga 2013). Access to financial assets is a catalyst for uptake of innovations, technologies and inputs such as improved seed varieties and agrochemicals (FAO, 2011) that are important for adapting to climate change. However, there is differential access to agricultural inputs Peterman *et al.* 2014). Female farmers have limited ability to secure loans (FAO, 2011; and often have no savings since they a higher proportion of their income is spend on the household's food, health and education (Saulière, 2011).

Because access to financial resources such as credit, is linked to access to land, property, information and education and information (ILO, 1998), women's access to the same is inhibited. This restricted access is an impediment to women obtaining guarantees that would enable them to secure access to credit from formal banks. (ILO, 1998; Kabeer, 2005: Quisumbing and Pandolfelli, 2010) established that access to financial credit alone is not enough if women invest only in micro-enterprises that have low returns and that women need more access to other resources.

Waithanji *et al.(*2013) reports that in Bangladesh Women's ability to generate income in the agricultural sector is severely constrained by their limited use, ownership, and control of productive physical and human capital. Bangladeshi women are disadvantaged relative to men with respect to assets brought to marriage, current productive assets (including land, livestock, and agricultural machinery. and human capital

Access to labour

The only resource at women's disposal is labour in parts of Africa. Furthermore, they are disadvantaged and are facing many challenges in obtaining male labour that is critical for particular tasks like land preparation and tree pruning (Swinkels *et al*., 2002). This leads to late planting and harvesting and consequently to significant yield losses (Kinkingninhoun-Mêdagbè *et al., 2010*). In many Africa, men hold claim over women's labour, but this cannot be reversed. For instance, females in male headed households in Benin work in men controlled fields which take precedence over their own (Abbas, 1997). Also women encounter difficulties in obtaining sufficient labour during peak labour activities as most are engaged by men (Swinkels *et al*., 2002). Women are not only unable to obtain needed male labour but also get it difficulty to hire labour because of lack of cash. This inability to mobilize labour to manage their farms puts them in a tricky and downward cycle of diminished yields, inadequate resources for managing their farms, and further reductions in yields. Female headed households also suffer more from labour shortages and heavier activities because women are smaller and their households have fewer working-age members (FAO, 2013).

Education and extension visits

Access to agricultural extension services is important in achieving food security and increasing agricultural productivity (Ragasa *et al*. 2012) besides facilitating climate change adaptation (Gbetibouo *et al.* 2010; Mustapha *et al.* 2012; DiFalco, 2013) The uptake of new strategies is often influenced by farmers' contact with extension workers and their services. Sufficient research has established that woman have lower access to agricultural extension workers and their services than men. In Malawi for instance, 19% of women had access to extension knowledge compared to 81% of men (Gilbert *et al.*, 2002). In Ethiopia, women had 20% contacts with extension services compared to men who had 27% (IFPRI and World Bank, 2010). UNEP/GRID-Arendal (2008) reports that 70% of agricultural work in Benin and Zimbabwe is basically carried out by women, there is only about 10% of female extension staff among the extension workers. Furthermore, the extensive extension services are focused on cash crops (which are considered a men's crops) rather than food and subsistence crops, which are considered to be women's crops. A study carried out by CIMMYT, (1998): Morris and Doss (1999) on the role of gender in the adoption of innovations in Ghana, reported fewer contacts of women with extension agents and a higher proportion of women report of no accessing extension contacts completely. Ragasa *et al*. (2012) reports that Ethiopian women have limited access to agricultural extension services, information and technology.

Lack of appropriate technology

Technology is the knowledge/information that permits some tasks to be accomplished more easily, some service to be rendered or the manufacture of a product (Lavison, 2013). Use of appropriate technology aims at improving a given situation or changing the status quo to a more desirable level. It assists the applicant to do work easier than he would have in the absence of the technology hence it helps save time and labor (Bonabana-Wabbi, 2002; Loevinsohn *et al*., 2013)

Many women in Africa undertake their activities manually because they lack suitable household, farm and processing technology. For example, women in Burkina Faso use three to four days to prepare *P. biglobasa* fermented seeds where extraction of Shea (*V.paradoxa*) nut butter is strenuous and time consuming (Teklehaimanot, 2004). Innovations aimed at improving crop production are limited for women small scale farmers. In Zambia for example, the use of a plough to weed, a task performed by women, can be performed six times faster (Allen, 1984) if improved technology is adopted.

Customs/taboos

The role of cultural beliefs in agroforestry adoption cannot be more emphasised. They are powerful determinants of peoples' actions, and influence how local rules and legislation are set by national government. In western Kenya, for example, tree planting activities are dominated by men. Similarly, the concept of tree ownership has been effectively sustained through well manipulated cultural practices (and taboos) that result in fewer women participating in tree activities (Chavangi, 19194). These taboos advanced in western Kenya and other parts of Africa are that if a woman plants a tree, she would become barren or her husband would die. The same applies to the Ibo of south-eastern Nigeria, Nwonwu (1996) where women are not allowed to climb certain types of trees such as the oil palm, raffia palm or coconut palm which is regarded as an abomination to do. Tripathi *et al*. (2012) reports that in Narok (Maasai community), men possess more of these assets, a culture that makes a community lag behind especially in terms of socio-economic development. Women are often not recognized as productive farmers, and rarely benefit from new agricultural research and technologies, and this has contributed greatly to persistence of underlying gender inequalities prevalent in both traditional and modern agricultural value chains,

2.6.4 Ability of women to manage agroforestry systems

Although men and women are both involved in agroforestry, earlier literature ascertain the role of women doing most of the work, especially during initial stages of trees establishment. For example, in Vietnam, women account for 58% of the workforce in agriculture, forestry and fisheries, and deliver more than 60% of agricultural products (FAO, 2015). More so, women continue to play important roles in all agriculture and forestry activities which include management and utilization of natural resources (ICARD, 2012). Women contribute many hours of labour in cultivation and raising livestock, agricultural processing, and marketing of agricultural goods (UN- and REDD, 2013). In forestry, women also dominate the work force (UN-REDD, 2013). Women tend to be highly involved in activities like nursery tending, seedling preparation and non- wood forest product collection.

A study conducted by Epaphra in Tanzania in 2001 and another by Gerhardt and Nemarundwe in Zimbabwe 2006 established that over 60% of Tanzania women are responsible for the management of tree species planted on farms while over 80% of Zimbabwean women manage the watering of young seedlings. These findings are confirmed yet by another study by Franzel *et al.*, (2002) that determined the adoption of fodder in the central highlands of Kenya. In spite of these, 91% of household respondents were male headed, with 89% of these households females responsible for managing fodder. A similar case was observed in Uganda by Nyeko *et al.*, (2004) where over 80% of households with calliandra, involved women in their management.

2.6.5 Benefits of agroforestry to women

Agroforestry is a key sustainable management practice in many parts of Africa with great impact on food security by increasing productivity (Pretty *et al*. 2011; Pinho *et al*. 2012; Minang *et al*. 2014) as well as biodiversity conservation. This is of great advantage to women who are the main vendors of family food. Minang *et al*. (2014, p. 80) further reports agroforestry provides opportunities for local people to engage in sustainable activities rather than deforestation especially women who for a large proportion of local population.

According to Kiptot and Franzel (2011), incorporation of trees and shrubs on crop lands is a low cost strategy that replenishes the fertility of soils for women farmers who find it difficult to acquire fertilizer and a sustainable source of firewood for households (socio-economic benefits)

These low cost agroforestry technologies for replenishing soil fertility are favourable and attractive to women farmers because they require low inputs and high returns. They also provide fuel wood and reduce the incidence of weeds such as *Striga hermonthica*. Results of focus group interviews with Zambian women, reports that women do benefit (Peterson, 1999). Provision of fuel wood from fallows is a benefit to women farmers since it reduces their burden of travelling long distances. Improved fallows do indeed generate considerable amounts of fuel wood with the amount varying in relation to species. For example, 5 - 42 t/ha is generated within duration of one to three years in western Kenya (Swinkels *et al*., 1997).

Women obtain substantial financial benefits from indigenous vegetables and fruits. Crélerot (1995) recorded earnings from kernel sales as US$ 15–35 per annum in south-western Burkina Faso. This represented 20-60% of women's income in that rural area. Another study of the contribution of the *shea* tree to local livelihoods in Benin, Schreckenberg (2004) established that the *shea* tree provided 2.8% of household income for women. Schreckenberg (2004), found that income from kernel sales in Benin varied between US$ 7–36 per annum, which sufficient for many women to cover a substantial part of their annual expenditures. In addition to income from the sale of nuts, fruits, butter, a substantial proportion of indigenous fruit products was also consumed by householders. For instance, 59% of *D. edulis* is consumed by the household (Ayuk *et a*l., 1999c).

According to Carsan *et al*. (2014) Agroforestry technologies have the potential of sustaining agricultural intensification in Africa without compromising yields. Agroforestry technologies provides many benefits to bio-physical and bio-chemical processes (biological benefits) that improve and rehabilitate nutrient poor soils which are advantageous to cultivation of food crops (Nair, 1993 cited in Jamala *et al.*,2013). Agroforestry technologies improve agricultural fields by contributing to soil erosion prevention, organic matter renewal and retention of soil nutrients. In addition, agroforestry minimize soil nutrients leaching losses, ameliorate soil degradation, facilitation pollination on farms and also improve the soil recycling potentials (Darkoh, 2003). Women access to agroforestry information. This increases food production, hence benefits the women who play a great role in looking for family food

More evidence has been documented since the 1990s displaying gender disparities in access to agricultural information (Saito and Wildermann, 1990; Quisumbing, 1996; Katungi, 2008; Peterman *et al.,* 2010 & Meinzen-Dick *et al*., 2010), showing fewer women than men reached. A study determining the effectiveness of various dissemination methods in reaching men and women farmers for advice on managing calliandra fodder shrubs farms in central Kenya, Wanyoike (2001) reported that fewer women receive this than men. When farms are categorized by gender, Wanyoike (2001) established that about 10% of male managed farms and those jointly owned had received at least one visit compared to only 5% of female managed farms. Factors contributing to this brassiness are, socio-cultural barriers where, 80–95% of extension agents are men, which limit them from communicating with female farmers (UNEP/GRID-Arendal, 2008).

Secondly, the perception that men are the decision makers, lead to any extension message passed directly to them (Saito and Wildermann, 1990). Third, is the perception in some places that women may seem not to be farmers but general perception for every aspect (Meinzen-Dick *et a*l., 2010). The few women with the ability to access extension information complain of lack of basic education and therefore their ability to access and use technical information is hindered (Saito and Wildermann 1990). The fact that women literacy is low place them in a disadvantaged position of adopting new innovations: Zimbabwe (15%); Tanzania (33%); Cameroon (36%) and Benin (48%) (UNESCO 2002). The implications of this extends to the adoption of agroforestry technologies by women farmers.

2.6.6 Involvement of women in agroforestry markets

Women are most involved in small-scale retail trade. Awono *et al*. (2002) in a study of production and marketing in Cameroon reported that women dominated in the collection of the fruit and were responsible for taking the same to the market, where the retail trade was dominated by women traderes (95% of whom were women). Men accounted for 71% of wholesale trade. This gender disparity was confirmed by Schreckenberg (2004), who established that women in Benin dominated the retail trade of the *shea* kernels and *shea* butter. A similar scenario was reported in Cameroon, Kanmegne *et al*. (2007) where the trading of *G. africanum*, was dominated by women 93%. The few men involved dominated the wholesale trade since it required significant capital which men obtained after selling cocoa.

Wholesale trade involves less market time but often extensive travelling which many women cannot manage to travel because of household chores. Even when women are involved in the production and collection of agroforestry products, their involvement in marketing is limited by the mode of transportation used. For instance in Tanga, Tanzania, where women farmers collect *calliandra* leaves (11 of 17 collectors) for processing into leaf meal, 10 of 11 traders were men. Bicycles are usually required for to transport this but they not considered culturally acceptable for women riders (Franzel *et al*., 2007). Women are relatively disadvantaged because of their low literacy levels than men. Furthermore, highly educated traders have access to better market information (marketing channels and prices) hence in a better position to make informed decisions.

2.7 Conceptual Framework

Figure 2.1 presents a conceptual framework of the study. It has independent variables, dependent variable and moderating variables. Independent variables are; agroforestry practices by women, empowering women and access to agroforestry technologies. Dependent variable is adoption of agroforestry technologies, moderating variable is climate change and adaptation. Success of agroforestry is dependent on agroforestry practices, adoption of agroforestry technologies by women and women access to agroforestry technologies. Adaptation moderates the impacts of climate change.

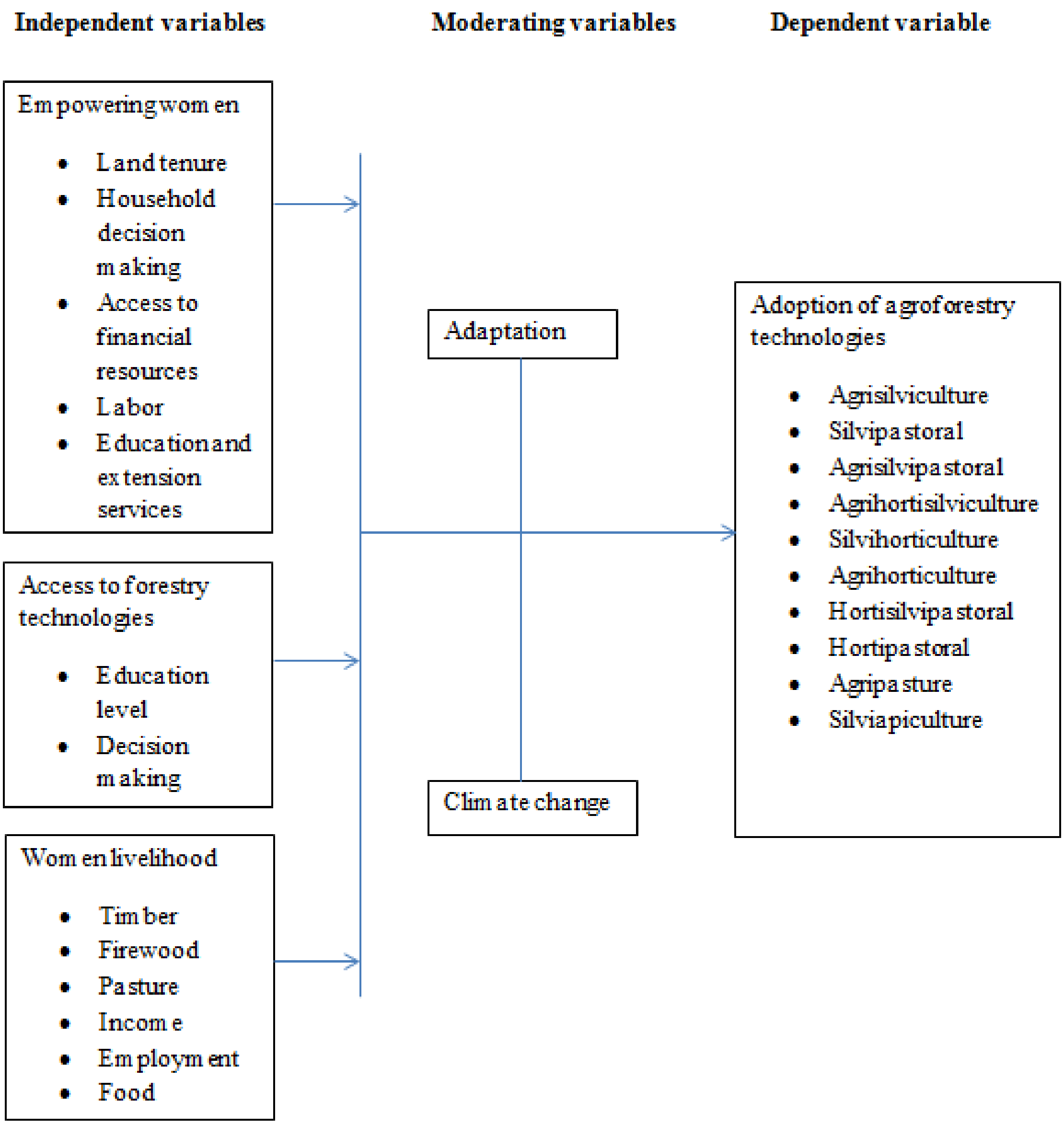

Figure 2.1: Conceptual framework

CHAPTER THREE: METHODOLOGY

3.1 Introduction

This chapter presents background information of the study sites including history of the settlement in the area. It also illustrates research design used in the study, sampling procedure, data collection methods and the key parameters studied and analysis procedures.

3.2 Study area

3.2.1 Location

The study was undertaken in Makueni County which covers an area of 8034.7km^2. The county boarders Kajiado to the west, Taita Taveta to the south, Kitui to the east and Machakos to the north. The county is divided into nine sub counties namely Makueni, Mukaa, Kilungu, Kibwezi, Kathozweni, Makindu, Mbooni (East, West) and Nzaui. Makindu Sub County is the target study area. It has three divisions Makindu, Tsavo West National Park, Chyulu Game Rerseve), four locations and fifteen sub-locations as shown in Figure 3.1. The study sites are Makindu and Nguumo locations in Makindu Sub County which covers four locations and fifteen sub- locations. Nguumo location has four sub locations namely Syumile, Muuni, Ndovoini, Kaunguni. Makindu location has five sub locations which are: Kiu, Manyatta, Kisingo,Kamboo, Kai. (Kibwezi community information Centre, 2009) This is because the other two divisions are game reserves and no agricultural activity takes place.

The choice of these two locations (Nguumo and Makindu) was influenced by the evident severe effects of climate change and the active participation of locals in agroforestry practices as an effort to adapt and cope with climate change. Also, there is reliable little rainfall in the area coupled with some reliable sources of water like wells, dams and boreholes that can provide water for irrigation purposes. The two locations are active in crop and livestock farming in spite of the challenges of climate change and variability (MOA Makindu, 2015). More so, Nguumo location had more fertile soils than Makindu location and Makindu location had a ready market (Makindu town) for sale of agroforestry products.

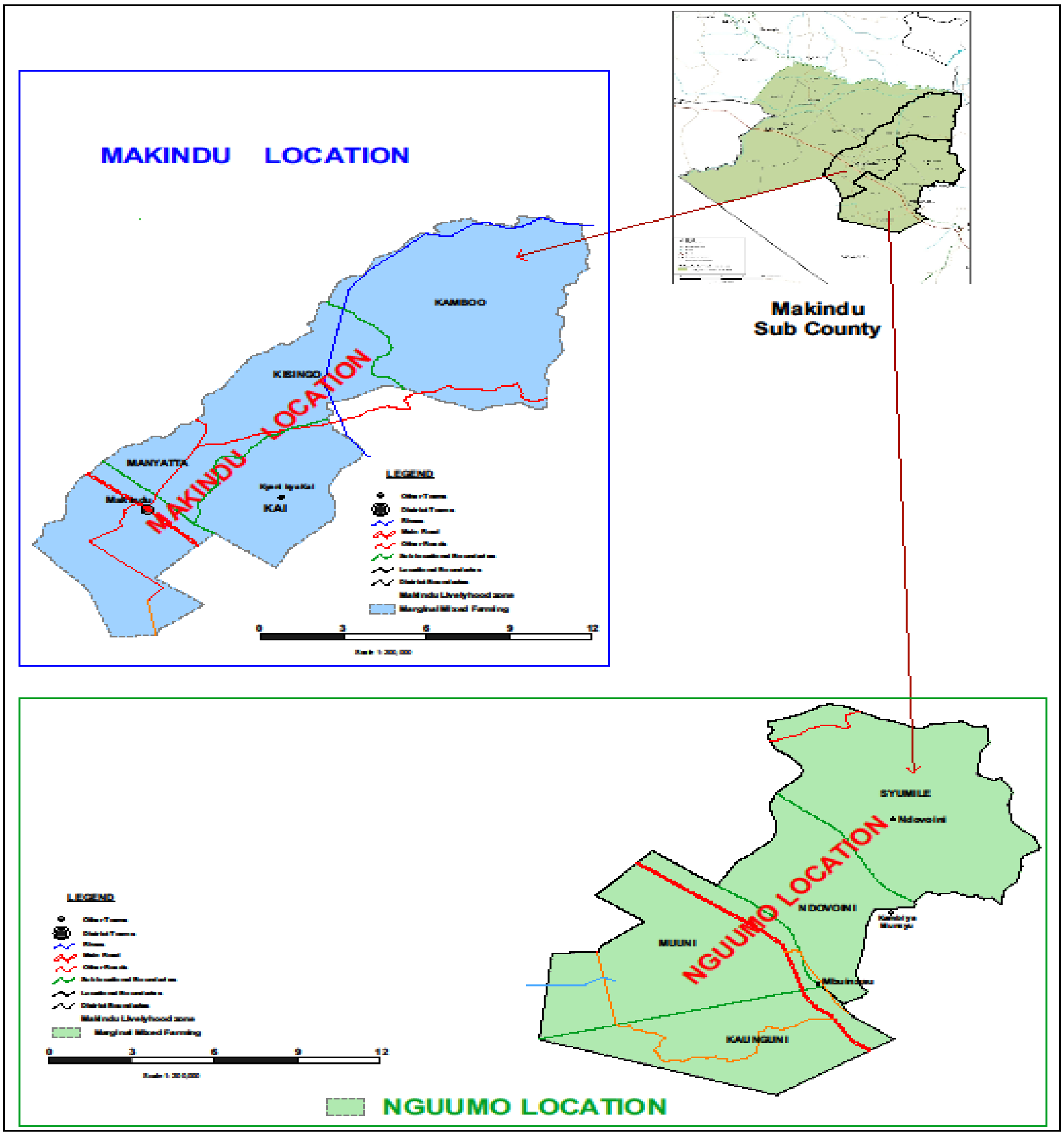

Figure 3.1 Map showing Nguumo and Makindu locations

Source: Chief's offices Nguumo and Makindu locations

3.2.2 Population and Economy

The total population of Nguumo and Makindu locations is 11571 households with Nguumo location having 5774 households where as Makindu location has 5797 households as shown in Table 3.1 (Census, 2009). 90% of these people live in the rural area. Crop farming and livestock production is back bone of the study area's economy and contribute up to three quarters of the household earnings in the area (Republic of Kenya, 2002). Main food crops include maize, beans, sorghum, pigeon peas, cowpeas, cassava, and green grams, sweet potatoes. Commonly grown vegetables are kales, cabbages, spinaches baririnals, okra, tomatoes, millet and finger millet. Fruits grown are mangoes, bananas, melons, passion fruits, papaws, oranges, lemons. Farmers intercrop crops, vegetables and fruits, this typical crop mix raised by a household varies substantially between, one zones to another, between households, between local landscapes. Mixed farming results to higher resource-use efficiency (Nyariki and Musimba, 1997).

It is determined by topographic location, soil type, soil moisture availability, temperature variations and Proximity to water points like dams, boreholes, wells, rivers, and ponds. Other reasons for the intercrop are to diversify resources, increase production through integration of various agroforestry technologies. Livestock species kept include sheep, cattle and goats (Mwang'ombe *et al.*, 2011). Crops such as beans, maize, sorghum, millet, pigeon peas, and cassava are cultivated. They are majorly for subsistence but sweet potatoes, green grams, fruits (melons, bananas, mangoes, etc.) and vegetables are grown for market (Mwang'ombe *et al.*, 2011).

Table 3.1 population data of Makindu sub county

Division	Location	Sub Location	Male	Female	Total	No of house holds	Area	Density
Makindu	Nguumo	Kaunguni	3,802	3,977	7,779	1,529	42.2	184
		Muuni	4,931	5,160	10,091	2,199	64.7	156
		Ndovoini	2,108	2,171	4,279	936	32.5	132
		Syumile	2,856	3,203	6,059	1,110	71.2	85
	Makindu	Kiu	3,044	2,913	5957	1307	27.9	213
		Manyatta	4227	4811	9038	2593	11.3	798
		Kisingo	1736	1856	3592	696	32.3	111
		Kamboo	1222	1266	2488	471	68.3	36
		Kai	1424	1429	2853	730	29.9	93
	Kiboko	Kyale	1876	1957	3833	717	100.2	38
		Kasuvi	1830	1644	3474	983	168.4	21
		Mulili	1820	1682	3502	734	77.7	45
	Twaandu	Twaandu	3530	3827	7357	1420	121.6	61
		Ngakaa	1094	1263	2357	46	23.7	100
		Mitendeu	1181	1299	2480	496	53.0	47
		Kalii	1255	1265	2520	468	44.9	56

Source: Nguumo and Makindu location chief offices, Data of the 2009 Kenya Population and Housing Census

3.2.3 Settlement History

Railway construction workers were the initial inhabitants of Makindu Sub County in the early 20th century. They used it as a base for railway construction workers on the Mombasa Kampala railway project. Over time, other people have settled in the area from different parts of the country like from Kitui, Machakos and others (MOA Makindu, 2015). The Sikh temple in Makindu built at that time, still bears reminiscence to the railway building days.

The temple was a place of worship and social centre for many of the Indian workers. It is well preserved and managed as a free lodge for any traveller. Makindu is also served by the Makindu airport (Makindu weather base, 2016).

3.2.4 Physical and agro-climatic conditions

Makindu Sub County is located on the Nairobi Mombasa High-way, in Makueni County in the South eastern part of Kenya (Figure 3.1). It lies approximately 135 kilometres by road, southeast by Machakos, and approximately 356 kilometres by road, North West of coastal city of Mombasa. The geographic coordinates are 2 16’30, 00’’S,’3749.12.00.’’E (latitude; 2.2275000; 37’ 49’12.00’’E (Latitude: - 2, 275000: 37, 820000). The climate of the area is semi-arid with very erratic and unreliable rainfall (Mwangombe *et al* 2011). The area is hot and dry throughout the year with temperatures ranging from a minimum of 15-22° centigrade to a maximum of 25-32° centigrade.

The months of February and September are the hottest months in the year. Rainfall is distributed within two seasons yearly and varies from 500 - 750mm with about 30% reliability. The long rains are experienced between March and May and short rains between October and December. The two rain seasons used to be reliable for crop and livestock production but farmers report that the long rains have become unreliable since 1980s and droughts have become frequent (Awour, 2009). The short rains are considered more reliable than the long rains because it is during the short rains that farmers get a better production opportunity (Musembi and Grifiths, 1986).The area has experienced very severe droughts for several years (Lawrence and mwanzia, 2004)

The study area is dominated by savannah vegetation which consists of savannah grassland and woodland. Common grasses include star grass, coach grass, guinea grass etc. Indigenous trees like acasia species *Melia volkenzii*, *Balanites indica* and *Tamarind* dominate the area.

3.2.5 Agriculture and livestock

Major agricultural activities are small scale livestock herding with cultivation of crops vegetables and fruits for commercial and subsistence purposes. Main crops grown are maize, beans, cowpeas, sorghum, pigeon peas, green gram, and cassava Livestock keeping is a most important occupation where mostly indigenous cattle, goats and sheep and sometimes donkeys thrive throughout the region (MLFD, 2005 and Mwangombe *et al*, 2011). Vegetables are kales, tomatoes, spinaches melons among others, fruits are mangoes, oranges, bananas, lemons and passion fruits (Nyariki and Musimba, 1997). Major environmental issues in the area include deforestation, rapid population growth, burning of vegetation and forests, use of forest resource fuels (wood and charcoal) among others. Overall crop and livestock productivity is low due to erratic rainfall, diseases, shortage of animal feeds and others (LUPRD, 1998).

3.2.6 Geology and soils

The soil types range from sandy loams to red sand soils, clay black cotton soils which are moderate in fertility (Republic of Kenya, 1997). They are well drained, well aerated with moderate fertility and have good water holding capacity.

3.3 Research design

Data was collected using a cross-sectional survey. The aim was to collect information from respondents on their opinions, attitudes, feelings and behaviours on women and agroforestry (Kothari, 2008). Target population was small-scale farmers in the area, unit of study was the household, the respondents were both men and women, and both primary and secondary data were collected. This design takes a sample of the target population and bases the overall findings on the views or behaviours of those sampled assuming them to be similar to the target population (Trochim, 2006). The design is fast, can study big sample sizes at low cost, less effort and one does not need to worry about respondents dropping out of the study (Kombo and Tromp, 2007). A cross-sectional survey research design also provides self-reported facts about the subjects on study.

3.4 Study population

The study targeted small-scale farmers (Those found practicing crop and tree planting, vegetable, fruit growing, livestock rearing, pasture establishment throughout the rain seasons) facing severe challenges of climate change and variability. These farmers were trying to practice agroforestry as a remedy to climate/variability in Nguumo and Makindu locations which are within Makindu Sub County. A total of 109 households were sampled because they acted as units of production. These households were engaged in farming activities such as horticultural and annual crop production, pasture production, livestock rearing from which they derive their livelihoods. Average household members range from four to seven persons.
The head household was interviewed (One proposed by other members of the household or one who is ready and willing to be interviewed, also any woman or man who was entrusted with the responsibility of overseeing the farm's activities for a period of two years or more (Lusweti, 2007). Secondary data was obtained from ministry of agriculture and livestock development in Makindu to triangulate the information obtained from agroforestry farmers.

3.5 Sampling procedure and sample size

3.5.1 Sampling procedure

The two locations (Nguumo and Makindu) had a total households population of 11, 571, where Nguumo location had 5774, Makindu, 5797 households. Using coefficient of variation method (Nassiuma, 2000), a sample size of 109 respondents from the two locations in the division were randomly selected from a sampling frame of 11,571 households. A total of 54 households were selected in Makindu location and 55 in Nguumo location both of Makindu sub-county (Table 3.2). Purpose sampling was used to select respondents in the two locations. The two locations were selected because farmers were actively practicing agroforestry technologies in the selected locations more than any other locations of Makindu. Snowballing technique was used to identify the farmers practicing agroforestry where the household sampled referred the next practicing agroforestry.

3.5.2 Sample size

According to Nassiuma (2000), for most surveys, a coefficient of variation range of 21% to 30%, standard error of 2% to 5% is acceptable. Therefore, a 21% coefficient of variation and a standard error of 2% was used in the study. The lower limits were selected in order to reduce sample variability and minimize degree of error. The formula given by Nassiuma (2000) was applied in this case as shown below.

$$n = \frac{NC^2}{C^2 + (N-1)e}$$

Where

n=sample size=x

N=population=11571

C=coefficient of variation=21%

e=standard error=2%

The sample size for Makindu sub-county (Nguumo and Makindu Locations) will be;

$$= \frac{11571 \times (21^2)/100}{0.21^2 + (11571-1)0.02^2}$$

$$= \frac{510.281}{4.628}$$

=109 respondents

Table 3.2 Sample size used to collect data in the two locations studied (Makindu and Nguumo locations)

Location	Households	Proportion by percentage	Sample size
Nguumo	5774	49.901	54
Makindu	5797	50.099	55
Total	**11571**	**100**	**109**

3.6 Data collection methods and instruments

Qualitative and quantitative methods were used to collect primary data, that included information gathered directly from respondents/inhabitants of the area. It used semi-structured questionnaires which had some fixed/closed and open ended questions. The answers for these questions were gathered through in-depth interviews with respondents, visiting various focused groups and obtaining their views through discussions and also observations on various farms. Both men and women participants were engaged without necessary targeting the women alone to avoid biased answers. For instance women may feel that they do most of household activities and therefore ignore the engagement of men.

The method was used to access women participation in agroforestry technologies as an adaptation measure to climate change and variability in the study area. More data was obtained from published literature and internal sources; journals, books, annual reports, workshop proceedings and periodicals, relevant literature from libraries and Ministry od Agriculture and internet. Table 3.3 shows data requirement as per objective. The questionnaire consisted of sections. Section A, will give demographic data of the respondents. B, Common agroforestry technologies practiced by women in the study area, C, role of agroforestry in climate change adaptation .D, agricultural performance under agroforestry technologies, E, women role in agroforestry as a climate change and variability adaptation strategy. For More details on the questionnaire check the Appendix section.

3.7 Data requirements as per objective

The required data in each objective are as shown in Table 3.3 below.

Table 3.3 Data requirements per objective

Objective	**Required data**	**Method of data analysis**
To establish AF technologies employed by women in Makindu and Nguumo locations to counter effects of climate change and variability.	Agroforestry technologies practiced:-Agrisilviculture, Silvipastoral, Agrisilvipastoral Silvihorticulture.	Household survey questionnaire
To determine the influence of women empowerment in and access to adoption of agroforestry technologies to counter climate change and variability in Makindu and Nguumo location.	Area of women empowerment:-access to resources, land tenure, education, extension information, market access, taboos, household decision making.	Household survey questionnaire
To establish the role played agroforestry technologies to the livelihoods of women and their environment in Makindu and Nguumo location.	Roles played by AF technologies:-source of income, food, firewood, controls soil erosion, conserves biodiversity, Provides employment	Household survey questionnaire

3.8 Data analysis

The generated qualitative and quantitative data was subjected to in-depth analysis and used to compliment discussion of the analysed quantitative data. The Quantitative data was cleaned, sorted, summarized and stored using Ms Excel and statistical package for social sciences (SPSS). Quantitative and qualitative data were summarized and presented in forms of charts, tables, frequencies, graphs and percentages where necessary. Both descriptive and inferential statistics were used to analyse the qualitative and quantitative data. In inferential statistics, correlation analysis and linear regression analysis were used. In descriptive statistics charts, graphs, mean, percentages and frequencies were used (Table 3.4).

Table 3.4 Methods of data analysis per objective

Objective	Method of data analysis
To establish AF technologies used by women in Makindu and Nguumo locations to counter effects of climate change and variability.	Frequency distribution Chi square test of independence
To determine the influence of women empowerment in and access to adoption of agroforestry technologies to counter climate change and variability in Makindu and Nguumo location.	Frequency distribution Linear regression Correlation analysis
To establish the role played agroforestry technologies to the livelihoods of women and their environment in Makindud Nguumo location.	Frequency distribution

Chi square test of independence

Chi square test of independence was used to test if there was a statistical association between two variables. The null hypothesis of chi square test for independence assumes that there is no association between the two variables tested. The following formula is used to calculate the chi square value.

$$\chi^2 = \left[\frac{(O-E)^2}{E}\right]$$

Where, χ^2 = Chi-Square test of independence

O= observed value

E= expected value

A p-value (probability value) is then obtained from chi square tables. If the p-value is less than 0.05, the null hypothesis is rejected and concluded that there is no significant association between the two variables.

Multiple linear regression model

Multiple linear regression attempts to model the relationship between two or more explanatory variables ($x_1, x_2, \ldots, x_n$) and a response variable(y) by fitting a linear equation to observed data. Every value of the independent variable *x* is associated with a value of the dependent variable *y*. Multiple linear regression analysis was conducted so as to determine the impact of the explanatory variables on the response variable.

The regression equation; **($Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \varepsilon$)**: Whereby

Y = Adoption rate

β_0= y intercept

β_1= Regression coefficients for Makindu

β_2= Regression coefficients for Nguumo

X_1 = Women empowerment in Makindu

X_2 = Women empowerment in Nguumo

ε = Error term

The Correlation coefficient (r_{xy})

The correlation coefficient was used to find out the strength of relationship between the variables in this study. The correlation coefficient varies from -1 (perfect negative correlation) to +1 (perfect positive correlation).

- Exactly –1. Indicates a perfect negative linear relationship
- –0.70. indicates a strong negative linear relationship
- –0.50. indicates a moderate negative relationship
- –0.30. indicates a weak negative linear relationship
- 0. Indicates no linear relationship
- +0.30. indicates a weak positive linear relationship

- +0.50. indicates a moderate positive relationship
- +0.70. indicates a strong positive linear relationship
- Exactly +1. Indicates perfect positive linear relationship

The Pearson correlation coefficient *r* can be defined as follows. Suppose that there are two variables *X* and *Y* , each having *n* values $X_1, X_2, \ldots, X_n$ and $Y_1, Y_2, \ldots, Y_n$ respectively. Let the mean of *X* be $\bar{X}$ and the mean of *Y* be $\bar{Y}$. Pearson's coefficient *r* is given as:

$$r = \frac{\sum(X_i - \bar{X})(Y_i - \bar{Y})}{\sqrt{\sum(X_i - \bar{X})^2 \sum(Y_i - \bar{Y})^2}}$$

Where the summation (∑) proceeds across all *n* possible values of *X* and *Y*

Y= Adoption of agroforestry technologies

X_1= Agroforestry practices by women

X_2= Empowering women towards adoption of agroforestry

3.9 Methodology assumptions

The method assumed the sample size of the study was a fair representation of the population. It also assumed that the respondents answered questions in the questionnaire honestly

3.10 Limitations of the method

The study was restricted by the fact that the sample of the respondents covered small scale farmers who were practicing agroforestry and especially women in Makindu and Nguumo locations. Therefore any generalizations made were restricted to that group of farmers.

3.11 Operationalization of variables

The study objectives had a dependent variable, independent variables and moderating variable. Table 3.5 summarizes the key variables which guided the study and how each variable was measured to realize the study objectives.

Table 3.5 Operationalization of variables

Objectives	Variable	Indicator	Measurement	Data analysis
To establish the agroforestry technologies used by women to counteract effects of climate change and variability in Makindu division.	Dependent variable Adoption of agroforestry technologies	Agrisilviculture ,silvipastoral, Agrisilvipastoral ,silvihorticulture	Norminal	Descriptive statistics. Inferential statistics
	Independent variables. Agroforestry practices by women.	Planting weeding, watering	Nominal	
To determine the influence of women empowerment in and access to adoption of agroforestry technologies in climate change adaptation	.Women empowerment Access to agroforestry technologies	Land tenure, housed decision making, labor, extension visits	Ordinal.	Descriptive statistics. Inferential statistics.
To establish the role played by AF technologies in livelihoods of women and their environment.	Access to financial resources, Education,	.	Ordinal	Descriptive statistics. Inferential statistics.

CHAPTER FOUR: RESULTS

4.1 Introduction

In this chapter results obtained during the study are presented. The results are presented by objectives starting from objective one to three.

4.1.1 Socio-economic characteristics of Nguumo and Makindu locations

These Socio-economic characteristics influenced women adoption of agroforestry.
On marital status, the study revealed that in Makindu location, 4% males, 14.3% females were single, 8% males, 10.7% females were widowed, 84% females, 67.9% males were married, 4% males, 7.1% males were divorced. In Nguumo location, 4% males, 21.4% females were single, 16% males, 3.6% females were widowed, 76% males, 64.3% females were married, 4% males,10.7% females were divorced.
In terms of household head by gender results indicated that in Makindu 88.1% were male headed, 11.9% female headed while in Nguumo 80.4% were male headed, 19.6% female headed.
A comparative analysis on level of education indicated that in Makindu location 4% males, 17.2% females did not go through any formal education, 28% males, and 27.6% females had attained primary level education, 48% males, 27% females had attained secondary education, 4% males, 24.1% females had gone through adult education, 16% males and 3.4% females had post-secondary education. In Nguumo location, 4% males, 17.9% females did not go through any formal education, 24% males, 46.4% females had gone through primary education, 48% males, 25% females had attained secondary education, 4% males, 7.1% females had attained adult education, 20% males, and 3.6% females had attained post-secondary education (Table 4.1).

On main economic activity, Table 4.1 reveals that in Makindu location 8% males, 51.7% females were practising agriculture, 24% males, 34.5% practised agroforestry, 24% males, 3.4% female had casual employment, 44% males, 10.3% females had permanent employment while in Nguumo location 20% males, 53.6% females were practising agriculture, 4% males, 25% females practised agroforestry, 44% males, 14,3% female had casual employment, 32% males, 7.1% females had permanent employment.

Concerning mode of land acquisition, results presented in Table 4.1 showed that in Makindu location 72.7% males, 27.3% females had purchased the land, 94.1% males, 5.9% females had inherited the land from parents, 75.0% males, and 25.0% females had leased the land. In Nguumo location 65.2% males, 34.8% females had purchased the land, 69.2% males, 30.8% females had inherited the land, 80.0% males, and 20.0% females had leased the land.
On mean land size owned (acres) by males and females, Makindu location had 10 acres land owned by males, 3 acres by females (widowed, single women). Nguumo location had 12 owned by males, 4 acres females (widowed, single women (Table 4.1).

Table 4.1 Socio-economic characteristics of Makindu and Nguumo locations

Demographic information		Location			
		Makindu		Nguumo	
		Male%	Female %	Male%	Female %
Household head gender		88.1	11.9	80.4	19.6
Marital Status	Single	4.0	14.3	4.0	21.4
	Widowed	8.0	10.7	16.0	3.6
	Married	84.0	67.9	76.0	64.3
	Separated	0.0	0.0	0.0	0.0
	Divorced	4.0	7.1	4.0	10.7
Highest level of education	No formal education	4.0	17.2	4.0	17.9
	Secondary education	48.0	27.6	48.0	25.0
	Adult education	4.0	24.1	4.0	7.1
	Post-secondary education	16.0	3.4	20.0	3.6
	Primary education	28.0	27.6	24.0	46.4
What is the main economic activity of your household	Agriculture	8.0	51.7	20.0	53.6
	Agroforestry	24.0	34.5	4.0	25.0
	Casual employment	24.0	3.4	44.0	14.3
	Permanent employment	44.0	10.3	32.0	7.1
Land ownership		78.1	21.9	80.6	19.4
Mode of acquisition	Purchased	72.7	27.3	65.2	34.8
	Given by government	0.0	0.0	0.0	0.0
	Inherited	94.1	5.9	69.2	30.8
	Leased	75.0	25.0	80.0	20.0
Mean land size owned(acres)		10	3	12	4

4.1.2 Climate change and variability in Nguumo and Makindu locations (Makindu sub-county)

Figure 4.1, shows total rainfall pattern per year between 1980 to 2010 and beyond. Results reveals a recurrent drop in rainfall in the year 2005 to 2015 and beyond from 900mm to 400 mm.

Figure 4.2 shows maximum and minimum temperatures per year. The results shows increased temperatures for the last ten years. Figure 4.2 shows a continuous temperature rise from 28 degrees in the year 1995 to 32 degrees in the year 2017. This depicts climate change and variability.

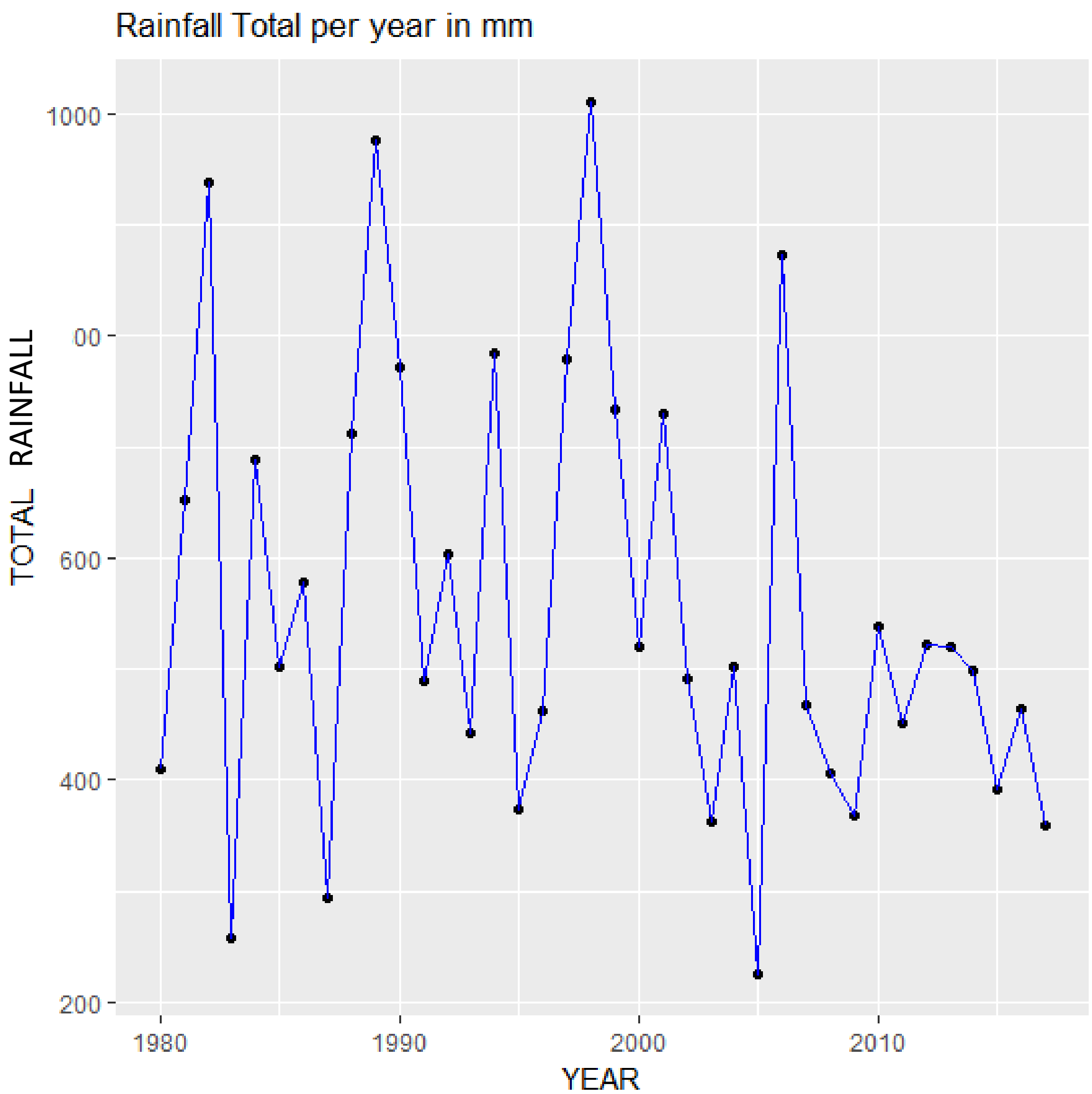

Figure 4.1: Total rainfall in mm per year

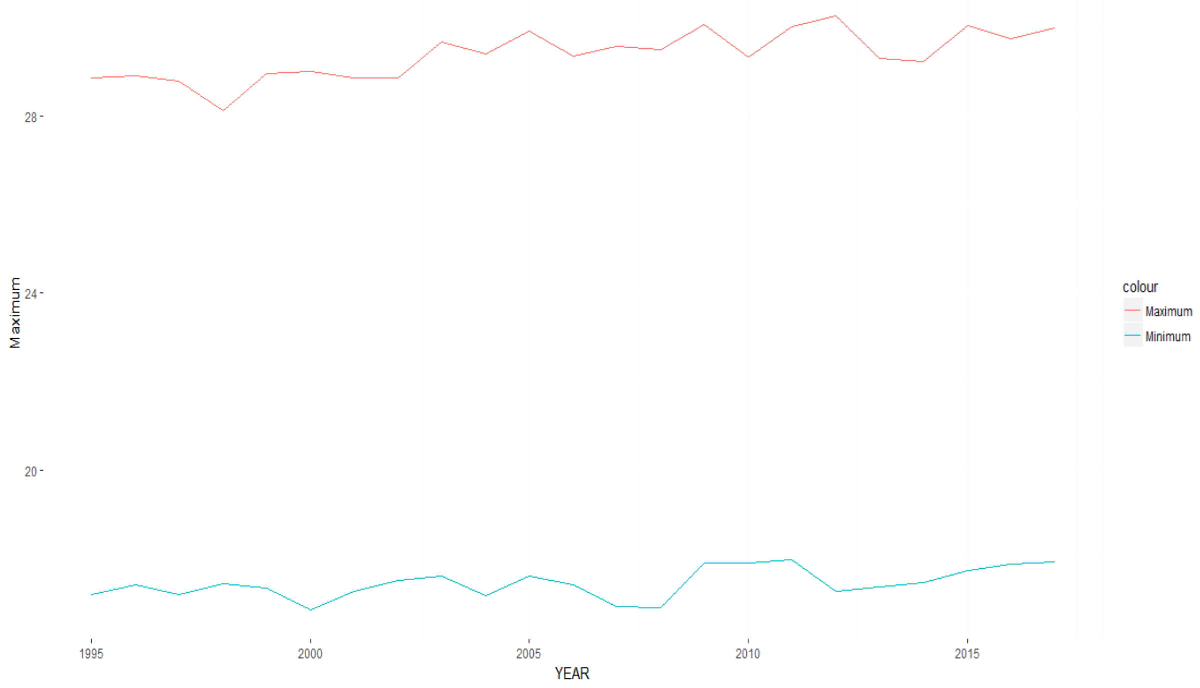

Figure 4.2: Maximum and minimum tempratures in °c per year

4.2 Agroforestry technologies practiced by women in Makindu and Nguumo locations to counteract the effect of climate change and variability

This section presents; proportions of households employing agroforestry technologies, size of land under agroforestry and the types of agroforestry technologies practised.

4.2.1 Proportions of households practicing agroforestry in Nguumo and Makindu locations

The study aimed at investigating whether the respondents practiced agroforestry. From those who practiced agroforestry in the selected study sites majority were females. Nguumo location led in number of females, 40.35% practicing agroforestry followed by Makindu location with 28.07% females. This indicates that women are mostly involved in agroforestry practices than men in the two study locations (Figure 4.3).

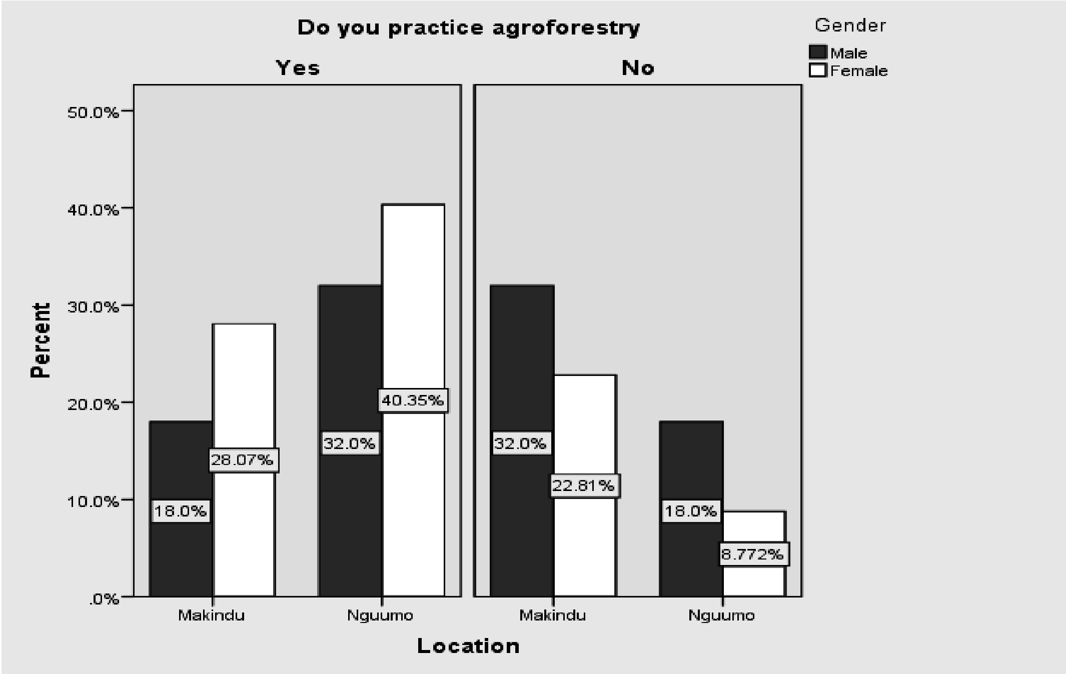

Figure 4.3: Proportions of household practicing agroforestry (%) by gender in Nguumo and Makindu locations

4.2.2 Proportion of land size under agroforestry in Nguumo and Makindu locations

The land owned and corresponding percentage of land under agro forestry is given in Table 4.2. Nguumo Location had the largest portion of total land (483.4 acres) as compared to Makindu (194.6). On the percentage of land under agro forestry, Makindu location on average had 16.4% while Nguumo had 28.5% of the land under agroforestry. Nguumo led in practising agroforestry due to presence of large land (Table 4.2) and favourable climate provided by Chyulu hills. Makindu location was active in practising agroforestry because of presence of Makindu River which provided irrigation water and also presence of Makindu town which provided a reliable market for agroforestry products.

Table 4.2 Land size and relative land under agroforestry in Nguumo and Makindu Locations

Locations	Total Land area (acres)	% of total land under agroforestry
Nguumo	483.4	28.5
Makindu	194.6	16.4
Overall mean	**339.0**	**42.2**

4.2.3 Type of agroforestry technologies adopted in Nguumo and Makindu locations

Table 4.3 presents different types of agroforestry technologies practiced by smallholders' farmers in Nguumo and Makindu locations. The results revealed that both locations females were leading in the practising most the agroforestry technologies adopted in the area with more than 50% in most of them. For example, females in Makindu scored 55.8% in both hortisilvipastoral and hortipastoral (highest) while males scored 44.2% in both (lowest). In Nguumo, females scored 54.7% in agrisilviculture, females 45.3%, agrisilvipastoral males scored 40.9%, females 59.1%. This revealed that women were more active than men in adopting and practising the technologies. Females in Nguumo location scored higher than Makindu location in most of the various agroforestry technologies practised.

Table 4.3 Agroforestry technologies adopted in Nguumo and Makindu locations by gender (%)

	Locations					
	Nguumo		Makindu		Chi sq.(X^2) value	p-value
Technology	**Males**	**Females**	**Males**	**Females**		
Agrisilviculture	45.3	54.7	49.0	51.0	2.12	0.145
Silvipastoral	46.0	54.0	48.9	51.1	5.26	0.022
Agrisilvipastoral	40.9	59.1	51.0	49.0	3.46	0.063
Agrihortisilviculture	45.5	54.5	46.5	53.5	2.96	0.086
Silvihorticulture	47.1	52.9	45.7	54.3	1.45	0.228
Agrihorticulture	48.1	51.9	46.7	53.3	1.18	0.277
Hortisilvipastoral	53.3	46.7	44.2	55.8	2.04	0.154
Hortipastoral	51.7	48.3	44.2	55.8	1.97	0.160
Agripasture	42.3	57.7	48.9	51.1	2.15	0.142
Silviapiculture	20.0	80.0	48.9	51.1	1.31	0.253
Chi-square test of independence					119.1	0.000

A chi-square test of independence was calculated comparing the frequency of agroforestry technologies applied and gender in Nguumo and Makindu locations. A significant interaction was found (X^2 (10) = 119.1, p <0.05). Women were more involved in agroforestry technologies application in both Nguumo and Makindu locations.

4.2.3 Proportions of households practicing tree planting and livestock keeping in Nguumo and Makindu locations

The agroforestry innovations practiced by women in Makindu and Nguumo locations included planting trees, growig crops, pastures and fodder crops and keping livestock. Results presented in Table 4.4 indicated that in Makindu location, 28.2% males, 71.8% females planted trees and 47.1% males, 52.9% females kept livestock. In Nguumo location, 42.3% males, 57.7% females planted trees while 42.4% males, 57.6% females kept livestock. Majority of the respondents who planted trees and kept livestock in both locations were females.

Table 4.4 Proportions of households planting trees and keeping livestock (%) in Nguumo and Makindu locationsf f

Sub-location	Tree planting		Chi sq.(X^2) value	p-value	Livestock keeping		Chi sq.(X^2) value	p-value
	Male	Female			Male	Female		
Nguumo	42.3	57.7	49.05	0.000	42.4	57.6	38.97	0.000
Makindu	28.2	71.8			47.1	52.9		
Overall mean	**35.25**	**64.75**			**44.75**	**55.25**		

A chi-square test of independence was calculated to compare the frequencies of households planting trees and gender in both locations. A significant interaction was found (X^2 (1) = 49.05, p <0.05). Women were the majority in planting trees in both Nguumo and Makindu locations.

A chi-square test of independence was also calculated comparing the frequencies of households keeping livestock and gender in both locations. A significant interaction was found (X^2 (1) = 38.97, p <0.05). Women here too were more involved in keeping livestock in.

4.2.4 Method of tree planting in Nguumo and Makindu locations

The results indicated that the respondents used different methods of planting trees.

Table 4.5 indicates that in Nguumo location, 38.1% males, 61.9% females planted trees scattered on crop land, while 40.7% males, 59.3% females planted the trees along boundaries. 33.3% males, 66.7% planted the as live fences around the homesteads and 66.7% male, 33.3% females planted them as around the farms or homesteads as wind break.

In Makindu location, 46.5% males, 53.5% females indicated that they planted trees scattered on crop land, 42.9% males, 51.7%, females planted along boundaries, 36.4%, 63.6% females plant as live fence and 25% males, 75% plant as wind break (Table 4.5)

Table 4.5 Method of tree planting in Nguumo and Makindu locations (%)

	Locations					
	Nguumo		Makindu		Chi sq.(X^2) value	p-value
Planting method	**Male**	**Females**	**Male**	**Females**		
Scattered on crop land	38.1	61.9	46.5	53.5	3.07	0.080
Along boundaries	40.7	59.3	42.9	57.1	1.48	0.220
Live fence	33.3	66.7	36.4	63.6	3.74	0.51
Wind break	66.7	33.3	25.0	75.0	2.03	0.152
Chi-square test of independence					4.89	0.299

A chi-square test of independence was calculated comparing the frequencies of planting methods of tree planting and gender in Nguumo and Makindu locations. An insignificant interaction was found (X^2 (4) = 4.89, p >0.05). There were no significant differences between planting methods applied and gender in both Nguumo and Makindu locations.

4.2.5 Sources of tree seedlings in Nguumo and Makindu locations

The study sought to establish the sources of the seedlings where in Nguumo location, 41.7% males, 58.3% females indicated that they were given free by friends, Government, Non-governmental institutions. 60 % males, 40 % females raised their own while 42.3% males, 57.7% bought. In Makindu location, 55.6% males, 44.4% females indicated that they were given free by friends, Government, Non-governmental institutions. 34.8% males, 65.2% females raised their own while 54.5% males, 45.5% bought (Table 4.6).

Table 4.6 Sources of tree seedlings in Nguumo and Makindu locations (%)

		Locations					
		Nguumo		Makindu		Chi sq.(X^2) value	p-value
Location		Male %	Female %	Male %	Female %		
Source of seedling	Given free	41.7	58.3	55.6	44.4	0.94	0.625
	Raised my own	60.0	40.0	34.8	65.2		
	Buy	42.3	57.7	54.5	45.5		

A chi-square test of independence was also calculated comparing the frequencies of sources of seedlings and gender in Nguumo and Makindu locations. An insignificant interaction was found (X^2 (2) = 0.94, p >0.05). There were no significant differences between sources of seedlings and gender in both Nguumo and Makindu locations.

4.3 Influence of women empowerment in and access to agroforestry technologies in adapting to climate change and variability Nguumo and Makindu locations

4.3.1 Gender role (gender effect) in agroforestry adoption and its adaption to climate change?

As indicated in the Table 4.7, majority of females in Nguumo and Makindu locations indicated that gender plays a big role in agroforestry adoption in Makindu location, 30.5% males, 69.5% females and Nguumo 32.8% males, 67.2% females stated that gender plays a critical role in agroforestry adoption and adaptation to climate change and variability.

Table 4.7 Gender role in Agroforestry adoption and adaption to climate change (%)

Location		Makindu		Nguumo	
		Male	**Female**	**Male**	**Female**
Role played	Planting	30.5	69.5	39.1	60.9
	Cultivating the land	44.4	55.6	47.0	53.0
	Watering young seedlings	34.6	65.4	30.6	69.4
	Harvesting	12.5	87.5	14.5	85.5
Overall average		**30.5**	**69.5**	**32.8**	**67.2**

4.3.2 Do women have the ability to manage agroforestry in Makindu and Nguumo locations?

As indicated in Figure 4.4, in Makindu location 47.2% males, females 52.8% males and in Nguumo location, 46.0% males, 54.0% females indicated that women had a capacity to manage agroforestry. The results confirmed that given an opportunity, women had the ability to manage agroforestry technologies.

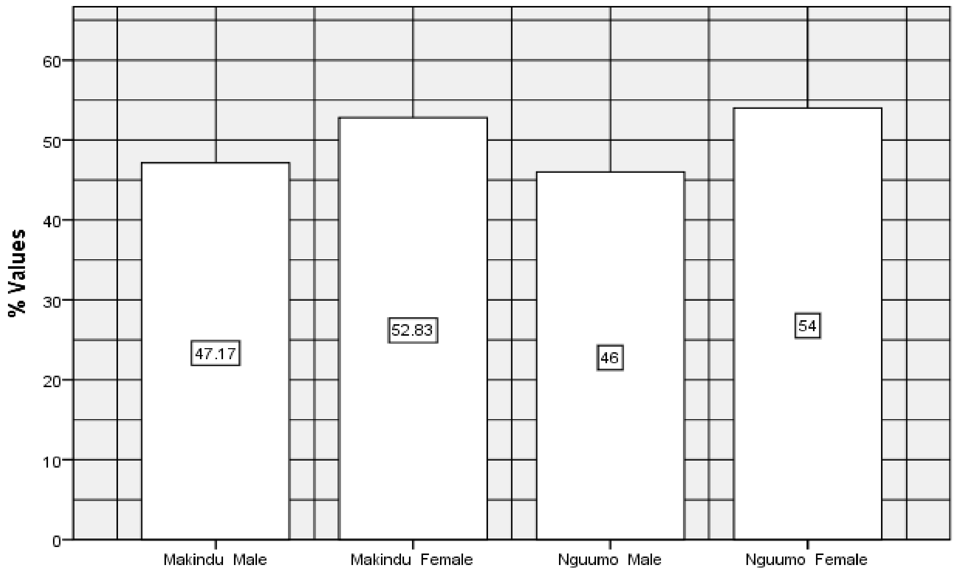

Figure 4.4: Ability of women to manage agroforestry in Makindu and Nguumo locations

4.3.3 Factors/challenges hindering women from accessing and adopting agroforestry technologies in Makindu and Nguumo locations

From Table 4.8, in Nguumo location 15.1% of the respondents indicated that women face socio cultural factors, 16.2%, are not decision makers, 19.9% lack basic education, 13.2% inadequate capital, pests and diseases 7.5%, drought 14.5%, expensive inputs 6.8%, lack of ready market 1.0%, poor infrastructure 0.9%, lack of support from the government 1.9%, inadequate extension officers 1.2%, lack of ICT information 0.9% and access to financial assets 0.9%. In Makindu location 16.7% of the respondents indicated that women face socio cultural factors, 16.7% women are not decision makers, 16.9% lack basic education, inadequate capital 9.8%, pests and diseases 9.3%, drought 11.1%, expensive inputs 5.6%, lack of ready market 5.6%, 1.9% poor infrastructure, 1.9% lack of support from the government, 1.6% inadequate extension officers, lack of ICT information 1.6% and access to financial assets 1.3%. Factors with major effects in both locations were lack of basic education, women are not decision makers, socio-cultural factors but their effects were more in Nguumo location than Makindu location.

Table 4.8 Factors hindering women from accessing and adopting agroforestry technologies in Makindu and Nguumo locations (%)

Factors	**Location**	
	Makindu	**Nguumo**
Socio-cultural factors	16.7	15.1
Women are not decision makers	16.7	16.2
Lack of basic education	16.9	19.9
Lack of inadequate capital	9.8	13.2
Pests and diseases	9.3	7.5
Drought	11.1	14.5
Expensive inputs	5.6	6.8
Lacks of ready market	5.6	1.0
Poor infrastructure	1.9	0.9
Lack of support from government	1.9	1.9
Inadequate extension officers	1.6	1.2
Lack of ICT information	1.6	0.9
Access to financial assets	1.3	0.9
	100.0	**100.0**

4.3.4 Effects of the hindering factors on women adoption of agroforestry technologies in adapting to climate change and variability

The study sought to know to what extent the following factors had an impact on women accessing and implementing agroforestry information gained from extension officers (whether they denied women easy access to agroforestry technology information and adoption the results are show in Table 4.9 below. In Makindu location, on socio-cultural factors, 8.2% indicated that it had no impact, 12.5% had low impact, 28.6% high, 17.8% had moderate impact and 32.9% had a very high impact, on whether women are decision makers, 7.9% indicated that it had no impact, 9.9% had low impact, 35 .1% very high impact, 18.2% had moderate, and 28.9% had high impact. On whether lack of basic education had an impact on women implementing agroforestry information, 10.0% said it had no impact, 15.0% said it had moderate impact, 12.1% said it had low impact,31.6% said it had high impact and 3 1.3% said it had very high impact.

In Nguumo location, on socio-cultural factors, 5.5% indicated that it had no impact, 10.5% had low impact, 27% high, 15% had moderate impact and 42% had a very high impact, on whether women are decision makers, 32.9% indicated that it had no impact, 7.9% had low impact, 25 .1% very high impact, 10.2% had moderate, and 23.9% had high impact. On whether lack of basic education had an impact on women implementing agroforestry information, 9.4% said it had no impact, 25.0% said it had moderate impact, 12.7% said it had low impact,11.6% said it had high impact and 41.3% said it had very high impact. In both locations this factors had very high impacts but slightly higher in Nguumo location than Makindu location (Table 4.9).

Table 4.9: Effects of the hindering factors on women adoption of agroforestry Technologies in Makindu and Nguumo locations (%)

Factors	Makindu					Nguumo				
	Very High	High	Moderate	Low	None	Very High	High	Moderate	Low	None
Socio-cultural	32.9	28.6	17.8	12.5	8.2	42.0	27.0	15.0	10.5	5.5
Women are not decision makers	35.1	28.9	18.2	9.9	7.9	25.1	23.9	10.2	7.9	32.9
Lack of basic education	31.3	31.6	15.0	12.1	10.0	41.3	11.6	25.0	12.7	9.4

4.3.5 Need for women empowerment, areas of women empowerment and women empowered in Makindu and Nguumo locations

The study sought to assess whether women need to be empowered in the areas where they had challenges in order to be able to easily access and adopt agroforestry innovations. They suggested that the empowerment could be done through county government, NGOs and ministry of agriculture (MoA) by providing them with soft loans, more extension workers, trainings through workshop, visits, shows, and seminars, provision of inputs like seeds, pesticides, insecticides, fertilizers and tools.

From the table 4.10, 83.3% women in Makindu and 87.3% women in Nguumo suggested that they needed to be empowered in agroforestry technologies**.** In Nguumo location, 67.92%, of women needed to be empowered in land tenure, 75.47% involvement in decision making, 88.89% access to resources, and 71.70% access to extension information. In Makindu location 64.8% needed empowerment in access to resources, 53.70% in land tenure, 59.26% in decision making, and 74.07% in access to extension information. Only small percentages of women were empowered in the two locations, Nguumo 12.7%, Makindu 16.7%.

Table 4.10: Need for women empowerment, areas of women empowerment and women empowered in Makindu and Nguumo locations (%)

	Location	
Area of Empowerment	**Nguumo**	**Makindu**
In need of empowerment	87.3	83.3
Access to resources	88.89	64.81
Owning land	67.92	53.70
Decision making	75.47	59.26
Access to extension information	71.70	74.07
Empowered	12.7	16.7

4.3.6 Regression coefficients for women empowerment and adoption of agroforestry technologies by women in Makindu Location and Nguumo locations

Linear regression analysis to investigate the degree to which women empowerment in and access to agroforestry technologies help in adapting to climate change and variability was fitted for both locations.

From Table 4.11, there was a positive and a significant relationship between women empowerment and agroforestry technologies ($p<0.05$) in Makindu Location and Nguumo Location. For the empowerment coefficient in Women for Makindu location an increment in women empowerment by one unit increases the adoption rate by 0.432 units. For the coefficient in Nguumo location an increment of women empowerment by one unit increases the adoption of agroforestry by 0.232 units.

Table 4.11: Regression coefficients for women empowerment and adoption of agroforestry technologies by women in Makindu Location and Nguumo locations

Variable	Location	Coefficient	P-value
Women empowerment	Makindu	0.432	0.000
	Nguumo	0.232	0.000

4.3.7 Relationship between factors influencing adoption of agroforestry technologies by women and various independent variables

The study aimed at establishing the strength of the relationship between Agroforestry practices by women, empowering them towards adoption of agroforestry, accessing and implementating of agroforestry information and adoption of agroforestry strategies by women. To achieve this Pearson's correlation coefficient was performed since both the independent and dependent variables are in a ratio scale. The study findings in Table 4.11 indicated that there was a significantly positive relationship between adoption of agroforestry technologies and agroforestry practices by women (rho = 0.627, p-value < 0.05). This implies that a unit change in agroforestry practices by women increases adoption of agroforestry technologies by 62.7%. There was a positive linear relationship between adoption of agroforestry technologies and empowering women towards adoption of agroforestry (rho = 0.501, p-value < 0.05). This indicates that a unit change in women empowerment towards adoption of agroforestry increases the adoption of agroforestry by women by 50.1%. Thirdly, there was a significant positive relationship between adoption of agroforestry and access and implementation of agroforestry information by women (rho = 0.630, p-value < 0.05). This implies that a unit increase on how women access and implement agroforestry information increases the adoption of agroforestry technologies by women by 63%. Finally, there was a significant positive relationship between empowering women towards adoption of agroforestry and access and implementation of agroforestry information by women (rho = 0.350, p-value < 0.05). This implies that a unit increase on how women access and implement agroforestry information increases the empowering of women towards adoption of agroforestry by 35%.

Table 4.12: Correlation Analysis on factors influencing of adoption of agroforestry technologies by women and various independent variables in Makindu and Nguumo locations

		Adoption of agroforestry technologies	Agroforestry practices by women	Empowering women towards adoption of agroforestry	Access and implementation of agroforestry information
Y	Pearson Correlation	1			
	Sig. (2-tailed)				
	N	70			
X1	Pearson Correlation	.627**	1		
	Sig. (2-tailed)	.000			
	N	70	70		
X2	Pearson Correlation	.501**	.370**	1	
	Sig. (2-tailed)	.000	.002		
	N	70	70	70	
X3	Pearson Correlation	.630**	.703**	.350**	1
	Sig. (2-tailed)	.000	.000	.003	
	N	70	70	70	70

**. Correlation is significant at the 0.01 level (2-tailed).

Y= Adoption of agroforestry technologies.

X1= Agroforestry practices by women.

X2= Empowering women towards adoption of agroforestry.

X3= Access and implementation of agroforestry information.

4.3.8 Adaptation strategies to cope with the challenges of climate change and variability in Nguumo and Makindu locations

From Figure 4.5 below, the study sought to know how the farmers cope with the challenges they face in accessing agroforestry technologies in Nguumo and Makindu respectively. 20% and 18% indicated that they acquire loans, 16% and 12% do water harvesting, 24% and 20%

sell the produce locally, 10 and 5% hire workers, 82 and 80% use drought resistant crops, 24% and 20 % do drill boreholes, 50% and 45% spray agrochemicals, and 28% and 25% seeks advice from NGOs.

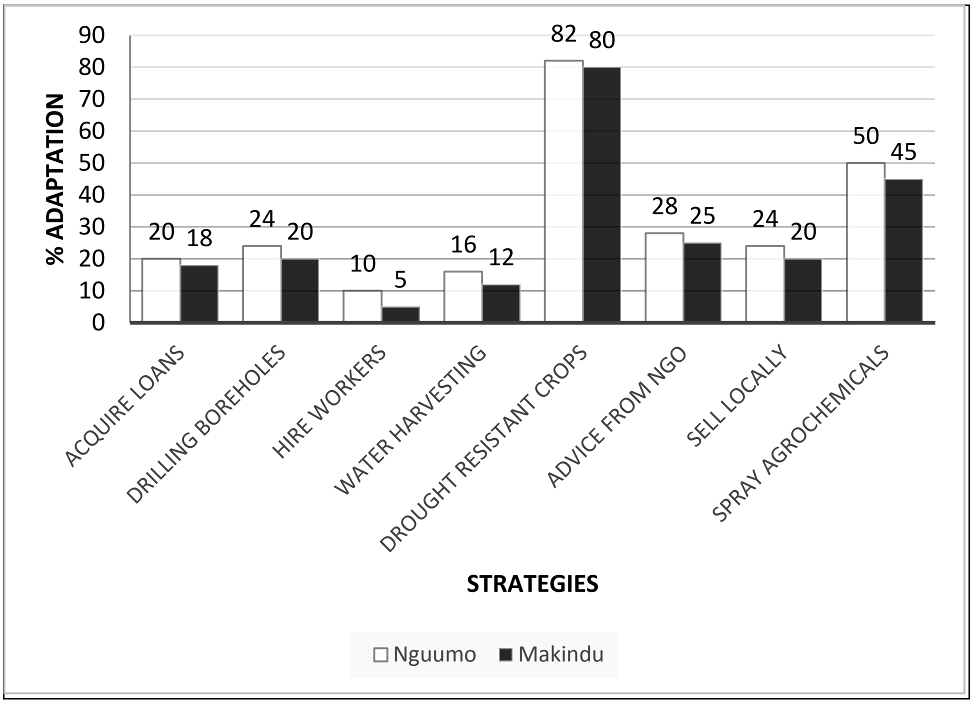

Figure 4.5: Adaptation strategies to cope with the challenges of climate change and variability in Nguumo and Makindu locations

4.4 Role played by agroforestry to livelihoods of women in Makindu and Nguumo locations

From the results in Table 4.13, agroforestry products and their benefits to the lives of women in Makindu and Nguumo locations is highlighted. In Makindu location majority of the respondents indicated that agroforestry products play a great role in the lives of women where 89.6% of respondents said women benefit from fruit trees, 89.1% livestock products, 88.4% benefit in terms of firewood provision, 68.3% food crops, 40.4% get pastures. More so, agroforestry also provides fibre, medicinal products. In location Nguumo location, 52.8%, of the respondents benefit from fruit trees, food crops 71.6%, livestock products 90.6%, pastures 73.6%, firewood 93.4%. Nguumo location benefited more from agroforestry products than Makindu location.

Table 4.13: Agroforestry products and their benefits (%) to women in Makindu and Nguumo locations

		Location			
Product	**Benefits**	**Makindu (%)**	**Monthly mean income (Ksh)**	**Nguumo (%)**	**Monthly mean income (Ksh)**
Fruit trees	Source of income, food, timber, manure	89.6	3,232.56	52.8	4,109.75
Food crops	Food for people. livestock, income	68.3	2,152.20	71.6	4,054.32
Livestock Products	Source of meat, milk, skin, income	89.1	2,327.09	90.6	3,506.89
Pastures	Livestock feed, manure, soil and water conservation, income	40.4	4,005.55	73.6	2,987.50
Firewood	Source of cooking fuel, income	88.4	2,169.45	94.3	3,435.66
Average		**75.16**	**2777.37**	**76.58**	**3618.82**

CHAPTER FIVE: DISCUSSION

5.1 Agroforestry technologies employed by residents of Nguumo and Makindu locations to counteract the effect of climate change and variability

The current study established that Makindu and Nguumo locations had experienced drought for the last ten years and more. Results of Figure 4.1 indicated a recurrent drop in rainfall from 900mm year 2005 to 400mm and below in year 2015. Also, results of Figure 4.2 indicated a continuous rise in temperature from 28 degrees in year 1995 to 32 degrees in the year 2017. This confirmed climate change and variability in the area. These results are in agreement with the findings by Charles *et al.*, (2013) who reported that the changes in the pattern and quantity of rainfall, high temperatures, strong wind and low relative humidity over the years had impacted the lives of farming communities in this region. Women in Makindu and Nguumo locations are vulnerable to climate change impacts because of the position and gender roles that have been attached to them. For example, they play significant roles in the family like vending for family food, addition to the family income by farming and collecting water and/or firewood for the family (Civil Society Forum for Climate Justice, 2011). To cope/react to these climate change and variability effects, women in Makindu and Nguumo locations had developed a large number of agroforestry technologies and strategies.

Results presented in Table 4.3 established such agroforestry technologies as hortisilvipastoral and hortipastoral (highly practised), agrisilviculture, silvipastoral, agrihortisilviculture among others. (ICRAF, 2015). These technologies provided innovative practices that enhanced food production while contributing to climate change adaptation by Gebrehiwot *et al*., (2016). Further, results presented in figure 4.5 indicated that women in Nguumo and Makindu locations used various adaption strategies to adapt to climate change and variability which included acquiring loans from various loan lenders, water harvesting through construction of weirs, dams, use of tanks to provide water for irrigation, selling the produce locally to individual consumers and in the local markets, hiring workers casually to reduce labour shortage especially during planting and harvesting, use of drought resistant crops, drilling boreholes to reduce water shortage, spraying agrochemicals to control pests and diseases and seeking advice from NGOs on application of agroforestry technologies. Barbhuiya *et al.,* (2016) reported that these strategies strengthens the agricultural system’s ability to adapt to the negative impacts of the changing environmental conditions while improving food productivity.

Results presented in Figure 4.3 indicated percentage proportion of households practicing agroforestry. Out of those practicing agroforestry in the selected study sites majority were females. Nguumo location led in number of females, 40.35% practicing agroforestry followed by Makindu location with 28.07% females. Males in Nguumo and Makindu were 32.0%, 18.0% respectively. This clearly indicates that women were involved in agroforestry practices than men in the two locations. This indicated that women headed households were more involved in agroforestry practices than male headed households in the two sub locations. The current trend of the results is in agreement with the other findings by Nhemachena and Hassan (2007) who established that female headed households are more likely to take up climate change adaptation options when they are exposed to information than male headed because they have more access to land.

From the results in Figure 4.3 it can also be deduced that majority of the respondents in the two locations are aware of most of the agroforestry strategies practiced in several parts of the world as an adaptation to climate change and variability and are practicing the same. The results concur with the findings by Mugure *et al*. 2013, who indicates that agroforestry is a long-established farming practice in many parts of the world for livelihood diversification and climate change adaptation.

Results of Table 4.2 showed that Nguumo Location had the largest portion of land (483.4 acres) owned as compared to Makindu location (194.6 acres).The percentage of land under agroforestry in Makindu location was 16.4% while Nguumo was 28.5 % of the total land owned. Nguumo led in practising agroforestry due to presence of large land and favourable climate provided by Chyulu hills. Makindu location was active in practising agroforestry because of presence of Makindu River which provided irrigation water and also presence of Makindu town which provided a reliable market for agroforestry products. These results indicated that both locations had turned to agroforestry as an adaption to climate change and variability effects .This is because they had put a large percentage of land under agroforestry activities. Zomer *et al.* (2009) concurs with the present findings by indicating that agroforestry is widespread. He found out that agroforestry was practised on 46% of all agricultural land area globally.

The results Table 4.3 revealed that in both locations Makindu location females were leading in practising various agroforestry technologies. In Makindu location, women led in hortsilvipastoral and hortipastoral (both with 55.8%). In Nguumo location, women led in agrisilviculture (54.7%) and agrisilvipastoral (59.1%) hence women were more involved in agroforestry technologies. These technologies diversifies agricultural production especially under current climate change scenarios which have affected these two locations. They have the potential to develop synergies between efforts to adapt to climate change and efforts to help vulnerable farmers to adapt to the negative consequences of climate change (Verchot *et al., 2*007). These technologies solve the problem of food shortage, fuel wood, and timber and conserve soil moisture. They also ameliorate the harsh climatic condition brought by climate change. (Gichuki *et al.,* 2000 and Lwakuba *et al.,*and ICRAF, 2013).

Further analysis of these results showed that generally both locations had adopted various types of agroforestry technologies as an adaptation to climate change and variability. These findings are supported by Bishaw *et al. (*2013) who stated that various agroforestry practices suitable for enhancing the adaptation of agro- ecosystems to climate change have been developed, tested, and popularized in Kenya and Ethiopia. From the results it was also deduced that the percentage of adoption in women was higher in female headed household (Table 4.1), Makindu 11.9%, Nguumo, 19.6% compared to male headed household in both locations because women had access to land and property rights and had freedom to make decisions on what agroforestry activities to choose. Findings of Smith *et al.,* (2012) indicated that women have limited control over land and property rights. In these two locations women had access to land and practised agroforestry activities only through permission and instructions from their husbands. This meant women could not freely access or make decision on land and property use without consent or permission from the husbands. Women in the study area are act as overseers on the agroforestry activities but not real owners. For instance in Sub-Saharan Africa (SSA), women only have rights to use and access land through men, especially in customary land tenure systems (Farnworth *et al*. 2013), while only 3 per cent of women own a title deed in Kenya, hence positioning women at the periphery of farm production decisions (Skinner, 2011). Unequal rights to land not only limit women's ability to access credit, but also restrict their decisions on land use as shown by the present study that are necessary to adapt to climate change.

A chi-square test of independence has been calculated to compare the frequency of agroforestry technologies applied and gender in the two locations. It found a significant interaction (X^2 (10) = 119.1, p <0.05). Women were more involved in agroforestry technologies application in both Nguumo and Makindu locations.

Results Table 4.4 revealed that Many of the respondents who planted trees and kept livestock in both locations were females.In Makindu location, 28.2% males, 71.8% females planted trees and 47.1% males, 52.9% females kept livestock. In Nguumo location, 42.3% males, 57.7% females planted trees while 42.4% males, 57.6% females kept livestock. Though women are highly in charge over these livestock keeping and tree planting activities (overseers), gender inequality still persists in livestock ownership and control of income where men own and control income from large livestock like cattle and draft livestock, whereas women own small livestock such goats, sheep and poultry. (Njuki & Sanginga, 2013). Therefore, though women are highly involved in tree planting and livestock keeping men highly control the returns.

A chi-square test of comparing the frequencies of households planting trees and gender in Nguumo and Makindu locations. A significant interaction was found (X^2 (1) = 49.05, p <0.05). Women were more involved in planting trees in both Nguumo and Makindu locations.

A chi-square test of independence comparing the frequencies of households keeping livestock and gender in Nguumo and Makindu locations. A significant interaction was found (X^2 (1) = 38.97, p <0.05). Women were more involved in keeping livestock in both Nguumo and Makindu locations.

5.2 Influence of women empowerment in and access to agroforestry technologies in adapting to climate change and variability in Makindu and Nguumo locations

5.2.1 Role of gender in agroforestry technologies adoption in Makindu and Nguumo locations (does gender play any role in agroforestry adoption)

The study revealed that (Table 4.8) gender plays a critical role in agroforestry adoption as an adaptation to climate change and variability. In both locations males and females highly supported that gender very much determines adoption of agroforestry activities. In Nguumo 46.5% males, 53.5% females, in Makindu 47.2%, 52.8% The results revealed that women as agents of change are the major actors in several areas of adaptation hence the role of women in agroforestry technologies as adaptation measures to climate change effects should not be under-estimated (Rodenberg, 2009). Civil Society Forum for Climate Justice (2011) Concurs with the findings who indicated that Women are the most vulnerable part to the impacts of climate change and are actually the one who have a lot of roles and initiatives to play in various crises and the negative impact of climate change. Women are more involved in agroforestry technologies as an adaptation strategy as confirmed by the findings of (Rakib & Matz, 2014). However, (OECD, 2012; UNFCC, 2013) further indicated that gender inequality persists in adoption of important technologies for climate change adaptation in areas of governance .and leadership, decision-making arena and in access to social institutions where women in Makindu and Nguumo locations were found not to be exceptions. This limits their access and implementation of agroforestry technologies.

Further, findings of (IUCN, 2009; Rodenberg, 2009; UNDP, 2009; UNFPA/WEDO, 2009) indicated that women role in adaptation measures to climate change has been highlighted in developing countries. This is because women play a particularly significant role in ensuring a family's food security. They Shoulder the responsibility for this activity and are at the forefront in the conservation and selection of seeds of different crops, providing energy for the household is usually a woman's job (IUCN/ UNDP/GGCA, 2009). In many areas of Nguumo and Makindu locations women were already adapting to the fallout of climate change.

From the present study it can be deduced that Gender matters in all spheres of production especially in use agroforestry technologies as an adaptation strategy to cope with effects of climate change.

5.2.2 Ability of women in managing agroforestry in Makindu and Nguumo locations

Results presented in figure 4.4 indicated that in Makindu location 47.2% females, 52.8% males and in Nguumo location, 46% females, 54% males indicated that women were able to manage agroforestry. The results confirmed that women had the ability to manage agroforestry despite the barriers they face.

This the findings are in agreement with those of (Kiptot *et al*., 2012) who established that women farmers form an integral part of agroforestry, since they are often responsible for managing trees especially at the initial stages of establishment as men consider this feminine work. Furthermore, women are known to be principal holders of knowledge and managers of traditional home gardens. They make up about 60% of the practitioners of innovative agroforestry practices such as domestication of indigenous fruit trees and production of dairy fodder.

This study revealed that an overwhelming majority of women in both locations were able to manage agroforestry technology in response to climate change and variability effects. The results concurs with findings from a similar study by (FAO, 2015) which established that women play significant roles in many agriculture and forestry activities, including management and utilization of natural resources and their protection, as was also confirmed by (ICARD, 2012). In the study locations, women have taken part in almost all production activities related to agricultural production like land preparation, planting, weeding, watering, harvesting but men are the ones who decide on whether to sell the product or not (dominate the marketing of the product). The results are in agreement with the findings of (UN-REDD, 2013) that found that Women contribute more hours of labour to cultivation, raising livestock and tree management and are highly involved in activities like nursery tending and seed preparation.

Also the results revealed that women were highly involved in agroforestry strategies because they were usually responsible for providing the family with food and also helped add the family income through farming. This is because they sold minor products like fruits, vegetables, milk, and other agroforestry products to get income. This was in line with the findings of (CSFCC, 2011) who found that women had greater burden of climate change impacts than men since they had primary responsibility of collecting water or firewood as well as providing food and other necessities for their families. Further findings by (Denton, 2002) concurred with current study by indicating that climate-induced crop failure also puts the food security of the entire population of women at risk because it is women who are responsible for collecting water and fuel (firewood) for the household. IUCN/UNDP/GGCA (2009: 155) indicated forests supply women with vital products and women not only gather firewood, but also obtain other raw materials, food or medicinal plants to provide for their families and to boost their income.

Women worldwide are at the forefront of the conservation of forests, the reforestation and afforestation of cleared land and the conservation of natural resources in general (IUCN/UNDP/GGCA, 2009: 155). The conservation and care of forests coupled with reforestation and afforestation for which women are responsible helps avoid the emissions caused by deforestation and leads to greater sequestration of greenhouse gases from the atmosphere. Women therefore contribute directly to climate adaptation. Given their significant role in adaptation efforts, it is imperative that women be involved in the relevant measures like agroforestry technologies.

5.2.3 Hindering factors on women access and adoption of agroforestry technologies in Makindu and Nguumo locations

From results of Table 4.8 it can be deduced that women face many challenges in adopting agroforestry technologies in both locations hence their limited access to agroforestry technologies as an adaptation strategy to climate change Factors with major effects in both locations were lack of basic education (Makindu 16.9%, Nguumo19.9%), women are not decision makers (Makindu 16.7%, Nguumo 16.2%), socio-cultural factors(Makindu 16.75, Nguumo 15.1%) but their effects were more in Nguumo location than Makindu location.. This is in line with the findings of (OECD, 2012) who indicated that gender inequality persists in climate change governance and leadership, decision-making arena, lack of basic education and in access to social institutions (socio-cultural factors). This also makes women to have limited control over land and property rights (land tenure). This was confirmed by the findings of (Farnworth *et al*. 2013) who indicated that women only have rights to use and access land through men, especially in customary land tenure system., hence positioning women at the periphery of crop production decisions (Skinner, 2011). From these observation study it was established that women in both locations access and use land with permission from their husbands.

The study also established limited access to agricultural extension services by women in Makindu and Nguumo locations (socio cultural factors) which is crucial in achieving food security and increasing agricultural productivity besides facilitating climate change adaptation. This was confirmed by the findings of (Ragasa *et al.* 2012). (Gbetibouo *et al.* 2010; Mustapha *et al*. 2012; DiFalco, 2013). Further findings by Ragasa *et al*. (2012) and McOmber, 2013) supported the findings of the current study by indicating that women were often left out of information and communication technologies (ICTs) that are crucial in disseminating climate and agricultural information to farmers. This unequal access to extension information and other forms of communication is likely to affect women's adaptive capacity.

Access to financial assets was another socio-cultural factor which limited women access to agroforestry technologies in Makindu and Nguumo locations. According to (FAO, 2011), access to financial assets is a catalyst for uptake of innovations, technologies and inputs such as improved seed varieties and agrochemicals that are important for adapting to climate change while (Peterman *et al.* 2014) indicated that there was differential access to agricultural inputs and Female farmers had limited ability to secure loans and often have no savings since they spend a higher proportion of their income on the household's food, health and education (Saulière, 2011). Further findings by (Croppenstedt *et al.* 2013) indicated that this has far-reaching consequences on gendered input use and low agricultural productive besides impacting on women's adaptive capacity.

Women in Makindu and Nguumo locations did not have much of a say in decisions taken by the family or the community and are therefore not able to diversify cultivation hence planted the crops which men had permitted them. This is in consonance with (Skinner, 2011) who indicated that this positions women at the periphery of crop production. Unequal rights to decision making not only limits women's ability to access credit, but also restrict their decisions on land use that are necessary to adapt to climate change.

From the study it was established that when women have little access and control over key productive assets such as land, financial capital, inputs and bargaining power, which translates positively into household's well-being, outcomes including food security, children's nutrition, education, health and survival rates, agricultural productivity and conservation of natural resources (FAO, 2011; OECD, 2012; Farnworth *et al*. 2013) .Social capital (group-based approaches) helps households or individuals in reducing vulnerability and enhancing coping, adaptive capacity and recovery from adverse events (Adger, 2003; Bezabih *et al*. 2013) and adapting to climate change (Nganga *et al*. 2013; Chen *et al.* 2014). At community level, social capital supports accumulation of assets, knowledge and building resilience to climate change (Mueller *et al.* 2013).

5.2.4 Need for women empowerment in agroforestry technologies in Makindu and Nguumo locations

The study aimed to establish whether women are in need of empowerment in agroforestry technologies. According to international women's conference in 1985 at Nairobi, empowerment was defined as the control over material assets, intellectual resources and ideology or as redistribution of social power and control of resources in favour of women. The material assets over which control can be established may be of any type – physical, human, financial; such as land, water, forests, people's bodies and agencies, lab our, money and access to money. Intellectual resources include knowledge, information and ideas. UNIFEM in its, guidelines on Women's Empowerment (1997) defined empowerment "as a process where women individually and collectively become aware of how power relations operate in their lives and gain the self-confidence and strength to challenge gender inequalities at the household, community, national, regional and international levels.

Results in table 4.10 indicated that only as small fraction of women had been empowered in the two location hence a deficiency in women empowerment (Nguumo 12.7%, Makindu 16.7%). 87.3%, of women in Nguumo location, 83.3% of women in Makindu, needed empowerment in agroforestry technologies in various areas such as, socio cultural factors, decision making and access to basic education in order for them to participate fully in agroforestry technologies as an adaptation to climate change. This was confirmed by another study (McCright, 2010; Safi *et al*. 2012) which indicated that there were gender-specific risk perceptions and worries about climate change which influenced adaptive behaviour that were due to prevailing social inequality and varying susceptibilities.

From this study's findings, (table 4.10) it is clear that access to information, own land, decision making and access to resources affect adoption of agroforestry technologies. Lack of access to these services burdens women in the production of food for the family and also feeding livestock and overseeing family's nutrition status, thus raising higher worries about declining agricultural productivity and higher incidences of food insecurity. It means that Women's roles in food production are affected when the food production deteriorates due to drought and erratic rainfall exposing households to food security risks as was confirmed by (Resurrección, 2013).

Also from results of table 4.10 it is clearly indicated that, insecure land rights, limited access to capital and productive inputs(resources) hindered women of both locations from taking up climate-smart practices such as agroforestry and conservation agriculture (Farnworth, 2013). Further findings by (Seiz, 1995) indicated that differential access to assets, information and bargaining power over land use disputes the ‘unitary household model’ on household decision-making that habitually ‘rationalize gender inequality’ in market-based or non-market livelihood.

5.2.5 Ways of women empowerment through agroforestry technologies in Nguumo and Makindu locations

Further the results of table 4.10 indicated that very few had been empowered in important areas which enable easy access and adoption of agroforestry technologies. In Nguumo location only 12.7% and 16.7% in Makindu location of women had been empowered, hence the need for women empowerment.

Women empowerment brings about a bargaining approach to gender inequality which has brought negative outcomes in adoption of agroforestry technologies (Doss, 2013). This in argument with the findings of (Agarwal, 1997) who argued that intra-household bargaining power interplays with other factors, such as economic status, legitimacy of social and legal claims, institutions, support systems, endowment / entitlement of resources and this largely determines adoption of agroforestry technologies.

Women empowerment in decision making develops their ability to organize and influence the direction to Climate change through agroforestry. This collaborates with the findings. (UNDP, 1998) Who indicated that “Empowerment” in decision making creates a condition that enable women to exercise their autonomy and “Self-empowerment” enables women find time and space of their own to begin to re-examine their lives critically and collectively. This can done through ‘Feminist institutionalism’ which encourage women to be included in decision-making processes, how to institutionalize gender and the interactions between gender and governing institutions. Ministry of Agriculture through extension services and farmers’ training programs to women groups (Mackay *et al.* 2010) can empower them morally and reduce gender discrimination in the field of agroforestry through women’s participation. Further, the Kenyan constitution that guarantees ‘elimination of gender discrimination in law, customs and practices related to land and property in land has also been out to educate women on how to take active role in development and adaptive strategies like agroforestry (GoK 2010b: 42).

Easy accessibility and availability of food products at cheaper rate may empower women physically. Easy and nearby accessibility to fuel wood, fodder and food products may help in reducing women's drudgery. This is because women do a lot of hard boring work as they are the main vendors of family food. This can be done through Group-based approaches which presented vital pathways for wives by promoting their livelihood through group-based entrepreneurship, income generation, training facilities, micro financing and group-based food and nutritional processes. Organization of women in self-help groups and co-operatives for agroforestry-based activities may empower them socially. These social groups have built women's assets such as livestock, physical, human, natural and financial capital and food security. For instance, group-based crop production and food acquisition help women enhance their role as a food producer and nutritional overseer in the household. This concurs with the findings of (Gichuki *et al*. 2000) who indicated that enabling food security in the household is likely to improve innovations and necessary changes in agricultural practices that is likely to facilitate uptake of essential adaptation practices such as improved management of crop and livestock in the wake of accelerating climate change. Besides, group-based income-generating alternatives are likely to increase women's fall-back position through promoting livelihood strategies and build-up of assets through securing loans, which in turn increase their intra-household negotiating power. At community level, group-based approaches provide a podium for community bargaining and participating in the decision-making arena, this increase the political voice and provide a forum for addressing traditions and social norms. Finings of (Meinzen-Dick *et al*. 2011) support women empowerment through women group based approaches by indicating that Women-only groups were likely to be effective pathways for women empowerment, nurturing self-confidence, as well as strengthening women's intra-household bargaining power particularly in the face of gender inequity and lobby for gender aspects and inclusion of women in governance at all levels. Organization of rural women in the area in self-help groups and co-operatives for running agro based enterprises may help them in establishing suitable linkages with credit and financial institutions. It will increase their access *to* the benefits of Government schemes.

Networking of their SHGs will impose high standard, which may increase their confidence, expectations and may improve their self.-image.

Women empowerment in Technical knowledge regarding agroforestry systems may help them in their technological empowerment and can increase their mental horizon. This is mostly agricultural production**,** in which most of the women work to ensure food security for the family as confirmed by (IUCN/UNDP/GGCA, 2009: 118), this is mostly in the use of cultivation and irrigation methods that allow for crop security even in the case of natural resource depletion or unforeseen weather events (IUCN/UNDP/GGCA, 2009: 129). Ideally, one can switch from traditional irrigation methods to efficient, technified irrigation systems. In cultivation methods, farmers need to select crops that can flourish despite of little rainfall and high temperatures for example those with a short growth cycle which can be planted during the (short) rainy season. Moreover, it would also be possible to grow different crops on one and the same field in order to optimize the use of soil and irrigation, locally produced organic fertilizer could also be used to fertilize the soil.

All in all, these adaptation measures could actually increase production and with the existing resources the highest possible yields could be attained. Complementary training and agricultural extension services are required to teach women about the economical use of scarce resources and about processing and marketing methods for agricultural products.

5.2.6 Regression Coefficients for women empowerment and adoption of agroforestry technologies by women in Makindu location and Nguumo locations

The results of table 4.11 indicated a positive and a significant relationship between women empowerment and access to agroforestry technologies ($p<0.05$) in Makindu Location and Nguumo Location. For the empowerment coefficient in Women for Makindu location and increment in women empowerment by one unit increases the adoption rate by 0.432 units. For the coefficient in Nguumo location an increment of women empowerment by one unit increases the adoption of agroforestry by 0.232 units.

This indicated that if many women in Makindu and Nguumo location were empowered in agroforestry technologies then their access to agroforestry technologies as an adaption strategy to climate change and variability would improve. This evident from the current study which established that women farmers in both locations frequently responsible for managing most of the farm activities like planting, weeding, watering harvesting. Also the results show that women farmers do most of the farm work because most men leave for urban areas leaving the women with all household chores. This in line with the findings of (Franzel *et al*., 2002a, Nyeko *at al*., 2004; Schreckenberg, 2004): Kalaba *et al.,* 2009) which indicated that in Kenya and Uganda the proportion of households in which women managed fodder shrubs was over 80%. Despite women's heavy responsibility, their decision making power in the households is limited to by-products of men's trees, subsistence crops that have low returns on labour (Chikoko, 2002).

5.2.7 Relationship between factors influencing adoption of agroforestry technologies by women and various independent variables

The study findings indicated that there was a significant positive relationship between adoption of agroforestry technologies and agroforestry practices by women (rho = 0.627, p-value < 0.05). This implies that a unit change in agroforestry practices by women increases adoption of agroforestry technologies by 62.7%.

There was a positive linear relationship between adoption of agroforestry technologies and empowering women towards adoption of agroforestry (rho = 0.501, p-value < 0.05). This indicates that a unit change in women empowerment towards adoption of agroforestry increases the adoption of agroforestry by women by 50.1%. Thirdly, there was a significant positive relationship between adoption of agroforestry and access and implementation of agroforestry information by women (rho = 0.630, p-value < 0.05). This implies that a unit increase on how women access and implement agroforestry information increases the adoption of agroforestry technologies by women by 63%.

5.3 Role and benefits agroforestry technologies to livelihoods of women and their environment in Makindu and Nguumo locations

The current study established that there is an overwhelming role played by agroforestry to the lives of women in Makindu and Nguumo location and agroforestry technologies provide an array of products and benefits.

5.3.1 Agroforestry products and their benefits to women in Makindu and Nguumo locations

From the results in table 4.13, important agroforestry products and their benefits to the lives of women in Makindu division is highlighted. In Makindu location majority of the respondents indicated that agroforestry products play a great role in the lives of women where 89.6% of respondents said women benefit from fruit trees, 89.1%livestock products, 88.4% benefit in terms of firewood provision, 68.3% food crops, 40.4% get pastures. More so, agroforestry also provides fibre, medicinal products. In location Nguumo location, 52.8%, of the respondents benefit from fruit trees, food crops 71.6%, livestock products 90.6%, pastures 73.6%, firewood 93.4%. Other products obtained gum, timber, medicinal products, recreation, and ecosystem services. Nguumo location benefited more from agroforestry products than Makindu location. This has become a force to reckon with in adapting to climate change impacts. This concurs with the findings of Focus group interviews with Zambian women which reported that women benefitted through provision of fuel wood from improved fallows which reduced the burden of women of having to travel long distances in search of wood fuel (Peterson, 1999).

From the results it can be concluded that agroforestry products are of great importance to women of both Nguumo and Makindu locations because they are the main vendors of family food, fuel and livestock feeds. The results are in consonance with the findings of (Gladwin *et al.*, 2001) who indicated that 30% of the rural smaller households were female-headed in Malawi and over 50% in Western Kenya due to rural-urban migration of men in search of off-farm income placing the responsibility for obtaining food, fuel wood, fodder and other tree products for the family on women. This also in consonance with findings of (Kalaba *et al*., 2009) who indicated that in Parklands of West Africa and in Southern Africa, women were the main collectors of indigenous fruits.

Moreover the current study also established that some of these agroforestry products conserves and protects the environmental resources which are benefit to women especially of Makindu and Nguumo locations. Low cost agroforestry technologies for replenishing soil fertility are attractive to women farmers because they involve low inputs but high returns. This stems from the fact that livestock manure and woody perennials are able to improve and enrich soil conditions through addition of organic matter through litter fall and dead decaying roots, modification of soil porosity and infiltration rates leading to reduced erosion. This collaborates with the findings of (Nair, 1984, 2012) who indicated that agroforestry practices increase organic matter in soil which improves soil nutrient availability, soil water-holding capacity, and carbon sequestration. This provides an effective synergy of adaptation strategies leading to increased food production hence increasing food security as indicated by (Foley *et al*., 2005).

Agroforestry products like trees, pastures, crops reduces impacts of extreme weather conditions especially high temperatures, strong winds recurrent drought and erratic rainfall. This is line with the findings of Boko *et al.*, (2007), Salami *et al* (2010), (FAO, 2010) who reported that changes in precipitation and temperature will make rainfall more erratic and reduce food productivity in the coming years, hence the need for agroforestry adaptation in the light of current climate change and variability situation. From the results it can be deduced that agroforestry has multifunctional benefits to farmers and especially women who in most cases undertake most of the farming activities as men flock in urban centres to seek for white collar jobs. This is in line with the findings of Smith *et al*., (2012) which reported agroforestry as a 'Win-Win' multifunctional land-use approach that balances the production of commodities such as food, feed, fuel, fibre and other non –commodity outputs such as environmental protection and other cultural and land scape amenities.

Agroforestry requires minimal inputs and offers a diversity of products and services. It provides innumerable opportunities to women who in most cases cannot afford to adopt high cost technologies due to their severe cash and credit constrains (Chikoko, 2002).

From the present study, it can therefore be deducted that women farmers in Makindu and Nguumo locations reap various economic benefits from agroforestry. This concurs with the findings of Mercer (2004) who indicated that agroforestry technologies contribute to increased productivity, output stability though risk reduction and enhanced economic viability compared to other land management alternatives. Women use the agroforestry products for subsistence and they sell the surplus to get money which enables them to lift their standards of living. These findings are in line with Kerkhof (1990) who reported that farmers in Rwanda who planted *L.leucocephala and Ccalothyrsus* for fodder increased their milk production and dung for manure which further led to improved crop production and household income. Similar findings from Chaga home gardens (Kerkhof, 1990), ICRAF

(1992) in Western Kenya found that *S.Sesban* was interpolated with maize ,beans, and sorghum because it had light crown with minimal effects on Agricultural crops, is fast growing and produced firewood in about a year.

Further, women in the study areas received substantial financial benefits from fruits and vegetables as agroforestry products because they sold them for money and use them in them household. This is in agreement with the findings of Schreckenberg (2004) who reported that in Benin apart from women earning money from sale of fruits, nuts, butter, and a substantial proportion of fruit products were consumed by the household.

CHAPTER SIX: CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

The study established that majority of the residents of Makindu and Nguumo locations practiced the several types of agroforestry technologies that helped them to counteract the effects of climate change and variability. These technologies include agrisiliviculture, silvipastoral, agrisilvipastoral, agrihortisilviculture, silvihorticulture, agrihorticulture, hortisilvipastoral, hortipastoral, agripasture and silviapiculture. It was established that women were highly involved in practicing most of these technologies.

From the study, it was established that women face several challenges which hinder their easy adoption of agroforestry technologies. These challenges were indicated as inadequate capital was the challenge women face, labour shortage, lack of basic education, land ownership problems, limited decision making, this calls for need of women empowerment to ensure their full participation in agroforestry technologies.

It was also established that women in Makindu and Nguumo locations had different ways in which agroforestry benefited the women. It can comprehensively be deduced that the benefits farmers get from agroforestry are that they are able to get fruits which they use as food and sell surplus to get income. They also get various crops which they use as food for the family and sell for income, also use the byproducts like maize stalks to feed livestock. From agroforestry women also obtain livestock products, pastures and also benefited them in terms of firewood provision.

6.2 Recommendations

From the findings, the study established the following recommendations:

1. The study results established strong factors which hinder women from easy adoption of agroforestry technologies. It also established that women play a critical role in agroforestry and are more vulnerable to the impacts of climate change, therefore the study recommends enhancement of women participation in agroforestry innovations as an adaption to climate change effects. This should be done by the Government and the society by addressing their major challenges. This will enable women fully engaged in agroforestry technologies

2. For future study, more research can be done on gender and climate mitigation. This is because climate change is real and its impacts are strong on human life and his environment. Findings from this research will be useful in solving climate change related problems.

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APPENDIX I: QUESTIONNAIRE

SECTION A: Demographic Data of the respondent

You are requested to participate in this study on; Factors determining adoption of agroforestry technologies among women as an adaptation strategy to climate change in Makindu division (Makindu and Nguumo locations) in Makueni County, Kenya. You responses will be treated with utmost confidentiality and for research purposes only.

A_1.Date of interview…………………….

A_2.District…………….Division…………Location…………….Sub location……

A_3.Name ………………………………...................... (Optional).

A_4.Gender Male [ ] Female [ ]

A_5. Years of residence in the Sub-location ______________________________

A_6. Marital Status: - (i) Single [ ] (ii) Widowed [ ] (iii) Married [ ]
(iv) Separated [ ] (v) Divorced [ ]

A_7. Highest level of education attained

(i) No formal education [ ] (ii) Secondary education [ ]
(iii) Adult education [ ] (iv) Post-secondary education [ ]
(v) Primary education [ ]

A_8. Total number of household members' ________ Dependents ___________

A_9. What is the main economic activity of your household?

(i) Agriculture [ ] (ii) Agroforestry [ ] (iii)) Casual employment [ ]
(vi) permanent employment [ ]

A_{10}. Land parcel, size and mode of acquisition

Land parcel size (ha) _____________________

Mode of acquisition (i) Purchased [ ] (ii) given by government [ ] (iii) inherited [ ] (iv) Cleared [ ] (v) lent [ ]

A_{11}. Do you cultivate more than one crop? Yes [ ] No [ ]

If yes mention the crops

____

A_{12}. Do you apply any fertilizer on you land? Yes [ ] No [ ]

If yes, name the fertilizers____

A_{13}. If you're not using mineral fertilizer give the reasons

____

____

A_{14}. What is the main source of labor for your farm activities?

(i) Family members [ ] (ii) Hired labor [ ] (iii) Both 1&2 [ ]

(iv) Others specify____

SECTION B: Common Agro Forestry technologies practiced by women in the Study Area

B_1. Do you practice agroforestry? Yes [ ] No [ ]

B_2. Do you practice it on your own or family land?

(i) Own [ ] (ii) Family land [ ] iii) others [ ]

If other, please specify ______________________________________

$B_{3.}$ If your answer to B2 above is i) how did you acquire your land?

Inherited [ ] Bought [ ]

B_4. Is the land you operate agroforestry on having any ownership dispute?

Yes [ ] No [ ]

If yes, please specify ______________________________________

B_5. How much land is under your ownership in acres?

(i) Less than 2 [ ] (ii) 2-4 [ ] (iii) more than 5 [ ]

B_{6a}. What percentage of the land in B5 above have you put under agroforestry?

(i) Up to 25% [ ] (ii) 26-50% [ ] (iii) 51-75% [ ] (iv) 75% or more [ ]

B6b. To what extent are women involved in the following agroforestry practices.

Agroforestry Practices	5 Very High	4 High	3 Moderate	2 Low	1 None
Planting					
Weeding					
Watering					

B_{7a} Have you adopted any agroforestry technologies/systems on your land?

Yes [ ] No [ ]

B7b. To what extend have you adopted the agroforestry technologies on your land?

Agroforestry technology	5 Very High	4 High	3 Moderate	2 Low	1 None
Agrisilviculture system					
Silvipastoral system					
Agrisilvipastoral system					
Agrihortisilviculture system					
Silvihorticulture system					
Agrihorticulture system					
Hortisilvipastoral system					
Hortipastoral system					
Agripasture system					
Silviapiculture system					

B_8. Do you plant trees on your land? Yes [ ] No [ ]

B_9. If the answer to B_8 above is "yes, how to you plant them?

(i) Scattered on the crop land [ ] (ii) Along the boundaries [ ]

(ii) Live fence [ ] (iv) Wind break [ ]

(v) Woodlots/block planting [ ]

B_{10}.What kind of trees do you commonly grow?

(i) Fruit trees [ ] (ii) Fodder crops e.g. lucaena [ ] (iii) Others [ ]

If others, please list ____

B_{11}. Where did you get seedlings from?

(i) Given free [ ] (ii) raised my own [ ] (iii) buy [ ]

(iv) others, (specify)

____

B_{12}. Do you intercrop other crops with the trees? Yes [ ] No [ ]

B_{13}.If the answer for B_{11} is yes, please list the crops you intercrop under:

i) Food crops ____

ii) Fodder crops ____

iii) Cash crops ____

B_{14}. Do you keep livestock? Yes [ ] No [ ]

B_{15}. If the answer in B_{13} above is yes which are the common types of livestock?

(i) Goats [ ] (ii) Sheep [ ] (iii) Cattle [ ] (iv) Poultry [ ] (v) Bees [ ] (vi) Fish [ ] (vii) Combination of animals [ ]

B_{16}. If you answered to combination of animals above, which one applies?

(i) Goats and sheep [ ] (ii) Sheep and cattle [ ] (iii) Cattle and goats [ ]

(i) cattle and poultry [ ] (ii) Sheep and poultry [ ] (iii) Cattle and bees [ ]

(i) Goats and bees [ ] (ii) Sheep and bees [ ] (iii) Cattle and fish [ ]

(iv) other, please

specify____

SECTION C: Role of agroforestry in climate change adaptation.

C_1. For the past 10 years have you experienced any prolonged drought?

(i) Yes [ ] (ii) No [ ]

C_2. Does prolonged droughts affect crop and livestock yields in your area?

(i) Yes [ ] (ii) No [ ]

C_3. If, Yes mention:

(a) crops which are most affected 1....... .... 2......................... 3...................................

(b) Tree species which are most affected 1.................... 2..........................

3.................................... (c) Livestock which are most affected 1....................... 2.......................... 3...................................

C_4. If, No mention

(a) crops which are drought resistance 1................. 2.......................... 3..........................

(b)Tree which are drought resistance 1................... 2.......................... 3............................

(c) Livestock which are drought resistance 1...................... 2...................3.......................

C_5. Mention benefits you obtained from your AF farm (s)

(i) fodder for livestock [ ] (ii) producing energy [ ]

(iii) supporting biodiversity [ ] (iv) reduces impacts of extreme weather [ ]

(v) protects crops from floods [ ] (vi) trapping sediments/nutrients [ ]

(vii) provide jobs [ ] (viii) others [ ]

If others, please

specify____

C_6. What challenges or problem are you experiencing in managing AF?

____

____

____

C_7. How do you cope with this challenges?____

____

____

____

C_8. Do extension officers visit you? (i) Yes (ii) No

C_9. If yes, who? (i) crops officer [ ] (ii) forester [ ] (ii) livestock officer [ ] (iv) Other, specify____

C_{10}. If not where do you get extension services from? (i) Friends [ ] (ii) Tv/radio [ ] (ii) others, please specify____

C_{11}. Are there any changes in tree/crop/livestock species intercropped in the past 10 years (i) Yes [ ] (ii) No [ ]

(a) If yes what are those plant species and crops intercropped previously

____

____

(b) What are the new ones?

____

____

C_{12}. What are the reasons for adopting this new crops/tree/livestock/mixed cropping?

____

____

____

C_{13}. Do you normally need wood based material daily? (i) Yes [ ] (ii) No [ ]

C_{14}. Are there changes in AF products demand over the past 10 years? (i) Yes [ ] (ii) No [ ]

C_{15}. If Yes which AF product is more demanded____

____

____

C16. What are the causes of increased AF product consumption?____

____

____

C_{17}. What percentage of the household income is generated from AF products?

____

SECTION D: Gender Role in Agroforestry as a Climate Change adaptation strategy.

D_1.Does gender play any critical role in success of agroforestry? Yes] No [ ]

If yes please specify____

____

____

D_2.Do women face any challenges in adoption of agroforestry? Yes [ ] No [ ]

D_3. On a scale of 5 to 1 please give your assessment on the extent to which you think the following challenges hinder women in the adoption of agroforestry technologies/systems.

Challenge	5 Very High	4 High	3 Moderate	2 Low	1 None
Land and tree tenure					
Household decision making					
Access to financial resources					
Labour					
Education and extension services					
Lack of appropriate technology					
Custom taboos					

D_4.According to your own opinion, do you think that women are able to manage agroforestry?

Yes [ ] No [ ]

D_5. If the answer in E_8 is “yes” give your reasons

____

____

D_6.How is agroforestry of benefit specifically to women farmers

____

____

E_{7a}.Are there any challenges hindering women from access agroforestry information from extension officers/other sources? Yes [ ] No [ ]

E_{7b}. To what extent do you think the following factors have an impact on women accessing and implementing agroforestry information gained from extension officers.

Factor	5 Very High	4 High	3 Moderate	2 Low	1 None
Socio-cultural factors					
Women are not decision makers					
Lack of basic education					

D7c.Do women need empowerment in AF technologies Yes [ ] No [ ]

D7d If yes, mention the areas

____

____

D7e Are you empowered in any of the above mentioned areas? Yes [ ] No [ ]

D_8.Who is mostly involved in marketing of agro forestry products? Men [ ] women D9.If the answer in E_{14} above is women, give your reasons

____

____

D_{10}.What are the common agroforestry products marketed by women?

(i) Fruits [ ] (ii)Food crops [ ] (iii) Livestock products [ ]

(iv) Pastures [ ] (v) Firewood [ ] (vi) Others, specify

____

____

Appendix 4 Checklist for key informants and leaders

Dear Leaders/extension officers/ Key Informants etc. (.....................................)

This study will be investigating gender roles in agroforestry practices as an adaptation strategy to climate change in Makindu division (Makindu and Nguumo locations) in Makueni County, Kenya. Therefore, you are kindly requested to respond trustfully to the following questions. You responses will be treated with utmost confidentiality and for research purposes only.

I thank you in advance.

1. What is the current trend of adoption in AF practices in the Division?
2. Which tree species are more preferred by farmer and there uses?
3. Where do farmers get planting materials?
4. Are there any existing organization(s) supporting AF in the division?
5. What do they do to support communities?
6. Are there challenges hindering the sustainability of AF? If yes which ones,
7. Is there any changes in AF practices over past 10 years? If Yes Why?
8. Where do communities obtain their wood products from?
9. Are there any changes in the uses or demand of wood products? If so what are they?
10. Are there any changes in crops in the past 10 years or more?
11. If yes what are new crops grown and adopted by the household?
12. Have the changes in crops grown affected households income?
13. Have new cash crops introduced in the past 10 years or more?
14. If yes, which are they?
15. Have the changes in cash crops affected AF practices

APPENDIX II: PLATES

Plate 1: Combination of fodder and multipurpose trees

Source: Students Field Photography: Date taken 10.08.2018

Plate 2: Maize intercropped with cowpeas, kales and mango trees

Source: Students Field Photography: Date taken 10.08.2018

Plate 3: Boundary planting using multipurpose trees

Source: Students Field Photography: Date taken 10.08.2018

Plate 4: Combination of fodder and multipurpose tree species

Source: Students Field Photography: Date taken 10.08.2018

APPENDIX III: RAINFALL AND TEMPERATURE DATA

RAINFALL DATA FOR MAKINDU MET STATION FROM 1980.(IN MM)

YEAR	JAN.	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	TOTAL
1980	48.4	20.7	71.4	66.5	21.2	TR	TR	7.1	0.1	0.6	137.1	37.8	410.6
1981	TR	TR	104.9	288.2	80.4	0.0	0.0	0.4	2.4	42.9	45.2	98.5	652.9
1982	1.0	TR	7.4	176.2	34.6	0.7	1.6	1.2	11.3	147.6	397.7	158.4	937.7
1983	0.5	36.9	3.0	40.8	12.0	0.1	0.5	0.0	2.3	0.3	15.8	147.2	257.4
1984	27.7	TR	6.0	86.9	TR	TR	1.2	TR	0.4	85.6	358.9	122.4	689.1
1985	5.3	83.1	34.1	81.9	13.8	0.2	1.6	TR	1.6	67.4	125.6	87.3	501.9
1986	19.7	0.1	36.3	169.5	20.4	6.5	0.0	3.0	TR	20.4	181.8	120.1	577.8
1987	16.5	TR	16.1	62.9	55.6	19.5	1.0	2.0	TR	0.5	108.9	10.4	293.4
1988	79.5	1.0	175.0	99.4	6.3	7.1	1.3	1.1	2.1	2.4	176.5	160.2	711.9
1989	131.4	1.2	76.6	260.6	49.8	0.3	TR	0.7	0.6	125.3	186.1	143.4	975.9
1990	49.9	87.7	130.3	109.3	8.7	0.0	0.0	0.0	0.2	5.5	180.7	199.8	772.1
1991	28.0	0.3	38.0	60.3	49.4	2.0	1.4	21.2	TR	0.2	190.6	97.5	488.9
1992	23.0	TR	9.7	154.7	24.7	0.0	TR	TR	2.6	107.6	139.0	142.6	603.9
1993	140.3	18.4	16.7	0.6	1.6	0.9	TR	2.2	TR	61.3	86.9	114.3	443.2
1994	0.4	40.2	56.2	101.7	12.0	TR	0.3	0.0	0.3	16.0	247.5	299.9	783.7
1995	2.7	57.9	95.6	27.0	12.1	90.0	0.3	0.7	TR	58.4	71.3	49.9	372.7
1996	8.8	65.5	105.3	48.4	25.7	1.7	0.8	TR	0.0	0.0	190.4	7.8	461.5
1997	0.6	0.5	10.0	150.1	37.4	3.7	TR	TR	TR	33.4	262.8	282.4	779.2
1998	405.2	232.8	42.9	86.5	121.3	16.5	5.0	TR	1.2	0.5	89.8	8.7	1010.3
1999	6.6	TR	84.7	49.3	2.1	0.5	T	0.9	TR	0.2	490.4	99.6	734.3

							R						
2000	3.9	TR	14.5	123.2	2.5	2.4	0.7	3.4	5.1	TR	185.5	179.8	521.0
2001	160.1	1.8	50.9	89.0	0.2	1.9	0.0	0.0	TR	0.1	278.4	148.8	730.3
2002	22.3	7.2	108.1	43.1	30.1	0.4	TR	4.1	19.5	25.9	99.5	131.2	491.4
2003	0.3	34.6	79.5	79.1	34.6	0.0	0.0	TR	0.6	0.6	67.4	65.3	362.0
2004	169.3	63.4	72.2	45.7	0.0	0.3	0.0	0.2	1.2	26.0	33.6	89.3	501.2
2005	4.0	TR	51.6	44.5	28.8	TR	0.4	2.9	1.6	14.5	71.4	6.1	225.8
2006	2.2	0.2	42.5	103.5	45.1	0.0	0.0	TR	6.8	57.2	252.8	363.3	873.6
2007	103.2	5.6	51.7	44.7	5.9	1.0	0.3	TR	TR	12.0	130.5	112.9	467.8
2008	57.7	7.3	222.4	13.4	1.0	0.0	0.0	0.0	1.3	14.2	82.5	5.8	405.6
2009	29.3	13.4	1.2	38.2	13.1	0.3	0.0	TR	TR	57.6	54.5	161.1	368.7
2010	11.8	121.4	160.7	63.6	13.5	0.0	0.0	TR	1.2	3.6	109.0	52.8	537.6
2011	12.9	47.8	111.0	1.5	4.1	0.0	TR	0.1	0.3	26.1	133.0	114.0	450.8
2012	3.7	5.9	24.4	155.1	20.5	19.5	TR	2.5	0.3	1.5	144.7	153.3	521.8
2013	31.2	TR	52.2	83.5	32.1	0.0	0.0	0.0	15.0	0.4	204.9	101.6	520.9
2014	TR	49.0	201.2	43.2	7.2	TR	TR	TR	3.0	TR	117.0	78.1	498.7
2015	0.0	52.0	48.8	71.4	70.6	1.0	1.2	TR	0.0	0.1	84.5	62.1	391.7
2016	47.7	61.2	7.7	114.8	5.5	0.2	0.0	0.0	1.3	0.1	187.6	38.1	464.2
2017	2.0	5.9	1.2	109.2	47.1	0.0	0.0	14.7	0.0	5.2	118.3	54.8	358.4

<u>Temperatures data</u>

	MEAN MAXIMUM FOR MAKINDU MET STN															
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC				
2017	**31.4**	**31.5**	**33.6**	**31.1**	**28.6**	**28.8**	**27.7**	**28.4**	**29.6**	**31.6**	**28.5**	**29.3**				
2016	30.1	31.4	34.0	31.1	28.9	28.0	27.3	28.3	28.7	31.4	29.0	28.7				
2015	31.5	32.4	32.0	30.7	28.9	28.4	27.7	27.9	30.3	31.5	30	29.3				
2014	29.9	30.9	30.6	29.8	29.1	26.9	27.3	28.5	28.7	31.1	29.5	28.5				
2013	30.3	32.3	32.5	30.0	28.8	26.9	26.7	27.1	29.8	30.9	29.2	27.3				
2012	31.7	32.5	33.0	30.2	29.4	28.3	27.9	28.4	30.2	31.5	30.7	29.4				
2011	31.1	31.8	31.8	31.3	30.7	28.9	28.5	28.0	29.8	30.0	29.1	29.4				
2010	30.0	31.1	29.4	29.7	29.4	28.6	27.8	27.7	29.0	31.2	28.9	29.2				
2009	30.3	31.3	32.8	31.8	30.2	29.2	27.8	27.7	30.0	29.5	30.0	30.3				
2008	29.3	30.9	31.5	29.4	29.4	27.6	26.4	27.9	30.3	31.6	29.4	30.3				
2007	27.8	31.6	31.6	30.9	30.1	29.2	27.8	28.1	30.0	30.5	28.9	28.5				
2006	30.8	32.2	31.9	29.6	28.9	28.5	26.7	28.9	29.2	30.5	27.7	27.4				
2005	31.0	32.1	32.4	30.8	31.3	28.2	26.7	26.9	29.3	30.8	29.5	30.0				
2004	29.1	29.4	31.7	29.8	30.1	27.9	27.9	27.9	29.8	30.4	30.4	28.4				
2003	30.1	32.5	32.6	30.8	28.1	28.1	27.4	27.4	29.6	30.5	29.1	29.8				
2002	28.0	28.4	30.2	30.4	29.8	28.4	28.5	26.6	29.1	30.0	29.1	27.8				
2001	27.7	30.0	31.7	29.3	29.9	27.7	26.6	28.6	29.6	30.6	27.8	27.0				
2000	28.3	31.6	32.1	30.0	29.0	27.3	26.4	27.7	28.5	30.6	28.9	27.8				
1999	30.8	32.0	31.1	29.0	29.3	27.5	25.8	27.2	29.6	30.3	28.1	26.9				
1998	27.0	27.8	29.6	29.3	27.7	27.3	25.8	26.7	28.4	29.3	29.2	29.5				
1997	30.9	32.7	31.7	29.4	27.0	27.5	27.0	28.3	27.9	29.0	27.7	26.5				
1996	30.7	31.7	30.8	29.7	28.9	26.7	26.1	27.0	28.3	29.9	28.3	28.8				
1995	27.9	29.6	30.0	30.2	29.3	28.2	27.0	28.0	29.3	30.0	28.3	28.5				
	MEAN MINIMUM FOR MAKINDU MET STN															
	JAN	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**				
2017	18.1	19.2	19.8	19.6	17.9	16	15.5	16.5	16.2	18.4	19.1	18.8				
2016	19.5	19.3	20.8	20.2	17.6	16.1	14.5	15.2	16.1	17.2	19.1	18.8				
2015	17.3	18.8	19.0	19.6	17.9	15.8	15.3	15.7	15.7	19.0	19.6	19.1				
2014	18.2	18.7	19.3	18.8	17.4	15.3	14.7	15.0	16.2	18.2	18.8	18.7				
2013	18.5	18.3	19.5	19.3	16.8	15.3	14.7	14.9	16.0	17.6	18.6	18.6				
2012	17.2	18.5	18.5	18.9	17.1	15.4	14.6	14.9	16.0	17.8	19.4	18.8				
2011	17.9	18.1	18.7	18.9	17.9	16.1	14.6	14.9	16.6	24.4	18.8	18.6				
2010	19.0	19.5	19.3	19.1	18.0	19.6	14.2	14.6	15.6	17.4	18.8	19.5				
2009	18.4	19.4	19.4	19.3	18.4	16.5	14.5	16.5	16.5	18.5	19.2	18.1				

2008	17.2	17.3	18.8	17.4	16.4	15.1	14.4	15.0	15.8	18.0	19.0	18.1				
2007	17.6	18.0	18.7	18.9	17.4	14.9	13.7	14.9	15.7	17.1	18.6	17.4				
2006	18.5	19.1	19.9	18.6	17.6	15.3	14.5	15.1	15.8	17.2	18.5	18.7				
2005	18.4	18.8	19.7	19.3	18.3	16.6	15.0	15.5	15.6	16.9	18.7	18.5				
2004	19.4	18.5	19.1	19.1	17.2	14.7	13.1	13.9	16.0	17.7	18.7	18.6				
2003	18.0	18.4	19.7	19.3	18.3	16.3	14.6	15.1	16.7	18.2	18.8	17.8				
2002	18.1	18.0	19.8	19.2	17.2	15.5	15.6	15.4	16.1	17.1	18.9	19.2				
2001	18.0	18.4	18.7	18.8	17.4	15.5	14.3	15.0	16.5	17.3	18.5	18.5				
2000	16.7	16.9	19.2	18.0	17.1	15.2	14.5	14.9	15.3	16.8	18.7	18.7				
1999	18.6	17.9	19.4	18.4	19.1	15.7	13.8	15.6	16.6	16.7	18.0	18.2				
1998	19.0	19.2	19.8	19.4	17.6	15.4	14.8	15.0	16.0	16.5	17.9	18.6				
1997	17.3	17.7	19.0	19.1	17.5	16.2	14.4	15.2	15.3	16.9	18.7	18.9				
1996	18.6	19.1	19.4	18.3	17.3	16.9	15.0	14.9	16.3	17.0	18.3	17.6				
1995	17.9	17.5	18.3	18.5	17.7	15.5	14.4	14.9	16.1	18.1	18.9	18.5				
	NOTE THAT TEMPERATURES BEFORE 1995 ARE NOT AT THE STATION															