THE POTENTIAL OF AGROFORESTRY AS AN ADAPTATION STRATEGY TO MITIGATE THE IMPACTS OF CLIMATE CHANGE: A CASE STUDY OF KIINE COMMUNITY- KIRINYAGA COUNTY

BY

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DECLARATION

This report is my original work and it has never been produced in this form and presented to any examination body, college or university

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DEDICATION

This work is dedicated to my family namely to Josphat Munene, Joyce Wanjiru, Humphrey Maina, Robert Gitonga, Caroline Wanjiku and Philip Wachira.

ABSTRACT

Kenya, just like other countries in the world, continues to feel the impacts of climate change. These impacts are huge more so in Africa, as the backbone of its economy is heavily reliant on agriculture. As we know, most agricultural activities in Kenya are rain fed, with very few under irrigation. Given that adverse effects such as climate variability and change continue to be observed, the livelihoods of farmers continues to be compromised. Further, irrigated areas are uncommon as most of the Countries populace are poor with limited pro-poor inputs to sustain agricultural practices.

The World Agroforestry Centre (2013) defines agroforestry as a dynamic, ecologically based, natural resource management system that, though integration of trees on farms and in agricultural landscapes, diversifies and sustain production and builds social institutions. This system has for many years demonstrated potential to mitigate impacts of climate change. For instance, Mbow Cheikh et al (2014) note that agroforestry provides assets and income from carbon, wood energy, improved soil fertility and enhancement of local climate conditions as well as provides ecosystem services and reduces human impacts on natural forests. FAO (2010) states that incorporating trees and shrubs in food crop systems help address food insecurity, increase CO_2 sequestration and reduce vulnerability of agricultural systems.

In Kenya, Kiine south area in Kirinyaga County is no different. It is mainly an agricultural area which over the years has been producing less food owing mostly to the impacts of climate change. For instance, observed prolonged dry seasons and shorter rainfall seasons continue to be observed. Additionally, its people continue to rely on unsustainable practices which limit the benefits which would otherwise be derived from the same agricultural land using improved practices such as agroforestry.

The purpose of this study was to evaluate the potential of agroforestry as an adaptation strategy to the impacts of climate change in the study area. The specific objectives were to profile agroforestry practices and climate change adaptation benefits derived from each

of them, to identify key agroforestry costs and benefits and to determine contribution of agroforestry to the improvement of livelihoods of the Kiine Community. Using stratified sampling technique, the study sample of 100 farmers was used to collect data. Both structured and unstructured questionnaires were used to obtain information from individual farmers.

The study employed questionnaires and observation schedules to gather data from individual farmers related to the study objectives.

Generally, the study established the following.

Planting of trees and shrubs as windbreakers, riparian forest buffers, silvopasturing, and boundary planting were the most preferred methods of agroforestry whereas forest farming, alley cropping and woodlots were least preferred. It was also found out that there is need for training as well as introduction of both indigenous and exotic agroforestry tree species. Specifically, 94% and 90% of the respondents felt that there is need for them to be trained on agroforestry practices as well as incorporation of exotic species which the respondents felt would assist in reducing the lengthy production period of trees on farm. On the other hand, 90% of the respondents believe that agroforestry can increase catchment for rivers and streams, improve climate, increase wood production as well as improve livestock health and products.

The finding established that agroforestry has a direct link in improving livelihoods of people in the study area. For example, farmers in the area would trade agroforestry products in the market such as food (fruits), fodder, fuel wood, medicinal substances, gums, tannins, essential oils, fibres and waxes. The money obtained, provides means for accessing second tier facilities such as paying school fees for their children or even accessing heal care facilities.

Given the findings, the study concludes that agroforestry is an approach to agricultural production that can reduce the impacts of human activities and global climate change on the local environment. Agroforestry can improve the resilience of agricultural production

to current climate variability as well as long-term climate change through the use of trees for intensification, diversification and buffering of farming systems.

The major recommendation from this study is that training in agroforestry practices is key to a successful integration of agroforestry as part of current agricultural practices. Equally important is the need for the county government or respective officials to establish farmers' links to the markets. Here, they will be assured of income as they trade agroforestry products.

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LIST OF ACRONYMS

AGW	Anthropogenic Global Warming
CFC	Chlorofluorocarbons
FAO	Food and Agricultural Organization of the United Nations
GHG	Green House Gases
ICRAF	International Centre for Research in Agroforestry, also known by the brand name World Agroforestry Centre
IPCC	Intergovernmental Panel on Climate Change
KPHC	Kenya Population and Housing Census report
SDG	Sustainable Development Goals
UNEP	United Nations Environmental Program

CHAPTER ONE: INTRODUCTION

1.1 Background of the Study

The World Summit on Social Development (1995) defines poverty as a "condition characterized by severe deprivation of basic human needs, including food, safe drinking water, sanitation facilities, health, shelter, education and information. It depends not only on income but also on access to services". Exacerbating this condition is the poor's direct reliance on the environment and its services for their livelihoods.

Poverty leads to extraction of environmental commodities at rates which often exceed replenishment rates. The result is a degraded environment which cannot satisfy the needs of the current population not forgetting threatening the existence of mankind's future needs. To date, widespread poverty and environmental degradation continues to be observed despite efforts put forth by governments, non-governmental organizations or even civil societies. Often fashioned by inadequate shelter, malnutrition, increase in infant mortality rates, lack of income as well as unsanitary living conditions, this state continues to weigh down developmental efforts targeted at diverse goals including reducing poverty and/or eradicating hunger, to mention but a few. Various studies have demonstrated the linkages between poverty and the environment such as those by Agarwal, B. (1997), Cleaver, K. (1997), and World Bank (2000).

In essence, where the populace is 'poor', the environment in that locality is more often than not degraded. Such degradation is caused by diverse activities which include population growth as well as technological advancements. Such activities contribute to great disparities between demand and supply of services such as energy, food, housing, transport, water, sewerage facilities, etc. Undoubtedly, the result has been undesirable changes in land use- deforestation, poor farming methods, deterioration of air and water quality, unsustainable generation and management of wastes, and proliferation of slums. The following are some of the factual impacts of environmental degradation.

1. Widespread impacts to climate change especially to the developing countries (DFID, EC, UNDP and World Bank, 2002)
2. Increase in the development and spread of vector-borne diseases which include malaria (WRI, 1998)
3. Emergence of acute respiratory infections in women who often cook using fuel wood (Ezzati and Kammen, 2001).
4. Major reduction in livelihood options as most of the services offered by the environment will be significantly reduced (Brocklesby and Hinshelwood, 2001).

It is unquestionable to say that the above conditions will be deteriorated by climate change given that the mean global temperature has increased by 0.3 – 0.6C over the past Century (IPCC, 1990. Greenhouse gases are mainly produced by human activities which include burning of fossil fuels, deforestation and poor agricultural practices. Clearing of land to make provision for agricultural activities has contributed to the loss of about 13 million Ha of forest annually (FAO, 2006)

The greenhouse effect basically increases surface temperatures by about 30°C by trapping heat emitted from the earth's surface Pearce (2003) and Pierrehumbert (2004).

The impacts of climate change-hugely caused by pollution, are varied in the countries, regions and continents (UNFCC, 2007).

Role of Agroforestry

The International Centre for Research in Agroforestry - ICRAF (2013) defines agroforestry as an agricultural system that integrates trees, shrubs and animals in a farm that results to multiple benefits. These benefits are multiple and include making available fodder for animals, timber for fuelwood, enrichment of soil as well as medicinal products (Sanches, 2000; Kwesiga *et al.*, (2003).

There are different types of Agroforestry systems. These are forest farming, riparian buffers, alley cropping, silvopasture, as well as forest. According to Agroforestry Research Trust (2010), various studies have noted the benefits of integrated farming

systems in comparison to monoculture systems as they increase diversity in areas of food production and livelihoods mainly through sale of farm produce. Without doubt agroforest is an agricultural system which is promising in solving numerous challenges of our time.

Kirinyaga County is no different. According to Kirinyaga County First Integrated Development Plan for 2013-2017, the major contributors to environmental degradation in the County are deforestation, poor solid waste disposal, cultivation along river banks, and pollution from industries and farmers. This report further states that these factors have led to huge climate variability and change which has adversely affecting the agricultural and health sectors due to unpredictable rainfall patterns, recession of the glaciers on Mt Kenya which is a water tower in the county among other things.

The Country continues to witness increasing negative effects of climate change and its impacts. This is made worse by the current environmental conditions (degraded soils, poor agricultural practices) as well as poverty. Therefore; this study seeks to clearly establish the potential of agroforestry as an adaptive strategy to the negative impacts presented by climate change in the study area.

1.2 Problem statement

Globally, one of the promising applications of agroforestry is in assisting communities to not only cushion themselves but also adapt to the negative impacts of climate change (Mbow, Cheikh, *et al.* (2014), Verchot, L.V, Noordwijk, M.V, *et.al* (2007). Without doubt, agroforestry presents possible solution to combat negative impacts of climate change (Rocheleau *et al*, 1989).

The need to have adaptation strategies is more so in the developing countries where there is huge reliance on agriculture for livelihoods. According to Koohafkan, P, *et.al* (2012), there are some forms of agroforestry which are pro-poor thus easily accessible and adopted as they require minimal inputs.

FAO (2012) states that in most parts of Africa, climate change mitigation focuses mainly on reforestation and conservation which presents further problems as majority of the populace require land for agricultural practices. The Current Opinion in Environmental Sustainability (2014) holds that numerous studies have shown a clear and unswerving link between climate change impacts and agricultural production. However, it noted further the need to conduct specific research on areas so as to identify which agroforestry systems are most suited to derive the most benefits including enhancing livelihoods of the population.

Cheikh Mbow, M.V Noordwijk *et al* (2014) note that many gaps exist when using agroforestry in rural areas in Africa. These gaps include areas in policy, institutional frameworks as well as capacity of local establishments including farmers that will contribute towards uptake of the pro-poor agroforestry strategies (Kiptot, E, *et. al*, 2014). Additionally, (FAO, 2104) notes that there are deficiencies in policy formulation and adoption as well as poor coordination amongst different actors thus limiting the numerous benefits that would be realized with the adoption of agroforestry practices.

As there is inadequate information on agroforestry links in the study area, this study investigated agroforestry practices which can derive maximum benefits in terms of adaptation, identification of key costs and associated benefits and establishment of whether agroforestry can significantly contribute to the improvements of livelihoods of the people in the Kiine.

1.3: Research Questions

1. Can some agroforestry practices contribute towards mitigating the vagaries of climate change at the community level?

2. What are the major agroforestry costs and benefits related to adaptations to climate change?

3. Will agroforestry adaptation significantly contribute towards livelihood improvement?

1.4: Objectives of the Study

The study endeavored to accomplish the following general and specific objectives:

1.4.1 General Objective

To investigate the potential of agroforestry as an adaptation strategy to mitigate the impacts of climate change.

1.4.2 Specific Objectives

1. To investigate which agroforestry practices provide maximum benefits in terms of adaptation to impacts of climate change in the study area.
2. To identify major agroforestry costs and benefits in adaptation to climate change.
3. To determine if agroforestry can significantly contribute to the improvements of livelihoods of the people in the study area.

1.5 Justification of the Study

There is not much research that has been undertaken in Kiine County to establish the potential of agroforestry as an adaptation strategy to the impacts of climate change. Given that this area continues to witness shifts in rainfall patters including associated challenges such as drought and reduced food production, it is important to examine if agroforestry can be successfully adopted which can in turn increase the resilience and diversify the livelihoods of the Community. For instance, the provision of fruits and medicine through the fruit and medicinal tree species, timber and income derived from timber sales through integration of wood/timber species, as well as incorporation of fertilizer trees which collectively enrich impoverished soils as well as provide anchorage to both plants and soils.

This study will contribute to the existing body of knowledge that demonstrate the benefits and potential of agroforestry as an adaptation strategy to the impacts of climate change. Outputs from this work can be used by local farmers and farmer

groups for upscaling in areas with similar climatic/environmental conditions (to that of Kiine) as well as by policy makers and other key stakeholders so that incentives can be identified and strengthened which will enhance uptake of agroforestry.

1.6 Scope of the Study

This study was conducted in Kiine south sub location in Kirinyaga county- Kenya.

According to the 2009 Kenya Population and Housing Census report (KPHC, 2009), the population of the county is "528,054 and has an annual growth rate of 1.5 percent and projected to be 595, 379 in 2017 as compared to 552,359 recorded in 2012". The population density for the County was 488 people per Km2 in 2012 and projected to increase further to 524 people per Km2 in 2017. The Kenya Integrated Household Budget Survey (KIHBS 2005/06) has it that 67% of land parcels in the county have title deeds, while 23% of farmers farm on land owned by National Irrigation Board. In addition, the County has a poverty rate of 36% compared with national average of 46%.

The Kirinyaga County Transition Plan (2014) notes that Kirinyaga County covers an area of 1,478.1 square kilometers and is divided into three ecological zones; the lowland areas that fall between 1,158 metres to 2,000 metres above sea level, the midland areas that lie between 2,000 metres to 3,400 metres above sea level and the highland comprising areas of falling between 3,400 metres to 5,380 metres above sea level. The lowland area is characterized by gentle rolling plains that cover most of Mwea constituency. The midland area includes Ndia, Gichugu and Kirinyaga Central constituencies. The highland area covers the upper areas of Ndia, Gichugu and Central constituencies and the whole of the mountain area. Kiine South is part of Ndia constituency in Kirinyaga County. This area was selected inspite of it being in the midlands, it has been impacted by the negative impacts of climate change coupled with the fact that about 87% of its population are employed in the agricultural sector and contributes 72% of household income. Farmers in the area provided data key in examining the objectives of this study.

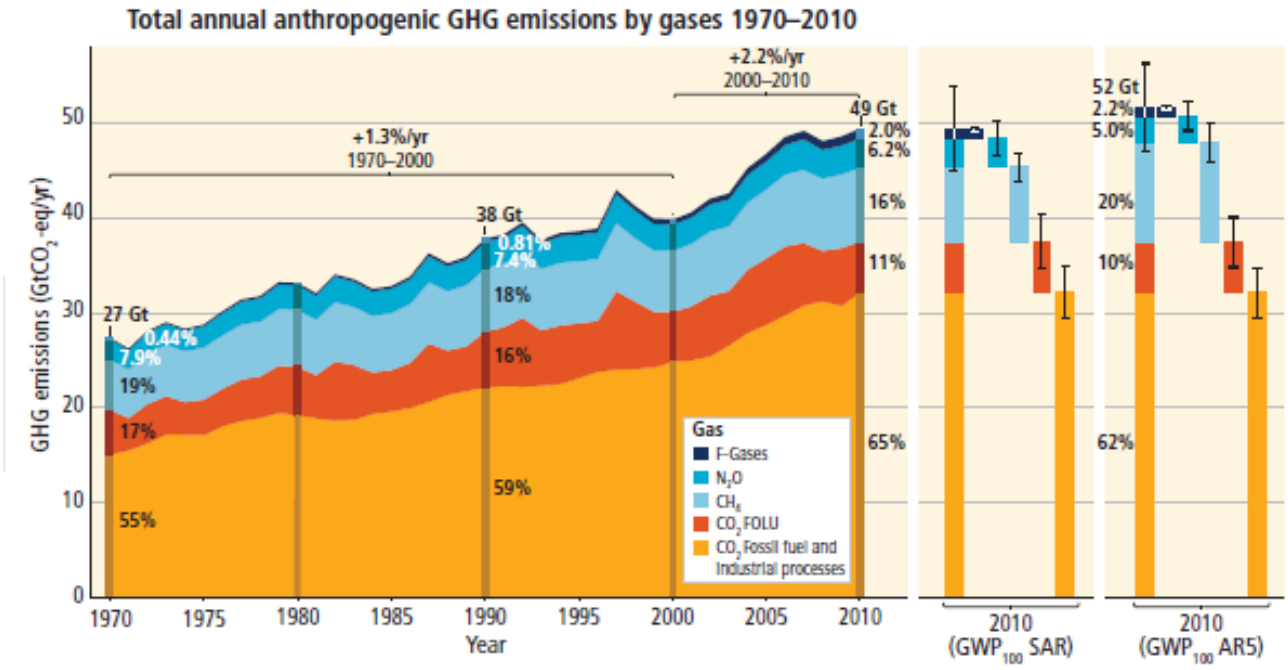
Figure 1.1 Map showing location of Kirinyaga County

CHAPTER TWO: LITERATURE REVIEW

2.0 Theoretical literature from global perspective

Climate change is a global issue and is predominantly thought to have been caused by human activities and observed over a period of time (UNFCCC, 2005). Such changes are observed in terms of various indicators which include characteristics of rainfall patters, duration of rainfall and dry seasons (The Kenya Climate Change Action Plan-2013-2017). The figure below shows the total anthropogenic Greenhouse gas emissions by gases between 1970 and 2010.

Figure 2.1 Total anthropogenic GHG emissions by gases 1970-2010



Source: IPCC (2014)

2.1 Concept of Climate Change

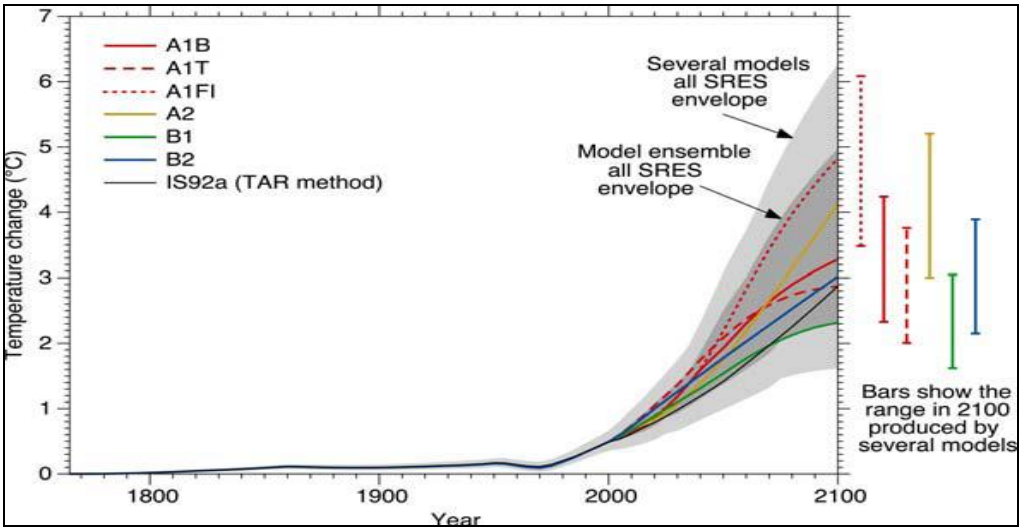
From the first half of the 20th Century, global surface temperatures continue to increase by between 0.3 to 0.6 degree Celsius (IPCC (1990) and much of this is attributed to anthropogenic activities related to poor agricultural practices, deforestation, use of fossil fuels that lead to emissions of greenhouse gases like methane, carbon dioxide and nitrous

oxide among others which contribute to the occurrence of the Greenhouse effect – a process and state where the earth's surface temperatures are higher by 30℃ to that which is expected. The greenhouse effect allows incoming radiation into the earth's surface but fails to allow infiltration of outgoing radiations from the earth's surface with a result of increase in temperatures.

2.2 Impacts of Climate Change

Various studies mentioned in this report clearly indicate the existence of climate change impacts that include an increase in surface temperatures. Given that the World's population will continue increasing, it is expected that the temperatures will also increase as a result of environmental stresses due to increased demands in agricultural lands (thus leading to deforestation) or even poor agricultural practices in an attempt to maximize output by use of fertilizers that end up producing greenhouse gases. Figure 2.2 below shows projections for the 21st Century and Figure 2.3 showing annual anthropogenic Carbon Dioxide emissions.

Figure 2.2 Temperature projections for the 21st Century



Source: IPCC (2001)

Figure 2.3 Annual anthropogenic CO2 emissions

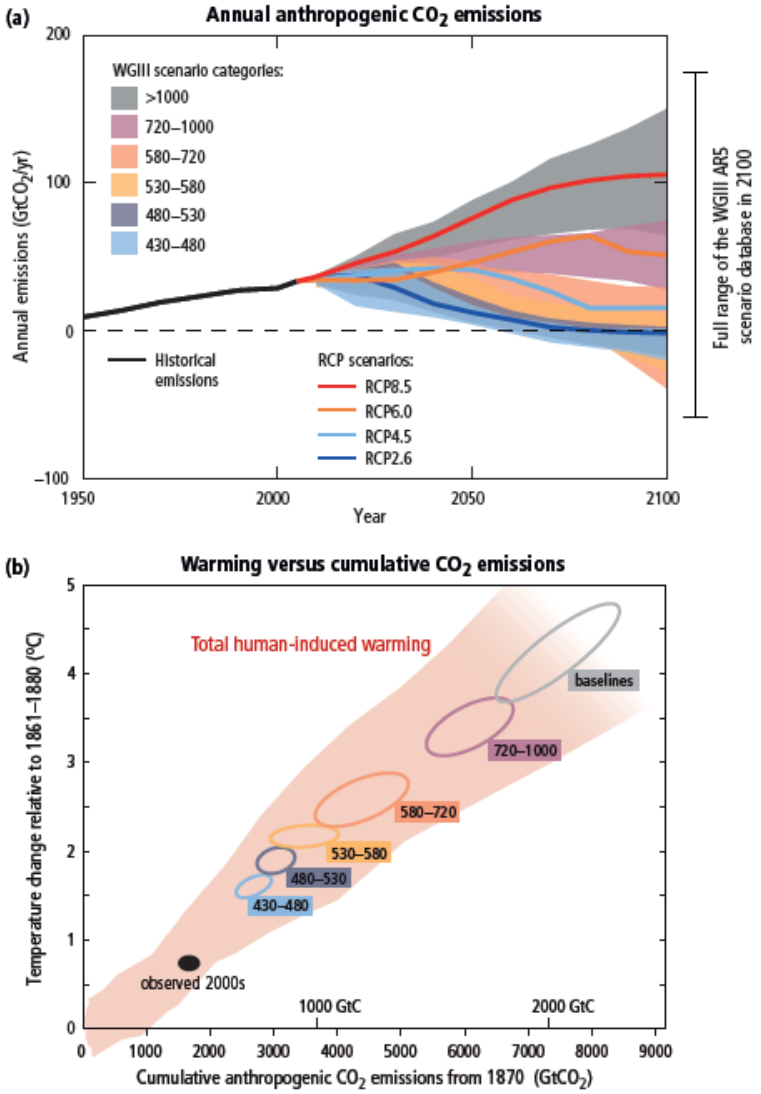


Figure SPM.5 | **(a)** Emissions of carbon dioxide (CO_2) alone in the Representative Concentration Pathways (RCPs) (lines) and the associated scenario categories used in WGIII (coloured areas show 5 to 95% range). The WGIII scenario categories summarize the wide range of emission scenarios published in the scientific literature and are defined on the basis of CO_2-eq concentration levels (in ppm) in 2100. The time series of other greenhouse gas emissions are shown in Box 2.2, Figure 1. **(b)** Global mean surface temperature increase at the time global CO_2 emissions reach a given net cumulative total, plotted as a function of that total, from various lines of evidence. Coloured plume shows the spread of past and future projections from a hierarchy of climate-carbon cycle models driven by historical emissions and the four RCPs over all times out to 2100, and fades with the decreasing number of available models. Ellipses show total anthropogenic warming in 2100 versus cumulative CO_2 emissions from 1870 to 2100 from a simple climate model (median climate response) under the scenario categories used in WGIII. The width of the ellipses in terms of temperature is caused by the impact of different scenarios for non-CO_2 climate drivers. The filled black ellipse shows observed emissions to 2005 and observed temperatures in the decade 2000–2009 with associated uncertainties. *(Box 2.2, Figure 1; Figure 2.3)*

Source: IPCC(2014)

2.3 Regional Impacts of climate change

Below are the prominent impacts of climate change experienced and expected to take place.

Other parts of the world

Asia

Impacts are in the agricultural sector where there will be significant reductions in food production as a result to declining availability of land for agricultural activities. Additionally, with the significant increase in surface temperatures, the Himalayan glaciers are expected to melt with a corresponding increase in sea levels.

Europe

Europe will mainly experience negative impacts as a result to climate related vulnerabilities. For instance, there will be increased storms which will result to increase in sea levels. Additionally, glaciers in the northern frontier are expected to continue melting significantly in the future.

Latin America

This region will mainly experience a major reduction in food production due to changes in land use as a result impacts of climate change.

North America and Polar regions

In North America, huge strains in water resources including catchments are expected. With increased temperatures, wild forest fires are anticipated which will also have an impact on the quality of soils and its wildlife.

The increased temperatures in the Polar regions will result to melting of ice-caps which will result to flooding of nearby areas and compromise quality of water.

Africa

Given the backbone of many African countries in agriculture, climate change is expected to have dire consequences to the continent. UNEP (2007) has it that climate change will have negative consequences on the quality of water that will result to widespread water-borne diseases, it will also lead to deforestation as more land will be cleared to pave way for agriculture.

Kenya

Kenya, similarly to most of other African countries, is dependent on rain-fed agriculture as well as reliance of agricultural export for its economic growth. According to the National Climate Change Response Strategy (GOK, 2010), indicate that current annual rainfall patters are much lower than those observed in the early 1960's. Climate change has resulted to shifts in rainfall patterns as well as trickling effects such as soil degradation. The result has been a decline in food production with unwanted effects on livelihoods – income, food security, employment.

2.4 Some Climate change control initiatives

One of the key global initiatives is the Kyoto Protocol which has taken the forefront on matters related to climate change. It has- for example, established a framework which includes funding mechanisms, rules and regulations for addressing global climate change issues. There is also the Framework for Integrated of Global Warming impacts, whose main objective is related to capacity building and information disseminated that relates to policies and climate change. Kenneth Fredrick and Norman Roseburg (1994) have it that Nordhaus (1991) was the pioneer of such a model that mainly looked into market impacts. The major challenge pegged on this remarkable initiative include: incapability of valuing non-market services, uncertainties surrounding the degrees of magnitude of the final climate change impacts as the model does not have an inclusion for uncertainty- due to this deficiency policy makers have found it challenging to know with precision the number and time of its output since it does not represent the results in terms of both the expected value and the variance (Mendelsohn, 1984.)

Globally, millions of livelihoods are threatened by the negative and unwanted results of climate change. Haerlin; and Heine (2008), point out to the urgency is having adaptive strategies that would also assist in achievement of other global goals such as the MDG's.

2.5 Agroforestry

According to (Beetz, 2002), agroforestry is a diversified farming system that incorporates trees, crops and livestock. Such an integration provides multiple benefits such as improved soil quality, production of fruits and timber, provision of micro-climate for growing crops as well as enhances the quality of water.

Alley cropping

In this system, trees are planted in rows and crops are grown in-between. Growing of crops in between is beneficial as a micro-climate is provided including provision of manure from tree detritus (the dropping tree leaves).

Silvopastoral agroforestry

This basically refers to growing trees in rows and allowing animals/livestock to graze in between the rows. Animal droppings as well as nutrient fixing tree species greatly increase the quality of soil in a silvopastoral system.

Windbreaks or Shelterbelts

This agroforestry system aims at significantly reducing the effect of strong winds to livestock and crops. To achieve this, trees are planted along the edge of a farm to cushion against the wind's velocity.

Riparian buffer strips

This agroforestry system aims at reducing agricultural inputs and outputs from reaching waterways. This is mainly achieved by growing trees along rivers ways and are intended to prevent agricultural inputs from polluting the waterways. Such may include fertilizers, pesticides as well as loose soils.

Forest farming and special forest products

This is an Agroforestry system whereby other on-farm activities such as growing crops and keeping livestock are managed within a forested area.

2.6 Agroforestry as an adaptation to Climate change

Agroforestry is defined as integration of trees in agricultural enterprises with the objective of deriving multiple benefits that include fodder for livestock, tree products both for subsistence and commercial purposes (ICRAF, 2013). According to Sanches, 2000; Kwesiga et al., (2003), agroforestry systems present multiple benefits which include enrichment of soil quality via the use of fertilizer trees, provision of a micro-climate due to tree canopies and generation of forest products such as firewood and other medicinal outputs.

All agroforestry systems are renowned for their important role in carbon sequestration as the tress integrates in agricultural systems act as carbon sinks. According to Agroforestry Research Trust (2010), research continues to demonstrate the benefits of agroforestry systems both in terms of environmental services as well as livelihood options. Without doubt this is an agricultural system which is promising in solving numerous challenges of our time.

According to (COSEPUP, 1992), there are several strategies – including technologies, that will increase the potential of agroforestry systems as adaptive strategies. They note the importance of capacity building to farmers that will enable them understand and evaluate potential systems for adoption based on their ecological zones that will enhance the communities resilience and adaptive capacity to climate change.

For agroforestry practices to cushion against negative impacts of climate change, it is prudent for relevant structures to critically examine the climatic characteristics, farming systems and their adaptive capacity to climatic stress, assessment of infrastructure that will forge links to markets, evaluate policies in an attempt to bridge any gaps that would exacerbate inadequate coping mechanisms, develop future climatic models with an

attempt to see what changes are required to enhance adaptive mechanism and last but not least, training and most importantly disseminating knowledge from research institutes to farmers would be idea.

2.7 Empirical studies

2.7.1 Agroforestry as a key adaptation strategy to the impacts of climate change

According to the Current Opinion in Environmental Sustainability (2014), there is an increasing interest in agroforestry adoption in Africa given its benefits that would assist in addressing most of the major food insecurity issues affecting the continent (Garrity, D, Akinnifesi, F. K et al. 2010) especially in Niger, Zambia, Malawi and Burkina Faso where significant numbers of tress on farms have been observed that have in turn strengthened their adaptive capacities.

2.7.2 Costs and benefits of agroforestry practices as a means to adaptation to climate change

FAO (2010) reports that in Africa, climate change mitigation efforts are mainly related to forest conservation measures which has proven to significantly compete with expansion of agricultural land. This becomes a serious problem especially for a continents whose backbone is in agriculture.

To assist in addressing the choice between choice between reforestation and agricultural land use, Unruh JD, Houghton RA, Lefebvre PA (1993) and Kumar BM, Nair PKR (2012) mention that agroforestry could be a win-win solution as it not only enhances on-farm productivity of various enterprises but also reduces the amount of carbon that is emitted directly to the atmosphere. Additionally, trees on farm can assist in capturing carbon both in the atmosphere as well as those emitted by soils, provide fodder for animals, nutrients for soils as well as fruits and medicine for homesteads.

2.7.3 Agroforestry as a source of livelihoods

Given the multiple benefits of agroforestry discussed, it is no doubt that agroforestry products are a great improvement to livelihoods. According to L.H (1980), farmers in Africa have fed tree foliage to their livestock for centuries. For example, in Chikwaka District, Zimbabwe, there has been significant increase in milk production as a result of using fodder tree species such as *A. angustissima and L. leucocephala* that have resulted to gross margins of about $US 13 to $US 334 (Moyo, S, Ayuk, E.T (2001).

Table 2.1 Benefits of fodder shrubs according to farmers, aside from increased milk production

Benefits of fodder shrubs according to farmers, aside from increased milk production

Type of benefit	% of farmers mentioning in	
	Embu area, Kenya (*N* = 60)	Kabale area, Uganda (*N* = 93)
Firewood	50	72
Soil fertility improvement	48	72
Improvement in animal health	38	5
Soil erosion control	18	20
Improved creaminess of milk (increase in butter fat)	18	6
Fencing	18	76
Revenue from sale of seedlings	13	9
Stakes	9	70

Percentages sum to greater than 100 because many farmers mentioned more than one benefit. *Source*: [21].

Source: Franzel S, Wambugu C (2007)

The above diagram shows the principal ways that fodder trees contribute to improved food security, incomes and livelihoods.

2.8 Research gaps

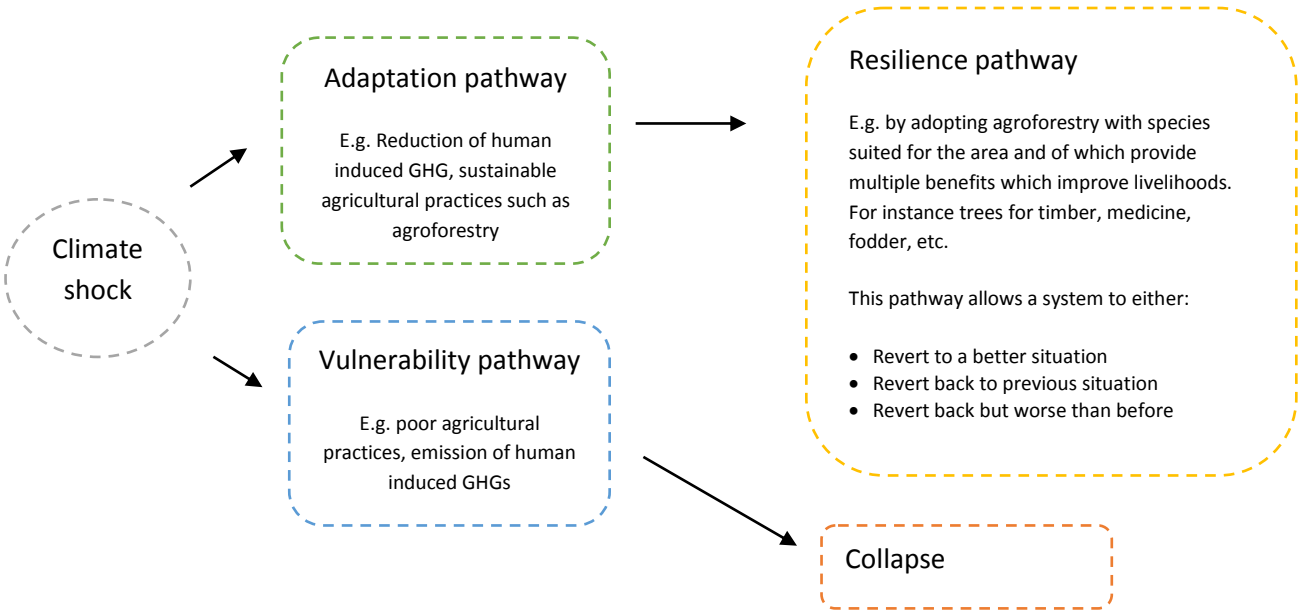
Numerous studies have been undertaken in the field of agroforestry and its potential as an adaptation strategy to the negative impacts of climate change. However, there is insufficient literature on the potential of agroforestry in combating impacts of climate change with specific focus on the investment that would be required to successfully integrate agroforestry in current agricultural practices/systems in the study area.

2.9 Conceptual Framework

Agricultural practices and livelihoods are both drivers of climate inconsistency and variation. However, adaptation of sustainable and appropriate agricultural practices such as agroforestry will significantly reduce not only the causes of climate change but also its

associated impacts. For instance, reduction of greenhouse gases (GHGs) while at the same time providing other products such as timber, fodder, fuel wood which can all be traded with a resultant effect of improved livelihoods.

Therefore, the dependent variable in the conceptual framework below is climate change. The independent variables are sustainable agricultural practices as well as livelihood options. To illustrate further, if a given people are poor, then they cannot exercise their due diligence towards sound environmental management which has negative impacts on the environment. Additionally, poverty will undoubtedly result in people directly depending on the environment for their basic needs and wants such as felling of tress for firewood, derailment of a rivers course to the farms due to varied rainfall patterns, etc.



Source: Modified from Musingi (2014)

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Introduction

This chapter deals with the research methodology used in the study. Its includes research design, target population, sampling procedure and sample size, research instruments, validity and reliability of research instruments, data collection techniques and data analysis.

3.2 Research Design

The study adopted a descriptive survey design to gather data for analysis. Kombo and Tromp (2006) defined a descriptive survey as a technique whose main objective is to collect and examine data to establish certain information. Given its efficiency in data collection especially for a large number, this method was preferred. In addition, the design was used because the method does no tin anyway compromise the population under study (Kothari, 2004).

3.3 Target Population

The study focused on a sample size of 100 farmers in Kiine south. The sample size was ideal and a good representative of the farmer population. Additionally, the sample size was ideal given the duration and budget available for the study. Main focus is on Karima ward, which has about 450 farmers.

3.4 Sampling procedure and Sample size

3.4.1 Sample Size

The study focused on a sample of 100 farmers in Kiine south. The sample size was ideal given the duration and budget available for the study.

3.4.2 Selection of study sample

This study employed stratified sampling technique to select farmers to be sampled. Stratified sampling technique mainly clusters a given population according to defined

characteristics which are then used to derive samples (Oso & Onen, 2005). This technique ensures fair representation of sub-groups in the samples selected.

3.5 Methods of Data Collection

To facilitate information gathering in response to the research questions, the study used three instruments namely questionnaires, interviews and observation.

In advance of data collection from the sampled respondents, the researcher obtained a research permit from the chief and any other local authorities. This official permit helped the researcher to engage with the farmers in an attempt to get responses that will assist in answering the study objectives. The researcher then visited the villages where the study would be carried out in order to familiarize herself as well as create rapport with the respondents.

3.5.1 Questionnaires

The written questionnaire was characterized by both open and closed ended questions and it was divided into five sections.

The questionnaires were delivered to the respondents and were picked one week later after responses had been provided. The method was preferred because it allowed the respondents enough time to respond to the questionnaires.

The use of questionnaires was advantageous to the study as it is simpler to administer as well as in analyzing the data that was provided by the respondents.

3.5.2 Interviews

For respondents who were illiterate or who showed insufficient time to respond to the questionnaires, an interview was held. Here, the research assistant would convene with the respondent and would update the questionnaire using the feedback provided. This method was extremely beneficial for respondents who could not write/read for one reason or another.

3.5.3 Observation

To complement feedback generated from the questionnaires, the researcher further used observation schedules. For this method, the research assistants examined the natural settings of the study area and provided responses against the set items captured in the interview schedule sheet.

3.5.1 Instrument validity

Mugenda and Mugenda (2003) define validity as the correctness of results. Validity was ensured through consulting research experts that is supervisors to ensure that the instruments of data collection can measure what they are intended to measure.

3.5.2 Instrument Reliability

Reliability is the ability of a research instrument to give constant results upon several trials. The reliability of the questionnaires was tested through test- retest technique, data being collected with the instruments from a few selected subjects. Same respondents were given the questionnaire to fill two times with an in-between period of two weeks.

3.6 Data Analysis Technique

Data collected from respondents was analyzed through descriptive statistics. The process of analysis entailed a review of the data captured in the questionnaires and observation schedules and detecting any errors and finally coding the responses in a manner that would assist in further analysis. The analysis presented the findings in terms of percentages and frequencies of occurrence using the Statistical Package of Social Sciences (SPSS).

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 Introduction

This chapter looks into data analysis, presentation and discussion of the findings. The results are presented based on the objectives of the study. The data analyzed is presented using frequency tables, pie charts and bar graphs and includes interpretation of the findings by the Researcher.

4.2 Response Rate

The sample population constituted 100 farmers in Kiine south, Kirinyaga County. Only 10 of them did not return completed questionnaires thus 90 percent response rate. This high percentage of participation enhances the findings as these would be perceived to be more representative of the population under study.

4.3 Demographic profile of the Respondents

This item sought for the farmers' gender, age, level of education and the length of time they have been practicing farming. This was important because before one undertakes a study on a given population, certain facts must be known about the respondents. The demographic profile of the respondents will determine how they complete the research instrument.

The findings are as detailed below.

4.3.1 Farmers Gender

The farmers were asked to indicate their gender and the results are as summarized in Table 4.1. below

Table 4.1 Distribution of farmers by gender

Gender	Frequency	Percentage
Male	60	66.7
Female	30	33.3
Total	**90**	**100**

Source: Author (2015)

As shown in Table 4.1, most farmers (66.7 percent) were male compared to 33.3 percent who were female. This could be attributed to land tenure and ownership issues which in many African settings belong to men.

4.3.2 Age of the farmers

The respondents were asked to indicate how old they are. Table 4.2 below presents the age of the farmers sampled in the study area.

Table 4.2 Ages of the Respondents

Age group	No of farmers	Percentage
below 20	0	0
21-30	10	11.11
31-40	15	16.67
41-50	45	50
over 50	20	22.22
Total	**90**	**100**

Source: Author (2015)

As shown, none of the farmers were below the age of 20 years, 11.11 percent were between 21-30 years old, and 16.67 percent were between the ages of 31-40 years, 50 percent were between ages 41-50 years, while the remaining 22.22 percent were above 50 years old. This suggests that majority of the farmers (50%) are between the age of 41-50.

It is noteworthy that the middle age group in the context of the respondents (41-50) formed the bulk of agroforestry practitioners who would be key in building capacity in agroforestry practices and whom would significantly impact its uptake.

The age range 41-50 years constituted the majority of respondents (50 percent), and has significant level of education, a factor that would increase the success of new agroforestry interventions to be introduced in the area.

4.3.3 Level of Education of Farmers

The respondents were asked to indicate their level of education. 11.11 percent were illiterate, 11.11 percent had reached primary level of education, 50 percent had attained

secondary level of education, 27.78 had attained tertiary level of education. Table 4.3 shows the level of education

Table 4.3 Level of education of farmers

Level of education	No. of farmers	Percentage
Illiterate	10	11.11
Primary	10	11.11
secondary	45	50.00
Tertiary	25	27.78
Total	**90**	**100**

Source: Author (2015)

4.3.4 Number of years the respondents had lived in Kiine area

The majority (38.89%) of farmers interviewed had lived between 10-19 years in the village while a few (5.55%) had lived between 50 and 59 years in the village. (Table 4.4)

Table 4.4 Number of years the respondents have been living in Kiine area

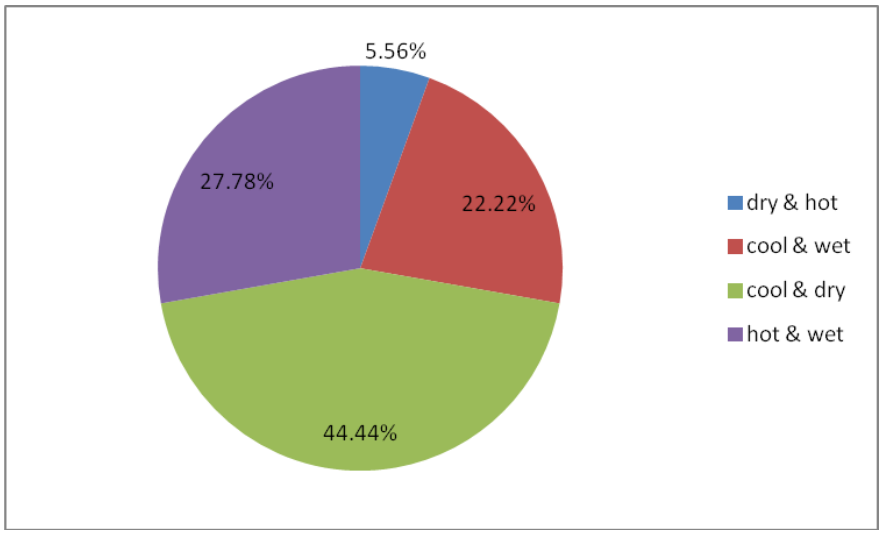
No. of years	No. of farmers	Percentage
0 to 9	3	16.67
10 to 19	7	38.89
20 to 29	5	27.78
30 to 39	2	11.11
40 to 49	1	5.55
50 to 59	0	0
Total	**18**	**100**

Source: Author (2015)

4.3.5 Climate of Kiine area

The respondents were asked to describe the climate of their area. 5.56% said that climate is dry and hot, 22.22% said that the climate is cool and wet 44.44% said that the climate is cool and dry while the remaining 27.78% said that the climate has been wet and hot. This indicates that the climate of Kiine area in Kirinyaga County is cool and dry as the majority (44.41%) described the climate as cool and dry. Figure 4.1 below depicts these.

Figure 4.1 Climate of Kiine area



Source: Author (2015)

A majority 60% felt that the climate has not always been like it is today while the remaining 40% were of the opinion that the climate has always been as it is today. Table 4.5 presents this response.

Table 4.5 Climatic change in Kiine area

Response	No. of farmers	Percentage
Climate has not always been as it is	54	60
The climate has changed	36	40

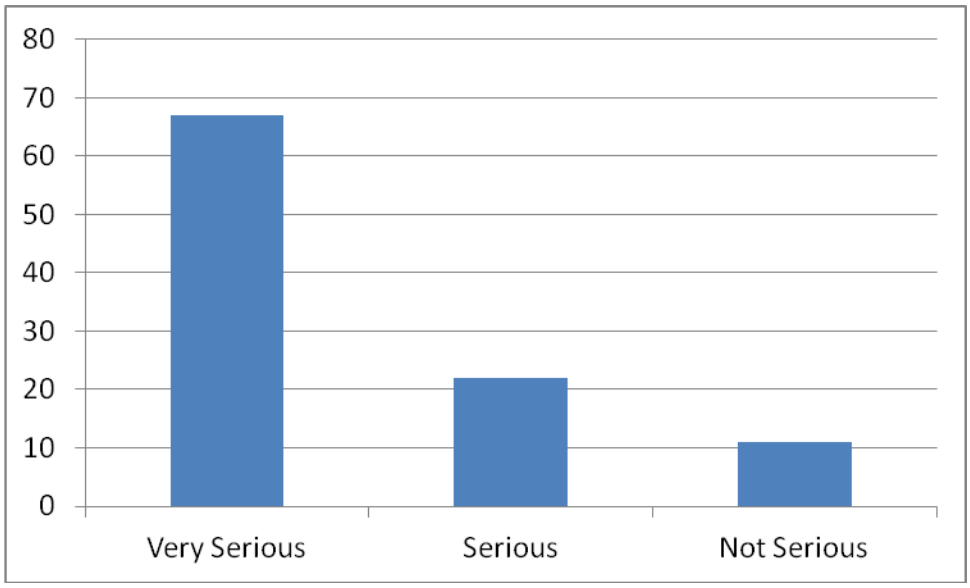
Source: Author (2015)

This implies that the climate has changed over the years due to human activities that impact negatively on the environment.

In terms of impact of climate change in their area, 65% said that the impact was very serious, 25% said such impact is serious while the remaining 10% stated that climate change is not serious. These findings allude that the impact of climate change in Kiine

area is considered a serious issue. Figure 4.2 depicts the impact of climate change in Kiine area.

Figure 4.2 Impact of climate change in Kiine area



Source: Author (2014)

A majority (80%) felt that of the local micro-climate can be improved. The remaining 20%felt that it cannot be improved. Of those who felt it can be improved cited method such as environmental conservation, afforestation, use of cheaper energy Agroforestry, and punishing environment polluters.

4.5 Investigation of agroforestry practices which provide maximum benefits in terms to adaptation of climate change impacts in the study area

To examine which agroforestry technologies were preferred, a five point likert scale was used and of which ranged from strongly agree, agree, not sure, disagree and strongly disagree where 1 being the most preferred while 5 being the least preferred. They were then asked to rate various agroforestry technologies in their village. Table 4.6 presents how the farmers rated the various agroforestry practices.

From the Table 4.6, it is evident that most farmers ranked highly planting trees and shrubs as windbreakers, planting of riparian forest buffers as trees, shrubs or grass and combination of trees with livestock. This is highly contrasted to Silvopasture which is the combination of trees with foliage and livestock in same field, planting of short rotation woody crops (woodlots) in moist regions and Alley cropping – widely spaced rows of trees that create alleyways of crops on hill sides which received the least ranking.

Table 4.6 Agroforestry Practices

Category	**Category**	**1**	**2**	**3**	**4**	**5**	**Total**
Planting trees & shrubs as windbreakers	No. of farmers	35	25	15	5	10	90
	% of farmers	38.89	27.8	16.67	5.56	11.11	100
Planting of riparian forest buffers	No. of farmers	30	30	10	10	10	90
	% of farmers	33.33	33.3	11.11	11.11	11.11	100
Silvopasture	No. of farmers	40	20	15	10	5	90
	% of farmers	44.44	22.2	16.67	11.11	5.56	100
Forest farming	No. of farmers	15	10	10	30	25	18
	% of farmers	16.67	11.1	11.11	33.33	27.78	100
Alley cropping	No. of farmers	4	4	1	4	5	18
	% of farmers	22.22	22.2	5.56	22.22	27.78	100
Boundary planting	No. of farmers	40	25	5	15	5	90
	% of farmers	44.44	27.8	5.56	16.67	5.56	100
Home garden	No. of farmers	7	6	1	2	2	18
	% of farmers	38.89	33.3	5.56	11.11	11.11	100
Planting of woodlots in moist region	No. of farmers	10	10	5	30	35	90
	% of farmers	11.11	11.1	5.56	33.33	38.89	100

Category	Category	1	2	3	4	5	Total
Combination of trees with food crops	No. of farmers	30	35	5	15	5	90
	% of farmers	33.33	38.9	5.56	16.67	5.56	100

Source: Author (2014)

Key

1. Strongly agree, 2. Disagree 3. Don't know 4. Disagree 5. Strongly disagree

From the table above, it is evident that the most preferred agroforestry practices are planting of trees and shrubs as windbreakers, planting of reparation forest buffers, silvo pasturing, boundary planting, home gardening and combination of trees with food crop. On the other hand, the least preferred agroforestry practices are forest farming, alley cropping and planting of woodlots in moist regions.

4.6 Major agroforestry costs and benefits in adaptation to climate change

4.6.1 Agroforestry Costs

The respondents were asked to rate agroforestry costs that they could relate to on a five point scale. The cost in this case refers to resources that would be required to enable the respondents adopt agroforestry practices and should not be perceived in monetary equivalent.

First, the respondents were asked whether training of residents on agroforestry should be enhanced. Of those interviewed, 44.4 percent strongly agreed that such training should be enhanced, 33.33 percent agreed, 5.56 were not sure whether such training should be enhanced or not, 11.11 percent disagreed while the remaining 5.56 percent strongly disagreed that training of residents on agroforestry should be enhanced.

These suggest that farmers in the study area are not knowledgeable on agroforestry farming practices. The government and other stakeholders should thus put in place mechanisms to provide proper training in this arena. This is collaborated when the respondents were asked whether they strong farmer knowledge regarding agroforestry

was required. A majority 44.4 percent stated that such knowledge is required as contrasted to 11.11 percent who disagreed such knowledge is required. Without doubt, it is imperative to invest in capacity building of farmers.

The respondents were also asked whether they needed both indigenous and exotic species of trees and crops. A majority 50 percent strongly agreed that they required both indigenous and exotic trees and plants species as opposed to 5.56 percent who strongly disagreed with this proposition. One of the captivating arguments about species requirements and adoption of agroforestry products has been put forward by Arnold (1987) as; "*It is widely argued that the lengthy production period and the incidence of most of the costs at the time of establishment, create financial problems for farmers in adopting practices involving tree growing*".

Other findings related to agroforestry costs are as detailed in table 4.7 below.

Table 4.7 Agroforestry Costs

Agroforestry Costs	**category**	**1**	**2**	**3**	**4**	**5**	**total**
Training on agroforestry be enhanced	No. of farmers	40	30	5	10	5	**90**
	% of farmers	44.44	33.33	5.56	11.11	5.56	**100**
Knowledge regarding agroforestry required	No. of farmers	35	40	0	5	10	**90**
	% of farmers	38.89	44.44	0.00	5.56	11.11	**100**
Indigenous & exotic species needed	No. of farmers	45	35	0	5	5	**90**
	% of farmers	50.00	38.89	0.00	5.56	5.56	**100**
Resistance to agroforestry practices evident	No. of farmers	35	30	15	5	5	**90**
	% of farmers	38.89	33.33	16.67	5.56	5.56	**100**
Residents adapted to the current conditions	No. of farmers	10	10	5	30	35	**90**
	% of farmers	11.11	11.11	5.56	33.33	38.89	**100**

Source: Author (2015)

Key

1. **Strongly agree, 2. Disagree 3. Don't know 4. Disagree 5. Strongly disagree**

The findings of the study show that there is resistance to agroforestry practices. This is evidenced when the respondents were asked to rate the issue of resistance to agroforestry practices. Table 4.8 presents this response.

Table 4.8 Resistance to agroforestry

Response	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
No. of people	45	20	5	10	10
percentage	50	22.23	5.55	11.11	11.11

Source: Author (2015)

A majority 50% strongly agreed that such resistance was evidenced in contrast to 11.11 % who strongly disagreed that such resistance was evidenced. This resistance can be attributed to various factors than revolve around capital, land tenure and tree ownership, social economic stratification, technology and the long period of time trees take before being ready for harvest.

Upon asked whether residents had adapted to the current conditions, 11.11 percent strongly agreed, 11.11 percent agreed, 5.56 percent were not sure, 33.33 percent disagreed while the remaining 5.56 percent disagreed. This is an indication that the impact of deforestation and environmental degradation is negatively affecting residents of Kiine and something needs to be done to restore the environment to its original conditions.

4.6.1 Benefits of Agroforestry

To find out the benefits of Agroforestry, the respondents were given a variety of positive impacts of Agroforestry and asked to rate them. Table 4.9 presents the responses of the farmers on benefits of agroforestry.

Table 4.9 Benefits of Agroforestry

Benefits of Agroforestry	Category	1	2	3	4	5	Total
Increased catchment for rivers, streams, wells	No. of farmers	50	20	5	10	5	90
	% of farmers	55.56	22.22	5.56	11.11	5.56	100
Improved climate	No. of farmers	45	25	5	5	10	90
	% of farmers	50.00	27.78	5.56	5.56	11.11	100
Increased wood	No. of farmers	30	30	5	15	10	90
	% of farmers	33.33	33.33	5.56	16.67	11.11	100
Increased food output, craft & medicinal crops	No. of farmers	30	45	0	10	5	18
	% of farmers	33.33	50.00	0.00	11.11	5.56	100
Improved livestock health & livestock products	No. of farmers	35	35	10	10	10	90
	% of farmers	38.89	38.89	11.11	5.56	5.56	100

Source: Author (2015)

As shown in table 11 above, 50 percent strongly agreed that agroforestry can improve the climate of the area. This finding is supported by studies undertaken by Torquebiau, (1992) which concluded that "Agroforestry can improve the resilience of agricultural production to current climate variability as well as long-term climate change through the use of trees for intensification, diversification and buffering of farming systems. For example, trees improve soil quality and fertility by contributing to water retention and by reducing water stress during low rainfall years. Trees can also reduce the impacts of weather extremes such as droughts or torrential rain".

A majority of those interviewed (33.33 %) strongly agreed that Agroforestry increases wood for fuel, construction, craft, (table 4.9). This is collaborated by Raintree (1991), who states that "agroforestry is an approach to agricultural production that can reduce the

impacts of human activities and global climate change on the local environment. Agroforestry systems integrate commercial crop production into the natural forest environment, harnessing trees for a variety of benefits: improving soil structure, drainage and nutrient levels; preserving biodiversity; increasing forage, firewood and other organic materials that are recycled and used as natural fertilizers; helping to regulate the water cycle; and providing shade".

Upon asked to state their feelings on the agroforestry and increased output in food, craft and medicinal crops, a majority 50 percent agreed, 33.33 percent strongly agreed, 11.11 percent disagreed while the remaining 5.56 percent strongly disagreed This is an indication that agroforestry increases food output, craft & medicinal crops.

4.7 Agroforestry contribution to livelihood improvements

The respondent were provided with a 5 point likert scale to rate agroforestry's contributions towards improvement of their livelihoods. Table 12 below summarizes the findings. The study established the following:

On the need to enhance the market link between growers and consumers, 44.44 percent strongly agreed that such link should be enhanced, 27.77 percent agreed, 5.56 percent were not sure, 11.11 percent disagreed while the remaining 11.11 percent strongly disagreed.

Upon asked whether processing, handling and marketing of products from agroforestry practices should be encouraged, 38.33 percent strongly agreed that processing of products from agroforestry produces should be encouraged, 33.33 percent agreed, 11.11 percent were not sure, 5.56 percent disagreed while the remaining 11.11 percent strongly disagreed that processing of products from traditional agroforestry practices should be encouraged (table 4.10).

As presented in table 4.10, upon asked to rate the issue of increased catchments areas for rivers, streams, wells, the majority 55.56 percent strong agreed that agroforestry increases catchments for rivers, streams, wells.

Table 4.10 Methods of encouraging agroforestry

Category		1	2	3	4	5	Tot
Enhancing the growers- consumers market link, value addition and processing of agroforestry products	frequency	8	5	1	2	2	18
	%	44	28	6	11	11	100
Improving nutrition and health for households through integration of fruit tree species	frequency	7	6	2	1	2	18
	%	39	33	11	6	11	100
Improving the production, processing, handling and marketing of agroforestry products	frequency	5	5	3	3	2	18
	%	28	28	17	17	11	100
Encouraging forest farming	frequency	6	7	2	1	2	18
	%	33	39	11	6	11	100
Introducing a new agroforestry germplasm	frequency	9	6	0	2	1	18
	%	50	33	0	11	6	100
Enhancing adaptive capacity of dry land farming to climate change	frequency	7	7	1	1	2	18
	%	39	39	6	6	11	100

Source: Author (2015)

As shown in table 4.10, a majority 27.77 percent of the respondents strongly agreed that nutrition and health of households should be improved through fruits based Agroforestry practices. This is contrasted to 11.11 percent who strongly disagreed with this approach of encouraging Agroforestry.

The respondents were asked if improving the products, processing handling and marketing of products from agro forestry will improve adoption of Agroforestry 33%

percent strongly agreed, 38.88% agreed, 11% were not sure, 5.56 percent disagreed while the remaining 11% percent strongly disagreed.

Upon asked whether introducing a new germplasm for Agroforestry with a focus on economically useful trees 50 percent strongly agreed, 33% percent agreed, 11% percent disagreed while the remaining 5.56 percent strongly disagreed.

A majority 39% percent of the respondents strongly agreed that adaptive capacity of dry lands farming to climate changes should be enhanced. This is contrast about 6% percent who strongly disagreed that adaptive capacity of dry lands farming to climate changes should be enhanced.

CHAPTER FIVE: SUMMARY OF FINDINGS,CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter presents summary, conclusions and recommendations of the study as well as suggestions for further study.

5.2 Summary of major findings

The sample population constituted 100 farmers in Kiine sub location and the response rate was 90 percent. 66.7 percent of the respondents were male while 33.3 percent female. The majority of the farmers (50%) who were interviewed were between the ages of 41-50 years old. The level of education among agroforestry practitioners in Kiine south was generally low with over 50 percent of the farmers having attained only secondary school; level of education. 39% of farmers had lived in Kiine for 10-19 years and thus could be able to tell the climatic changes that had occurred in the region.

The climate of Kiine area is generally cool and dry. The study, according to respondents shows that the climate of the area has not always been like it is today as human activities according to the respondents have negatively impacted on it. Most residents of Kiine area felt that the impact of climate change was very serious and suggested methods of improving the climate such as environmental conservation, tree planting, punishing polluters and using fuel efficient sources of energy.

5.2.1 Agroforestry practices which provide maximum benefits in terms of adaptation to impacts of climate change in the study area

Residents of Kiine area majorly preferred three agroforestry practices. These were windbreaks, buffer-zone agroforestry and silvopastoralism. On the other hand, they least preferred Forest farming, woodlots where multi-purpose woody perennials are planted and managed over time to produce fuelwood, poles, and stakes for climbing crops; food and animal components may be integrated into woodlots, especially during

the initial establishment phase and, Alley Cropping which is an agrosilvicultural practice and the components are spatial zoned and home gardens.

5.1.2: Major agroforestry costs and benefits in adaptation to climate change

Most residents of Kiine area wanted stakeholders to enhance training of residents on agroforestry, strong farmer knowledge regarding Agroforestry, introduction of both indigenous and exotic trees and plants species. It was however evidenced that farmers were resisting agroforestry practices as they were viewed as economically not viable (perhaps due to the duration it would take for the trees to grow). On the issue of benefits that may emanate from Agroforestry products, the majority felt that it could increase catchment areas, improve climate, increase wood for fuel, construction and craft, increased output in food and medicinal crops and improve livestock health.

In order to encourage adoption of agroforestry, the respondents felt that stakeholders should enhance the growers-consumers market link, value chain development, processing of products from traditional agroforestry practices, improve the production, processing, handling, and marketing of products from agroforests, encouraging forest farming as cultivation of high value non-timber, introduction of new germplasm(s) for agroforestry adopted to their environment.

5.1.3: Significance of agroforestry in contributing to the improvements of livelihoods of the people in the study area

The finding established that agroforestry has a direct link in improving livelihoods of people in the study area. For example, farmers in the area would trade agroforestry products in the market such as fruits, fodder, fuel wood, food crops, animal meat and medicinal materials. The money obtained, provides means for accessing second tier facilities such as paying school fees for their children or even accessing heal care facilities.

5.3 Conclusions

Based on the findings of this study, it can be concluded as follows**.** Agroforestry practices can significantly cushion the community in dealing with unwanted impacts of climate change in the present time while at the same time increasing resilience for future impacts.

This conclusion is supported by conclusions made by other scholars. For example, Oram (1993) reported that agroforestry practices enable farmers and their families by mainly diversifying their farm portfolio and opening up channels to ensure sustainability such as having products to trade in the market.

Torquebiau (1994) found in Sumatra, for example, some people plant trees as a source of food, as well as rubber trees in their fallow fields. In Borneo, some people, plant rattan canes in rice fields during the last rice season and that rattan, a very aggressive vine, will use the trees as supports. He stated that rattan is a very profitable cash crop and can be harvested after 8 – 10 years.

5.4 Recommendations

5.4.1 The Government

The Government, through its Ministry of Agriculture and Livestock, should make it compulsory for civil or even community based organizations to include sustainable agroforestry practices as part of their capacity building exercises. This will ensure that appropriate knowledge triggers to the farmers on not only appropriate agroforestry practices to adopt in a given area, but also conduct research, in conjunction with farmers, on its adaptability to the unpredictable future climate.

As regards incentives, the government should provide incentives that will ensure uptake of new practices such as agroforestry. These may include establishing market links where agroforestry products can either be sold or exchanges for a service at good prices (for instance medical access), etc., as well as integrating it into school curriculum as a compulsory subject.

5.4.2 Civil Societies

The Civil Societies, such as Non-Governmental Organizations, can be extremely instrumental in the successful implementation of agroforestry practices. For instance, with funding from various sources, they are often well equipped and resourced to access remote areas where interventions, such as agroforestry, is required. They are also perceived to be more transparent and accountable in comparison to the Government, a factor that would motivate the interest of farmers to engage.

5.4.3 The residents of the study area

Without disregard to culture, it is important for the residents in the study area to remain optimistic to new farming practices that are introduced. It is very common to see culture being a key role on the successful uptake of new practices, which are often perceived to be unsustainable.

5.5 Recommendation for further research

Findings of this study presents the following three areas for further research.

1. Impact of pests and diseases on agroforestry practices.
2. Adaptability of agroforestry tree species on future climate (which is unpredictable).
3. Identify sustainable mechanisms which will encourage farmers to adopt agroforestry practices.

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APPENDIX 1: INTRODUCTION LETTER

Munene Anne Nyaruai

Nairobi, Kenya

Cell phone: +254 7241331

To …….

Dear Sir or Madam,

RE: REQUEST FOR PARTICIPATION IN RESEARCH STUDY

I am a final year Master of Arts student in university of Nairobi. I am specializing in environmental planning. I am currently undertaking research study on the potential of agroforestry as an adaptation strategy to the impacts of climate change: a case study of Kiine community- Kirinyaga County

I would be grateful if you could spare some time and complete the enclosed questionnaire. Your identity will be treated with utmost confidentiality. Your timely response will be highly appreciated.

Yours faithfully,

Anne Nyaruai Munene

APPENDIX 2: QUESTIONNAIRE

I am Anne Munene a final year student in the University of Nairobi. I am carrying out a study on the on the potential of agroforestry as an adaptation strategy to the impacts of climate change: a case study of Kiine community- Kirinyaga County. Kindly respond honestly and accurately to questions listed below. Your identity will be treated with utmost confidence and the information collected will not be used for any other purpose other than which pertains to this research.

Part one: Personal Information

1. Name of Respondent (Optional) ……
2. Male [ ]

   Female [ ]
3. Age

   Below 20 years [ ]

   21 – 30 [ ]

   31 – 40 [ ]

   41 – 50 [ ]

   Over 50 years [ ]

4. Education Level

Illiterate [ ]

Primary [ ]

Secondary [ ]

Diploma [ ]

Degree [ ]

Master [ ]

5. Marital status

Single [ ]

Married [ ]

Divorced/Separated [ ]

Widow/Widowed [ ]

Please describe the climate of the area

Dry and hot [ ]

Cool and dry [ ]

Cool and wet [ ]

Hot and wet [ ]

Any other (Specify) …….

Has this climate always been like it is today?

Explain **……**

In your view in what ways has the current climate affected livelihoods in your area?

……

How serious do you rate the impact of climate change in your area?

a) **Very serious b) serious c) Not serious**

From the above response, can this kind of climate be improved?

Yes [ ]

No [ ]

If yes, how can the climate of the area be improved?

1. _____
2. _____
3. _____

Part Two: Agroforestry Practices; Agroforestry is the deliberate integration of woody species with agricultural crops and/or pastures on the same land-unit resulting in the integration of economical and ecological interactions between components.

Please tick appropriately how you agree with the following statements on agroforestry practices, 1 (strongly agree), 2 (agree), 3 (not sure), 4 (disagree) and 5 (strongly disagree).

Category	1	2	3	4	5
Planting trees and shrubs as windbreakers					
Planting of riparian forest buffers as trees, shrubs or grass					
Silvopasture as combining trees with foliage and livestock in same field					
Forest farming as cultivation of high value non-timber (craft, medicinal and food)					
Alley cropping – widely spaced rows of trees that create alleyways of crops on hill sides					
Boundary planting: Lines of multipurpose trees or shrubs planted along borderlines and boundaries dividing properties or land uses					

Home garden: A complex collection of woody and herbaceous plants deliberately grown in small plots in or near home compounds					
Planting of short rotation woody crops (woodlots) in moist regions					
Combination of trees with food crops					
Combination of trees with livestock					

Part Three: Agroforestry Costs and Benefits 1 (strongly agree), 2 (agree), 3 (not sure), 4 (disagree) and 5 (strongly disagree).

Category	1	2	3	4	5
COSTS					
Training of residents on agroforestry should be enhanced					
Strong farmer knowledge regarding agroforestry required					
Both indigenous and exotic trees and plants species needed					
Farmers' resistance to agroforestry practices evident					
Residents have adapted to the current environmental conditions					
BENEFITS					
Increased catchment areas for rivers, streams, wells, etc.					
Improved climate: rain, air cycle, minimal wind and dust, etc					
Increased wood for fuel, construction, craft, etc					

Increased output in food, craft and medicinal crops					
Improved livestock health and increased livestock products					

Part Four: please rate the following statements on how they have positively contributed towards Livelihood Improvement,

1 (strongly agree), 2 (agree), 3 (not sure), 4 (disagree) and 5 (strongly disagree).

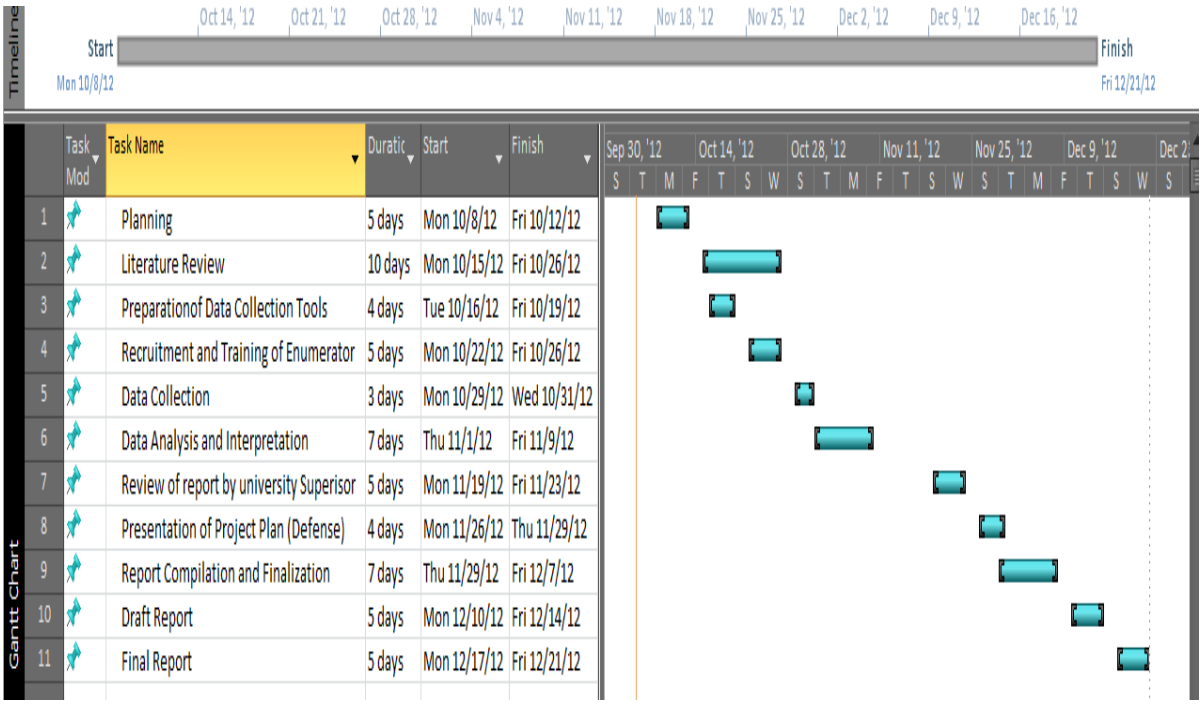
Category	1	2	3	4	5
Enhancing the growers-consumers market link, value addition, processing of products from traditional agroforestry practices					
Improving nutrition and health of households through fruit-tree-based agroforestry practices					
Improving the production, processing, handling, and marketing of products from agroforests					
Encouraging forest farming as cultivation of high value non-timber (craft, medicinal and food)					
Introducing a new germplasm for agroforestry with a focus on economically useful trees					
Enhancing the adaptive capacity of drylands farming to climate change					

THANK YOU FOR YOUR RESPONSES AND COOPERATION

APPENDIX 3: OBSERVATION SCHEDULE

OBSERVATION	**DETAILS**
Number of farmers	
Home gardens	
Windbreakers	
Silvopasture	
Ally cropping	
Any other farming activity	
Climate	
Weather	
Soil types and structure	
Challenges faced by farmers	
Economic activities	
Benefits of agroforestry	

APPENDIX 4: TIME FRAME



APPENDIX 5: BUDGET

	Cost category	**Amount in Kenya Shillings**
1	Transport to and From *Kiine* Village (2 trips)	2,000
2	Overnight stay in Kirinyaga (inclusive of food)	3,000
3	Printing of questionnaires and observation sheet	200
4	Use of computer and associated resources e.g. electricity	500
5	Report binding (3 copies)	2,000
5	Contingency (5%)	3,850
	Total budget	**11, 550**