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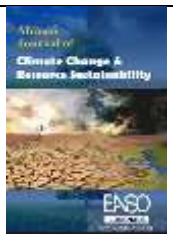

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Original Article

Social Economic Challenges of Adaptation to Climate Change in Masinga Sub-County, Kenya

Douglas Bosire[1*], *Benso Kamau*[1] *& John Muriuki*[1]

[1] Kenyatta University, P. O. Box 43844-00100. Nairobi, Kenya.
[*] Author for Correspondence Email: dean-envs@ku.ac.ke
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ABSTRACT

Climate in Masinga sub-county has been changing at a momentum which is unprecedented in the recent human history. This area consists mainly small-scale farmers who depend on rain to carry out their farming activities. Coping strategies to the changing climate in the area has faced various challenges ranging from high poverty, low levels of education, age, gender among others. This study investigated how social-economic challenges affecting adaptation strategies on climate change among the households living in Masinga sub-county, in Kenya. The main objectives of the study included; 1) To examine the adaptation strategies employed by households in Masinga sub-county 2) To determine the main factors that affect household in adaptation to climate change in Masinga sub-county 3) To investigate the environmental implications of adaptation to climate change in Masinga sub-county. Essentially, variables such as education levels, age, gender, were assessed. In order to gain an understanding on adaptation strategies used by households in Masinga sub-county, the study was conducted in all six divisions. Various methods of sampling were used in the survey which included stratified random sampling based on the number of households proportionately in the six divisions. In essence, 384 household heads were sampled through stratified random sampling. The study employed specific data collection tools in order acquire data from the six divisions; structured questionnaires, interviews schedules, Focused Group Discussions (FGDs) and direct observation were used. Qualitative data was collected through; interviews, Desk research, Focus Group Discussions comprising six to eight sampled through stratified random sampling and purposive sampling. The households coping strategies, influence of adaptation strategy to climate change and environmental implications of household adaptation was analyzed through both qualitative and quantitative interpretation. Data from survey was organized and analyzed using descriptive and inferential statistics. The results were subjected to statistical package for social sciences (SPSS) to determine their reliability. When applying descriptive statistics, the results were presented in tables, bar graphs, and charts. In this study Chi-squire was used because it was easier to compare the results from a two dimensional perspective. These results after analysis by chi-square test, the

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p-value was found to be .001, thus, smaller than the significance level (α = .05). Using Chi-square tests, this study established that there is strong evidence of an association between the education level and the implementation of green-house farming (X2 (3) = 1.064, p = 0.001). Further analysis by chi-square test indicated that the p-value was found to be .008, thus, less than the significance level (α = .05). This study established that early warning as a strategy to adaptation to climate change was not common amongst households in the area. Further research is suggested on impact of charcoal burning on climate change adaptation and cost implications in semi- arid areas. The study findings will enable the government and other relevant stakeholders to ensure that early warning system information is able to reach the local residents at all times.

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INTRODUCTION

Global developments on the changing climate are evident having serious effects to infrastructure and economies. The United Nations Framework Convention on Climate Change highlighted most crucial ways in handling the challenges of the changing climate; total elimination which aims at limiting greenhouse reductions and its emissions, adaptation also aims at alleviating the adverse effects through selected actions (Fussel and Klein, 2002).

The last decades, for instance have witnessed numerous arguments and agreements on adaptations to the changing climate (Parry *et al*., 2005). Developed nations have always continued to deal with the socio-economic challenges and their implications on the environment in terms of impacts that results from climate change. The developing world is no exception. Therefore, strategies for adapting to the changing climate is a necessity that involves both developing and developed nations of the world; and as a growing concern, there is need for well-organized structures to deal with associated effects (Parry *et al*. 2005).

Africa is facing and will continue face the hardest impacts of change in climate, it is ranked number two as the driest continent having many areas as arid lands and covers approximately 66% (UN, 2013). Water stress is likely to impact between 75-250 million people, 50% decline on areas that depends on rain for their irrigation, reduction of coastal land areas, and ASALs rise for about 8%, also adapting expenditures rises to about 10% of GDP (IPCC 2007). Most African countries depend on foreign aid food due to political instability such as wars,

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high food prices and decline in crop yields (FAO, 2014). Perennial problems such as conflicts for the available resources, low rainfall and recurrent droughts are always noted as the main problems associated with reduced food production (FAO, 2014). IPCC has noted the main points of evidence of changing climate on highland areas because of sophisticated interactions coupled with feedbacks (IPCC, 2007).

Climate change consequences, especially extreme and severe weather conditions have been reported in Kenya (GOK, 2010). Inadequate adaptive capacity means that the expenditures of dealing with change in climate is already high and are likely to increase in future. Increasing momentum of adjusting lifestyle is a major milestone of coping with sudden impacts of change in climate (Ellis, 1998).

Strategies of coping with the changing climate to make it more resilient and many climatic impacts are very significant. Adapting mechanisms are noted that they are not responsible for reducing household poverty, (Eriksen and O'Brien, 2007). For example (Osbahr *et al.,* 2008) in Mozambique found increasing crop varieties including management and communal use of land all applied as climatic responses. Less developed countries have got different groups that area vulnerable to various climatic events and their associated impacts on consumption and income by households (McMahon *et al.,* 2011). Most developing countries, female-headed households are vulnerable in rural and urban areas. Female-headed households are either consumers or producers and mostly have little ownership of main assets (e.g. ownership of land or human capital, savings, loan access (FAO, 2008b).

Female farmers achieve lower yields than men hence more vulnerable and exposed to yield and earning shocks (FAO, 2011). Adapting to the changing climate by households at farm level involves many activities, which include planting crops early, proper choosing of the field and planting a variety of crops. Ploughing of land, practicing agro forestry (planting or soil conservation), putting farms on irrigation, practicing water harvesting technologies, and mixed livestock and crops. Several methods of agricultural and non- farm activities are considered some of the best management in land practices (Brklasich *et al.,* 1997; Bryant *et al*., 2000: Smit and Skinner, 2002: Kabubo-Maraiara, 2008). Advancing adaptations will seriously lead to a decline of the severity to changing climate by making rural societies adjust and cope better, regulate serious damages and be able to cope with severe impacts (IPCC, 2001).

Latest studies (DiFalco *et al*., (2012) have examined and indicated the connection between agricultural production and climate change. More factors which influence adaptation strategy where stakeholders' support adaptation to the changing of climate. Many researchers have developed interest which have got significant influence and mechanism of adapting to changing climate in which they have identified policymakers who are determined to give support of adaptation to the changing climate, through providing information regarding inputs, field services, giving credit services (Maddison, 2007; Nhemachena and Hassan, 2008; Gbetibouo, 2009; Bryan *et al*., 2009; Deressa *et al.,* 2009; Hisali *et al.,* 2011; Tambo and Abdoulaye, 2012).

It is for the above challenges that this finds it necessary to comprehensively address the adaptation mechanisms employed by Kenyan households, in the arid and semi-arid areas. This study, therefore, seeks to address the adaptation to climate change programs employed by households and associated challenges in Masinga sub-county, Machakos County, Kenya. Moreover, due to limited expertise in this field, human capacity building forms an integral part of the study in relation to population sensitivity and preparedness for climate change challenges.

Statement of the problem

Global mechanisms of adapting to the changing spectrum of climate change have become platform

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of scientific and political discourse for the past two decades (Niang *et al.,* 2014). So far, the link between climate change, farm productivity and food security has been reported elsewhere (Wheeler and Von Braun, 2013). Thus, adapting proper farming systems to climate change is crucial to enhancing food security in Masinga sub-county, Kenya. A gap in inadequate financial resources, as well as households' different level of education exposes them to the risks of climate change. There is need for more sustainable adaptation strategies to maintain rural livelihoods and increased crop production which will ensure that there is food security for rural farmers under the changing climate (Bryan *et al.,* 2013; Wheeler and Von Braun, 2013), Masinga sub-county is not an exceptional in this case and proper adaptation strategies by household farmers is fundamental in addressing climate variability in the area.

The IPCC (2007) has noted that most farmers in Africa have embraced many adaptation strategies so as to adjust to recent changing climate, however in Masinga sub-county, there are various social economic challenges that limits adaptation to climate variability which include; low education levels, age, family size, poor adaptation strategies such as sand harvesting and charcoal burning. These adaptation strategies, however, are not enough to address future change in climate.

Social-economic challenges of adaptation to climate change are increasingly becoming major concerns in Kenya and hence there is justifiable concern over the ways which should be employed by households to contain adverse consequences of climate variability. Notably, ASAL areas in Kenya are most vulnerable, Masinga sub-county being one of them. However, in ASAL Kenya the social-economic factors, such as income levels, age, gender, poverty levels, increasing population, land degradation, levels of education, poor infrastructure, and render households more vulnerable to climate change.

A study done in Yatta District recently has indicated that rural residents have also reported more perennial droughts, low and sometimes total crop failures and severe water shortages. Households fundamentally depend on relief food, which is more popular in the area and has become part of their normal life (LTI, 2007). This recent research study on effects of climate variability and change on food shortage in Yatta District in Kenya, affirmed that, there are serious and severe situations of accessing, availability and sufficiency of food among small scale farmers (Mburu *et al*. 2014). Even with these evidence there is still more evidence that climate is changing and there is need for households to adapt. For instance, there is increased dwindling of biodiversity due to increased human demographics who in turn seriously interfere with biodiversity to create space for settlement and also to earn income. Studies done by Asfaw and Admassie (2004) noted that households that are headed by male are likely to adopt more because they are more likely to access information on the latest technologies concerning farming and can face risky ventures than female headed households. On the other hand, female-headed adopt less due to little access to ownership of land, information and other resources however more research should be done in order to empower household to cope with climate change risks. Nhemachena and Hassan (2007) argued that farmers with experience are almost similar with those farmers' basic education levels and hence are able to take adoption to climate change more keenly, however the households farmers experience is based only on indigenous farming techniques.

This current research study seeks to be part of addressing some of these knowledge gaps and provide sound scientific basis for both short-term and long-term consistent evaluation of adaptation mechanisms to climate change effects and support evidence-based government policy and regulatory regimes. The significance of results generated will be used to devise and advise on appropriate programs to adaptation against year to year undesirable effects of changing climate in Kenya.

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Overall, this project seeks to offer two key benefits. Ease of results take-up by diverse stakeholders (e.g. regulators, government regulatory authorities and industry) as the study will consider local typical climate conditions and implementation patterns and demographic characteristics. It is for these reasons, from which the study anchors three key objectives of climate change: i) To examine the adaptation strategies employed by households to counter the effects of climate change, ii) investigate the main factors that affects households to adapt to climate change, iii) investigate environmental implications in adaptation to climate change.

Objectives of the study

Within the social economic domain of climate change, this research project endeavors to contribute fundamentally solutions in addressing key adaptive mechanisms employed by vulnerable communities in Kenya. It is in this context; the proposed research is; of cutting-edge in nature and of national interest. Consequently, the following objectives formed the basis of this current research.

General objective

This study aims at social-economic challenges on adaptation to climate change in Masinga sub-county, Kenya.

Specific objectives

The specific objectives are:

- To determine the adaptation strategies employed by households in Masinga sub-county to counter the effects of climate change.
- To analyze the main factors that affects adoption of climate change adaptation strategies by households in Masinga sub-county.
- To evaluate the environmental implications in adapting to climate change in Masinga sub-county.

Research Questions

To achieve the above-mentioned objectives, the study intends to answer the following questions:

- How do households in Masinga sub-county employ adaptation strategies to counter effects of climate change?
- Which factors constrain households to adapt to climate change in Masinga sub-county?
- How do household's adaptations to climate change in Masinga sub-county affect the environment?

Hypotheses

The hypotheses tested in the study were:

- Social-economic factors such as income levels, family size have effects on adaptation to climate change in Masinga sub-county.
- There are significant environmental implications on the choice of adaptation strategies to climate change by households in Masinga sub-county.

Significance and anticipated output

The findings of this study will assist households, policy making by the government, researchers, scientists and the public in the following ways:

(a) Regarding the households, the study will play a very important role since it will assist households to employ the best adaptation strategies to changing climate.

(**b**) The study will help the different stakeholders in the Ministry of Environment and Natural resources, Kenya Meteorological Department (KMD), development partners and the local stakeholders to come up with effective adaptation policies to climate change.

(**c**) The study will also make a fundamental contribution to the existing institutions of scientific research that deal with social-economic challenges of adaptation to climate change.

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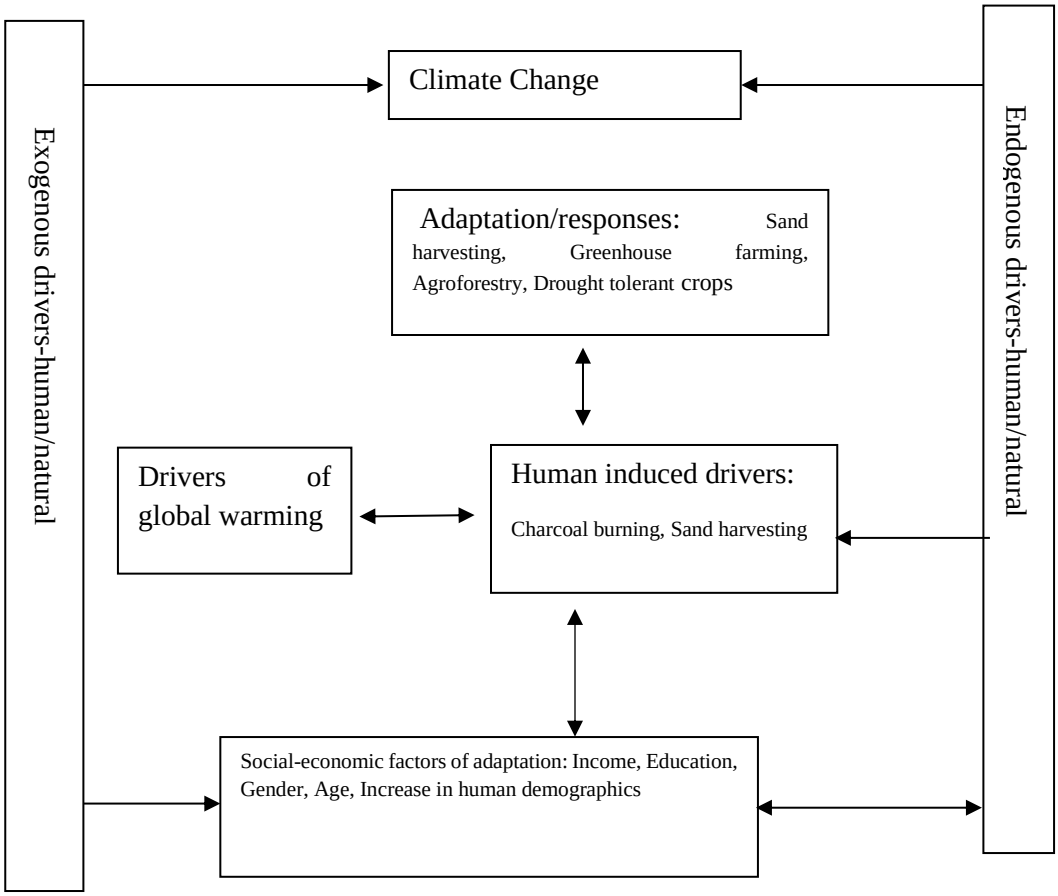
Conceptual framework

The conceptual framework below was adapted from FAO (2008a) as a measure of clarity between the changing climate coupled with, social economic challenges and adaptation responses. Social and economic factors such as: limited capital, low level of education, gender, age and limited access to income accelerates the problem of the changing climate in relation to making it resilient and coping. Generally, with continued climate change in arid and semi-arid areas, most people are susceptible to the impacts of changing climate. Exogenous drivers also contribute to the change of climate in Masinga sub-county by altering rainfall precipitation patterns. Endogenous drivers were also considered to contribute to increased impacts of climate change in Masinga sub-county.

The conceptual framework for this study is illustrated below in (**Fig 1.1).**

Figure 1.1: Conceptual framework:



Source: modified from FAO (2008a)

Limitations of the Study

The researcher established that respondents were not willing to be interviewed. Some respondents required strong persuation to answer all the questions asked. The study was conducted during severe dry season and most respondents were expecting quick assistance to the challenges of current drought they were facing.

Definition of operational terms

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Adaptation	This involves the adjusting to enhance viability of social and economic activities and to reduce their vulnerability to climate, including its current variability and extreme events as well as long term climate change
Adaptive capacity	This is refers to the ability of the individuals to adjust to climate variability and moderate potential damages, to take advantage of opportunities, or to cope with consequences of diminishing water resources
Climate change	IPCC (2007) defines climate change as statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer).
Adaptation strategies	Refers to mechanisms or potential of a system to adapt to climatic stimuli.

LITERATURE REVIEW

Under this chapter, reviewed literature was sought containing information that was in line with climate change and the social-economic challenges on adaptation globally, Africa regional and Kenya. It also investigated the social-economic challenges on adaptation by households in Masinga Sub-County, Kenya.

Climate change adaptation

Global environmental changes especially the ones that deal with accumulation of atmospheric greenhouse gases have increased curiosity of many political leaders, scientists and general humanity. Human induced changes in climate have been widely accepted and impact the environment and development seriously (Houghton *et al*., 1996; Watson *et al.,* 1996; Bruce *et al*., 1996). Climate change is affecting household farmers' crop production and requires proper adaptation strategies (Gornall *et al.,* 2010). Household famers have adapted to a wide range of responses to increase crop yield (Barbier *et al.,* 2008).

Human efforts on adapting to the changing climate have been included in changing climate debates (Stern *et al*., 1992; Rosenberg *et al*., 1989; Goklany, 1995). It is worth noting that the impacts of the climate are affecting many sectors of the world which include; agriculture, fisheries, ecological systems, health and settlement, less developed will continue being more vulnerable to risks of the changing climate (IPCC 2000a). This is because less developed countries do not have necessary resources for making climate change manageable. This condition is more severe among the poorest people in the societies (IPCC 2001:8).

Social-Economic Challenges of Climate Change Adaptation

Globally, African continent is more vulnerable to the impacts of the changing climate because of increased limitations and low adaptation capabilities (Watson *et al.,* 1998). Okonya *et al* (2013) and Hepworth (2010), in their research noted that the small-scale farmers dominate in crop farming which is mostly undermined by poor traditional farming practices.

Global warming has led global changes and climatic variability which has adversely affected the development trajectory in the developing nations and more especially in the sub- Saharan Africa (Asiimwe, 2007, GoU, 2007; IPCC, 2014). Evidently climate change is impacting on various sectors of life (Cooper *et al*., 2008). Projections of climate in Uganda indicate that the country experiences high variability in temperature and rainfall which likely to cause food insecurity (NDP, 2010; Hepworth, 2010).

A study that was done by Parry *et al* (1999) demonstrated that the changing climate lowers crop yields bearing in mind it is more vulnerable to climate variability and therefore making household farmers to be more fragile to the impacts of the changing climate. Orindi *et al.,* (2005) made an

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indication that Uganda's situation will be worsened by the impacts of changing climate.

Many studies (Komba *et al.,* 2012; Maponya *et al*., 2012; Fosu-Mensah *et al.,* 2010; Okonya *et al*., 2013) that have been done have indicated that farmers in Africa have developed different perceptions in handling the impacts of the changing climate in many countries in Africa which includes; Uganda, South Africa, Ghana, Ethiopia and Tanzania.

Further, many coping strategies are being and have been embraced in order to handle the impacts of the changing climate that include: irrigation, crop diversification, changing of land use such as planting period, and practicing activities that do not involve farming like trading (Okonya *et al*., 2013; Maponya *et al.,* 2012; Fosu-Mensah *et al.,* 2010; Okoye, 1998). These cases are educative, except for Okoya *et al* (2013), the impacts of changing climate are more pronounced in the local regions and therefore certain factors of adaptation are crucial.

Great efforts are being made by farmers in adaptation to the changing climate (Maponya and Mpandeli, 2012; Okonya *et al.,* 2013; Asiimwe and Mpuga, 2007. Over- dependence on agriculture to develop their economies and the amount of rain during the rain period makes most countries fragile to the impacts of the changing climate. Drought hazards occurrences point out the most damaging locus for food security (Downing *et al*., 1997). Recent studies (Osman- Elasha, 2007; IPCC WGII, 2007 affirm that Africa, especially the ASALs areas are most vulnerable to the changing climate due to many constrains and less adaptation ability (Osman-Elasha, 2007; IPCC WGII, 2007).

African continent consists only a half of cultivable land mainly in ASALs which includes (aridosols and entisols) desert soils. These soils consist very low organic matter content. Approximately 65 percent of the area is under crop land, 30 percent of the total land area under pasture land of Africa is greatly impacted by soil erosion leading to low crop yields and serious food shortages. Other estimations are less than twenty percent from agricultural soil erosion result from removal of vegetation and less than fifty percent is from overgrazing (ECA, 2001).

Estimations of Africans that are moderately to severely degraded accounts for approximately of about 90 percent, 70 percent of the poor African people work in agriculture (World Bank, 2000). Repeated drought cycles coupled with social – economic challenges contribute to the high vulnerability of the most current environmental change including economic activities globally. Seasons that are dry consecutively coupled with increased disability to adjust to changing climate to cope with drought (Adger, 2000) make the societies more fragile to the impacts of the changing climate.

There is a lot of debate and concern in Africa that approximately 300 million individuals are faced with water shortage (UNEP, 1999). Currently, water that is available is reducing in Africa with great differences between the location of and need for water resources. The TAR (Third Assessment Report) which was produced by Working Group11 (WG11) of the IPCC which aims environmental, social-economic challenges and consequently adaptation responses and the projections that are associated with increased water shortage challenges in Africa. However, Sahel region scenarios indicate that there is increased water stress according to (Hulme *et al*., 2001) and (IPCC, 2001), showing inadequate data of the recent availability of resources of water. Rainfall will be more variable by 2050 and will decline by 5 percent (UNEP, 2002) in Africa.

Challenges of climate change adaptation in Kenya

Agriculture in Kenya contributes approximately 26 percent of the GDP (Republic of Kenya, 2005, 2007). The changing climate poses serious threats and pressure in agricultural production (Lambrou & Nelson, 2010; ROK, 2010). This means that the

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climate has been changing and this has greatly impacted on agricultural production.

Kenya has developed National Climate Change Strategy (NCCRS) to tackle climate change, but it lacks a national adaptation program (GOK, 2010). NCCRS is not consistent on how small-scale farmers' views and social-economic challenges that should be included to national policies concerning climate change to enable stakeholders act appropriately. Developing countries like Kenya will be hit hardest by the impacts of the changing climate (Adger *et al*., 2007; Bunce *etal*.,. (2010); IPCC, 2007a; Kurukulasuriya & Mendelsohn, (2008); Lambrou & Nelson, 2010). One of the reasons why Kenya will be hit hardest is because of limited adaptation capacities in prevailing small agricultural production due to overdependence on rain-fed agriculture (GOK, 2010).

A recent study (Marenya & Barrett, 2007) done shows evidently, that smallholder's efforts towards resource management how they are hindered. However, at the National level, a study done by Eriksen and Lind (2009) report that politics and economic structures play a major economic and political structures have helped household to cope better in many regions in Kenya. Model forecasts are being established to help household farmers to cope better with the changing climate (Alexandrov *et al*., 1999; Jaspe, 1999; Mearns, Rosenzweig & Goldberg, 1997; Mkanda, 1999; Moise & Hudson, 2008; Mortha, 2007).

Women and children in Kenya are more fragile to the changing climate to overdependence on resources that are fueled by the changing climate and inequality in gender roles suggests that they do not have control to the adaptive pressures of the changing climate (UNDP, 2008). Climate change challenges for women are as a result of limited capacity to ownership of property that can enable them to raise capital, lack of sufficient education, negative socialization among others. This limits them to adapt to the changing climate in a big way.

Climate change instability has negatively affected agricultural production in Kenya leading to the importation of commodities in some sensitive sectors. These challenges have impacted on smallholder farmers, because of unpredictable rainfall for agriculture and have low strategies in coping with this severe changing climate effects (FAO, 2012). Studies done have indicated that in Kenya awareness to climate change and variability at society level is still low and farmers have a problem in distinguishing between impacts arising from climate change and challenges associated with environmental degradation (Mutimba *et al*., 2010). Kenya is encouraging many programs related to farming which include; management of soil in order to increase crop yields (Nyangena, 2008). This is attributed to poor traditional farming practices to meet the demand for food in Kenya, necessitating the use of modern ways to curb these problems.

Environmental implications of adaptation to climate change

Climate change adaptation is referred as the ways that are used to regulate and adjust with the impacts of changing climate that can be facilitated, developed and adopted (UNDP, 2004). Changing climate and variability and adaptation at farm level involve changes in agricultural synergies that form the best practices in response to changes in climate conditions and often involve various individual responses level. Adapting mechanisms to the changing climate and variability are reported to be having negative environmental implications. Notwithstanding the effects of sand harvesting is evidently shown by hollows that are left on the ground after the sand has been scooped Nyangena (2008). Honey bee harvesting techniques using smoke to send away honey bees' results to fire outbreak leading large bushes being cleared if not handled efficiently (Laris, 2011 and Pyne, 2011). The growing of drought resistant crops also yields low income to farmers since the quantity produced and market demand is low.

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There is also inadequate and proper water harvesting and storage facility which leads to a lot of water wastage during the rainy season. Inadequate finances to purchase water tanks that can be used to harvest water during the rainy season was a critical challenge to the households. Charcoal burning has made many households to almost entirely depend on trees for their livelihoods (Muriuki *et al*., 2011b). This has greatly impacted on reduction of indigenous trees, thickets and shrubs coverage in Masinga sub-county. This has greatly negatively impacted on the environment by accelerating dry conditions. Most trees in the area are stunted in terms of growth and because of the desire for money by households they do not allow trees to grow as they cut them down for charcoal for selling to earn income (Muriuki *et al.,* 2011b). This has left some places bare hence enhancing degradation of soil in the area, making the land to be greatly dissected.

Gachathi and Eriksen (2011), in their recent studies established that the use of indigenous plant resources such as wild fruits will promote sustainable adaptation to climate change in arid and semi-arid regions of Kenya. Consequently, the use of wild fruits has been used by household farmers in Masinga sub-county for a long time. This has helped household farmers to supplement their nutritional value in their diet amidst climate variability in the area.

Research Gaps

Despite the adaptive responses employed by household farmers in Masinga Sub-County, there still exist challenges of climate change and hence calls for effective adaptation strategies. However, the adaptation strategies employed are not effective to address the existing challenges. There is need for embracing agricultural innovation that can help stakeholders with proper adaptation strategies (Schut *et al*., 2015; Wigboldus *et al*., 2016). However, in Masinga Sub-County agricultural technologies are inadequate. It is this context that has geared increasing momentum and demand for agricultural scientists that have a wider understanding of farming technologies and innovation systems (Leeuwis 2004; Foran *et al*., 2014), hence there is need for household farmers in Masinga sub-county to be conversant with the latest technologies in farming in order to increase productivity and enhance coping with climate variability in Masinga sub-county.

Recent research studies done tend to insist focus on changing climate. Information on changing climate in most developing countries is comparably low compared to developed countries, with African continent known to be least informed (Pelham, 2009). However, in Masinga sub-county, low levels of education tends to limit household farmers to the best agricultural practices hence low crop yields. Rural livelihoods in Masinga sub-county is greatly jeopardized by low amounts of rainfall and high levels of temperatures (Mano and Nhemachena, 2006) hence affecting crop production dependent on rainfed, hence there is need for application of modern farming such as greenhouse farming, although it requires sufficient water which call for proper water harvesting technologies. Water harvesting and greenhouse farming have not fully exploited and hence calls for keen attention.

Study done by Gregory *et al.* (2005) has similar opinion that in some areas will have inadequate water due to decline in rainfall received in the area; high cost of drilling and pumping water was also noted to be a big challenge. Hence, low amounts of water for irrigation in such areas and consequently causing food insecurity. Ludi (2009) in his study indicated that using water for irrigation will fuel availability of food production in the area since there is already shortage of water in the area, however in Masinga sub-county food insecurity remains a challenge and hence calls for proper water harvesting that can be used for irrigation. This has also been greatly noted especially in rain-fed agricultural arid and semi- arid areas. Agriculture technologies requires small scale household farmers to have access to credit markets (Shiferaw *et al*.,

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2015), Households in Masinga sub-county lack access to credit facilities and hence poses challenges that requires keen diversification sources of credit facilities.

Studies done by (IPCC, 2007, Muller *et al.,* 2011) highlight factors that hinder adaptation to the changing climate especially in arid and semi-arid areas. These factors are also similar to the ones that undermine adaptation to the changing climate in Masinga sub-county. In Kenya, research has indicated that adapting to the changing climate is already low and there is a problem of environmental degradation (Mutimba *et al.,* 2010). Small scale farming in Kenya has been greatly affected by recurrent drought especially in Yatta District as affirmed by (Mburu, 2013). The study findings also portray similarities with the one in Masinga sub-county. Food security in Kenya has been greatly dwindled by La Nina droughts of 1999/2000, which led to great contribution in starvation of averagely five million people in Kenya. Recent studies done by (Mburu *et al.,* 2014) affirmed that severe effects in terms of access, availability and sufficiency among small scale farmers. Masinga sub-county is not an exception that is why this study was very instrumental in addressing the social-economic challenges of adapting to the changing climate in the area. Proper policy is vital for adaptation to climate change (Jayne *et al*., 2018), hence Masinga sub-county not exceptional and hence needs keen coping mechanisms by household farmers. The County government of Machakos has not established climate change adaptation policy; however, it has banned human activities that accelerate climate change in the area such as charcoal burning and sand harvesting. Although there are efforts by the County government to combat land degradation through cutting down trees for charcoal, there is still illegal burning of charcoal and uncontrolled sand harvesting.

RESEARCH METHODOLOGY

This chapter describes the main attributes of Masinga sub county, and selection of the study sites; the methods of data collection and analysis. All the divisions investigated are generally categorized as semi-arid areas in Kenya. In the domain of the study scope, a number of techniques were used in well profiled and portioned sites and observations made and data that was collected were discussed appropriately under the results section in chapter four.

Study Area

This current study conducted in Masinga sub county, Machakos County in Kenya. Machakos County is grouped in five agro-ecological zones (AEZs) in relation to the crops yields (Jaetzold et al., 2010; KNBS, 2015). The agro-ecological zones are grouped as follows:

(a) LM 5-6: This AEZs is mainly suitable for the purposes of ranging; it is found within Matungulu and Mavoko sub counties.

(b) LM3: This AEZs is mainly suitable for the growing of mangoes, pigeon peas, cow peas and rearing of indigenous poultry and is found in Mwala, Kathiani, Kangundo, Yatta, Masinga and Matungulu.

(c) LM4: This AEZs falls in Kangundo, Matungulu, Kathiani, Machakos, Mwala, Yatta and Masinga and is suitable for the growing of mangoes, pigeon peas, beans, maize, cow peas and indigenous chicken.

(d) LM5: This AEZs contains soils that are suitable for cow peas, maize, mangoes and indigenous chicken and is found within Masinga, Mwala and Yatta sub counties respectively.

The specific study area was Masinga and the grid reference is in latitudes of $00^0$17’ and $01^0$22’ south and longitudes $36^0$58’ and $37^0$68’ east (WRMA, 2010) and approximately covers an area of 6,255km^2 (Mutua and Klik, 2007). This study area was categorized into the following landscape sub-sections.

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Topography

Masinga is an area which is dominated by open valleys and hills. The steep slopes are deeply cut in altitude ranges of about 1,500m-2,400m above the sea level. The deeply cut areas are more pronounced due to erosion and by rivers which leads to the formation of valleys that are parallel (Kareri, 2012). The topography basically is gently which allows easy ploughing by household farmers, although some areas are difficult to plough during the rainy season because of the black cotton soils in the area.

Geology/Soils

The Masinga sub-county has a wide range of soil types which have got different water retaining abilities (Wilschut, 2010). The general geology of this area consists of andosols in the higher altitudes, nitosols in the relatively average altitudes and vertisols in the lowest altitudes of the area (Kareri, 2012; Mutua and Klik, 2012; Jacobs *et al.*, 2007). These soils are easily carried downslope by running water during rainy season.

Climate

The climate of Masinga sub-county ranges from semi-arid in the east to humid in the western part of the area (Saenyi, 2002). The area has got two main distinct types of rainfall patterns due to inter-tropical convergence zone (Wilschut, 2010). The two distinct rainfall periods are experienced that is short rains and long rains. Amount of rainfall experienced in this area has got orographic effects in the surrounding areas (Saenyi, 2002). On average Masinga sub-county receives approximately 600mm in the east and 2000mm in the humid area towards the west part of the area (Mutua and Klik, 2007).

The area also experiences high and low mean annual temperature which ranges from 26-31^{0}C and 21-24^{0}C respectively per year (Mutua and Klik, 2007).

Vegetation

Vegetation cover in Masinga sub-county generally comprises mixed plant species which include savanna grasslands, shrubs, thickets, and stunted tree species (Mutua and Klik, 2007). Other vegetation types include acacia trees, scattered trees, short grass and bushes.

Land use

The area is characterized by mixed land use patterns which include: crop growing, residential plots, livestock rearing, extraction of building stones, sand harvesting, irrigation activities along the riverine, educational institutions (both public and private), road side traders selling vegetables, fruits, maize, beans, tomatoes and the growing of farm food crops (Mutua and Klik, 2007). The map showing the location of Masinga sub-county is shown in **Figure 3.1.**

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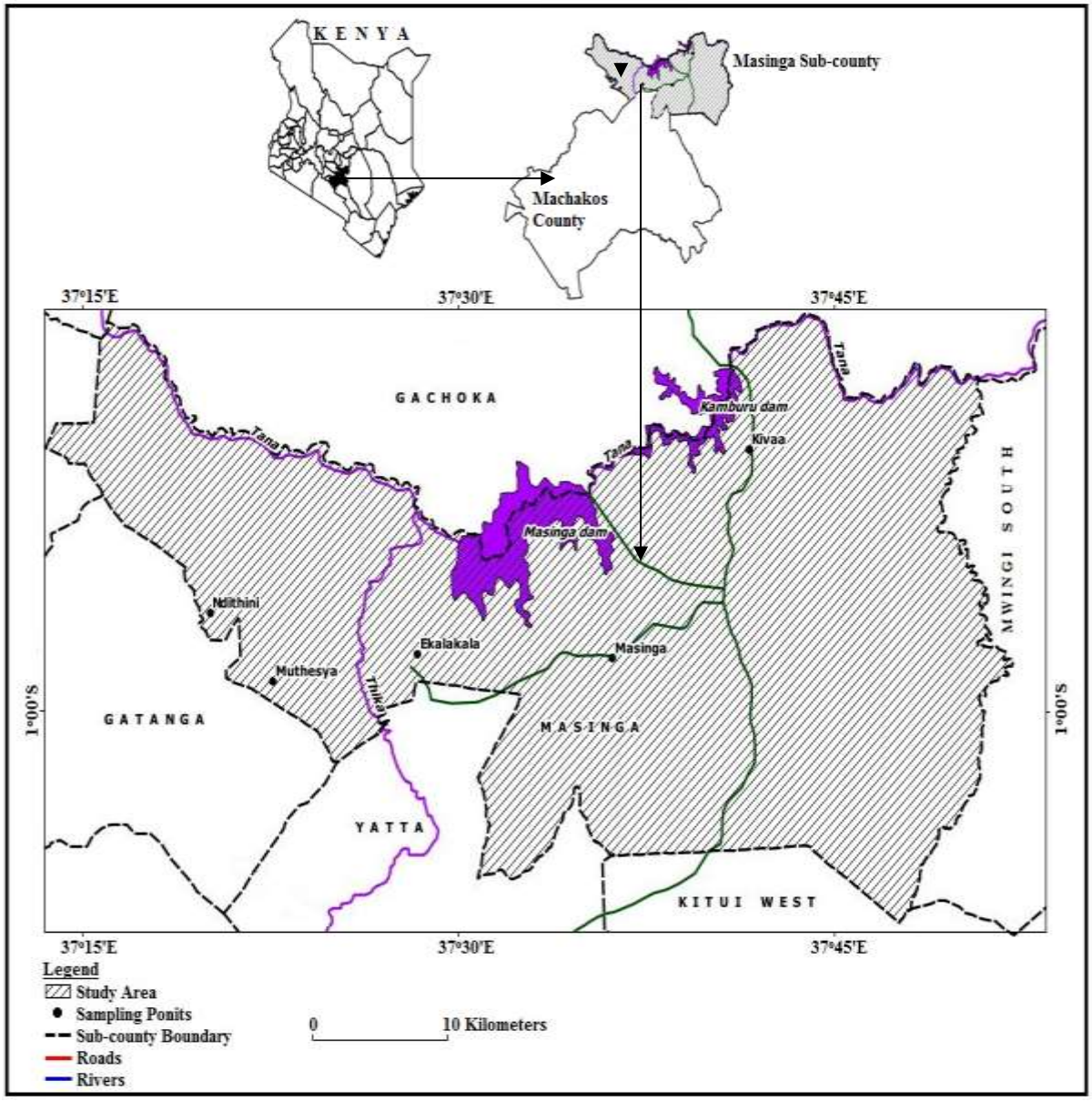
Figure 3.1 Map of the study area



Research design

This research study involved the use of survey design method appropriate as envisaged by (Mugenda and Mugenda, 2003) as it involved interviews of peoples' opinions. In this regard various methods were employed in order to collect and analyze the necessary data for this particular study. The specific methods included quantitative and qualitative techniques. Primary data was collected from the field by the researcher to provide information concerning coping mechanisms to climate change by household farmers. Secondary data was obtained by reviewing scholarly journal articles, books, statistical abstracts and reports. The involvement of both methods in the study was to ensure that data to be collected and analyzed is in tandem with the approaches and the overall strength is greater than that of separate qualitative or quantitative research (Creswell and Plano-Clark, 2007).

Data collection

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Specific procedures for data collection consisted primary sources, which included the administration of questionnaires, interview schedules, and direct observation from the field and desk research, while secondary sources included reports and unpublished data on social- economic challenges on adapting to the changing climate. To determine the adaptation strategies employed by household heads and the social economic challenges on climate change, qualitative and quantitative data were collected using questionnaire administered to 384 household heads which were properly filled. Desk research and interviews were conducted on existing efforts to deal with climate change effects in Masinga sub-county with relevant stakeholders, which included three departments of Agriculture, Water and Environment respectively.

Types of data that were collected

In the context of the current research objectives data was obtained and presented in the various sub-sections in chapter 4.

(a) Social-economic data, b) Adaptation strategies, c) Factors influencing the choice of adaptation strategies, d) Crop yield from agricultural department ministry of agriculture in Masinga sub-county.

Target Population

The population of Masinga sub-county consists of approximately 125,222 people (Kenya National Bureau of Statistics, 2103)). The sampling unit involved 384 households' heads comprising only farmers. This population was distributed proportionately in five geographical zones in the respective wards as follows: Masinga 32,905, Ekalakala 18,816, Kivaa 33,779, Mutheysa 17,145, Ndithini, 22,677(Kenya National of Bureau of Statistics, 2013). The formula below by Fisher's was used to determine the sample size that was applied in the sampling area.

Sample size

The following formula described by (Fisher *et al., 1983)* was used in order to determine the sample size of the household heads.

$$N= \frac{z^2\, pq}{d^2}$$

N is the desired sample size (when the target population is greater than 10,000),

Z is also the standard normal deviation at the required confidence level,

P is the proportion in the target population estimated to have characteristics being measured, q= 1-p and d is the statistical significance test level 95% confidence level, a 50% percentage probability of selecting a household head and a confidence level of ±5%. Thus, the overall sample size was calculated as follows:

$$N= \frac{(1.96)^2(.50)\,(.50)}{(.005)^2}$$

$$= 384$$

Table 3.1: Sample size distribution

Division	Total population	Sample size	Successfully administered questionnaires
Masinga	32,905	100	100
Ekalakala	18,816	64	64
Kivaa	33,779	81	81
Mutheysa	17,145	50	50
Ndithini	22,677	89	89
Totals	**125,222**	**384**	**384**

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Three hundred and eighty- four respondents were able to give the relevant information that was required in the questionnaire.

Sampling Procedure

Household's heads were determined proportionately in this five divisions using Fisher's formula (Fisher *et al*., 1983). For the household's survey, stratified random sampling was used based on the number of household heads proportionately in the six divisions that were surveyed, while key informants were selected purposively. Stratified random sampling involved the distribution of the population proportionately in the five divisions. A random sample from each stratum was compared with the stratum size and the population. Purposive sampling was used to target key informant persons who would offer specific information in the three target departments of social-economic; Agriculture, Water, and Environment. Different stakeholders from department of; Agriculture, Water, and Environment in Masinga sub-county where interviewed and were able to give substantial information regarding social-economic challenges of adaptation to climate change in Masinga sub-county. Further the, the selection of study site is described in section **3.1.** In summary, 5 divisions in Masinga sub-county were profiled demographically and sample sizes established proportionately using the Fischer's formula as indicated in the table below. Detailed and comparable findings are discussed and presented in Chapter 4.

Data collection instruments

The study employed different types of data collection tools for both qualitative and quantitative data. Altrichter *et al*., (2008). This was aimed at making it clearer for both qualitative and quantitative data. The study therefore employed questionnaires, interviews, field observations and desk research methods for quantitative data. Qualitative data was collected through four single sex Focus Group Discussions comprising six to eight households who were sampled through stratified random sampling and purposive sampling respectively.

Ethical considerations

Ethical consideration involved getting consent from the local authorities and the targeted respondents in the study area. The respondents were not forced in any manner and privacy was highly maintained. Children below 18 years were not considered in interviews.

Protocol for Research

Permission to conduct research was granted by Graduate school, Machakos County Commissioner, Ministry of Education Machakos County, the local leaders were also informed about the research. Five enumerators were trained for four days, the semi-questionnaire was well developed and focused on the research topic and objectives.

Data analysis

When analyzing of data both qualitative and quantitative techniques were used. Quantitative data were analyzed using statistical package for social sciences (SPSS). Descriptive statistics, such as percentages, means and standard deviations were computed for all the quantitative data and the results presented using frequency distribution tables, bar graphs and pie charts. Chi-square was used to test the independence of the variables measured. Qualitative data were being organized using qualitative techniques (Gray, 2004). The data analysis matrix is shown in the **Table 3.2**. The results were subjected to statistical test chi-square to determine their reliability.

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Table 3.2: Data Analysis Matrix

Objectives	Data sets	Source of Data	Methods of Analysis	Statistical Test
1	Adaptation strategies employed by households to counter effects of climate change	Surveys Questionnaires Field observations	SPSS	Chi-square
2	Main factors that affects households in adaptation to climate change	Questionnaires Field observations	SPSS	Chi-square
3	Environmental implications in adaptation to climate change	Questionnaires Field observations	SPSS	Chi-square
4	Qualitative data	FGDs Interview schedules	Inferential, Descriptive statistics	

Source: From the field data, 2018(Author)

RESULTS AND DISCUSSION

This chapter presents the results from the field study, interpretations and discussions of the findings. The information presented here was collected from 384 respondents. The research objectives were. i) To examine the adaptation strategies employed by household in Masinga sub-county to counter the effects of climate change; ii) To investigate the main factors that affects the households in adaptation to climate change in Masinga sub-county; iii) To investigate the environmental implications in Masinga sub-county in adaptation to climate change. The research findings were then discussed in tandem with reviewed literature of the changing climate and the social-economic challenges on adaptation in Masinga sub-county, Machakos County, Kenya in the following sub-sections below. In the research findings, it was established that social-economic factors have no effects of climate change in Masinga sub-county, and therefore it was in tandem with the first hypothesis. The study findings also established that, there was a significant difference in the choice of adaptation strategy used by household in Masinga sub-county in terms of education level and gender and was therefore in agreement with the second hypothesis.

Questionnaire response rate

Table 4.1: Questionnaire response rate for 384 respondents

Respondent/ Questionnaires	Administered	Properly filled	Percentage (%)
Total	384	384	100

Out of 384 questionnaires that were administered in this study, 384 were properly filled and returned translating to a response rate of 100% of both male and female. However, this is because majority of these respondents are local farmers and are mainly old people who rely on rain fed agriculture and their traditional methods of farming. On the other hand, majority of the young people have moved to towns for further studies and also for searching for employment and that is why they are not really there at the local level to understand and participate in climate change adaptation. Children below 18 years and below were found not to participate in climate change adaptation since their level of understanding is far below. These study findings are greatly supported with the research findings of (Grothmann and Patt 2005; Deressa *et al*., 2009; Below *et al*., 2012; Hisali *et al*., 2011) which indicated that behavioral factors such as sex, age, level of education are well known to influence the choice of

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adapting strategy. In this regard objective one which was dealing with adaptation strategies employed by household was well represented here. The research study consequently established similarities with Masinga sub-county that low education level played a big role in the choice of coping strategies that are used by household and were similar with studies done by (Arjan *et al.*, 2011).

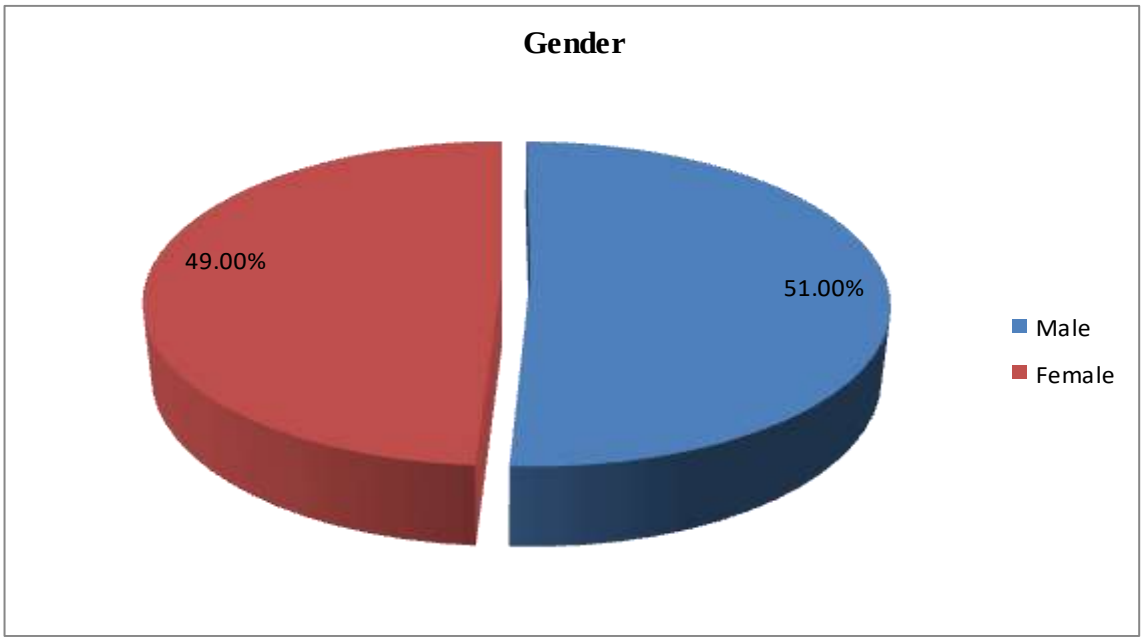
Demographic information

The findings described the information based on gender, age, and education level of respondents. The findings are presented in sub- sections below.

Gender

The demographic profiling of the study showed that many of the household respondents was male (51%) followed by female (49%) as represented in (**Fig 4.1)**. The study findings indicated that male head-headed households adapted more simply because they own most of the assets such as land, livestock and capital Therefore, the study findings were similar with those of (FAO, 2008b) that noted that women were more vulnerable to climatic shocks since they do not own most of the assets such as land, capital, livestock and hence could not acquire loans. This research study also established that more males adapted to climate change than females because they formed the majority and women engage more in other family chores like feeding the young ones, fetching water, collecting firewood and farming than men. The study findings came up with the following pie chart below in order to illustrate the information based on gender per households. (**Figure 4.1**).

Figure 4.1: Distribution of respondents by gender:



The household respondents were having roughly the same ratio; that is female: male. Deliberate efforts were made by the researcher to ensure that all households' respondents were mainly adults. The youngest adults were to those who had finished form four level. Different age sets are illustrated in the table below.

Distribution of respondents by age

Majority of the respondents were derived from young families of 18-35 years. These young respondents constituted 48.8% while older families of 36-45+ years constituted 49.8% of all the respondents.

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Table 4.2: Distribution of respondents by age

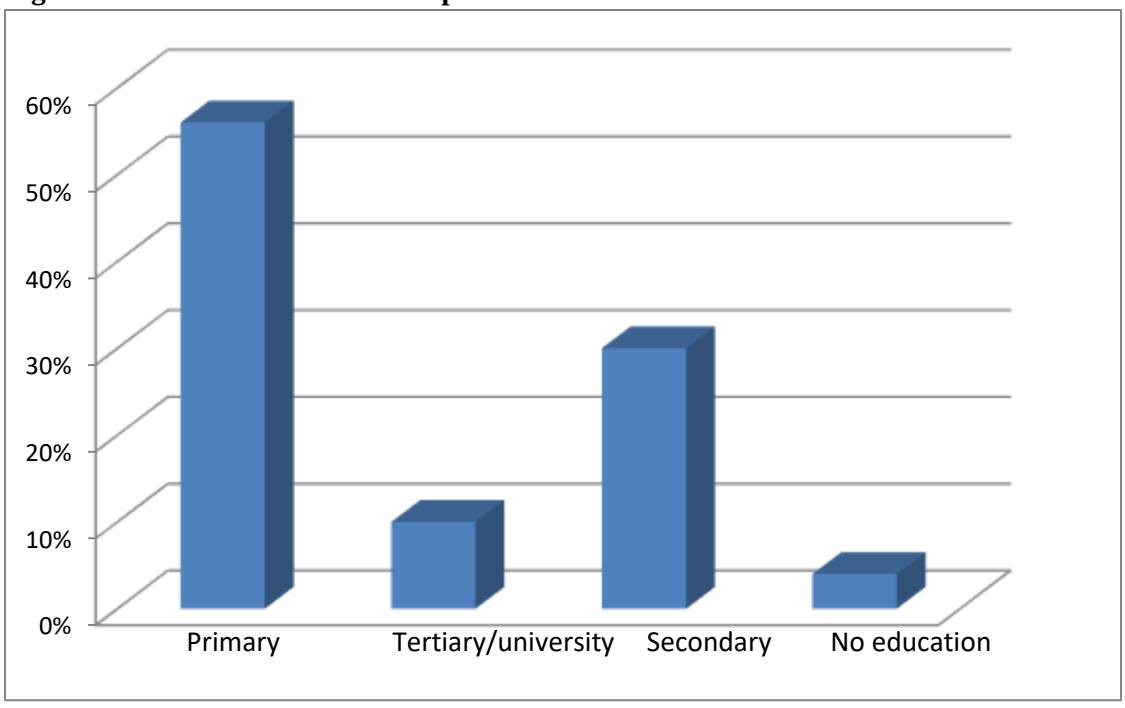
Age set Frequency and percentage of respondents	(F)	(%)
Age 18 years and below	25	1.4
18-25 years	87	24.1
26-35 years	89	24.7
36-45 years	95	26
Above 45 years	88	23.8
Total	384	100

Ingrained within the research findings, it was determined that the majority of the household respondents who were involved in climate change adaptation were found to be within the age bracket of 36-45 years (26%). This is because, this age bracket formed the adult group and was considered to have better knowledge and levels of education and were adapting more to climate change. The household heads aged between 26-36 years (24.7%) formed the average number of households in terms of percentage who were involved in climate change adaptation. The older people who were age 45years and above were considered to stick to their traditional ways of farming and hence adapted less to climate change.

Children aged 18 years and below formed the least number that were involved in climate change adaptation. Similar findings were established by Fussel *et al.*, (2006) and indicated that older people adapted less to changing climate because they were resistant to change but instead they preferred traditional modes of farming. Young children adapted less to the changing climate due to little knowledge about adaptation to the changing climate.

Level of education

Figure 4.2: Educational level of respondents



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This research study established that majority of the household respondents attended primary institutions (56%), followed by those who attended secondary school (30%), tertiary (10%) and those who did not attend any institution of learning constituted (4%) formed the least number. This study established that those who attended secondary school and primary institutions were more informed in the changing climate adaptation matters. Further, the research study established that those who were not actively participating in climate change adaptation constituted only 4%. The study also established that those respondents who attended secondary (10%), only a small percentage number was involved in climate change adaptation. Therefore, those who attended primary school were able get the basic foundation of knowledge in adaptation to climate change in Masinga sub-county.

Family size

Table 4.3 Distribution of Respondents by Family Size

Respondent	Family size	%
Less than 2	97	24.1
Three	88	22.7
Four	98	25.5
Over four	101	27.7
Total	384	100

Based on appropriate computations, it was established that a small number of household's respondents had a family size of less than two family members (24.1%) while the others had a family size of three members (22.7%) respectively. Further, family size that constituted a bigger number was between family size of four members (25.5%) and over four family members (27.7%). From the research findings, it was established that; the larger the family size the more the adapting to the changing climate since more people are involved in various activities that can reduce the impacts of changing climate in Masinga sub-county than a small family size were few people are involved in adapting to the changing climate. The research findings were also affirmed by Croppenstedt *et al*. (2003) suggested that families with larger households are able to pool greater labor and hence more likely to adapt to agricultural technologies than smaller family households. These findings also had similarities with the studies undertaken by (Deressa *et al*., 2008) that the size of family is very important in determining the adaptation strategy used by households in Masinga sub-county.

Adaptation strategies to counter the effects of climate change

Table 4.4: Adaptation strategies employed by households in Masinga

Strategy	Being implemented/practiced		Not implemented/practiced	
	(f)	(%)	(f)	(%)
Improved early warning of climate change	83	23	278	77
Financing water institutions to enhance adaptive capacity	56	15.5	305	84.5
More credit and financial services for small businesses and rural development	103	28.5	258	71.5
Better education and information	77	21.3	284	78.7

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Strategy	Being implemented/practiced (f)	(%)	Not implemented/practiced (f)	(%)
for the rural areas regarding environmental conservation				
Enhanced water storage facilities	64	17.5	297	82.3
Building of deep wells to provide drinking water for people and animals	76	21	285	79
Adoption of grain storage facilities	102	28.3	259	71.7
Engaging in sand harvesting	277	76.7	84	23.3
Engaging in charcoal burning	269	75.5	92	25.5
Engaging in fishing	88	24.4	273	75.6
Engaging in brick making	113	31.3	248	68.7

This research study sought to establish whether there are improved early warnings of climate change as a strategy to counter the effects of climate change in Masinga sub-county was employed. The study findings indicated that majority of the respondents (77%) reported that the strategy in adaptation to climate change is not practiced in the area while (23%) indicated that the strategy was not applied. This was attributed to the fact that the households only relied on information from the local radio stations about climate change. A further majority (84.5%) of the household respondents affirmed that the strategy of financing water institutions to enhance adaptive capacity is not practiced. Financing any water projects in Masinga sub-county was confirmed to pose a serious challenge to adaptation to climate change in Masinga sub-county. Only a small number (15.5%) affirmed that financing of water as an adaptation strategy was used in the area. The small number attributed was a result of few organizations which supported financing of water which included NGOs.

When the household were interviewed whether there are more credit and financial services for small businesses and rural development as a strategy to counter the effects of climate change in Masinga sub-county, most of the respondents (71.5%) reported that the strategy is not implemented while a small number agreed (28.5%) that the strategy was used. The research study also sought to determine if there is better education and information for the rural areas regarding environmental conservation. It's worth noting that the fact that there were no elaborate deep wells constructed to provide drinking water for people and animals, as affirmed by the majority (82.3%) of the respondents. Only a small number (17.7%) of the respondents acknowledged the existence of deep wells constructed to provide drinking water for people and animals as a strategy to counter the effects of climate change in Masinga sub-county. This study established similar findings and characteristics with the one done by (Oremo, 2013, Mburu, 2013, Kalungu *et al.*, 2013).

In addition, the current study sought to establish whether the Masinga sub-county residents engage in sand harvesting. Premised on the findings illustrated in **Table 4.4**, (76.7%) of the household respondents reported that sand harvesting is real. The study done by (Muriuki *et al*., 2011b) also established that charcoal burning was practiced by majority (74.5%) of the households and formed the main source of income for their livelihood in Masinga sub-county and is a very important cause of fire and loss of biodiversity in the area. One person reported that fire is sometimes intentional or accidental and hence large areas lose large vegetation cover.

A further a small number (25.5%) of households acknowledged that charcoal burning is practiced in Masinga sub-county. The findings represented in **Table 4.4** affirmed that less than forty percent

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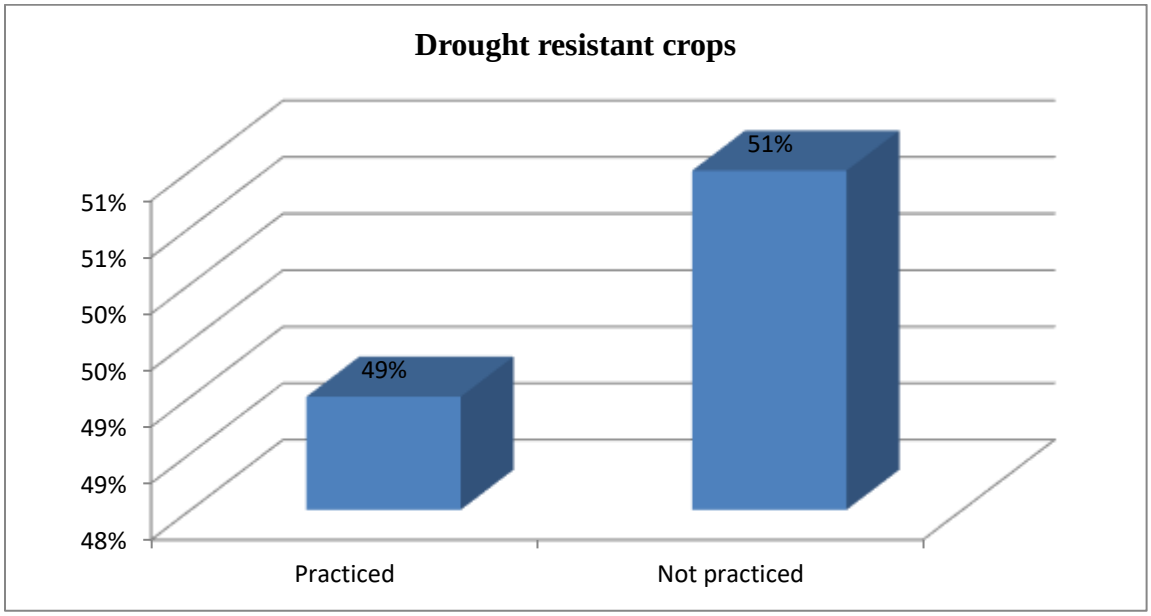
(31.3%) of the respondents confirmed that brick making is practiced in Masinga sub-county as an adaptation strategy while majority (68.7%) of the respondents acknowledged that brick making is not practiced in the area as way of adapting to climate to climate because most people live in simple houses.

Figure 4.4: Practice of growing drought-resistant crops



The research findings revealed that majority of the households, 51%, did not utilize short rain seasons and plant crops that are drought resistant as an adapting strategy in order to deal with the changing climate in the area. However only (49%) of the households acknowledged to be utilizing short rain seasons and planting crops that are drought tolerant. The research findings established that inadequate use of short rain season to plant crops that are resilient to the changing climate was a major challenge. This is due to inadequate information about the rain seasons so that they can prepare themselves adequately for growing crops. The study findings in Masinga sub-county were similar with the one done in Yatta by (Mburu *et al*., (2014) that established how household farmers have adopted to the changing climate in the area by using drought tolerant crops, burning of charcoal and also rainwater harvesting.

The research study was interested in determining whether residents in Masinga sub-county practice agro-forestry. The findings of the study were illustrated in **figure 4.5** below.

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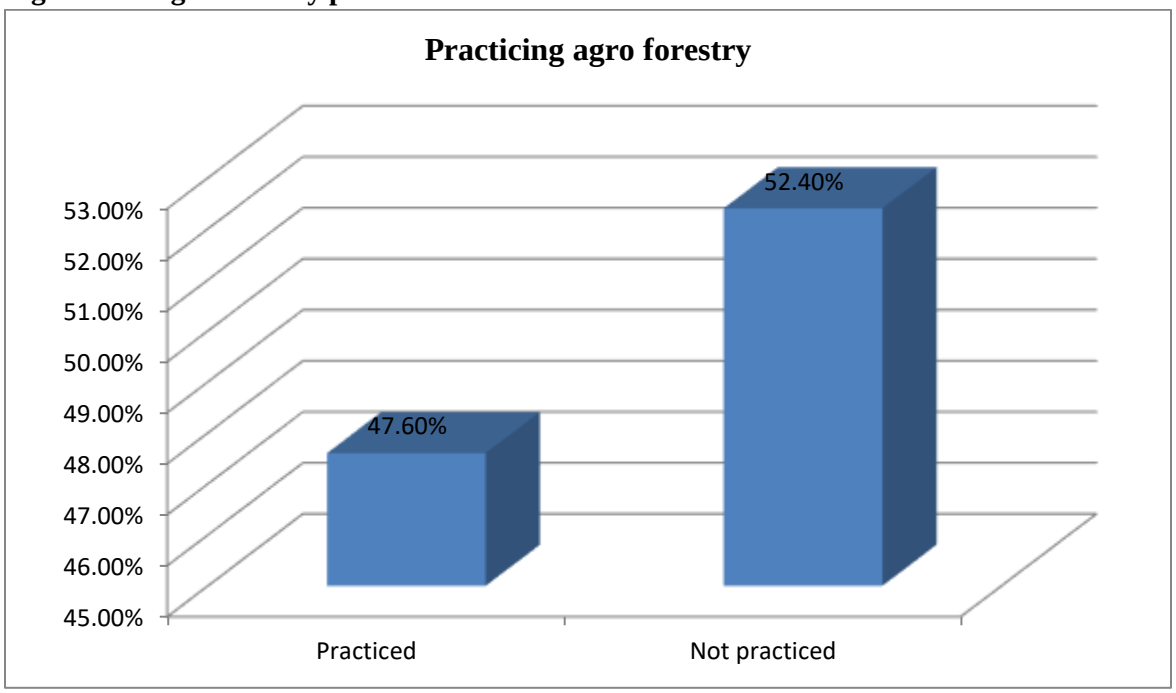
Figure 4.5: Agro-forestry practice



Majority of the household farmers (52.4%) do not practice agro forestry in adapting to the changing climate in the area. The research study also established that it is only (47.6%) of the household farmers in Masinga sub-county that practiced soil conservation agriculture in order to deal with the changing climate in the area. This means that majority of the farmers in the area were found not to be informed about agro forestry as a way of handling the changing climate in the area. Studies that were done by Bryan *et al*., (2011) affirmed and showed similarities with the one done in Masinga sub-county that indicated adopting to crop varieties, changing planting dates, reducing livestock numbers and using conservation measures led to controlled climate change impacts.

This research study also found similar findings after analysis with that of (IPCC, 2000a) that established that climate change in most parts of the world severely affects social-economic sectors with less developed countries being the most fragile to the impacts of the changing climate. Masinga sub-county being in a developing country was also found to fall under this category of the research findings.

Factors affecting household adaptation to climate change

Examining the main factors affecting household adaptation to climate change in Masinga sub-county constituted the larger scope of this study. As such, the researcher sought the opinion of the respondents regarding the effectiveness of the strategies used to adapt to climatic change. The study results are summarized as percentages in **Table 4.6.**

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Table 4.6: Effectiveness of the strategies used to adapt to climatic change

Strategy	Not very effective %	Neutral %	Effective %	Very effective %
Greenhouse farming is practiced in the area	79.6	2.7	12.8	4.9
Better utilization of short rain seasons, drought-resistant crops to prepare for drought	51.4	4.9	20.7	23
Better household and community management and use of natural resources, including wild fruits	65	3	22.7	9.3
Practice of soil conservation agriculture (Agro-forestry)	79.7	3	14.9	2.4

Premised on the findings envisioned on **Table 4.6,** many of the respondents (79.6%) reported that greenhouse farming is not very effectively practiced by farmers in Masinga sub-county. This was due to high cost incurred during installation and because most farmers are poor they tend apply only traditional methods of farming hence increased vulnerability. The researcher also sought to establish whether Masinga sub-county residents utilize short rain seasons and plant drought resistant crops. Most respondents (51.4%) reported that the use of short rain season and planting of drought resistant crops to prepare for drought was not effectively implemented. This was due to lack of information about weather patterns which hindered most of the farmers in dealing with the changing climate in the area. Therefore, it was necessary for farmers to plant drought resistant crops which use minimal water for the growth of crops.

Further, the research study was interested in determining whether household engage in better and community management and use of natural resources strategies are implemented. After analysis, the researcher established that many of the respondents (65%) confirmed the strategy is not effective. Whether Masinga sub-county residents practice soil conservation agriculture, majority of the respondents (79.7%) said that agro forestry is not effectively implemented.

This was determined to establish the effectiveness in financing water institutions in order to enhance adaptive capacity. Based on the findings presented in **figure 4.6**, majority of the households in Masinga sub-county elucidated that the financing water institutions as a strategy of enhancing adaptive capacity to climate change not very effective. (9.4%) of the households remained neutral while (12.4%) of the households and a further (11%) effectively and very effectively acknowledged that financing water institutions to enhance adaptive capacity is effective.

Figure 4.6: Effectiveness of financing water institutions

The research study was also interested in determining the effectiveness of educational programs regarding environmental conservation in Masinga sub-county by household's heads. The study findings established that many (63.4%) of the household farmers explained that the educational programs and information for the rural Masinga sub-county are effective. This was in agreement with studies done by (Grothmann and Patt; Deressa *et al*., 2009; Below *et al*., 2012). Regarding environmental conservation, it was established that the method is not very effective by a bigger number of household respondents. Further relatively a small number of household respondents were neutral on the effectiveness of the educational programs. On

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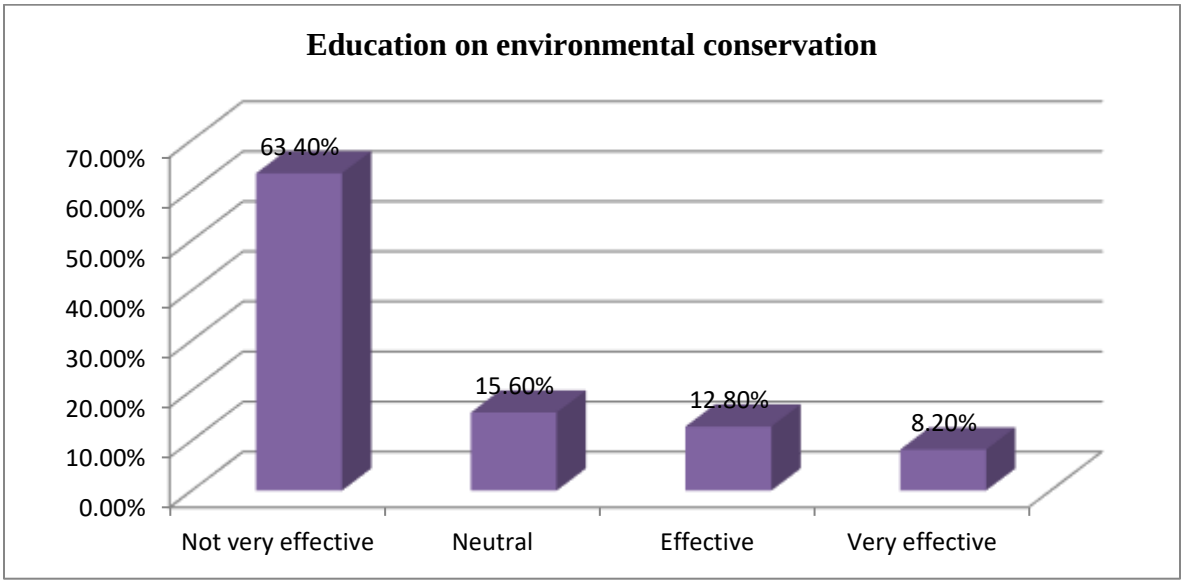
the other hand, also a small number only of the households acknowledged that the educational programs regarding environmental conservation are effective.

Figure 4.7: Effectiveness of the educational programs



From the study findings many of the households (63.40%) acknowledged that educational programs in adapting to the changing climate are not working. On the other hand, (15%) of the respondents remained undecided on the effectiveness of the educational programs. Other household (12.80%) confirmed that the use of educational programs in dealing with the changing climate was effective strategy. Only a very small number (8.20%) accepted that educational programs were very effective in coping with the changing climate. Therefore, majority of the household respondents found the strategy not effective in dealing with the changing climate, hence making majority of the household farmers are vulnerable.

Table 4.7: Environmental implications of climate change adaptations

Statement	Strongly disagree		Disagree		Neutral		Agree		Strongly Agree	
	f	%	f	%	f	%	f	%	f	%
There has been an increase in land degradation over the years	22	9.9	34	3.3	10	18.3	158	31.6	137	36.9
There has been a decrease in river water supply	79	11.9	68	18.8	67	8.6	74	30.2	73	30.5
The area experiences varying rainfall patterns	54	13.3	6	8.3	9	6.3	191	52.9	111	40.7
There has been an increase in the number of malnourished children over the years	18	5.0	11	3.04	4	1.1	182	50.4	146	40.4
Increased population changed the patterns of use of land	24	6.6	14	3.9	9	2.5	210	58.2	104	28.8
The yearly rainfall is not enough to support agricultural activities	2	0 .6	7	1.9	5	1.4	165	45.7	182	50.4

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Respondents were asked by the researcher to respond to a number of questions. Premised of the respondents (68.5%) majority either agreed or strongly agreed that there has been an increase in land degradation over the years due to climate change effects in Masinga sub-county as a result of sand harvesting. As to whether Masinga sub-county experiences varying rainfall patterns, (93.6%) who constituted the majority of the respondents acknowledged that the area experiences varying rainfall patterns. Further findings by the researcher indicated that (96.1%) of the household respondents were in agreement that increased population has led to changing use of land patterns in Masinga sub-county. The study findings were in agreement that there has been change in the use of land by households in view of fire in hunting of bee as integral ways of diversification of livelihood strategies in dealing with climate change (Ellis, 1998). It was further established that fire used in hunting of honey bees had greater influence on biodiversity and hence needs a good understanding by the people to handle those fires when they are carrying out their hunting honey bee activities (Laris, 2011 and Pyne, 2001). This was established to cause fire outbreak which makes the area to lose big size of vegetation over. Charcoal burning has made many local households to almost entirely depend on cutting trees for their livelihoods (Muriuki *et al*., 2011b). This study concurred with the findings which indicated that households in Masinga sub-county engaged in charcoal burning to earn income for their livelihoods.

According to (Chang'a, Kijazi, *et al*., (2017) concurred with the previous studies that the changing climate impacts such as perennial droughts and low adaptive mechanism will continue to hit hard regions of developing nations and their economies since they entirely depend on rain fed agriculture. Masinga sub-county was confirmed by the study findings to have similar characteristics droughts and hence justifiable for this study.

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