CONTRIBUTIONS OF SOCIOECONOMIC, CULTURAL AND INSTITUTIONAL FACTORS ON CLIMATE CHANGE ADAPTATION STRATEGIES BY SMALLHOLDER FARMERS IN HOMA BAY COUNTY, KENYA

BY

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SCHOOL OF AGRICULTURE, FOOD SECURITY AND ENVIRONMENTAL SCIENCES

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DECLARATION

I certify that this is my original work and has not been presented elsewhere for an award of a degree, diploma or certificate

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DEDICATION

This piece of work is dedicated with affection and love to my wife Caroline Achieng Otieno and my children, Ian, Glen, Lynn and Shalom for their patience, understanding and support during the period of my study.

and

My late father Silvanus Awinda and my mother Eunice Awinda for her moral support that encouraged me to undertake a great task as this, may the Almighty God bless her.

ABSTRACT

Climate change poses significant challenges to smallholder farmers globally, particularly agricultural production in developing countries. This makes it necessary for agricultural systems to adapt to climate change effects. However, smallholder farmers have limited capacity or resources to adapt to climate change. Studies have provided insights into particular adaptation strategies and impacts, but remains unclear to what extent socioeconomic, cultural and institutional factors contribute to the choice of climate change adaptation strategies at household level. The main objective of this study was to assess the contributions of socioeconomic, cultural and institutional factors on choice of climate change adaptation strstegies by smallholder farmers in Homa Bay County. The specific objectives were to establish the contribution of socioeconomic factors (land size, gender, age, marital status, educational level) on choice of climate change adaptation strategies by smallholder farmers in Homa Bay County; determine the contribution of cultural factors (place attachment, cultural and religious beliefs) on choice of climate change adaptation strategies by smallholder farmers in Homa Bay County; find out the contribution of indigenous local knowledge (Farming experience, climate change experience) on choice of climate change adaptation strategies by smallholder farmers in Homa Bay County; and to examine the contribution of local institutions (group membership, types of institutions) on choice of climate change adaptation strategies by smallholder farmers in Homa Bay County. The study used cross sectional survey design and a sample size of 398 smallholder farming households out of a target population of 158,827 smallholder faming households in the study area. Quantitative data were collected using a structured household questionnaire administered to 398 household heads and qualitative data were collected using interview schedule administered to 24 key informants and focus group discussions administered to 12 groups. Quantitative data were analysed using frequencies percentages, cross-tabulation and Chi-square test of independence at 5% significance level. The Cramer's V coefficient of effect size was used to measure the contributions of these factors on choice of climate change adaptation strategies. Qualitative data were analysed thematically based on study objectives. The results revealed that the socioeconomic factors with very strong statistically significant contribution to choice of climate change adaptation strategies included marital status (V= 0.257), household size (V=0.268), while size of farm (V=0.194) and source of farm labour (V=0.219) had strong contribution to choice of climate change adaptation strategies. Cultural factors with very strong contribution included level of attachment to place of residence (V= 0.372), family order in farm operations (V= 0.272) and religious beliefs (V= 0.412), to the choice of climate change adaptation strategies. Indigenous knowledge factors with very strong contribution included farming experience (V=0.250) and climate change experience (V=0.338), while duration of stay in the study area (V=0.232) had a strong contribution to choice of climate change adaptation strategies. The institutional factors with strong contribution included sponsorship by local institutions (V=0.195) and types of assistance received (V=0.181). The study concluded that the four factors (socioeconomic factors. cultural factors, indigenous local knowledge and local institutions) examined significantly contributed to choice of change adaptation strategies by smallholder farmers in the study area. However, culture was found to be central and had an influence on the effect of all the four factors in determining the choice of climate change adaptation strategies. The study recommended the need to strengthen cultural practices that enhance climate change adapyatio. Development of agricultural production should consider the socioeconomic, cultural and institutional factors contributing to climate change adaptation at household level for improved household food security in the study area.

WORKING DEFINITION OF TERMS

Climate: is the weather in the study area averaged over time of 30 years.

Climate change: refers to shifts in the mean state of the climate or in its variability, persisting for a longer period of time, of which 10 years was deemed to be appropriate for this study.

Climate change adaptation: a response to climate change markers (floods, drought, prevalence of pest and disease, unreliable rainfall) that seeks to reduce the vulnerability of social and biological systems to relatively sudden change and thus offset the effects of climate change to smallholder farmers.

Climate change adaptive capacity: ability of smallholder farmers to return to or exceed functional capacity that existed prior to exposure to harsh climatic conditions or ability of smallholder farmer to adjust to climate change by moderating potential damages through application of affordable climate change adaptation strategies or coping with the consequences.

Climate change adaptation strategies: actions taken to enable smallholder farmers and ecosystems moderate, cope with, or take advantage of actual or expected change in climate conditions. In this study it was measured by measures taken to adapt to climate change such as changing planting date, planting short season crops, planting drought resistant crop varieties, planting trees alongside crops, keeping of drought tolerant livestock breeds i and water harvesting.

Climate variability: refers to variations in the mean state of climate on all temporal and spatial scales beyond that of individual weather events, which may negatively or positively influence agricultural production of the smallholder farmer.

Culture: Culture is defined here as the symbols that express meaning, including beliefs, rituals, art and stories that create collective outlooks and behaviours, and from which strategies by smallholder farmers to respond to impacts of climate change are devised and implemented.

Cultural factors: refers to beliefs, values and practices that are passed down from generation to generation within a community and can be used to define the community. These may include customs and traditions held and practiced by members of a community and may contribute to climate change adaptation by smallholder farmers.

Cultural factors of climate change adaptation: these are factors associated with personal values and worldviews which may shape how smallholder farmers perceive and adapt to climate change. The cultural factors in this study include religious beliefs, traditions such as family order in carrying out farm operations, place identity and place attachment.

Food security: a situation when all small-holder farming households, at all times, have physical, social and economic access to sufficient, safe, and nutritious food that meets their dietary needs.

Indigenous local knowledge: knowledge accumulated by smallholder farmers over a long time about their environment to guide their resource use and management, and adapt to the effects of climate change. In this study it was measured by duration of stay in the study area, farming experience and climate change experience and perception.

Institutional factors: refers to formal and informal rules in governmental or non-governmental organizations that constrain the behavior of individuals and reflects efficiency of performance in enabling smallholder farmers to adapt to climate change.

Local institutions: are formal or informal agencies at community levels which may be civic, public or private which empower smallholder farmers to take charge of climate change adaptation strategies. The institutional factors in the study include group membership, assistance offered by the institutions and how they contribute to climate change adaptation by smallholder farmers.

Private adaptation: actions taken by individual smallholder farmers against climate change markers that seeks to reduce their vulnerability and thus off-set the effects of climate change.

Smallholder farmer: defined here as the farmer with average land holdings of less than 5 acres and is involved in small-scale agricultural production mostly for subsistence purposes. These farmers have low levels of income and technology, poor marketing structures, low investment costs and lack of institutional support.

Socioeconomic factors: refers to social and economic experiences and realities that define regions and neighbourhoods of smallholder farmers and can help mold their personality with regard to climate change adaptation.

Socioeconomic factors of climate adaptation: these are factors arising from the interaction between society and economy which shape how smallholder farmers perceive and adapt to climate change. These factors include the household income, climate change awareness and adaptation, level of education of the smallholder farmers and their spouses, age of the household head, gender of the head of the household, size of the household, livestock ownership, and source of farm labor and availability of financial capital.

Vulnerability: this is exposure to climate conditions, sensitivity of those conditions and the capacity to adapt to the changes by the smallholder farmer.

Weather: refers to atmospheric conditions in the study area in terms of air, temperature, pressure, humidity, wind speed and precipitation

Worldviews: are a group of values and beliefs about how society should be organized and may have an influence on climate change adaptation of smallholder farmers.

LIST OF ABBREVIATIONS AND ACRONYMS

ASAL	Arid and Semi-Arid Lands
AEZ	Agro-Ecological Zone
CTR	Climate Change Risk
DIMS	Disaster Information Management Systems
EAC	East African Community
EWIS	Early Warning and Information Systems
FAO	Food and Agriculture Organization
GAW	Global Atmosphere Watch
GDP	Gross Domestic Product
GIPB	Global Initiative on Plant Breeding
IPCC	Intergovernmental Panel on Climate Change
KENJOM	Kenya Network of Journalists and Meteorologists
KMD	Kenya Metrological Department
MDGs	Millennium Development Goals
NGOs	Non-Governmental Organizations
RANET	Radio Internet Project
ROK	Republic of Kenya
SDGs	Sustainable Development Goals
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
WOCAT	World Overview of Conservation Approaches and Technologies

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CHAPTER ONE
INTRODUCTION

1.1 Background to the Study

Climate change poses significant challenges to smallholder farmers globally, particularly in developing countries and adaptation is essential for sustaining livelihoods, ensuring food security, and mitigating adverse climate effects (Jin et al., 2023). The United Nations Framework Convention on Climate Change (UNFCCC) advocates that all parties must formulate and implement national programmes containing measures to facilitate adequate adaptation to climate change (UNFCCC, 2019). It outlines specific domains in particular need of adaptation, which include coastal zones, water resources, agriculture, and areas affected by drought and desertification, as well as flood (FAO, 2019). Climate change can impact socioeconomic and environmental systems and shape the prospects for energy, food, water and health security (Sissoko *et al*., 2011). The change in climatic patterns result in change in the spatial distribution of agro-ecological zones, habitats, distribution patterns of plant diseases and pests, fish population and ocean circulation patterns. These can have significant impacts on agriculture and food production (FAO, 2019).

Floods, droughts and extreme weather events, for example, are already putting social and economic relations under stress in many areas, while changes in energy and forestry sectors are transforming the world of work for many women and men throughout the world (ILO, 2018). The Parties to the UNFCCC and its Paris Agreement stresses that countries and communities need to develop climate change adaptation actions and implement solutions that are responsive to the current and future climate impacts (UNFCC, 2021). The farms, pastures and forests that occupy over 60 per cent of the earth's surface are progressively being exposed to threats from increased weather variability and, in the longer run, to climate change (UNFCC, 2021).

In agriculture, adaptation to climate change is dynamic and occurs in the context of climatic, economic, technology, social and political forces that are difficult to isolate, and most adaptation strategies serve multiple purposes and are strongly interrelated (Smit and Skinner 2002; Adger *et. al.,* 2007). The most common climate change adaptation measures practised by smallholder farmers in Sub-Saharan Africa are changing crop varieties, changes in planting dates, smallholder

irrigation, soil conservation measures, tree planting, water harvesting, keeping of drought tolerant livestock breeds and changing crop types (Bryan et al., 2009; Deressa et al., 2009).

Africa has been classified as one of the regions that are most vulnerable to the impacts of climate change (Bryan et al., 2013; IPCC, 2014a). Climate change is one of the major factors limiting Africa's efforts to achieve food security because of the continent's reliance on rain-fed agriculture and the low capacity of smallholder farmers to adapt to climate change (IPCC, 2014b; Phirri et al., 2016). It is predicted that Africa will witness increased temperatures, changes in rainfall intensity and distribution and a rise in incidences of extreme weather events (e.g. droughts and floods), pests (e.g. desert locusts and fall army worms), weeds and disease epidemics (e.g. maize necrotic disease) (FAO, 2015; Connolly-Boutin and Smit, 2015).

Climate projections from existing data have shown that prolonged and more intense dryness in Sub-Saharan Africa by 2040 (Trenberth *et al*., 2015; Boyd et al., 2013). Changing rainfall patterns, increasing temperature and severe weather events including floods and droughts are posing significant threats to weather and food security, human health and socioeconomic development in this region (Mohammed and Uraguchi, 2013; Kusangaya et. al., 2014). Climate-related extreme events such as floods, heat waves, storm surges and droughts are imposing heavy burden on societies (Mishra, 2017). FAO reports that the level of world hunger is constantly increasing since 2014 and the number of undernourished people reached 821 million in 2017 (FAO et. al, 2018) due to effects of climate change. The climate related disturbances would not only have adverse impacts on food distribution patterns, but also on its quality and access. It will also raise humanitarian crisis as food security and public health are deeply linked (Arora, 2019).

Kenya has a total land area of 582,646 square kilometres of which, about 83 per cent is classified as arid and semi-arid lands (ASAL). It is estimated that about 11 per cent of arable land could be affected by climate change, including a reduction of cereal production, which is about 16 per cent of agricultural GDP (FAO, 2005). It requires that farmers cope by making changes in farming and land management decisions that lower the negative consequences associated with climate change and variability (Jarvis et al., 2011). About 99,050 square kilometres (17%) is classified as medium to high agricultural potential experiencing at least 700mm of rainfall per annum (RoK, 2013). This potion is already experiencing the effects of climate change and the farming communities have begun to respond by introducing local livestock breeds such as zebu and boran cattle that can withstand increased temperatures, introducing drought-resistant crop varieties such as millet,

sorghum and cassava, and adopting water saving methods for small-scale irrigation (RoK, 2013) for their livelihoods.

Agricultural production contributes about 25.4 per cent of Kenya's Gross Domestic Product (GDP) directly and another 27 per cent indirectly through its links with agro-based industries and the service sector (FAO, 2015). While most parts of the country already experience an increase in rainfall variability, 75% of the agricultural output mostly come from rain-fed small-scale agriculture (Herrero et al., 2010). The majority of the population live in rural areas, with smallholder rain-fed agriculture as the main economic activity (Bryan et al., 2013; Barasa et al., 2015b). These smallholder farming systems are faced with many challenges, including climate change (Bryan et al., 2013; Mugi-Ngenga et al., 2016; Wetende et al., 2018).

Food and Agriculture Organisation (FAO) reports that achieving the target of sustainable development goals (SDGs) by 2030 to eradicate hunger looks slim (FAO et. al, 2018) due to effects of climate change. Therefore, implementing actions and policies to mitigate and adapt to the effects of climate change is urgently required (Arora, 2019). The increased effects of climate change among smallholder farmers in Kenya call for enhanced adoption of adaptation and mitigation measures that result in improved food security (Kimaru- Muchai et al., 2020; Musafiri et al., 2020). However, Parties to the UNFCCC and its Paris Agreement recognizes that adaptation to climate change is a global challenge faced by all with local, subnational, national, regional and international dimensions (UNFCCC, 2021) and context specific socio0economic and cultural factors.

The climate change poses significant risks to all communities including smallholder farmers in Lake Victoria basin and the land they depend on for their livelihood, subsistence, and physical and spiritual being (Hanna, 2007). Climate change and variability is a major economic challenge in the Lake Victoria Basin (LVB) and is likely to increase poverty levels due to its implications with respect to agriculture and food security, water resources, natural resources including ecosystem goods and services and its adverse effects on human health (Mogaka et.al 2006; Mugisha et.al 2007). The effects of climate change on agriculture will greatly rely on the rate and severity of the change and the degree to which crop and livestock farmers can adapt to climate change (Gowda et. al, 2018), pointing to the significance of climate change adaptation.

In Homa Bay County, where crop production is majorly rain-fed and livestock farmers depend mostly on natural pasture, long dry spells and irregular rainfall exacerbate the problem of low

yields and leave rural households even more susceptible to food insecurity (MoALF, 2016). Agriculture is leading in income contribution to households in the County as it employs about 74% of the labour force (RoK, 2018a). However, over 90% of the farmers use traditional production and storage methods, which limit their output (RoK, 2013) and about 82% of the households do not have enough food to meet their household requirements throughout the year (MoALF, 2016). The mean land holding size in Homa Bay County stands at 6 acres, meaning that majority of farmers fall in the bracket of smallholders (RoK, 2013).

The key challenges facing land use and hence agriculture include drought, lack of access to agricultural credit, outbreak of pests and diseases such as army worms, inadequate agricultural extension staff, high poverty levels and low soil fertility (RoK, 2018a). Thus, application of climate change adaptation strategies such as soil and water conservation, staggering planting dates, improved storage methods among others would be necessary to improve food security in the County. This calls for an understanding of how smallholder farmers perceive climate change and the factors contributing to climate change adaptation. Adaptation is a critical component of the long-term response to climate change to protect people, livelihoods and ecosystems (UNFCCC, 2021) particularly at household level. However, a number of factors (socioeconomic, institutional and cultural) could be constraining climate change adaptation.

Research at the community and household level have analysed particular adaptation strategies and impacts (Below et al., 2012; Vermeulen et al., 2011), but have not clearly explained the contributions of socioeconomic (gender, educational level, marital status land size, source of labour), institutional (group membership, types of institutions, assistance offered) and cultural factors (place attachment, cultural and religious beliefs) on climate change adaptation by smallholder farmers at household level. Some other studies on climate change have shown that Africa, including Kenya is vulnerable to climate change due to poverty, inadequate technology, economic challenges, weather extremes and poor governmental agriculture policies (Lobell et al. 2011). Other researches have shown that financial, educational, socio-cultural, institutional, and technological factors increase farmers' vulnerability to climate change (Antwi-Agyei et al. 2012; Boyd et al. 2013; Kithiia et al. 2011), but are not clear on how these factors contribute to climate change adaptation strategies (change of planting date, planting of short season crops, planting drought resistant varieties, tree planting with crops and water harvesting) by smallholder farmers at household level.

Farmers' decisions to adopt an adaptation strategy to reduce the impacts of climate change relies largely on some socioeconomic (gender, age, education, marital status, source of labour), cultural (cultural and religious beliefs) and institutional factors (group membership, types of institutions, assistance offered), which must be known (Damnyag et. al., 2021). Knowing the factors that influence the choice of climate change adaptation strategies is significant in the formulation of interventions to enhance farmers' adaptive capacities (Mabe et. al., 2014), particularly by smallholder farmers at household level. Farmers' adaptive response is however weak because adaptation options available to farmers are influenced by a number of socioeconomic and cultural factors (Nyanga et al., 2011). Adaptation options however focus majorly on technical skills and technologies and fail to address critical socioeconomic, institutional and cultural factors (land access, gender, educational level, role of institutions, beliefs, values) that contribute to climate change adaptation and effective implementation of new adaptation technologies, skills and capacity (Felladam and Agana, 2021).

As many studies have been conducted on climate change adaptation in other regions such as Australia, Canada, the USA, Europe and some parts of Asia, empirical evidence on the extent to which adaptation barriers hinder the implementation of adaptation strategies in Africa have been limited (Mabe et al., 2014; Antwi-Agyei et al., 2015; Fagariba et al., 2018), including Kenya. Despite the uncertainties surrounding the future risk of climate change, the complete picture of future risk trends and adaptation pathways is still unclear to the decision makers (Berry et al, 2017; Clay and King, 2019). This could be as a result of the fact that scientific methods and tools to assess future risks are biased towards assessing future climate hazards, leading to incomplete picture with limited validity and usability for adaptation planning (Birkmann et al, 2021; Garschargent et al, 2021).

Farmers may change decisions on cropping for example, without awareness of changes in environmental risk (Reilly and Schimmelpfennig, 2000) especially if there are no appropriate measures for them to access environmental information. Climate change has been shown to significantly impact crop yields (Lobell et al., 2011b). However, it may be an uphill task for farmers to appropriately adjust to these risks on their own given difficulty for an individual to predict weather patterns. Reliable and valid climate information provides farmers with predictive knowledge about environmental risks that helps them to adjust to these risks early enough (Adger et al., 2005; Adger et al., 2009 and Rosonzweig and Udry, 2013).

Information aids farmers in deciding which agricultural technologies and adaptation strategies are most useful in responding to climate change (Hansen et al., 2007 and Ziervogel and Ericksen, 2010). However, the resource poor smallholder farmers may not be able to access this information as this information is sometimes channelled through methods that they may not access making it difficult for them to adjust to these risks. Access to information can build the capacity of smallholder farmers to adopt various adaptation strategies available to them.

Culture is a resource for climate change adaptation because cultural heritage, natural heritage and traditional knowledge all support the resilience of communities to respond to climate change impacts, including extreme weather, natural disasters and conflicts (UNESCO & UNEP, 2016). Despite the fundamental relationship between culture and climate change mitigation and adaptation, culture is largely absent from discussions on climate change today (UNESCO & UNEP, 2016). Adaptation to climate change should be based on and guided by the best available science and as appropriate, traditional knowledge, knowledge of indigenous people and local knowledge systems, with a view to integrating adaptation into socioeconomic and environmental policies and actions (UNFCCC, 2021).

The lack of integration of cultural factors in climate change adaptation creates a large information gap that needs to be addressed. Although climate change has been experienced for quite some time, not all people perceive it in a similar way. This perception is influenced by several factors that include socio-cultural, political and religious beliefs (Van der Linden, 2017; Ruhlemann and Jordan, 2021). Religion is a significant factor given that religion and climate change awareness and response have not always had a positive relationship (Jenkins et al, 2018). It is therefore important to understand the contribution of these factors to climate change adaptation and mitigation and how they influence decision making at household level.

A number of studies have shown the value of indigenous people's observations of changes in climate-related weather patterns, using such indicators as size of the moon (Green and Raygorodetsky, 2010), ocean behaviour (Fineup-Riordan and Rearden, 2010), phenology, including bird nesting, plant flowering and animal migration (Egeru, 2012) and fire behaviour (Mason et al. 2012). Their knowledge of weather patterns can assist in reconstruction of historical baselines, which can be used to predict the future (Thornton and Scheer, 2012).

Indigenous knowledge of ecosystem health and species distributions can contribute to culturally appropriate climate change adaptation (Girot et al. 2011). Traditional water related knowledge,

water harvesting and storage have enabled indigenous people to survive in arid and semi-arid lands and cope with drought for many years (Johnstone, 2012). With changes in rainfall patterns and corresponding variations in food availability, some farmers have developed strategies to adapt to climate change. For instance, some farmers use traditional methods of weather forecasting such as behaviour of plants and animals to predict weather conditions and decide when to prepare lands and sow seeds (Gyampoh and Asante, 2011; Newsham and Thomas, 2011).

The indigenous knowledge can be significant in building climate resilience in smallholder farming communities through promotion of climate resilient innovations (Mafongoya and Ajayi, 2017), that fits their environmental conditions. This indigenous knowledge is useful for farmers to prepare early enough for climate related risks. Indigenous knowledge is recognized for its potential to play a key role in climate change adaptation (IPCC, 2022; IPCC, 2021), resource governance, conservation and sustainable use of biodiversity and ecosystems (IPBES, 2018; Tengo et al. 2014). Therefore, supporting the climate change adaptation strategies of local farmers through recognition of the role plaid by indigenous knowledge can help increase the adoption of measures that will reduce the negative consequences of predicted change in future climate. However, there has been limited documentation of indigenous knowledge in the literature on climate change in Africa, including Kenya as compared to other regions (Leal Filho et al. 2021).

Despite its contributions, indigenous knowledge faces challenges in mainstream climate adaptation policies. The increasing promotion of modern agricultural technologies often leads to the marginalization of indigenous practices, reducing their role in formal adaptation strategies (Sanni et al., 2024). Furthermore, intergenerational knowledge transfer is declining due to urbanization and changing socioeconomic structures, threatening the sustainability of these traditional adaptation mechanisms (Orlove et al., 2023). It is therefore necessary to analyse the role of indigenous traditional knowledge on the choice of climate change adaptation strategies at household level.

Local institutions are effective at aiding knowledge generation that may be important for adaptive capacity (Pelling et al., 2008) and in the spreading of environmental information and technologies through extension services (Isaac, 2012). For example, where local based financial institutions sometimes provide access to financial assistance in form of short term credit and information that may help individuals to adopt costly adaptation strategies. These institutions also participate in building resilience of smallholder farmers and reducing vulnerability to climate variability and

change through provision of physical infrastructure and services, early warning and disaster response planning, regulation of property rights and information dissemination (Agarwal et al., 2009).

Despite all this however, little systematic analysis has been done to identify the factors that strengthen climate resilience, the roles of different local institutions in climate change adaptation by smallholder farmers, features of the local institutions that are important for successful adaptation by farmers and external support they require to enhance their role in facilitating adaptation (Agrawal, et al, 2009; Mubaya and Mafongoya, 2017).

Literature that sets out to highlight climate change adaptation illuminates on adaptation options that deal with everyday vulnerability instead (Mubaya et al., 2015), leaving out the contribution of local institutions to climate change adaptation. While there is evidence of deliberate efforts for governance systems that help respond to climate change and other challenges across the Sub-Saharan African continent, the capacity of local institutions to effectively coordinate the implemented initiatives is still inadequate (IPCC, 2012). It is important to note that most of the smallholder farmers probably due to some hidden constraints find it hard to actively participate in these institutions. It is therefore important to determine how the local institutions contribute to the ability of smallholder farmers to adapt to the effects of climate change.

Previous research and policy on adaptation and mitigation have largely focused on the material aspects of climate change, including risks to lives and livelihood systems, the costs of decarbonising economies and the costs of impacts on various sectors, but the contribution socioeconomic, institutional and cultural factors to climate change adaptation by smallholder farmers are missing in most of these studies. Therefore, it was imperative to study the contributions of socioeconomic, cultural and institutional factors to climate change adaptation by smallholder farmers in Homa Bay County, Kenya.

1.2 Statement of the Problem

Climate change poses a significant threat to smallholder farmers in most parts of Kenya who are particularly vulnerable due to their over-dependence on rain-fed agriculture. For example, in Homa Bay County, where crop production is majorly rain-fed and livestock farmers depend mostly on natural pasture, long dry spells and irregular rainfall exacerbate the problem of low yields and leave rural households even more susceptible to food insecurity. Given that climate change mitigation efforts will take a long time, adaptation to the effects of climate change is critical and

of concern particularly to smallholder farmers in most parts of Kenya including Homa Bay County. Most households in Homa Bay County still realize massive crop failures and poor livestock production despite efforts by various stakeholders to promote climate change adaptation strategies at regional levels. This could be as a result of socioeconomic, cultural and institutional factors, hindering climate change adaptation at household level. However, most researches on climate change adaptation have focused majorly on technical skills and technologies and fail to highlight the extent to which socioeconomic (size of the land, gender, age, marital status, educational level, household size, source of farm labour), cultural factors (place attachment, cultural and religious beliefs) institutional (group membership, types of institutions and support offered by institutions) contributes to the choice of climate change adaptation strategies (changing planting date, planting of short season crops, planting drought resistant crop varieties, planting trees with crops and water harvesting). Therefore, there is a need to analyse the contributions of socioeconomic, cultural and institutional factors on climate resilience for climate change adaptation at household level. The main objective of this study was to assess the contributions of the socioeconomic (size of the land, gender, age, marital status, educational level, household size, source of farm labour) cultural (place attachment, cultural and religious beliefs), indigenous knowledge (duration of stay in the study area, farming experience and climate change experience) and institutional (group membership, types of institutions and assistance offered) factors on choice of climate change adaptation strategies (changing planting date, planting of short season crops, planting drought resistant crop varieties, planting trees with crops and water harvesting) by smallholder farmers in Homa Bay County. The study would be necessary to document the contributions of these factors on choice of climate change adaptation strategies by smallholder farmers at household level and how they can be improved for sustainable food security.

1.3 Objective of the Study

The main objective of the study was to assess the contributions of socioeconomic, cultural and institutional factors on choice of climate change adaptation strategies (changing planting date, planting of short season crops, planting drought resistant crop varieties, planting trees with crops and water harvesting) by the smallholder farmers in Homa Bay County.

The Specific objectives were:

1) To establish the contribution of socioeconomic factors (Gender, age, level of education, marital status, household size, source of labour, source of climate information) on climate change adaptation by smallholder farmers in Homa Bay County.
2) To determine the contribution of cultural factors (Attachment to place of residence, cultural beliefs and religious beliefs) on climate change adaptation by smallholder farmers in Homa Bay County.
3) To find out the contribution of indigenous local knowledge (Duration of stay in the study area, farming experience and climate change experience) on climate change adaptation by smallholder farmers in Homa Bay County.
4) To examine the contribution of local institutions (Membership to local institutions, sponsorship by local institutions and types of local istitutions) on climate change adaptation by smallholder farmers in Homa Bay County.

1.4 Research Hypotheses

H_{01}: There is no significant contribution of socioeconomic factors (Gender, age, level of education, marital status, household size, source of labour, source of climate information) on climate change adaptation by smallholder farmers in Homa Bay County.

H_{02}: Cultural factors (Attachment to place of residence, cultural beliefs and religious beliefs) do not have any significant contribution to climate change adaptation by smallholder farmers in Homa Bay County.

H_{03}: There is no significant contribution of indigenous local knowledge (Duration of stay in the study area, farming experience and climate change experience) on climate change adaptation by smallholder farmers in Homa Bay County

$H_{04.}$ There is no significant contribution of local institutions (Membership to local institutions, sponsorship by local institutions and types of local istitutions) on climate change adaptation by smallholder farmers in Homa Bay County.

1.5 Justification of the Study

The climate is changing fast and mitigation practices to reduce the sources or enhance the sinks of greenhouse gases will take time. Adaptation is therefore critical and of concern, particularly in Kenya where rain-fed agriculture is the main economic activity. Adaptation can enable farmers to achieve their food, income and livelihood security objectives given the changing climatic and socioeconomic conditions, including climate variability, extreme weather conditions such as droughts and floods and increased incidences of pests and diseases. Although the farmers have a low ability to adapt to such changes, they have, however survived and coped in various ways over time. Better understanding of how they have done this is essential for designing incentives to enhance private adaptation at smallholder household level. It is also important to note that potential changes in climate may not be globally uniform and the ability of each farmer to adapt to effects of climate change may not be the same. This study would therefore be essential to document the contributions of socioeconomic (Gender, age, level of education, marital status, household size, source of labour, source of climate information), cultural (Attachment to place of residence, cultural beliefs and religious beliefs) and institutional (Membership to local institutions, sponsorship by local institutions and types of local istitutions) factors on choice of climate change adaptation strategies (changing planting date, planting short season crops, planting drought resistant crop varieties, planting trees alongside crops and water harvesting) by smallholder farmers and how these factors could be improved for sustainable household food security. Given the extent to which local communities have been adversely affected by climate change, the study would be necessary to highlight drivers and barriers to the choice of climate change adaptation strategies at household level. The information obtained from the study would be useful for climate change adaptation planners from private and government institutions in order to target suitable intervention programs to improve food security at local level.

1.6 Scope of the Study

The study was done in Homa Bay County, which according to the Kenya National Adaptation Plan 2015-2030 is one of the counties facing high risk of floods and moderate risk of drought occurrence (RoK, 2016a). The county has varied agro-ecological zones that are representative of the Kenya's agro-ecological zones. Most of the households in the county rely on primary production for their livelihoods, which include rain-fed smallholder farming and fisheries, practices that are highly

vulnerable to environmental degradation and effects of climate change. The population in the Homa Bay County is fairly homogeneous in terms of ethnic composition (RoK, 2019), making it suitable for the study to achieve its objectives. The study focused on smallholder farmers because they are the majority in the farming community in the study area and their activities impact greatly on food security at household level.

The study dwelt on the socioeconomic (Gender, age, level of education, marital status, household size, source of labour, source of climate information), cultural (Attachment to place of residence, cultural beliefs and religious beliefs) and institutional (Membership to local institutions, sponsorship by local institutions and types of local istitutions) factors contributing to the choice of climate change adaptation strategies by smallholder farmers. The study focused on a set of principles to guide climate change adaptation strategies (changing planting date, planting short season crops, planting drought resistant crop varieties, planting trees alongside crops and water harvesting) and programs in Kenya, especially for smallholder farmers. These principles would incorporate sustainability and equitable development, water allocation strategies, risk reduction and diversification, and interactions and trade-offs with health and environmental objectives. The study recognized that achievement of sustainable development objectives is hindered by climate change, and this is one of the major environmental problems that humanity is facing. The study also considered gender issues related to climate change. The study recognized the fact that women are the main actors in smallholder farming communities and natural resource management and therefore play a major role in ensuring water and food security. In this regard, the proposed interventions would strive toward adaptation measures that target but not limited to enhancing the role of women in agricultural water management and agricultural productivity, thereby improving household food security at household level.

1.7 Limitation of the Study

Given that climate change and variability is an ongoing process and that the behaviour decisions of smallholder farmers in response to the effects climate change and variability may also be changing, longitudinal studies would have been appropriate for the study. But due to time and budgetary constraints, the study employed cross-sectional survey design in which information was collected in one round from the smallholder farmers. This may have limited the scope of the study.

1.8 Assumptions of the Study

The study assumed that all the households sampled are practising smallholder farming and that each smallholder farmer in Homa Bay County was being influenced differently based on their socioeconomic and cultural characteristics. That the smallholder farmers randomly selected for the study were spread across various farming systems including horticulture, food crops, and livestock production and that they would respond appropriately to the study instruments in order to achieve the study objectives. The study also assumed that the results could be applied to other counties with similar environmental conditions.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter outlines the key concepts of the literature reviewed to enrich the study. It discusses the socioeconomic factors and climate change adaptation strategies; the influence of cultural factors on climate change adaptation strategies; indigenous knowledge and climate change adaptation strategies; local institutions and climate change adaptation; smallholder farmers and climate change adaptation; the environmental legislations and policy frameworks relevant to climate change adaptation; the theoretical framework; and the conceptual framework of the study.

2.2 Socioeconomic factors and climate change adaptation strategies

Developing countries are experiencing the brunt of climate change due to environmental and land degrading activities such as poor farming practices, lumbering, hunting, unregulated mining, and infrastructure development in an attempt to meet human needs (Miyan 2015). The impact of these human activities on the environment in sub-Saharan Africa is bound to increase with increase in population, due to overutilization of natural resources. The countries in tropical Africa are particularly considered to be experiencing the adverse impacts of climate due to their dependence on agriculture as their main source of livelihoods (Apata et al., 2011, 2011b; Badigger, 2010; IAC, 2004; Dixon, et al., 2001; IPCC, 2001).

Various studies have shown that sub-Saharan Africa, including Kenya is likely to experience the effect of climate change than any other continent due to poverty, inadequate technology, economic challenges, weather extremes and poor governmental agriculture policies (Lobell et al. 2011). Other studies have showed that financial, educational and technological barriers in Africa increase farmers' vulnerability to climate change (Antwi-Agyei et al. 2012; Boyd et al. 2013; Kithiia et al. 2011). A study indicated that smallholder households are highly susceptible to climate change as a result of over-reliance on rain-fed agriculture, poor income levels and lack of alternative source of employment in the sub-Saharan Africa (Fosu-Mensah et al. 2012). Smallholder households can no longer tell when short and long rains begin and how intense they will be and this uncertainty hampers preparations for planting crops. Thus, support from relevant government and private

agencies may be necessary to enable farmers to cope with changing climate and improve on their livelihoods.

In order to implement appropriate climate change interventions, there is need to understand the socioeconomic drivers of climate change adaptation. Some studies have identified several socioeconomic, environmental and institutional factors, as well as the economic structure, as key drivers influencing African farmers to choose specific strategies of adapting to climate risks (Deressa et al. 2009; Kabubo-Mariara 2008; Mideksa 2009; and Bryan et al. 2009). Factors such as gender, income level, education, land tenure security, social capital, and institutional support directly impact farmers' decision-making and responsiveness to climate risks (Olayide et al., 2024). Gender roles often limit women's ability to access land, credit, training, and extension services that are necessary for effective climate change adaptation (FAO, 2021), impacting negatively on the choice of climate change adaptation strategies. Education and access to extension services increase farmers' awareness and knowledge of climate risks, fostering informed decision-making and innovative responses (Kassie et al., 2024).

The socioeconomic factors for this study as they contribute to climate change adaptation included gender of the smallholder farmer, level of education of the farmer and the spouse, number of household members, climate change awareness, source of financial capital, source labour for farm operations, and source of household income. Among these factors, the study revealed that marital status of the smallholder farmer and the size of the household had statistically very strong contributions on the choice of climate change adaptation strategies by the smallholder farmers in Homa Bay County, while size of the farm under agricultural production and source of labour had statistically strong contributions on the choice of climate change adaptation strategies. Factors such as gender of the farmer, level of education, source of environmental/agricultural information and source of income of the farmer had statistically moderate contributions on the choice of climate change adaptation strategies by the smallholder farmers in the study area.

Drivers of climate change adaptation are incentives that motivate individuals to respond to climatic risks (Gawel et al. (2012). A study carried out in the United Kingdom (UK) identified three drivers of household adaptation, which include previous exposure to extreme weather, social acceptability, and long-term financial reward (Porter et al. (2014). For instance, individual households in UK who have experienced flooding show more willingness to adopt flood defense measures than households that have not experienced flooding (Walker et al., 2011; Whitmarsh, 2008). Farming

households would be more willing to adapt if they perceive the long term financial benefit of adaptation (Porter et al., 2014; Stenek et al. 2013; Fankhauser and Burton, 2011; and Kunreuther and Kerjan, 2009).

Another study identified self-motivation and desire for comfort as other major drivers of adaptation, which make some individuals to have more adaptive capacity than others. People are self -motivated to take precautionary measures to protect themselves against climatic risks, as well as install adaptation features that will make their houses more comfortable, without necessarily having an external motivation (Grothmann and Patt, 2003).) If adaptation to Climate Change is to help the most vulnerable social groups such as smallholder households, then it must involve individuals at the local level, and its effectiveness depends among other things on building individual capacities, and understanding the key drivers and socioeconomic factors influencing their choices of adaptation strategies (Agrawal, 2008).

Climate Change Adaptation do not take place in isolation, it happens within the context of society, shaped by socioeconomic scenarios (United Kingdom Climate Impacts Program (UKCIP), 2004). A better understanding of socioeconomic variables that influence level of adaptation will thus provide decision makers with concrete information about the capacity of individuals and households to build resilience to Climate Change (Smit et al., 2007). This implies that the capacity of smallholder farmers to develop adaptive strategies is influenced by socioeconomic factors thereby justifying the importance of this study which investigated the contributions of socioeconomic factors on choice of climate change adaptation strategies by smallholder farmers in Homa Bay County, Kenya.

2.3 Cultural factors and climate change adaptation strategies

Culture plays an important role in understanding both mitigation and adaptation to climate change and is crucial in shaping perceptions and framing climate change as a phenomenon of concern to society, smallholder households included. It is inherently embedded in the dominant modes of production, consumption, life styles and social organization that give rise to emissions of greenhouse gases, which lead to environmental changes (Shove, 2003; Hulme, 2008). Culture is at the focal point in understanding and implementing adaptation to climate change through the identification of risks, decisions about responses, and means of implementation (Adger et. al, 2013).

Culture refers to the symbols that express meaning, including beliefs, rituals, artifacts and stories that create collective outlooks and behaviour, and from which strategies to respond to problems including environmental risks are devised and implemented (Swidler, 1986; Hays, 1994). It constitutes both non-material and material aspects. The non-material aspects may include norms, values and beliefs while material aspects may include artifacts such as tools and equipment, which are also shaped by landscapes and regions. Culture is closely related to places (physical spaces that are given meaning by people), such as shrines, even as both have become increasingly trans-nationalized through processes of globalization (Escobar, 2001; McPherson et. al, 2001; Hess et. al 2008). Thus, as culture and community are mostly rooted in physical spaces i.e. from metropolitan areas, such as towns through to marginal rural settlements, where culture is deemed to be homogeneous and climate change impacts in these places could also change cultures and communities, often in ways that people find undesirable and perceive as loss (Kirsch, 2001).

Cultural attributes can shape people's perceptions of climate risks, impacts and adaptation options (Quandt, 2019) and that in some cases this may encourage resistance to change (Antwi-Agyei, et. al, 2015). This includes religious beliefs to engender negative responses to seasonal forecasts (ebhuoma and Simatele, 2019) and for deep-seated values and tastes to impede transitions to different livestock types (Volpato and King, 2019). Cultural perspectives could be used to explain differences in responses across populations to the same environmental risks, including climate change (Adger et al, 2013). Cognitive traditions and collective patterns shape how individuals, groups or societies perceive climate change and institute adaptation strategies (Norgaard, 2011). However, recent research shows that information about climate change does not connect with all cultures and worldviews in the same way. Communities with shared values and beliefs generate their own selective view of the natural environment, which determine how they interpret and respond to risk (Douglas & Wildavsky, 1982).

The attachment that people have to their community and place of residence may be an important predictor of how they might perceive climate change, adapt and support strategies designed at higher levels (Agyeman et al, 2009). Place attachment may positively or negatively influence climate change adaptation. For example, people with high levels of place attachment are more likely to prepare for climate change events such as flooding because of their social and economic investments within their regions (Agyeman et al, 2009). But at the same time may not be willing

to move to higher ground, especially where migration is an adaptation measure. Place attachment may inspire smallholder households to develop or participate in climate change adaptation planning processes. Relocation of people as adaptation to climate change may result in social instability, leading to deterioration in quality of life (Wolf et al., 2009). When people are relocated from the places that they value, their social ties are broken and their cultures are diminished, and in many cases endangered. There is often no effective substitution for, or adequate compensation for, lost sites of significance (Kirsch, 2001; Crate, 2008; Garrett, 2010). Attachment to place of residence can influence how individuals perceive risk, accept adaptation policies, and engage in collective environmental action (Raymond et al., 2021).

Attachment to place is a concept that describes the level of connection that individuals have with the people and environments in which they live (Twigger-Ross & Uzzell, 1996; Hidalgo & Hernandez, 2001; Lewicka, 2010). The concept, well established within sociology and geography, describes the identity created around a settlement or place, the sense of pride associated with belonging to a village, town or city, and the friendships and networks that exist within them (Flora, 1998; Stedman, 1999). Place attachment can contribute to individual and community well-being and can be used to predict community sustainability. It can also improve societal patriotism which is important for participation in projects such as environmental conservation for societal well-being. Individuals with a strong attachment to their community are often unwilling to migrate to maintain their income levels because they are reluctant to leave behind their social and emotional support groups and adapt to a new community (Field & Burch, 1988). Place attachment may inspire individuals to develop or participate in climate adaptation planning processes (Adger, et. al, 2013). Place attachment is thus emerging as an important factor for climate adaptation in regions where existing livelihoods are unlikely to be maintained as the impacts of climate change are increasingly manifest (Igor, 2005; Agyeman et. al, 2009; Adger, 2011).

Religious beliefs could also have an influence on how smallholder households perceive climate change and consequently mitigation and adaptation. Human behaviour is strongly influenced by religious beliefs and doctrines (Hulme, 2009; Slimak & Dietz, 2006). Such behavioral influences include the way in which people perceive and interact with the physical environment (Schuman et. al, 2018). The way in which people perceive environmental risk is informed by their social interactions and cultural worldviews and beliefs about society and nature (McNeeley and Lazrus, 2014). Our beliefs about the Supreme Being, about the spiritual and the transcendent, and about

our role in the world as moral agents, shape our sense of duty and responsibility to care for others and for nature (Hulme (2009). Thus, perceptions of climate change risk and vulnerability, as dictated by religious conceptualizations of nature, influence the feasibility and acceptability of adaptation planning, policy-making and implementation (Schuman et. al, 2018).

Religious beliefs consist of those social practices authorized by reference to a super-empirical reality, that is, a reference to the will of the Supreme Being, the metaphysical nature of things, or the like (Schilbrack 2013). Within these religious institutions, the significance of nature is not just instrumental but nature forms part of God's creation, and humankind's relationship with it is fundamental (Cooper & Palmer, 1998). Christian doctrine, when describing humankind and nature, relies on two key concepts including relationship and responsibility. To Christians, the term relationship entails a direct connection of humankind with nature whereas, responsibility involves moral issues and includes the stewardship over nature that God gives humankind (Davies 1994). This stewardship, however, can be interpreted in two very different ways depending on the level of the interaction between humankind and nature. First, it implies humankind's dominance over nature, where nature is given a fundamental value and used for the well-being of humankind without giving much thought to the consequences (Edwards 2007; Hulme 2009). On the other hand, is the interpretation of caretaker, where humans are appointed as nature's guardians, where conservation of Earth's resources is squarely in the hands of man (Russell 1994). The two views of stewardship explain the relationship between religion and climate and may influence climate change adaptation.

However, Islam's main concern is obedience to God (Allah) and the penalties for disobedience (Forward & Alam 1994). This explains the relationship between humankind and nature, as the religion warns of the consequences of disobedience in human plunder and exploitation of the earth's resources (Forward & Alam 1994). To them the world that they inhabit is perishable and finite, and there is no reason to safeguard or protect it (Forward & Alam 1994). This view may however influence climate change adaptation negatively. For the Traditional African Religions, nature is placed within the domain of the spirit beings and the impersonal powers that govern the world which, although seen as a holistic part of creation, is created by the Supreme Being (God) (Turaki 1999). The implication of the shared religious beliefs is that climate change adaptation could be influenced by the way each religious framework views the relationship between humankind and nature. The way in which religion engages with climate change adaptation in one

location can differ significantly to the way it does in another (Veldman et al., 2013; Hulme, 2009). This makes this study important as it contextualizes the influence of religious beliefs on climate change adaptation among smallholder households in Homa Bay County, Kenya.

Climate change perceptions often interact with other cultural beliefs to motivate responses, which in most cases may not be consistent with the formal responses advocated by institutions promoting climate change adaptation (Bravo, 2009). The intangible cultural heritage practices, including traditional land and water management practices, traditional food security strategies and the use of traditional architecture and building materials could help communities mitigate and adapt to changing climate (UNESCO, 2020). Cultural and natural heritage sites can serve as a refuge, both physical and psychological, for communities during and after climate-related emergencies (UNESCO, 2020).

However, despite the fundamental relationship between culture and climate change mitigation and adaptation, culture is largely absent from discussions on climate change today (UNESCO, 2020). This further underscored the significance of this study. Culture also shapes values, and many researches have been conducted in the fields of social sciences and humanities that considers how values are related to culture, cognitive and economic factors (Boudon, 2001). This is reflected in recent climate change research that examines the relationship between values and climate change adaptation choices (O'Brien & Wolf. 2010; Hulme, 2009). This calls for the need to investigate the contribution of certain aspects of culture such as norms, beliefs and artefacts to choice climate change adaptation measures. The cultural factors in this study included place attachment, cultural beliefs and religious beliefs. The study revealed that all these factors had very strong contribution on the choice of climate change adaptation strategies by the smallholder farmers in Homa Bay County.

2.4 Indigenous Knowledge and climate change adaptation strategies

Coping with the impacts of climate change requires integration of a variety of knowledge systems and decision making processes so as to improve understanding of the issue and manage risk (Gilligan et al. 2006). Traditional technical and local knowledge plays a crucial role, which is important in understanding environmental and social change (Riewe and Oakes, 2006) and this

also emphasizes knowledge accumulated over a time about an area, community, population or species (Gilchrist et al. 2005).

Indigenous or traditional knowledge has been defined as institutionalized local knowledge that has been accumulated and passed on from one generation to the other verbally or sometimes through artefacts (Osunade 1994; Warren 1992). It plays an important role in local-level decision-making processes in many rural communities, including smallholder households. The knowledge is important not only for the culture or community in which it is found, but equally for scientists, planners and decision makers trying to improve livelihoods in rural localities (Mundy and Compton 1991). The traditional knowledge is determined by the previous generations' worldviews and experiment and provides an inherent link to one's surroundings and environment. Therefore, Indigenous Knowledge is not transferable but provides relationships that link people directly to their environments and the changes that occur within it, including climate change and variability (Woodley 1991). Indigenous or traditional knowledge is that knowledge which has been built over generations of people living in a particular environment and is very crucial in responding to environmental challenges including floods, droughts, storms, disease and pest infestations, and their expected effects (UNEP, 2008).

Most traditional societies have accumulated local knowledge over long periods about environmental change and have devised elaborate methods to recognize and adapt to these changes (Egeru, 2012). Traditional or indigenous people have vital lessons to offer about successful and unsuccessful adaptations to climate change and variability, and this could be valuable in the context of global climate change and variability (Macchi, 2008).

Traditional or Indigenous knowledge provides a basic foundation for community-based climate change adaptation and remedial actions that sustain resilience of social-ecological systems at the interconnected local, regional and global scales (Macchi, 2008). For instance, the local populations in Sahel, through their traditional knowledge systems, have developed and implemented extensive remedial and adaptation strategies that have helped them to reduce their vulnerability to past climate variability and change (Nyong et. al, 2007). This implies that use of indigenous or traditional knowledge in climate change adaptation will provide cheaper, more local and effective ways to predict climate variability and ultimately enable communities to adapt to climate change at household level.

The IPCC Assessment report of 2007 noted that indigenous or traditional ecological knowledge provides a valuable basis for developing climate change remedial measures and natural resource management strategies in response to environmental and other forms of change (IPPC, 2007). This is also contained in the IPCC report of 2010 which reported that indigenous or traditional knowledge could be essential for understanding the effectiveness of certain adaptation strategies that are cost-effective, participatory and sustainable. Indigenous knowledge has been identified as crucial to adapting to climate change in Africa and the urge to be further studied has been emphasized by the IPCC Working Group II in chapter 9: Africa (Trisos, et al., 2022).

Across Africa, indigenous knowledge informs decision-making about fundamental aspects of life, from day-to-day livelihood activities to longer term actions (Leal Filho, et al. 2021). Over 30% of the world's indigenous languages come from Africa and are exceptionally rich in ecosystem-specific knowledge on biodiversity, soil systems, and water (Trisos et al., 2022). Understanding different indigenous knowledge practices can help effective adaptation planning by establishing a greater diversity of projects or innovative mitigation measures, contextually appropriate interventions and avoiding unintentional damage to ecosystems or culture (Nyadze, et al., 2021; Theodory, 2016).

Traditional or indigenous knowledge can be beneficial or can also have its own shortcomings in the context of climate change adaptation. For instance, Siedenburg (2008) analysed indigenous knowledge about agro-forestry practices in the context of rapid environmental change in the Rural District of Tanzania. The study found that some smallholder farmers do not actively practice the re-generation of key farm-based natural resources, and concluded that variations in indigenous knowledge could be a key determinant of their use of this practice. This implies that the application of indigenous knowledge on climate change adaptation could be site specific, influenced by accumulated knowledge at local level. However, existing indigenous knowledge of rain-water harvesting technologies was found to be an important asset for designing and implementing irrigation technologies in the future (Mbilinyi *et al*., 2005). However, various studies have shown that the traditional knowledge and skills of indigenous women and men go unrecognized and are undervalued (UN, 2017; ILO, 2017c), in enabling smallholder households to cope with environmental changes.

Local climate prediction by indigenous people and weather forecasting knowledge can provide information and insights that can be used for successful climate change and variability adaptation

at the local level (Chisadza et al., 2015). The vital role played by indigenous knowledge in climate prediction makes it a critical element that needs to be taken into consideration by the county and national weather forecasting systems. Some studies comparing indigenous with modern weather forecasting knowledge have revealed a positive correlation between the climate and weather indicators used by indigenous and by modern science (Chisadza et al., 2015; Ziervogel and Opere, 2010). These studies have recommended the co-production of weather and climate knowledge by these two knowledge systems to create a system having the benefit of accuracy from the modern science as well as from the local relevance of traditional systems (Weatherhead et al., 2010; Mugabe et al., 2010; Kalanda-Joshua et al., 2011).

Even though the value of indigenous local knowledge has been recognized in the design and implementation of sustainable development projects, not much has been done to incorporate it into formal climate change adaptation strategies (Nyong et al. 2007), at local levels. Climate change cannot be separated from sustainable development as this could be the most effective way to frame the mitigation question and a crucial dimension of climate change adaptation (Swart et al. 2003; Cohen et al. 1998). Incorporating indigenous or traditional knowledge into climate change policies and decisions can lead to the development of effective mitigation and adaptation strategies (Robinson and Herbert 2001; Hunn 1993). However, integrating indigenous knowledge into climate change concerns should not be done exclusively of modern/ western scientific knowledge. Indigenous or traditional knowledge should complement, rather than compete with global knowledge systems (Nyong et al. 2007).

Previous research in Kenya has observed that indigenous communities recognize that to be able to cope with the natural disasters, they have to monitor the environmental conditions, including the weather, using such indicators as size and position of the moon among others to be able to make meaningful prediction and take appropriate actions (UNEP, 2003). However, it is reported that in many Kenyan communities the indigenous or traditional knowledge is in the custody of the older members of the society is likely to be lost due to limited documentation and condemnation of its ability in natural hazard management (RoK, 2004).

Based on this and given the variation on indigenous knowledge, the study investigated the contribution of indigenous knowledge on the choice of climate change adaptation strategies by smallholder farmers at household level. The study concentrated on the factors that would enhance accumulation of indigenous knowledge which included farming experience by the smallholder

farmers, climate change experience and the duration of stay in the area by the smallholder farmers. The study revealed a very strong contributions of farming experience and climate change experience on the choice of climate change adaptation strategies, while duration of stay in the study area gave a strong contribution to the choice of climate change adaptation strategies by smallholder farmers in Homa Bay County. These factors therefore enabled the farmers to acquire enough knowledge on climate patterns and ability to determine the most effective climate change adaptation strategies.

2.5 Local institutions and climate change adaptation strategies

The impact of climate change has been localized and is severely affecting the livelihoods of households which predominantly rely on natural resources for their wellbeing. Among these are the smallholder agricultural households who depend mostly on rain-fed agriculture and other climate-related activities. This has created the need to address climate change impacts at the local levels, with local institutions at the focal point. Local institutions have an important role to play in planning and implementation of adaptation activities at the local level (Agrawal and Perrin 2009; Agrawal *et al.* 2009; Amaru and Chhetri 2013; Rodima-Taylor *et al.* 2011).

Local organisations also provide a channel through which external interventions reinforce or undermine the existing adaptation practices. Local organisations play a crucial role in enhancing the capacity of local communities to cope with climate variability and providing mechanisms that help to shape the social and individual interactions within the society (Burch, 2010; Seitz et al., 2011). Participation in local organisations encourages the farmers to engage in a united strategies orientation; farmers involved in these organizations share knowledge and innovation ideas, discuss problems and challenges with others, and engage in collaborative decision making (Uddin et al., 2014). Participation in farmer-based organisations enhances social networking and increases social capital (Egyir et al., 2015). This could positively influence climate change adaptation by smallholder farmers.

Local institutions may be effective in knowledge generation that could be important for improved adaptive capacity (Pelling et al., 2008) and in the diffusion of information and technologies (Isaac, 2012), among smallholder households. For example, where local based financial institutions sometimes provide access to financial assistance in form of short term credit either in kind or cash and information that could help smallholder households to pursue costly climate change adaptation

strategies. Some studies have revealed that natural resources have often been managed collectively (Meinzen-Dick et al., 2002), especially in the context of environmental change, thus creating room for participation in local groups for adaptation at the group level (Adger, 2003 and Agarwal, 2010). These institutions participate in building resilience of smallholder farmers and reducing vulnerability to climate change through provision of materials and services, early warning and disaster response planning, regulation of property rights and information dissemination (Agarwal et al., 2009).

Many researches in climate change adaptation have pointed out the significant role of local institutions in climate change adaptation, especially at community level. Climate change adaptation does not occur in an institutional vacuum, rather institutional and social factors play a key role in shaping the extent to which farming households and communities become vulnerable to different environmental risks and respond to such risks (Agrawal *et al.* 2009; Amaru and Chhetri 2013). Local institutions are formal and informal rules through which social structures share decision making and take collective action (Agrawal *et al.* 2009), such as decisions on climate change adaptation. Institutions are leverage points to determine the direction and magnitude of flow of resources to different social groups (Agrawal and Perrin, 2009).

Institutions play a crucial role in holding society together, giving it a sense of direction and purpose and enabling it to adapt to environmental risks (O'Riordan and Jordan 1999). Thus countries with well-developed social institutions are considered to have greater adaptive capacity than those with less effective institutional arrangements, commonly developing nations in Sub-Saharan Africa and those in transition (Smith and Lenhart, 1996). Institutional and social factors play a significant role in shaping vulnerability of households depending on local governance and institutional arrangements (Mubaya and Mafongoya, 2017). Inadequate institutional support in the context of climate change has frequently been cited in the literature as a hindrance to adaptation. For example, institutional constraints were found to limit entitlements and access to resources for communities in coastal Vietnam and thereby increasing vulnerability (Kelly and Adger 1999). Equally, Bangladesh has been found to be particularly vulnerable to climate change especially in the areas of food production, settlements, and human life, reflecting serious constraints on adaptive capacity in the existing institutional arrangements, which is not conducive to ease the hardship of the people (Huq et al. (1999).

Institutions have influenced the livelihoods and adaptation of rural households in the past, by way of strengthening their adaptive capacity. They structure risk and sensitivity to climate hazards, and thereby facilitate or impede individual and collective responses and ultimately shape the outcomes of such responses (Agrawal 2008, 2010). Rural local institutions contribute to sustainable livelihoods in a number of ways and are crucial for addressing and mitigating various aspects of climate insecurity and vulnerability (Uphoff and Buck 2006). These institutions acquire and store knowledge and experiences, and create flexibility in problem solving, thereby increasing people's adaptability and resilience (Tompkins and Adger 2004; Walker et al., 2006). Effective local institutions also mediate external interventions that can reinforce or undermine climate change adaptation practices (Agrawal 2008). It is therefore important when planning for climate change adaptation to promote the capacity of local institutions and improve the relationships between local and national-level adaptation planning (Agrawal et al. 2012).

In spite of the fact that the role of local institutions in facilitating adaptation to climate change has been recognized, little systematic analysis has been conducted to identify the factors that strengthen climate resilience of smallholder households, the roles of different local institutions in climate change adaptation, features of institutions that are important for successful adaptation and the support they require to enhance their role in facilitating adaptation (Agrawal, et al, 2009). However, a review of the climate change adaptation action program of 45 developing countries including Kenya shows that the role of local institutions had received little attention (Agrawal and Perrin 2009).

It is also important to note that most of the smallholder households probably due to some hidden constraints find it hard to actively participate in these institutions. These institutions include local government, service organizations, private businesses, local cooperative societies and local financial institutions. It is therefore important to understand why some of the smallholder households are unable to participate in these institutions and how these institutions influence climate change adaptation by smallholder farmers.

2.6 Focus on Smallholder Farmers

Smallholder households represent about 75% of the world's agricultural farms (Lowder, et al., 2016), comprise of about 60% of the agricultural workforce worldwide (Fyfe, 2002) and provide over 80% of the food consumed in the developing world (UNEP, 2013). Approximately 80% of agriculture in sub-Saharan Africa is managed by households cultivating less than 10 hectares of

land, which makes smallholder production the backbone of agriculture in sub-Saharan Africa (FAO, 2012). Food supply and the livelihood of billions of people heavily rely on the productivity of smallholder agriculture (FAO, 2012). Besides lower investment costs and higher rates of returns, smallholder farming has direct impact on household food security (Awinda, 2014). Although smallholder farming systems have proven to be resilient and viable in resource poor households, climate change is likely to overtake their current coping capabilities (Morton, 2007). Low levels of income and technology, poor marketing structures and lack of institutional support are common characteristics of smallholder farming systems that make them particularly vulnerable to changes in external conditions (Morton, 2007).

Most of the smallholder farmers, especially in Sub-Saharan Africa, have low capacity to adapt to climate change, due to their low education, low income, limited land areas, and poor access to agricultural extension services, market and credit (Morton, 2007 and Harvey et al., 2014). Low income producers often do not have the means to invest in climate risk adaptation technologies and strategies (Vermeulen et al., 2012). Additionally, many smallholders in Africa live in remote areas with dilapidated infrastructure that further hinders their access to markets, financial assistance, disaster relief, and government support (Harvey et al., 2014).

Smallholder households are particularly vulnerable to environmental risks, which reduces productivity and negatively affect their weather-dependent livelihood systems. For example, in Kenya, frequent droughts and floods have eroded assets and knowledge base, leaving smallholder farming households more vulnerable to disasters such as water pollution, food insecurity, diseases and land degradation (Awinda, 2014). Climate change is seen as one of the major threats to agricultural productivity by smallholder households in most parts of Kenya (Bryan et al., 2013; Tongruksawattana, 2013), resulting in food shortages.

Adaptation will be necessary to cope with these climate risks. However, inadequate resources, limited water access and not low rates of information dissemination pose major challenges to the adoption of more costly adaptive measures by smallholder households (Bryan et al., 2013). The most common strategies to cope with consequences from drought, floods and impacts from pests and diseases among the poorer smallholder households include replanting, selling of assets, reducing consumption and borrowing of assets (Tongruksawattana, 2013). Adaptation strategies

often include simple measures, such as changes of planting dates, mixed cropping, planting of drought tolerant crop varieties, migration and sale of livestock (Ogalleh et al., 2012).

Many studies have shown that increased droughts and floods may be increasing poverty levels, leaving many rural households trapped in a cycle of poverty and vulnerability to diminishing natural resources (Phiri *et al*., 2005). Water scarcity is already posing a major problem in arid and semi-arid areas of Sub-Saharan Africa (Rijsberman, 2006), areas mainly inhabited by smallholder farmers in both agro-pastoral and pastoral communities. The effects of climate change are further exacerbated by population explosion which contribute to water scarcity and limit its availability for irrigation (Turner, 2006), and other productive uses including watering livestock.

Many agencies including governments, non-governmental organizations and multilateral organizations however, are now promoting initiatives to enable smallholder farmers adapt to climate change (FAO, 2013). One way is to focus on the use farm management practices based on agro-biodiversity and ecosystem services that provide climate change adaptation benefits (Van Jackson et al., 2010). There is however need for more sustainable adaptation strategies to maintain rural livelihoods, increase yields and use natural resources efficiently in order to ensure food security under a changing climate (Bryan et al., 2013; Wheeler and von Braun, 2013).

2.7 Environmental Policies and Legislations Relevant to Climate Change in Kenya

The Government of Kenya has responded to various national and international challenges by enacting various policies and legislations to address them and meet international obligations. Climate change remains one of the important challenges that need international attention. The government of Kenya has given prominence to climate change and has developed policies and strategies to address the effects associated with it (Ogungo et al., 2014).

2.7.1 National Climate Change Act 2016

This legislation by act of parliament provides for an enhanced response to climate change, and provides mechanisms and strategies to achieve carbon resilient development (RoK, 2018b). The main institution for implementation of the Act is National Climate Change Council, which is charged with an overarching role of coordination of national climate change mechanisms, particularly in the preparation of action plans, strategies and policies. The Act also provides for financing of climate mitigation at national and county levels through creation of the Climate

Change Fund which receives monies from the Consolidated Fund and other budgetary allocations (RoK, 2016). The Act plays a role in mainstreaming climate change considerations and actions into various relevant sectors, and provides the legal foundation for National Climate Change Action Plans (NCCAPs) (RoK, 2018b).

2.7.2 Agriculture Act 2012

This is intended to promote and maintain a stable agriculture for the conservation of the soil and its fertility and to stimulate the development of agricultural land with regard to sound practices of good land management and good husbandry (RoK, 2012a). The Act provides for good agricultural practices particularly legislations for the sustainable use of agricultural land (FAO, 2020), thereby reducing the impact of climate change on agricultural land. The act further provides for administrative instruments to ensure a sound agricultural development and marketing of agricultural products (FAO, 2020). This Act has provisions on the management of catchments and riparian areas to support agriculture (Yatich et al. 2007). The law gives authority to the Minister in-charge of Agriculture to prescribe land-use systems to control soil erosion and deforestation, and to protect hilly zones and catchment areas from degradation. The Act has the provision for penalizing people who are involved in deforestation practices on lands with slopes exceeding 35%, and prohibits cultivation in slopes greater than 12% when the soil is not protected against agents of soil erosion (Ogungo et al., 2014).

2.7.3 Land Act, 2012

This is Act of gives power to article 68 of the constitution of Kenya, to revise, consolidate, rationalize and implement land laws; to provide for sustainable administration and management of land and land based resources for agricultural production (RoK, 2012). The Act provides for among others equitable access to land, security of land ownership, sustainable and productive management of land resources, elimination of gender discrimination in law, customs and practices related to land and property in land and conflict resolution of land disputes through recognized local community initiatives (RoK, 2012b). The Act ensures that equity among different classes of people including smallholder farmers and equity among and between generations is enhanced. The Act also advocates for control of agents that may degrade land lower agricultural productivity. It

also provides for sustainable utilization and management of land and resources on it for the provision of food security and sustainable development (RoK, 2018b).

2.7.4 Environmental Management and Coordination Act (EMCA), 1999 (rev. 2015)

This is an Act of parliament that was enacted 1999, and amended in 2015 to align it to the constitution of 2010 (RoK, 2015). It has environmental conservation provisions, including climatic change considerations in the agenda. EMCA is the legal framework on environmental management and conservation in Kenya, and plays a role in coordinating other sectoral legislations dealing with environmental resources (RoK, 2015). It guides relevant ministries to consider climate change mitigation measures in their actions and budgetary allocations, requesting the establishment of environmental departments or designated officers at national and county levels (RoK, 2016b). The Act provides for County Environment Committees (CECs) whose mandate is the management of the environmental issues including climate change at the county level by developing county environment action plan every five years (RoK, 2015). It advocates for environmental impact assessment and strategic environmental assessment of development projects, programs, plans and policies for the protection of the environment (RoK, 2016b).

2.7.5 The East African Community (EAC) Climate Change Policy, 2011

The EAC Climate Change Policy has the objective of guiding Member States and other stakeholders on the preparation and implementation of collective measures to address Climate Change in the region while providing for sustainable social and economic development (EAC, 2011). The Policy has put in place statements and actions to guide climate change adaptation and mitigation to reduce the vulnerability of the region, especially of smallholder households and enhance resilience of vulnerable ecosystems. Due to the high vulnerability of the region to the impacts of climate change, given it's over reliance on rain-fed agriculture, adaptation to climate change is crucial to the East African Community region (EAC, 2011). The Policy aims at implementing urgent and immediate adaptation priorities identified in the National Adaptation Programmes of Action (NAPAs), National Adaptation Plans (NAPs) and climate change strategies of member states (EAC, 2011). The policy advocates for each Partner State to create an enabling environment through policy, legislative and institutional frameworks to operationalize the Policy provisions (EAC, 2011).

2.8 Summary of Research Gaps

While available literature provides valuable insights into the socioeconomic, cultural and institutional factors determining climate change adaptation, gaps remain. There is limited research on the contribution of these factors on the choice of climate change adaptation strategies by the smallholder farmers. Further, there is limited research on the particular challenges faced by women farmers that restrict their ability to make decisions on climate change adaptation strategies. Equally, more studies are needed to assess the contribution of financial interventions such as agricultural insurance and agricultural credit on adaptation outcomes. More studies are needed to assess how indigenous knowledge can effectively be integrated with modern adaptation technologies, without undermining traditional practices. There is also limited research on how religious beliefs and religious institutions can actively support climate change adaptation efforts. Several knowledge gaps remain particularly regarding the integration of local and formal governance systems, the inclusisvity and financial sustainability of local institutions and their contribution to the choice of climate change adaptation strategies by smllholder farmers. Addressing these gaps will provide a more comprehensive understanding of the socioeconomic, cultural and institutional dynamics of climate resilience among smallholder farmers.

2.9 Theoretical Framework

Cultural and socioeconomic contexts are critical factors to consider in understanding the determinants of adaptation by the smallholder farmers. However, the social and cultural limits to adaptation are not well researched, acknowledging the scant attention with in the climate change discourse devoted to addressing social and cultural dimensions (IPCC, 2007:737). The cultural aspects such as beliefs, values, norms, artefacts may be very useful in determining choice of adaptation strategies at the household level. Culture could shape how people support adaptation interventions, and their motivation to design response mechanisms (Agyeman et al., 2009).

In order to understand the contributions of cultural and socioeconomic factors on climate change adaptation by smallholder farmers in Homa Bay County, the study engaged the Cultural Theory of climate change Risk (CTR), originally developed by Mary Douglas and colleagues (Rayner, 1992) and Protection Motivation Theory (PMT), propounded by Rodgers (1983). The Culture Risk

Theory is applied because it provides a useful problem-solving technique and has explanatory power for understanding the role of socioeconomic (Gender, age, level of education, marital status, household size, source of labour, source of climate information) and cultural (Attachment to place of residence, cultural beliefs and religious beliefs) factors on climate change adaptation (McNeely and Lazrus, 2014), by smallholder farmers in Homa Bay County. CTR postulates that certain forms of social organizations are associated with world views of nature and that different forms of social organizations perceive and manage environmental risks differently, including climate change (Rayner, 1992). This difference in risk perception can lead to conflicts between groups with different institutional cultures about how they recognize risks and approach solutions (Thompson and Rayner, 1991). CTR thus explains conflicts a rising from mismatched worldviews about how environmental risk is identified and managed in different social set ups. Individuals tend to perceive climate change as a more serious threat and are more supportive of collective and precautionary adaptation measures (Kahan et al., 2021).

Protection Motivation Theory (PMT) explains the concept of persuasive communication and how people behave and cope during stressful conditions (Rogers, 1983). The core assumption of the theory is that people will normally protect themselves against four perceptions: perceived probability of the occurrence of a threatening event or vulnerability; perceived severity of such a threatening event; perceived self -efficacy in managing such a threatening event; and finally perceived efficacy of recommended preventive measures (Rogers, 1983).

This theory fits into explanations around how people respond to climate change threats and coping strategies against such threats. This is because the protection motivation theory anchors on two factors: threat appraisal and coping appraisal (Ihemezie et al., 2018). In the climate change discourse, the threat appraisal assesses the severity of the climate change event and its adverse impacts while, the coping appraisal assesses how smallholder farmers can respond to such situations. Therefore, the theory could be adopted to explain why smallholder farmers accept or reject some coping/adaptation strategies (Herath and Rao, 2009). It goes further to suggest ways through which negative response/behaviour towards climate change adaptation could be changed. One of the ways is the role of socioeconomic factors such as education and motivation in changing peoples' attitude including smallholder farmers towards climate change adaptation (Ifinedo, 2012).

To understand the contribution of indigenous knowledge on climate change adaptation, the study employed the Theory of Planned Behaviour (TPB) by Ajzen (1991). The theory deals with the aspect of perceived behavioural control, which predicts the behavioural intention in the decision making process, subsequently leading to the performance itself (Ajzen, 1991; Meijer et al., 2015). Cenral to this theory is attitude formation as a result of accumulated knowledge, which controls behaviour and may or may not eventually favour the uptake of climate change adaptation strategies by the smallholder farmers in Homa Bay County.

The theory illustrates how various socially constructed influences work together to achieve the desired behaviour (Mudekhere et al., 2024). Indigenous knowledge practices stem from socially learned processes, which can result in desired behaviours that may increase vulnerability to climate change-related hazards. In the context of the uptake of climate change adaptation strategies, this theory offers an elaborate illustration on how the attitudes and perceptions of the farmers may only be modified positively if the social environment is set up in such a way that behaviour, normative beliefs are taken into consideration so that the intended behaviour is acceptable.

In order to understand the contribution of local institutions on climate change adaptation by smallholder farmers, the study engaged the institutional theory. This theory has been used as a powerful framework to examine individual (including smallholder farmers) responses to institutional contexts (Zanette and scaraboto, 2019), and it is relevant to address climate change adaptation (Bartlett, et. al, 2009) at household level. It helps in examining the structures that orient individuals and their relationships with the environment. Institutional theory provides a theoretical framework to analyse the processes and mechanisms by which organisations produce models of activities and methods that guide behaviours and attitudes (Scott, 2001). Institutions and institutional contexts influence individual attitudes and behaviours in distinct areas, including climate change adaptation (Hulme, 2009). Some studies suggest the influence of national institutional contexts on sustainable corporate decisions (Ortiz-de-Mandojana, et. al, 2016). Berrone et al, (2013) show that organisations facing regulative and normative pressures related to environmental issues are more likely to take innovative environmental decisions.

However, most of the studies focus on stakeholders like companies, firms or countries (Glover et. al, 2014), underexploring how individuals at household level including smallholder farmers respond to actions to adapt to climate change within institutional systems. Despite their intention

of providing generally applicable guidelines on climate change adaptation, most studies provide only very limited references to local - level adaptation processes and, especially, to the adaptation of smallholder farmers (Below et al., 2012), with limited literature on the contribution of socioeconomic, institutional and cultural factors on climate change adaptation. This justifies the importance of this study as it investigated the contributions of socioeconomic, institutional and cultural factors on climate change adaptation by smallholder households. It is the social organization of institutions, rather than the threat itself, which determines what risks are recognized, the process for obtaining social consent about each risk, and how each risk is managed (Wildarsky, 1982; Rayner, 1984; Gross and Rayner, 1995).

2.10 Conceptual Framework

This study investigated the contributions of socioeconomic, institutional and cultural factors on the choice of climate change adaptation strategies. The independent variables were contributions of socioeconomic factors, cultural factors, indigenous knowledge and local institutions, and. The dependent variable was the choice of climate change adaptation strategies by the smallholder farmers. The contribution of socioeconomic factors was measured by the contributions of gender of the smallholder farmer, age, and level of education, household size, marital status, size of the farm, source of capital, access to environmental and agricultural information, and source of farm income. The contribution of Cultural factors was measured by attachment to place of residence, religious and other cultural beliefs. The indigenous knowledge was measured by farming experience, duration of stay in the study area and climate change experience as they determine the amount of indigenous knowledge accumulated on climate events. The contribution of local institutions was measured by group membership, sponsorship by local institutions and the type of aassistance offered by local institutions. The relationship between the independent, intervening and the dependent variables is depicted in Figure 1.

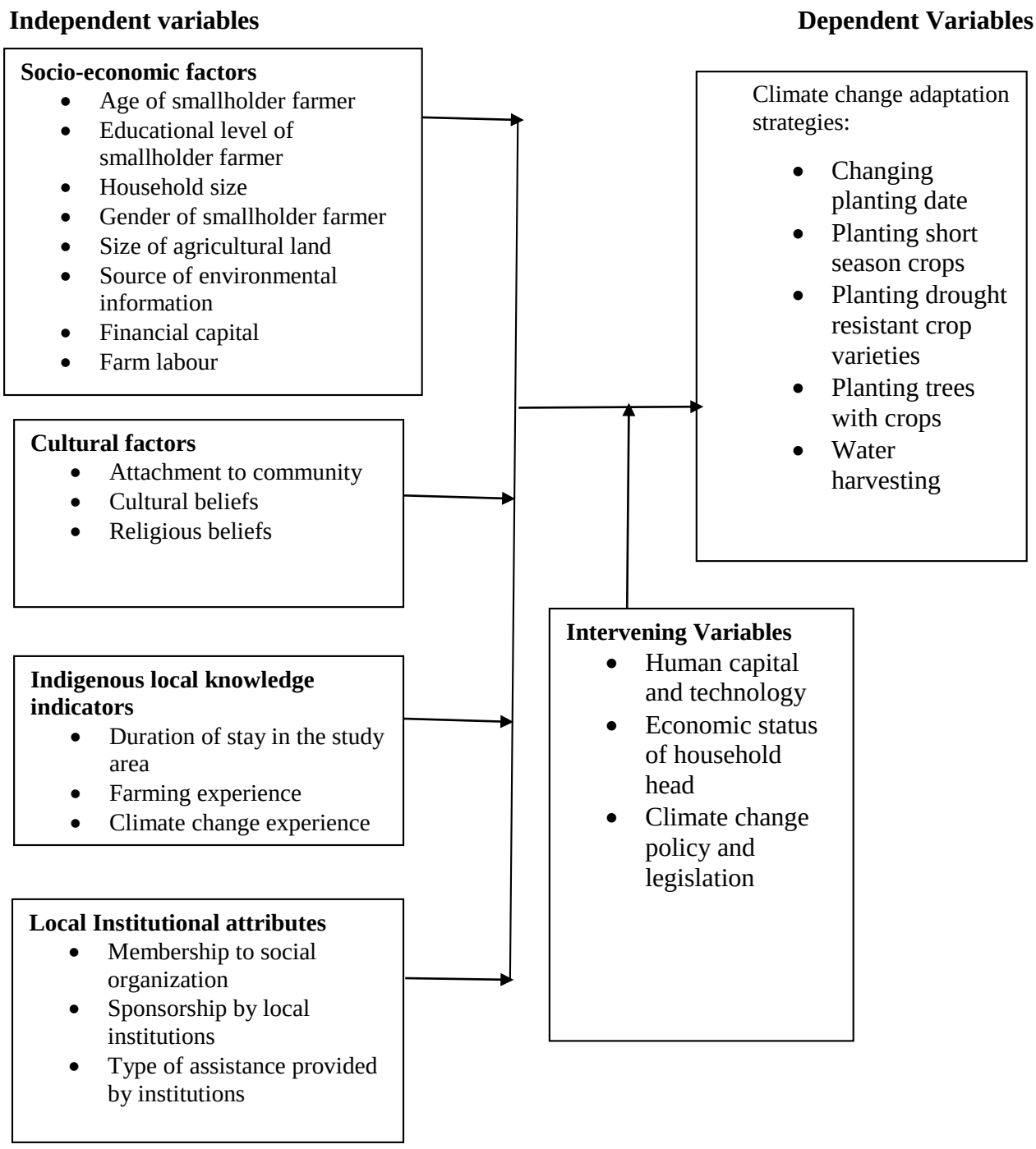


Figure 1: Conceptual Framework showing relationship between Independent and Dependent variables

Source: Researcher, 2016

CHAPTER THREE
RESEARCH METHODOLOGY

3.1 Introduction

This chapter provides a logical description of how the research was done. It is designed to facilitate the achievement of the objectives of the study. It contains the study area, research design, target population, sample size and sampling procedure, instrumentation and data collection methods, pilot testing, validity, and reliability, data organization and analysis and research ethics.

3.2 The Study Area

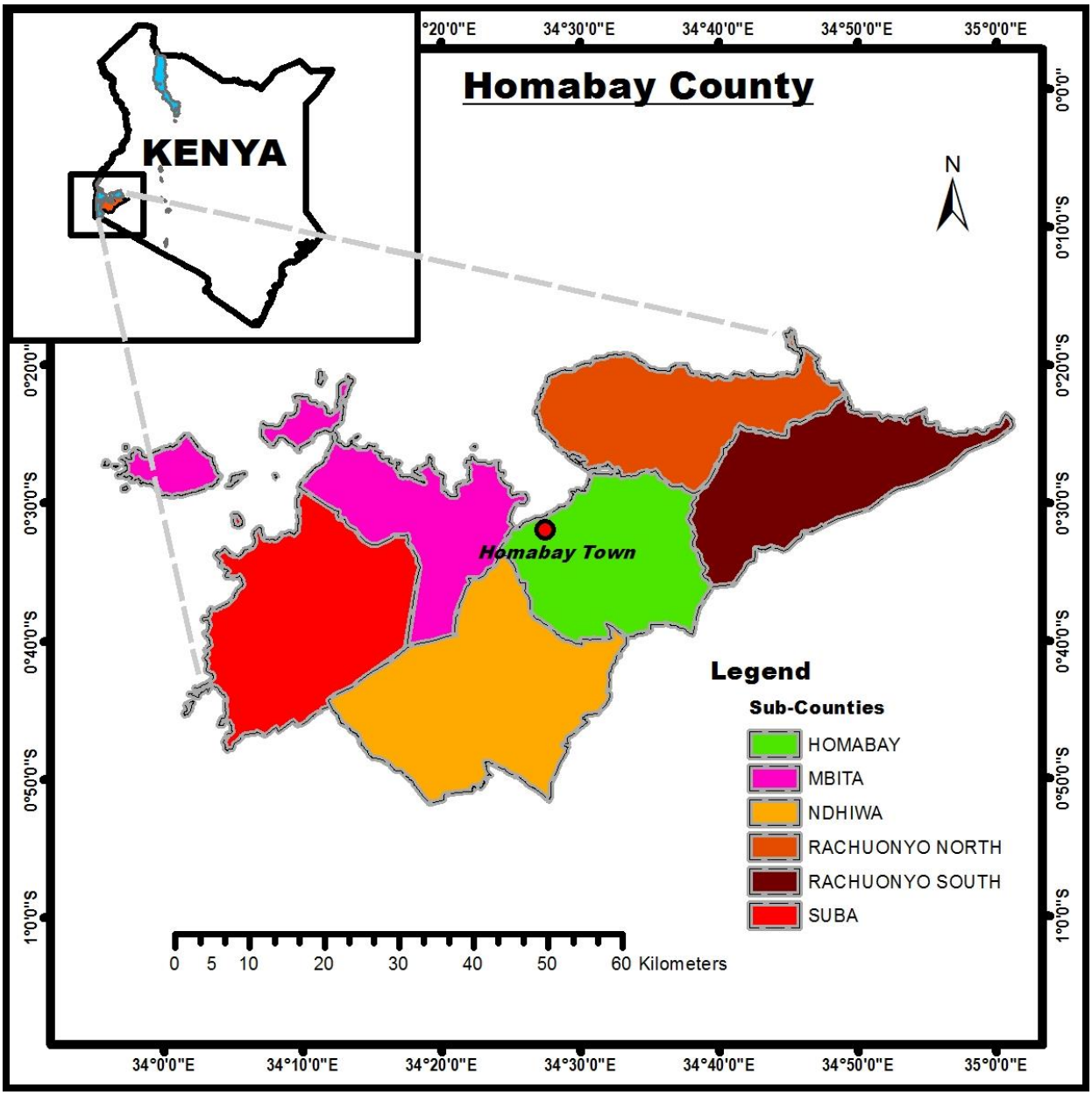
The study was carried out in Homa Bay County. The county is characterised by a rapidly growing population, high population density, falling food production and low resilience to climate change. It is within the Lake Victoria Basin which is experiencing erratic weather as a result of perceived effects of climate change and variability. Poverty is prevalent in the county with about 48% of the population living below poverty line (KNBS & UNICEF, 2013). This is slightly higher than the national average of about 45%. The county faces perennial food shortages and food insecurity due to low productivity (County Government of Homa Bay, 2023), driven by factors such as extreme weather, climatic shocks, unsustainable natural resource management, high prevalence of HIV/AIDS (21.75%) and limited access to farm inputs (County Government of Homa Bay, 2023). The population in the county is fairly homogeneous in terms of ethnic composition (RoK, 2019), making it suitable for the study to achieve its objectives.

The county has a low forest cover of 2.59% compared to the current national average of 6.9% (RoK, 2016c), probably due to low rates of tree planting and degradation from activities such as charcoal burning and clearing of forests to create room for settlements and agricultural production. This is likely to aggravate the problems of climate change. The areas affected include Kodera forest, Wire forest, Ruma National park and Gembe Hills (RoK, 2016c). Promotion of climate change adaptation among smallholder households in the county is pro-growth and achievement of sustainable development goals. The county has varied agro-ecological zones giving rise to different land uses. These zones include Upper Midlands 1 (UM1), Upper Midland 3 (UM3), Upper Midlands 4 (UM4), Lower midlands 2 (LM 2), Lower Midlands 3 (LM3), Lower Midlands

4 (LM 4) and Lower Midlands 5 (LM 5). This is representative of Kenya's agro-ecological zones, making Homa Bay County suitable for the study (RoK, 2016c).

3.2.1 Location and Size

Homa Bay county is located between latitude 0º 15' South and 0º 52' South, and between longitudes 34º East and 35º East. The county covers an area of about 4,267.1 Km^2 inclusive of the water surface which on its own covers an area of about 1,227 Km^2. The county lies in South Western Kenya along Lake Victoria where it borders Kisumu and Siaya Counties to the North, Kisii and Nyamira Counties to the East, Migori County to the South and Lake Victoria and the Republic of Uganda to the West. The county has six administrative sub-counties namely; Rachuonyo south, Rachuonyo north, Homa Bay town, Ndhiwa, Mbita and Suba sub-counties. Figure 2 shows the map of Homa Bay County.



Source: Survey of Kenya, 2014

Figure 2: Map of Homa Bay County

3.2.2 Physical and Topographic Features

The county has two main relief regions namely the lakeshore lowlands and the upland plateau. The lakeshore lowlands lie between 1,163-1,219 m above the sea level and comprises of a narrow stretch bordering the Lake Victoria especially in the northern parts of the county (RoK, 2013). The upland plateau starts at 1,219-1580 m above the sea level and has an undulating surface which has

resulted from erosion of an ancient plateau or highlands. It is characterized by residual highlands such as Gwassi and Ngorome Hills in Suba, Gembe and Ruri Hills in Mbita, Wire Hills in Kasipul as well as Homa Hills in Karachuonyo. Kodera forest in Kasipul and the Kanyamwa escarpment that runs along the borders of Ndhiwa and Mbita also form part of the upland plateau. Another important feature is Ruma National Park in the vast Lambwe Valley (RoK, 2013)

The county has five permanent rivers which is the source of water for domestic and small scale irrigation, majorly for horticultural crops. The rivers include; Awach Kibuon, Awach Tende, Sondu Miriu, Riana and Oluch rivers some of which form the boundaries of the county. There are also several seasonal rivers and streams which originate from the highlands within the county (RoK, 2013).

3.2.3 Climatic Conditions

Homa Bay County has an inland equatorial type of climate, which is however modified by the effects of altitude and nearness to the lake, making temperatures lower than in equatorial climate. The county receives a bimodal type of rainfall ranging from 800mm-1200mm per annum which is sometimes erratic with prolonged dry spells in the months of November and February. The dry spells make the short season almost unbearable for crop survival. Irrigation potential is high because of gentle slopping land bordering the Lake Region and dry weather conditions in most part of the year (County Government of Homa Bay, 2021)

The soils are predominantly black cotton soils and sandy loam soils. The maximum day temperature reaches 30^0C and night's minimum temperatures 26^0C with mean temperature of 29.4^0C. The County is classified as semi-arid county experiencing between 10-29% aridity levels (County Government of Homa Bay, 2021)

The county experiences significant variations in climate parameters which is impacting on agricultural production. The trend analysis of rainfall data (Figure 3) from Kenya Sugar research station in Homa Bay County showed that that the amount of rainfall has been declining over the years from 2009 to 2018 with the highest rainfall being experienced during the years of 2009-2010 while the least amount of rainfall experienced during the year of 2014 (RoK, 2018a). The year 2014 also represents the year when the county recorded the highest average temperature during the long rains. This could impact negatively on crop production given that most of the smallholder

farmers depend on precipitation for their agricultural production. In order to improve on agricultural production, smallholder farmers will need to invest on climate change adaptation strategies such as irrigation and planting of early maturing and drought tolerant crop varieties among others to escape the effects of drought.

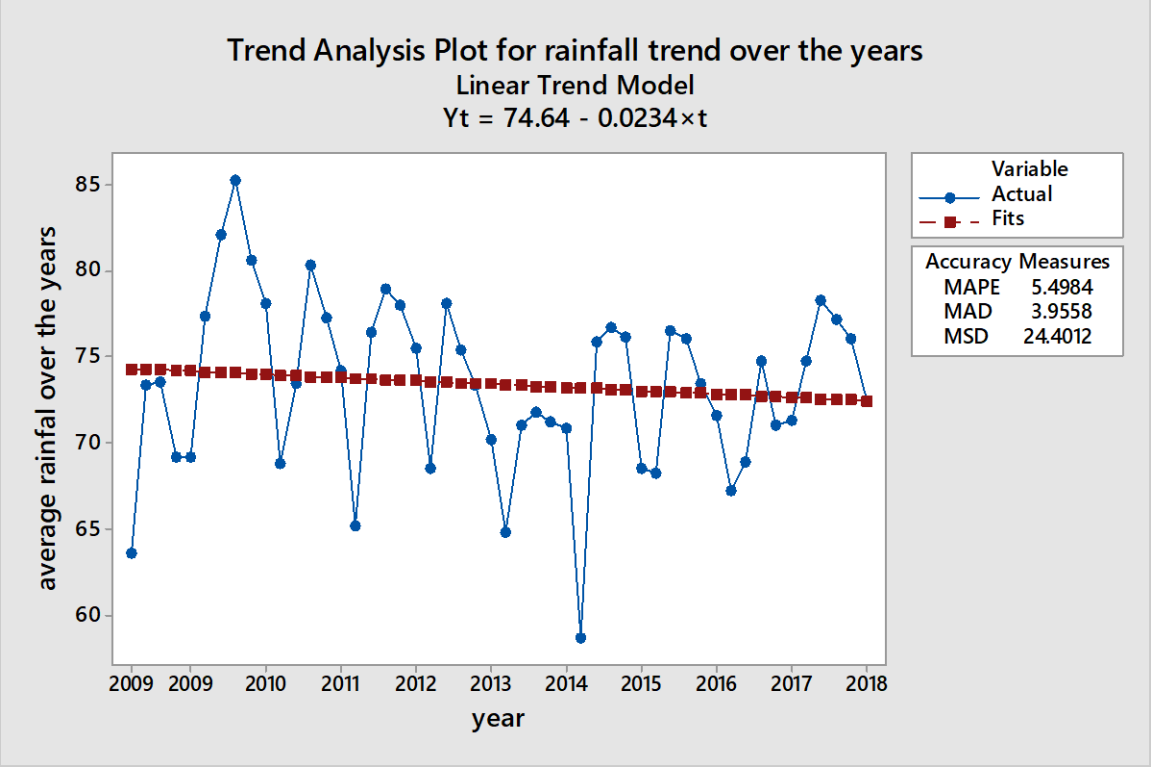


Figure 3: Average Rainfall trend in Homa Bay County

The trend analysis also showed a significant increase in the temperature levels from 2009 to 2018 (Figure 4). But the highest temperature was in 2014 and the least in 2010. This increase in temperature coupled with unreliable rainfall results in reduced agricultural production. The trend analysis of temperature confirms the perception of increasing temperatures by smallholder farmers in Homa Bay County.

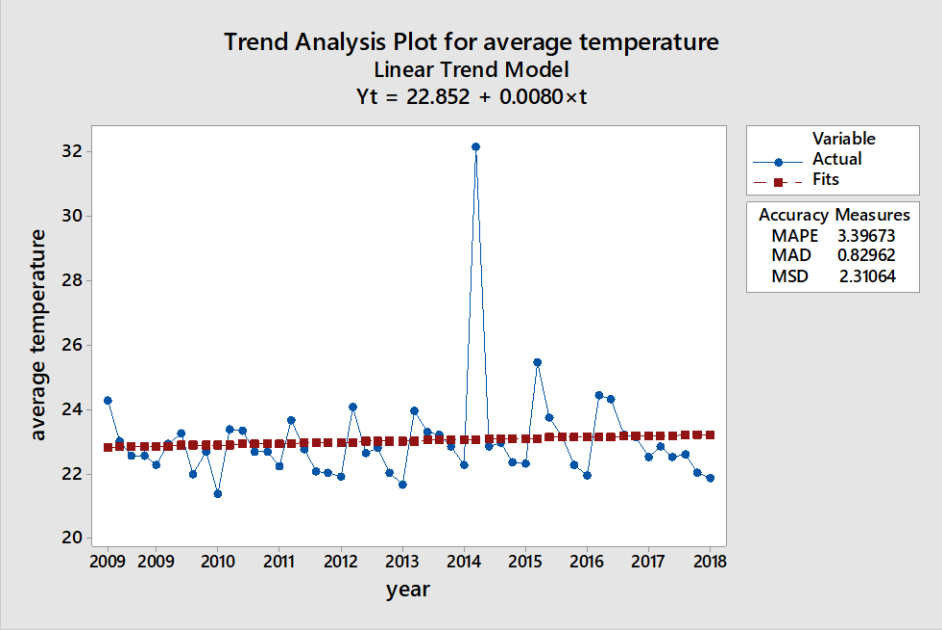


Figure 4: Average temperature trends in Homa Bay County

3.2.4 Economic Activities

Most households in Homa Bay County rely on primary production for their livelihoods, which include rain-fed smallholder farming, livestock rearing and fisheries, practices that are highly vulnerable to environmental degradation and effects of climate change (County Government of Homa Bay, 2023). The major climate hazards are droughts and floods caused by variations in temperature and precipitation. These hazards have led to increased emergence of crop and livestock pests and diseases (County Government of Homa Bay, 2023), impacting negatively on food security in the county.

Agricultural activities in the County is determined by varied Agro-ecological Zones (AEZs) (RoK, 2014). These include the upper midlands (UM1), which occupy the southern parts of Rachuonyo South Sub County where tea and coffee are grown; the upper midlands (UM3) cover the Gwassi hills of Suba Sub County where millet, sorghum, maize and sunflower are grown; the upper midlands (UM4), which cover areas surrounding Gwassi hills of Suba sub-county and Nyarongi areas of Ndhiwa sub-county where maize, soya beans and pineapples are grown; the lower midlands (LM2), which occupy some parts of Ndhiwa, Homa Bay Town, Rangwe, Kasipul and north Kabondo in Rachuonyo South sub-county, where millet, sorghum, pineapples, tobacco, sunflower and sugarcane are grown; the lower midlands (LM3) occupy parts of Homa Bay Town

sub-county where sweet potatoes, simsim, rice and green grams are grown; the lower midlands (LM4), which occupy a strip along east of Karachuonyo, central Mbita and Gwassi areas of Suba Sub County which is predominant for cotton growing and; the lower midlands (LM5), which occupy south-west Suba, Rusinga and Mfangano islands, Lambwe Valley and Gembe and Kasgunga areas of Mbita Sub County and supports livestock rearing and millet growing (RoK, 2014).

3.3 Research Design

The study adopted cross-sectional survey design to collect data from the study population according to the study objectives. In this design data collection is conducted in only one survey round (Casley and Kumar, 1988). The design is useful in research because it is fast and can allow researcher to collect data on different variables to see how they affect a certain condition (Casley and Kumar, 1988)The survey design has been found to be effective in describing characteristics of population under study (Kathuri & Pals, 1993; Fraenkel & Wallen, 2000), and therefore this design was appropriate because the study involved description of the characteristics of the smallholder farmers as they relate to their capacity to adapt to the effects of climate change. Surveys are cost effective and also exploratory enabling the researcher to make conclusions though not to the level of cause and effect (O'Connor, 2002). However, non–responses have been found to be a problem in almost all surveys (Fraenkel & Wallen, 2000), but this study applied appropriate measures to help reduce this problem including raising sample size, calling back on absentee respondent or a random replacement where necessary (Creswell, 2014). Given the nature of the objectives, the study adopted mixed methods approach (Creswell, 2014), where collection, analysis and integration of both quantitative and qualitative data are conducted within a single research study in order to answer complex research questions (Creswell and Plano, 2011). The use of quantitative and qualitative approaches in combination provides a better understanding of research problems through in-depth information search than either of the approaches alone (Creswell and Plano, 2011). The study focused on the smallholder farming households and how they adapt to effects of climate change in the study area. Central to the concept of adaptive capacity to climate change is the system as unit of analysis, in this case the smallholder household (Gallopín,

2006), as represented by the household head. The study therefore used the head of smallholder household as the unit of analysis.

3.4 Target Population

The population for were households involved in smallholder farming in Homa Bay County. The county has a total of 158,827 smallholder farming households; with Rachuonyo North sub-county having 26,000 farming households, Rachuonyo south having 37,333 farming households, Homa Bay having 31,350 farming households, Ndhiwa having 33,410 farming households, Suba having 14,752 farming households and Mbita having 15,982 farming households (RoK, 2018a). The population of smallholder households as represented by household heads was used to select the required sample for the study.

3.5 Sample Size and Sampling Procedure

3.5.1 Household Survey

The sample size for the study was 404 smallholder farming households. The sample size was determined using the Fischer's (1998) formula:

$n = Z^2 p (1-p)/e^2$

Where **n** is the minimum sample size (population>10,000) required, **Z** is the standard normal deviate at the required confidence level, (set at 1.96 corresponding at 95% confidence level adopted for the study), **p** is population proportion estimated to have a particular characteristic (where there is no reasonable estimate, a default of 50% or 0.5 is acceptable) and **e** is the level of precision or sampling error at 95% confidence level, giving the value of **e** as 0.05 (Glenn, 1992). This is calculated as:

$n = (1.96)^2(.5\times.5)/ (.05)^2 = 384.2 \approx 384$ smallholder farming households. However, 5 % of the sample size was added to cater for non-responses among the study participants. This gave a sample size of 404 households as represented by household heads.

In order to obtain a representative sample from each of the six sub-counties, stratified sampling technique was conducted, using Neyman's method, $n_h = \left(\frac{n}{N}\right)N_h$ of proportional allocation where

n_h is the stratum sample size; n is the sample size for the study; N is the target population and; N_h is the stratum population (Lavrakas, 2011).

Stratified sampling is preferred because it reduces the sampling error. Stratified sampling has the advantage of a built-in insurance that the sample will accurately reflect the numerical composition of the various sub-groups (Cozby, 2003). The goal of stratified random sampling is to achieve the desired representation from various subgroups of the population (Bhardwaj, 2019).
Stratification based on the sub-counties is presented in table 1 as follows:

Table 1: Sample Size per Sub-County

Sub-county	Number of households	Sample size $n_h = \left(\frac{n}{N}\right)N_h$
Homa Bay Town	31,350	80
Ndhiwa	33,410	85
Mbita	15,982	41
Rachuonyo North	26,000	66
Suba	14,752	37
Rachuonyo South	37,333	95
Total	**158,827**	**404**

However, systematic random sampling was used to select individual smallholder farmers from each sub-county. Systematic sampling is simple and reduces biasness by ensuring that every member of the population has an equal probability of being selected for the sample (Kothari, 2004).

3.5.2 Focus Group Discussion

Focus group discussion was used for the purposes of obtaining in-depth information for the study achieve its objectives. The study employed single focus group discussion to obtain qualitative data, which according to Yayeh, 2021 involves the interactive discussion of a topic by a group of participants and two facilitators as one group in one place. It is the most common type of focus

group discussion (Morgan, 1996). Focus group discussion allow for broader and deeper insights about a research topic that requires collective views including their experiences and beliefs (Asmamaw, et. al, 2011). This is as opposed to structured questionnaires that limit respondents to single word or multiple choice responses. This was useful for the study since it needed an in-depth understanding about socioeconomic and cultural factors influencing climate change adaptation by smallholder farmers in the study area. The participants were purposively sampled based on their ability to provide relevant information. The study conducted 12 focus group discussions with two groups from each sub-county. The groups consisted of 10 to 12 participants. Although it is generally accepted that between six and ten participants are sufficient (Krueger and Casey, 2000), some studies have reported as few as four and as many as fifteen participants (Ochieng et. al., 2018). According to Krueger 1994, ten participants are considered large enough to gain a variety of perspectives and small enough not to become disorderly or fragmented.

3.5.3 Key Informant Interviews

This was also conducted to obtain detailed information on socioeconomic and cultural factors influencing climate change adaptation by smallholder farmers in the study area. Key informant interviews are useful in providing descriptive information pertaining to socioeconomic conditions of an area or the general characteristics of the target populations such as religion, values and beliefs (USAID, 1996). The study purposefully sampled 4 key informants in each of the six sub-counties from the departments of Forestry, Agriculture, Environment and Non-governmental Organisations dealing with environmental issues in Homa Bay County. This was considered to be within the threshold of data saturation. Data saturation refers to the point in data collection when no new information arises from subsequent data collection efforts (Hennink et. al., 2015). According to USAID, 1996, 15 to 35 key informant interviews is sufficient to provide the required information.

3.6 Data Collection Methods and instrumentation

For the purpose of this research, both primary and secondary data were collected. The secondary data was collected from journals, reports from government of Kenya departments county government of Homa Bay and research publications related to climate change adaptation and data on crop yields and climate events for the last ten years in the county. Maseno university library was used to access the publications among other data sources. Primary data was collected using questionnaire, interview schedule, and focus group discussion.

A pre-tested structured questionnaire was used to collect quantitative data from the respondents (Appendix I, page 170). The purpose of this method was to record the situation on climate change adaptation and the demographic profiles of the respondents in the study area. Data was collected at one point in time from a sample of 404 farming households with the smallholder farmers (household heads) being interviewed.

The questionnaire was designed to obtain among others a) profile of the respondents b) socioeconomic and cultural characteristics of the respondents c) water resources d) environmental issues and d) climate change awareness and adaptation. This was used with the available secondary information on climate change to enrich the study. The questionnaire was administered face-to-face by team of four research assistants working under direct supervision of the main investigator. Questionnaire is typically efficient, economical and practical when large samples are used (Fraenkel & Wallen, 2000), and therefore was appropriate for this study. Administration and processing of structured questionnaire is also straightforward and the results readily lend themselves for analysis (Mugenda & Mugenda, 1999). The disadvantage with structured questionnaire is that it may have ambiguous questions and the respondent may not have a chance to expand on, or react verbally to, a question of particular interest (Cozby, 2003). This was solved in this study by use of standard instructions given to all respondents and conducting face-to-face interview where necessary. Structured questionnaires are also considered inappropriate in investigations where the aim happens to be to probe for attitudes and reasons for certain actions or feelings (Kothari, 1990). However, focus group discussion was conducted obtain in-depth information.

The qualitative data approaches included 24 Key Informant Interview (KII), which was conducted to a) government officers in the departments of forestry, agriculture, and Environment b) staff of non-governmental organizations, (KII guide- Appendix II, page 179); Focus group discussion (FDGs), which is considered an effective participatory method for exploring and comparing views of smallholder farmers on climate change adaptation. Twelve focus group discussions were conducted in the study area. Each FDG had between 10 and 12 farmers and lasted between one hour and one hour thirty minutes. This was held with community administrative and opinion leaders among the smallholder farmers (FDG guide- Appendix III, page 181). The focus group

discussions were conducted in the month of April, 2018 while key informant interviews were conducted in the month of May, 2018.

3.7 Reliability and Validity of the Instrument

Reliability is the measure of the consistency of the results from tests of the instruments. It measures the degree to which a research instrument yields consistent results or data after repeated trials (Kothari, 2004). Reliability should be at least 0.70 or preferably higher for research purposes (Fraenkel & Wallen, 2000). A high coefficient (0.7 and above) implies that items correlate highly among themselves, i.e. there is consistency among the items in measuring the concept of interest (Mugenda & Mugenda, 1999). Cronbach alpha of about 0.7 is a reliable coefficient that indicates how well the items are correlated to one another (Sekaran, 2003). The reliability of the questionnaire for this study was calculated after the pilot study using the Cronbach reliability test. Piloting was done in Nyakach sub-county in Kisumu County. Nyakach sub-county was selected because it borders the study area and the sample size 20 smallholder farmers was used for piloting, which was equal to 5%. Howver only 15 questionnaires were returned.

From the results of reliability, it was observed that the Cronbach alpha value was 0.815 which was greater that the standardized Cronbach Alpha =0.70 (Table 2), implying that the accuracy level of the questionnaire was up to 81.5%. This means that questionnaire used for collecting the data gave data that would be able to meet the objectives of the study.

Table 2: Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.815	.752	15

Validity is the accuracy and meaningfulness of conclusions, which are based on the results of a study (Kothari, 2004). It is the extent of how well a test measures what it is supposed to measure and is concerned with the accurate representation of the variables under study. However, it is influenced by systematic errors in data. This was addressed in this study by good instrument design to reflect the research objectives and pre-testing the instruments. The instrument was subjected to

reviews by the supervisors and peers to ascertain its content. It was then analyzed statistically using Hotelling's T-Squared Test. The analysis indicate that the Hottelling's T-Square statistics was 28.483 with a p-value = 0.000 which was less than 0.05 significant level (Table 3). This means that the questionnaire met the need of the study objectives.

Table 3: Hotelling's T-Squared Test

Hotelling's T-Squared	F	df1	df2	Sig
28.483	5.618	5	287	.000

3.8 Data Analysis and Results Presentation

Data was collected for both closed and open ended questions as well as secondary data. Data processing included coding and entering in computers before being analyzed to address the research objectives. Both descriptive and inferential statistical tests were carried out. Descriptive statistics (percentages, frequencies, and cross-tabulations) were used. Inferential statistics like Chi-square test of independence and Cramer's V coefficients to test the relationship among variables were used.

All inferential statistical tests were conducted at $\propto = 0.05$ significance level. This was done with the aid of a computer programme, Statistical Application System (SAS).

The questionnaire was cleaned of errors made during data collection. The data was then summarized, coded and entered into the computer system for analysis. Coding allows for efficient analysis and through it, several replies may be reduced to a small number of classes which contain the critical information required for analysis (Kothari, 2004). Data analysis was done using quantitative and qualitative techniques. Frequency, means percentages and proportions were used to analyse data descriptively. Chi-square test at 5% level of significance and cross-tabulations were used to determine the individual relationships between the independent variables and the dependent variable. The Chi-square test of independence was necessary since the proportions alone are not sufficient in determining the significant relationships. In the statistical examination, the test statistic P-value ($\propto = 0.05$) was used to check for statistical significance. Cramer's V was used to test the strength of association between variables. Cramer's V test was necessary to determine the

contribution of socioeconomic, institutional and cultural factors on the choice of climate change adaptation stratregies by smallholder farmers in the study area. It measures the effect size and hence the contribution of independent variables have on dependent variables. It is an alternative to phi in tables bigger than 2 x 2 tabulation. Cramer's V varies between 0 and 1 without a negatve value and is interpreted as shown in Table 4 (Akoglu, 2018). The summary of data analysis is presented in Table 5.

Table 4: Phi and Cramer's V coefficients and interpretation

Phi & Cramer's V	**Interpretation**
Greater than 0.25	Very strong association
Greater than 0.15	Strong
Greater than 0.10	Moderate
Greater than 0.05	Weak association
0	No association

Table 5: Summary of Data Analysis

Hypothesis	**Independent variable**	**Dependent variable**	**Test**
Ho_1: There is no significant contribution of socioeconomic factors on climate change adaptation by smallholder farmers in Homa Bay County.	Socioeconomic factors • Gender of smallholder farmer • Age • Level of education • Marital status • Household size • Source of farm labour • Source climate information	Choice of climate change adaptation strategies • Changing planting date • Planting short season crops • Planting drought resistant crop varieties • Planting trees with crops • Water harvesting	• Frequency • Percentages • Cross-tabulations • Chi-square test of independence • Cramer's V test of effect size
Ho_2: Cultural factors (cultural beliefs and religious beliefs) do not have any significant contribution to climate change adaptation by smallholder farmers in Homa Bay County.	Cultural factors • Attachment to place of residence, • Cultural beliefs • Religious beliefs	Choice of climate change adaptation strategies • Changing planting date • Planting short season crops • Planting drought resistant crop varieties • Planting trees with crops	• Frequency • Percentages • Cross-tabulations • Chi-square test of independence • Cramer's V test of effect size

		• Water harvesting	
Ho_3: There is no significant contribution of indigenous local knowledge on climate change adaptation by smallholder farmers in Homa Bay County	Indigenous local knowledge • Duration of stay in the study area • Farming experience • Climate change experience	Choice of climate change adaptation strategies • Changing planting date • Planting short season crops • Planting drought resistant crop varieties • Planting trees with crops • Water harvesting	• Frequency • Percentages • Cross-tabulations • Chi-square test of independence • Cramer's V test of effect size
H_{O4}. There is no significant contribution of local institutions on climate change adaptation by smallholder farmers in Homa Bay County.	Participation in local minstitutions • Membership to local institutions • Sponsorship by local institutions • Types of local istitutions	Choice of adaptation strategies • Planting drought resistant crops • Planting trees with crops • Changing planting dates • Short season crops • Water harvesting	• Frequency • Percentages • Cross-tabulations • Chi-square test of independence • Cramer's V test of effect size

3.9 Ethical considerations

The permission to conduct research was obtained from Maseno University as well as a research permit from the National Commission for Science, Technology and Innovation (NACOSTI). The respondents' privacy and confidentiality was guaranteed by the researcher, assuring the respondents that the information gathered was for research purposes. The research assistants were sensitized and checked at intervals on the need to maintain confidentiality. Interviewers were inducted on the importance of minimizing anxiety or stress and of the absolute requirement of not leaking any information obtained from the study participants. The respondents were also assured of anonymity as they were not required to indicate their names or identities in the questionnaire.

Informed consent was obtained from the respondents, highlighting their voluntary participation and the right to withdraw at any point. Data, results, methods and procedures followed in conducting research were reported with utmost honesty to avoid any misrepresentation. Any form of bias was avoided in research design, data analysis, data interpretation and other aspects of research where objectivity is required. Good records of research activities such as data collection and research design were kept carefully to minimize error. The researcher maintained a formal yet relaxed relationship with the research participants during the process of data collection.

The researcher sought to be open in sharing of data, results, ideas, tools and resources and any positive criticism and new ideas were accepted and incorporated in the research. All contributors to research were adequately acknowledged and any form of plagiarism was avoided as much as possible. The research sought to remain non-discriminative on the basis of ethnicity, sex, race or other factors not related to scientific competence and integrity. The researcher sought to secure the records of the study keeping them in a locked file, and all electronic information would be coded and secured using a password protected file. The researcher reserves all the rights to this document and no part of it may be reproduced or transmitted in any form or any means, mechanically, photocopying, reading or any information storage system or retrieval system without written permission from the author or Maseno University on that behalf.

CHAPTER FOUR
RESULTS AND DISCUSSION

4.1 Introduction

This chapter highlights the results of the study in relation to each objective and hypothesis. The chapter begins by presenting the response rate of the respondents to the survey instrument and climate change adaptation strategies by smallholder farmers in Homa Bay County. In addition, the results discuss the contribution of socioeconomic factors in climate change adaptation by smallholder farmers in the study area, the contribution of cultural factors on climate change adaptation strategies by smallholder farmers in the study area, the contribution of indigenous knowledge on climate change adaptation by smallholder farmers, and the contribution of local institutions in climate change adaptation by smallholder farmers.

4.2 Response rate for the survey instrument

Out of the 404 questionnaires administered, 398 were accurately filled and and used for analysis for the study to achieve its objectives. This gave a response rate of 98.5%. This high response rate was achieved because most of the questionnaires were administered face to face to the heads of the smallholder farming households in the study area. The response rate per subcounty is presented in table 6.

Table 6: Response rate to the questionnaires

Sub-county	Number of questinnaires distributed based on sample size	Number of questionnaires accurately filled and analysed
Homa Bay town	80	78
Ndhiwa	85	84
Mbita	41	40
Rachuonyo North	66	65
Suba	37	36
Rachuonyo South	95	95
Total	404	398

4.3 Climate change adaptation strategies by smallholder farmers in the study area

Farmers in the study area reported several adaptation strategies that they practice to reduce the effects of climate change. These included changing of planting date (25.63% of the respondents), planting short season crop varieties (14.82%), and planting drought resistant crop varieties (19.60%), planting trees (32.42%), and water harvesting (6.03%), as presented in Table 7.

Table 7: Types of climate change adaptation strategies practiced by smallholder farmers expressed as percentage of total respondents

Types of climate change adaptation strategies	Frequency	Percent
Changing planting date	102	25.63
Planting of short season crops	59	14.82
Planting of drought resistant crop varieties	78	19.60
Planting of trees alongside crops	129	32.41
Water harvesting	24	6.03
Don't know	6	1.51

Other climate change adaptation measures reported by a male key informant interviewee include *"planting of crop varieties tolerant and resistant to both pests and diseases, keeping animals tolerant to diseases, parasites such as zebu cattle, crop rotation, soil and water conservation, mixed farming and mixed cropping, conservation agriculture and rehabilitation of degraded pastures" (Senior Agricultural Officer, Ministry of agriculture, Homa Bay County – May, 2018)*. Different cropping systems enable farmers to diversify their farm operations and hence are able to adapt to effects of climate change especially where early maturing varieties are incorporated in the system. Crop diversification is a widely used adaptation strategy in many parts of Africa as well (Bryan, et al., 2011; Akponikpe, et al., 2010). For instance, Merz et al. (2009) found in Senegal that a wide range of new crops were taken up by farmers in response to climatic variability and climate change, the most important new crop being water melon (*Citrullus lanatus*). On-farm diversification by mixed planting of maize with common beans or pigeon peas is a recently promoted agricultural strategy in order to minimize impacts from low and irregular rainfall (Tongruksawattana, 2014).

It was observed that tree planting was more preferred adaptation strategy by households in the study area. This could be partly because trees supplemented household incomes and probably due to concerted efforts by government and other agencies in the study area encouraging the farmers

to plant trees to improve vegetation cover. This was indicated by two male key informant interview participants who said that *"we encourage households and schools to plant trees, particularly indigenous species to improve on the vegetation cover through training and provision of tree seedlings" (Environmental Officer, World Vision, Kwabwayi Division; Project Coordinator, Securing Community Resilience (SCORES) Homa Bay County- May, 2018).*

Rain water harvesting was observed to be not popular with most households even though over 50% of Homa Bay County is classified as semi-arid. Responding to water scarcity stress and the threat of declines in crop yields require farm level intervention such as rainwater harvesting and establishing small-scale water reservoirs on farmlands (Osman-Elasha, 2010). Water harvesting structures includes a number of topographical measures that are used for collecting rainwater from a surface area (Bernier et al., 2015). Rainwater harvesting schemes have also made more water available closer to communities, meaning less time and energy spent on gathering water from distant and possibly unsafe water sources (Aroka, 2010). According to Malesu et al. (2006), water harvesting in Lare Division, Kenya has improved access to clean water and consequently improved health status of the local community. However, high investment costs and knowledge requirements restrict widespread up-take by smallholder farmers in SSA (Fox et al., 2005).

Tree planting was commonly practiced to supplement household incomes. However, due to limited land, most farmers practiced agroforestry where annual crops are intercropped with woody perennials. Agroforestry provides a means of diversification and enables the farmers to spread risks and environmental benefits.

4.4 Socioeconomic factors and climate change adaptation strategies by smallholder farmers

The hypothesis that "there is no significant contribution of socioeconomic factors to choice of climate change adaptation strategies by smallholder farmers in the study area" was analysed using percentages, frequencies, chi-square test and cramer's V coefficient. The factors analysed included the age of the household head, gender of the smallholder farmer, education level of the farmer and education level of the spouse, household size, household income, climate change awareness and adaptation, and source of farm labour and availability of financial capital among other socioeconomic factors.

4.4.1 Gender and Age of the respondents and climate change adaptation strategies

The results of the study indicate that about 52% of respondents were female while 48% were males (Table 8a). This reflects gender distribution of Kenyan population as presented by census results of 2019 (RoK, 2019). This however indicates that women participate more in decisions regarding farm production and climate change adaptation. Achieving greater gender equality and women's voice in decision-making is critical in climate negotiations, and in national/sub-regional mitigation and adaptation planning (Valery & Tanya, 2009).

The results of cross-tabulation between gender of the respondents and choice of strategies to adapt to climate change gave a significant association as presented in Table 8b.

Table 8a-c: Cross tabulation between Gender of smallholder farmers and measures to adapt to climate change

Count

		Gender of the farmer		Total
		Male	Female	
Types of Climate change adaptation strategies	Changing planting date	23	28	51
	Planting short season crops	34	42	76
	Planting of drought resistant crop varieties	32	19	51
	Planting of trees with crops	97	106	203
	Water harvesting	5	12	17
Total		191	207	398

Table 8b Chi-square of test of independence results

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	8.755[a]	3	.033
Likelihood Ratio	8.843	3	.031
Linear-by-Linear Association	.863	1	.353
N of Valid Cases	398		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 24.54.

Table 8c: Cramer's V test of effect size between gender of the smallholder farmer and choice of climate change adaptation strategies

Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Phi	.135	.121
	Cramer's V	.135	.121
N of Valid Cases		398	

a. Not assuming the null hypothesis.
b. Using the asymptotic standard error assuming the null hypothesis.

The null hypothesis tested was that types of climate change adaptation strategies and gender of the smallholder farmer were independent. The result in Table 8b ($\chi^2 = 8.755$, $p = 0.033$, $\alpha = 0.05$) shows significant association and hence null hypothesis was rejected. The results in Table 8c show a Cramer's V of 0.135 which indicates a statistically moderate contribution of gender of the smallholder farmer to the choice of climate change adaptation strategies. This implies that gender was contributing to choice of climate change adaptation strategies though moderately. The results of the study indicate that both female and male smallholder farmers implement climate change adaptation strategies to reduce climate related risks in Homa Bay County (Table 8a). The adaptation strategies varied from changing planting dates, planting of short-season crops to planting of tress. There were remarkable differences between male and female farmers implementing adaptation practices including change of planting dates, planting short-season crops, planting drought resistant crop varieties and planting of trees (Table 8a).

The results show that about 7.05% (n = 28) of the female farmers used change of planting dates as opposed to about 5.8% (n = 23) of the male farmers. The observed gender differences could be due to their relative differences in vulnerabilities to climate change and dictates of cultural norms that limit their access to resources necessary for climate change adaptation. For example, gender norms embedded in cultural systems can restrict women's access to adaptation resources and decision-making, further exacerbating vulnerability to climate change (Tambo & Abdoulaye, 2023). Female farmers generally tend to be more prone to effects of climate change and are more likely to employ this strategy to reduce their vulnerability to climate related risks. This strategy

may also not require financial investment and therefore cheaper to implement particularly by female farmers who have little control over household financial resources. According Tesfaye and Seifu, 2016; Wrigley-Asante et al, 2019, climate change has resulted in change of rainfall patterns and farmers have always employed changing planting dates to reduce the risks associated with climate change.

Planting short-season crop varieties was another strategy used to adapt to climate change smallholder farmers in the study area. The results show a remarkable difference between male and female farmers in using this strategy. Majority female farmers (n = 52; 13.1%) employed this strategy as compared to 8.6% of the male farmers (n = 34). This could still be attributed to different levels of vulnerability between female and male farmers. Farmers plant short-season crops that mature within a short time to protect them from low rainfall or drought. This is consistent with previous studies by (Twyman et al., 2014; Adzawla et al., 2019; Alhassan et al., 2019) conducted in Ghana and other parts of Africa.

Growing of drought tolerant crop varieties is an adaptation strategy used by farmers to minimize climate change threats (Fisher et al., 2015). Planting drought resistant crop varieties enhances high crop yields especially in the face of extreme climatic conditions. Majority of male farmers (n = 32; 8.04%) used this strategy as compared to female farmers (n = 19; 4.8%). This corroborates previous studies by Alhassan et al, 2019; Fisher et al, 2019; Wrigley-Asante et al, 2019 conducted in sub-Saharan Africa where they found that male farmers used drought tolerant crop varieties more than female farmers. This could be due to the fact that males have control over household financial resources to be able to purchase drought tolerant crop varieties as compared to their female counterparts (Anaglo et al., 2014, Fisher et al., 2019). Male farmers have better access to economic resources, which include diversity of incomes and better access to credit, and training such as level of literacy, access to climate information and extension services (Abdul-Razak & Kruse, 2017).

Tree planting as an adaptation strategy to climate change was observed to be more popular across households in the study area. However, more female farmers (n = 106; 26.63%) reported this strategy as compared to male farmers (n = 97; 24.37%). This could be attributed to the fact that trees, apart from directly mitigate climate change, can also provide additional household incomes,

which further protects farmers from climate related risks. Trees also provide cheap source of household energy.

Women also bear the bigger burden of the effects of climate change on household livelihoods due to their over reliance on natural resources and hence more vulnerable to effects of climate change. The gender-based division of labour leaves men and women with different levels of exposure to climate risks and opportunities (Rossi and Lambrou 2008). Gender of the smallholder farmer has a great influence on the farmer's adaptive capacity to the effects of climate change.

Considering respondents age groups, about 29.9% of the respondents were above 45 years of age. About 43.47% had 35-44 years of age, while the rest (about 26.6%) had below 34 years of age (Table 9a). This is a prime age when the farmers are active and may work for long hours and for many years. This is an important aspect for sustainable food production. People in this age bracket may be more willing to adopt new technologies delivered to them faster. Farmers who are within the age group 18 – 43 years tend to be more active in practical work as compared to older farmers. Majority of the farmers interviewed had the age of forty-two years and above. This is an aging group and may not be willing to change from their old farming practices thereby influencing climate change adaptation.

The results of cross tabulation between age group of farmers and measures to adapt to climate change gave an insignificant relationship, (Table 9a).

Table 9a-c: Cross tabulation between measures adapt to climate change and age group of smallholder farmers

Count

		Measures to adapt to climate change					Total
		changing planting date	planting short season crops	planting drought resistant crops	planting trees with crops	water harvesting	
Age	<30	12	8	14	18	5	57
	30-34	13	7	9	15	5	49
	35-39	18	9	14	26	7	74
	40-44	22	14	18	36	9	99
	>45	26	12	32	43	6	119
Total		91	50	87	138	32	398

Table 9b: Chi-Square Test of Independence Results

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	7.040[a]	16	.972
Likelihood Ratio	7.159	16	.970
Linear-by-Linear Association	.003	1	.954
N of Valid Cases	398		

a. 1 cells (4.0%) have expected count less than 5. The minimum expected count is 4.76.

Table 9c: Cramer's V test of effect size between age group of the smallholder farmer and choice of climate change adaptation strategies

Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Phi	.091	.006
	Cramer's V	.072	.006
N of Valid Cases		398	

a. Not assuming the null hypothesis.
b. Using the asymptotic standard error assuming the null hypothesis.

The null hypothesis tested was that types of climate change adaptation strategies and age group of the smallholder farmer were independent. The result in Table 9b ($\chi^2 = 7.040$, $p = 0.972$, $\alpha = 0.05$) shows insignificant association and hence null hypothesis was accepted. This means that the choice of climate change adaptation strategies was not dependent on the age of the farmer. This is justified by the results in Table 9c showing a Cramer's V of 0.072, which indicates a statistically weak contribution of age group of the smallholder farmer to the choice of climate change adaptation strategies. The weak relationship could be attributed to the fact that most of the smallholder farmers were elderly with low level of education and might have been reluctant to adopt agricultural technologies for climate change adaptation. This is consistent with findings from other studies, which suggest that older farmers are more likely to be resistant to change and are less likely to adopt new practices. Younger farmers are more likely to have received formal education or training in agriculture and tend to be more open to adopting new farming practices (Juhstin et al, 2017; Negera et al, 2022).

4.4.2 Marital status of the household head and climate change adaptation strategies

Marital status of the household head is represented on Figure 5. Majority of respondents about 57% were married while 26.38% are widowed. 8.04% account for household heads that had never married, 7.04% accounting for widowers and 1.51% representing divorced household heads.

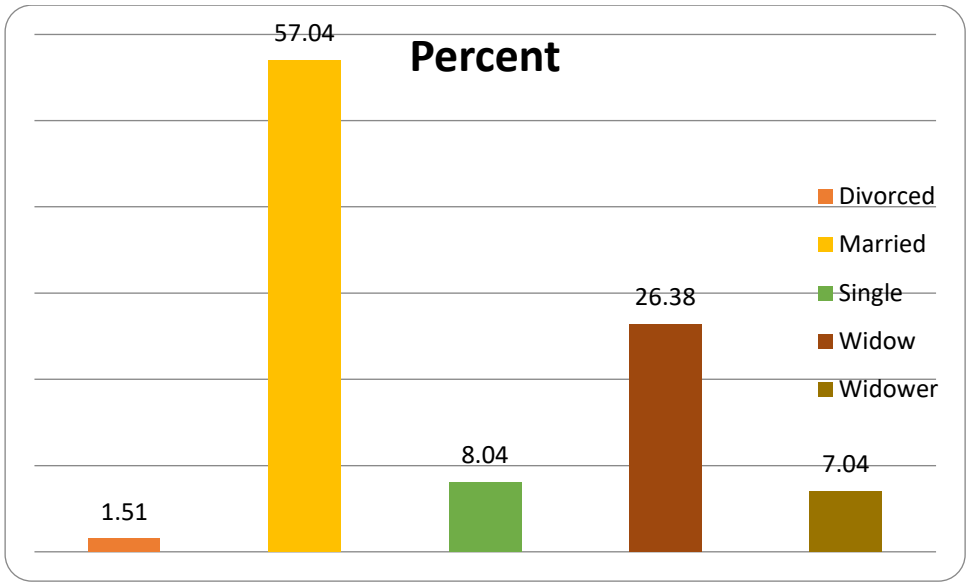


Figure 5: Marital status of the household head

The results of cross-tabulation between choice of measures to adapt to climate change and marital status indicated a significant relationship, (Table 10a).

Table 10a-c: Cross tabulation between marital status and measures to adapt to climate change

Count

		marital status			Total
		Married	Single	Widow/widower	
mitigation	changing planting date	29	12	18	59
	planting short season crops	58	10	20	88
	planting drought resistant crops	39	17	31	87
	planting trees with crops	53	11	35	99
	water harvesting	15	18	32	65
Total		194	68	136	398

Table 10b: Chi-Square Test of Independence Results

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	51.553[a]	8	.000
Likelihood Ratio	52.748	8	.000
Linear-by-Linear Association	.824	1	.334
N of Valid Cases	398		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 12.05.

Table 10c: Cramer's V test of effect size between marital status and choice of climate change adaptation strategies

Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Phi	.363	.000
	Cramer's V	.257	.000
N of Valid Cases		398	

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

The null hypothesis tested was that types of climate change adaptation strategies and marital status of the smallholder farmer were independent. The result in Table 10b ($\chi^2 = 51.553$, $p = 0.000$, $\alpha = 0.05$) shows a significant association and hence null hypothesis was rejected. The results in Table 10c show a Cramer's V of 0.257, which indicates a statistically significant and very strong contribution of marital status of the smallholder farmer to the choice of climate change adaptation strategies. This implies that marital status of the smallholder farmers contributed significantly to the choice of climate change adaptation strategies in the study area. Marital status may be critical in adoption of effective climate change adaptation strategies because the couple can make decision on the best adaptation practices. This is because if married farmers can discuss farming decisions with their spouses they could make better adaptation decisions than single, widowed or divorced farmers (Obayelu et al., 2014; Apata, 2011). Results of the study showed that most of the farmers are married (48.74%, Table 10a) and were participating in climate change adaptation. This could be attributed to the fact that married farmers may have high adaptive capacity as they can make joint decisions with their spouses on adaptation strategies. The results indicate that tree planting as climate change adaptation strategy was commonly practiced by married farmers. Households where husbands are engaged in off-farm employment tend to have the greatest available disposable income to invest on their farms. Marital status can influence decision making by the household head (Oka, 2000).

4.4.3 Level of education of the household head and climate change adaptation strategies

The study sought to analyze the level of education of the household head. The results indicate that 47.49% of the farmers interviewed had primary education, while 43.21% had secondary education and above. It can however be observed that elderly respondents are dominated by primary school education level.

The results of cross tabulation between level of education of smallholder farmers and measures to adapt to climate change gave an insignificant relationship, as presented in Table 11b.

Table 11a-c: Cross tabulation between measures to adapt to climate change and education level of smallholder farmers

Count

		Measures to adapt to climate change					Total
		changing planting date	planting short season crops	planting drought resistant crops	planting trees with crops	water harvesting	
Education	None	13	3	4	6	2	28
	Primary	55	31	37	89	13	225
	Secondary	22	12	17	42	6	99
	College	6	8	12	18	2	46
Total		96	54	70	155	23	398

Table 11b: Chi-Square Test of Independence Results

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	18.317[a]	12	.106
Likelihood Ratio	17.294	12	.139
Linear-by-Linear Association	3.549	1	.060
N of Valid Cases	398		

a. 1 cells (5.0%) have expected count less than 5. The minimum expected count is 3.31.

Table 11c: Cramer's V test of effect size between level of education of smallholder farmers and choice of climate change adaptation strategies

Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Phi	.188	.292
	Cramer's V	.109	.292
N of Valid Cases		398	

a. Not assuming the null hypothesis.
b. Using the asymptotic standard error assuming the null hypothesis.

The null hypothesis tested was that types of climate change adaptation strategies and education level of the smallholder farmer were independent. The result in Table 11b ($\chi^2 = 18.317$, $p = 0.106$, $\alpha = 0.05$) shows a statistically insignificant association and hence null hypothesis was accepted. The results in Table 11c show a Cramer's V of 0.109 which indicates a statistically significant moderate contribution of education level of the smallholder farmer to the choice of climate change adaptation strategies. This is consistent with some studies that found that education level of the farmer can determine choice of climate change adaptation strategies. Abdul-Razak and Kruse (2017) reported that farmers with formal education have better adaptive capacity to climate change than those farmers without formal education. Education level is paramount in enabling the farmers to understand and adopt new farming techniques, which is important in adaptation to climate change. The farmers with high level of education are expected to have high intellectual capacity. This high level of education enhances the understanding of information given and should also improve the farmer's level of participation in agricultural activities. Educated farmers are also expected to adopt environmentally friendly technologies, which are important in conservation of environment.

The results of chi-square imply that choice of climate change adaptation strategies was not dependent on the level of education of farmers. This could be attributed to the fact that most farmers interviewed had low level of education and might not have been able to adopt agricultural technologies for climate change adaptation. The results are consistent with the findings of Qazlbash et al, (2020) who reported that education negatively predicted adaptation among

communities in Pakistan. This was due to increased efforts to disseminate information on climate change adaptation practices among illiterate farmers (Qazlbash et al., 2020).

It is however observed that planting of trees is more preferred across the education levels at about 36%, though not significantly dominating over other measures. The preference of tree planting as climate change adaptation measure could be due to economic benefits obtained from trees by farmers. Water harvesting was least mentioned adaptation strategy across all education levels. This could be due to high cost of installing water harvesting structures and knowledge required for installation.

4.4.4 Level of education of the spouse and climate change adaptation strategies

The results of this study indicate that 40.95% of the smallholder farmers' spouses had secondary education and above. 52.42% had primary education, while 6.61% did not have any formal education as presented in Figure 4.

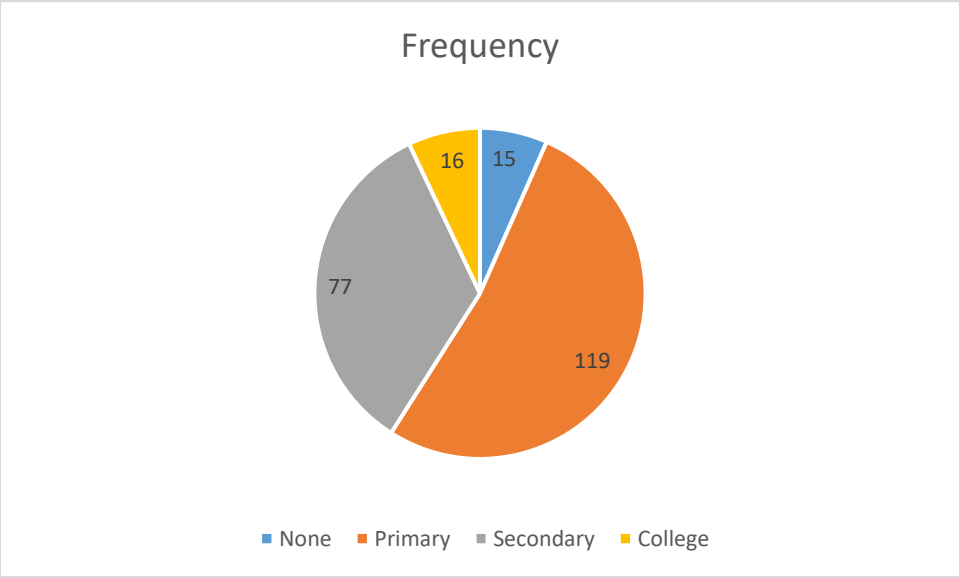


Figure 6: Level of education of the spouse

The results of cross tabulation between measures to adapt to climate change and level of education the smallholder farmers' spouses gave an insignificant relationship (Table 12a).

Table 12a-c: Cross Tabulation between measures to adapt to climate change and level of education of spouses of smallholder farmers

Count

		Measures to adapt to climate change					Total
		changing planting date	planting short season crops	planting drought resistant crops	planting trees with crops	water harvesting	
Education	None	5	2	3	4	1	15
	Primary	19	13	22	56	9	119
	Secondary	22	11	13	25	6	77
	College	3	2	2	8	1	16
Total		49	28	40	93	17	227

Table 12b: Chi-Square Test of Independence Results

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	5.218[a]	12	.950
Likelihood Ratio	5.226	12	.950
Linear-by-Linear Association	.222	1	.637
N of Valid Cases	227		

a. 7 cells (35.0%) have expected count less than 5. The minimum expected count is 1.36.

Table 12c: Cramer's V test of effect size between level of education of the spouse of smallholder farmer and choice of climate change adaptation strategies

Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Phi	.102	.092
	Cramer's V	.068	.092
N of Valid Cases		227	

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

The null hypothesis tested was that types of climate change adaptation strategies and education level of the spouses of the smallholder farmers were independent. The result in Table 12b (χ^2 = 5.218, p = 0.950, α = 0.05) shows an insignificant association and hence null hypothesis was accepted. The results in Table 12c show a Cramer's V of 0.068, which indicates a statistically weak contribution of education level of the spouse of smallholder farmer to the choice of climate change adaptation strategies. This means that the level of education of the spouse of the famer had little contribution to the choice of climate change adaptation strategies by smallholder farmers. This could be due to the fact that most of the spouses had low level of education and therefore majority of smallholder farmers were not involving their spouses in making decisions regarding choice of climate change adaptation strategies. It can be observed from the results that majority of the spouses had primary education and this could negatively influence their contribution towards adoption of agricultural technologies for climate change adaptation. It is expected that households where both the household head and spouse are educated will have higher adaptive capacity to effects of climate change. Knowledge and access to information are essential for effective environmental management and have significant impacts on the economy and the livelihood choices people make (Tadesse, 2010).

4.4.5 Household size of the smallholder farmers and climate change adaptation strategies

Household size refers to the number of dependants in the household including children and relatives staying within a household. The results of the study indicate that 45.48% of the households had 1-3 members, 41.71% had 4-6 members while 12.81% had 7-10 members (Table 13a). The results of cross tabulation between household size and measures to adapt to climate change gave a significant relationship (Table 13b).

Table 13a-c: Cross tabulation between household size and measures to adapt to climate change

Count

Climate change adaptation strategies		household size			Total
		1-3 members	4-6 members	7-10 members	
	changing planting date	27	25	8	60
	planting short season crops	41	33	12	86
	planting drought resistant crops	31	26	9	66
	planting trees with crops	67	58	16	141
	water harvesting	15	24	6	45
Total		181	166	51	398

Table 13b: Chi-Square Test of Independence Results

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	52.453[a]	8	.000
Likelihood Ratio	53.648	8	.000
Linear-by-Linear Association	.926	1	.336
N of Valid Cases	398		

a. 0 cells (0.0%) have expected count less than 5.

b. The minimum expected count is 13.05.

Table 13c: Cramer's V test of effect size between household size of smallholder farmers and choice of climate change adaptation strategies

Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Phi	.375	.000
	Cramer's V	.268	.000
N of Valid Cases		398	

a. Not assuming the null hypothesis.
b. Using the asymptotic standard error assuming the null hypothesis.

The null hypothesis tested was that types of climate change adaptation strategies and household size of the smallholder farmer were independent. The result in Table 13b ($\chi^2 = 52.453$, $p = 0.000$, $\alpha = 0.05$) shows a significant association and hence null hypothesis was rejected. The results in Table 13c show a Cramer's V of 0.268, which indicates a statistically significant and very strong contribution of household size of the smallholder farmer to the choice of climate change adaptation strategies. This implies that household size significantly contributes to choice of climate change adaptation strategies in the study area. Household size provides a measure of the availability of family labour for farming activities, including labour intensive climate change adaptation strategies such as tree planting. Households with more resident members should be able to practice a variety of climate change adaptation strategies due to reduced labour costs. This supports the results of other studies. Adoption of improved irrigation technologies increases with the size of the household because of reduced labour burdens (Abdulai et al., 2011).

However, household size may negatively affect the net revenue from agricultural production due to the presence of many dependent people such as children, the elderly and the sick. Poor households with large sizes will therefore have low adaptive capacity to climate change. This is supported by another research related to food security and family size which showed that large farm families with poor yield could be underfed in the situation where there is no alternative source of food to supplement farm yield (Armah et al. 2010; Challinor et al. 2007). The results of this study indicate that 45.48% of the households had three members and below accounting for low

availability of family labour for agricultural activities. Such households will probably have to spend more on hired labour for meaningful agricultural production thereby limiting climate change adaptation. 41.71% had four to six members in the household, while 12.82% had seven members and above. These households may spend less on farm labour but may have to contend with many mouths to feed.

4.4.6 Social Status of smallholder farmers and climate change adaptation strategies

In order to assess the ability of the farmers to adapt to effects of climate change, farmers were asked to state their social status. Only 14.58% indicated that they were at least better off. This group of farmers is able to adopt diverse climate change adaptation strategies. 56. 53% said that they were average in terms of social status while 28.89% were poor (Table 14a). Poor farmers are not able to apply new farming technologies which enhance adaptation as these technologies require financial resources.

The results of cross tabulation between social status of smallholder farmers and measures to adapt to climate change gave an insignificant relationship (Table 14b).

Table 14a-c: Cross tabulation between Social status of smallholder farmers and measures to adapt to climate change

		Measures to adapt to climate change					Total
		changing planting date	planting short season crops	planting drought resistant crops	planting trees with crops	water harvesting	
Social status	better off	14	6	8	25	5	58
	average	59	31	38	85	12	225
	poor	28	14	21	44	8	115
Total		101	51	67	154	25	398

Table 14b: Chi-Square Test of Independence Results

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	8.618[a]	8	.376
Likelihood Ratio	8.605	8	.377
Linear-by-Linear Association	.007	1	.935
N of Valid Cases	398		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 6.01.

Table 14c: Cramer's V test of effect size between social status of smallholder farmers and choice of climate change adaptation strategies

Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Phi	.194	.014
	Cramer's V	.105	.014
N of Valid Cases		398	

a. Not assuming the null hypothesis.
b. Using the asymptotic standard error assuming the null hypothesis.

The null hypothesis tested was that types of climate change adaptation strategies and social status of the smallholder farmer were independent. The result in Table 14b ($\chi^2 = 8.618$, $p = 0.376$, $\alpha = 0.05$) shows a statistically insignificant association and hence null hypothesis was accepted. The results in Table 14c show a Cramer's V of 0.105, which indicates a statistically significant moderate contribution of social status of the smallholder farmer to the choice of climate change adaptation strategies. This implies thatsocial status of the smallholder farmer contributed to the the choice climate change adaptation strategies to a moderate extent in the study area. This could be attributed to the fact that majority of the farmers were resource poor were taking up adaptation strategies that were less financial intensive. It is expected that farmers with higher social status should have a higher adaptaive capacity and hence adoption climate change adaptation strategies.

4.4.7 Size of the farm and climate change adaptation strategies

The results of the study indicated that 21.86% had below one acre of land, while 54.27% (216 farmers) had between one and three acres of land, as presented in Figure 5.

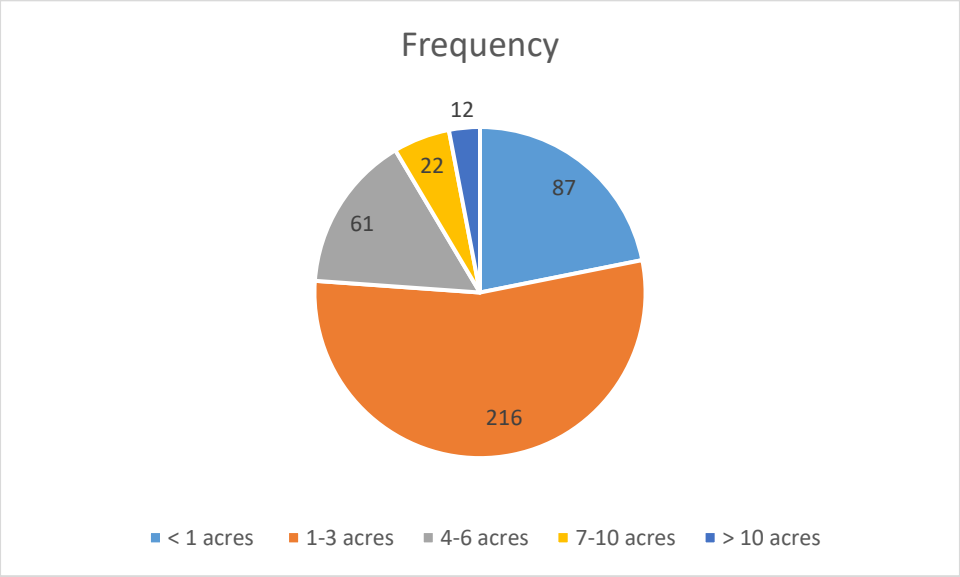


Figure 7: Size of farm in acres

The results indicate that majority of farmers in the study area are smallholder farmers. A smallholder farmer represents a farmer with a farm size of at most two hectares (Wiggins, 2009). The size of land held is the main determinant of household food security in rural households. The size of the land can have a great influence on the ability of the farmers to adapt to effects of climate change. Farmers with large sizes of land can diversify their land use systems in order to adapt to climate change. Farmers with large landholdings stand a better chance of diversifying their farming practice to adapt to climate change than those with small landholdings (Defiesta & Rapera, 2014). Larger cultivated land allows for flexibility regarding changes in farming practices (Tonruksawattana, 2013). Only 3.02% of the farmers interviewed had more ten acres of land.

The results of cross tabulation of measures to adapt to climate change and size of the farm revealed a significant relationship, (Table 15b).

Table 15a-c: Cross tabulation between measures to adapt to climate change and size of the farm

Climate change adaptation measures		Size of farm in acres					Total
		Less than 1	1-3 acres	4-6 acres	7-10 acres	> 10 acres	
	Changing planting date	11	32	11	5	4	63
	Planting short season crops	10	10	6	2	0	28
	Planting of drought resistant crop varieties	15	53	19	2	2	91
	Planting of trees with crops	46	109	20	12	5	192
	Water harvesting	5	12	5	1	1	24
Total		87	216	61	22	12	398

Table 15b: Chi-Square Test of Independence Results

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	60.414[a]	20	.000
Likelihood Ratio	68.698	20	.000
Linear-by-Linear Association	.005	1	.942
N of Valid Cases	398		

a. 20 cells (66.7%) have expected count less than 5. The minimum expected count is .06.

Table 15c: Cramer's V test of effect size between size of the farm of smallholder farmers and choice of climate change adaptation strategies

Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Phi	.224	.006
	Cramer's V	.194	.006
N of Valid Cases		398	

a. Not assuming the null hypothesis.
b. Using the asymptotic standard error assuming the null hypothesis.

The null hypothesis tested was that types of climate change adaptation strategies and size of the farm in acres were independent. The result in Table 15b ($\chi^2 = 60.414$, $p = 0.000$, $\alpha = 0.05$), shows a statistically significant association and hence null hypothesis was rejected. The results in Table 15c show a Cramer's V of 0.194, which indicates a statistically significant strong contribution of size of the farmof the smallholder farmer. This means the size of the farm of the smallholder farmer contributes to the choice of measures to adapt to climate change. The results indicate that the majority of the farmers had between one and three acres of land and this was limiting farmers from adopting a variety of climate change adaptation strategies. As the farm size increases, the probability of adopting various adaptation strategies increases. The results corroborate studies by Fadina and Barjole, 2018 who concluded that the larger the farm, the more the farmers opt for combination of several coping strategies. Farm size positively and significantly increases the likelihood of adaptation to climate change. Furthermore, large far sizes can provide an opportunity for diversification of crop and livestock enterprises, and it can help to distribute risks associated with unpredictable weather (Belay et. al, 2017).

Given that majority of farmers in the study area had small pieces of land ranging between 1 and 3 acres, climate change adaptation practices such as water harvesting for irrigation purposes were not popular. This is supported by some other studies (e.g. Kassa and Abdi, 2022; Teklu at al., 2023; Negera et al., 2022) which found that larger farms are more likely to adopt climate smart agricultural practices such as water harvesting, agroforestry and effective use of nitrogenous fertilizer. As is the same case in this study, a study by Azumah et al., 2022 found that smaller farms

were more likely to adopt practices such as drought-tolerant varieties and improved crop varieties. However, this study revealed that tree planting was the most practiced climate change adaptation strategy (53.5% of the respondents) despite the small land sizes. This could be attributed to some tenure security that farmers had given most of the farms had parcel numbers and therefore farmers were safer investing in more permanent climate change adaptation strategies like tree planting. Tree planting is also a means of diversification and can improve household incomes.

4.4.7.1 Status of land registration

Majority of the farmers interviewed (67.59%) indicated that their land had been registered in their names. However, most them did not have title deeds but only parcel numbers. 32.41% percent had their lands not registered as presented in Figure 6.

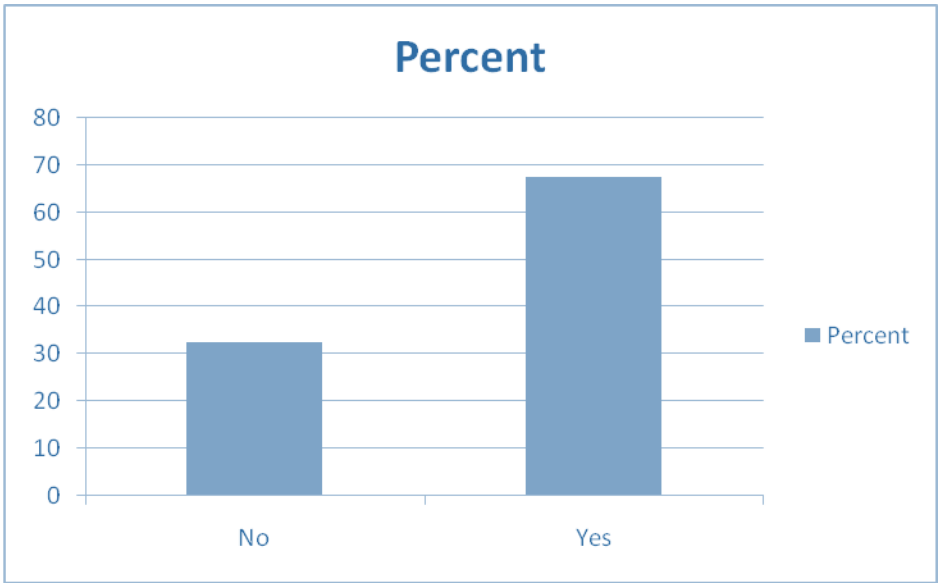


Figure 8: Status of land registration

The cross tabulation between status of land registration and types of climate change adaptation strategies gave a significant relationship (Table 16b).

Table 16a-c: Cross tabulation of status of land registration and types of climate change adaptation strategies

Count

		Types of climate change adaptation strategies					Total
		changing planting date	planting short season crops	planting drought resistant crops	planting trees with crops	water harvesting	
Status of land Registration	YES	61	45	41	104	18	269
	NO	35	18	12	49	15	129
Total		96	63	53	153	33	398

Table 16b Chi-square test of independence

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	17.302[a]	4	.003
Likelihood Ratio	17.879	4	.003
Linear-by-Linear Association	2.325	1	.127
N of Valid Cases	398		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 16.03.

Table 16c: Cramer's V test of effect size between the status of land registration and choice of climate change adaptation strategies

Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Phi	.123	.197
	Cramer's V	.123	.197
N of Valid Cases		398	

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

The null hypothesis tested was that types of climate change adaptation strategies and status of land registration were independent. The result in Table 16b ($\chi^2 = 17.302$, $p = 0.003$, $\alpha = 0.05$), shows a significant association and hence null hypothesis was rejected. However, the results in Table 16c show a Cramer's V of 0.123, which indicates a statistically significant moderate contribution of status of land registration and the choice of climate change adaptation strategies. This implies that status of land registration contributes to the choice of climate change adaptation strategies in the study area, though with a small effect size. Tree planting as an adaptation strategy was being adopted by majority of farmers. This could be attributed to some tenure security that farmers enjoyed from registered lands. The results of the study indicate that majority of the smallholder farmers had their lands registered, though very few of them had title deeds. With lack of title deeds, farmers may not access agricultural credit especially where title deeds are used as collaterals to get credit. This might impact negatively on farmers' ability to adapt to climate change as credit provides capital needed to apply climate resilient technologies. Lack of land titles also imply that there is some level of tenure insecurity and this could mean that the farmers may not invest in long term projects. The length and type of land tenure arrangement influences the farmer's preparedness to apply adaptation technologies Long or reliable tenure arrangements create a more conducive environment for adaptation than short tenure or less reliable tenure arrangements (Jones et al., 2010).

Land tenure security plays an important role in adoption of certain climate change adaptation strategies. Farmers with secure land tenure are more likely to invest in certain climate change adaptation strategies that require long-term investments such as tree planting. Previous studies have shown that where policies that improve land tenure security are lacking, it discourages farmers from investing in their land and adopting new practices (Kpadonou et al, 2017; Kurgat et al, 2020; Mizik, 2021).

4.4.7.2 Name in which the land is registered

Land ownership by smallholder farmers is crucial in climate change adaptation especially in making decisions regarding specific climate change adaptation strategies such as soil and water conservation. The results of the study indicated that 31.97% (86 farmers) of the study participants own land individually. This implies that they have some autonomy in deciding what to do with the

land and therefore can freely adopt farming technologies necessary for climate change adaptation. 38.29% (103 farmers) of the farmers interviewed said that the land they farm is owned by their spouses. Most of these were female participants who must consult their husbands before deciding on the land use. This delays decision making which impacts negatively on climate change adaptation. 25.28% (68 farmers) indicated that the lands were still in the names of their parents and had not been transferred in their names. The results are presented in Table 17.

Table 17: Name in which land is registered

Land registration name	Frequency	Percent
Self	86	31.97
Spouse	103	38.29
Parents	68	25.28
Others (grand father, brother in law, friends, ministry of lands)	12	4.46

The cross tabulation between the name in which land is registered and the types of climate change adaptation strategies gave a significant relationship (Table 18b)

Table 18a-c: Cross tabulation of name in which land is registered and types of climate change adaptation strategies

		Types of Climate change adaptation strategies					Total
		changing planting date	planting short season crops	planting drought resistant crops	planting trees with crops	water harvesting	
Name in which land is registered	Self	18	15	12	32	7	84
	Spouse	20	17	14	44	6	101
	Parents	16	14	8	26	3	67
	Others (grandfather, brother in law)	3	2	2	5	0	12
Total		57	46	36	107	16	269

Table 18b: Chi-square tests of independence Results

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	26.701[a]	12	.018
Likelihood Ratio	32.699	12	.002
Linear-by-Linear Association	3.642	1	.064
N of Valid Cases	264		

a. 2 cells (10.0%) have expected count less than 5. The minimum expected count is 4.64.

Table 18c: Cramer's V test of effect size between name in which land is registered and types of climate change adaptation strategies

Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Phi	.109	.994
	Cramer's V	.063	.994
N of Valid Cases		264	

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

The null hypothesis tested was that types of climate change adaptation strategies and the name in which land is registered were independent. The result in Table 18b ($\chi^2 = 26.701$, $p = 0.018$, $\alpha = 0.05$), shows a significant association and hence null hypothesis was rejected. However, the results in Table 18c show a Cramer's V of 0.063, which indicates a statistically insignificant contribution of the name in which land is registered to the choice of climate change adaptation strategies. The results indicate that the name in which land is registered had very little contribution to the choice of climate change adaptation strategies by the smallholder farmers.

4.4.8 Household income sources and climate change adaptation strategies

The results of the study show that majority of the farmers (36.69%) obtain their income from crop and animal farming, as presented in Table 19a. However, with the effects of climate change especially on climate sensitive activities such as agriculture, the income sources for majority of farming households in the study area is likely to be affected thereby influencing climate change adaptation negatively.

The results of cross-tabulation of measures to adapt to climate change and income source of the respondents indicated that the measures adopted by respondents to cope with environmental changes were not dependent on their income source (Table 19b)

Table 19a-c: Cross tabulation of measures to adapt to climate change and income source of smallholder farmers

Count

		Measures to adapt to climate change				Total
		changing planting date	planting drought resistant crops	planting trees with crops	water harvesting	
Income source	No information	3	2	8	3	16
	Animal farming	2	3	8	0	13
	Business	34	16	59	8	117
	Crop farming	32	20	68	12	132
	Remittance	10	8	16	2	36
	Salary	12	15	19	3	49
	Wages	6	11	16	2	35
Total		99	75	194	30	398

Table 19b: Chi-square test if independence Results

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	15.749[a]	18	.610
Likelihood Ratio	16.363	18	.567
Linear-by-Linear Association	.117	1	.732
N of Valid Cases	398		

a. 7 cells (25.0%) have expected count less than 5. The minimum expected count is 1.04.

Table 19c: Cramer's V test of effect size between income source of farmers and types of climate change adaptation strategies

Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Phi	.194	.006
	Cramer's V	.115	.006
N of Valid Cases		398	

a. Not assuming the null hypothesis.
b. Using the asymptotic standard error assuming the null hypothesis.

The null hypothesis tested was that types of climate change adaptation strategies and income source of farmers were independent. The result in Table 19b ($\chi^2 = 15.749$, $p = 0.610$, $\alpha = 0.05$), shows a statistically insignificant association and hence null hypothesis was accepted. However, the results of Cramer's V of 0.115 (Table 19c) indicates a statistically significant moderate contribution of income source of the smallholder farmer to the choice of climate change adaptation strategies. This implies that income source of the farmer had little contribution to climate change adaptation strategies by smallholder farmers. Majority of the farmers had their income coming from crop farming and this is being used in farming activities as indicated in the results (Table 19a). 33.17% of the farming households in the study area indicated that they get their income from doing business and this income is used for carrying out farming activities and other household requirements. 9.3% of the respondents indicated that they source their income from remittances, majorly from their children engaged in off-farm employment. This is partly used by the farmers to purchase farm inputs such as seeds and fertilizers to improve their agricultural production. This supports study by Defiesta & Rapera, 2014, who reported that the remittances farmers receive play an important role in enhancing their capacity to adapt to climate change. Kpadonou et al., (2017) found that remittance was a positive determinant of soil water conservation practices in West Sahel. Remittances provide poor farmers with cash that could be used to invest in agricultural technologies.

Some studies have found out that income for farming activities has an influence on climate change adaptation as it empowers farmers to diversify their adaptation strategies and even to engage in more expensive but reliable strategies such as irrigation. A farmer with more diverse sources of income has a higher adaptive capacity than a farmer with less diverse sources of income (Armah et al., 2010; Defiesta & Rapera, 2014). A higher farm income increases the likelihood of adopting

climate smart agricultural practices (Garcia de Jalon et al, 2017; Kassa and Abdi, 2022; Negera et al, 2022). Households with low incomes may not adopt high cost strategies such as irrigation and soil and water conservation practices. Households without access to finance have limited ability to respond to climate change, especially in circumstances that require heavy capital investments and technical skills (Salau, Onuk, & Ibrahim, 2012). Households with high levels of income are more likely to cope and adapt to the impacts of climate change (Uddin et al, 2014; Ihemezie et al, 2018), especially by adopting more technically and financially intensive adaptation strategies.

The farmers in the study area were observed to be undertaking more than one climate change adaptation measures as exemplified by the results (Table 19a). This integrated approach to climate change adaptation could help farmers escape the vagaries of weather even with little income sources. However, tree planting was the most preferred climate change adaptation strategy among households in the study area (48.74%) (Table 19a). Most of the farmers were observed to be practicing agro-forestry and this informed the preference of tree planting over all other measures. Trees, apart from environmental benefits, supplement income sources for farmers and can act as a safety net when crop and animal farming is not doing well. Agroforestry is a land use strategy that provides a room for diversification of agricultural practices and hence climate change adaptation.

4.4.9 Source of financial capital and climate change adaptation strategies

The results of the study indicate that over 50% of the farmers interviewed were self-financing their farm operations as presented in Table 20a. Most of the farmers reported that they had never accessed credit from any lending institution and faced difficulties financing their farming operations thereby influencing climate change adaptation negatively. The results of cross-tabulation between the source of financial capital and measures to cope with environmental changes revealed that measures to cope with environmental changes were not dependent on sources of financial capital (Table 20b)

Table 20a-c: Cross tabulation between f Measures to adapt to climate change and source of the financial capital of smallholder farmers

Count

		Measures to adapt to climate change					Total
		changing planting date	planting short season crops	planting drought resistant crops	planting trees with crops	water harvesting	
Source of capital	Self-financed + bank loan	9	5	8	16	4	42
	Self	46	19	28	82	14	189
	Cooperative loan + self	21	14	12	42	5	94
	Friends and relatives	19	12	14	25	3	73
Total		95	50	62	165	26	398

Table 20b Chi-Square Test of independence Results

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	6.025[a]	12	.915
Likelihood Ratio	5.899	12	.921
Linear-by-Linear Association	.644	1	.422
N of Valid Cases	398		

a. 1 cells (5.0%) have expected count less than 5. The minimum expected count is 4.38.

Table 20c: Cramer's V test of effect size between source of financial capital of farmers and choice of climate change adaptation strategies

Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Phi	.134	.846
	Cramer's V	.078	.846
N of Valid Cases		398	

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

The null hypothesis tested was that types of climate change adaptation strategies and source of financial capital of farmers were independent. The result in Table 19b ($\chi^2 = 6.025$ p = 0.915, α = 0.05), shows a statistically insignificant association and hence null hypothesis was accepted. The Cramer's V test also gives a weak association between the two variables. The results in Table 19c show a Cramer's V of 0.078 which indicates a statistically insignificant contribution of source of financial capital to the choice of climate change adaptation strategies. This implies that source of capital of the farmer had weak contribution on the choice of climate change adaptation strategies in the study area. This could be attributed to the fact that most farmers did not have diverse sources of financial capital such as farm credit and hence were not actively taking up agricultural technologies for climate change adaptation. The results indicate that majority of farmers were self-financing their farm activities and this was likely to limit them from adopting more capital intensive agricultural activities like use of improved seed varieties.

About 25% of the farmers interviewed reported that they had at least accessed some credit from cooperative societies, while 8.29% reported that they had accessed some bank loans. However, this is a small percentage, indicating that credit facilities were still inadequate for the farmers in the study area. Lack of agricultural credit to support farmers taking up climate change adaptation strategies that involve additional costs inhibit farmers' ability to adopt these strategies even if the farmer is willing to do so (Mujeyi et al, 2020; Antwi-Agyei et al, 2021; Teklu et al, 2023). With access to credit, farmers are able to diversify their production in response to climate change and variability. This supports the studies by Frank and Penrose (2012); Defiesta and Rapera (2014) who reported that farmers with access to credit are more economically able to adapt to climate change than those with less access to credit. Several other studies conducted on the determinants of adaptation show a positive relationship between adaptation and credit (Vogel, 2000; Below et al, 2010; Hassan and Nhemachena 2008; Deressa, 2009, Nabikolo et al, 2010; Gbetibuo, 2009; Faosu-Mensah et al, 2010; Tazeze et al, 2012). Similar information gathered showed that farmers with easy access to credit facilities have high preferences for adapting to climate change than those without access to credit because some adaptation strategies increase the cost of production (Feola et al. 2015).

The results also indicated that seventy three farmers (18.34%) sought assistance from friends and relatives in order to finance their farming operations. This is a source that could not be guaranteed resulting in delay in farm operations and influencing climate change adaptation negatively. The availability of financial capital for farming operations is important as it enables farmers to adopt various climate change adaptation strategies including more costly operations such as terracing. Farmers who are able to access more financial resources can apply new farming techniques such as use of fertilizers and improved seed varieties and this is good for climate change adaptation. In addition, wealthier households may be better able to reduce economic vulnerability with off-farm wages such as investment in education, high wage earnings, and migration; poor farmers also seek off-farm wages, but may not earn as much as individuals with prior capital access (Fishman and Jain, 2013).

4.4.10 Source of farm labour and climate change adaptation strategies

The results of the study indicate that one hundred and sixty farming households (40.20%) use own family to provide labour for farming activities, while one hundred and fifteen farmers (28.89%) use hired labour to carry out farm operations. Seventy six farmers (19.1%) use both self and hired labour for farming activities. The results of the study are presented in Table 21a. The results of cross-tabulation between climate change adaptation strategies and sources of farm labour revealed that the choice of measures adopted by the smallholder farmers to adapt to climate change were dependent on their source of labour as shown in Table 21b.

Table 21a-c: Cross tabulation between types of climate change adaptation strategies and sources of farm labour

		Measures to adapt to climate change					Total
		changing planting date	planting short season crops	planting drought resistant crops	planting trees with crops	water harvesting	
Source of labour	Own family	43	26	29	53	9	160
	Self	14	4	0	18	11	47
	Hired labour	28	18	8	49	12	115
	Self+hired	17	12	14	28	5	76
Total		102	60	51	148	37	398

Table 21b: Chi-Square Test of Independence Results

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	57.494[a]	12	.000
Likelihood Ratio	62.098	12	.000
Linear-by-Linear Association	1.273	1	.259
N of Valid Cases	398		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 6.57.

Table 21c: Cramer's V test of effect size between source of farm labour of the farmers and choice of climate change adaptation strategies

Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Phi	.282	.002
	Cramer's V	.219	.002
N of Valid Cases		398	

a. Not assuming the null hypothesis.
b. Using the asymptotic standard error assuming the null hypothesis.

The null hypothesis tested was that types of climate change adaptation strategies and source of farm labour of farmers were independent. The result in Table 21b ($\chi^2 = 57.494$ $p = 0.000$, $\alpha = 0.05$), shows a significant association and hence null hypothesis was rejected. The results in Table 21c show a Cramer's V of 0.219, which indicates a statistically significant strong contribution of source of farm labour of the smallholder farmer to the choice of climate change adaptation strategies. This implies that source of farm labour of smallholder farmers strongly contributed to the choice climate change adaptation strategies in the study area. It was observed that households with more members were mostly using own family to provide the farm labour. These households should have a higher adaptive capacity due to reduced labour costs. As reported elsewhere in the study, the size of household is a measure of the available workforce for the farm activities. The use of family labour also improves efficiency of decision making with regard to farming activities within the household and this improves adaptive capacity. This is in consonance with the studies by Eakin et al. (2011); Ibrahim (2014) who reported that more access to family/household labour enhances social capital of the farmers and improving adaptive capacity. However, fourty seven (11.81%, Table 21a) farmers indicated that they carryout farm operations individually. This would definitely delay farming activities resulting in low production thereby influencing adaptation negatively.

It is however observed that tree planting as adaptation measure was most preferred especially by family labour (13.32%, Table 21a). This could be attributed to the fact that tree planting is a labour intensive adaptation strategy and could be easily adopted by most farmers because of availability

of cheap family labour. Family labour was observed to be the main source of labour for smallholder farmers in the study area (40.2%) and therefore was significantly contributing the choice of climate change adaptation strategies. Family labour greatly depends on the household size and thus households with many family members are expected to have higher chances of adapting to climate change through adoption of labour intensive strategies such as tree planting. The results corroborate findings by Mudzonga, (2012) who observed that households with large families are able to take up labour intensive adaptive measures such as dry planting and conservation agriculture than smaller households. Asfaw et al (2012) found a positive relationship between family size and the propensity to adopt improved varieties of chick pea. Simeilarly, Abdulai et al (2011) found that adoption of improved irrigation technologies increased with size of the household arguably because of eased labour. On the other hand, Apata et al (2009) found that an increase in household size negatively influenced farmers' adaptation to climate change and variability. This could be because as household size increases, households tend to venture into off farm activities in order to diversify their livelihood sources to be able to meet the basic needs of their households particularly where farming is not sustainable.

4.4.11 Climate Change Awareness and climate change adaptation strategies

The results of cross tabulation of measures adopted by farmers to adapt to climate change and climate change awareness revealed that the measures adopted by farmers to cope with environmental changes were dependent on their source of information as presented in Table 22b.

Table 22a-c: Cross tabulation between measures to adapt to climate change and source of information of smallholder farmers

		Measures to adapt to climate change					Total
		changing planting date	planting short season crops	planting drought resistant crops	planting trees with crops	water harvesting	
Source of information	Radio	56	34	33	73	12	208
	News paper	12	6	9	18	2	47
	Extension agents	2	2	3	4	1	12
	Experience	10	4	8	28	2	52
	Fellow farmers	24	16	14	22	3	79
Total		104	62	67	145	20	398

Table 22b: Chi-Square Test of Independence Results

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	34.210[a]	16	.033
Likelihood Ratio	32.074	16	.031
Linear-by-Linear Association	.209	1	.348
N of Valid Cases	398		

a. 5 cells (20.0%) have expected count less than 5. The minimum expected count is .93.

Table 22c: Cramer's V test of effect size between source of information of the farmers and choice of climate change adaptation strategies

Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Phi	.182	.002
	Cramer's V	.150	.002
N of Valid Cases		398	

a. Not assuming the null hypothesis.
b. Using the asymptotic standard error assuming the null hypothesis.

The null hypothesis tested was that types of climate change adaptation strategies and source of climate information of farmers were independent. The result in Table 22b ($\chi^2 = 34.210$, $p = 0.033$, $\alpha = 0.05$), shows a significant association and hence null hypothesis was rejected. The results in Table 22c show a Cramer's V of 0.150, which indicates a statistically significant moderate contribution of source of information of the smallholder farmer to the choice of climate change adaptation strategies. This implies that the source climate information of the smallholder farmers was contributing to the choice of climate change adaptation strategies by the farmers. Climate change awareness is a key factor in climate change adaptation. Awareness enables the farmers to accept that climate change is a reality and thus become more prepared to adapt to its effects. It embodies sensitization and skills acquisition which is necessary for improving adaptive capacity of farmers since it provides them with information on how to access important services for adaptation. The sources of climate information included radio, newspapers, extension agents, farmer's experience and fellow farmers. The results of the study indicate that majority of the smallholder farmers (52.26%) sourced climate information from radio while only 3.02% sourced the climate information fom agricultural extension agents (Table 22a). This implies that radio was readily available to most farmers as compared to other sources.

The ability of the farmer to access reliable weather and climate information is important in enabling the farmer to prepare in advance against prevailing climate discrepancies. Access to climate information increases adaptive capacity. This implies that farmers with greater access to climate information are more prepared to adapt to climate change than those with less access to

such information (Lo and Emmanuel, 2013). It is however noted with concern that agricultural extension services that gives a two-way communication is inadequate as only 3.02% of the farmers reported that they had accessed climate change information from extension agents. This is inconsistent with findings of other studies. Given that access to extension services was minimal among the smallholder farmers in the study area farmers had limited opportunity to access refined information information on locally based climate change adaptation strategies. The findings by Below et al., 2012; Bryan et al., 2013 revealed that access to extension services is one of the most important predictors of climate change adaptation. Access to agricultural extension services enhances farmers' knowledge and skills in climate change and adaptation related practices and technologies (Frank and Penrose (2012). Provision of reliable extension services is crucial for improved agricultural production and improved farm management techniques, which could help in climate change adaptation.

4.5 Cultural factors and climate change adaptation strategies by smallholder farmers

The hypothesis that "Cultural factors do not contribute to the choice of climate change adaptation strategies by smallholder farmers in the study area" was analysed using cramer's V coefficient while the association between the variables was tested using chi-square test of independence. The factors analysed included level of attachment to place of residence, family order in carrying out farm operations and how it influences climate change adaptation, relationship between religious beliefs and climate change adaptation and relationship between other cultural considerations and climate change adaptation.

4.5.1 Level of attachment to place of residence and climate change adaptation strategies

The study sought to understand the level attachment of the smallholder farmers to their areas of residence and how it contributes to climate change adaptation. The results of the study indicate that 39.7% and 36.18% of the respondents had strong and very strong attachment to their places of residence respectively while 13.57% had weak attachment to their places of residence as shown in Figure 7. This implies that majority of the smallholder farmers have strong ties with their

community that they would be reluctant to migrate to other places to escape effects of climate change markers such as floods and drought.

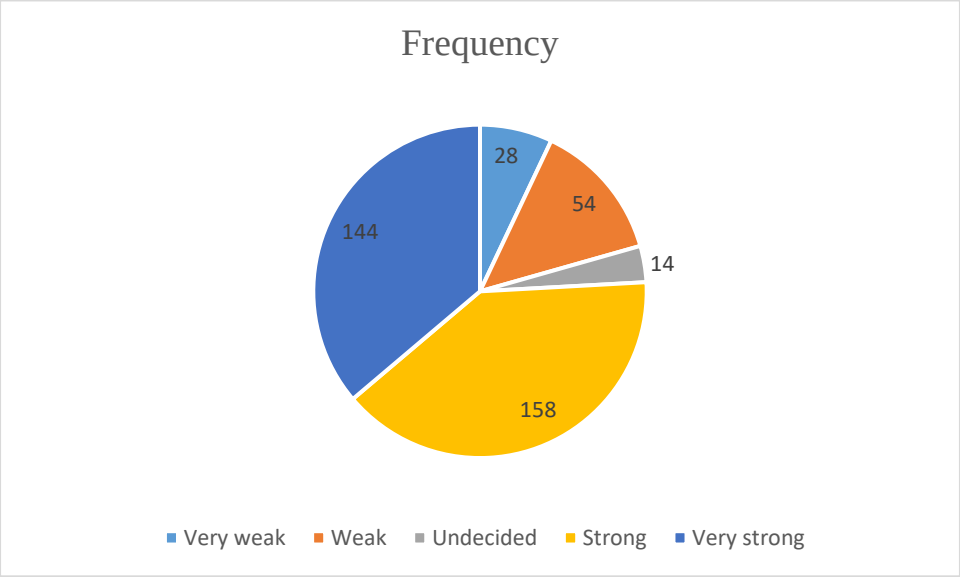


Figure 9: Level of attachment to the place of residence

Attachment to the place of residence is important because it brings a sense of belonging to the community and can help in predicting whether an individual will be able to adapt to climate change especially where migration to escape climate change effects is one of the adaptation strategies. The results of cross tabulation between place attachment and choice of measures to cope with climate change revealed a significant relationship. The results are presented in Table 23b.

Table 23a-c: Cross tabulation between level of attachment on the place of residence and types of climate change adaptation strategies

Count

		Level of attachment on the place of residence					Total
		Very weak	Weak	Undecided	Strong	Very strong	
Climate change adaptations measures	Changing planting date	0	5	0	10	19	34
	Planting short season crops	0	0	0	20	0	20
	Planting of drought resistant crop varieties	5	5	0	55	37	102
	Planting of trees with crops	25	35	10	65	78	213
	Water harvesting	0	10	0	15	0	25
	Don't know	0	0	4	0	0	4
Total		30	55	14	165	134	398

Table 23b Chi-square test of Independence results

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	220.178[a]	20	.000
Likelihood Ratio	147.065	20	.000
Linear-by-Linear Association	18.742	1	.000
N of Valid Cases	398		

a. 15 cells (50.0%) have expected count less than 5. The minimum expected count is .19.

Table 23c: Cramer's V test of effect size between levels of attachment to place of residence and choice of climate change adaptation strategies

Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Phi	.498	.000
	Cramer's V	.372	.000
N of Valid Cases		398	

a. Not assuming the null hypothesis.
b. Using the asymptotic standard error assuming the null hypothesis.

Null hypothesis tested was that level of attachment on the place of residence and types of climate change adaptation strategies were independent. The result in Table 23b (χ^2 = 220. 178, p = 0.000, α = 0.05) shows significant association and hence null hypothesis was rejected. The results in Table 23c show a Cramer's V of 0.372, which indicates a statistically significant and very strong contribution of levels of attachment at place of residence to choice of climate change adaptation strategies by smallholder farmers. There was sufficient evidence to conclude that place attachment of the smallholder farmers contribute to choice of climate change adaptation strategies in the study area.

The results indicate that tree planting alongside crops was popular as an adaption strategy among those with strong and very strong attachment to the place of residence. This could be attributed to the fact that strong attachment to the place of residence encourages smallholder farmers to invest in more permanent climate change adaptation strategies such as tree planting. Tree planting could be a motivating factor of strong attachment to the place of residence and individuals may not be willing to move even if migration was the most appropriate adaptation strategy. Place attachment can be critical in making decisions about climate change adaptation especially with regard to migration and resettlement. Individuals with a high level of place attachment can be distressed at the prospect of moving from their home communities. There is also strong evidence to suggest that control over whether and how change in location occurs is important for psychological and emotional well-being (Adger et. al, 2013). This implies that any form of movement in order to escape the effect of climate variables may cause emotional stress to the smallholder farmers and may lead to loss of identity. Continuity of place can be an important component in maintaining or reinforcing identity (Hernandez et. al, 2010) while discontinuing identity is associated with grief

and strong social impacts related to loss (Danglova, 1995; Fried, 2000). Although migrating to new places to secure income can positively contribute to the adaptation process through opening new economic opportunities, migration can also diminish the benefits by increasing financial and emotional stress and weakening social structures in both source and destination of communities (Agyeman et. al, 2009; Force, et. al, 1993).

Place attachment may also shape adaptive responses. For example, Mishra et. al, (2010) observed that people with high levels of place attachment were more likely to be motivated to prepare for climate change events such as flooding because of their social and economic investments within their region. Several other researchers have also suggested that attachment to place is more likely to result in pro-environmental behaviour (Marshall et. al, 2007; Devine-Wright, 2009; Scannell & Gifford, 2010). These observations suggest that place attachment may inspire citizens to develop or participate in climate adaptation planning processes (Wolf et. al, 2009).

4.5.2 Family hierarchy in carrying out farm operations and climate change adaptation strategies

The results of the study indicate that three hundred and thirty-six farmers (84.42%) follow chronological order in carrying out farm operations. Sixty-two farmers (15.58%) indicated that they don't follow any family order and would just do farming anytime when it is appropriate (Table 24a). This could be common where nuclear family dominates. This may influence climate change adaptation positively as the household can make decisions regarding farming activities without having to consult another party. However, in extended family which is still very common in the study area as is the case in most African communities, decisions regarding when to cultivate or plant is shared among various households in that extended family. During focus group discussion a group participant reported that "*An order of hierarchy is followed during the events of cultivation at the beginning of the long rain season. The families where the parents are still alive have to wait until they notice the parents commencing cultivation is when the rest will follow but still in order of birth hierarchy" (Focus group discussion participant from Rachuonyo South sub-county, April 2018).*

The results of cross tabulation of measures to cope with climate change and family order of carrying out farm operations revealed a significant relationship (Table 24b).

Table 24a-c: Cross tabulation between types of climate change adaptation strategies family order in farm operations

Count

		Family order in farm operations		Total
		Yes	No	
Types of Climate change adaptation strategies	Changing planting date	34	0	34
	Planting short season crops	20	0	20
	Planting of drought resistant crop varieties	92	10	102
	Planting of trees with crops	161	52	213
	Water harvesting	25	0	25
	Don't know	4	0	4
Total		336	62	398

Table 24b: Chi-square of test of independence results

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	30.791[a]	5	.000
Likelihood Ratio	42.488	5	.000
Linear-by-Linear Association	9.066	1	.003
N of Valid Cases	398		

a. 4 cells (33.3%) have expected count less than 5. The minimum expected count is .78.

Table 24c: Cramer's V test of effect size between family order in carrying out farm operations and choice of climate change adaptation strategies

Symmetric measures

		Value	Approx. Sig.
Nominal by Nominal	Phi	.277	.000
	Cramer's V	.277	.000
N of Valid Cases		398	

a. Not assuming the null hypothesis.
b. Using the asymptotic standard error assuming the null hypothesis.

Null hypothesis tested was that types of climate change adaptation strategies and family order in farm operations were independent. The result in Table 24b ($\chi^2 = 30.791$, $p = 0.000$, $\alpha = 0.05$) shows significant association and hence null hypothesis was rejected. The results in Table 24c show a Cramer's V of 0.277, which indicates a statistically significant and very strong contribution of family order in carrying out farm operations to the choice of climate change adaptation strategies. The results of the study indicate that the family order of carrying out farm operations was significantly contributing to choice of climate change adaptation strategies with change of planting date being significantly affected. The family order limits decision making among farmers especially the younger farmers who may need to wait for their older relatives to commence farm operations. It is however observed that tree planting alongside crops as an adaptation strategy was more popular among the smallholder farmers probably because there may not be any family order to be followed in planting trees. There was sufficient evidence to conclude that there was significant association between the choice of climate change adaptation measures and family order in carrying out farm operations.

4.5.2.1 Extent to which family order affects farm operations

On the extent to which the hierarchical order farm operations, 57.59% of the smallholder farmers reported that the effect was great while 14.01% reported that there was very little effect as presented in Table 25.

Table 25: Extent of effect of hierarchical order of farm operations

Effect hierarchical order of farm operations	Frequency	Percentage
Little extent	48	14.29
No effect	29	8.63
Great extent	178	52.98
Very great extent	81	24.10
Total	336	100

The sequential order in carrying out farming operation is a common traditional practice among communities within the study area. This is a practice where all farming operations follow some chronological order starting with the most senior member of the family. The practice, even though may bring some order in carrying out farming activities, may lead to delay in decision making regarding farming operations especially where the most senior person is not in a position to start farming early due to some reasons which may include inadequate financial capital. This implies that the decision making of a household regarding farming activities like cultivation and planting is influenced by another household which is chronologically seen to be senior. This may influence adaptation negatively especially where early planting is an adaptation strategy.

4.5.2.2 Sequence of carrying out farm operations

On the sequence of carrying out farm operations, one hundred and sixty-two farmers (63.03%) reported that all farming operations are carried out chronologically beginning with grandparents where they are still alive. Fourty nine farmers (19.07%) indicated that traditionally the parents are the first ones to start farm operations as presented in Table 26. 10.12% of the farmers said that it begins with the elder brother (Table 26). This was common in child headed households.

Table 26: Sequence in the order of farm operations

Family order of farm operations	Frequency	Percent
Application of cultural law during planting	18	7.00
None	2	0.78
The farm operation always begins from the parents	49	19.07
The farm operation begins from the grandparents	162	63.03
The operation always begins with the elder brother	26	10.12
Total	257	100

This means that decision making regarding farm operations is shared among various households resulting in unprecedented delays in farming activities thereby negatively influencing climate change adaptation. Where timely planting is an adaptation strategy, this order may result in late planting leading to poor crop yields. The results corroborate the findings focus group discussion. A member of a group discussion from Rota village of Ndhiwa sub-county *talked of the rituals during commencement of cultivation and planting ("Golo Pur" and "Golo Kodhi") where hierarchical order is followed during cultivation and planting (Focu group discussion, April, 2018).* In an extended family, cultivation must begin from the senior household and the order flows downwards till the youngest. Planting follows in the same line and must be adhered to. In case the first person in the line is not ready or is sick or not around then cultivation and planting has to be delayed and this may lead to late planting. Harvesting also follow in the same order with the first to plant being the first one to harvest. This implies that if the junior family plants an early maturing seed variety as opposed to the senior family in that hierarchical order, then the junior family will have to wait leading to post-harvest losses.

4.5.3 Religious and other cultural beliefs and climate change adaptation

The study sought to know if the respondents perceive climate patterns along cultural lines. The results of the study indicate that about 47% of the smallholder farmers to a great extent linked climate variability to some religious and cultural belief, while 38% of the farmers linked climate change with religion and other cultural belies to a little extent (Figure 10).

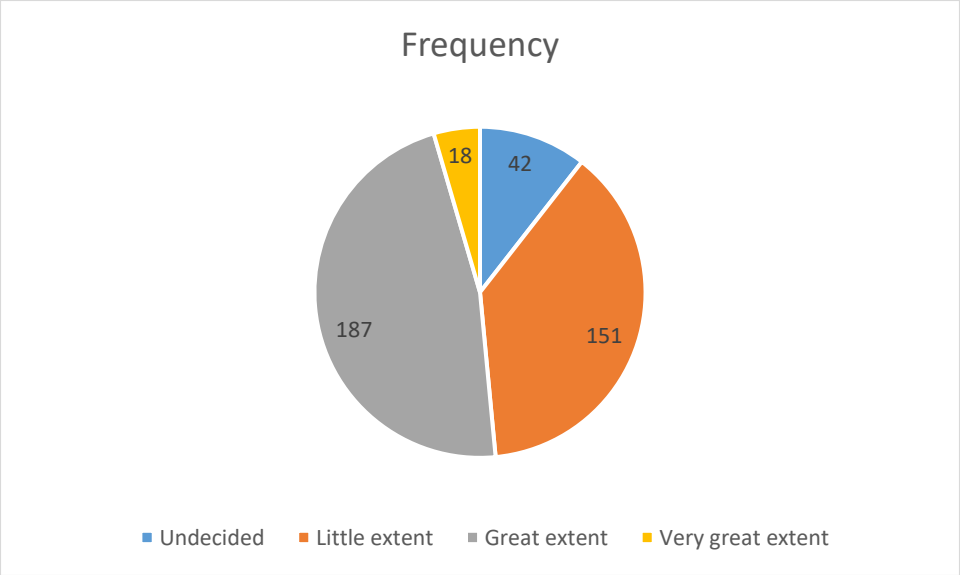


Figure 10: Linking climate change adaptation to religious and cultural beliefs

The results of cross tabulation between religious beliefs of smallholder farmers and the choice of climate change adaptation revealed a significant relationship (Table 27b)

Table 27a-c: Cross tabulation between religious beliefs and choice of climate change adaptation strategies

		Types of Climate change adaptation strategies					Total
		changing planting date	planting short season crops	planting drought resistant crops	planting trees with crops	water harvesting	
Linking climate change adaptation to religious beliefs	Little extent	23	16	18	86	8	151
	Great extent	32	25	17	101	12	187
	Very great extent	12	8	6	14	2	42
	Undecided	2	3	4	9	0	18
Total		69	52	45	210	22	398

Table 27b Chi-square tests of independence results

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	203.590[a]	12	.000
Likelihood Ratio	138.564	12	.000
Linear-by-Linear Association	16.734	1	.000
N of Valid Cases	398		

a. 15 cells (50.0%) have expected count less than 5. The minimum expected count is .17.

Table 27c: Cramer's V test of effect size between religious beliefs and choice of climate change adaptation strategies

Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Phi	.501	.000
	Cramer's V	.412	.000
N of Valid Cases		398	

a. Not assuming the null hypothesis.
b. Using the asymptotic standard error assuming the null hypothesis.

Null hypothesis tested was that types of climate change adaptation strategies and religious beliefs were independent. The result in Table 27b ($\chi^2 = 203.59$, $p = 0.000$, $\alpha = 0.05$) shows significant association and hence null hypothesis was rejected. The results in Table 27c show a Cramer's V of 0.412, which indicates a statistically significant and very strong contribution of religious beliefs to the choice of climate change adaptation strategies. This implies that religious beliefs of farmers were contributing to the choice of climate change adaptation strategies.

In this study, religion is considered a cultural factor. Religion is the cultural resource that the households draw in seeking livelihood outcomes such as networks and connectedness. The results the focus group discussion points to the fact that some farmers do not believe in occurrence of climate change as a scientific phenomenon and one of the group members said that "*Christians view the effects of climate change as God's wrath because of the sins (including murder, abortion and witchcraft) that the community might have committed. Climate change and its effects are*

God's plans and man has no powers over them" (Focus group discussion participant – Rangwe Village, Homa Bay sub-county, April 2018). This emphasizes denial by some smallholder farmers that climate change is a scientific phenomenon accelerated by human activities. The belief in a God who created the climate and the rest of the earth prevents individuals from believing that they can have any effect on climate. Climate change is a punishment from God for committing certain crimes. When people are presented with information that is too disturbing, too threatening or too atypical to be fully absorbed by the human psyche, denial can set in (Cohen, 2001). Denial may negatively affect climate change adaptation by smallholder farmers. The results of the study are in line with other studies that pointed out that religious beliefs have both negative and positive influence on climate change adaptation. Nunn et al, (2016) found out that the high degree of spiritual engagement of communities, including smallholder farmers with nature creates possibilities for the communication of climate change adaptation measures to these communities and if these communications are made through religious channels, rather than secular ones, the reception will be more positive. This will enable them to make informed decisions on climate change adaptation strategies.

However, research conducted by Veldman (2016) points to Evangelical's unique religious outlook as being a possible determinant of the climate sceptism prevalent within this religious group. Self-proclaimed religiosity of individuals has a significant influence on their environmental concerns, for example where Catholics were found to have low levels of concern for the effect of climate change on food production (Cullen and Anderson, 2016).

The study found out that smallholder farmers were participating in climate change adaptation at individual level in spite of their religious inclination and contradicts a study by Brink and Wamsler (2019) who found out that there was a gap between motivation to adapt due to religious beliefs and actual climate change adaptation. The study shows that religion as one of the cultural factors has the ability to shape farmers' perception to climate variability and hence choice of climate change adaptation strategies. Cultural factors usually structure the mind-set of individuals and social organizations to adopt certain values and reject others (Kollmair and Gamper, 2002). Strongly held beliefs, cultural practices and value systems and the worldviews of individuals or groups, greatly influence the way they perceive climate change, and thereby their subsequent adaptation strategies (Adger et al., 2012; Jones & Boyd, 2011).

In this study, individuals exposed to similar cultural factors form judgments in similar ways thereby influencing adaptation positively or negatively. The results of the household survey are in consonance with the results of the focus group discussion where one of the group members said that "*hailstones are realized when an elderly person dies during the day and his/her body is viewed and people start mourning without waiting for evening to reach*" *(A female focus group discussion participant, Rota Village, April 2018)*. Culture is central to the decision to adapt and thus, the identification of risks and the subsequent implementation of appropriate adaptation strategies (Adger et al., 2012).

4.5.4 Number of cattle owned

Two hundred and nineteen (74.74%) farmers out of two hundred and ninety-three livestock famers interviewed indicated that they own less than four heads of cattle. This means that most households own few heads of cattle probably as a way to adjust to effects of climate change through destocking.

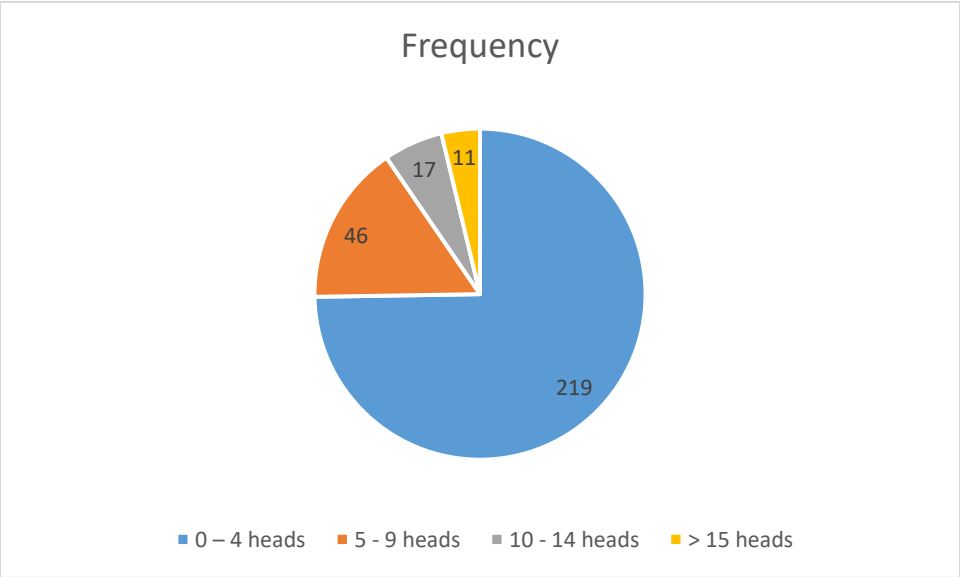


Figure 11: Number of cattle owned

Keeping many livestock would put pressure on the farmers to search for livestock feed and large areas for grazing. But given that most households own small land sizes, accessing adequate grazing land could be a challenge. Having few livestock may also mean that some of the households may be having other sources of livelihood. Households that engage in destocking have other livelihood

sources or investment alternatives they can rely on (Silvestri et al., 2012). Livestock is very important to the resource poor households as it is used to measure the amount of wealth in a household. Households with many livestock are considered wealthy and should be able to have greater adaptive capacity as livestock provides away of diversification when crops fail due to poor weather. Crop and livestock diversification is a widely used adaptation strategy in many parts of Africa (Bryan et al., 2010; Akponikpe et al., 2010). Additionally, livestock are culturally used to pay dowery.

The results of the study further indicated that most of the livestock owned by households were local breeds such as zebu cattle, which are able to survive under harsh climatic conditions. The results corroborate study by Roncoli et al. (2010) that reported that farmers sometimes adapt to effects of climate change by planting more fodder crops rather than maize, shifting towards livestock production, and adopting more drought resistant livestock breeds, such as boran cattle. This could provide a safety net for farmers to adapt to the effects of climate change, especially for poor households. Embarking on animals that are more tolerant to drought or diseases can improve productivity and drought resilience of livestock production (Bernier et al., 2015), especially local breeds that are already adapted to harsh climate conditions (Silvestri et al., 2012).
However, poorer households may hold on to their livestock as their only investment option. Eleven (3.75%) farmers out of two ninety three livestock farmers reported that they own more than fifteen heads of zebu cattle. This could be from the households that regard cattle as a source of wealth and an indicator of social status. The result on the number of cattle owned is presented in Figure 11.

4.6 Indigenous local knowledge and climate change adaptation strategies by smallholder farmers

The hypothesis that "there is no contribution of indigenous local knowledge to choice of climate change adaptation strategies in the study area" was tested using cramer's V coefficient. Chi-square test of independence was used to test the association between indigenous local knowledge (duration of stay in the study area, farming experience, and climate change experience) and types of climate change adaptation strategies.

4.6.1 Duration of stay and Climate change adaptation strategies

The number of years that the smallholder farmers had stayed in the study area by type of household head was analysed. This one was done to determine the amount of accumulated knowledge of

climate events and originality of the respondents. Cross-tabulation between types of climate change adaptation strategies and duration of stay in the study area indicates that 229 farmers (%7.54%) out of the total respondents had stayed in the study for 30 years and above, while 28 farmers (7%) of the respondents had stayed in the study area for less than 10 years (Table 28a). The Chi-square test of independence between the types of climate change adaptation strategies and duration of stay in the study area was performed.

Table 28a-c: Cross-tabulation between measures of climate change adaptation strategies and duration of stay in the study area

Count

		Duration of stay in the study area				Total
		Less than 10 years	10-20 years	20-30 years	Greater than 30 years	
Types of climate change adaptation strategies	Changing planting date	0	14	5	15	34
	Planting short season crops	0	0	10	10	20
	Planting of drought resistant crop varieties	12	10	20	60	102
	Planting of trees with crops	16	27	55	115	213
	Water harvesting	0	0	0	25	25
	Don't know	0	0	0	4	4
Total		28	51	90	229	398

Table 28b: Chi-square test of independence results

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	64.701[a]	15	.000
Likelihood Ratio	72.045	15	.000
Linear-by-Linear Association	6.730	1	.009
N of Valid Cases	398		

a. 11 cells (45.8%) have expected count less than 5. The minimum expected count is .35.

Table 28c: Cramer's V test of effect size

		Value	Approx. Sig.
Nominal by Nominal	Phi	.312	.000
	Cramer's V	.232	.000
N of Valid Cases		398	

a. Not assuming the null hypothesis.
b. Using the asymptotic standard error assuming the null hypothesis.

Null hypothesis tested was that types of climate change adaptation strategies and duration of stay in the study area were independent. The result in Table 28b ($\chi^2 = 64.701$, $p = 0.000$, $\alpha = 0.05$) shows a significant association and hence null hypothesis was rejected. The results in Table 28c show a Cramer's V of 0.232, which indicates a statistically significant strong contribution of the duration of stay in the study area to the types of climate change adaptation strategies. This finding implies that the duration of stay in the study area amounted to indigenous knowledge accumulated on climate events and hence climate change experience and was contributing to the choice of climate change adaptation strategies in the study area. The climate change experience shapes climate change perception of the farmers and thus understand and recognize the need to adapt their practices accordingly (Egeru, 2012). People who have stayed in a particular area for a long time have sufficient long-term experience to provide a reliable assessment of environmental changes and will be able to make right choices on climate change adaptation strategies.

The study noted that farmers who had stayed in the study area for more than 30 years were adopting a variety of climate change adaptation strategies with planting of trees being most preferred, (Table 28a). This could be attributed to the fact that these farmers were using their past experiences of climate regimes to predict the likely climate events and hence choice of climate change adaptation strategies. Some of the specific indicators of changing weather patterns mentioned during focus group discussion included: *Migration of rare birds from northern Kenya passing through the community towards the south was a sign of dry spell that had begun up there and would soon escalate to the Lake Victoria region; presence of flamingoes (Phoenicopterus roseus) in Lake*

Simbi Nyaima in Homa Bay county was a clear indication that prolonged rainfall was about to start (Male focus group participant, from Mbita sub-county, April, 2018); presence of safari ants trailing from one point to the other was a sign of the start of the rainy season and people were advised to start cultivation. *The community would also predict the likelihood of prolonged drought when "Nyakoyi" (Cyclone) was noticed at night close to Migingo Island or at the foot of Homa Hills (Male focus group participant, from Rachuonyo North sub-county, April, 2018).* Equally, when traditional earthen water pot was noticed to be absorbing a lot of water then it indicated that dry period was about to set in; appearance of a new moon without any brief of rainfall was a sign of dry spell; and deflowering and shading of leaves of some trees such as "Ober" (*Albizia coriaria*) and "Ng'owu" (*Ficus sycomorus*) would indicate preparations for long perids of drought.

However, most farmers indicated that climate variables had become very much unpredictable that it had become very difficult for them to be very sure of the predicted events. Egeru (2012) also observed that indigenous knowledge is being challenged by a number of factors including unreliable seasons, short return period of climate variability events; break down in social inclusion systems and a low mastery of indigenous knowledge among younger community members.

4.6.2 Farming experience and Climate change adaptation strategies

The duration of practicing agriculture is an important aspect in climate change adaptation by smallholder farmers since it is a measure farming experience, which enhances accumulation of knowledge on climate events and application of climate change adaptation strategies. Those who have practiced farming for long are expected to apply suitable climate change adaptation strategies. Cross-tabulation between types of climate change adaptation strategies and farming experience indicates that 192 farmers out of the total respondents interviewed had practiced farming for over 10 years, whereas 51 farmers had been in farming for 1 to 3 years. 70 farmers out of the total respondents had been practicing farming for 4 to 6 years, while 85 farmers had been in farming for 7 to 10 years (Table 29a). This implies that majority of the farmers are old time farmers and could use their experiences gained over the years to adapt to effects of climate change. It is expected that farmers who have spent many years in farming are more equipped with indigenous technical knowledge in climate change adaptation. This corroborates a study by Defiesta and Rapera (2014) who reported that the number of years of experience in farming is highly correlated

with the level of knowledge and skill related to adapting to climate change and climate variability using technology.

The Chi-square test of independence between the types of climate change adaptation strategies and farming experience was performed as presented in Table 29b.

Table 29a-c: Cross-tabulation on between farming experience and types of climate change adaptation strategies

		Types of climate change adaptation strategies					Total
		changing planting date	planting short season crops	planting drought resistant crops	planting trees with crops	water harvesting	
Years	1-3 years	9	4	8	12	18	51
	4-6 years	12	8	19	25	6	70
	7-10 years	13	14	18	29	11	85
	>10 years	43	26	29	81	13	192
Total		77	52	74	147	48	398

Table 29b: Chi-square test of independence results

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	75.080[a]	12	.000
Likelihood Ratio	58.515	12	.000
Linear-by-Linear Association	11.593	1	.001
N of Valid Cases	398		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 6.73.

Table 29c: Cramer's V test of effect size

		Value	Approx. Sig.
Nominal by Nominal	Phi	.314	.000
	Cramer's V	.250	.000
N of Valid Cases		398	

a. Not assuming the null hypothesis.
b. Using the asymptotic standard error assuming the null hypothesis.

The null hypothesis tested was that types of climate change adaptation strategies and farming experience were independent. The result in Table 29b ($\chi^2 = 75.080$, $p = 0.000$, $\alpha = 0.05$) shows a statistically significant association and hence null hypothesis was rejected. The results in Table 29c show a Cramer's V of 0.250, which indicates a statistically and strong contribution of farming experience to the types of climate change adaptation strategies. The findings indicate that farming experience contribute to the choice of climate change adaptation strategies by smallholder farmers. Farming experience is found to have a positive association with the choice of climate change adaptation strategies i.e. adoption of climate change strategies increases with the years of farming experience (Abegunde, et al, 2019a; Nyangau, et al, 2021). Farmers who have experience with various farming practices are more likely to adopt new technologies to adapt to climate change. Farming experience enables farmers to accumulate new farming skills which help them to improve their resilience. Fadina and Barjolle, (2018), put it that farming experience facilitates the identification and implementation of any adaptation strategy.

The results of the study show that farmers who had practiced farming for 10 years and above were likely to adopt various climate change adaptation strategies as can be seen in Table 8a. This could be due to the fact that these farmers will have experienced more problems of climate change and as such have accumulated more knowledge for climate change adaptation. These results are consistent with the results of other studies (Osumanu et al., 2017; Tessems et al., 2018) that concluded that farming experience was a significant predictor of climate change adaptation. Farming experience could influence risk perceptions and preferences about agricultural technologies and practices among farmers (Martey and Kuwornu, 2021). On the other hand, less

experienced farmers may not garner enough knowledge on climate variability hence not able to effectively apply these agricultural technologies.

4.6.2.1 Farming experience and knowledge on climatic events

On whether there is a relationship between farming experience and the amount of knowledge on climate events gathered, farmers were asked if they agree that farming experience enhances knowledge accumulation which is vital for climate change adaptation. The results of the study indicated that 33.67% strongly agree, 46.73% of the respondents agree, while 5.78% of the respondents strongly disagreed as shown in Table 30. Most of the respondents who agreed that farming experience enhanced their knowledge of climate regimes in the study area were those who had practiced farming for more than 7 years and therefore had clear knowledge of climate variability in the study area. Farmers who have spent many years in farming are more equipped with local knowledge in adaptation to climate change. This corroborates a study by Defiesta and Rapera (2014) who reported that the number of years of experience in farming is highly correlated with the level of knowledge and skill related to adapting to climate change and climate variability using technology.

Table 30: Likert scale on perception of whether farming experience enhances indigenous knowledge

Farming experience results in accumulation of knowledge about climate events	Frequency	Percentag
Strongly agree	134	33.67
Agree	186	46.73
Not sure	25	6.28
Disagree	30	7.54
Strongly disagree	23	5.78
Total	398	100

The experience that farmers have in farming enables them to acquire knowledge on climate events and this facilitate climate change adaptation. The longer the time taken in farming as an activity, the more the knowledge and skills acquired for improved agricultural production. Experienced farmers perceive climate change better as they are exposed to past and present climatic conditions over their life span (Mburu et. al, 2015) and hence higher chances of adopting various strategies to cope with climatic changes. Farmers with more farming experience are more likely to perceive

long-term changes in rainfall variability, an increase in average temperature, and a decrease in average rainfall (Bryan et al, 2013).

4.6.3 Climate change experience and Climate change adaptation strategies

181(45.48%) farmers out of the total respondents interviewed reported that they had experienced changes in weather patterns for between 5 to ten years, while 193 (48.49%) farmers had experienced climate changes for between 11 to 15 years (Table 31a).

The cross tabulation of measures to cope with climate and climate change experience in years revealed a significant relationship, (Table 31b).

Table 31a-c: Cross tabulation between types of climate change adaptation strategies and climate change experience in years

Count

		Climate change experience in years			Total
		5-10 years	11-15 years	16-20 years	
Types of climate change adaptations strategies	Changing planting date	15	19	0	34
	Planting short season crops	18	16	0	34
	Planting of drought resistant crop varieties	75	17	12	104
	Planting of trees with crops	55	129	12	196
	Water harvesting	14	12	0	26
	Don't know	4	0	0	4
Total		181	193	24	398

Table 31b Chi-square test of independence results

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	52.496[a]	10	.000
Likelihood Ratio	62.925	10	.000
Linear-by-Linear Association	3.822	1	.051
N of Valid Cases	398		

7 cells (38.9%) have expected count less than 5. The minimum expected count is .30.

Table 31c: Cramer's test of effect size between climate change experience and choice of climate change adaptation strategies

		Value	Approx. Sig.
Nominal by Nominal	Phi	.478	.000
	Cramer's V	.338	.000
N of Valid Cases		391	

a. Not assuming the null hypothesis.
b. Using the asymptotic standard error assuming the null hypothesis.

Null hypothesis tested was that types of climate change adaptation strategies and climate change experience were independent. The result in Table 31b ($\chi^2 = 52.496$, $p = 0.000$, $\alpha = 0.05$) shows a significant association and hence null hypothesis was rejected. The results in Table 31c show a Cramer's V of 0.338, which indicate a statistically significant and very strong contribution of climate change experience to the types of climate change adaptation strategies. This means that the choice climate change adaptation strategies was dependent on climate change experience in years by farmers. Experience of climate change occurrence is associated with the number of years that the farmer had spent in farming and hence accumulated local knowledge in adapting to climate change (Defiesta and Rapera, 2014). This means that farmers who had experienced climate change for long had accumulated more local knowledge and should be able to adapt to climate change than those who had few years of climate change experience. The number of years of experience in farming is highly correlated with the level of knowledge and skill related to adapting to climate change and climate variability (Defiesta and Rapera, 2014).

4.7 Local institutions and climate change adaptation strategies by smallholder farmers

The hypothesis that "Participation in local institutions do not contribute to choice of climate change adaptation strategies by smallholder farmers in the study area" was analyzed descriptively using frequencies and percentages and inferentially using chi-square and cramer's V coefficient. The factors considered include farmers' membership to local institutions, the extent to which the institutions had assisted them in climate change adaptation and the presence of other external organisations supporting climate change adaptation.

4.7.1 Membership to social organisations and climate change adaptation strategies

On membership to local institutions, 60.55% (241 smallholder farmers) of the respondents reported that they belonged to at least one social organisation. The results also indicate that 39.45% (157 smallholder farmers) of the households are not members of any social organisation and could miss on the benefits of social organisations, hampering ability to adapt to climate variability and change. Seitz et al. (2011) reported that institutional barriers at household levels could influence mainstreaming of adaptation strategies. The results are presented in Figure 12.

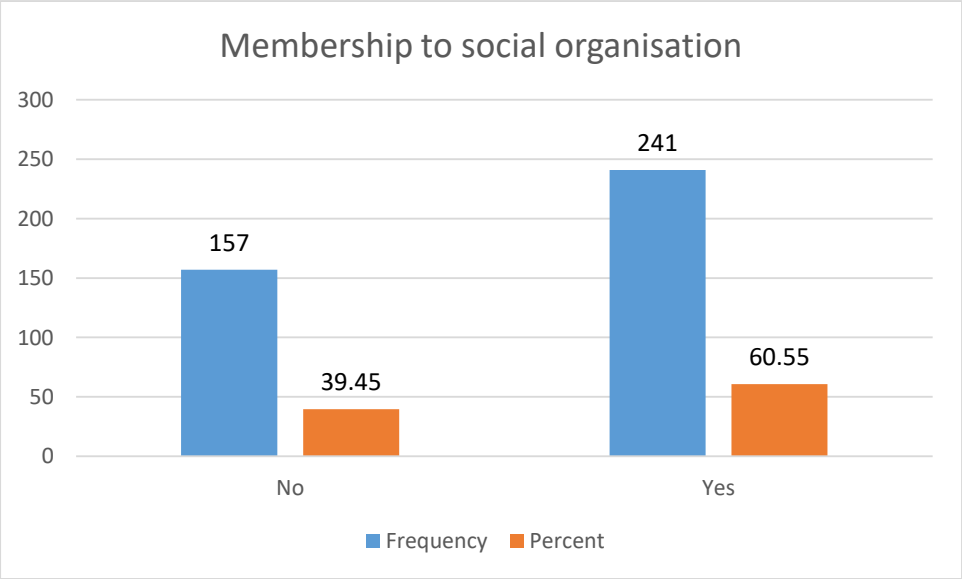


Figure 12: Membership to social organizations

The results of cross tabulation between the membership to local institutions offering assistance in the study area and measures to adapt to climate change revealed an insignificant relationship as presented in Table 32a.

Table 32a-c: Cross-tabulation on between Membership to social organisations and types of climate change adaptation strategies

		Types of climate change adaptations strategies					Total
		changing planting date	planting short season crops	planting drought resistant crops	planting trees with crops	water harvesting	
Membership to social organizations	NO	37	19	31	58	12	157
	YES	55	25	38	104	19	241
Total		92	44	69	162	31	398

Table 32b Chi square test of independence results

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	4.629[a]	4	.328
Likelihood Ratio	4.629	4	.328
Linear-by-Linear Association	1.616	1	.204
N of Valid Cases	398		

0 cells (0.0%) have expected count less than 5. The minimum expected count is 16.55.

Table 32c: Cramer's V test of effect size between group membership and choice of climate change adaptation strategies

		Value	Approx. Sig.
Nominal by Nominal	Phi	.278	.000
	Cramer's V	.158	.000
N of Valid Cases		398	

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

Null hypothesis tested was that types of climate change adaptation strategies and membership to social organisations were independent. The result in Table 32b ($\chi^2 = 4.629$, $p = 0.328$, $\alpha = 0.05$) shows insignificant association and hence null hypothesis was accepted. The results in Table 32c show a Cramer's V of 0.158 which indicates a statistically significant and strong contribution of group membership to the choice of climate change adaptation strategies. This implies that group membership of smallholder farmers contributed to the choice of climate change adaptation strategies. Group membership provides room for sharing among farmers on climate-smart agricultural technologies, thereby promoting climate change adaptation. The findings of the study are supported by previous studies in Africa which reported group membership as a positive significant determinant of agricultural practices adoption (Ehiakpor et al., 2021; Kimaru-Muchai et al., 2020; Mango et al., 2017), which positively influences climate change adaptation. Membership to local institutions enables farmers to share experiences which may allow them to make choices on climate change adaptation strategies. These institutions, both formal and informal play an important role in building resilience through community pooling and reducing vulnerability to climate variability and change. As indicated by a male key informant interviewee, *"farmers who get training and financial support from organisations have better adaptive capacity" (Environmental officer, World Vision-Kwabwayi Division, Homa Bay County- May, 2018).* Although households have historically adapted to climate variability through many different strategies, their capacity to adapt depends in significant measures on the ways organizations regulate and structure their interactions, both amongst themselves and with external actors (Agrawal et al., 2009). Group participation allows farmers to pool together labour (Teklewold et al., 2013) especially on labour intensive adaptation strategies such as soil conservation practices. However, some other studies in Sub-Saharan Africa such as (Musafiri et al., 2020 a; Okeyo et al., 2020) found a negative relationship between group membership and climate change adaptation. The negative relationship between group membership and choice of measures to adapt to climate change could be attributed to other roles played by these groups including provision of credit to finance other household needs rather than climate change mitigation.

On the type local institutions that respondents belonged to, majority of the farmers interviewed indicated that they are members of self-help groups. Others belonged to women groups and youth groups. However all the respondents belonged to a family as a social institution. This institution is important in supplying cheap labour to supplement the hired labour in some households while other households use family labour exclusively to carry out farm operations. Family labour increases social interaction and networking among family members, which increases adaptive capacity of households. More access to family labour enhances social capital of households (Eakin et. al, 2011; Ibrahim, 2014).

4.7.2 Sponsorship by local organisations and climate change adaptation Strategies

Farmers were further asked whether there were organisations in the study area that were assisting them in adapting to climate change. 36.43% of the respondents reported that there were some organisations supporting them to adapt to climate change while 63.57% that they had not accessed any assistance from any organisation to help them adapt to climate change (Table 33a).

The results of cross tabulation between the sponsorship by local organisations in the study area and measures to adapt to climate change revealed a significant relationship (Table 33a).

Table 33a-c: Cross tabulation of Sponsorship by local organisation and types of climate change adaptation strategies

Count

		Types of climate change adaptation strategies					Total
		changing planting date	planting short season crops	planting drought resistant crops	planting trees with crops	water harvesting	
Sponsorship by local institution	NO	61	45	41	88	18	253
	YES	45	18	12	55	15	145
Total		106	63	53	143	33	398

Table 33b Chi-square test of independence

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	15.102[a]	4	.004
Likelihood Ratio	15.579	4	.004
Linear-by-Linear Association	2.325	1	.127
N of Valid Cases	398		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 15.03.

Table 33c: Cramer's V test of effect size between sponsorship by local institutions and choice of climate change adaptation strategies

Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Phi	.231	.058
	Cramer's V	.195	.058
N of Valid Cases		398	

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

Null hypothesis tested was that sponsorship by local institutions and types of climate change adaptation strategies were independent. The result in Table 33b ($\chi^2 = 15.102$, $p = 0.004$, $\alpha = 0.05$) shows a significant association and hence null hypothesis was rejected. The results in Table 33c show a Cramer's V of 0.198 which indicates a statistically significant and strong contribution of sponsorship by local institutions to the choice of climate change adaptation strategies. Presence of these organisations within the reach of farmers enables them to access their services and therefore able to make right choices on adaptation strategies. Participation in social organisations enable households to choose specific adaptation practices especially those that may need external support. Members of farmers groups can share experiences and exchange information about new technologies when they meet (Kassie et al., 2013). Group membership can enhance social learning and knowledge spillover (Bandiera & Rasul, 2006) about climate change adaptation.

The farmers who had accessed assistance reported that these groups were providing them with loans to pay school fees for their children and purchase farm inputs among other benefits. This could improve farmers' economic status thereby influencing their ability adapt to climate variability and change. This is consonance with the work of Frank and Penrosa (2012) and Defiesta and Rapera (2014) who reported that farmers with access to credit are more economically able to adapt to climate change than those who are not able to access credit.

These organisations can help communities to undertake the appropriate adaptive actions to reduce vulnerability, mitigate risks and build resilience. This is supported by a female key informant interviewee who reported that *"our institution usually organizes field days, workshops and seminars where communities are trained on the importance of forest protection, water harvesting and adoption of alternative energy resources to protect forests" (Forest Officer, Ruma Forest, Homa Bay County- May, 2018).* These organisations shape the livelihood impacts of climate hazards through a range of important functions they perform in rural contexts, which include but not limited to information gathering and dissemination, resource mobilization and allocation, skills development and capacity building, and networking with other actors (Agrawal et. al, 2009). However, with a large percentage (63.57%) of the smallholder households in the study area not able to access any support from these organisations, climate change adaptation may be influenced negatively. For the communities to properly realize the support of these organisations in climate change adaptation, there may be a need in changing the strategy of how this support is to be channeled by involving the communities at the grass root level.

Local organisations may also act as safety nets for their members by enhancing livelihood systems. Local organisations improve livelihood security in arid areas with disengagement of governmental services and limited access to income generating activities (Washington-Ottombre & Pijanowski, 2013).

On the type of organisations providing support to the community, 42 farmers (28.97%) out of the total respondents reported that they had got support from Non-governmental Organisations (NGOs), 20 farmers (13.79%) got support from individuals, 37 farmers (25.52%) had got support from government ministry, and 13 farmers (8.97%) got support from CBOs, while 33 farmers (22.76%) got support from farmer's union (Table 34a). The most commonly mentioned NGO in

the study area was Vi Agroforestry which was promoting climate resilient projects including grafted fruit production and honey production.

However, the results of cross tabulation between type of local institutions offering assistance in the study area and choice of measures to adapt to climate change revealed an insignificant relationship (Table 34b)

Table 34a-c: Cross tabulation of types of institutions offering assistance and types of climate change adaptation strategies

Count

		Climate change adaptation strategies					Total
		changing planting date	planting short season crops	planting drought resistant crops	planting trees with crops	water harvesting	
Type of organisation	NGO	15	6	5	13	3	42
	Individuals	4	3	4	9	0	20
	Government	6	4	2	23	2	37
	CBOs	1	2	3	6	1	13
	Farmer union	7	3	8	14	1	33
Total		33	18	22	65	7	145

Table 34b Chi square test of Independence results

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	19.632[a]	12	.074
Likelihood Ratio	21.350	12	.045
Linear-by-Linear Association	4.492	1	.034
N of Valid Cases	145		

a. 5 cells (25.0%) have expected count less than 5. The minimum expected count is 2.21.

Table 34c: Cramer's V test of effect size between types of institutions offering assistance and choice of climate change adaptation strategies

Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Phi	.211	.038
	Cramer's V	.171	.038
N of Valid Cases		145	

a. Not assuming the null hypothesis.
b. Using the asymptotic standard error assuming the null hypothesis.

Null hypothesis tested was that type of local institutions offering assistance and types of climate change adaptation strategies were independent. The result in Table 34b ($\chi^2 = 19.632$, $p = 0.074$, $\alpha = 0.05$) shows insignificant association and hence null hypothesis was accepted. This implies that the choice of climate change adaptation strategies was not dependent on the type of local institution offering assistance in the study area. However, the results in Table 34c show a Cramer's V of 0.171, which indicates a statistically significant and strong contribution of the type local institutions offering to the choice of climate change adaptation strategies. These instituitons empower farmers to make the right climate change decisions based on their areas of specialization.

4.7.3 Type of assistance offered by local institutions and climate change adaptation strategies

The results of cross tabulation between the type of assistance received by farmers and measures to adapt to climate change in the study area revealed a significant relationship as presented in Table 35b.

Table 35a:-c Cross tabulation of types of assistance offered by local institutions and types of climate change adaptation strategies

		Types of Climate change adaptation strategies					Total
		changing planting date	planting short season crops	planting drought resistant crops	planting trees with crops	water harvesting	
Types of assistance received	Loan	12	8	6	22	7	55
	Environmental information	15	2	5	28	7	57
	Agricultural information	16	9	16	29	7	77
	Provision of farm inputs	14	13	15	18	0	60
Total		57	32	42	97	21	249

Table 35b Chi-square tests of independence results

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	24.700[a]	12	.016
Likelihood Ratio	30.699	12	.002
Linear-by-Linear Association	3.744	1	.053
N of Valid Cases	249		

a. 2 cells (10.0%) have expected count less than 5. The minimum expected count is 4.64.

Table 35c: Cramer's V test of effect size between types of assistance offered by local institutions and choice of climate change adaptation strategies

Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Phi	.238	.026
	Cramer's V	.181	.026
N of Valid Cases		249	

a. Not assuming the null hypothesis.
b. Using the asymptotic standard error assuming the null hypothesis.

Null hypothesis tested was that type of assistance offered by local institutions and types of climate change adaptation strategies were independent. The result in Table 35b ($\chi^2 = 24.700$, $p = 0.016$, $\alpha = 0.05$) shows significant association and hence null hypothesis was rejected. The results in Table 35c show a Cramer's V of 0.181, which indicates a statistically significant and strong contribution of type of assistance offered by local institutions to the choice of climate change adaptation strategies. This indicate that the type of support provided by these organisations significantly contributes to the choice of climate change adaptation strategies by smallholder farmers in the study area. The support provided by these institutions including agricultural information and farm inputs empowers the farmers and enables them to make right decisions over choice of climate change adaptation strategies. This corroborates another research in Kenya which demonstrated that local institutions reduce local vulnerabilities and increase livelihood security in areas experiencing climate variability (Washington-Ottombre and Pijanowski, 2013).

During focus group discussions, respondents classified these institutions into credit and savings facilities, Non-governmental organisations, and government departments. They gave specific roles of these institutions as giving loans, provision of training on financial management, education on tree planting, provision of tree seeds and seedlings, training on modern agricultural practices, training on water harvesting, construction of wells, spring protection and management and protection of water catchment zones.

The study observed that culture is central in determining the contributions of four compound variables (socioeconomic, cultural, indigenous knowledge and institutional factors) on choice of climate change adaptation strategies in the study area. Culture shapes the way of life of the

smallholder farmers and therefore plays an important role in decision making processes regarding choice of climate change adaptation strategies in Homa Bay County. Even with socioe-economic and institutional factors in play, communities follow cultural norms in making decisions on choice of climate change adaptation strategies. For example, farmers often rely on social learning, observing and emulating their peers when adopting new climate adaptation strategies (Gbetibouo et al., 2024). While some farmers are willing to incorporate scientific climate information, others perceive modern techniques as contradictory to their cultural traditions, leading to resistance (Nyantakyi-Frimpong and Kerr, 2023). Cultural beliefs, traditions, and indigenous knowledge systems shape farming practices, influence decision-making, and determine the adoption of climate adaptation strategies (Adimassu et al., 2024). Culture therefore plays a significant role in shaping smallholder farmers' decision making processes leading to acceptance or rejection of certain climate change adaptation practices.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary of the Study Findings

The study found out that gender of the smallholder farmer had a significant moderate contribution to choice of climate change adaptation strategies in the study (Cramer's V = 0.135) There were significant differences between male and female farmers in terms of choice of climate change adaptation strategies, which could be due to cultural norms resulting in vulnerabilities to climate change. The study established that marital status, which is largely determined by cultural orientation of the smallholder farmer had a significant and very strong contribution to the choice of climate change adaptation strategies (Cramer's V = 0.257). Marital status is critical in adoption of effective climate change adaptation strategies because married farmers can make joint decisions with their spouses on the best climate change adaptation practices. The study also revealed that household size of the smallholder farmer significantly contributed to the choice of climate change adaptation strategies (χ^2 = 52.453, p = 0.000, α = 0.05; Cramer's V = 0.268). Household size, which is largely determined by culture provides a measure of the availability of family labour for farming activities. The study established that source of farm labour significantly contributed to choice of strategies to adapt to climate change (χ^2 = 57.494, p = 0.000, α = 0.05; Cramer's V of 0.268). The study also found out that the choice of measures adopted by smallholder farmers to adapt to climate change was dependent on their sources of climate information (χ^2 = 34.210, p = 0.033, α = 0.05; Cramer's V = 0.149). The ability of the smallholder farmer to access reliable weather and climate information is important in enabling the farmer to prepare in advance against prevailing climate discrepancies.

The study established that the level of attachment to the place of residence had a significant contribution to choice of climate change adaptation strategies (χ^2 = 220.178, p = 0.000, α = 0.05; Cramer's V = 0.372). The study revealed that tree planting alongside crops was popular as an adaption strategy among those with strong and very strong attachment to the place of residence. This could be attributed to the fact that strong attachment to the place of residence encourages smallholder farmers to invest in more permanent climate change adaptation strategies such as tree planting. The study revealed that family order in carrying out farm operations had a significant contribution to choice of climate change adaptation strategies in the study area (χ^2 = 30.791, p =

0.000, α = 0.05; Cramer's V = 0.277). The study established that some hierarchical order in carrying out farm operations was commonly followed by communities in the study area and this was causing delay in decision making thereby constraining some climate change adaptation strategies particularly early planting. The study established that there was a significant and very strong contribution of religious beliefs of smallholder farmers to the choice of climate change adaptation strategies (χ^2 = 203.59, p = 0.000, α = 0.05; Cramer's V = 0.412). The study found out that smallholder farmers were participating in climate change adaptation at individual level in spite of their religious inclination.

The study revealed a significant and strong contribution of the length of time stayed in the study area to the choice of strategies to adapt to climate change (χ^2 = 64.701, p = 0.000, α = 0.05; Cramer's V = 0.232). This implies that the duration of stay in the study area amounted to climate change experience and was contributing to choice of climate change adaptation strategies. The study also established a significant and strong contribution of farming experience to the choice of climate change adaptation strategies (χ^2 = 75.080, p = 0.000, α = 0.05; Cramer's V = 0.250). Farmers who have experience with various farming practices are more likely to adopt new technologies to adapt to climate change. The study found out that climate change experience of the smallholder farmer contributed significantly to choice of climate adaptation strategies (χ^2 = 52.496, p = 0.000, α = 0.05; Cramer's V = 0.338). The study established that farmers who had experienced climate change for long had accumulated more local knowledge and should be able to adapt to climate change than those who had few years of climate change experience.

The study established a statistically significant and strong contribution of group membership of the smallholder farmer to the choice of climate change adaptation strategies in the study area (Cramer's V = 0.158). Group membership provides room for sharing among farmers on climate-smart agricultural technologies, thereby promoting climate change adaptation strategies. The study also revealed a significant and strong contribution of the sponsorship by local institutions to the choice of climate change adaptation strategies (χ^2 = 15.102, p = 0.004, α = 0.05; Cramer's V = 0.198). This indicates that support provided by these organisations facilitate climate change adaptation by smallholder farmers in the study area. The study found out that type of local institutions offering assistance to smallholder farmers had a statistically strong contribution to the choice of measures to adapt to climate change by smallholder farmers in the study area (Cramer's

V of 0.181). These institutions empower farmers to make the right climate change decisions based on their areas of specialization.

5.2 Conclusions

The study established that the four factors (socioeconomic factors, cultural factors, indigenous local knowledge, and local institutions) examined were contributing to the choice of climate change adaptation strategies by smallholder farmers in the study area. Despite the contribution of these factors to choice of climate change adaptation strategies, culture remains the main determinant of how smallholder farmers make decisions. Culture influences adaptation behaviours by determining which practices are accepted or rejected. The climate change adaptation strategies included change of planting dates, tree planting alongside crops, planting drought resistant crop varieties and water harvesting.

The socioeconomic factors enhanced decision making by the smallholder farmers and therefore contributed to the choice of climate change adaptation strategies in the study area. There were remarkable differences between male and female farmers in implementing adaptation practices due to relative differences in vulnerabilities to climate change as a result of cultural norms. Education enhances farmer understanding of climate change adaptation strategies, resulting in sound decision making regarding choice of climate adaptation strategies. Farm size positively increases the likelihood of adaptation to climate change. As farm size increases, the probability of adopting various climate change adaptation strategies increases. Access to information on climate change and adaptation techniques enhanced climate change awareness among smallholder farmers and facilitated decision making on the choice of climate change adaptation strategies.

Cultural practices of smallholder farmers shape the way they live and how they interact with the environment around them and therefore influences how they make choices on climate change adaptation strategies. Some of these cultural practices such as family order of carrying out farm operations can lead to delay in decision making thereby impacting negatively on choice of certain climate change adaptation strategies such as change of planting dates. Strong attachment to the place of residence enhances long term climate change adaptation strategies such as tree planting. Religion as a cultural factor has the ability to shape farmers' perception to climate variability and hence choice of climate change adaptation strategies.

Indigenous knowledge as measured by factors as measured by duration of stay in the study area, farming experience and climate change experience facilitates the choice of climate change adaptation strategies by smallholder farmers in the study area. Farmers who had stayed in the study area for long or had practiced farming for long had more years of experience in climatic changes and therefore were able to make decisions on the type of climate change adaptation strategies to adopt. Farming experience enables farmers to accumulate knowledge about new farming skills which help them to improve their resilience. The climate change experience also accounts for the amount of indigenous knowledge accumulated which is important for climate change adaptation.

Local institutions enable smallholder farmers to deploy specific climate change adaptation practices. They pursue adoption of effective adaptation strategies relevant to local needs of the smallholder farmers. These institutions provide finances and knowledge to facilitate choice of climate change adaptation strategies by smallholder farmers. They also provide information on climate change adaptation options to enable farmers cope with climate change. This will enable smallholder farmers to move from short-term coping mechanisms in response to climate shocks and to invest in long-term strategies that enhance resilience to climate change through livelihood diversification and adoption of more expensive but efficient agricultural technologies.

5.3 Recommendations

Based on the findings and conclusion, the study makes the following recommendations;

There is need to establish meteorological stations at levels that can be accessed by the farmers for easy dissemination of weather information and strengthen training and access to climate information through agricultural extension services and exchange visits by state and non-state actors in the study area. These could include community resource centres and schools and community resource persons and teachers empowered to disseminate climate information to the farmers. There is also need to provide agricultural credit at reasonable conditions to enable farmers invest in climate change adaptation strategies. The study recommends promotion of cultural practices that enhance gender equity for fair resource distribution and access particularly for women smallholder farmers to increase their adaptive capacity.

There is need to strengthen cultural practices that enhance climate change adaptation and re-examine the retrogressive aspects of culture to conform to the current needs. Adapting to climate

change requires that communities embrace efficient production technologies which will call for a re-examination of certain aspects of culture.

The study proposes the need to integrate indigenous knowledge of climate events from different cultures with modern scientific knowledge for better forecasting by the meteorological department. This will enhance climate change adaptation at local levels. There is also need to document the indigenous knowledge indicators from different cultures and strengthening of indigenous knowledge among the younger community members in the study area and how it has been used in climate change adaptation at household level.

The study suggests the need to promote institutional partnership by government and private agencies to enhance climate change adaptation at local level. There is also need by the government to enhance the capacity of local institutions as the impacts of climate change are likely to intensify with time. The study overally recommends that the development of smallholder agricultural production should factor in cultural and social norms that influences choice of climate change adaptation strategies at household level for improved household food security in the study area

5.4 Suggestions for further research

1. Cultural barriers determining the adaptive capacity of smallholder farmers. Are there context specific adaptation strategies given the geographical contions and cultural differences among communities.

2. Smallholder farmer dynamics with respect to climate change adaptation considering different cultural contexts and agro-ecological conditions.

3. Establish community-driven knowledge systems linked to strategic levels of decision making to inform cultural context specific and adaptive responses to climate change.

REFERENCES

Abdulai, A., Owusu, V. and Bakang, J.E.A. (2011). Adoption of safer irrigation technologies and cropping patterns: Evidence from Southern Ghana. Ecol. Econ. 70, 1415-1423.

Abdul-Razak, M. and Kruse, S. (2017). The Adaptive Capacity of Smallholder Farmers to Climate Change in Northern Region of Ghana. Climate Risk Management. 17, 104-122.

Adger, W. (2003). Social capital, collective action, and adaptation to climate change. Econ. Geogr., 79 (2003), pp. 387–404.

Adger, W. N (2011). Resilience Implications of Policy responses to Climate Change. WIRES Clim. Change 2. 757-766.

Adger, W. N. (2006). Vulnerability. *Global Environmental Change-Human and Policy Dimensions* 16 (3): 268–281.

Adger, W. N., Barnett, J., Chapin III, F. S. and Ellemor, H. (2011). This must be the Place: Under representation of identity and meaning in Climate Change Decision-making. Global Environmental Politics 11(2), 1–25.

Adger, W. N., Paavola J., Huq S., and Mace M.J. (Ed) (2006) Fairness in Adaptation to Climate Change, The MIT Press, pp1-19.

Adger, W., Arnell, N. and Tompkins, E. (2005). Successful adaptation to climate change across scales. Global Environ. Change, 15 (2005), pp. 77–86.

Adger, W., Dessai, S., Goulden, M., Hulme, M, Lorenzoni, I., Nelson, D., Naess, L., Wolf, J. and Wreford, A. (2009). Are there social limits to adaptation to climate change? Clim. Change, 93 (2009), pp. 335–354.

Adger, W.N., Barnett, J., Brown, K., Marshall, N., and O'Brien, K. (2013). Cultural dimensions of climate change impacts and adaptation. Nat. Clim. Chang. 3, 112–117.

Adger, W.N., Barnett, J., Brown, K., Marshall, N., and O'Brien, K. (2012). Cultural dimensions of climate change impacts and adaptation. Nature Climate Change, 3(2), 112–117.

Adimassu, Z., Langan, S., and Johnston, R. (2024). The role of indigenous knowledge in smallholder farmers' adaptation to climate change: Evidence from East Africa. Climate and Development, 16(1), 45-62.

Adzawla, W., Azumah, S.B., Anani, P.Y. and Donkoh, S.A., (2019). Gender perspectives of climate change adaptation in two selected districts of Ghana. *Heliyon*, 5(11), p.e02854. https://doi.org/10.1016/j.heliyon.2019.e02854.

African Development Bank, (AfDB) (2011). The Cost of Climate Change in Africa. Tunis: African Development Bank

Agarwal, A. (2010). Local Institutions and Adaptation to Climate Change, Social Dimensions of Climate Change: Equity and Vulnerability in a Warming World

Agrawal, A. (2008). The role of local institutions in adaptation to climate change. International Forestry Resources and Institutions Program. IFRI Working Paper #W08I-3. International Forestry Resources and Institutions Program, Ann Arbor, Michigan, USA.

Agrawal, A. and Perrin, N. (2009). Climate Adaptation, Local Institutions and Rural Livelihoods. In: W.N. Adger, I. Lorenzoni and K. O'Brien (Eds.), *Adapting to Climate Change: Thresholds, Values, Governance.* Cambridge, UK: Cambridge University Press.

Agrawal, A., Perrin, N., Chhatre, A., Benson, C. and Kononen, M. (2009). Climate Policy Processes, Local Institutions, and Adaptation Actions: Mechanisms of Translation and Influence. Washington, DC: The World Bank.

Agrawal, A., Perrin, N., Chhatre, A., Benson, C. and Kononen, M. (2012). Climate Policy Processes, Local Institutions, and Adaptation Actions: Mechanisms of Translation and Influence. WIREs Climate Change 3(6): 565-579.

Agyeman, J., Devine-Wright, P and Prange, J. (2009). Close the edge down by the river? Joining up Management retreat and place attachment in a climate change world. Environment and Planning A 41, 509-513.

Ajzen, I. (1991). The theory of planned behavior. Organizational Behavior and Human Decision Processes. Academic Press.

Aklilu, A., Desalegn, W., Mesfin, K. and Negash, T. (2013). Climate change impacts on Pastoral Women in Ethiopia: Some evidences from the Southern lowlands. PHE Ethiopia Consortium.1-6p.

Akponikpe, P. B. I., Johnson, P., and Agbossou, E. K., (2010). Farmers Perception of Climate Change and Adaptation Strategies in sub-Saharan West Africa. Second International Conference on Climate, Sustainability and Development in Semi-arid Region, 16-20. August 2010, Fortaleza-Ceara, Brazil.

Alhassan, S.I., Kuwornu, J.K. and Osei-Asare, Y.B., (2019). Gender dimension of vulnerability to climate change and variability: Empirical evidence of smallholder farming households in Ghana. *International Journal of Climate Change Strategies and Management*. 11, 195-214. https://doi.org/10.1108/IJCCSM-10-2016-0156.

Alliance for a Green Revolution in Africa, (AGRA). (2014). Africa Agriculture Status Report: Climate Change and Smallholder Agriculture in Sub-Saharan Africa. Nairobi, Kenya.

Amaru, S. and Chhetri, N.B. (2013). Climate Adaptation: Institutional Response to Environmental Constraints, and the Need for Increased Flexibility, Participation and Integration of Approaches. *Applied Geography*, 39: 128-139.

Anaglo, J.N., Boateng, S.D. and Boateng, C.A., (2014). Gender and access to agricultural resources by smallholder farmers in the Upper West Region of Ghana. *Journal of Education and Practice*, 5(5), 13-19.

Antwi-Agyei, P., Fraser, E.D.G., Dougill, A.J., Stringer, L.C. and Simelton, E., (2012).Mapping the vulnerability of crop production to drought in Ghana using rainfall, yield and socioeconomic data. *Applied Geography*, 32,324-334.

Antwi-Agyei, P., Stringer, L.C. and Dougill, A.J. (2014). Livelihood adaptations to climate variability: Insights from farming households in Ghana. Regional Environmental Change. 14 (4), 1615-1626. https://doi.org/10.1007/s10113-014-0597-9.

Antwi-Agyei, P., Dougill, A.J., and Stringer, L.C. (2015). Barriers to climate change adaptation: Evidence from North East Ghana in the context of a systematic literature review. Climate and Development. 7 (4), 297-309. https://doi.org/10.1080/17565529.2014.951013.

Antwi-Agyei, P., Abalo, E. M., Dougll, A. J. and Baffour, F. (2021). Motivations, enablers, and barriers to the adoption of climate-smart agricultural practices by smallholder farmers; evidence from the transitional and savanna agroecological zones of Ghana. Reg. sustain. 2 (4), 375-386. https://doi.org/10.1016/j.regsus.2022.01.005.

Apata, T. G. (2011). Factors influencing the perception and choice of adaptation measures to climate change among farmers in Nigeria. Evidence from farm households in southwest Nigeria. Environ Econ. 2:74-83.

Apata, T.G., Agboola, T.O., Kehinde, A.S.L., and Sanusi, R.A. (2011b). Economic Impacts of Climate Change on Nigerian Agriculture and Adaptation Strategies Response among

Farming Households in Nigeria, *Journal of Agricultural Science and Technology*, Vol. 5, No.2 (Serial No. 33), pp. 203-214.

Armah, D. O., Yawson, G. T., Yengoh, J.O. and Odoi, E.K. (2010). Impact of floods on livelihoods and vulnerability of natural resource development communities in Norhtern Ghana. Water, 2 (2) (2010), pp. 120-139.

Aroka, N. (2010). Rainwater Harvesting in Rural Kenya. Reliability in a Variable and Changing Climate.Master‘s thesis. Physical Geogr. Quaternary Geol. 45 HECs.

Arora, N. K. (2019). Impact of Climate Change on Agriculture Production and its Sustainable Solutions. Environmental Sustainability (2019). Vol. 2, pp 95-95. https//doi/10.1007//s42398-019-00078-w.

Asafu-Adjaye, J. (2014). The Economic Impacts of Climate Change on Agriculture in Africa. Oxford University Press. Journal of African Economies, Vol. 23, AERC Supplement 2, pp. ii17–ii49

Asmamaw, I. ., Mohammed, A. A., and Lulseged, T. D. (2011). Land use/cover dynamics and their effects in the Gerado Catchment, North-eastern Ethiopia. International Journal of Environmental, 68, 883-900.

Awinda, D.O. (2014). Assessment of Environmental Impacts of Irrigation on Sustainable Food Production by Smallholder Farmers in Gem Rae Irrigation Scheme. Published MSc Thesis. Kabarak University Journal of Research and Innovation. Kabarak University, Kenya.

Aymone, G. G. (2009). Understanding farmers’ perceptions and adaptation to climate change and variability: The case of the Limpopo basin, South Africa. IFPRI Discussion paper 00849: 3. International Food Policy Research Institute: Washington DC.

Azuma, S. B., ZAkaria, A., Yegbemery, R. N., Apalogta, P. A., Dgar, V. and Mahama, A. (2022). Climate smart production, gross income and downstream risk characterization of rice farmers in Ghana. J. Agric. Stud. 10 (2). 13-35. https://doi.org/10.5296/jas.v10i2.19495.

Badiger, S. (2010). “Integrated Modeling Framework for Assessing Impacts of Changes in Land-use and Climate on Hydrologic Regimes and Water Distribution”, presentation made at SANDEE, MSE and MSSRF Workshop on *Economics of Climate Change Adaptation*, during 12-13 February, Madras School of Economics, Chennai.

Bandiera, O. and Rasul, L. (2006). Social networks and technology adoption in northern Mozambique. Econ. J. 116 (514), 869-902.

Barasa, B.M.O., Otengi, S.B.B. and Wakhungu, J.W. (2015b). Farmer awareness of Climate Change and Variability in Kakamega County, Kenya. The International Journal of Science and technology, Vol 3 No. 7.

Belay, A., Recha, J. W., Woldeamanuel, T. and Morton, J. F. (2017). Smallholder farmes' adaptation to climate change and determinants of their adaptation decisions in the Central Rift Valley of Ethiopia. Agric & Food Secu (2017) 6: 24. Doi10.1186/s40066-017-0100-1

Below T., Mutabazi K., Kirschke D., Franke C., Sieber S., Siebert R. and Tscherning K. (2012). Can farmers' adaptation to climate change be explained by socioeconomic household-level variables? Global Environ. Change, 22 (2012), pp. 223–235

Below, T., Artner, A., Siebert, R., and Sieber, S. (2010). Micro-level Practices to Adapt to Climate Change for African Small-scale Farmers: A Review of Selected Literature IFPRI Discussion Paper 00953. International Food Policy Research Institute: Washington DC.

Bernier, Q., Meinzen-Dick, R., Kristjanson, P., Haglund, E., Kovarik, C., Bryan, E., Ringler, C., Silvestri, S., (2015). Gender and Institutional Aspects of Climate-Smart Agricultural Practices: *Evidence from Kenya*. CCAFS Working Paper No. 79. CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Copenhagen, Denmark.

Berry, P., Sanchez-Aralla, A., Bette, R., Harrison, P. (2017). Highland climate change in Europe: Impacts, Vulnerability and Adaptation.

Bhardwaj, P. (2019). Types of sampling in research. *Journal of the Practice of Cardiovascular Sciences, 5*(3) 157-168.

Birkmann, J., Sauter, H., Garschagen, M., Fleischhauer, M., Puntab, W., Klose, C., Buter, B., Gottsche, F., Laranjeira, K., and Muller, J. (2021). New methods for local VulnerabilityScenanarios to heat stress to inform urban planning: Case study city of Ludwigsburg/Germany. Clim Change. 165 (1): 1-20.doi:10.1007/s10584-021-03005-3.

Boudon, R. (2001). The origin of values: Sociology and Philosophy of Beliefs.

Boyd, E., Eornforth, R.J., Lamb, P.J., Tarhule, A., and Brouder, A., 2013. Building resilience to face recurring environmental crisis in African Sahel. *Nature Climate Change*, 3, 631–637. doi:10.1038/nclimate1856

Bradshaw, B., Dolan, H. and Smit, B. (2004). Farm-level adaptation to climatic variability and change: Crop Diversification in the Canadian Priaries. Climatic Change, Vol. 67 No. 1, pp 119-141.

Bravo, M. T. (2009). Voices from the Sea Ice: The Reception of Climate Impact Narratives. J Histor. Geog. 35, 256-278.

Brink, E. and Wamsler, C. (2019). Citizen engagement in climate adaptation: The role of Values, Worldviews, Gender and Place. Journal of cleaner Production 209, 1342-1353.

Brown, J.D. (2002): *Reliability, Testing and Evaluation*. SIG Newsletter, Vol.6 No.1 of February 2002. Available online at http://www.jatt.org/test/bro-13 htm

Bryan, E., Deressa, T.T., Gbetibouo, G.A., and Ringler, C., (2009). Adaptation to climate change in Ethiopia and South Africa: options and constraints. *Environmental Science Policy* 12, 413–426.

Bryan, E., Ringler, C., Okoba, B., Roncoli, C., Silvestri, S. and Herrero, M. (2013). Adapting Agriculture to Climate Change in Kenya: Household Strategies and Determinants. Journal of Environmental Management 114, 26-35.

Bryan, E., Ringler, C., Okoba, B., Roncoli, C., Silvestri, S. and Herrero, M. (2011). Adapting Agriculture to Climate Change in Kenya: Household Strategies and Determinants. Research Report, World Bank, Washington, DC.

Bunyavanich, S., Landriga, C. P., McMichael, A. J. and Epstein, P. R. (2003). The Impact of climate change on child health. Ambulatory Pediatrics, 3(1):44-52.

Burch, S. (2010). In pursuit of resilient, low carbon communities: An examination of barriers to action in three Canadian Cities. Energy policy, 38, 7575-7585.

Burch, S. and Robinson J. (2007). A framework for explaining the Links between Capacity and Action in Response to Global Climate Change. Climate Policy 7, pp. 304 – 316.

Casely D.J. and Kumar K. (1988). Project Management and Evaluation in Agriculture. John Hopkins University Press. Baltimore.

Challinor, A., Wheeler, T., Garforth, C., Craufurd, P., and Kas-sam, A. (2007). Assessing the vulnerability of food crop sys-tems in Africa to climate change. *Climatic Change,* 83(3) 381-399. doi:10.1007/s10584-007-9249-0.

Chisadza, B.; Tumbare, M.J.; Nyabeze, W.R.; Nhapi, I. (2015). Linkages between local knowledge drought forecasting indicators and scientific drought forecasting parameters in the

Limpopo River Basin in Southern Africa: In *International Journal of Disaster Risk Reduction*, Vol. 12, pp. 226–233.

Claessens, L., Autle, J. M., Stoorvogel, J. J., Valdivia, R. O., Thornton, P. K., and Herrero, M. (2012). A method for Evaluating Climate Change Adaptation Strategies for Small-scale Farmers using Survey, Experimental and Modeled Data. Agricultural Systems 47, 395-410.

Clay, N. and King, B. (2019). Smallholders' unseen capacities to adapt to climate change amid Africa's green revolution: Case study of Rwanda's crop intensification Program. World Dev. 116: 1-14.doi: 10-1016/j.worlddev.2018.11.022.

Coe, R. and Stern, R.D., (2011). Assessing and Addressing Climate-induced Risk in sub-Saharan rainfed agriculture: Lessons Learned. *Expermiental Agriculture* 47, 395–410.

Cohen, S. (2001). States of Denial: Knowing about Atrocities and Suffering. Polity, Press. Bridge Street, Cambridge CB2 1UR, UK.

Cohen, S., Demeritt, J., Robinson, J., and Rothman, D. (1998) Climate change and sustainable development: towards dialogue. Glob Environ Change 8(4):341–371

Comoé, H., and Siegrist, M., (2015). Relevant drivers of farmers' decision behavior regarding their adaptation to climate change: a case study of two regions in Côte d'Ivoire. Mitigation and Adaptation Strategies for Global Change 20, 179–199.

Connolly-Boutin, L. and Smit, B. (2015). Climate change, food security and livelihoods in Sub-Saharan Africa. Regional Environmental Change, Vol. 26 No 2, pp 385-399, doi.org/10.1007/S 10113-015-0761-X.

Cooper, D.E. and Palmer, J.A., (1998). Spirit of the Environment: Religion, value, and environmental concern. Routledge, London.

County Government of Homa Bay (2021). County Government of Homa Bay Climate Change Policy (Kenya): 2021. Homa Bay, Kenya.

County Government of Homa Bay (2023). County Government of Homa Bay Climate Change Action Plan (Kenya): 2023-2027 Homa Bay Kenya.

Cozby, P.C. (2003). Methods of behavioural research. 7th ed. McGraw-Hill Companies, Inc., 1221 Avenue of the Americas, new York, NY,10020.

Crate, S. A. (2008). Gone the bull of winter? Grappling with the cultural implications of and anthropology's role(s) in global climate change. *Curr. Anthropol*. **49,** 569–595 (2008).

Creswell, J.W and Plano, C.V.L. (2011). Designing and Conducting Mixed Methods Research.

Creswell, J.W. (2014). Research Design: Qualitative, Quantitative and Mixed Method Approaches (4thEd.).Thousand Oaks: CA: Sage Publications

Cullen, A. C. and Anderson, C. L. (2016). Perceptions of Climate risk among rural farmers in Vietnam: Consistency within households and with the empirical record. Risk Analys 36 (6), 1-15.

Damnyag, L., Mwinkom, F. X. K., Abugre, S. and Alhassan, S. I. (2021). Factors influencing climate change adaptation strategies in North-Western Ghana: Evidence of farmers in the Black Volta Basin in upper West region. SN Applied Sciences (2021) 3:548. https://doi.org/10.1007/s42452-021-04503-w.

Danglova, O. (1995). Rural-community in the Process of Socioeconomic Changes. Colleg. Antropol 19, 129–144.

Davies, D., (1994). Christianity: In J. Holm & J.W. Bowker (eds.), *Attitudes to nature*, pp. 28–52, Pinter, London.

Defiesta, G. D. and Rapera, C. L. (2014). Measuring adaptive capacity of farmers to climate change and variability: Application of a composite index to an agricultural community in the Philippines. J. Environ. Manage., 17 (2) (2014).

Deressa, T.T., Hassan, R.M., Ringler, C., Alemu, T., and Yesuf, M. (2009). Determinants of farmers' choice of adaptation methods to climate change in the Nile Basin of Ethiopia. *Global Environmental Change* 19, 248–255.

Devine-Wright, P. (2009). Rethinking Nimbyism: The role of Place Attachment and Place Identity in explaining Place-protective Action. J. Commun. Appl. Soc. Psychol. 19, 426–441.

Dixon, J., Gulliver, A. and Gibbon, D. (2001). *Farming systems and poverty: improving farmers' livelihoods in a changing world*, Rome and Washington, D.C.: FAO and World Bank.

Dixon, J., Stringer, L., and Challinor, A., (2014). Farming System Evolution and Adaptive Capacity: Insights for Adaptation Support. *Resources* 3, 182–214.

Douglas, M. and Wildavsky, A. (1982). Risk and culture: An Essay on the Selection of Technological and Environmental Dangers. University of California Press.

Eakin, H., Bojorquez-Tapia, L. A., Diaz, R. M., Castellanos, E. and Haggar, J. (2011). Adaptive capacity and social-environmental change: Theoritical and operational modeling of smallholder coffee systems response in Mesoamerican Pacific Rim. Environ. Manage, 47 (3), pp 352-367.

East African Community (EAC), (2011). The East African Community Climate Change Policy, 2011. East African Community Secretariat. Arusha, Tanzania.

Ebhuoma, E. E. and Simatele, D. m. (2019). "We know our terrain." Indigenous knowledge preferred to scientific systems of weather forecasting in the Delta state of Nigeria. Climate and Development, 11(2); 112-123. https://doi.org/10.1080/17565529.2017.1374239.

Eckstein D., Kunzel, V. and Schafer, L. (2017). *Global Climate Risk Index 2018: Who Suffers Most from Extreme Weather Events? Weather-related Loss Events in 2016 and from 1997 to 2016*. Bonn: Germanwatch.

Edwards, D., (2007). Ecology at the heart of faith. Orbis Books, New York.

Egeru, A. (2012). Role of indigenous knowledge in climate change adaptation: A case study of the Teso Sub-region, Eastern Uganda. Indian J Tradit Knowl 11: 217-224.

Egyir, I. S., Ofori, K., Antwi, G. and Ntiamon-Baidu, Y. (2015). Adaptive Capacity and Coping Strategies in the face of Climate Change: A comparative study of communities around two protected areas in the coastal and transitional zones of Ghana. J. Sustainable Dev., 8 (1) 2015, pp. 1-15.

Ehiakpor, D.S., Danso-Abbeam, G., and Mubashiru, Y., (2021). Adoption of interrelated sustainable agricultural practices among smallholder farmers in Ghana. Land Use Policy 101, 105142. doi: 10.1016/j.landusepol.2020.105142 .

Emergency Events Database (EED), (2015). The International Disaster Database. Brussels: Centre for Research on Epidemiology of Disaster. University of Louvain.

Escobar, A. (2001). Culture sits in places: Reflections on globalism and subaltern strategies of localization. Polit. Geogr. 20, 139–179.

Fadina, R. and Barjole, D. (2018). Farmers' Adaptation Strategies to Climate Change and Their Implications in the Zou Department of South Sudan. Environments. Vol 5(15).

Fagariba, C. J., Song, S. and Soule-Baoro, S. K. G., (2018). Climate change adaptation strategies and constraints in Northern Ghana: Evidence of farmers in Sissala West District. Sustainability, 10 (5), 1484. https//doi.org/10.3390/su/0051484.

Fankhauser, S., and Burton, I. (2011). Spending adaptation money wisely Centre for Climate Change Economics and Policy. Centre for Climate Change Economics and Policy 47:1-22.

FAO, IFAD, UNICEF, WFP and WHO (2018). The State of Food Security and Nutrition in the World 2018. Building Climate Resilience for Food Security and Nutrition. Rome, FAO.

Food and Agriculture Organisation (FAO), (2021). The gender dimensions of Climate Change: Insights for Rural Women and Agricultural Production. FAO Policy Brief. Rome, Italy.

Food and Agriculture Organisation (FAO). (2019). Adaptation to Climate Change in Agriculture, Forestry and Fisheries. Monitoring and Evaluation of Climate Change Adaptation in Agricultural Sectors. Rome, Italy.

FAO (2015). Climate Change and Food Systems: Global Assessments and Implications for Food Security and Trade. Food, Agriculture Organization of the United Nations (FAO), Rome.

FAO. (2013). Submissions by the Food and Agriculture Organization on the Support to Least Developed and Developing Countries in the National Adaptation Plan Process Regarding the Integration of Agriculture, Fisheries and Forestry Perspectives. FAO, Rome, Italy.

FAO. (2012). Factsheet: Smallholders and family farmers. Available at http://www.fao.org/nr/sustainability/fact-sheets: accessed on 2 November 2015.

FAO. (2005). Impact of Climate Change, Pests and Diseases on Food Security and Poverty Reduction. *Special event background document for the 31st Session of the Committee on World Food Security*. Rome. 23-26 May 2005.

Felladam, D. and Agana, G. (2021). Socioeconomic factors influencing farmers' specific adaptive strategies to climate change in Talensi District, Ghana. Journal of Ecofeminism and Climate Change. Vol 2, No 2, pp 50-68. Emerald Publishing Limited.

Feola, G., Lerner, A.M., Jain, M., Montefrio, M.J.F. and Nicholas, K.A. (2015). Researching farmer behaviour in climate change adaptation and sustainable agriculture: Lessons learned from five case studies. *Journal of Rural Studies*. **39**, 74–84.

Field, D. R. and Burch, W. R. J. (1988). *Rural Sociology and the Environment* (Greenwood, 1988).

Fineup-Riordan A, and Rearden A. (2010). The ice is always changing: Yup'ik understandings of sea ice, Past and Present. In: Krupnik I, AportaC, Gearheard S, Laidler G.J, Holm L.K,

(eds) SIKU: Knowing Our Ice: Documenting Inuit Sea Ice knowledge and Use. Springer, Berlin, pp 303-328.Centre Working Paper (2013)

Fisher, M., Abate, T., Lunduka, R.W., Asnake, W., Alemayehu, Y. and Madulu, R.B., (2015). Drought tolerant maize for farmer adaptation to drought in sub-Saharan Africa: Determinants of adoption in eastern and southern Africa. *Climatic Change*, 133(2), 283-299. https://doi.org/10.1007/s10584-015-1459-2.

Fisher, M., Habte, E., Ekere, W., Abate, T., & Lewin, P. A. (2019). Reducing gender gaps in the awareness and uptake of drought-tolerant maize in Uganda: The role of education, extension services and social networks. *Journal of Gender, Agriculture and Food Security (Agri-Gender), 4*(302-2020-394), 38-50. DOI: 10.22004/ag.econ.301197

Fishman, M. and Jain, A. (2013). Groundwater depletion, adaptation and mitigation: Evidence from Gujarat, India. International Growth

Flora, J. L. (1998). Social capital and communities of place. *Rural Sociol*. **63,** 481–506

Force, J. E., Machlis, G. E., Zhang, C. and Kearney, A. (1993). The relationship between timber production, local historical events, and community social change: A quantitative case study. Forest Sci. 39, 722–742.

Forward, M. and Alam, M., (1994). Islam: In J. Holm & J.W. Bowker (eds.), *Attitudes to nature*, pp. 79–100, Pinter, London.

Fosu-Mensah, B. Y., Vlek P. L. G., and Manschadi, A. M. (2010). Farmers' Perceptions and Adaption to climate Change: A Case Study of Sekyedumase District in Ghana. Centre for Development Research, University of Bonn.

Fox, P., Rockström, J., and Barron, J., (2005). Risk analysis and economic viability of water harvesting for supplemental irrigation in semi-arid Burkina Faso and Kenya. *Agricultural Systems* 83, 231–250.

Fraenkel.J.R. and Wallen, N.E. (2000): *How to Design and Evaluate Research in Education*, New York, NY: Mc Graw-Hill Publishing Co.

Frank, J., and Penrose, B. (2012). Small-scale Farmers and Climate Change. How can Farmer Organisations and Fair-trade build the Adaptive Capacity of Smallholders?

Fried, M. (2000). Continuities and discontinuities of place. J. Environ. Psychol. 20, 193–205.

Fussel, H. M. (2007). Vulnerability: A generally Applicable Conceptual Framework for Climate Change Research. Global Environmental Change 17, pp. 155 -167.

Fyefe, A. (2002). Bitter Harvest, Child Labour in Agriculture. Geneva: International Labour Organization.

Gallopín, G.C., (2006). Linkages between vulnerability, resilience, and adaptive capacity. *Global Environmental Change* 16, 293–303.

Gandure, S., Walker, S. and Botha, J.J. (2013), Farmers' perceptions of adaptation to climate change and water in a South African rural community, *Environment Development*, Vol. 5 No. 1, pp. 39-53.

Garrett, B. L. (2010). Drowned memories: The submerged places of the Winnemem Wintu. *Archaeologies*, **6,** 346–371.

Garschagen, M., Doshi, D., Reith, J. and Hagenlocher, M. (2021). Global patterns of disaster and climate risk-an analysis of the consistency of leading index-based assessments and their results. Clim Change. 169 (1): 1-19.doi:10.10.1007/s10584-021-03209-7.

Garcia de Jalon, S., Silvstri, S. and Barnes, A. P. (2017). The potential for adoption of climate smart agricultural practices in Sub-saharan livestock systems. Reg. Environ. Change 17 (2), 399-410. https://doi.org/10.1007/s10113-016-1026-2.

Gawel, E., Heuson, C., and Lehmann, P. (2012). Public choice perspective on climate change. Helmholtz-Zentrum 4:1-10.

Gbetibouo, G. A. (2009). Understanding Farmers' Perception and Adaptations to climate change and Variability. Washington, DC: International Food Policy Research Institute Discussion paper No 849. 36p.

Gbetibouo, G. A. Hassan, R., and Ringler, C. (2024). Cultural resistance to climate adaptation: Exploring barriers in rural communities. Global Environmental Change, 85, 102341.

Gilchrist, Grant, Mark M., and Flemming M. (2005). Can Local Ecological Knowledge Contribute to Wildlife Management? Case Studies of Migratory Birds. *Ecology and Society* 10, no. 1: 20.

Gilligan, J., Jadie, C. P., Joel, E. R., Karin, J., Robin, G., Tyler G., Ginger, A., Joel, H., and Ryan, B. (2006). The Value of Integrating Traditional, Local and Scientific Knowledge in Climate Change: *Linking Traditional and Scientific Knowledge.* eds. Riewe R. R. and Oakes J. E., 3-12. Manitoba: Aboriginal Issues Press.

Girot P, Ehrhart C, Oglethorpe J, Rossing T, Gambrelli G, Jeans H, Martin S, and Philips J. (2011). Integrating Community and Ecosystem-based Approaches in Climate Change Adaptation Responses. Ecosystems and Livelihoods Adaptation Network (ELAN), P.19pp.

Glenn I. D. (1992). Sampling the evidence of Extension Program Impact. Program Evaluation and Organizational Development, IFAS, University of Florida. Available online at http://www.sampling/pd006.htm

Gould, B. W., Saupe, W. E., and Klemme, R. M. (1989). Conservation tillage: The role of farm and operation characteristics and the perception of soil erosion. Land Economics 6:167-182.

Gowda, P. H., Steiner, J. L., Grusak, M. A., Bogess, M. V. and Farrigan, T. (2018). Chapter 10: Agriculture and Rural Communities. In: Impacts, Risks and Adaptation in the United States: Fo National Climate Assessment, Vol. II. US Global Change Research program, Washington DC, pp 391-437.

Grace D, Bett B, Lindahl J, and Robinson T., (2015). Climate and Livestock Disease: assessing the vulnerability of agricultural systems to livestock pests under climate change scenarios. CCAFS Working Paper No. 116. Copenhagen, Denmark: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS).

Green D, and Raygorodetsky G. (2010). Indigenous Knowledge of a Changing Climate. Clim Chang 100: 239-242.

Grothmann, T. and Patt, A. (2003). Adaptive capacity and human cognition prepared for presentation at the open meeting of the global environmental change research Community, Montreal, Canada, 16-18 October, 2003. Global Environmental Change 15:16-18.

Guerra, C. A., Gikandi, P. W., Tatem, A. J. et al. (2008). The limits and intensity of *Plasmodium falciparum* transmission: Implications for Malaria control and elimination Worldwide. PLoS Med, 5 (2): e38.

Guiteras R. (2009). The Impact of Climate Change on Indian Agriculture. Department of Economics, University of Maryland, College Park, MD (2009)

Gyampoh and Asante (2011). Mapping and determining indigenous Kwoledge in Climate Change Adaptation in Ghana. Research Gate, doi; 10.13140 IRG. 2.1.4818.6640.

Hanna, J.M. (2007). Native Communities and Climate Change: Legal and Policy Approaches to Protect Tribal Legal Rights. Boulder: University of Colorado School of Law.

Hansen J.W., Baethgen W., Osgood D., Ceccato P. and Ngugi R.K. (2007). Innovations in climate risk management: protecting and building rural livelihoods in a variable and changing climate J. Semi-Arid Trop. Agric. Res., 4 (2007), pp. 1–38.

Harvell, C. D., Mitchell, C. E., Ward, J. R. et al. (2002). Climate Warming and disease risks for terrestrial and marine biota. Science, 296 (5576): 2158-62.

Harvey, C. A., Rakotobe, Z. L., Rao, N. S., Dave, R., Razafimatratra, H., Rabarijohn, R. H., Rajaofara, H., and Mackinnon, J. L., (2014). Extreme Vulnerability of Smallholder Farmers to Agricultural Risks and Climate Change in Madagascar. Philos. Trans. R. Soc. B: Biol. Sci 369, 20130089.

Hays, S. (1994). Structure and Agency, and the Stickey Problem of Culture. Social. Theory 12, 57-72.

Hennink, M. M., Kaiser, B. N., and Marconi, V. C. (2015). Code Saturation versus meaning Saturation: How many interviews are enough? Qual Health Res; 27(4): 592-608.

Herath T, Rao HR (2009). Protection motivation and deterrence: a framework for security policy compliance in organisations. European Journal of Information Systems 18(2):106-125.

Hernandez, B., Martín, A. M., Ruiz, C. and Hidalgo, M. C. (2010). The role of Place Identity and Place Attachment in breaking Environmental Protection Laws. J. Environ. Psychol. 30, 281–288.

Herrero, M., Ringler, C., van de Steeg, J., Thornton, P., Zhu, T., Bryan, E., Omolo, A., Koo, J., and Notenbaert, A. (2010). Climate Variability and Climate Change and Their Impacts on Kenya's Agriculture Sector. International Livestock Research Institute.

Herrero, M., Thornton, P.K., Bernués, A., Baltenweck, I., Vervoort, J., van de Steeg, J., Makokha, S., van Wijk, M.T., Karanja, S., Rufino, M.C., and Staal, S.J., (2014). Exploring future changes in smallholder farming systems by linking socioeconomic scenarios with regional and household models. Global Environmental Change 24, 165–182.

Hess, J. J., Malilay, J. N. and Parkinson, A. J. (2008). Climate change: The importance of place. Am. J. Prevent. Med. 35, 468–478.

Hidalgo, M. C. and Hernandez, B. (2001). Place attachment: Conceptual and empirical questions. *J. Environ. Psychol*. **21,** 273–281.

https://www.ipcc.ch/ipccreports/tar/wg2/pdf/wg2TARchap18.pdf

Hulme, M. (2008). The Conquering of climate: Discourses of Fear and their Dissolution. Geogr. J. 174, 5-16.

Hulme, M. (2009). Why we disagree about Climate Change. Cambridge University Press.

Hunn, E. (1993). What is traditional ecological knowledge? In: Williams N, Baines G (eds) Traditional ecological knowledge: wisdom for sustainable development. Centre for Resource and Environmental Studies, ANU, Canberra, pp 13–15.

Huq, S., Karim, Z., Asaduzzaman, M. and Mahtab, F. (1999). (eds.). Vulnerability and Adaptation to Climate Change in Bangladesh. J. Kluwer Academic Publishers, Dordrecht, The Netherlands, 147 pp.

IAC (Inter Academy Council) Report (2004). *Realizing the promise and potential of African agriculture*, Royal Netherlands Academy of Arts and Sciences, NL-1000 GC Amsterdam, The Netherlands.

Ibrahim, A. (2014). Gendered analysis of the determinants of adaptive capacity to climate change among smallholder farmers in Meatu and Iramba Districts, Tanzania. Sokoine University of Agriculture, Tanzania.

IFAD (International Fund for Agricultural Development), (2010). Livestock and climate change. In, Iglesias, A., Avis, K., Benzie, M., Fisher, P., Harley, M., Hodgson, N., Horrocks, L., Moneo, M., Webb, J., (2007). Adaptation to climate change in the agricultural sector. Energy & Environment and Universidad de Politécnica de Madrid.

Ifinedo P (2012). Understanding information systems security policy compliance: An integration of the theory of planned behavior and the protection motivation theory. Computer and Security 13(1):83-95.

Igor, K. (2005). Attachment and identity as related to a place and its perceived climate. J. Environ. Psychol. 25, 207–218.

Ihemezie, E. J., Onunka, C. N. and Nnaji, A. P. (2018). Drivers and Socioeconomic factors influencing individual and household adaptation to climate change: a case study of residents of Leeds, UK. Dev. Agri Econom. 10 (9): 279-291.

IISD (International Institute for Sustainable Development), (2007). Community based adaptation to climate change Bulletin. A Summary of the Second International Workshop on Community-Based Adaptation to Climate Change. IISD Reporting Services.

ILO (International Labour Organization), (2018). *World Employment and Social Outlook 2018: Greening with jobs* (Geneva, Switzerland).

ILO, (2017c). *Decent work for indigenous and tribal peoples in the rural economy*, Decent Work in the Rural Economy: Policy Guidance Notes (Geneva, Switzerland).

IPBES (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services) (2018). In: Archer, E., Dziba, L. E., Mulongoy, K. J., Maoela, M. A., Walters, M., Biggs, R., Cornier-Salem, M. C., DeClerk, F., Diawo, M. C., Dunham, A. E., Failler, P., Gordon, C., Harshash, K. A., Kazito, F., nyingi, W. D., Oguge, N., Osman-Elasha, B., Stringer, L. C., Tito de Morais, L., Assogbajo, A., Egoh, B. N., Halomy, M. W., henbach, K., Mensah, A., Pereira, L., and Sitas, N. (Eds). Summary for Policy makers of the regional assessment report on biodiversity and ecosystem services for Africa of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, IPBES Secretariat, Bonn, Germany, p. 49.

IPCC (2001) Climate Change 2001: The Scientific Basis. Climate Change 2001: The Scientific Basis P 881.

IPCC (2001). Climate Change 2001: Impacts, Vulnerability and Adaptation. *Contribution of Working Group III to the Third Assessment Report on the Intergovernmental Panel on Climate Change.* Cambridge University Press, Cambridge.

IPCC (2002). Climate change and biodiversity. In: Gitay, H., Suarez, R. T., Watson, D. J. IPPC Technical Paper V.

IPCC (2007). Climate Change 2007: *The Physical Science Basis (Summary for Policy)*, IPCC, Geneva.

IPCC (2007). Climate Change: Synthesis Report. Contribution of Working Groups I, II, and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. IPCC, Geneva.

IPCC (2010). Climate Change: The role of the IPCC and key elements of the IPCC Assessment Process. Contributions of Working Groups I, II, III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. IPCC, Geneva.

IPCC (2012). Climate Change 2012. Summary for Policy Makers. In: Managing the Risks of extreme Events and Disasters to Advance Climate Change Adaptation. A special Report of

Working Groups I and II of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK and New York. NY, USA, pp 1-19.

IPCC (2014a). Climate Change 2014. Impacts, Adaptation and Vulnerability. Part b: Regional Aspects; Contribution of Working Group 11 to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, New York, P. 688.

IPCC (2014b). Fifth Assessment Report-climate Change 2014: impacts, adaptation and vulnerability, IPCC, accessed at www.ipcc.ch/report/ars/wgz/.

IPCC (2021). Climate change 2021: The Physical Science Basis. Contributions of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press.

IPCC (2022). Climate change 2022: Impacts, Adaptation and Vulnerability. Contributions of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press.

Isaac M. (2012). Agricultural information exchange and organizational ties: the effect of network topology on managing agro-diversity. Agric. Syst., 109 (2012), pp. 9–15

Jackson, L., Van Noordwijk, M., Bengtsson, J., Foster, W., Lipper, L., Pulleman, M., Said, M., Snaddon, J., and Vodouhe, R., (2010). Biodiversity and Agricultural Sustainability: from Assessment to Adaptive Management. Curr. Opin. Environ. Sustain. 2, 80-87.

Jarvis A., Lau C., Cook S., Wollenberg E., Hansen J., Bonilla O. and Challinor A. (2011). An integrated adaptation and mitigation framework for developing agricultural research: synergies and trade-offs. Exp. Agric., 47 (2011), pp. 185–203.

Jenkins, W., Berry, E. and Kreider, L. B. (2018). Religion and Climate Change. Annual Review of environment and Resources 43, 85-108.

Jin, H., Wang, X., and Li, Z. (2023). Socioeconomic Determinants of Climate Change Adaptation Strategies in Small Scale Agriculture. Climate Policy, 23(4), 567-583.

Johnstone B.R. (2012). Water, cultural diversity and global environmental change: emerging trends, sustainable futures? United Nations Educational Scientific and Cultural Organization (UNESCO), Paris.

Jones, L. and Boyd, E. (2011). Exploring social barriers to adaptation: insights from Western Nepal. Global Environmental Change 21 (4), 1262e1274.

Jones, L., Ludi, E., and Levine, S. (2010). Towards a Characterization of Adaptive Capacity: A Framework Analyzing Adaptive Capacity at the Local Level. ODI Background Notes December 2010. Overseas Development Institute, London.

Jose, S. (2009). Agroforestry for ecosystem services and environmental benefits: An overview. Agrofor. Syst. 76, 1-10.

Justin, C. O., Williams, C. E. and Vera, T. S. (2017). Understanding the factors affecting adoption of Sub-packages of CSA in Southern Malawi. Int. J. agric. Econ. Extens. 5 (2), 259-265.

Kabubo-Mariara, J. (2008). Global Warming and Livestock Husbandry in Kenya: Impacts and Adaptations. *Ecological Economics* 68: 1915-1924.

Kahan, D. M., Jenkins-Smith, H., and Braman, D. (2021). Cultural cognition of scientific consensus on climate change. Nature Climate Change, 11(4)**,** 296–302.

Kalanda-Joshua, M., Ngongondo, C., Chipeta, L. and Mpembeka, F. (2011). Integrating indigenous knowledge with conventional science: Enhancing localized climate and weather forecasts in Nessa, Mulanje, Malawi. Physics and Chemistry of the Earth, Parts A/B/C, Vol. 36, pp. 996–1003.

Kandlinkar, M and Risbey, J, (2000). Agricultural impacts of climate change: If adaptation is the answer, what is the question? Climatic Change 45, 529–39.

Kassa, B. A., and Abdi, A. T. (2022). Factors influencing the adoption of climate-smart agricultural practices by small-scale farming households in Wondo genet, Southern Ethiopia. Sage Open 12 (3). https://doi.org/10.1177/2158, 2440221121604

Kassie, M., Jalet, M., Shiferaw, B., mmbando, F and Mulugetta, M. (2013). Adoption of interrrlated sustainable agricultural practices in smallholder system: Evidence from rural Tanazania. Technol. Forcast. Soc. Chang. 80, 525-540.

Kathuri, N.J. and Pals, D.A. (1993). *Introduction to Educational Research*. Egerton University, Njoro, Kenya; Education Materials Centre, Kenya.

Kelly, P. M. and Ager, W. N. (1999). Theory and Practice in Assessing Vulnerability to Climate Change and Facilitating Adaptation. Climate Change 2000; 47: 325-52

Kenya Metrological Department (KMD). (2018). Review of rainfall during March to May 2018. Long rain season and the outlook of June-July-August 2018. Ministry of Environment and Forestry. Nairobi Kenya.

Kenya National Bureau of Statistics (KNBS) and United Nations Children's Fund (UNICEF). (2013). Homa Bay County Multiple Indicator Cluster Survey 2011. Nairobi: KNBS and UNICEF.

Kimaru-Muchai, S.W., Ngetich, F.K., Baaru, M., and Mucheru-Muna, M.W., (2020). Adoption and utilisation of Zai pits for improved farm productivity in drier upper Eastern Kenya. J. Agric. Rural Dev. Trop. 121, 13–22. doi: 10.17170/kobra-202002281030 .

Kirsch, S. (2001). Lost worlds: Environmental disaster, 'culture loss', and the law. Curr. Anthropol. 42, 167–198 (2001).

Kithiia, J. (2011). Climate change risk responses in East African cities: need, barriers and opportunities. Current Opinion in Environmental Sustainability, 3(3), 176-180. Doi:org/10.1016/j.cosust.2010.12.002

Kollmair, M. and Gamper, S. (2002). The sustainable livelihoods approach. Input Paper for the Integrated Training Course of NCCR North-South Aeschiried. Development Study Group, University of Zurich, Switzerland.

Kothari C. R. (2004). Research Methodology: Methods and Techniques. 3rd Ed. New Age International (P) Ltd, New Delhi.

Kothari, C.R. (1990). *Research Methodology*: Methods and Techniques, 2nd Ed. New Age International (P) Limited Publishers, New Delhi.

Kpadonou, R.A.B., Owiyo, T., Barbier, B., Denton, F., Rutabingwa, F., and Kiema, A., (2017). Advancing climate-smart agriculture in developing drylands: Joint analysis of the adoption of multiple on-farm soil and water conservation technologies in West African Sahel. Land Use Policy 61, 196–207. doi: 10.1016/j.landusepol.2016.10.050.

Krueger, R. A. (1994). Focus Groups: A practical guide for applied research. Thousand Oaks, CA: Sage Publications Inc.

Krueger, R. A. and Casey, M. A. (2000). Focus groups; A practical guide for applied research, 4th ed. Thousand Oaks, CA: Sage Publications Inc.

Kuhn, K., Campbell-Ledrum, D. and Haines, A. (2005). Using climate to predict Infectious Disease Epidemics. World Health Organisation, Geneva Switzerland.

Kunreuther, H., and Kerjan, E.M. (2009). Encouraging Adaptation to Climate Change: Long- term flood insurance. Available at http://opim.wharton.upenn.edu/risk/library/RFF-IB-09-13.pdf

Kurgat, B. K., Lamanna, C., Kimaru, A., Namoi, N., Manda, L. and Rosenstock, T. S. (2020). Adoption of climate-smart agriculture technologies in Tanzania. Front. Sustain. Food Sys. 4, 55. https://doi.org/103389/fsufs.2020.00055.

Kurukulasuriya P., Mendelsohn R., Hassan R., Benhin J., Deressa T., Diop M., Eid H.M., Fosu K.Y., Gbetibouo G., Jain S., Mahamadou A., Mano R., Kabubo-Mariara J., El-Marsafawy S., Molua E., Ouda S., Ouedraogo M., Sene I., Maddison D., Seo S.N. and Dinar A. (2006). Will African agriculture survive climate change? World Bank Econ. Rev., 20 (2006), pp. 367–388.

Kusangaya, S., Warburton, M. L., van Garderen, E. A., and Jewitt, G. P., (2014). Impact of climate change on water resources in Southern Africa: A review, Physics and Chemistry of the Earth, 67 (1) 47-54. https://doi.org/10.1016/j.pcc.2013.09.014.

LaDuke W, Bob G., and Tom G. (2009). *Energy Justice in Native America: A Policy Paper for consideration by the Obama Administration and the 111th Congress.* Honor the Earth, Intertribal Council on Utility Policy, Indigenous Environmental Network, and International Indian Treaty Council.

Lal, R. (1995). Erosion – Crop Productivity Relationships for Soils of Africa. Soil science Society of America Journal, 59 (3): 661-667.

Lasco, R. D., Delfino, R. J., Catacutan, D. C., Simelton, E. S., and Wilson, D. M. (2014). Climate Risk Adaptation by smallholder farmers: The role of trees and agroforestry. Curr. Opin Eviron Sustain 6:83-88.

Lasco, R. D., Habito, M. S., Delfino, R. J., Pulhin, F. B. and Concepcion, R. G. (2011). Climate Change Adaptation Guide book for Smallholder Farmers in South East Asia. Philippines. World Agroforestry Centre.

Lavrakas, P. J. (2011). Eds. Encyclopedia of Survey Research Methods. Sage Publications, Inc. Available Online at http://dx.doi.org/10.4135/9781412963947. Viewed on 19-06-2017 at 5.27 pm.

Leal Filho, W., Matandirotya, N.R., Lütz, J.M., et al., (2021). Impacts of climate change to African indigenous communities and examples of adaptation responses. Nat. Commun. 12 (6224), 2021. https://doi.org/10.1038/s41467-021-26540-0.

Lewicka, M. (2010).What makes neighbourhood different from home and city? Effects of place scale on place attachment. *J. Environ. Psychol*. **30,** 35–51.

Lo, H., and Emmanuel T., (2013). The Influence of US Development Assistance on the Adaptive Capacity to Climate Change: Insights from Senegal. Oxfam America Research Backgrounder series.

Lobell, D. B., Schlenker, W., and Costa-Roberts J. (2011b). Climate Trends and Global Crop Production since 1980. Science 333:616-620.

Lobell, D.B., Bänziger, M., Magorokosho, C. and Vivek, B., (2011). Nonlinear heat effects on African maize as evidenced by historical yield trials. *Nature Climate Change*, 1(1), 42-45. Doi: 10.1038/nclimate1043.

Lowder, S. K., Skoet, J., and Raney, T. (2016). The number, Size and Distribution of farms, Smallholder farms and family farms worldwide. World Development, 87, 16-29

Mabe, F.N., Sarpong, D.B., and Osei-Asare, Y. (2012). Adaptive capacities of farmers to climate change adaptation strategies and their effects on rice production in the northern region of Ghana. Russian Journal of Agricultural and Socioeconomic Sciences.

Mabe, F. N, Sienso, G, and Donkoh, S. A. (2014). Determinants of choice of climate Change Adaptation Strategies in Northern Ghana.

Macchi, M. (2008). Indigenous and Traditional Peoples and Climate Change Issues. IUCN, 2008, (9).

Maddison, D. (2006). The perception of and adaptation to climate change in Africa. CEEPA Discussion Paper No. 10. Centre for Environmental Economics and Policy in Africa. University of Pretoria.

Mafongoya, P. and Ajayi, O. C. (2017). Indigenous Knowledge Systems and Climate Change Management in Africa, CTA, Wageningen.

Malesu, M. M., Sang, J. K., Oduor, A. R., Orodi, J., Odhiambo, J.O. and Nyabenge, M. (2006). Hydrologic impacts of ponds on land cover change: Runoff water harvesting in Lare. Kenya. Technical Report No. 32 Nairobi, Kenya: Regional Land Management Unit (RELMA-in-ICRAF), Netherlands Ministry of Foreign Affairs and Swedish International Development Cooperation Agency (Sida) 41p + xii includes bibliography.

Mango, N., Makate, C., Tamene, L., Mponela, P., and Ndengu, G., (2017). Awareness and adoption of land, soil and water conservation practices in the Chinyanja Triangle, Southern Africa. Soil Water Conserv. Res. 5, 122–129. doi: 10.1016/j.iswcr.2017.04.003 .

Marshall, N. A., Fenton, D. M., Marshall, P. A. and Sutton, S. (2007). How resource-dependency can influence social resilience within a primary resource industry. Rural Sociol. 72, 359–390.

Martey, E., and Kuwornu, J.K., 92021). Perceptions of climate variability and soil fertility management choices among smallholder farmers in Northern Ghana. Ecol. Econ. 180, 106870. doi.org/ 10.1016/j.ecolecon.2020.106870.

Mason L, white G, and Gea M. (2012). Listening and learning from traditional knowledge and western science: A dialogue on contemporary challenges of forest health and wildfire. J For 110:187:193.

Mbilinyi, B. P., Tumbo, S. D., Mahoo, H. F. Senkondo, E. M. and Hatibu, N. (2005). Indigenous knowledge as decision support tool in rainwater harvesting. *Physics and Chemistry of the Earth* 30 (11-16): 792–798.

Mburu, B. K., Kung'u, J. B. and Muruiki, J. N. (2015). Climate change adaptation strategies by small-scale farmers in Yatta District, Kenya. Afri. J. Environ. Sci. Technol. Vol. 9 (9), 712-722.

McNeely, S. M. and Lazrus H. (2014). The Cultural Theory of Risk for Climate change Adaptation. Weather, Climate and Society, Vol. 6. Colorado State University. Fort Collins, Colorado

McPherson, M., Smith-Lovin, L. and Cook, J. (2001). Birds of a feather: Homophily in social networks. Annu. Rev. Sociol. 27, 415–444.

Meijer, S. S., Catacutan, D., Ajayi, O. C., Sileshi, G. W., and Nieuwenhuis, M. (2015). The role of knowledge, attitudes and perceptions in the uptake of agricultural and agroforestry innovations among smallholder farmers in sub Saharan Africa. International Journal https://doi.org/10.1080/14735903.2014.912493

Meinzen-Dick R., Knox A., Place F. and Swallow B. (2002). Innovation in Natural Resource Management: The Role of Property Rights and Collective Action in Developing Countries. Johns Hopkins University Press, Baltimore, MD (2002).

Mendelsohn R., Nordhaus W.D. and Shaw D. (1994). The Impact of Global Warming on Agriculture - a Ricardian Analysis. Am. Econ. Rev., 84 (1994), pp. 753–771

Mendelsohn, R. and Seo, S. (2006). Climate Change on Livestock Management in Africa: A Structural Ricardian Analysis, World Bank Policy Research Working Paper 4279, Washington DC.

Mertz, O., Mbow, C., Reenberg, A. and Diouf, A., (2009). Farmers' perceptions of climate change and agricultural adaptation strategies in rural Sahel. Environmental Management, 43, 804–816.

Mideksa, T.K. (2009). Economic and Distributional Impacts of Climate Change: The Case of Ethiopia. *Global Environmental Change* 20: 278-286.

Minimizing the Risks to Maximize the Opportunities. Food and Agriculture Organisation, Rome.

Mishra, S., Mazumdar, S. and Suar, D. (2010). Place attachment and flood preparedness. J. Environ. Psychol. 30, 187–197.

Mishra, P. K. (2017). Socioeconomic impacts of climate change in odisha: Issues, Challenges and Policy options. J Clim Change. 3 (1): 93-107.doi:10.3233/Jcc-17009.

Miyan, M.A. (2015). Droughts in Asian least developed countries: Vulnerability and sustainability. *Weather Climate Extremes*. 7 (8).

Mizik, T. (2021). Climate-smart agriculture on small-scale farms: A systematic Literature review. Agronomy 11 (6), 1096. https://doi.org/103390/agronomy. 1061096.

Mogaka H, Gicheru S, Davis R and Hirji R, (2006). Climate Variability and Water Resources Degradation in Kenya. World Bank Group Paper No. 69.

Morgan, D. L. (1996). Focus Groups: Annual Review of Sociology, 22, 129-152.

Mohammed, E. Y. and Uraguchi, Z. B. (2013). Impacts of climate change on Fisheries: Implications for food security in Sub-Saharan Africa. Global Food Security: Nova Science Publisher, Inc, 114-135.

Morton, J. F. (2007). The impact of climate change on smallholder and subsistence agriculture. Proc. Natl. Acad. Sci. USA. 104, 1980-1985.

Mubaya, C.P., Njuki, J., Mutsvangwa, E.P., Mugabe, F.T., and Nanja, D., (2012). Climate Variability and Change or Multiple Stressors? Farmer Perceptions regarding threats to Livelihoods in Zimbabwe and Zambia. *Journal of Environmental Management* 102, 9–17.

Mubaya, C. P., Mutopo, P., and Ndebele, M. (2015). Local level opportunities to deal with climate risk and vulnerability in Dares Salam. In: Mark Swilling, Adriana Allen and Andrea Lamp's (eds). Untamed Urbanizations, Routeledge.

Mubaya, C. P. and Mafongoya, P. (2017). The role of institutions in managing local level climate change adaptation in semi-arid Zimbabwe. Climate Risk Management. Vol 16 pp 93-105. https://doi.org/10.1016/j.crm.2017.03.003.

Mudekhere, S. M, Mugalavi, E. M, and Nabiswa, F. M. (2024). Nexus between Indigenous Knowledge systems and Adaptation to Climate Change Strategies by Farmers in Kajiado County, Kenya. African Journal of empirical Research. Vol 5(2) 2024. ISSN 2709-2607.

Mudzonga, E. (2012). Farmers' Adaptation to Climate Change in Chivi District of Zimbabwe: Paper Presented at TRAPCA's Trade Policy Research Forum, 2012 on 'African Trade under Climate Change and the Green Economy, 6-7th August, 2012, Arusha, Tanzania.

Mugabe, F.T., Mubaya, C.P., Nanja, D., Gondwe, P., Munodawafa, A., Mutswangwa, E., Chagonda, I., Masere, P., Dimes, J., and Murewi, C. (2010). Use of indigenous knowledge systems and scientific methods for climate forecasting in southern Zambia and north western Zimbabwe. Zimbabwe Journal of Technological Sciences, Vol. 1, pp. 19–30.

Mugenda, O. and Mugenda, A.G. (1999). *Research Methods*: Quantitative and Qualitative Approach, African Centre for Technology Studies, Nairobi Kenya

Mugi-Ngenga, E.W., Mucheru-Muna, M.W., Mugwe, J.N., Ngetich, F.K., Mairura, F.S., and Mugendi, D., (2016). Household's socioeconomic factors influencing the level of adapta- tion to climate variability in the dry zones of Eastern Kenya. J. Rural Stud. 43, 49–60. doi: 10.1016/j.jrurstud.2015.11.004 .

Mugisha, S., Olson, J., Natumanya, E., Ndagire, B., and Ndagire, H., (2007). An evaluation of the level of knowledge and its use for the adaptation process to climate change in Uganda: A working paper for climate-land interaction.

Mujeyi, A., Mudhara, M., and Mutenje M. J. (2020). Adoption determinants of multiple climate-smart agricultural technologies in Zimbabwe: considerations for scaling-up and out. African J. Sci. Technol. Innovat. Develop. 12 (6), 735-746. https://doi.org/10.1080/20421338.2019.1694780.

Mundy, P., and Compton, L. (1991). Indigenous communication and indigenous knowledge. Dev Commun Report 74(3):1–3.

Musafiri, C.M., Macharia, J.M., Ng'etich, O.K., Kiboi, M.N., Okeyo, J., Shisanya, C.A., Okwuosa, E.A., Mugendi, D.N., and Ngetich, F.K., (2020a). Farming systems' typologies anal- ysis to inform agricultural greenhouse gas emissions potential from smallholder rainfed farms in Kenya. Sci. Afr. 8, e00458. doi: 10.1016/j.sciaf.2020.e00458 .

Mutai, C. C., Ochola, S. O. Mukiira, H. K., Gachimbi, L.N., Otiono, M., King'uyu, S. M., and Marigi, S. N. (2011). Chapter 3: Climate Change and Vulnerability. In: State of the environment and Outlook 2010. Supporting the Delivery of Vision 2030. National Environment Mnagement Authority (NEMA), Nairobi, Kenya.

Nabikolo, D. B. Bashaasha, B., Mangheni, M. N., and Majaliwa, J.G.M. (2010). Determinants of Climate Change Adaptation among Male and Female Headed Farm Households in Eastern Uganda: African Crop Science Journal, Vol. 20, Issue Supplement S2, Pp. 203 – 212.

Nardone, A., Ronchi, B., Lacetera, N., Ranieri, M.S., and Bernabucci, U., (2010). Effects of climate Change on animal production and sustainability of livestock systems. Livest. Sci. 130, 57–69.

Ndiritu, S.W., Kassie, M., and Shiferaw, B., (2014). Are there systematic gender differences in the adoption of sustainable agricultural intensification practices? Evid. Kenya, Food Policy 49, 117–127. doi: 10.1016/j.foodpol.2014.06.010 .

Negera, M., Alemu, T. Hagos, F. and Hailleslassie, A. (2022). Determinants of adoption of Climate-smart agricultural practices among farmers in Bale-Eco region, Ethiopia. Heliyon 8 (7)/ e09824.

Nelson, D. R., Adger, W. N and Brown, K. (2007). Adaptation to Environmental Change: Contributions of A resilience Framework. Annual Review of Environment and Resources 32, pp. 395 – 419.

Nelson, N. C., Rosegrant, M. W., Koo, J., Robertson, R., Sulser, T., Zhu, T., Ringler, C., Msangi, S., Palazzo, A., Batka, M., Magalhaes, M., Valmonte-Santos, R., Ewing, M. and Lee, D. (2009). Climate Change Impact on Agriculture and Costs of Adaptation (Vol. 21). International Food Policy Research Institute.

Newsham, A. J, and Thomas, D. S, (2011). Knowing, farming and climate change adaptation in North-Central Namibia. Global Environmental Change, Vol. 21 No

Nhemachena, C. and Hassan, R., (2007). Micro-level analysis of farmers' adaptation to climate change in South Africa. IFPRI Discussion Paper No. 00714. International Food Policy Research Institute, Washington, DC.

Nhemachena, C. and Hassan, R., (2008). Determinants of African Farmers' Strategies for Adapting to Climate Change: Multinomial Choice Analysis, AfJARE Vol 2, No.1, March 2008, page 83-104.

Nielsen, J.O. and Reenberg, A. (2010). Cultural barriers to climate change adaptation: a case study from Northern Burkina Faso. *Global Environmental Change*, 20(1), 142-152. Doi: org/10.1016/j. gloenvcha.2009.10.002.

Norgaard, K. M. (2011). Living in Denial: Climate Change, Emotions, and Everyday Life. Cambridge, Mass: MIT Press

Nunn, R. D., Mulgren, K., Scott-Parker, B., Hine, D. W., Monks, A. D., Mahat, D. et al, (2016). Spirituality and attitudes towards nature in the Pacific Islands: Insights for enabling climate change adaptation. *Climate Change,* 136 (3/4), 477-493. https://doi.org/10.1007/s10584-01646-9.

Nunnally, J. C., and Bernstein, I. (1994). *Psychometric Theory*. *Rdsepiucsforg* (3rd ed., Vol. 3). McGraw-Hill. http://doi.org/10.1037/018882

Nyanga, P., Johnsen, F. H., Aune, J. B, and Kalinda, T. H. (2011). Smallholder Farmers' Perception of Climate Change and Conservation Agriculture: Evidence from Zambia. Jsustain Dev, Vol. 4, pp 73-85.

Nyadze, E.., Ajayi, O. C. and Ludwig, F. (2021). Indigenous Knowledge and climate change adaptation in Africa. A systematic review. CAB Rev. 16 (029), 1-29.

Nyantakyi-Frimpong, H., and Kerr, R. (2023). Culture, climate change, and food security: How traditions shape adaptation strategies in Sub-Saharan Africa. World Development, 167, 106130.

Nyong A, Adesina F and Osman E, (2007). The value of indigenous knowledge in climate change mitigation and adaptation strategies in the African Sahel, *Mitig Adapt Strat Glob Change*, 12, 787–797.

Nyong, A. (2005). Abstract in Impacts of Climate Change in the Tropics: The African Experience. Avoiding Dangerous Climate Change (Meteorological Office, Exeter, UK, 2005) (www.stabilisation2005.com)

Nzeadibe, T.C., Egbule, C.L., Chukwuone, N. and Agu, V. (2011). Farmers' perceptions of climate change governance and adaptation constraints in Niger delta region of Nigeria. African Technology Policy Network, Research Paper No. 7.

O'Brien, K. and Wolf, J. (2010). A value-based approach to vulnerability and adaptation to climate change. WIREs Clim. Change 1, 232-242

O'Connor. (2002). *Research Methods*. Available online at http://faculty.ncwc.edu/toconnor/308/308/ect07.htm, viewed on 28/10/2015 at 2.00pm

O'Riordan, T. and Jordan, A. (1999): Institutions, climate change and cultural theory: towards a common analytical framework. *Global Environmental Change*, **9,** 81–93.

Obayelu, O. A., Adepoju, A. O., and Idowu T. (2014). Factors influencing choices of adaptation to climate change in Ekiti State, Nigeria. J Agri Environ Int Develop 108:3-16.

Ochieng, N. T., Wilson, K., Derrick, C. J., and Mukherjee, N. (2018). The use of focus group discussion methodology: Insights from two decades of application in conservation Methods. Ecol Evol 2018; 9:20-32. https://doi.org/10.1111/2041-210x.12860.

Ofuoku, A.U., (2013). Rural farmers' perception of climate change in central agricultural zone of Delta state, Nigeria. *Indonesian Journal of Agricultural Science*. 12(2), 63-69.

Ogalleh, S., Vogl, C., Eitzinger, J., and Hauser, M., (2012). Local Perceptions and Responses to Climate Change and Variability: The Case of Laikipia District, Kenya. *Sustainability* 4, 3302–3325.

Ogungo, P.O., Langat, D., Oeba, V.O., Kimondo, J.M., Owuor, B., Njuguna, J., Okwaro, G. and Russell, A.J.M. (2014). A review of Kenya's national policies relevant to climate change adaptation and mitigation: *Insights from Mount Elgon*. Working Paper 155. Bogor, Indonesia: CIFOR.

Oka, C. (2000). An analysis of women's labour saving technologies in semi-arid Zimbabwe. Unpublished work. Bsc thesis, University of Zimbabwe.

Okeyo, S.O., Ndirangu, S.N., Isaboke, H.N., Njeru, L.K., and Omenda, J.A., (2020). Analysis of the determinants of farmer participation in sorghum farming among smallscale farmers in Siaya County, Kenya. Sci. Afr. 10, e00559. doi: 10.1016/j.sciaf.2020.e00559 .

Orlove, B., Roncoli, C., Kabugo, M., and Majugu, A. (2023). Climate change, local knowledge and adaptation in Africa. Mitigation and Adaptation Strategies for Global Change, 28(1), 45-62.

Osbahr, H., Dorward, P., Stern, R., and Cooper, S., (2011). Supporting agricultural innovation in Uganda to respond to climate risk: Linking climate change and variability with farmer perceptions. *Experimental Agriculture* 47, 293–316.

Osman-Elasha, B. (2010). Climate Change Adaptation: Options and Good Practices for the Arab Region.

Ostrom E., Ahn T. (2003). Foundations of Social Capital. Edward Elgar, Cheltenham, UK (2003) Pan African Climate Justice Alliance, PACJA (2009). The Economic Cost of Climate Change in Africa, PACJA, 41 pp.

Osumanu, I. K., Aniah, P. and Yelfaanibe, A. (2017). Determinants of adaptive capacity to climate change among smallholder rural households in the Bongo District, Ghana. J. Dev. Stud 14 (2): 142-163. https://doi.org/10.4314/gids.v14i2.8.

Osunade, M. A. (1994). Indigenous Climate Knowledge and Agricultural Practices in Southwestern Nigeria. Malays J Trop Geogr 1:21–28.

Otiende, B. (2009). The economic impacts of climate change in Kenya: Riparian flood impacts and cost of adaptation. Accessed at: http://static.weadapt.org/knowledge-base/files/758/4e25a4b8c8bf61c-kenya-riparian-floods-case-study.

Parry M, Rosenzweig C. and Iglesias A. (1999). Climate change and world food security: A new Assessment. Global environmental change, 9 (1999), S51-S67.

Pelling M., High C., Dearing J. and Smith D. (2008). Shadow spaces for social learning: a relational understanding of adaptive capacity to climate change within organizations. Environ. Plann. A, 40 (2008), pp. 867–884

Phiri, M.G., Saka, I. and Alex, R. (2005). The impacts of changing environmental conditions on vulnerable communities of Shine Valley, Southern Malawi. Lilongwe, Malawi.

Phirri, G.K., Egeru, A. and Ekwamu, A. (2016). Climate Change and Agriculture nexus in Sub-Saharan Africa: the agonizing reality for smallholder farmers. International Journal of Current pharmaceutical Review and Research, Vol. 8 No. 2.

Polley, H. W., Briske, D. D., Morgan, J. A., Wolter, K., Baily, D. W., and Brown, J. R. (2013). Climate change and North American Rangelands: trends, projections and implications. Rangeland Ecol. Manage. 66, 493-511.

Porter, J.J., Dessai, S., and Tompkins, E. L. (2014).What do we know about UK household adaptation to climate change? A systematic review. Climatic Change 2:371-379.

Porter, L., Xie, A. J., Challinor, K., Cochrane, S. M., Howden, M. M., Iqbal, D. B. and Lobell, M. I. (2014). Eds. Food security and Food systems. In Climate Change 2014: Impacts, Adaptation and Vulnerability. Part A: Global Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA (2014), pp. 485-533.

Qazlbash, S.K., Zubair, M., Manzoor, S.A., ul Haq, A., and Baloch, M.S., (2020). Socioeconomic determinants of climate change adaptations in the flood-prone rural community of Indus Basin, Pakistan. Environ. Dev. 37, 100603. doi: 10.1016/j.envdev.2020.100603

Quadnt, A. (2019). Variability in percepions of household livelihood resilience and drought at the intersection of gender and ethnicity. Climate change, 152; 1-15. https://doi.org/10.1007/s10584-018-2343-7

Rao, K.P.C., Ndegwa, W.G., Kizito, K., and Oyoo, A., (2011). Climate variability and change: farmer perceptions and understanding of intra-seasonal variability in rainfall and associated risk in semi-arid Kenya. *Experimental Agriculture* 47, 267–291.

Raymond, C. M., Giusti, M., and Barthel, S. (2021). Connecting with place and nature through civic environmentalism. People and Nature, 3(1), 21–37.

Rayner, S. (1984). Disagreeing about Risk: The Institutional Cultures of Risk Management and Planning for Future Generations. Risk Analysis, Institutions and Public Policy, Hadden S. G. Ed, Associated Press, 150 – 168.

Rayner, S. (1991). A Cultural Perspective on the Structure and Implementation of Global Environmental Agreements. Eval. Rev., 15, 75 – 102.

Rayner, S. (1992). Cultural Theory and Risk Analysis. Social Theories of Risk, Krinsky S. and Golding D. Eds, Praeger, 83 – 115

Rayner, S. (1995). A Conceptual Map of Human Values for Climate Change Decision Making. Equity and Social Considerations Related to Climate Change: Papers Presented at the IPCC Working Group III Workshop. ICIPE Science Press, 57 – 73.

Reilly J. and Schimmelpfennig D. (2000). Irreversibility, Uncertainty, and Learning: Portraits of Adaptation to Long-Term Climate Change. Springer, The Netherlands.

Riewe, R. and Oakes, J. E. (2006). Eds. *Climate Change: Linking Traditional and Scientific Knowledge.* Winnipeg: Aboriginal Issues Press.

Rijsberman, F.R (2006). Water Scarcity: Fact or Fiction? AWM, 180:5-22.

Robinson, J. and Herbert, D. (2001). Integrating Climate Change and Sustainable Development. International Journal of Global Environmental issues, 1(2):130-148.

Rodima-Taylor, D., Olwig, M.F. and Chhetri, N. (2011). Adaptation as Innovation, Innovation as Adaptation: An Institutional Approach to Climate Change. *Applied Geography*, 1-5.

RoK (Republic of Kenya), (2004). Early Warning Manual for Arid and Semi-arid Lands. Government Printer, Nairobi, Kenya.

RoK. (2012a). Agriculture Act, CAP 318, as Amended in 2012. Published by the National Council for Law Reporting with the Authority of the Attorney-General. Nairobi, Kenya.

RoK. (2012b). Land Act, 2012 No 6 of 2012. Published by the National Council for Law Reporting with the Authority of the Attorney-General. Nairobi, Kenya.

RoK. (2013). National Climate Change Action Plan, 2013-2017. Ministry of Environment and Mineral Resources, Nairobi Kenya.

RoK. (2014). Agricultural Sector Development Support Program (ASDSP). Ministry of Agriculture Livestock and Fisheries, Nairobi, Kenya.

RoK. (2015). Environmental Management and Coordination Act of 1999 as Amended in 2015. Government Printer. Nairobi, Kenya.

RoK. (2016a). Kenya National Adaptation Plan, 2015-2030. Enhanced Climate Resilience towards attainment of Vision 2030. Government Printer. Nairobi, Kenya.

RoK. (2016b). The Climate Change Act 2016. http://www.kenyaforests.org/resources/The Kenya Climate Change Act 2016 pdf.

RoK. (2016c). Climate Risk Profile for Homa Bay County. Kenya County Climate Risk Profile Series. The Ministry of Agriculture, Livestock and Fisheries (MoALF), Nairobi, Kenya.

Rok. (2018a). Homa Bay County Integrated Development Plan (CIDP) 2018-2022. Government Printer, Nairobi Kenya.

RoK. (2018b). National climate change action plan (Kenya): 2018-2022. Government Printer. Nairobi, Kenya.

RoK. (2019). Kenya Population and Housing Cencus, 2019. Government Printer, Nairobi Kenya. ISBN: 978-9966-102-11-9.

Roncoli, C., Okoba, B., Gathaara, V., Ngugi, J., and Nga'nga, T., (2010). Adaptation to Climate Change for Smallholder Agriculture in Kenya: Community-based Perspectives from Five

Districts. University of Georgia Report to the World Bank for the Project "Adaptation to Climate Change of Smallholder Agriculture in Kenya", June 2010.

Rosenzweig M. and Udry C.R. (2013). Forecasting Probability. National Bureau of Economic Research (2013) NBER Working Paper No. 19334

Rossi, A. and Lambrou, Y. (2008). Gender and Equity Issues in Liquid Biofuels Production:

Ruhlemann and Jordan, J. C. (2021). Risk perception and culture: Implications for vulnerability and adaptation to climate change. Disasters 45, 424-452.

Salau, E. S., Onuk, E. G., and Ibrahim, A. (2012). Knowledge, Perception and Adaptation Strategies to Climate Change among Farmers in Southern Agricultural Zone of Nasarawa state, Nigeria. Journal of Agricultural Extension, 16 (2), 199-211.

Sanni, M., Oladipo, E., andToure, A. (2024). Bridging indigenous and scientific knowledge for climate resilience: Policy implications for smallholder farmers. Sustainability, 16(5), 6123.

Sanz-Saez, A., Erice, G., Aguirreolea, J., Murioz, F., Sanchez-Diaz, M., and Irigoyen, J. J. (2012). Alfalfa forage digestibility, quality and yield under future Climate Change Scenarios vary with *Sinorhizobium meliloti* Strain. Plant Physiol. 169, 782-788.

Scannell, L. and Gifford, R. (2010). The relations between Natural and Civic Place Attachment and Pro-environmental Behavior. J. Environ. Psychol. 30, 289–297.

Schilbrack, K., (2013). What isn't religion? *Journal of Religion* 93(3), 291–318, viewed 10 March 2016, from http://libres.uncg.edu/ir/asu/f/Schilbrack_Kevin.

Schlenker W. and Lobell D.B. (2010). Robust Negative Impacts of Climate Change on African Agriculture. Environ. Res. Lett., 5 (2010), p. 014010

Schlenker W., Roberts M.J. (2009). Nonlinear temperature effects indicate severe damages to US crop yields under climate change. Proc. Natl. Acad. Sci. U.S.A., 106 (2009), pp. 15594–15598

Schoeneberger, M., Bentrup, G., de Gooijer, H., and Soolanayakanahally, R. (2012). Agroforestry as a climate change mitigation and adaptation tool for agriculture. http://dx.doi.org/10.2489/jSNC.675.128A.

Schuman, S., Dokken, J-V., Van Niekerk, D. and Loubser, R.A., (2018). Religious beliefs and climate change adaptation: A study of three rural South African communities. Jàmbá: Journal of Disaster Risk Studies 10(1), a509. https:// doi.org/10.4102/jamba. v10i1.509

Sekaran, U. (2003). Research Methods for Business: A skill-Building Approach. Ney York, NY: John Wiley and Sons.

Seo S.N. and Mendelsohn R. (2008). A Ricardian analysis of the impact of climate change on South American farms. Chilean J. Agric. Res., 68 (2008), pp. 69–79

Shove, E. (2003). Comfort, Cleanliness and Convenience: The Social Organization of Normality.

Siedenburg, J. (2008). Local knowledge and natural resource management in a peasant farming community facing rapid change: A critical examination. Queen Elizabeth House Working Paper Series WPS166. Oxford: Oxford University.

Sietz, D., Boschitz, M. and Klein, R. J. T. (2011). Mainstreaming Climate Adaptation into Development Assistance: Rationale, Institutional barriers and Opportunities in Mozambique. Environmental Science and Policy, 14 (4), 493-502).

Silvestri, S., Bryan, E., Ringler, C., Herrero, M., and Okoba, B., (2012). Climate Change Perception and Adaptation of Agro-pastoral Communities in Kenya. Regional Environmental Change, 12 (4), 791-802.

Sissoko, K., van Keulen, H., Verhagen, J., Tekken, V, and Haglini, A. (2011). Agriculture, livelihoods and climate change in the West African Sahel. Reg Environm Change 11 (1): 119-125.

Slimak, M.W. and Dietz, T. (2006). Personal values, beliefs, and ecological risk perception. *Risk Analysis* 26(6), 1689–1705. https://doi.org/10.1111/j.1539-6924.2006.00832.x

Smit, B. and Wandel, J. (2006). Adaptation, adaptive capacity and vulnerability. Global environmental change. Vol. 16 No. 3, pp 282-292.

Smit, B., and Skinner, M. (2002). Adaptation options in agriculture to climate change: a typology. *Mitigation and Adaptation Practices and Policies for Global Change* 7 (1): 85–114.

Smit, B., Pilifosova, O., Burton, I., Challenger, B., Huq S, Klein, T., and Yohe, G. (2007). Adaptation to Climate Change in the Context of Sustainable Development and Equity. Working group II: Impacts, adaptation and vulnerability.

Smit, B., Pilifosova, O., Burton, I., Challenger, B., Huq, S., Klein, J. R. and Yohe, G. (2001). Adaptation to climate change in the context of sustainable development and equity. In: McCarthy, J. J., Canziani O. F., Leary, W. A., Dokken, D. J. and White K. S. (Eds): Climate Change 2001: Impacts, Adaptation and Vulnerability. Cambridge University Press. Cambridge, New York.

Smith, J. P., Pearce, B. D. and Wolfe, M. S. (2012). Reconciling Productivity with Protection of the Environment: Is Temperate Agroforestry the Answer? Renewable Agric. Food Syst. 28(1), 80-92.

Smith, J.B. and Lenhart, S.S. (1996). Climate change adaptation policy options. *Climate Research*, 6(2**),** 193–201.

Solh, M. and Saxena, M.C. (2011). Food Security and Climate Change in Dry Areas: proceedings of an International Conference: 1-4 February 2010, Amman, Jordan. International Centre for Agricultural Research in the Dry Areas (ICARDA).

Sonne, C., Letcher, R. J., Jenssen, B. M. et al. (2017). A veterinary Perspective on One Health in the Arctic. Acta Vet Scand, 59(1): 84.

Speranza, C. I. (2006). Drought Vulnerability and Risk in Agro-Pastoral Areas: An Integrative Approach and its Application in Kenya, Centre for Development and Environment-CDE, Bern.

Stedman, R. C. (1999). Sense of place as an indicator of community sustainability. *Forest. Chron*. **75,** 765–770.

Stenek, V., Amado, J., and Greenall, D. (2013). Enabling environment for private sector adaptation- An Index Assessment Framework 4:1-10. Tompkins E, Adger N (2003). Building resilience to climate change through adaptive management of natural resources. Tyndall Centre for Climate Change Research. Working Paper 27.

Straus, S. and Corbin, R. G. (1998). Basic Qualitative Research: Techniques and Procedures for Developing Grounded Theory. SAGE Publishers. Thousand Oaks, New York.

Swart, R., Robinson J. and Cohen S (2003) Climate change and sustainable development: expanding the options. Climate Policy 3S1:S19–S40

Swindler, A. (1986). Culture in Action: Symbols and Strategies. Am. Social. Rev. 51, 273-286.

Syampungami, S., Chirwa, P. W., Akkinifesi, F.K., and Ayayi, O.C. (2010). The potential of using Agroforestry as a win-win solution to Climate Change Mitigation and Adaptation and Meeting Food Security Challenges in Southern Africa. Agric. J 2010, 5:80-88.

Tadesse, D. (2010). The Impacts of Climate Change in Africa. Institute for Security Studies Paper 220.

Tambo, J. A., and Abdoulaye, T. (2023). Gender, cultural norms, and climate adaptation: Analyzing the constraints faced by women farmers. Sustainability, 15(6), 4512.

Tazeze A, Haji J, and Ketema, M. (2012). Climate Change Adaptation Strategies of Smallholder Farmers: The Case of Babilie District, East Harerghe Zone of Oromia Regional State of Ethiopia. Journal of Economics and Sustainable Development 3 (14): 1-12.

Teklewold, H., Kassie, M., Shiferaw, B. and Kohlin, G. (2013). Cropping System Diversification, Conservation tillage and Modern seed adoption in Ethopia: Impacts on Household income, Agrochemical use and Demand for Labour. Ecol. Econ. 93, 85-93.

Teklu, A., Simane, B. and Bizabih, M. (2023). Multiple adoption of climate-smart agricultural innovation for agricultural sustainability. Empirical evidence form the Upper Blue Nile Highlands of Ethiopia. Clim. Risk Manage. 10047. https://doi.org/10.1016/j.cm. 2023.100477.

Tengo, M., Brondizo, E. S., Elmqvist, T., Malner, P., and spierenburg, M. (2014). Connecting diverse Knowledge systems for enhanced ecosystem governance: the multiple evidence base approach. AMBIO 43, 579-591.

Tesfaye, W., and Seifu, L. (2016). Climate change perception and choice of adaptation strategies: Empirical evidence from smallholder farmers in east Ethiopia. *International Journal of Climate Change Strategies and Management*. Vol. 8 No. 2, pp. 253-270. https://doi.org/10.1108/IJCCSM-01-2014-0017

Tessema, Y. A., Joerin, J. and Patt, A. (2018). Factors affecting smallholder farmers' adaptation to climate change through non-technological adjustments. Envron Dev 25: 33-42. https://doi.org/10.1016/j.envdev.2017.11.001.

Theodory, F. T. (2016). Dealing with change: Indigenous Knowledge and adaptation to climate change in Ngono River Basin, Tanzania. PhD. Diss. Univ. Bonn.

Thomas, D.S.G., Twyman, C., Osbahr, H., and Hewitson, B., (2007). Adaptation to climate change and variability: farmer responses to intra-seasonal precipitation trends in South Africa. *Climatic Change* 83, 301–322.

Thornton, P.K., Jones, P.G., Alagarswamy, A. and Andresen K. (2009). The temporal dynamics of crop yield responses to climate change in East Africa. Global Environmental Change.

Thornton, P.K., Van de Steeg, J., Notenbaert, A.,and Herrrero, M., (2009). The impacts of climate change on livestock and livestock systems in developing countries: A review of what we know and what we need to know. Agric. Syst. 101, 113–127.

Thornton, T. F., and Scheer, A. M. (2012). Collaborative Engagement of Local and Traditional knowledge and Science in Marine Environments: A review of ecological society 17:8.

Tian, H., Zhou, S., Dong, L. et al. (2015). Avian Influenza HSNI Viral and bird migration networks in Asia. Proc Natl Acad Sci USA, 112(1): 172-7.

Tiruneh, S. and Tegene, F. (2018). Impacts of climate change on livestock production and productivity and different adaptation strategies in Ethiopia. Phoenix Research Publishers. Applied and Advanced Research, 2018: 3(3) 52-58.

Tompkins, E.L., and Adger, W.N. 2004. Does adaptive management of natural resources enhance resilience to climate change? *Ecology and Society* 9(2): 10. [online] URL: http://www.ecologyandsociety.org/vol9/iss2/art10/

Tongruksawattana, S. (2014). Climate Shocks and Choice of Adaptation Strategy for Kenya Maize-Legume Farmers: Insights from Poverty, Food Security and Gender Perspectives. International Maize and Wheat Improvement Centre (CIMMYT). DF (Mexico), Mexico.

Trenberth, K. E., Fasullo, J. T and Shepherd, T. G, (2015). Attribution of Climate extreme events. Nat Clim Chang 5 (8): 725-730.

Trisos, C. H., Adelekan, I. O., Totin, E., Ayanlade, A., Efitre, J., Gemeda, A., Kalaba, K., Lennard, C., Masao, C., Mgaya, Y., Nganiya, G., Olago, D., Simpson, N. P., and Zakieldeen, S. (2022). Africa. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. In: portner, H. O., Roberts, D. C., Tignor, M., Poloczanska, E. S., Mintenbeck, K., Alegria, A., Langsdorf, S., Moller, V., Okem, A., and Rama, B. (Eds). Contributions of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press.

Tubiello, F., Schmidhuber, J., Howden, M., Neofotis, P.G., Park, S., Fernandes, E., and Thapa, D., (2008). Climate Change Response Strategies for Agriculture: Challenges and Opportunities for the 21st Century. The World Bank, Washington, DC.

Turaki, Y., (1999). Christianity and African gods: *A method in theology*, PU vir CHO, Potchefstroom.

Turner, N.C. (2006). Water Scarcity: Challenges and Opportunities for Crop Science. AWM, Special Issue 80 (1-3): 1-3.doi:10.10166/j.agwat.2005.07.002.

Twigger-Ross, C. L. and Uzzell, D. L. (1996).Place and identity processes. *J. Environ. Psychol*. **16,** 205–220.

Twyman, J., Green, M., Bernier, Q., Kristjanson, P. M., Russo, S., Tall, A., and Badiane Ndour, N. Y. (2014). Adaptation actions in Africa: evidence that gender matters. *CCAFS Working Paper* no. 83. Copenhagen, Denmark: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS)

Uddin, M. N., Bokelmann, W. and Entsminger, J. S. (2014). Factors Affecting Farmers, Adaptation Strategies to Environmental Degradation and Climate Change Effects: A Farm Level Study in Bangladesh. ISSN 2225-1154. Climate 2014, 2, 223-241.

United Nations Framework Convention on Climate Change (UNFCCC), (2019). Climate change: Report of Adaptation Committee: United Nations Framework Convention on Climate Change.

UNFCCC, (2021). Introduction to Adaptation and Resilience/Loss and Damage. Bonn, Germany: United Nations Framework Convention on Climate Change. Available at: unfccc.int/topics/adaptation-and-resilience/the-big picture/introduct.

United Kingdom Climate Impacts Program (UKCIP), (2004). Costing the impacts of climate change in the UK. Metroeconomica P 377.

United Nations (UN), (2017). State of the world's indigenous peoples: *Education* (New York, USA, Department of Economic and Social Affairs (DESA)).

United Nations Educational, Scientific and Cultural Organisation (UNESCO), (2020). Role of Culture in Climate Change Mitigation and Adaptation. Available online at https://en.unesco.org.news, experts. Viewed on 23/4/2020.

UNESCO and UNEP. (2016). World Heritage and Tourism in a changing climate. ISBN 978-92-3-100152-9. United Nations Environmental Program (UNEP) Nairobi, Kenya; the United Nations Educational, Scientific and Cultural Organisation (UNESCO) Paris, France and the Union of Concerned Scientists, Cambridge, MA, USA.

United Nations Environmental Programme (UNEP) (2008). Indigenous Knowledge in Disaster Management in Africa. UNEP, Nairobi, Kenya, 2008, 6-10.

UNEP (2007). Indigenous Knowledge in Disaster Management: In Environmental Emergencies News, Issue 6 April 2007.

UNEP. (2013). Smallholders, Food Security and the Environment. Rome: IFAD, UNEP.

Uphoff, N., and Buck, L. (2006). Strengthening rural local institutional capacities for sustainable livelihoods and equitable development. World Bank, Washington, D.C., USA.

USAID (2007). Adapting to Climate Variability and Change. *A guidance Manual for Development Planning.* 1300 Pennsylvania Avenue, NW. Washington, DC.

USAID Center for Development Information and Evaluation (1996). Conducting Key Informant Interviews. Performance, Monitoring and Evaluation Tips. Washington DC, USAID.

Valery, N. and Tanya, S. (2009). Resilience, Power, Culture and Climate: A case study from Semi-arid Tanzania and new research directions. Gender and Development, 17 (1), 81-94.

Van der Linden, S. (2017). Determinants and Measurement of Climate Change Risk, Perception, Worry and Concern. The Oxford encyclopedia of climate change communication. Oxford University Press, Oxford, UK.

Veldman, R. G. (2016). What is the meaning of greening? Cultural analysis of a southern Baptist Environmental text. Journal of Contemporary Religion, 31 (2) 199-222. https://doi.org/10/10.1080/13537903. 2016.1152676.

Veldman, R.G., Szasz, A. and Haluza-DeLay, R., (2013). Social science, religions and climate change: In R.G. Veldman, A. Szasz and R. Haluza-DeLay (eds.), *How the world's religions are responding to climate change: Social scientific investigations*, pp. 3–19, Routledge, New York.

Vermeulen S.J., Campbell B.M and Ingram J.S.I (2011). Climate change and food systems. Annu. Rev. Environ. Res., 37 (2011) 120802110603008

Vermeulen S.J., Campbell B.M and Ingram J.S.I (2012). Climate Change and Food Systems. Annual Review of Environmental Resources, 37, 195-222.

Vogel, C. (2000). Usable Science: An Assessment of Long-term Seasonal Forecasts among Farmers in Rural Areas of South Africa. South African Geographical Journal 82: 107–116.

Volpato, G. and King, E. G (2019). From cattle to camel: Transitions of livelihood adaptation and social-ecological resilience in a Kenyan pastoralist community. Regional Environmental Change, 19; 849-865. https://doi.org/10.1007//s10113-018-1438-z

Walker, W., Lieble, D., Gilbert, L., Lacro, J., Nowak, P., and Sullivan, J. (2011). Adaptation to Climate Change: why adaptation policy is more difficult than we think. Adaptation Working Group Report.

Walker, B., Gunderson, L., Kinzig, A., Folke, C., Carpenter, S., and Schultz, L. (2006). A handful of Heuristics and some Propositions for understanding Resilience in Socio-ecological Systems. Ecology and Society 11 (1): 13.

Warren, D. M. (1992). Strengthening indigenous Nigerian organizations and associations for rural development: the case of Ara Community. Occasional Paper No. 1, African Resource Centre for Indigenous Knowledge, Ibadan.

Washington-Ottombre, C. and Pijanowski, B. C. (2013). Rural Organisations and Adaptation to Climate Change and Variability in Rural Kenya. Regional Environmental Change 13, 130-143.

Wetende, E., Olago, D., and Ogara, W., (2018). Perceptions of climate change variability and adaptation strategies on smallholder dairy farming systems: insights from Siaya Sub-County of Western Kenya. Environ. Dev. 27, 14–25. doi: 10.1016/j.envdev.2018.08.001 .

Watson, R.T., Zinyoera, M.C. and Moss, R.H. (1998). The Regional Impacts of Climate Change: An Assessment of Vulnerability. A Special Report of IPPC Working Group II. Cambridge: Cambridge University.

Weatherhead, E., Gearheard, S., and Barry, R.G. (2010). Changes in weather persistence: Insight from Inuit knowledge. *Global Environmental Change*, Vol. 20, 523–528.

Wheeler, T. and von Braun, J. (2013). Climate Change Impacts on Global Food Security. Science, 314, 508-513.

Whitmarsh, L. (2008). Are flood victims more concerned about climate change than other people? The role of direct experience in risk perception and behavioural response. Journal of Risk Research 11:351-374

Wiggins, S. (2009). Can the smallholder Model Deliver Poverty Reduction and Food Security for a Rapidly Growing Population in Africa? Paper for the Expert Meeting on How to Feed the World in 2050. FAO, Rome.

Wildarsky, A. (1982). The Three Cultures: Explaining Anomalies in American Welfare State. Public Interest, 69, 45 – 58.

Wolf, J., Brown, K. and Conway, D. (2009). Ecological citizenship and climate change: Perceptions and practice. Environ. Polit. 18, 503–521

Woodley, E, (1991). Indigenous Ecological Knowledge Systems and Development. Agric. Human Values 8:173–178

World Bank (2011). Options for the Development of Liberia's Energy Sector. Africa Energy Unit: Energy Sector Policy Note Series. Report No. 63735-LR.

World Bank (2012). World Development Indicators, Online Version. Washington DC: World Bank.

World Bank, (2003). Africa Rainfall and Temperature Evaluation System. World Bank, Washington, DC.

World Bank. (2009). Convenient Solutions to an Inconvenient Truth: *Ecosystem Based Approaches to Climate Change*. Environment and Department, World Bank. Washington DC.

World Wide Fund for Nature (WWF), (2006). *Climate Change Impacts on East Africa. A review of the Scientific Literature,* Gland Switzerland.

Wrigley-Asante, C., Owusu, K., Egyir, I.S. and Owiyo, T.M., (2019). Gender dimensions of climate change adaptation practices: the experiences of smallholder crop farmers in the transition zone of Ghana. *African Geographical Review*, 38(2), 126-139. https://doi.org/10.1080/19376812.2017.1340168.

Yatich, T., Awiti, A., Nyukuri, E., Mutua, J., Kyalo, A., Tanui, J. and Catacutan, D. (2007). *Policy and institutional context for NRM in Kenya: Challenges and opportunities for landcare*. ICRAF Working Paper No. 43. Nairobi: World Agroforestry Centre.

Yayeh, F. A. (2021). Focus Group Discussion as a data collection tool in Economics. Daagn International Journal of basic and Applied Research – DUBAR. Vol 3(1), 52-61.

Yesuf, M., Di Falco, S., Deressa, T., Ringler, C. and Kohlin, G. (2008). The Impact of Climate Change and Adaptation on Food Production in Low-Income Countries: *Evidence from the Nile Basin*. EDRI, Ethiopia.

Yohe, G. and Tol R. S. (2002). Indicators for Social and Economic Coping Capacity: Moving Toward a Working Definition of Adaptive Capacity. Global Environmental Change 12, pp. 25.

Ziervogel G. and Ericksen P.J. (2010). Adapting to climate change to sustain food security. Wiley Interdiscip. Rev. Clim. Change, 1 (2010), pp. 525–540.

Ziervogel, G., and Opere, A. (2010). (eds). Integrating meteorological and indigenous knowledge-based seasonal climate forecasts for the agricultural sector: *Lessons from participatory action research in sub-Saharan Africa.* International Development Research Centre (IDRC), Ottawa, Climate Change Adaptation in Africa (CCAA) Learning paper series), 24 pp.

APPENDICES

APPENDIX I

QUESTIONNAIRE FOR SMALLHOLDER FARMERS IN HOMA BAY COUNTY

You have been selected among smallholder farmers to assist in providing information on the influence of socioeconomic and cultural factors in climate change adaptation of the smallholder farmers in Homa Bay County. The information obtained is for academic purpose and will be treated with utmost confidentiality.

A. Farmer's Personal Characteristics

1. Serial number of the farmer…….

2. Age 30 – 34 years ☐ 35 – 39 years ☐ 40 – 44 years ☐ > 45 years ☐

3. Gender

Male ☐ Female ☐

4. Level of education

None ☐ Primary ☐ Secondary ☐ College ☐

5. Marital status

Married ☐ Widow ☐ Widower ☐ Single ☐ Divorced ☐

6. If married what is the highest level of education attained by your partner?

None ☐ Primary ☐ Secondary ☐ College ☐

7. Size of the household

1 – 3 ☐ 4 – 6 ☐ 7 – 10 ☐ > 10 ☐

8. Indicate the type of household you belong to.

Male headed ☐ Female headed ☐ Youth headed ☐

B. Indigenous Knowledge and climate change adaptation by smallholder farmers

1. How long have you stayed in this area? ……Years……. Months. To what extent does your stay in the study area influences your knowledge of climate events?

Little extent ☐ Undecided ☐ Great extent ☐ Very great extent ☐

2. Has your length of stay in the study area contributed to decision making on climate change adaptation? Yes ☐ No ☐

3. How long have you been practicing farming?

1 – 3 years ☐ 4 – 6 years ☐ 7 – 10 years ☐ > 10 years ☐

4. Do you agree that farming experience results in accumulation of knowledge about climate events? Strongly agree ☐ Agree ☐ Not sure ☐ Disagree ☐ Strongly disagree ☐

5. To what extent farming experience influences your choice of climate change adaptation strategy? No influence ☐ Very low extent ☐ Not sure ☐ very great extent ☐

6. Do you usually apply new techniques in farming operations? Yes ☐ No ☐

If yes, specify at least two……..

If no, give a reason…….

7. Have you experienced changes in climatic conditions? Yes ☐ No ☐

8. For how long have you experienced these changes? 5 -10 years ☐ 11 – 15 years ☐

16 – 20 years ☐ more than 20 years ☐

9. In what form have these changes manifested themselves?

Floods ☐ Drought ☐ Alternating drought and floods ☐

10. How much do you agree with the following statement? Climate change poses risk to me personally. Strongly Disagree ☐ Disagree ☐ Neutral ☐ Agree ☐

Strongly Agree ☐ NA ☐

11. Has your experience in changes in climatic conditions contributed to climate adaptation?

Yes ☐ No ☐

12. What measures have you put in place to cope with the above changes?

Changing planting date ☐ Planting drought resistant crop varieties ☐

Planting short season crops ☐ Planting trees ☐ Water harvesting ☐

13. How far is the nearest water source? 1 Km ☐ 1 – 2 Km ☐

3 – 5 Km ☐ > 5 Km ☐

14. What problems do you experience in accessing water?

Long distances ☐ Dirty water ☐ Scarcity of water ☐

Conflict with neighbouring communities ☐ Don't know ☐

15. How do you think the above problems can be resolved?

Protect water sources ☐ Construct wells ☐ Encourage roof catchment ☐

Promote water storage during dry season ☐ Don't know ☐

16. What are some of the changes that have occurred in relation to accessibility to water resources in the last 10 years? Rivers have dried up ☐ Dams have dried up ☐

Water everywhere due to floods ☐ Others (specify) ☐

17. To what extent has the experience on changes in water accessibility assisted you to cope with water problems? Little extent ☐ Not sure ☐ Great extent ☐ Very great extent ☐

18. What do you attribute these changes to?

Changes in rainfall patterns ☐ Prolonged drought ☐ Failure to protect rivers ☐

Destruction of catchment areas ☐ Others (specify)

C. Local institutions and climate change adaptation by smallholder farmers

1. Do you belong to any local organization or institution? Yes ☐ No ☐

If yes, specify……..

2. Are there any institutions or organizations that have offered you any assistance to address the effects of changes in weather? Yes ☐ No ☐

If yes, please indicate the type of institutions or organizations

Non-governmental organizations ☐ Government ministry ☐

An individual ☐ Farmers' unions ☐ Others (specify) ☐

3. Which institution (s) do you view as the most effective in channeling external support?

Non-governmental organization ☐ Government ministry ☐

An individual ☐ Farmers' union ☐ Others (specify ☐

4. What type of assistance do you receive from these institutions?

Grants ☐ Loans ☐ Environmental information ☐

Agricultural information ☐ Others (specify) ☐

5. Have these institutions assisted you in making decisions regarding climate change adaptation strategies? Yes ☐ No ☐

D. Cultural factors and climate change adaptation by smallholder farmers

1. Do you identify yourself with your residential area? Yes ☐ No ☐

2. How do you rate your level of attachment to the residential area?

Very low ☐ Low ☐ Undecided ☐ High ☐ Very high ☐

3. Has attachment to your area of residence influenced your decision regarding choice of climate change adaptation strategies? Yes ☐ No ☐

4. Do you follow any family order in carrying out farm operations? Yes ☐ No ☐

If yes, specify the sequence……

5. What is the effect of this hierarchical order of farm operations on crop production?

Very high ☐ High ☐ No effect ☐ Low ☐ Very low ☐

6. Has this hierarchical order of carrying out farm operations influenced your decision regarding choice of climate change adaptation strategies? Yes ☐ No ☐

7. Do you subscribe to any religious outfit? Yes ☐ No ☐

If yes, specify……

8. To what extent can you link these changes in climatic conditions to religion and other cultural beliefs?

Not sure ☐ Little extent ☐ Great extent ☐ Very great extent ☐

9. Is your land registered? Yes ☐ No ☐

If yes, under whose name is it registered? Self ☐ Spouse ☐ Parent ☐ Others ☐

10. What kind livestock do you own and in what numbers?

Cattle a) Local…… b) Improved……..

Goats a) Local……..b) Improved……..

Poultry a) Local……..b) Improved…….

Sheep……

Rabbits…….

Donkeys……

11. Has livestock rearing assisted you to cope with changes in climatic conditions? Yes ☐

No ☐

If yes, indicate how: increased incomes ☐ improved food security ☐

Improved social status ☐ reduce vulnerability ☐

E. Socioeconomic factors and climate change adaptation by smallholder farmers

1. In your opinion, have the following factors influenced your decision regarding the choice of climate adaptation strategies?

i) Age: Yes ☐ No ☐

ii) Gender Yes ☐ No ☐

iii) Level of education Yes ☐ No ☐

iv) Marital status Yes ☐ No ☐

v) Level of education of spouse Yes ☐ No ☐

vi) Household size Yes ☐ No ☐

2. What is the size of your farm in hectares? < 1 ☐ 1 – 3 ☐ 4 – 6 ☐

7 – 10 ☐ > 10 ☐

3. Has the size of your farm influenced your decision making on the choice of climate change adaptation strategy? Yes ☐ No. ☐ If yes, explain……

……

4. How can you gauge your social status? Better off ☐ Average ☐ Poor ☐

5. Do you agree that your social status can contribute to climate change adaptation?

Strongly Disagree ☐ Disagree ☐ Not sure ☐ Agree ☐

Strongly Agree ☐ Don't know ☐

6. What is your main source of income? Salary ☐ Wages ☐ Business ☐

Crop farming ☐ Animal farming ☐ Remittances ☐

7. In your opinion, does climate change affect household incomes? Yes ☐ No ☐

If yes to what extent does it affect the household incomes? No effect ☐

Little extent ☐ Great extent ☐ Very great extent ☐ Don't know ☐

8. What is the source of your financial capital?

Cooperative ☐ Friends and Relatives ☐ Self ☐

Cooperative + Self ☐ Self financed + bank loan ☐

9. Does your source of financial capital contribute to climate change adaptation?

Yes ☐ No ☐

10. What are the sources of your farm labour?

Own family Hired labour ☐

Self ☐ Self + Hired ☐

11. Does your source of farm labour contribute to climate change adaptation?

Yes ☐ No ☐

12. Are you aware of the perceived changes in climatic conditions? Yes No

If yes, what is the source of your information? Radio ☐ Newspaper ☐

Extension agents ☐ Experience ☐ Fellow farmers ☐

13. Does your source of climate change information contribute to climate change adaptation?

Yes ☐ No ☐

14. What have been the effects of these climatic changes to this community?

Crop failure ☐ Human disease outbreak ☐

Animal disease outbreak ☐ Famine ☐ Disruption in settlement ☐

15. Please explain the effects that the climate change has had on each of the following:

Crop production…….

Livestock production…….

Income generation……..

Settlement patterns…….

Disease prevalence…….

16. Which cropping system do you practice?

Intercropping ☐ Mixed cropping ☐ Monocropping ☐

17. What food crops do you grow? Maize ☐ Beans ☐ Sorghum ☐

Cassava ☐ Others ☐ specify…….

18. Does the yield for the crop adequate to sustain the family until the next harvesting season?

Yes ☐ No ☐

If No, what could be the main cause of low production? Drought ☐ Floods ☐

Lack of farm inputs ☐ Lack of land ☐ Others ☐

What are the possible solutions to these problems? Conservation of flood water ☐

Irrigation of land during drought ☐ Provision of farm input by government ☐

19. How many meals are available for the household in a day?

One meal ☐ Two meals ☐ Three meals ☐

20. How many food deficient months do you experience in a year?

Less than 3 months ☐ 4 – 5 months ☐ More than 5 months ☐

21. How do you cope when there is insufficient food for the household?

Reduce quantity of food consumed ☐ Burn charcoal for income ☐

Sell livestock for income ☐ Migrate ☐ Relief food ☐

22. What is the major problem regarding livestock rearing in this community?

Lack of pasture ☐ Lack of water ☐

Inadequate grazing land ☐ Livestock diseases ☐

23. What type of trees do you have in your home/farm?

Exotic ☐ Indigenous ☐ Indigenous and exotic ☐

24. How are these trees established? Natural regeneration ☐ Seedlings ☐

Natural regeneration and seedlings ☐

25. What changes have you noticed in the vegetation cover at the community level?

Diminishing tree cover ☐ Diminishing grasslands ☐ Increasing tree cover ☐

Increasing grasslands ☐

APPENDIX II

INTERVIEW SCHEDULE FOR KEY INFORMANTS

You have been selected to assist in providing information on the influence of socioeconomic and cultural factors in climate change adaptation of the smallholder farmers in Homa Bay County. The information obtained is for academic purpose and will be treated with utmost confidentiality.

1. Which institution do you belong to and what is your designation.

……
……

2. Age of the respondent in years

……
……

3. Gender of the respondent

……
……

4. Level of education of respondent

……
……

5. In your opinion has climate changed? If yes, what is the nature and impact of climate change hazards relevant to the prevailing agro-ecological zone?.....
.....
.....

6. In your opinion are the smallholder farmers knowledgeable about climate change adaptation practices? If yes, what are the specific adaptation practices used by households in Homa Bay County?

……

……

……

7. How do you rank the effectiveness of different climate change adaptation strategies?

……

……

……

8. What are the best strategies that can be implemented in to enable households adapt to effects of climate change in Homa Bay County?

……

……

……

9. In your opinion, what are the reasons for effectiveness or non-effectiveness of adaptation responses by smallholder farmers in the study area?

……

……

……

10. What role does your institution play in climate change adaptation by the smallholder farmers in Homa Bay County?

……

……

……

11. What external forms of support are available to facilitate local adaptation?

……

……

……

12. How does your institution channel such support for improvements in adaptive capacity?

……

……

……

13. Do you believe that the smallholder farmers who receive external support have a better adaptive capacity? Elaborate your point.

……

……

……

14. a) Are the smallholder farmers able to access the environmental information?

……

b) How do the smallholder farmers access environmental information to facilitate local adaptation?

……

……

……

c) How do you rate the reliability of the environmental information available to the farmers in this area? .....

15. Are there any policies in place that deal with climate change adaptation in this area? If yes, have they been implemented? How have these been implemented?

……

……

……

APPENDIX III

FOCUS GROUP DISCUSSION GUIDE

You have been selected assist in providing information on the influence of socioeconomic and cultural factors in climate change adaptation of the smallholder farmers in Homa Bay County. The information obtained is for academic purpose and will be treated with utmost confidentiality.

1. Does the community receive any agriculture training? From whom did you receive the training and what kind of training?

2. What are the major climate changes that the area has faced in the past 10 years? Rank these changes in order of importance by giving 6 points to the most significant change and one point to the least significant change.

3. In your view, what are the reasons for these changes and what has been done to combat these changes?

4. How have these changes affected the community and what coping mechanisms have been put in place to reduce these effects.

5. Mention some of the major indicators of changing climatic events acquired from local weather predictions. Explain how each indicator has been used in coping with changing climatic events.

6. How are decisions made in the household with regard to the responses to climate related changes?

7. Who makes specific decisions on farm operations and general management of natural resources in the household?

8. Does everyone in the community have equal access to land? Explain.

9. Who makes decision on land allocation?

10. Are there some cultural events that affect farming operations in this community? If yes, enumerate those events and explain how they impact on farm operations.

11. Do people link climate change with religion? Elaborate.

12. Which organizations/institutions/groups are working in or with the community?

13. Which institutions/groups do the members of the community regard as the most important and why?

14. Which institutions/groups are addressing household food security and climate change? List the specific roles played by these institutions.

15. Are particular groups or kind of people excluded from being members of or receiving services from certain institutions?

16. Which local groups are organized along environmental issues (water, grazing, change in climate conditions), economic issues (saving, credit, agriculture and livestock), social issues (health, literacy, religion, tradition)?

17. From which medium do you receive weather information and what kind of weather information do you receive? How has this information assisted you in adjusting to the climatic changes?

18. How have your past experiences on weather patterns assisted you in coping with climate related changes?

19. Are there certain instances when changes in weather conditions are culturally linked to certain occurrences in this community? Elaborate.

APPENDIX IV
CONSENT FORM
CONSENT TO PARTICIPANTE IN THE RESEARCH STUDY

TITLE OF THE STUDY:

CONTRIBUTIONS OF SOCIOECONOMIC, CULTURAL AND INSTITUTIONAL FACTORS ON CLIMATE CHANGE ADAPTATION STRATEGIES BY SMALLHOLDER FARMERS IN HOMA BAY COUNTY, KENYA

INVESTIGATOR: DANICE OTIENO AWINDA

The main objective of the study will be to determine the contributions of socioeconomic, institutional and cultural factors on climate change adaptation by the smallholder farmers in Homa Bay County, Kenya.

The Specific objectives are:

1. To determine the role of indigenous local knowledge on climate change adaptation by smallholder farmers study area
2. To establish the contribution of local institutions and social networks on the rate of climate change adaptation by smallholder farmers in the study area.
3. To determine the contribution of cultural values on adaptation to climate change by smallholder farmers in the study area.
4. To determine the contribution of socioeconomic factors on climate change adaptation by smallholder farmers in the study area.

Significance of the study

This study will be essential to document the actual climate change adaptation measures by smallholder farmers in Homa Bay County and their effectiveness in improving household food security. Most researches in available literature have dealt mostly with the material aspects of climate change adaptation, including general adaptation strategies, albeit with little systematic analysis on cultural and socioeconomic factors influencing the adaptive capacity of smallholder farmers. The study therefore seeks to bridge this information gap by investigating the influence of local institutions, traditional technical knowledge, cultural dimensions and socioeconomic factors on climate change adaptation by smallholder farmers in the study area. The findings of the study

will be used by policy makers and other actors to facilitate adaptation to effects of climate change by smallholder farmers in the study area and Kenya at large.

Risk and Risk Management

The participants may find it uncomfortable responding to the set of questions but the questionnaire has however been shortened to ensure that it takes reasonably short time to administer. To cater for the language barrier, the questionnaire will be administered face to face and the respondent's language of convenience will be used. The consent form provided is to make it clear that participation in this study is voluntary.

Benefits

The study will be important in documenting the contributions of socioeconomic, cultural and institutional factors influencing climate change adaptation at household level and recommending strategies for climate change adaptation at household level for improved food security. No direct monetary benefit or gift is available from this study.

Confidentiality

The research assistants have been sensitized on the need to maintain confidentiality. Interviewers have been made aware of the importance of minimizing anxiety or stress and of the absolute requirement of not leaking any information obtained from the study participants. All data collected will be treated with confidentiality. No names of study participants will appear on any tool used to capture information. The records of this study will be kept in a locked file, and all electronic information will be coded and secured using a password protected file.

Right to refuse or withdraw

The decision to participate in this study is entirely upon the respondent. The respondent may refuse to take part in the study at any time without affecting his relationship with the investigator or Maseno University. The respondent's decision not to participate in the study will not result in any loss of benefits to which he is otherwise entitled. The respondent has a right not to answer any single question or to withdraw completely from the interview at any point during the process.

Right to Ask Questions and Report Concerns

The respondent has the right to ask questions about this research study and have those questions answered by me before, during and after the research. Should there be any further questions about the study, the respondent is free to contact me through e-mail or telephone, both of which are provided below. Any other concerns on the rights of the participants that have not been adequately handled by the investigator can be raised with the Secretary of the Maseno University Ethics and Review Committee.

Principle Investigator: Danice Otieno Awinda

Address: Private Bag-20157, KABARAK

Telephone No: +254-722680156

E-mail: doawinda@gmail.com

The Secretary,

Maseno University Ethics Review Committee

+254-721548976

E-mail: sanyona@maseno.ac.ke

I……. (Name of the Participant) hereby confirm that the researcher has explained to me the purpose of the research, risk and benefits, time committed and that my participation in this research is voluntary. I understand that the study has no negative consequences to the study subjects and the data will be treated with utmost confidentiality as explained to me by……. (Name of Research Assistant). I have been given a chance to ask questions and make inquiries about the research and I am satisfied with the results I have got. I have been informed that I can choose to withdraw from the research at any time or not participate at all.

Participant's signature…… Date…….

YIE MAR BEDO JADUOK PENJO E NONRO

THORORO MAR NONRE

CHAL MAR DAK, YORE MAG YUTO KOD KIDO MAR JO PUR KALUORE KOD KAKRUOK GI POGRUOK MIKELO GI LOKRUOK MAR CHAL MAR KOR LUASI EI HOMA BAY KAUNTI, KENYA

JATIM NONRO: DANICE OTIENO AWINDA

Nonro ni dwaro ngiyo kaka chal mar dak, yore mag yuto kod kido mar jo pur osebedo kaluore kod rakruok gi pogruok mikelo gi lokruok mar chal mar kor luasi ei Homa Bay Kaunti, Kenya

Weche ma idwa non matut gin:-

1. Fwenyo gima ngeyo kinyadala kaka inyalo tim kaluore kod lokruok mar kor lwase osekonyo jo pur e kama itimiye nonro.
2. Fwenyo kaka migepe mag kor gweng gi tudruoge mag dongruok osekonyo e rakruok gi pogruok mikelo gi lokruok mar chal mar kor luasi ei Homa Bay Kaunti.
3. Ngeyo kaka kido kod timbe osekonyo e rakruok gi pogruok mikelo gi lokruok mar chal mar kor luasi ei Homa Bay Kaunti.
4. Ngeyo kaka chal mar dak kod yuto osekonyo e rakruok gi pogruok mikelo gi lokruok mar chal mar kor luasi ei Homa Bay Kaunti.

Gima omiyo itimo nonro ni

Nonro ni biro bedo maber e keto e rikod yore mag rakruok gi pogruok mikelo gi lokruok mar chal mar kor luasi ei Homa Bay Kaunti to kod gik ma gisetimo mondo chiemo obedi e udi. Nonro mangeny mosetim ngenygi osengiyo mana matin kuom kaka inyalo rakruok gi pogruok mikelo gi lokruok mar chal mar kor luasi kanya achiel gi yore mapile mag rakruok, to kata kamano pok oket sinani e chenro mar nono kaka kido gi timbe kod chal mar dak gi yore yuto konyo e ranginy mar rakruok mar jo pur matindo. Nonro ni dwa yango matut gima migepe mag kor gweng, ngeyo kinyadala, weche mag kido gi timbe kod chal mar dak gi yore mag yuto osetimo e rakruok gi pogruok mikelo gi lokruok mar chal mar kor luasi ei Homa Bay Kaunti. Duoko mag nonro ni biro

konyo jo pang chenro kod migepe mamoko e ngiyo yore mag rakruok gi pogruok mikelo gi lokruok mar chal mar kor luasi ei Homa Bay Kaunti kod Kenya mangima.

Rach kod yore mag rakruok gi rach minyalo kel gi nonroni.

Joma duoko penjo nyalo bedo gi pek mar duoko penjo to kata kamano nonro ni otem ket machuok mondo kik kaw thuolo malach mar jaduok penjo. Mondo mi winjruok obedi maber, penjo gi ibiro penji achiel ka achiel gi jaduok penjo ka itiyo gi dhook ma ja duok penjo winjo maber. Form ni en mar nyiso ni ngato ochiwore mar duoko penjo.

Ber mar nonro

Nonro ni biro konyo keto e andiko kaka chal mar dak gi yore yuto kod kido gi timbe mar ot ka ot osebedo kaluore kod rakruok gi pogruok mikelo gi lokruok mar chal mar kor luasi ka achiel gi jiwo ot ka ot e yore mag rakruok gi lokruok mar chal mar kor luasi e ngiyo ni chiemo obedo moromo. Onge yuto ma achiel ka achiel kata mich michiwo kuom bedo e nonro ni.

Siri

Joma penjo penjo gi otiegi e keto weche duto ma owach e nonro mondo obed mana e kindgi gi ngama duoko penjo. Jopenj penjo bende ongeyo ber duoko chien geno mangeny gi parruok ma inyalo kel gi nonro ni ka achiel gi ngiyo ni ok gigolo oko weche mawuok kuom nonro. Weche duto biro bedo siri. Nying kata gimora amora manyalo yango ngama ipenjo penjo ok bi ndiki kamoro amora. Rekod mowuok e nonro ni ibiro kan kama olor matek kendo weche moket e yor mbui ibiro lor gi password.

Ratiro mar tamruok kata weyo nonro

Hero mar bedo achiel kuom joduok penjo ni kuom ngat mipenjo penjo. Ngama ipenjo nyalo tamore bedo e nonro samoro amora kendo mano ok bi ketho tudruok e kinde gi Jatim nonro maduong kata gi Mbalariany ma Maseno. Hero mar ngato mondo kik obed e nonro ok bi miyo ngato wit ber mane onyalo yudo. Ja duok penjo nigi ratiro mar weyo duoko penjo moro amora kata weyo chuth bedo e nonro saa moro amora.

Ratiro mar penjo kod goyo ripot

Ja duok penjo nigi ratiro mar penjo penjo kuom nonro ni kendo neno ni aduoko penjo go kapok ochaki, seche ma ipenjo e penjo kata bang tieko penjo mag nonro. Ka in gi penjo moro amora kuom nonro ni, jaduok penjo nigi thuolo mar tudruok koda e yor mbui kata e yor simu, duto ma oket piny mar form ni. Wach moro amora e wi ratiro mar bedo ja duok penjo maok iyudo duoko

mare maber koa kuom japenj penjo inyalo choro ne Jagoro mar duol mangiyo tim makere e weche Nonro ma Mbalariany ma Maseno.

Principle Investigator: Danice Otieno Awinda
Address: Private Bag-20157, KABARAK
Telephone No: +254-722680156
E-mail: doawinda@gmail.com

The Secretary,
Maseno University Ethics Review Committee
+254-721548976
E-mail: sanyona@maseno.ac.ke

An ..... (Nying Jaduok penjo) ayie ni Ja tim Nonro oselerona kuom nonro, rach kod berne, thuolo mokao to gi ni bedo achiel kuom jaduok penjo en chiwruok nono maonge chudo. Ase ngeyo ni nonro ni onge gi rach moro amora monyalo kelo ne jaduok penjo kendo weche duto mag nonro ibiro ket siri kaka olerna gi ..... (Jatim nonro/Japenj penjo). Omiya thuolo mar penjo penjo kod nono mangeny kuom nonro kendo ayie gi duoko ma ayudo. Onyisa ni anyalo weyo bedo e nonro saa moro amora kata weyo chuth.

Lwet Jaduok penjo ..... Tarik .....

APPENDIX V: APPROVAL TO CONDUCT RESEARCH

MASENO UNIVERSITY
SCHOOL OF GRADUATE STUDIES

Office of the Dean

Our Ref: PG/PHD/078/2011

Private Bag, MASENO, KENYA
Tel:(057)351 22/351008/351011
FAX: 254-057-351153/351221
Email: sgs@maseno.ac.ke

Date: 1st September 2017

TO WHOM IT MAY CONCERN

RE: PROPOSAL APPROVAL FOR AWINDA DANICE OTIENO PG/PHD/078/2011

The above named is registered in the Doctor of Philosophy in Environmental Science Programme of the School of Environment and Earth Sciences, Maseno University. This is to confirm that his research proposal titled **"Socio-Economic and Cultural factors in Climate change Adaptation of the Smallholder Farmers in Kenya,"** has been approved for conduct of research subject to obtaining all other permissions/clearances that may be required beforehand.

Dr. Patrick Onyango
ASSOCIATE DEAN, SCHOOL OF GRADUATE STUDIES

SCHOOL OF GRADUATE STUDIES * MASENO UNIVERSITY * P.O. Box PRIVATE BAG, MASENO
- 8 SEP 2017

Maseno University *ISO 9001:2008 Certified*

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION

Telephone: 020 400 7000,
0713 788787,0735404245
Fax: +254-20-318245,318249
Email: dg@nacosti.go.ke
Website: www.nacosti.go.ke
When replying please quote

NACOSTI, Upper Kabete
Off Waiyaki Way
P.O. Box 30623-00100
NAIROBI-KENYA

Ref: No. **NACOSTI/P/17/89210/20548**

Date: **11th December, 2017**

Danice Otieno Awinda
Maseno University
Private Bag
MASENO.

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on ***"Socio-economic and cultural factors in climate change adaptation of the smallholder farmers in Kenya,"*** I am pleased to inform you that you have been authorized to undertake research in **Homabay County** for the period ending **11th December, 2018.**

You are advised to report to **the County Commissioner and the County Director of Education, Homabay County** before embarking on the research project.

Kindly note that, as an applicant who has been licensed under the Science, Technology and Innovation Act, 2013 to conduct research in Kenya, you shall deposit **a copy** of the final research report to the Commission within **one year** of completion. The soft copy of the same should be submitted through the Online Research Information System.

GP Kalerwa

GODFREY P. KALERWA MSc., MBA, MKIM
FOR: DIRECTOR-GENERAL/CEO

Copy to:

The County Commissioner
Homabay County.

The County Director of Education
Homabay County.

OFFICE OF THE PRESIDENT

MINISTRY OF INTERIOR AND COORDINATION OF NATIONAL GOVERNMENT

Telephone: Homa Bay 22104 or 22105/Fax: 22491
E-mail: cc_homabay@yahoo.com
When replying please quote

COUNTY COMMISSIONER
HOMA BAY COUNTY
P. O. BOX 1 – 40300
HOMA BAY

REF NO: EDUC 12/I VOL.III/54 **18th January, 2018**

All Deputy County Commissioners
HOMA BAY COUNTY.

RE: RESEARCH AUTHORIZATION-DANICE OTIENO AWINDA

This is to inform you that the above mentioned person has been authorized to carry out research on **"Socio-economic and cultural factors in climate change adaptation of the smallholder farmers in Kenya"** in Homa Bay County for the period ending **11th December, 2018.**

Kindly accord him necessary assistance and note that all ethical practices should be observed.

J.B.ALUODO
FOR: COUNTY COMMISSIONER
HOMA BAY COUNTY.

cc

The County Director of Education
HOMA BAY COUNTY

Danice Otieno Awinda

MINISTRY OF EDUCATION

STATE DEPARTMENT OF BASIC EDUCATION

Telegrams: "SCHOOLING" Homa Bay
Telephone + 254722767574
When replying please quote
cdehomabay@gmail.com

COUNTY DIRECTOR OF EDUCATION
HOMA BAY COUNTY
P.O BOX 710
HOMA BAY
DATE: 18th JANUARY, 2018

REF: MOE/CDE/HBC/ADM/11/VOL.II/31

Danice Otieno Awinda
Maseno University.
Private Bag
KISUMU.

RE: RESEARCH AUTHORIZATION.

In response to the letter from the National Commission for Science, Technology and Innovation dated 11th December, 2017, giving you authority to carry out the research on "***Socio-economic and cultural factors in climate change adaptation of the smallholder farmers in Homa Bay County, Kenya"*** I hereby give you permission to carry out the research in **Homa Bay County** for the period ending **11th December, 2018.**

Please submit a copy of your findings both in soft and hard copies to us.

COUNTY DIRECTOR OF EDUCATION
HOMA BAY COUNTY
P. O. Box 710 - 40300, HOMA BAY
Email: cdehomabay@gmail.com

MR. JUSTUS M. ICHWARA
FOR: COUNTY DIRECTOR OF EDUCATION
HOMA BAY COUNTY.

Cc

County Commissioner
Homa Bay County

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BUREAU VERITAS
Certification
UKAS