AN ASSESSMENT OF THE CLIMATE CHANGE ADAPTIVE CAPACITY AMONG SMALLHOLDER FARMERS IN TRANS-MARA EAST SUB-COUNTY OF NAROK COUNTY, KENYA.

BY

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A research project report submitted in partial fulfilment of the requirements for a degree in Master of Arts in Environmental Planning and Management, University of Nairobi.

DECLARATION

This research project is my original work and has not been presented for a degree or publication in any other institution

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ACRONYMS AND ABBREVIATIONS

AEZ	Agro-ecological zones
CBO	Community-based Organization
CIDP	County Integrated Development Plan
CRA	Commission for Revenue Allocation
IFAD	International Fund for Agricultural Development
FAO	Food and Agriculture Organization
FGD	Focus Group Discussions
GDP	Gross Domestic Product
GoK	Government of the Republic of Kenya
IPCC	Intergovernmental Panel on Climate Change
KMD	Kenya Meteorological Department
KARLO	Kenya Agricultural Research and Livestock Organization
KNBS	Kenya National Bureau of Statistics
KES	Kenya Shillings
NEMA	National Environment Management Authority
USD	United States Dollars
SDGs	Sustainable Development Goals
SPSS	Statistical Package for Social Sciences
SSA	Sub-Saharan Africa

ABSTRACT

Concerted efforts are required to sustain smallholders' productivity in the face of rising climatic shifts. The present study sought to reveal the smallholders' experiences in responding to climate change and variability at Kenya's Trans-Mara East sub-County. Its main objective was to empirically ascertain whether their experiences and response strategies were associated with their socio-economic profiles. Among the key approaches used were surveying the area's historical data on precipitation and temperatures, covering years 1980 to 2015. This was in addition to the collection of primary data on 100 randomly selected respondents from 22,488 smallholders across the sub-County. The primary data included performances of farm-level crops and livestock, as well as the smallholders' experiences and actual socio-economic profiles. Guiding these processes was an overall hypothesis which generally negated smallholders' experiences against their socio-economic profiles, in line with the *Protection Motivation Theory*. To analyse the data, descriptive and inferential statistics were applied. Specifically, the Spearman's correlation coefficient (r_s) was used to ascertain the level of significance between the key variables under consideration. Mean annual precipitation data indicated little changes for the covered period, though it uncovered a declining trend in 2000-2015, with monthly data indicating huge shifts in the area's established regimes. Mean annual temperature data had a generally rising trend. These situations were marked by dwindling farm output in 2010-2015. Among the smallholders' socio-economic profiles, only farm sizes had significant relationships with their perceptions on climate change (r_s = 0.396, $p \leq 0.05$), compared with other characteristics namely; age, marital status and livelihood streams which did not show any significant relationship. As well, climate change adaptation strategies showed significant levels of association with formal education (r_s = 0.216, $p \leq 0.05$) and farm sizes (r_s = 0.541; n=100; $p \leq 0.05$). At individual level, significant relationships were observed between smallholders' constraints and education levels (r_s= -0.495, $p \leq 0.05$), range income flows (r_s = -0.450, $p \leq 0.05$), and age (r_s = 0.266, $p \leq 0.05$). At the institutional and policy level, expensive of agricultural inputs, financial limits, price fluctuations, and derelict transport systems, emerged as the key adaptation constraints. The study, through these results, thus concludes that the smallholding farming communities in the study area have experienced various challenges associated with climate change, with the main ones being on adaptation constraints. The study thus recommends for a need to put in place structured institutional and policy-related responses that can aid the area's smallholders to adapt to the mounting climatic shifts. It also recommends a need for other studies to explore options of using emerging technologies and other innovative options to enhance smallholders' adaptation mechanisms.

CHAPTER 1: INTRODUCTION

1.1. Background of the study

Climate change, manifested through shifting rainfall and temperature patterns (Gemenne et al., 2014;), is increasingly becoming a challenge to the productivity of smallholder farming. This situation harbours a profoundly huge concern among countries with low-income economies across the world. At the centre of this phenomenon, as experts point out, is swelling levels of atmospheric carbon dioxide. Key farming impacts of these states include an adverse impact on the output of food and commercial crops. These, in turn, affects the levels of food security and livelihood streams of economies that largely rely on nature-dependent agriculture (Godfray et al., 2010). These scenarios are common in the rural areas of many developing countries.

A number of reports (Godfray et al., 2010; Oluoko-Odingo, 2011; Tittonell & Giller, 2013), for instance, have indicated more than 50% of the world's low-income populations with residences farming areas rely on these climate-vulnerable forms of agriculture. Given the increasingly challenging climatic situations, majority of these rural area-based and weather-reliant smallholders are likely to be most affected in the absence of proactive and more concrete coping and adaptation mechanisms (Mertz et al., 2009). Such interventions should, however, be tailored (Thorn et al., 2015), in line with the smallholders' miscellany of key their respective enterprises (Fischer & Qaim, 2012). It would thus be imperative for all key stakeholders to ensure there is up-to-date assessments on spatial-temporal dynamics for any given area. This will aid in making appropriate responses such as smallholders' capacity development needs against climate variability.

As a key climate change response strategy, adaptation denotes the capacity for one to persist in spite of the presence unfavourable impacts of climatic shifts. With intensifying climate-related adversities, concrete adaptation options, as well as interventions must be constantly pursued, evaluated and rolled out, in order to safeguard people and ecosystems (Mertz et al., 2009; Musingi & Ayiemba, 2012). Weak institutional and policy frameworks, as well as escalating poverty and burgeoning human populations, all of which are common among many countries in the global south, have been cited (Labbé et al., 2016) as key ingredients to vulnerability to climate-related events.

There is thus a need to continuously explore possible avenues through which these bottlenecks can be controlled, with a view to paving the way for meaningful adaptation strategies. The first

step entails obtaining reliable data and information through which decision-making processes can be anchored, especially at the downstream levels of action. Mainstreaming adaptation at all levels of relevant decision-making constitutes another critical step in addressing the climate variability challenges. However, these actions in most of the developing world are mostly fraught with myopic political expediencies and limited actionable data and information (Mertz et al., 2009). For instance, new agricultural policies among in various parts of Africa are reported to be capital-intensive farmers (Silvestri et al., 2015) at the expense of the smallholders who are the majority actors, in terms of population and the overall agricultural output. Such situations are synonymous to various models of development which encourage overall economic growth but with very little or no impact on household poverty (Oluoko-Odingo, 2011). But with limited actionable data and information to advocate for a meaningful and more inclusive policy shift and prioritization, smallholders will continue to get a raw deal.

Responding to climate change in Kenya, like in other parts of Africa demands urgent attention. Proactive measures will useful in alleviating adverse impacts on human beings and ecosystems. In rural farmlands that harbour most of the populations that largely rely on weather-dependent resources from the environment, this issue is even more important. And this is especially so, among the smallholders who contribute to a huge portion of agricultural output in Kenya, but whose performances are largely hinged on the climatic situations and soil productivity (Jalón et al., 2015; Kalungu et al., 2013). Consequently, climate-related factors on smallholders' farm productivity, by extension get to undermine the household food security and income positions, with far-reaching toll on national economies.

Cognizant of these situations, the present study sought to focus on the smallholders whose response strategies are mostly fraught with various biophysical and socio-economic challenges (Wambua, et al., 2014). Accordingly, the study has assessed smallholder performances in Trans-Mara East sub-County, as a case for other smallholders under similar circumstances in Kenya. It presents uniquely assessed climatic situations in the area based on current and historical data. Key demographic elements including each smallholders' age, education, and marital status, as well as landholding size and livelihood streams, have been examined with respect to individual's perceptions, adaptation status, and adaptation constraints. These factors have a higher potential to influence smallholders' response strategies against climate variability (Ahsan & Warner, 2014). As such, they ought to be tackled through the relevant policy and institutional frameworks to cushion smallholder farmers against the impending impacts.

Adopting the *System's Approach* (Oluoko-Odingo, 2006), the current study takes up a smallholder farmer as the epicentre for related sub-systems constituting a pyramid of systems. This way, specific farm-level socioeconomic profiles including the smallholders' age, gender, marital status, access to formal education, owned farm sizes, and livelihoods, among others, can easily be surveyed against a specific area's climatic states and farm output performances. This is in addition to smallholders' perceptions, adaptation status, and adaptation constraints. The outcome of such a process inclusively captures the analysis of key issues in a unified approach.

1.2. Statement of the research problem

Climate change constitutes a significant constraint to the viability of rainfall-dependent agriculture in nearly all parts of sub-Saharan Africa (SSA). Unpredictable climatic situations have been reported in many parts of the region, with most of the areas previously regarded as havens for agriculture and those in the semi-arid zones, being largely affected. But the region's biggest challenge is not there yet since various scenarios have indicated (Khan et al., 2015) greater chances of worsening climatic situations in the near future. In the front-line to face these worsening situations are smallholders, due to be excessively affected, as a result of their rainfall-dependent farming systems. These circumstances harbour potential challenges in the future since smallholders are responsible for the production of more than half of all food needs in the region (Fisher et al., 2015; Shackleton et al., 2015). Besides, most of the economies in SSA rely on streams from smallholder-led agricultural output.

Furthermore, the region's uneven vulnerability to extreme climatic events is compounded by burgeoning human populations, wobbly economic growth, and the continued political turmoil in countries such as Somalia, South Sudan, Burundi, Central Africa Republic, Cameroon, and Nigeria, among others.

In the Eastern part of the SSA, increasing extreme weather events are increasingly becoming common, with the greatest impacts being felt by smallholders across large swaths of Kenya, Uganda and Tanzania (Kassie et al., 2013). This currently grim situation is being spiralled by common inter-ethnic loathing and conflicts which often escalate during electioneering seasons. Besides, many climate prediction models (Khan et al., 2015; Pol et al., 2010) have shown progressively worsening drought situations accompanied by snowballing temperatures and declining rainfall regimes in the region. These situations have therefore attracted a lot of attention among the research community, especially on questions related to the ability of

communities and ecosystems to continue thriving now, and in the future, notwithstanding the forbidding scenarios.

Kenya's smallholders produce about 70% of the entire national yields, with direct linkages to food stability and income situations many parts of the country (Kassie et al., 2014; Mikalitsa, 2010). Thus, changes in the state of climatic trends have got far-reaching effects on both the farmers and state of national income productivity. However, appropriate response strategies are increasingly being recognized as opportunities that can be harnessed to aid in curtailing the detrimental effects of shifting climatic situations (Klisch et al., 2015). Targeting smallholders would be beneficial in making the most out of such an intervention. It would, therefore, be imperative to specifically understand the current farm-level states of these smallholders regarding their socioeconomic positions. This is in addition to their perceptions, adaptive capacity and constraints against climate change response strategies, as amplified by the current study.

Various models and propositions on smallholder response strategies to climate change and other key environmental challenges have been put forward (Ndamani & Watanabe, 2015). Their outcome will most likely drive approaches for adaptation at individual and institutional levels. However, meaningful actions, such as from the policymakers, will be better structured if guided by solid pieces of evidence, especially on what is actually appropriate for downstream level actions (Raworth, 2007; Watts et al., 2015). Consequently, continued empirical assessments, such as the present study, would be pivotal. The outcomes from such studies, however, need to be simplified and shared to accelerate the intended actions.

Evidence on the prevailing smallholder adaptation strategies is vital to interventions that can enhance household food security situations. This is in addition to tracking and broadening income flows, while also tackling poverty and issues of inequality in a holistic manner (Tittonell & Giller, 2013). As such, it would be essential to appreciate smallholders' farm-level experiences and response strategies. This is central to their readiness and resultant actions. Moreover, it is important to examine the constraints against their quest to put in place substantive response measures, particularly in closing any gaps that undermine their progress. The results of such targeted interventions harbour multiple co-benefits not only to smallholders but also to other people, ecosystems, and economies.

Kenya's Trans-Mara East sub-County was identified as a suitable location to broaden climate-related discourses at the community level through the smallholders. This area's livelihoods are deemed much more exposed to shifting climatic situations due to vast socioeconomic, political, and environmental dynamics that are peculiar to it. For instance, the area has undergone various levels of land-use changes, loss of vegetation cover, falling groundwater levels and frequent cases of inter-ethnic tensions and conflicts (Kipsisei, 2011). A combination of such anthropogenic and biophysical dynamics will most likely to aggravate climate change impacts in the area.

The current study utilized data and information from the field and other sources. Among these were rainfall and temperature details covering 1980 to 2015. This is in addition to primary data obtained from randomly selected one hundred respondents from a smallholder population of 22,488. Their socioeconomic profiles were considered as independent variables, while their experiences as the dependent variables. Descriptive data were ranked using the Weighted Average Index (Ndamani & Watanabe, 2015) in addition to adaptation constraints whose level of influence was assessed using *Problem Confrontational Index* (Uddin et al., 2014). Spearman's correlation coefficient (r_s) was used in inferential analysis.

1.3. Research questions

To implement the current study, key research questions were set to guide in navigating through it, namely:

1) What are the precipitation and temperatures trends in Trans-Mara East during the period 1980 and 2015?
2) What are the perceptions of smallholders on the state of climatic situations in the area?
3) What adaptation measures exist among smallholders in the area?
4) What constraints do the smallholders face in implementing the adaptation strategies?

1.3.1. Research objectives

1.3.1.1. Main objective

As its main objective, the current study sought to evaluate the smallholders' experiences and climate change response strategies against their socio-economic profiles in Trans-Mara East sub-County.

1.3.1.2. Specific objectives

The current study's specific objectives were as follows:

1) To assess the rainfall and temperature trends for Trans-Mara East sub-County between 1980 and 2015.
2) To evaluate the smallholders' experiences with climatic shifts in the area.
3) To examine the smallholders' present climate change adaptation strategies.
4) To assess the constraints facing smallholders against their quest for adaptation.

1.4. Research hypotheses

Each objective of the current study was guided by a hypothesis which negated smallholders' experiences and response strategies against their socio-economic profiles, in line with the *Protection Motivation Theory*, as follows:

1 Smallholders' experiences with climate change in Trans-Mara East sub-County

H_0 Smallholders' experiences do not correlate with and their socio-economic profiles.

H_1 Smallholders' experiences correlate with their socio-economic profiles.

2 Smallholders' climate change response approaches in Trans-Mara East sub-County

H_0 Smallholders' adaptation techniques do not correlate with their socio-economic profiles.

H_1 Smallholders' adaptation techniques correlate with their socio-economic profiles.

3 Smallholders' constraints to climate change adaptation in Trans-Mara East sub-County

H_0 Smallholders' adaptation constraints do not correlate with their socio-economic profiles.

H_1 Smallholders' adaptation constraints correlate with their socio-economic profiles.

1.5. Justification of the study

Various studies have demonstrated the power of stemming the tide of poverty, food insecurity and environmental degradation in rural areas by enhancing smallholder farmers' performances (Labbé et al., 2016; Ndamani & Watanabe, 2015). These farmers have a strong attachment to the environment and a rich wealth of indigenous knowledge, which can easily be tapped to help improve the farmland conditions on which they largely depend on (Mikalitsa, 2010).

Understanding the readiness of Kenya's smallholders against extreme climatic conditions, particularly under the current states of unpredictable climatic situations (Rao et al., 2011) is all-important. This is because smallholders in many parts of the country are already battling with a varied range of environmental and socio-economic challenges (Wambua & Omoke,

2014). For instance, reported rising costs of farm inputs and uncoordinated information for weather-dependent agriculture will likely exacerbate the vulnerability of smallholders to climatic dynamics. These scenarios aside, Kenya's decentralisation of government structures offers huge opportunities to catalyse targeted climate change response strategies with greater results at the community levels, where majority of the smallholders reside (Kithia, 2014).

However, the adverse impacts of increasing climatic shifts have the potential to amplify rural area environmental challenges (Uddin et al., 2014) with the possibility of even generating new combinations of risks. Among the areas particularly at risk include the agro-pastoral sub-Counties of Kenya, such as Trans-Mara East, due to rife poverty and high dependence on the nature-based resources. This, thus, demands the adoption of proactive adaptation measures. These processes can be significantly boosted through increased understanding of smallholders' perceptions, their desired adaptation options, and the constraints thereto (Juana et al., 2013).

In particular, and with the projections for increasing effects of shifting climatic situations and other pressures affecting smallholders (Wambua et al., 2014), it is vital to document micro-level choices as well as constraints to accelerate the recognition and inform suitable response options against identified risks (Campbell et al., 2016). The present study, therefore, examined climate change response strategies at the level of smallholders through a cross-sectional research design.

The downstream level approach employed in this study was found to be apt to contemporary Kenya's devolved administrative structures. Environmental conservation and implementation of agricultural interventions are currently done at the decentralised levels of administration, i.e. at the subnational levels. As a result, key climate change response strategies are best handled at these downstream levels.

Trends in precipitation and temperature for the study area were selected as the key indicators of the climatic conditions given that they are easy to measure and analyse. This is in addition to the impact that results from any given changes in them, with adverse consequences crop and livestock production through their direct interaction with the earth's biophysical systems.

1.6. Study area

1.6.1. Location

Being the study area, Kenya's Trans-Mara East sub-County is situated in Narok County, to the south-western part of Kenya (Wiesmann et al., 2014). It lies within latitudinal zero degrees, fifty minutes, and six degrees fifty minutes to the south, as well as on the eastern longitudinal ranges of about thirty-four degrees, thirty-five minutes and thirty-five degrees fourteen minutes. This is in addition to an above the sea level altitudinal range of about one thousand four hundred and fifty meters. Its area covers about three-hundred and twenty square kilometres, with four sub-levels of administration. Figure 1.1 locates the sub-County, and the administrative boundaries of its four Wards, which informed the study's sampling strategy.

1.6.2. Topography

The topography of Trans-Mara East consists of varied and semi-arid landscapes, which favour crop farming and livestock rearing. The fact that these activities are undertaken with rudimentary technologies makes them exposed to significant varied risks of climate change (Narok County's 2014 CIDP[1]). Additionally, the area's geography is much like the majority of the ecosystems in undulating landscapes, with a general slope from west to the eastern part (Kipsisei, 2011).

1.6.3. Soils

Nyamwaro et al (2006) describe the soil conditions in most areas of the sub-County as black cotton soils which crack when dry and become sticky when wet. This is in addition to being with moderately impeded drainage and with no restricted plant types.

1.6.4. Flora

Natural vegetation in almost all the unsettled areas of Trans-Mara East varies widely with arrays that include sparse non-perennial grasslands and other above-ground biomass mingled with dwarf and mature trees. Many parts of the sub-County harbour dwarf shrubs and bush species, with various types of rangeland trees dominating the area. These trees play a vital role among the smallholders, including by availing fuelwood and fodder for the livestock –mostly as a browse to the goats and as a good honey bee (*Apis mellifera*) forage (Kelemu, Niassy, & Torto, 2015). Moreover, many of these trees in the area support the construction of livestock

[1] County Integrated Development Plan

bomas and fencing. The area's dominance by different forms of Acacia trees may have been favoured by their tolerance to a wide range of soils, as well as their deep rooting systems which boost access to the moisture deep beneath the top earth's surface (Kinnaird & O'brien, 2012).

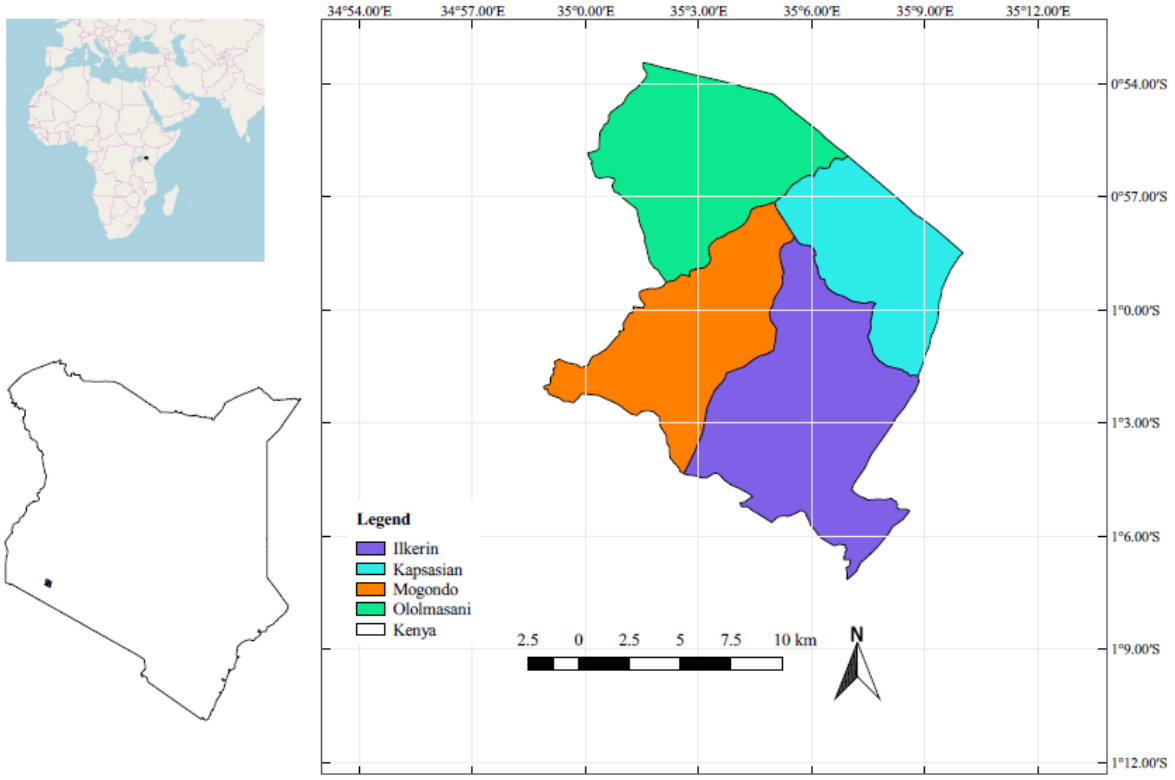

Figure 1.1 Location map of Trans-Mara East sub-County

(Source: Modified from the Kenya Survey Data, 2017)

1.6.5. Climate

Records from KMD[2] and NDMA[3], among others (Kipsisei, 2011; Nyamwaro et al., 2006), indicate that the sub-County experiences a variable annual two-time precipitation, around the second and last quarters of the year. This is in addition mutable atmospheric temperature situations of about eighteen degrees Celsius (Kipsisei, 2011; Wiesmann et al., 2014). This illustrates the sub-County's situation as that of limited or no rainfall in a greater part of the year, though many farmers rely on the two rainfall seasons for most of their cropping activities.

[2] Kenya Meteorological Department
[3] National Drought Management Authority

1.6.6. Cropping systems

Majority of the smallholders in Trans-Mara East sub-County practice mixed cropping systems. Among these crops in the area include a wide range of cereals such as corn and wheat coupled with horticultural crops such as beans and various vegetables. These crops are mostly used in the supply of food and income needs in the sub-County and its surrounding areas.

1.6.7. Livestock production

Like many parts of Kenya, livestock in Trans-Mara East sub-County constitutes a vital source of nutrition and revenue at household levels (Kinnaird & O'brien, 2012; Opiyo, Wasonga, Nyangito, Schilling, & Munang, 2015). Key among the enterprises reared include cattle, goats, sheep, donkeys and bees.

1.6.8. Demography

Kenya's household surveys of 2009 captured Trans-Mara East at a population of ninety-four thousand one hundred and fifteen. 94,115, with both the KNBS[4] and CRA[5] estimates, six years later indicating one hundred and five thousand eight hundred and seventy-nine. From these counts, twenty-two thousand four hundred and eighty-eight were considered as smallholders, with each of the four administrative units in the sub-county having between four thousand and six thousand and slighting more than six thousand three hundred of them.

1.7. Scope and delimitations

The study presents discussions on the linkages between smallholders' experiences with climate change and their response strategies within Trans-Mara East sub-County. It also attempts to position this specific study and its outcomes in the context of similar researches at national and international levels.

Accordingly, this study considers key smallholder experiences which include those related to their farming crop and livestock farming activities. In line with this, the study captures their socio-economic characteristics, namely age, gender, marital status, formal education levels, livelihood streams, and farm sizes, which are clustered as the independent variables. It also, on the other hand, features dependent variables which are the smallholders' climate-related

[4] Kenya National Bureau of Statistics
[5] Commission for Revenue Allocation

experiences, response strategies and constraints. The constraints were assessed at micro and macro levels, i.e. individual and policy levels, respectively.

On the climatic factors, the study focused on precipitation and temperatures for the study area using climatological records between 1980 and 2015. Drought conditions were also studied for the period 2000 to 2015, using smallholders' experiences and the area's existing records.

Moreover, the survey used a cross-sectional study design, coupled with field data collection and other complementary methods. These included questionnaires, key informant interview, and other qualitative approaches, with the results being analysed using various statistical measures.

1.8. Definition[6] of key terms and concepts

Adaptation: shifting the systems to conform to the prevailing external realities.

Adaptive capacity: the systems' and people's capability to adjust for adaptation.

Climate change: "longterm shifts in the climatological conditions" (UNFCCC).

Climate variability: "short-term shifts in weather-related elements" (UNFCCC).

Ecosystem: "a dynamic complex of plant, animal and micro-organism communities, and their non-living environment, interacting as a functional unit" (UNEP).

Food security: "physical and economic access to food that meets people's dietary needs as well as their food preferences" (FAO).

Institutions: "regularised patterns of interaction by which society organises itself; the rules, practices, practices and conventions that structure human interaction" (UNEP).

Poverty: involuntary situation of minimal access to essential needs due to inhibited purchasing power.

Resilience: "the ability of a system to thrive in spite of an external shock" (UNFCCC).

Smallholders (smallholder farmers): farming households with less than five hectares.

[6] These definitions have been drawn from various sources including published reports of World Meteorological Organization, United Nations Framework Convention on Climate Change (UNFCCC), United Nations Environment Programme (UNEP), and the Food and Agriculture Organization (FAO).

Sustainability: thriving without undermining the foundations on which the progress being made is anchored on.

Vulnerability: “an intrinsic feature of people at risk, as a function of exposure, sensitivity to impacts of the specific unit exposed, and the ability or inability to cope or adapt” (FAO).

CHAPTER 2: LITERATURE REVIEW

2.1. Introduction

Detailed discussions of both the available and empirical works on climatic situations for smallholder farmer performances from the upstream to downstream levels are availed in this chapter. These include an outlook on smallholders in the context of climate change at national, regional, and global levels, as well as various adaptation options, and the gaps encountered in the review of previous empirical studies. The last part of this chapter also shares models and contexts on which the study is centred on.

2.2. Agriculture and climate change

2.2.1. Smallholders and key dynamics in Africa

Agricultural development plays a vital role in the African continent as compared to other parts of the globe (Bizikova et al., 2013; Campbell et al., 2016; Douxchamps et al., 2016; Kristjanson et al., 2017; Ndamani & Watanabe, 2017; Uddin et al., 2014). In the continent, nearly 70% of the entire population relies on farm output for household nutrition and revenue flows (Oluoko-Odingo, 2011). Nevertheless, a large part of the mainstream farmers in this region are smallholders whose leading enterprises are dependent on the prevailing climatic conditions, with limited or no off-farm income streams which would otherwise supplement their on-farm output. Thus, the region is most likely to face disproportionate climate variability challenges, unlike other parts of the globe (Godfray et al., 2010). Vulnerability in the region is escalated by cross-cutting development challenges such as high levels of poverty, weak political and institutional arrangements, as well as massive population growth which currently makes a huge proportion of the global population (Godfray et al., 2010; Khisa et al., 2014).

Several parts of the continent, particularly the sub-Saharan region, have been faced with declining farmland productivity coupled with diminishing state of water resources. Climate change is largely blamed for these scenarios although authorities in the region are yet to invest in meaningful capacity development options, with specific target to vulnerable communities (Morton, 2007; Senaratna et al., 2013). Such situations would possibly exacerbate the strains allied to smallholder activities. These include aspects such as remote locations, constrained farm sizes, indefinite land tenure issues, and use of rudimentary technologies, among others (Mikalitsa, 2010; Musingi & Ayiemba, 2012; Ndamani & Watanabe, 2015). This is coupled with impulsive and bumpy marketplaces confronting smallholders.

Additionally, there has been constrained support towards smallholders to take advantage of emerging opportunities against climate change (Kabubo-Mariara & Karanja, 2007; Opiyo et al., 2015). This limitation puts them at the disadvantage of accessing technical and financial assistance, that are needed to effectively address the complications associated with climate change. Therefore, there is a need for comprehensive response strategies so as to successfully counter the adverse climatic situations.

2.2.2. Response options to climatic change

A comprehensive strategy for addressing the serious impacts of the shifting climatic situations ought to take into account the appropriate response strategies (Li & Urban, 2016; Oxfam, 2007). But for the most vulnerable communities, largely domiciled in SSA as is the case for developing regions, robust response options are vital. As well, multi-faceted interventions should include the input of the biggest carbon-emitting countries (Khan et al., 2015; Morton, 2007; Nielsen & Reenberg, 2010) to aid in halting any further deterioration of the state of climate. Well-structured response mechanisms implemented at the downstream level have co-benefits that can create positive multiplier effects on the output among a majority of smallholder farmers and other vulnerable groups (Morton, 2007; Opiyo et al., 2015). Many of these opportunities lie in the roles played by these downstream communities through their daily activities. These include the areas of land-use management and resource utilization at macro and micro levels (Adhikari et al., 2015).

Further, smallholder farmers in rural areas comprise a key component of actors that are important in establishing opportunities for addressing climatic shifts (Thornton, Ericksen, Herrero, & Challinor, 2014). Their role in climate change mitigation through various forms of land uses is beneficial to the environment (Musingi & Ayiemba, 2012; Tibesigwa et al., 2015). These farmers harbour immense indigenous knowledge which is important in addressing the climate change phenomenon at various levels of action (Uddin et al., 2014). However, their potential to contribute in solution-seeking is often undermined by several key factors (Kalungu et al., 2013), including meagre financial resources, lack of incentives to innovate, “unfriendly” policies, and resource degradation.

A continued search for data and information that would shed more light on the constraints and opportunities related to climate shifts and smallholder farming communities, would easily widen the availability of options for handling the current situations in the region. Progressive decision-making processes have been shown to correspond with the availability of empirical

data on any given matter at hand. Thus, in the process of seeking to address the various challenges around smallholder farming and current climatic states in the SSA, it would be vital to continually gather and utilise a wide range of data and information. This targeted approach will help in developing results-based lines for responding to the challenge at all levels.

2.3. Adaptation to climate change

2.3.1. Adaptation strategies

Adaptation in itself is a process which entails a deliberate change of thoughts and actions owing to external perturbations and dynamics relating to both the environment and society (Field, 2012; Opiyo et al., 2015). However, the definite identification of the key factors behind these shifts, especially at micro-levels, has not been rightly defined. Effective adaptations can, therefore, be considered as decisions that reduce susceptibility, while vastly enhancing stability against climate-related constraints at various temporal and spatial scales. (Campbell et al., 2016; Thorn et al., 2015).

Morton (2007) and Field, (2012) describe adaptation as the versatility of socio-ecological systems in relation to external pressures as a coping strategy against the consequences of change. This includes the modifications made in anthropogenic and biophysical levels against the prevailing climatic states. Adaptation, therefore, includes a process of targeted readiness and persistence against strenuous events (Bizikova, 2013). It is essential to ward off inevitable climatological adversities (Wheeler & Von Braun, 2013) especially the communities with increased levels of exposure that is associated with their enterprises (Lal, 2015; Müller et al., 2011). Nevertheless, authoritative analyses of approaches for effective responses have not been in tandem with the prevailing realities at the community levels (Thornton et al., 2014).

Accordingly, it would be pivotal to understand and integrate climate-related adaptation measures on development strategies and practices. Such interventions are important in enhancing flexibility against extreme climatic events, which subsequently contributes to greater development objectives at all levels (Opiyo et al., 2015). Besides, the common adaptation approaches "tend to be either actor-oriented, focusing on the agency of social actors or institutions to respond to specific environmental inducements, or systematically aligned to the prevailing external situations" (Nielsen & Reenberg, 2010). It is however clear that in spite of the increasing levels of discussions around adaptation at various levels in the society, adaptive capacity, particularly among the vulnerable communities has not been well-

illuminated. There still exist many "missing links" on the specific adaptation approaches for the smallholder rural farming communities. These encompass careful adjustments towards unfavourable shifts in the biophysical systems (Silvestri et al., 2015), led by climate variability.

2.3.2. Autonomous adaptation

Adaptation strategies largely fall into two categories i.e. *planned,* which is aligned to policies and institutional interventions, and *autonomous*, which largely originates from the intuition and other forms of awareness among the affected persons (Wheeler & Von Braun, 2013). Downstream adaptations are generally regarded as passive forms of adaptation, whereas strategy-driven adjustments tend to be anticipatory and more impactful in terms of the outcomes (Morton, 2007). But it is essential to understand the nuances of adaption at all levels of action to pave way for sustained impact.

Autonomous adjustments refer to "the continuous implementation of existing knowledge and technology in response to the prevailing climate change and variability" (Rao et al., 2011; Thornton et al., 2014). Conversely, *planned* adaptation is *"*the increase in adaptive capacity by mobilizing institutions and policies to establish or strengthen conditions that are favourable to effective adaptation and investment in new technologies and infrastructure" (Musingi & Ayiemba, 2012; Muzamhindo, 2015).

Common among many smallholders are self-directed adaptation, especially in areas that are prone to frequent environmental uncertainties (Oluoko-Odingo, 2011), mostly located in areas of ecological fragility. This is often inspired by their endowment with extensive indigenous knowledge base, through which they often draw upon to boost their coping strategies against adverse environmental conditions and shocks.

According to (Khan et al., 2015; Morton, 2007) autonomous adaptation options include an application of either one or all of the following practices:

a) selecting adaptable cropping by appropriately adjusting various planting materials such as the seeds and fertilizer application rates to enhance the yields in spite of the climate, and ensuring prudent water utilization in the farms;
b) employing efficient technologies in water harvesting, soil moisture retention and other water-use practices, especially in areas with depressed precipitation;
c) employing sustainable hydrological solutions to address water-related issues in areas with enhanced precipitation;

d) effectively adjusting the cropping seasons and crop rotation practices;
e) encouraging the adoption of options that can easily lead to broadening of the income streams, such as through the integration of crop and livestock husbandry; and,
f) making good use of the weather information from the mandated authorities.

Various smallholders have for a long time managed to attain sustainable utilization of their farmlands by using responsive and more strategies, taking cues from previous challenges of similar nature changes (Morton, 2007). Although such interventions have been beneficial towards a large extent of climatological fluctuations, rapidly increasing shifts will likely overshadow them in the near future if not adjusted accordingly. (Opiyo et al., 2015).

Understanding the options and constraints for *autonomous* responses is consequently essential to cushioning smallholders farmers, while at the same time reducing the rate of environmental degradation (IIPCC, 2012; Morton, 2007; Sheahan & Barrett, 2014). The achievement of this quest can be accelerated through researches with the potential to avail and strongly articulate useful information regarding the actual situations and suitable measures to be employed in order to minimise vulnerability among communities.

With respect to technical options, some of the appropriate approaches include many forms of land-use options, sustainable cultivation practices, and adaptable inputs, among others. These also encompass fitting incentive schemes that can potentially expand viable options for poor communities and indigenous peoples in climate-related adaptation and mitigation (Labbé et al., 2016). Further, ensuring successful adaptation strategies at the local level constitute an integral part of achieving the global community's Agenda 2030 for Sustainable Development, accentuating on the need to "leave no one behind". It would thus be imperative to suggest that, well-planed adaptation options constitute an integral component of deliberately addressing the climate variability challenges.

2.3.3. Crop adaptation strategies

For many smallholder farmers, whose livelihoods are often tied to subsistence cropping systems, successful adaptations can immensely enhance their resilience while at the same time decreasing their vulnerability to multiple threats (Wheeler & Von Braun, 2013). Thus, there is a need for viable cropping adaptation options. Crop adaptation options, in particular, involve the measures which can sustain the productivity of crop performances (IPCC), 2012) in spite of the existing climatic variability. Many reports (Godfray et al., 2010; Kelemu et al., 2015; Sheahan & Barrett, 2014) are projecting an imminent plummeting of crop yields in various

parts of the globe. To be affected most include key cereals such as corn if substantial schemes were not employed to counter the potential impacts of climatic shifts. However, smallholders would easily have better yields if they were to access and incorporate a wide range of the presently available and suitable cropping interventions (Labbé et al., 2016).

Some farmers in various parts of Kenya are implementing various response mechanism against climate change (Kalungu et al., 2013; Okumu, 2013; Oluoko-Odingo, 2011). However, their actual strategies have not been well-documented in smallholder-dominated arable lands of Kenya. Among the enlisted options being applied include irrigation, timely planting, migration to other productive areas, and seeking employment in urban areas, among others.

Nevertheless, most of the previous studies on the subject in Kenya have been largely dwelling on maize cultivation (Ali-Olubandwa et al., 2010; Marenya & Barrett, 2009; Okumu, 2013; Rao et al., 2011), yet there are dozens of other crops beneficial not only to the smallholder farmers but also to a larger part the country's rural and urban economy. For instance, scanty information exists on the utilisation of crops with a shorter growing period these have got promising adaptation opportunities.

2.3.4. Livestock adaptation strategies

According to Ghahramani and Moore, (2016), and Rigolot et al., (2017), livestock rearing in many parts of Africa are vital sources of nutrition and income earnings. The enterprise is important to the region's resources and earnings, especially on meat and dairy industry (Rigolot et al., 2017). The enterprise's transformation has, however, not been adequately captured in the region's development agenda. As a result, livestock performances in the region have been operating much below the potential production. These situations are compounded by various socioeconomic and environmental challenges, the latter including shifting climatic conditions.

In Kenya, animal farming practices are under the purview of decentralized levels of administration (Ndung'u et al., 2010). A lot of the country's subnational governance structures are widely reported to lack a definite road map for addressing the livestock-climate associated challenges. The availability of quality feeding materials for extensively-reared livestock largely depends on the prevailing climatic situations and extension services which need to be captured in the medium -to – long-term county development plans. Targeted interventions would thus be vital. The dividends of such actions feed into the overall livestock performances, with potentially impactful multiplier effects on socioeconomic positions of households and revenues accrued to these administrations.

Key among the issues affecting Kenya's livestock sector is burgeoning human population, which proliferates ecological and socioeconomic challenges (Morton, 2007; Thornton et al., 2014). Enhancing livestock productivity thus requires an integrated approach for the sector to achieve full potential. One essential step in this quest is contributing to the availability of comprehensive information on livestock rearing dynamics in the face of mounting climatic shifts. Beneficial impacts of this action include continuity of the livestock-related goods and services to people and the environment (Mearns, 1996). These purposes are associated with specific demands on types of farm animals, their products and distinct food security concerns.

The current study examined the contribution of livestock to smallholder adaptation options in Trans-Mara East sub-County. Such an approach is particularly imperative since the smallholder livestock including cattle, common in the area, contribute to the rural economy with a multiplier effect on the entire country's economy (Kabubo-Mariara & Karanja, 2007). These aspects include food security and nutrition, broadening livelihood streams, and farm labour, among others (Mikalitsa, 2015; Oluoko-Odingo, 2011).

2.4. Empirical studies

Various studies have explored the linkages between farmers' standings in the face of shifting climatic situations. In Africa, studies such as (Ndamani & Watanabe, 2017) in Ghana examined socio-economic profiles of farmers as indicators of their perceptions about climate change. Their conclusion was that the communities under their surveyed area had a relatively high level of awareness on climate change and its associated risks and were willing to put in place appropriate response strategies. They, however, reported that various levels of perception were aligned with one's socio-economic characteristics such as the level of income.

In South-East Asia focusing on Bangladesh, (Uddin et al., 2014) looked at smallholder farmers' behavioural responses to changing environments. Their study focused on environmental degradation that is associated with climate change, and how smallholders were responding to these situations through a wide range of adaptation mechanisms. Its report features extensive adaptation measures that are already in place, with irrigation being the leading strategy under when weight an Adaptation Strategy Index employed by the study. On the side of challenges, the study implicated climate change policies in Bangladesh as one of the weakest links.

In Kenya, (Opiyo et al., 2015) focused on climatological-related response strategies among the pastoral communities in northern Kenya. Like other studies around this subject, (Opiyo et al., 2015) used both the socioeconomic profiles of the respondents as well as the meteorological

data to gauge the efficacy of each response strategy. Key among their documented strategies were livestock management interventions implemented at the individual level, with none on the policy levels.

2.5. Measuring adaptation options and challenges

Ascertaining levels of efficacy under any given measures employed against an external threat requires standard approaches applied at scales of interventions. However, given the existence of no universal technique, various studies tend to contextualise the measures according to their set objectives and targeted data (Field, 2013; Grothmann & Patt, 2005; Ndamani & Watanabe, 2017; Uddin et al., 2014). Both the direct and proxy indicators of adaptation constitute the shared areas of interest in these findings, with the strength of each of them being evaluated against several indices. Among these indices is the problem confrontational index and weighted average index.

Problem confrontational index (PCI) (Hossain, 2011; Roy, Farouque, & Rahman, 2014)has been used in various studies attempting to understand the constraints on behavioural responses against an external threat in line with the "Protection Motivation Theory*"* (Maddux & Rogers, 1983; Rogers, 1975). PCI refers to the level at which constraints on a threat-response measure is evaluated against other responses. Many climate change adaptation studies (Uddin et al., 2014) consider PCI as one of the useful indices for surveying and ranking key factors impeding climate-related response approaches, utilising the values obtained from the Likert scale. It has been used by (Ndamani & Watanabe, 2015; Roy et al., 2014). In many cases, these constraints are external to the individual, i.e. mostly associated with policies and institutional level readiness. Nonetheless, PCI has not been widely used in climate-related studies for smallholders in Kenya.

On the other hand, the Weighted Average Index (WAI) refers to the level of influence of a response strategy employed against external threats such as climate change (Ndamani & Watanabe, 2015). It utilises the frequency of occurrences of scores associated with each response measure. Like the PCI, this index despite being versatile has not been widely used in locally on climate-related studies.

2.6. Gaps in literature

From the literature reviewed, it is apparent that academic debates on downstream adaptation to climatic shifts have been amorphous and fragmented, with fewer insights on the empirical

setting of the smallholder farmers. However, this and other aspects relating to the current conditions have been substantially examined in the current study with the overall aim of making an objective contribution to the knowledge to accelerate adaptation at downstream levels.

It is also worth noting that, whereas many studies in Kenya and other parts of Africa have been centred on climatological readiness and resilience, very few of them have systematically captured the current standings and constraints at micro-levels. This is seen, for instance, on response capacities and constraints in smallholder cropping and livestock systems. This disjointed link has not been covered holistically yet nearly all the smallholders in the region practice mixed farming activities.

Besides, and in Kenya alone, nearly all the climate change adaptation-related studies have been mostly concentrating on maize cultivation and common commercial crops. This has been happening yet there are many other crops likely to be affected by climatic scenarios, with concomitant effects on the overall socio-economic and food security potentials. Further, livestock production in mixed farming systems have not been given the deserving attention by many researchers in climate-related studies. This has also been the case in spite of the sub-sectors huge contribution to the smallholders' availability of food and income streams, in addition to injecting tidy sums of money into the country's GDP. As such, a systems approach that would otherwise capture the state and trends while also point out the critical areas of greater impact in an integrated manner, are mainly lacking.

Additionally, in Trans-Mara East sub-County, no research has ever given attention to the association between smallholders and prevailing climatic situations. The only comprehensive study (Sitati & Walpole, 2006) in the area's neighbouring Trans-Mara West focused on human-wildlife conflicts, with farmers being the only thread linking it with this study. Therefore, this area's circumstances are prevalent, yet incomes of many residents are mostly hinged on the nature-dependent smallholder performances. Farmers in the area mainly rely on small-scale activities, particularly in their food security demands and income generation, with direct links to their children's education, healthcare needs, and other key household demands.

Therefore, the current study was deemed timely. Its employs a holistic approach to examine the area's climatic situations using historical data and smallholders' experiences regarding their activities, as well as the available and desired adaptation options and constraints thereof. Besides, the recommendations provided would possibly be useful in refocusing the adaptation

objectives in the area. Success in this would easily be realized if the recommendations were to be implemented with synergies involving communities and other key actors.

2.7. Theoretical framework

The present study used a "theoretical framework" that is anchored "Protection Motivation Theory (PMT)" advanced by (Rogers, 1975). PMT explores human behavioural responses to perceived threats and has been widely applied to various studies, including on natural and technological hazards. On climatic threats, (Grothmann & Patt, 2005) explores the efficacy of PMT in resilience and adaptation. Others such as (Keshavarz & Karami, 2016) have looked at pro-environmental behaviours in response to extreme weather situations.

Specifically, Grothmann & Patt (2005), identified allied responses as a process that considers individual and institutional adjustments. At the individual level, behavioural responses include the conscientious decisions taken by households and communities to either pre-empt or react to their perceived pressures from climatic shifts. At institutional-level, focus is given to actions that largely assume the integration of sequential and logical processes as well as periods of recycling, iteration and reformulation, according to the situations at hand. These actors, together or separately, can influence the adaptive capacity, threat appraisal, and the overall outcome, including climatic adaptation measures.

The theory applies to the present study in that, both the smallholder farmers and other stakeholders in the agricultural sector are motivated by the need to avert the adverse impacts of climate change and variability. Further, any successfully applied options against climatic extremes (IPCC, 2012) would have a multiplier effect on the farmers' adaptive capacity and in the collective goals of sustainability (Bizikova et al., 2013), both at the downstream and national levels (Figure 2.1). In addition, the overall adoption and implementation of robust climate change adaptation options and outcomes eventually result in processes with positive feedback to environmental sustainability and enhanced socioeconomic drivers of human wellbeing (Sheahan & Barrett, 2014).

To analyse the interactions of adaptation options and smallholder farming activities in the area, based on the theory, adaptation was broadly conceived to include the determinants and outcomes of its activities (Marenya & Barrett, 2009). The determinants describe the bio-geophysical and societal interfaces that influence the adaptive capacity and the overall adaption options. Combined, these would, in turn, lead to a number of positive social and environmental

outcomes associated with farm-level enterprises, in a sustainable manner (Thornton et al., 2014).

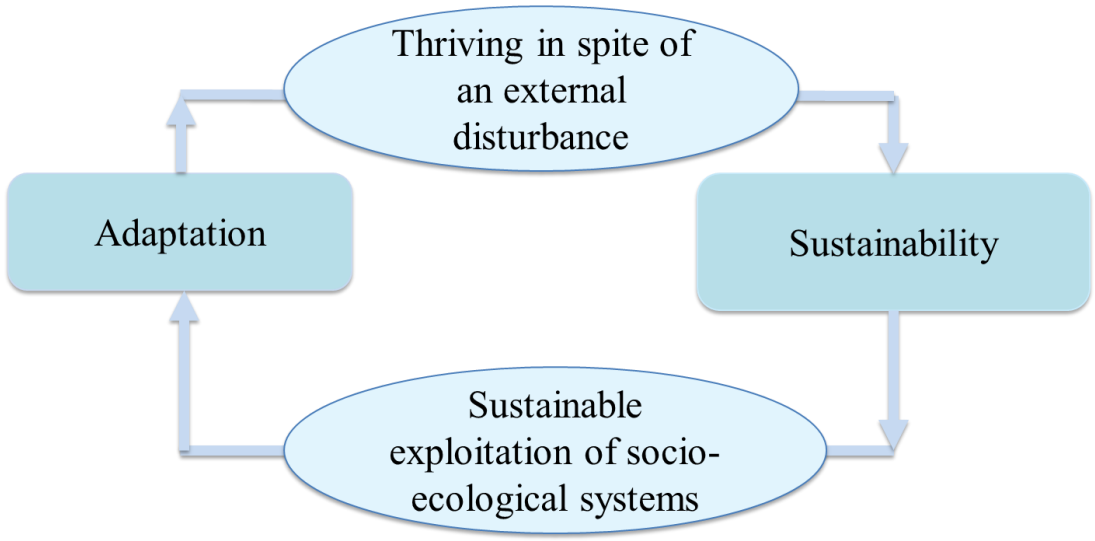

Figure 2.1 Adaptation and sustainability as complementary concepts

(Modified from Food Resilience Model of Ericksen et al., 2011)

2.8. Conceptual framework

The present research utilized a conceptual framework that was based on regional political ecology (Black, 1990; Walker, 2003). Application of the framework to understanding the role of various societal factors in swaying the corresponding response options among smallholder farmers in Trans-Mara East is particularly important (Reid et al., 2009). The main concept of this framework, as presented in Figure 2.2, is that the overall performances of farming systems, jointly with knowledge levels, attitude and practices among the smallholder farmers, are influenced by collective input from climatic, institutional, regulatory, and technological environments (IPCC, 2012).

However, the socio-demographics (age, education attainment, occupation, organisational affiliation), and both the policy and institutional setup are considered as intervening factors for they can have an influence on the performances of farm-related enterprises, as well as the levels of familiarity, perception, and interventions among the smallholder farmers (Fischer & Qaim, 2012; Morton, 2007). The intervening factors considered in the concept under the policy-institutional arrangements include land tenure, financial services, extension services, and infrastructure, among others.

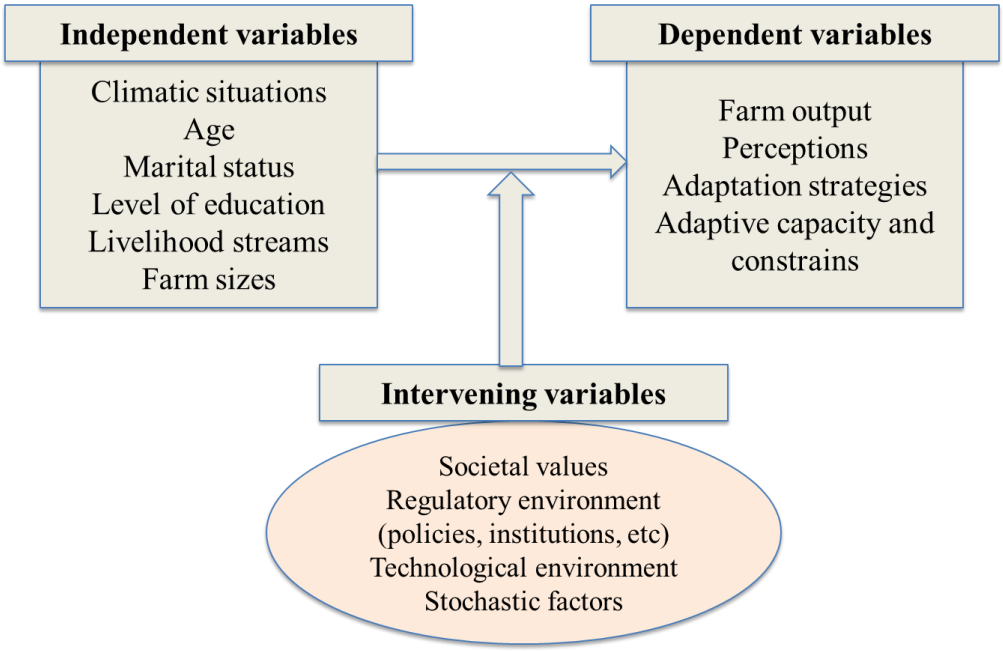

Figure 2.2 Conceptual framework applied under the current study

(Source: Researcher, 2017)

CHAPTER 3: RESEARCH METHODOLOGY

3.1. Introduction

Covered in this section of the study is the research methodology used to obtain and process the resultant field data. It entails concise descriptions of the study design, study population, data sources, sample size, data collection strategies, and subsequent processing options.

3.2. Research Methodology

3.2.1. Study design

This study used a cross-sectional survey (Kothari, 2004) of quantitative and qualitative variables of smallholders in Trans-Mara East sub-County between March and October 2016. The design was found to be appropriate to make sound arguments about farm-level experiences among smallholders with respect to their responses against the climate change scenario. For instance, the design helped in simplifying various aspects of the data collection such as farm-level perceptions, adaptive capacity, and constraints.

3.2.2. Study population

The targeted population of the study were smallholders from Trans-Mara East sub-County of Narok County. Estimates from the KNBS and Kenya's socio-economic atlas (Wiesmann et al., 2016) report on the area's population of practising smallholders to be 22,488. This population largely informed the choice of sample size (Nassiuma, 2000) that was effectively utilised in the study.

3.2.3. Sources of data

The study effectively utilised both the primary and secondary sources of data (Field, 2009).

3.2.3.1. Primary data

Questionnaire surveys, semi-structured interviews, and focus group discussions were the main means employed to capture the targeted primary data (Field, 2009; Kothari, 2004).

Self-administered questionnaires helped in obtaining quantitative data across 100 households. This was in addition to semi-structured interviews which were used to get information from 13 key informants, who included officers from agricultural, water, environment and social development sectors from the sub-County. Others were the area's representatives of non-state actors and community leaders. Deliberations with the key informants bordered on institutional

and policy concerns. To further glean qualitative data on the targeted issues, the study included four "focus group discussions".

3.2.3.2. Secondary data

The study's climatological variables on precipitation and temperature largely constituted the secondary data. These were obtained from the KMD for the period between 1980 and 2015. Other secondary data was gleaned by reviewing various forms of scholarly materials, deemed fit to the research. Among them include maps, scholarly materials, textbooks, and government reports (Kothari, 2004).

3.2.4. Sampling size and sampling technique

3.2.4.1. Sample size

The 2009 nation-wide household survey in Kenya placed Trans-Mara East sub-County's total population at ninety-four thousand one hundred and fifteen, with 2015 estimates from KNBS and CRA putting it at one hundred and five thousand eight hundred and seventy-nine. From the latter estimates, smallholders added to twenty-two thousand four hundred and eighty-eight. The four Wards in the area had their estimates at 6297 for "Ilkerin"; 5599 for "Kapsasian"; 4205 for "Mogondo"; and 6387 for "Ololmasani". Based on these population data, the study's sample size was obtained by applying (Nassiuma, 2000) model. The model yields a sample size (n) using the following equation:

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

*Where, **N** = the target population; **Cv**= the coefficient of variation; **e** = desired level of confidence.*

*For this study, **N** = 22, 488, as the estimated population of smallholder farmers in the sub-County; **Cv**= 0.5; **e** = 0.05.*

Therefore,

$$n = \frac{22{,}488\ (0.5^2)}{\{(0.5^2) + (N-1)0.05^2\}}$$

$$n = 99.122$$

$$n \sim 100$$

The study's calculated sample size was thus, one hundred households. Further, thirteen key informants were purposively selected for detailed interviews, in addition to four focus group discussions (Kothari, 2004). Key informants came from a pool of crucial actors involved at various levels of socio-economic interventions in the sub-county. Among them were elected representatives, agricultural officers, community development experts, and meteorological department officers.

3.2.4.2. Sampling technique

The present study utilised a multi-stage sampling (Kothari, 2004) with a sample size of one hundred households. This entailed stratifying the area into four blocks, each covering an administrative Ward, to simplify accessibility and distribution of the sample size. Further, data from KNBS on population census for the sub-County goes up to the county assembly level, beyond which no reliable data on population could be obtained.

Accordingly, a sample of one hundred farming households was picked from the study population of twenty-two thousand four hundred and eighty-eight farming households. This process was implemented with the use of Nassiuma (2000) model. Following was a distribution of face-to-face questionnaires that were spread in relation to a pre-established proportion of households in the area's Wards. Each of them had had these as follows: twenty-eight for "Ilkerin", nineteen for "Mogondo", twenty-five for "Kapsasian" and twenty-eight for "Ololmasani".

Augmenting the details from questionnaires were "focus group discussions", where each Ward had a chance for one. These were accompanied by targeted "key informant interviews". Within each of the four wards, the respondents were nominated using a "simple random sampling method" (Kothari, 2004). The area's grid map was used to geolocate respondents, with each grid being numbered to represent the location of each respondent. Target respondents were then identified by generating random numbers from the calibrated grid map.

The survey involved male and female respondents from ages 25 to 64 years old, each of whom was the *de facto* 'head' of farming activities and decision-making responsibilities in the household. The choice of this age bracket was informed by studies which have shown the ages of 15-64 years being the economically active segment of the population with the ages below 15 and above 64 being classified as "dependent". However, in Kenya, the earliest age with which one can be considered to be economically productive largely starts from age 25 (Sam & Pokhariyal, 2016). In the field, the youngest and oldest respondents encountered were 28 and

64 years old, respectively, a situation which corroborates the questionnaire's projected farmers age structure.

On the other hand, getting each of the key informants to participate in the survey entailed the use of purposive sampling (Kothari, 2004). As such, key informants were considered with their level of awareness and participation with the area's smallholder practises.

3.2.5. Data collection methods

The research captured qualitative and quantitative variables the following data collection methods:

3.2.5.1. Interviews

Key informant interviews (Kothari, 2004; Unwin, 2013) included in the study captured experiences of foremost actors from both the national and county governments. These included representatives for the departments of social development, public administration, education, environment, water, and agriculture. This exercise also included the views of community representatives, among them being political leaders, non-state actors, and prominent traditional leaders from the area. The study purposively (Etikan et al., 2016) targeted these group of stakeholders as they were deemed much more aware of the general happenings in the area. These included the issue at hand, owing to their level of responsibilities and influence, compared to the commoners (Kothari, 2004). Thus, the main role of the key informants engaged was to illuminate on policy, institutional and technological perspectives vis-à-vis the smallholders and climatic situations in the area.

3.2.5.2. Questionnaires

Questionnaires were administered face-to-face with the smallholders for the purposes of obtaining a large amount of quantitative data (Kothari, 2004). This process made use of structured questionnaires (Appendix 1) which have been shown to yield easily analysable data in SPSS (Unwin, 2013). Among the key concerns captured include demographic dimensions, socioeconomic variables and smallholder experiences with the area's climatic situations (perceptions and adaptation). Records of the resulting data were later cleaned, coded and summarised in SPSS. A pilot test of the questionnaire (Kothari, 2004; Nassiuma, 2000) was earlier deployed. This process greatly was useful in amending some of the questions to suit the area's socioeconomic dynamics.

3.2.5.3. Observation, GPS records and other notes

This study utilized participant observation (Kothari, 2004), where the researcher took records of any essential variables observed in the study area while running the questionnaire and key informant interviews. The process played a key role in filling some inadvertent gaps in the other data collection methods. Besides, the method was useful in verifying the existence of some of the farm-level responses including on farm size, cropping systems, livestock types kept, and employed farming techniques, among others (Plate 3.1).

GPS locations for each respondent were also recorded, with concise notes about their physical locations, just in case the researcher or anyone else may later develop an interest in doing a follow-up study in the area. Any informal but relevant conversations with smallholders and the area's other key players were also noted down. A combination of these methods was deemed necessary for a detailed view of the data in the study area.

3.2.5.4. Focus group discussions

Four "focus group discussions", i.e. one per administrative Ward, were also conducted in the area (Plate 3.2). Local networks of CBOs and individuals were instrumental in mobilising for participation and logistical arrangements.

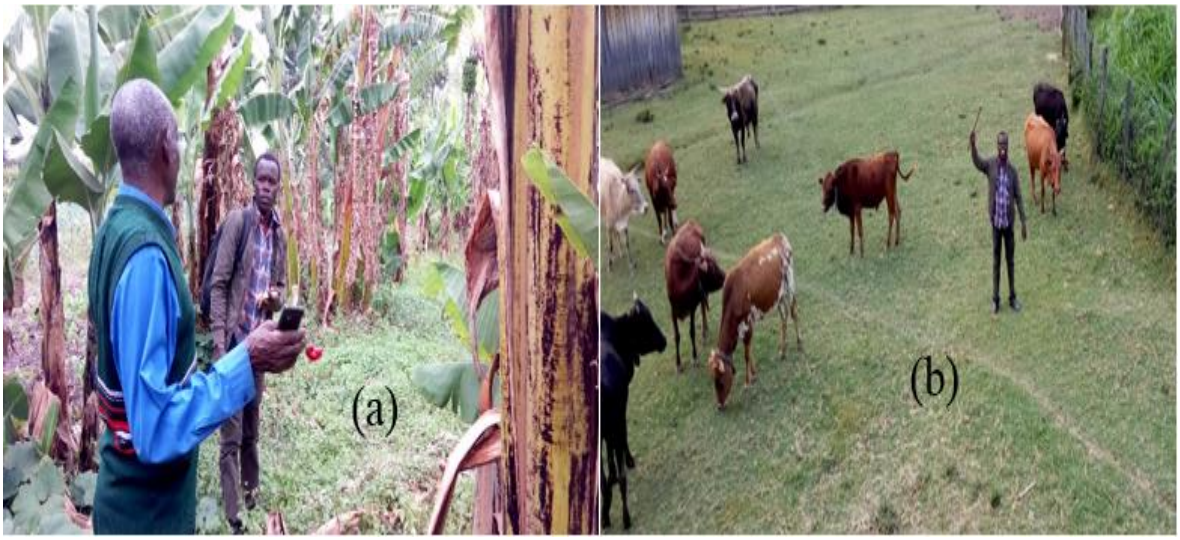

Plate 3.1 Sorghum and finger millet fields in the Trans-Mara East sub-County Location: (a) Kapsasian, and (b) Ilkerin Wards (Source: Field Data, 2017*)*

3.2.6. Statistical analysis

The compilation and analysis of data was performed with SPSS[7] (version 21) (Field, 2009), where data on each of the variables under consideration were processed using descriptive and inferential statistics.

For instance, smallholders' climate change response strategies together with their opinions on the hierarchical standing for each of the approaches, came from their participation in scoring each of them on "Likert scale" of zero(0) to three(3) as performed (Ndamani & Watanabe, 2015). Here, zero (0) and three (3) denoted the least and peak heights of status, respectively. Each of these observations were further assessed using a "Weighted Average Index (WAI)". The method has been applied in similar studies such as (Devkota et al., 2017), through which the observations were scored hierarchically.

$$"WAI = \sum(F_i W_i)/\sum F_i" \quad (1)$$

(*F* = regularity of incidence; *W* = score's level of influence; *i* = values)

The degree of influence of each adaptation-related limiting factors was appraised using a "*Problem Confrontational Index* (PCI)" as performed by (Ndamani & Watanabe, 2015). The process involved an evaluation of experiences deemed to be limiting adaptation in a "Likert scale" from with varying levels of influence of the approaches employed against climate-related challenges, with the PCI value being calculated using the following equation:

$$"PCI = [(P_n \times 0) + (P_1 \times 1) + (P_m \times 2) + (P_h \times 3)]/100" \quad (2)$$

(*Pn* observations classifying a factor to be "non-issue"; *P1* least factor; *Pm* discreetly important factors; *Ph* topmost factor)

The study's research hypotheses were evaluated using the "Spearman's Rank correlation coefficient" (Unwin, 2013). Some of the data were captured in nominal and ordinal scales of measurement, thus being appropriate to use the Spearman's correlation to examine relationships between the variables under study. The evaluation thus entailed an analysis of the smallholders' socioeconomic characteristics that were captured as the independent variables against the

[7] **SPSS** Statistical Package for the Social Sciences

dependent variables. Smallholders' climate change adaptation experiences, response strategies and constraints were considered as the dependent variables.

Plate 3.2 Participants in focus group discussions at Trans-Mara East sub-County Location: (a) Ilkerin, (b) Mogondo, and (c) Ololmasani Wards
(Source: Field Data, 2017).

3.2.7. Ethical considerations

Details and purposes for each of the processes, in the entire data collection exercise, were disclosed to the participants ahead of time. Besides, acquiring any kind of data using each of the established methods in the farming households, entailed an entirely consensual undertaking, between the researcher and each participant, but always at the discretion of the participant. Additionally, they were informed beforehand that should any segment of their responses be used in a publication, their right to privacy as enshrined in the Kenyan Law[8], would not be infringed.

[8] Article 31, Constitution of Kenya 2010

CHAPTER 4: RESULTS AND DISCUSSIONS

4.1. Introduction

Summary of the findings, data analysis as well as discussions in line with the research problem, objectives, and hypotheses given in *Chapter One,* constitute the gist of this chapter. It entails an outlining of the results from examining smallholders' socioeconomic characteristics as constituent of key aspects likely to be associated with their experiences on climatological trends in the study area. Thereafter, specific findings from the study are elucidated chronologically.

4.2. Demographic characteristics of the sample

4.2.1. Age profiles

Most of the respondents (76 per cent) were of age thirty-five and above (Figure 4.1), with their average and median ages being forty-two and forty years old, correspondingly. Similar studies in Africa and other parts of the globe corroborate these findings, with special focus on the "ageing farmer population". Such a situation is said to threaten the "future food security" as well as the other socioeconomic aspects farming in the developing parts of the world. Worryingly, this state of affairs is likely to aggravate by the bulging urban populations, which demand a commensurate increase in food resources. For instance, current projections (UNDESA, 2017) indicate that the world population will hit a nine billionth mark by the year 2050. Various United Nations entities including FAO[9], agree on the need to nourish populations by expanding food resources by at least 70% of the current production levels, in an ecologically sustainable manner. Healthy and resilient ecosystems constitute the foundation of sustainable food systems and economies (Costanza et al., 2014; Kumar, 2012).

Further, among the respondents, male and female composition was 47 per cent and 53 per cent, respectively. Regarding the male respondents, all of them were *de jure* household heads, while for the female respondents, most of them were found to have more distributed farm-related errands their husbands (69.8 per cent). The rest were as standalone heads of smallholding households (30.2 per cent). Various scholarly works such as (Khisa et al., 2014; Mikalitsa, 2010; Oluoko-Odingo, 2011) seem to suggest a higher chance of vulnerability among the standalone heads of smallholding households, including on climate-related shocks. This research, however, was not able to determine the reliability of these suggestions in Trans-Mara East. One of the postulations that could have titled the state of affairs here is that the female-

[9] Food and Agriculture Organization

headed farming households here had additional livelihood streams from off-farm activities, including those who were getting regular financial support from Kenya's "National Safety Net Programme (NSNP)". NSNP is a Kenyan Government initiative aimed at reducing poverty through cash transfers to vulnerable members of the society (Ndung'u et al., 2010). It is administered through Kenya's Department of Gender and Social Affairs, with backing from the World Bank.

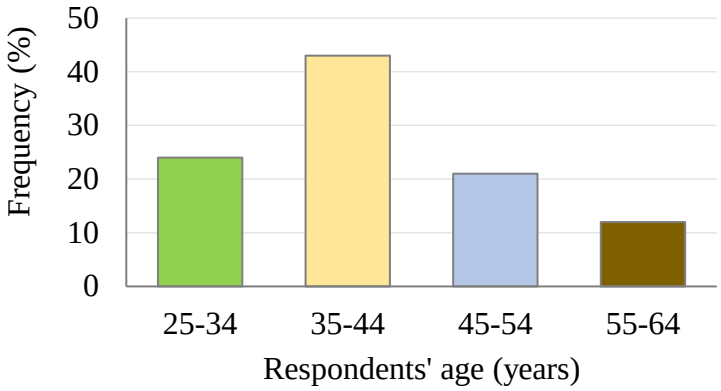

Figure 4.1 Respondents age structure details in Trans-Mara East sub-County
(Source: Field Data, 2017)

4.2.2. Educational profiles

More than half of the smallholders surveyed had elementary levels of formal education (55 per cent), with the least share of them having post-secondary schooling (9 per cent) (Figure 4.2). In addition, schooling profiles in the area had some sort of relations with smallholder's oldness. The younger populations appeared to have higher levels of formal schooling compared to their counterparts with more advanced ages. These situations have a higher level of probability to influence the penetration of climate-related skill-sets, and thus the level of susceptibility among the areas' smallholders. For example, it can affect smallholders' abilities to diversify their livelihood streams through non-farm confined activities as a way of broadening adaptation to climate-related risks (Kassie et al., 2014; Oluoko-Odingo, 2009; Pérez et al., 2015).

4.2.3. Livelihood streams

More than three-quarters of the respondents had on-farm agricultural activities as their only means of living, while the least of them had supplementary income opportunities, albeit being meagre (Table 4.1).

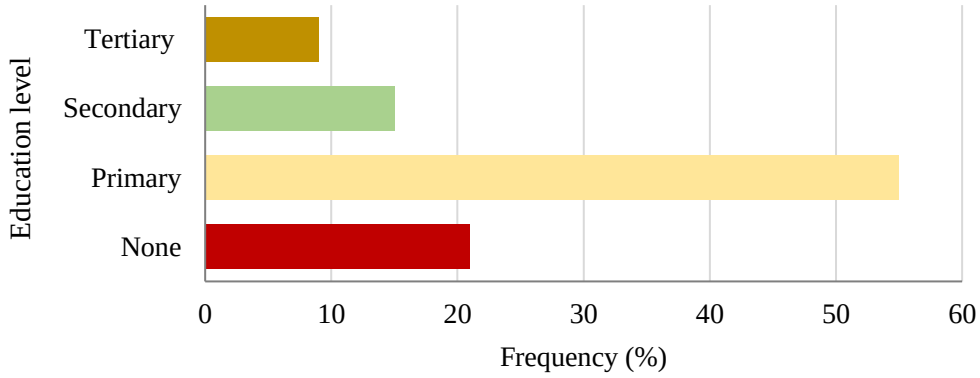

Figure 4.2 Education levels among respondents in Trans-Mara East sub-County

(Source: Field Data, 2017)

Table 4.1 Diversity of smallholders' livelihood streams in Trans-Mara East sub-County

Key livelihood source	Frequency (%)
Entirely farming	83
Farming and fulltime employment	6
Farming and casual labour	3
Farming and small-scale business	8

(Source: Field Data, 2017)

Any given community's adjustments against external shocks such as those associated with climatological situations are closely linked with the multiplicity their accessible income opportunities (Nielsen & Reenberg, 2010). This position, thus, suggest that smallholders in Trans-Mara East sub-County may not be able to adjust accordingly towards the climate-related shocks, yet such an option is presented as the most viable strategy (IPCC, 2012). However, all is not lost as such circumstances can be addressed by putting place various response options that can accelerate climatic-readiness at household and policy levels (Oluoko-Odingo, 2011). These include avenues for channelling interest-free funds which can help them start small and medium enterprises. The author's engagement with women in the area indicated captured a huge potential that is hindered by access to capital related to finance and land ownership. For instance, in the area, at least one in every two villages surveyed had women who belonged to a *Chama* – a social welfare group (Plate 4.1), where each member was making monthly cash subscriptions of as low as KES 100 (approximately 1 USD). If significant amounts of financial

capital were to be injected into such groups, huge livelihood dividends would easily be realised, given their demonstrated determination to "kick-off" poverty out of their families and villages.

Plate 4.1 Women attending a monthly Chama meeting in Trans-Mara East sub-County

Location: Takitech Women Group at Ololmasani Ward in the sub-County
(Source: Researcher, 2017).

4.2.4. Farm sizes

A huge share of the smallholders (33 per cent) owned farms whose sizes ranged from 2.1 to 2.5 ha (Figure 4.3). These farms were largely underproduction of maize and rearing of livestock whose main enterprise was cattle (Figure 4.4). The apparently smaller allocations going towards livestock rearing compared to crop-related activities, according to the gathered information, was mostly driven by the possibility of using crop residues to feed livestock. However, other smallholders indicated that it was much easier for them to lease a foraging field or purchase feed for their livestock thus gaining what they termed as a "higher return on investment per unit area". As well, a third biggest portion of the land was allocated to the production of beans and other pulses, with these mostly being intercropped with other types.

Among the area's key more climate-resilient cereal and root-crops thrived under insignificant portions of farmlands relative to other crops, notwithstanding their immense role in securing the area's food situations in periods of prolonged and extreme droughts. These state of affairs is an indicator that more hardy crops (Tittonell & Giller, 2013) have not been given adequate recognition in this area, with a glaring need for appropriate interventions such as sensitisation.

As well, the majority of the smallholders had their livestock reared under the extensive and traditional rearing systems. These systems demand less intense levels of investment in terms

of capital and labour requirements. However, these types of livestock production are vulnerable to adverse climatological impacts, such as declining pasture resources and surface water.

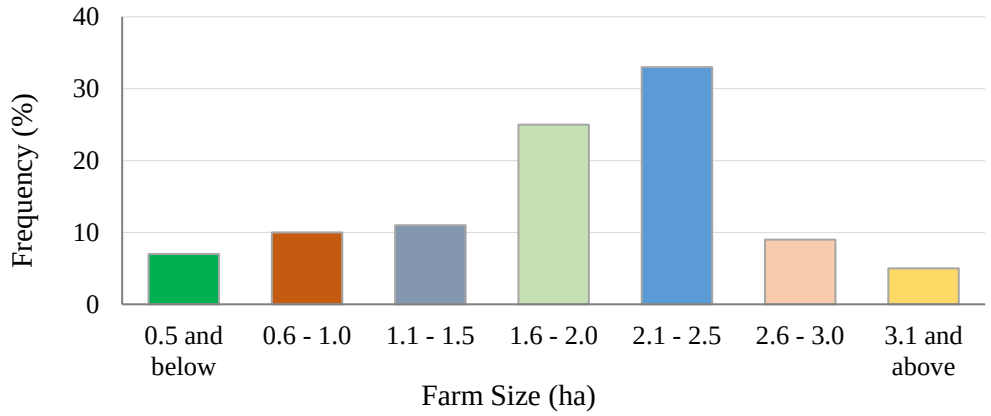

Figure 4.3 Characterisation of farm sizes in Trans-Mara East sub-County
(Source: Field Data, 2017)

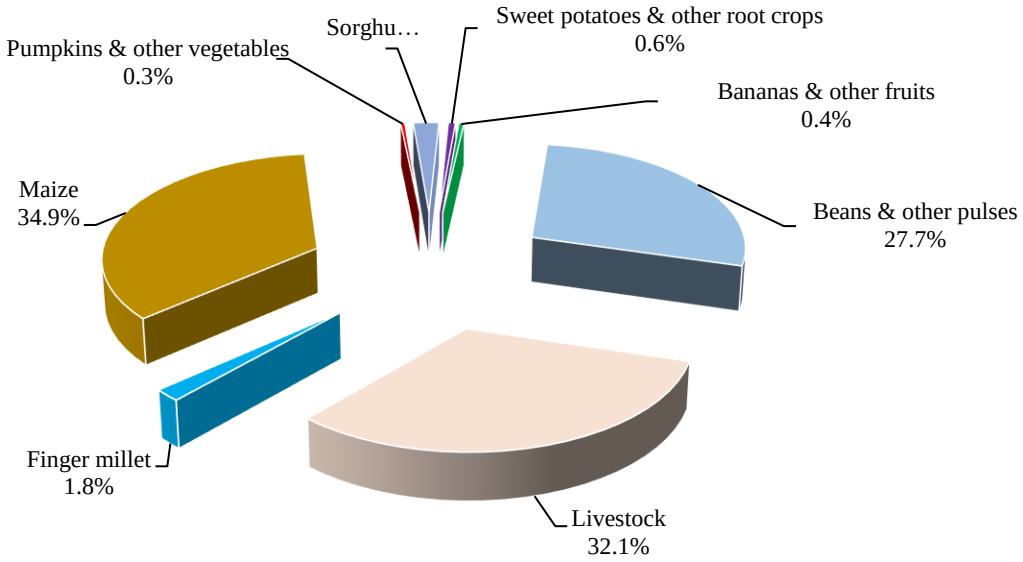

Figure 4.4 Key farming activities per unit area of land in Trans-Mara East sub-County
(Source: Field Data, 2017)

As a way of enhancing smallholders' resilience, especially in the context of livestock, it would be crucial for them to adopt more innovative strategies for producing adaptable animal feeds. These may include versatile forages such as Boma Rhodes (*Chloris gayana*) (Koech et al., 2015), that can easily curtail paucities livestock feed resources. Other robust measures could include the adoption of the less weather-dependent rearing options such as zero-grazing, which

in spite of demanding high levels of investments, have more beneficial advantages in the longer term.

4.3. Rainfall and temperature trends for Trans-Mara East sub-County

4.3.1. Analysis of meteorological data

Climatological data for Trans-Mara East showed limited deviations from the yearly average values in the 1980 to 2015 records. Nonetheless, records for the period 2000 to 2015 exhibit a slightly falling trend (Figure 4.5). This is in addition to intra-annual precipitation which had vast aberrations, relative to the area's established annals. As an example, this area is known to have two-time seasons of enhanced precipitation in the second and last quarter of every year, but these observations, as well as the information gathered from the field, suggest increasingly uneven patterns. Depictions by 2000 to 2015 data displays each of these two wet seasons were missed on at least four occasions, as compared to the period 1980 to 1999, where the two wet seasons failed on at most three occasions each.

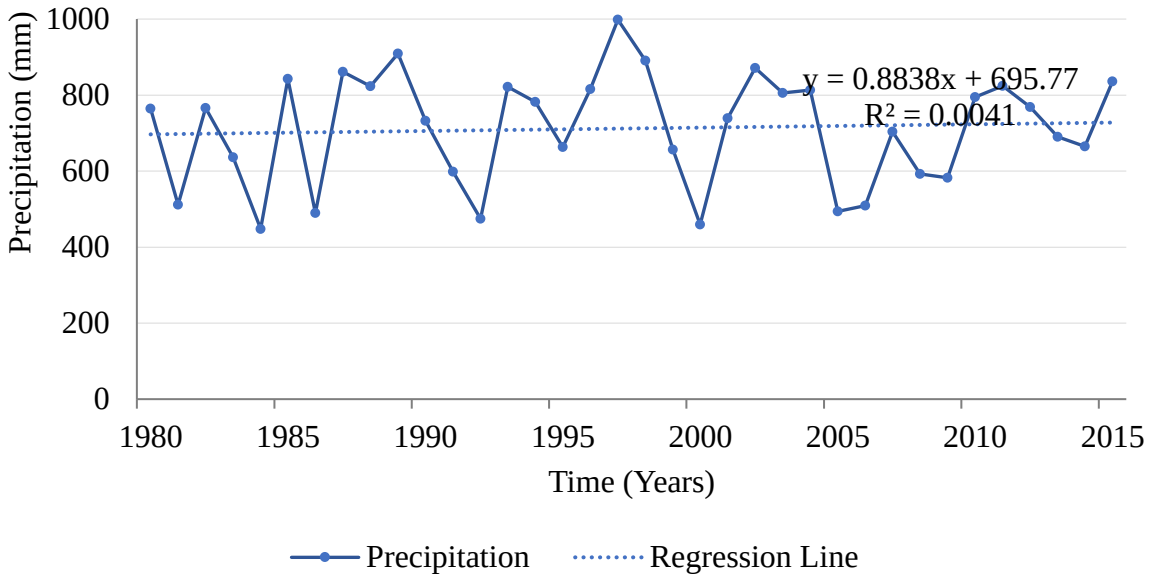

Figure 4.5 Mean annual trends in precipitation for Narok Station

(Data source: KMD, 2016

Atmospheric temperatures for Trans-Mara East for 1980 to 2015 exposed a largely intensifying drift (Figure 4.6). These periodic data displayed the warmest months were in January, February, and March. As well, the average once-a-month extreme levels of the area's atmospheric heat steadily rose during the first 15 years of the current century, unlike for the earlier years under consideration.

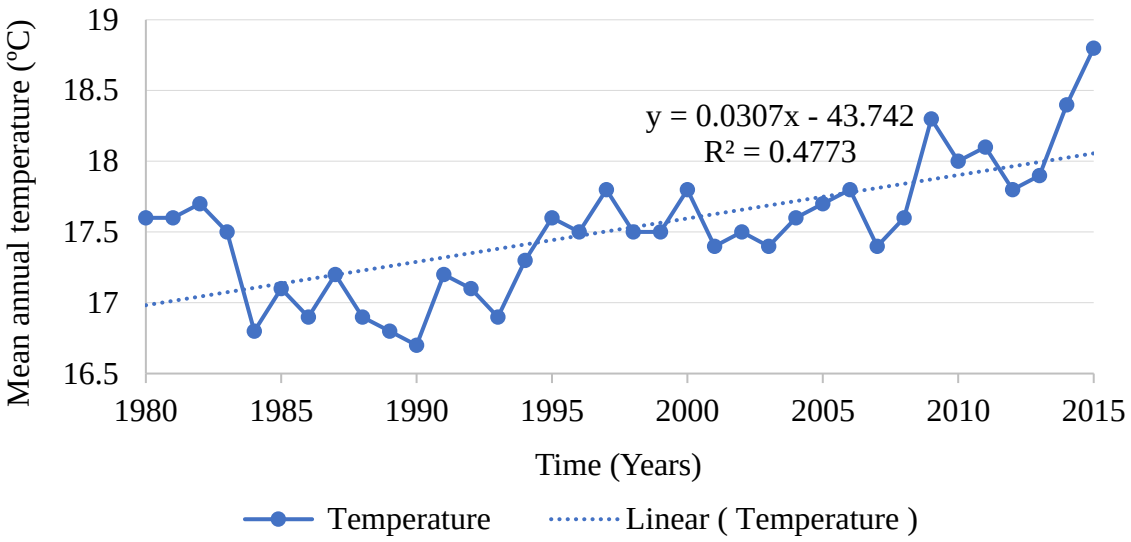

Figure 4.6 Yearly mean atmospheric temperature trends for Narok Station

(Data source: KMD, 2016)

These climatic situations were in congruence with the field observations and smallholders' experiences on the uneven climatological conditions. Other studies such as also corroborate these findings on the conditions at local and international scales (Asseng et al., 2014; Labbé et al., 2016; Mutunga et al., 2017; Thornton et al., 2014). Snowballing climatological peculiarities including these ones, portend serious challenges to smallholders. Detrimental impacts of these situations have been reported by various researchers, including (Campbell et al., 2016; Opiyo et al., 2015; Silvestri et al., 2015). KNBS data (2016) shows a consistent relationship between declining rainfall situations in Kenya and plummeting subsistence and commercial production from both the country's crop and livestock sectors.

4.3.2. Climatic situations through crop and livestock performances

This study also used performances key agricultural enterprises as a second indicator of climatic situations. Looking at the crop yields (Figure 4.7) in the first 15 years of the current century, main cereal crops such as corn, were excessively hit-hard by the prevailing climatic and environmental situations, using a *Weighted Average Index*. However, other than the climate-related effects on maize, the smallholders also highlighted that the presence of stochastic factors, including a *Maize Lethal Necrosis Disease*. This crop disease emerged in 2011 from the neighbouring county of Bomet before rapidly spreading into other areas such as Trans-Mara East. Since then, most of the farmers have opted to increase the cultivation of alternative root, fruit, and vegetable crops to supplement their dipping food and income needs. These new

developments are evidenced by the recorded responses from the area on different levels of crop performances between 2005 and 2015 in the area.

Rearing of farm animals in Trans-Mara East is also increasingly being faced with climate-related limitations (Figure 4.8). The area's leading farm animals were found to be plagued by inadequate forage availability, compounded by climatic shifts, with the most affected types being the grazing ruminants (Table 4.2). Similar studies such as (Opiyo et al., 2015) have documented results in other parts of Kenya which agree with these findings.

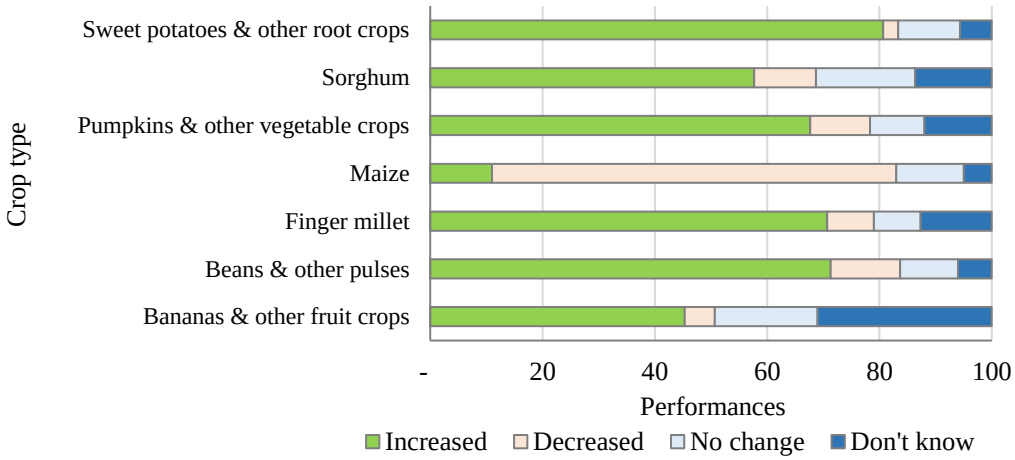

Figure 4.7 Mean performances of key crops in 2000-2015 at Trans-Mara East sub-County
(Source: Field Data, 2017)

Table 4.2 Climate-induced decline in animal forages in Trans-Mara East sub-County

Livestock	High impact	Moderate impact	Low impact	Zero	WAI	Grade
Domestic asses (N = 41)	12	21	5	3	2.02	1
Cows (N = 93)	23	46	13	11	1.87	2
Domestic lamb (N = 63)	9	27	13	14	1.49	3
Domestic goats (N = 61)	0	10	19	32	0.64	4

High impact –accompanied by major losses; Moderately high – no major losses; Low impact - limited impact (Source: Field Data, 2017)

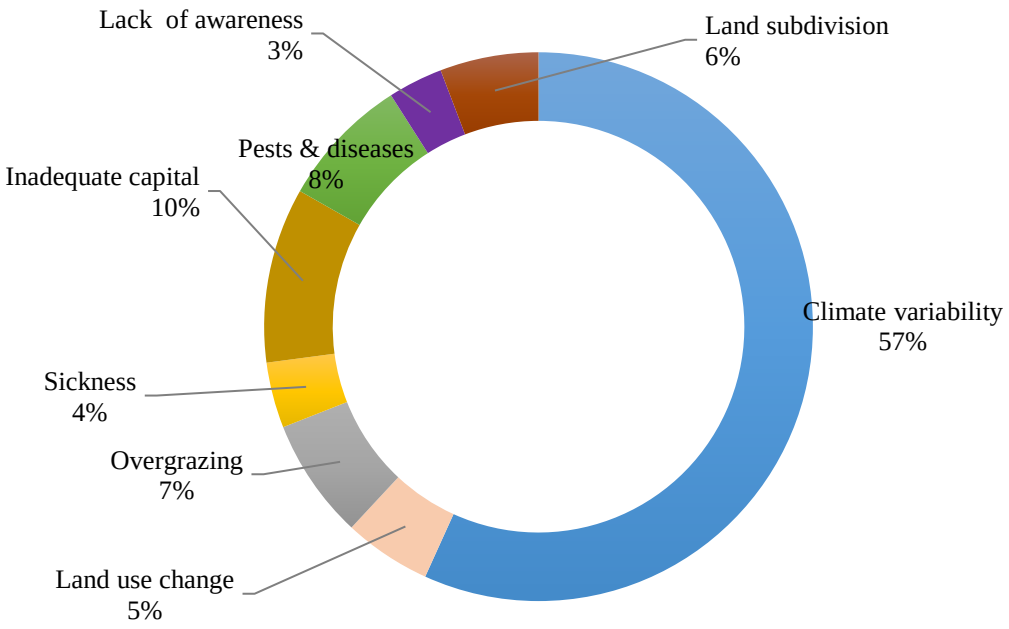

Figure 4.8 Issues ascribed to low yields in Trans-Mara East sub-County

(Source: Field Data, 2017)

Uneven trends in precipitation disrupt the ability of smallholders' predictions and timing for farmed enterprises. These scenarios predispose them to external shocks such as long periods of low availability of crop moisture and enhanced agronomic infestations (Mutunga et al., 2017). These, in turn, dent the possibility of sustaining farm output.

4.3.3. Smallholder perceptions on climatic trends in Trans-Mara East

4.3.3.1. Perceptions of the climatological conditions

Planning and other forms of preparations against external perturbations have been reported to have corresponding levels of readiness in the context t of attitudes and understanding at all levels action in the society. Among them include those associated with the biophysical environment such as shifting climatic situations (Rigolot et al., 2017; Silvestri et al., 2015). Accordingly, respondents in the study area were examined on their understanding and readiness for various climatological situations covering the first 15 years of the current century. Concurrently with this was an evaluation of a hypothesis on the relationships between their perceptions and the area's prevailing socioeconomic situations.

A huge majority of the respondents reported to have experienced increased warming conditions, coupled with a relatively uneven rainfall tendencies (Figure 4.9).

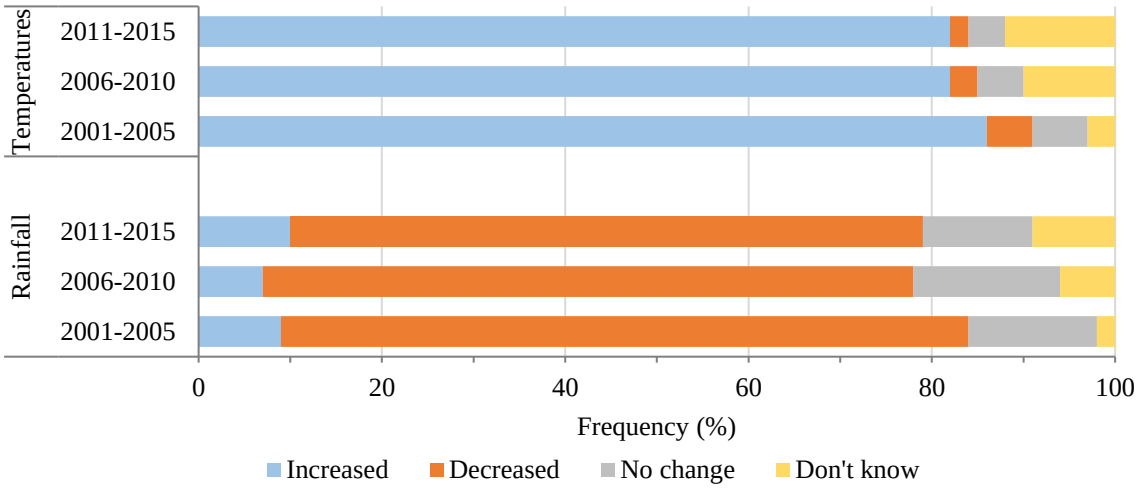

Figure 4.9 Smallholders' climatic perceptions in Trans-Mara East sub-County

(Source: Field Data, 2017)

These findings clearly showcase a semblance between the long-term climatological records and the smallholders' perceptions on the gradually uneven trends in atmospheric warming and moisture conditions in Trans-Mara East. To back these observations are comparable findings in Kenya and beyond by (Asseng et al., 2014; Okumu, 2013; Opiyo et al., 2015; Thornton et al., 2014).

4.3.3.2. Perceptions about drought situations

A survey on smallholder experiences with drought situations between 2000 and 2015, indicated variable dry spells with increasingly intensifying levels of ruggedness (Table 4.3). For instance, the duration between droughts appeared to have been shortening, with any given drought phenomenon lasting longer than before, and often accompanied by adverse implications on the mainstream agricultural systems. These observations on escalating drought conditions in the study area agree with (Kipsisei, 2011; Opiyo et al., 2015). Adaptation readiness by smallholders is thus an essential imperative that needs to be embraced in this area. It will help avert challenges reported negative impacts on people and ecosystems.

Besides, drought-related food scarcities are largely attributed to the rising cases of malnutrition, which is "currently a serious public health issue in the area" (source: key informant). Malnutrition in itself has been shown to compound a vicious cycle of poverty as it paves the way to many opportunistic diseases in addition to affecting the children's cognitive abilities (Labbé et al., 2016). In particular, children are the hope for the future, and anything that

compromises on their cognitive abilities will most likely destabilise their chances of dynamic and responsible adulthood later in life.

Table 4.3 Incidences of scarcity in Trans-Mara East sub-County

Period	Time (Months)	Severity*	Incidence (%)
2000	4	High	61
2003	3	High	73
2005/6	3	Moderate	65
2011	5	High	69
2013	2	Low	62
2015	3	Low	71

Severity*: *moderately severe* – major impact on agricultural enterprises; *moderate*– moderate impact on farm enterprises; *low* – only with indirect effects

(Source: Field Data, 2017)

4.3.3.3. Smallholders' socioeconomic characteristics and climate change perception

A Spearman rank-order correlation coefficient (Table 4.4) on smallholders' socioeconomic strata, relative to their perceptions, indicated a largely weak association. This was especially on gender, age, marital status, education, and income options. However, a moderate, positive monotonic correlation ($r_{s\ (\alpha=0.05)} = 0.396$, n= 100, $p < 0.05$) was observed between farm sizes and smallholders' perceptions. As such, the null hypothesis ($H_0\ r_{s\ (farm\ sizes)} = 0$) in the context of the profiles of farm sizes, did not negate a monotonic relation.

Table 4.4 The r_s between smallholders' socio-economic profiles and perceptions

Variable	Spearman's rho, r_s *(2-tailed, $\alpha = 0.05$, n= 100)*	Critical values
Gender	-0.156	0.121
Marital status	0.053	0.598
Age (years)	0.134	0.184
Level of education	0.154	0.127
Livelihoods streams	0.049	0.626
Farm size (ha)	0.396	0.000

(Source: Field Data, 2017)

The increasingly expanding space for information technology in Kenya (Musingi & Ayiemba, 2012; Thugge et al., 2011) is pivotal in access to information at various levels of society. The

phenomenon has broadened people's engagements on subjects or materials dear to them. Such situations will most likely shape their experiences and perceptions.

In the study area, smallholders reported to be accessing a range of information access options. They specifically singled out local radio broadcasts as the most popular source of information on farming in the face of shifting climatic situations. Such scenarios may have been key in shaping their perceptions across different layers of their socioeconomic characteristics, as indicated by the weak Spearman's correlation coefficient.

Conversely, smallholders' sizes of owned arable lands and climate-related acuities depicted significant levels of association. Behind these observations could be the effect of various enterprise typology of responses against the prevailing climatic situations in "larger-sized" farms as compared to "smaller-sized" farms which limit diversification of enterprises.

4.3.4. Smallholders' adaptive capacity

4.3.4.1. Smallholders' coping strategies

Results from the survey of smallholders' current coping strategies (Figure 4.10) indicated the purchasing of food, down-sizing of their food intake, deviating from their key diets, and selling key assets including livestock, as the leading options. Food aid featured as the least coping option within their disposal.

To counter any imminent impacts of climatological situations, smallholder put in place different levels of interventions. Most of these interventions are underpinned by their scale of acuity and socioeconomic profiles (Le Dang, Li, Bruwer, & Nuberg, 2014; Legesse, Ayele, & Bewket, 2013; Morton, 2007; Ndamani & Watanabe, 2015).

In Trans-Mara East, the current study's recorded smallholder coping strategies include those related to perpetuating their survival in the face of challenging environmental dynamics, led by climate variability. Among those captured are eating less diet, purchasing food from far-flung areas, and restricting key diets to affordable options –rather than desired, selling livestock, and borrowing food and/or money from friends and relatives. Others included seeking off-farm income streams and dependence on charitable supplies. Various studies have found similar coping mechanisms among groups and communities sieged by climate variability extremes (Opiyo et al., 2015; Uddin et al., 2014).

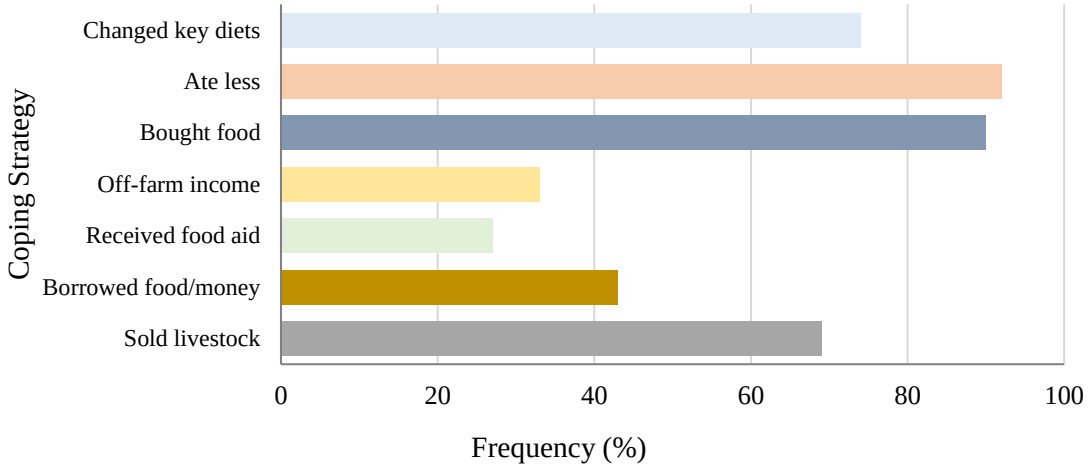

Figure 4.10 Coping strategies employed by smallholders in Trans-Mara East sub-County (Source: Field Data, 2017)

Nonetheless, such options only serve the immediate needs (Morton, 2007) of the affected populace, and as such should be complemented with sustainable adaptation options which will eventually reduce their exposure and vulnerability to similar perils. This fact informed the current study's move to also examine the suitable adaptation needs in the area, according to the smallholders' own views. Such an approach has been shown to yield a more meaningful outcome as it subscribes to the reputable bottom-up scheme of policy planning, consultations, and implementations (Oxfam, 2007; Thorn et al., 2015).

4.3.4.2. Smallholders' desired adaptation strategies

A survey of the smallholders' most desired adaptation options in Trans-Mara East (Table 4.5) indicated various agronomic and livestock management practices as the leading options. It is worth noting that some of these practices, such as crop diversification and alternative cropping, are already in place in the area, where some of the smallholders have largely shifted to growing of sorghum and finger-millet in place of maize (Plate 4.2).

Smallholders' palpable desire for workable adaptation schemes featured a number of strategies, ranked as per their identified scale of relevance in the context of enhancing the resilience and productivity of farm enterprises (Oxfam, 2007). For example, crop development-related interventions featured at the highest level of demand. This could have been influenced mainly by their quest for robust varieties of leading cereal crops such as corn in the area, which has been mainly affected by a *Maize Lethal Necrosis* disease. The bug is mostly blamed for the poor performance of this crucial food crop in the area.

Table 4.5 Smallholders' ranking of their favourite options for adaptation

Response option	*Respondents*				WAI	Rank
	Very vital	Moderately vital	Less vital	Not vital		
Crop development	79	20	1	0	2.78	1
Improving animal forage	76	21	3	0	2.73	2
Broadening crop varieties	73	24	2	1	2.69	3
Watering	72	21	5	2	2.63	4
Storage and handling	68	27	4	1	2.62	5
Other income options	71	19	7	3	2.58	6
Modified timing	59	27	11	3	2.42	7
Land-use management	61	21	13	5	2.38	8
Reducing stock	53	29	10	8	2.27	9

*Not vital **0**; Less vital **1**; Moderately vital **2**; Very vital **3**; **WAI "**Weighted Average Index."*

(Source: Field Data, 2017)

Plate 4.2 Sorghum and finger millet fields in Trans-Mara East sub-County

(Source: Field Data, 2017)

Policy-related interventions such as, crop development, topped other agronomic interventions that are deemed to be essential in boosting smallholders' readiness options against any shifting climatic situations. Accompanying these observations are other policy-inclined interventions

geared towards enhancing and sustaining the accessibility of animal forage. This could have been inclined by the immense role and positioning of livestock in the area's socio-economic relevance. Local and regional studies such as (Okumu, 2013; Silvestri et al., 2015) support these findings.

Household-level interventions also emerged among the most desired adaptation options. These include timely planting, crop and livestock water supplementation, as well as storage and other handlings options along the value chain of major agricultural produce. Others included land use management and income diversification. These findings are supported by other studies including (Barrett & Carter, 2013; Fisher et al., 2015; Godfray et al., 2010) which not only established compatible findings but also proposed the need for government and other stakeholders to support initiatives that can accelerate policy-driven as well as household-originating response strategies.

4.3.4.3. Smallholders' socioeconomic characteristics and adaptive capacity

Table 4.6 outlines the results of the Spearman rank-order correlation coefficient, on the veracity of the second hypothesis on the association between the socioeconomic characteristics and smallholders' response strategies. Smallholders' levels of education ($r_{s\ (\alpha=0.05)} = 0.216$, n=100, $p < 0.05$) and farm sizes ($r_{s\ (\alpha=0.05)} = 0.541$, n=100, $p < 0.05$) exhibited significant weak and strong monotonic relations with smallholder's adaptive capacity, respectively. As a result, null hypotheses ($H_0\ r_{s\ (farm\ size)} = 0$; $H_0\ r_{s\ (level\ of\ education)} = 0$) do not entirely negate the existence of monotonic relationships between smallholders' socio-economic profiles and their adaptive capacity given these observations.

Other smallholders' socioeconomic features, however, did not show any significant level of monotonic relationship with their adaptive capacity. The null hypothesis was thus rejected on these specific characteristics, with a conclusion that there was no relationship between each smallholders' gender, marital status, age, and income options.

Fruitful climate response strategies are mainly corresponding with the level of preparedness at policy and citizen levels. Paired with these are the citizens' socioeconomic profiles such as their age since birth, access to formal schooling, income opportunities, and the sizes of their owned or hired farmlands, among others (Godfray et al., 2010; Rigolot et al., 2017). In line with these, are the present study's findings on the connexions between smallholders'

socioeconomic profiles and readiness to confront the climate change encounters at community levels.

Table 4.6 The r_s between smallholders' socio-economic profiles and adaptation strategies

Variable	Spearman's rho, r_s *(2-tailed, α= 0.05, n= 100)*	Critical values
Gender	-0.014	0.894
Marital status	0.154	0.125
Age (years)	-0.044	0.666
Level of education	0.216	0.031
Livelihoods streams	0.034	0.734
Farmland (ha)	0.541	0.000

(Source: Field Data, 2017)

For instance, smallholders' skill-sets acquired through formal schooling and public extension services, have been reported to enhance one's opportunities to understand and practice various practicable interventions against any external shocks (Barrett & Carter, 2013; Kassie et al., 2013). On the other hand, the size of farmlands owned or hired by smallholders are pivotal in defining the kind of enterprises and technologies to be adopted in the face of mounting environmental shocks (Tey & Brindal, 2012).

4.3.5. Constraints against smallholders' adaptive capacity

4.3.5.1. Constraints against farm-level adaptation

Farm-level interventions against the biting impacts of climate change are beleaguered by many challenges which limit smallholders' capabilities (Table 4.7). Among these challenges are those appearing at either the policy level or household levels. Policy-related challenges appeared at the as the most constraining factors. These include out-of-reach prices of inputs, limited finances, fluctuating markets, and broken-down roads which dominated the smallholders' concerns against their determination for appropriate adjustments. Given that such situations are essential to smallholders' beneficial positioning against adverse climatological situations, their limitations would likely influence adjustments(Mutunga et al., 2017; Oxfam, 2007; Tittonell & Giller, 2013).

Table 4.7 Key challenges constraining climatological responses

Pressure	Strong	Slightly strong	Little	None	PCI	Rank
Expensive inputs	75	21	4	0	2.71	1
Limited finances	66	31	2	1	2.62	2
Fluctuating markets	69	24	6	1	2.61	3
Decrepit roads	74	13	10	3	2.58	4
Inadequate income	56	42	2	0	2.54	5
Weather services	71	16	7	6	2.52	6
Expert support	67	13	14	6	2.41	7
Small farmlands	61	12	10	17	2.17	8
Land ownership	55	11	19	15	2.06	9
Tensions and fights	43	21	25	11	1.96	10

Strong = 3; Moderate = 2; Low = 1; Non-issue = 0. DWIS = Disjointed Weather Information Services

(Source: Field Data, 2017)

Besides, smallholders' limited income opportunities, coupled with skewed possibilities of complementary financing schemes, lowers their chances to adequately resource substantial response strategies. Such lost opportunities include farm-level innovative and more sustainable climatological interventions (Oluoko-Odingo, 2011; Sheahan & Barrett, 2014). For instance, the area's road networks, according to the respondents, constitutes a fundamental impairment, by dimming their abilities to obtain actual market value for their produce. These situations are most likely to demoralise them from venturing into robust and adaptable farming options in the face of shifting climatic patterns.

Thus, the Trans-Mara East's road networks constitute one of the leading limitations against smallholders' ability to be part of transformative value chains in the face of climatic qualms. It affects the transportation of their produce to the markets. This problem escalates during rainy seasons, as the unpaved roads there would always be impassable to motorbikes (the main means of transportation in the area) and other engine-powered vehicles. During such seasons, the farmers would mainly rely on the donkeys and their labour (their body backs) to transport any products to nearby markets.

Such scenarios result in loss of several man-hours that would have otherwise been used in more innovative, productive and sustainable farming options. Besides, transportation challenges have been shown to hamper the possibility of accessing better market prices which can enable the farmers to get a good value for their produce (Mutunga et al., 2017; Oluoko-Odingo, 2011).

Further, undeveloped road networks expose the farmers to the often exploitative 'middlemen' thus dwindling their chances of getting the actual value of their produce. The eventual outcome of this is demotivated farmers with limited to no incentives to adopt meaningful climate-smart agricultural options. Likewise, environmental education, awareness, public participation and other aspects of capacity development among smallholder farmers are pivotal in addressing climatic challenges (Marenya & Barrett, 2007; Oxfam, 2007; Thornton et al., 2014). These observations agree with comparable concerns documented in other areas (Opiyo et al., 2015), including Ethiopia (Deressa et al., 2011) and Ghana (Ndamani & Watanabe, 2015).

Limited to no value-addition options for farm output affects the returns accrued to the farmers. In Trans-Mara East, this phenomenon undermines smallholders' output, including from milk, sweet potatoes, and fruit crops like bananas and pumpkins, which thrive in the area. For instance, one of the findings covered an acute problem with milk prices that are extremely low (as low as KES 25/litre). This certainly discourages the smallholders from expanding their activities to sufficiently productive levels, in the face of climatic uncertainties.

Most of the smallholders -especially women, interviewed, decried the sad state of milk-market prices. Interestingly, they would still yield to the low prices. This is because if they did not sell the milk to these at these low prices, their families would "sleep without ugali (food)" as they did not have any maize (a staple food) in their granaries. For instance, these smallholders, as captured in Plate 4.3, rely on derelict make-shift structures put up by exploitative dealers who collect and transport their milk to major Kenyan dairy industry players. These include a *Brookside Limited* with a milk cooling plant situated at about 120 km in Siongiroi Market of the neighbouring county of Bomet. These challenges certainly get to impede the adoption of meaningful adaptation strategies. One of the immediate impacts being ridiculously low earnings to the smallholder farmers (Mertz et al., 2009).

Water scarcity also emerged as another big challenge that affects the smallholders of Trans-Mara East from establishing climate-resilient farming systems (Silvestri et al., 2015) in the area. Their chief dependence on undeveloped surface and underground sources of water located in far-flung areas, with up to 7 km away from homes. This is despite billions of Kenya money

being channelled into the water resources sector through annual budgetary allocations, a situation which leaves a lot to be desired. Such circumstances prolong gender disparities, while at the same time being against the dictates of the global community's Agenda 2030 for Sustainable Development, which Kenya has signed in to its delivery. The Agenda emphasizes on "leaving no one behind", with its Goal 5 on gender equality being unequivocal. But in Trans-Mara East, women disproportionally bear the burden of such hard-to-access water, given the societal responsibilities bestowed upon them.

Besides, water situations in the Trans-Mara East is an indictment to the Kenya's Vision 2030 as well as the country's 2010 constitution. Both of them encourage for, and stipulate, actions for guaranteeing services reach the tax-paying Kenyan people, to enable them to live dignified lives, among other aspirations (Ndung'u et al., 2010; Wiesmann et al., 2016). Instead, the few existing, and far-apart, options for accessing portable water in the area were found to have been largely established by non-state actors. These include World Vision and DANIDA[10] among other humanitarian agencies in the area (Plate 4.4).

Plate 4.3 Smallholders' milk- handling centre in Trans-Mara East sub-County

Location: (a) a makeshift structure in Dikirr market centre where the smallholders assemble their milk awaiting transportation to a cooling plant at Siongiroi, which is about 120 km away from this point, in the neighbouring county of Bomet; (b) tens of litres of milk assembled near the structure (Source: Field Data, 2017)

[10] Danish International Development Agency

Plate 4.4 Smallholders' few watering points at Trans-Mara East sub-County

Location: (a) water tank at Ilkerin; (b) an extension of a water pan at Kapsasian; developed by non-state actors (Source: Field Data, 2017)

4.3.5.2. Smallholders' socioeconomic characteristics and adaptation constraints

A Spearman rank-order correlation coefficient (Field, 2009) for the association between smallholders' socioeconomic characteristics and adaptation constraints revealed a significant monotonic relationship with their age ($r_{s\ (\alpha=0.05)} = 0.266$; n=100; $p < 0.05$), formal schooling ($r_{s\ (\alpha=0.05)} = -0.495$; n=100; $p < 0.05$), as well as the income opportunities ($r_{s\ (\alpha=0.05)} = -0.450$; n=100; $p < 0.05$) (Table 4.8). Consequently, could not be rejected for these characteristics, with an observation that there is a monotonic relationship between adaptation constraints and smallholders' age, formal education, and livelihood streams. Other features on gender, marital status, and farm sizes did not show any significant relationship.

Table 4.8 The r_s between smallholders' socio-economic profiles and adaptation constraints

Variable	Spearman's rho, r_s *(2-tailed, α= 0.05, n= 100)*	Critical values
Gender	0.014	0.887
Marital status	-0.083	0.411
Age (years)	0.26	0.008
Level of education	-0.495	0.000
Livelihoods streams	-0.450	0.000
Farmland (ha)	-0.137	0.174

(Source: Field Data, 2017)

With increased opportunities to further one's formal schooling, chances of gaining robust critical thinking gets to rise, with corresponding readiness in adjustments and responses to any given adversities (Nielsen & Reenberg, 2010; Oxfam, 2007). This is in addition to expanding opportunities for diverse levels of incomes (Wambua et al., 2014).

CHAPTER 5: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1. Introduction

In this last section of the study, a concise recap of the results from the previous chapters are availed. This is in addition to matching conclusions and the recommended actions at policy and other levels.

5.2. Summary of key results

5.2.1. Climatological states

Through this objective, climatic situations for Trans-Mara East sub-County were examined, with a focus on the levels of atmospheric warming and precipitation outlines utilising data from KMD covering 1980 to 2015.

Observations on the levels and trends of the area's precipitation yielded little deviations from the established regimes, with a minor fall in the yearly trends for the first 15 years of the current century. Nevertheless, a further examination of the intra-annual month-to-month data showed lop-sided patterns. The previously known wet and dry seasons currently display higher levels of unpredictability.

Atmospheric warming in Trans-Mara East sub-County also exhibited new trends that seem to be shifting from long-term historical patterns for the area, with an overall rising outline. For instance, the area's mean monthly temperature records displayed a continual increase between since the year 2000, as compared to the years before.

Put together the atmospheric warming and the current precipitation events with the area's crop and livestock performances, as well as with the smallholders' experiences between the years 2010 and 2015, demonstrate a common ground of increasingly irregular climatic situations with rising adverse impacts on their farm productivity. Further, and on examining the overall environmental challenges with a possibility affect farm productivity in the area, climatological shifts emerged at the highest level of blame for declining smallholders' agricultural output between the years 2000 and 2015.

5.2.2. Smallholders' climatological experiences

The socio-economic profiles of Trans-Mara East's smallholders were evaluated against their climate-related knowledge and practices in 2000 to 2015. In running this, "Weighted Average Index" and Spearman's rank correlation analysis. On temperature conditions, their experiences

were examined with respect to the regularity of incidences and duration of dry seasons. This was, in addition, to the associated actual feel, which indicated an overall upward trend. Concurrently, rainfall experiences which were recorded in terms of the amounts, duration, and frequency revealed an overall downward trend. As well, smallholders' in the area drought-related experiences portrayed increasing levels of incidences, with detrimental impacts on yields from farmlands.

The Spearman's rank correlation coefficient demonstrated a significant relationship with only the farm sizes, compared to other socioeconomic profiles against smallholders' experiences. These observations exhibit a semblance between their perceptions and metrological data on climate situations for the area. This is in addition to validating other reports on the climatic situations in Kenya, especially on intensifying droughts, rising temperatures and increasingly irregular and unpredictable rainfall patterns. Such situations, if not urgently address, will most likely undermine smallholders' capacity to withstand climatic challenges and progress towards local-level sustainability objectives, due to the resulting impacts on their overall well-being.

5.2.3. Smallholders' adaptation strategies

This objective assessed smallholders' current copping strategies, desired adaptation options, as well as the relationship between their adaptive capacity and their socio-economic strata. Among the recorded coping strategies, purchasing of food, down-sizing of their food intake, deviating from their key diets, and selling key assets including livestock, emerged as the leading options, while receiving food aid featured as the least coping option.

On considering smallholders' preferred response strategies crop development-related pursuits were highlighted at the foremost level, owing to increasingly rising desire for versatile crop varieties that can not only withstand the environmental shocks but also give better yields. Animal rearing also had feed-related interventions as the most preferred options for cushioning them against climate-related limits.

A Spearman's rank correlation coefficient showed smallholders' formal schooling levels and their farmlands revealed a significant positive relationship with their response strategies, unlike other socioeconomic profiles.

5.2.4. Smallholders' adaptation constraints

This objective assessed the smallholders' constraints to adaptation, with the observations being analysed using Problem Confrontational Index, as well as the Spearman's correlation

coefficient. Each constraint was specifically looked at in terms of the smallholders' social, financial, and technical capital. Among the key constraints that emerged from this study include those that are associated with policy and household-level interventions, with policy-related challenges being featured as the most constraining factors. At the top of these were cited out-of-reach prices of inputs, inhibited assets, unstable markets, and broken-down roads. Given that such situations are essential to smallholders' beneficial positioning against adverse climatological situations, their limitations would likely affect their response options.

Furthermore, a Spearman's rank correlation coefficient on relationships between smallholders' socioeconomic characteristics and adaptation constraints uncovered a significant monotonic relationship with their age, formal schooling and income opportunities. But their other features such as gender, marital status, and farmland sizes did not show any noteworthy relationship.

5.3. Conclusions

The results of this study paints Trans-Mara East sub-County as an area that has certainly experienced climatic shifts and their associated challenges in the period under review. Supporting these observations are recorded incidences of rising atmospheric warming and increasingly erratic patterns of precipitation, and that both the documented qualitative and quantitative data justify these situations.

The consequences of these scenarios reverberate across the area and has already upset the productivity of animal and crop enterprises in the area. At the moment, however, survival tactics such as procuring household food, reducing the regularity of meal and disposing of key assets, albeit being negative, are the leading option.

Regarding smallholders' preferred response strategies, crop development-related pursuits were highlighted at the foremost level, owing to increasingly rising desire for versatile crop varieties that can not only withstand the environmental shocks but also give better yields. Animal rearing also had feed-related interventions as the most preferred options for cushioning them against climate-related limits. As well, Spearman's rank correlation coefficient showed smallholders' formal schooling levels and their farmlands revealed a significant positive relationship with their response strategies, unlike other socioeconomic profiles.

However, most of these desired options were found to be under constraints from policy and household-related challenges such as poor state of roads, as well as limited sizes farmlands and low-level of formal schooling among a sizeable portion of the population.

5.4. Recommendations

As a way forward regarding readiness against climatic shifts, the current study recommends the following options to both the policymakers and the research community:

5.4.1. Recommendations to policymakers

In order to enhance smallholders' adaptive capacity in Trans-Mara East, recommended approaches may include the following:

- Broadening options to access financial capital by women and youth, who largely constitute a vulnerable, but huge, segment of the population, yet with greater potentials of rejuvenating sustainable farming options in the area. Such initiatives will enable them to venture into climate-smart options while at the same time bolstering their means of acquiring the requisite farm inputs in a timely and effective manner. This can provide a catalytic boost for better chances of raising the quality and quantity of output from their small farms.
- Setting up all-weather roads, and upgrading the existing ones, in order to enable smallholders to access available markets within and outside their neighbourhoods is another initiative worth being taken seriously. It can easily incentivise them to adopt and effectively implement meaningful farm-level adaptation options. Besides, investing in such public-good projects may easily motivate big investors to venture into rural areas, and upcoming market centres, thus broadening the market for farm produce and equally opening floodgates for venturing into value-addition options for smallholders' produce.
- The existing women- and youth-led social welfare groups constitute a low-hanging fruit to which various stakeholders can leverage. This can be harnessed through capacity development in catalytic areas such as financial literacy and feasible investment options, which can cumulatively uplift their adaptation statuses. Most of the groups encountered in the area demonstrated a great desire for capacity development related to initiating sustainable livelihood streams through re-skilling and re-tooling them in line with the present climatic swings. Such schemes can lead to positive multiplier effects on their farm productivity.

- Greenhouse farming offers a good example of systems that are tolerant to climate variability in farming. Its possibility to allow for manipulations of micro-environmental situations inside the greenhouses can help smallholders overcome the widespread climate-related challenges. However, the cost of acquisition and installation is still beyond the reach of the commoners. It would thus be helpful if such innovative strategies were to be supported by the relevant stakeholders, including through innovative partnerships for technical support, financing, and value chain transformation.
- Investing in sustainable strategies to facilitate the development and/or acquisition of locally adaptable animal feeds constitutes one of the options for enhancing the farmer adaptability to uncertain climatic visibilities in Trans-Mara East. The remarkable potential for feed materials such as the *Lucerne* and *Lilies*, that do well in the area in the area, have not been fully exploited. These harbour immense opportunities for leapfrogging climate-driven animal feed deficiency. It would thus be incumbent upon the policymakers at national and sub-national levels of administration to consider options for creating and sustaining a conducive policy environment for such strategies to thrive.
- There is also a need to explore into other existing sustainable livelihood options which are viable to the area. These include apiculture and aquaculture, among others. Farmers who have been practising these systems of farming reported stable revenue streams from these sources, as opposed to other enterprises which heavily rely on the prevailing climatic conditions.

5.4.2. Recommendations to the research community

As a consequence of the current findings and ideas which emerged during the compilation of this study, while also taking cues from the scarcity of credible data and information related the subject in question, the following recommendations are made to the research community:

- Kenya's mobile telephony technology has rapidly transformed how people access and share information. It has simultaneously transformed the movement of money from one end to the other. However, few researches have been done to ascertain the level of impact of these dynamics on smallholder productivity, as well as on their adaptive capacity, not only in Trans-Mara East but the rest of Kenya. It may, thus, be worthy to explore these dynamics.
- In Kenya, still, some local, regional and global players have reported diverse levels of partnerships with smallholders. These include through value-addition and marketability of their produce, as well as through various environmental conservation initiatives. It may be

interesting to find out whether these approaches have contributed to their adaptation schemes against climate variability, and to what extent have they been successful in incorporating key socioecological imperatives.

- Finally, in the recent past, huge infrastructure projects have been put up in Kenya, and many others are still in the pipeline. Among them are the extensive railway lines, road networks, and multi-purpose dams, at various parts of the country. It may be fascinating to scrutinise how these developmental projects, (which by the way have guzzled billions of taxpayers' Kenya shillings), have impacted or are likely to impact on the smallholder performances vis-à-vis the current and future climatic uncertainties.

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APPENDICES: RESEARCH INSTRUMENTS

Appendix 1: Questionnaire

This questionnaire is meant for collecting data on the key socioeconomic characteristics that are thought to influence smallholders' responses against key climatic shifts in Trans-Mara East sub-County in Narok. All the data obtained from this research shall be used for academic purposes, only. Consequently, any information provided will be confidential, and always at the discretion of the respondent.

Questionnaire No……	**Date (Day/Month/Year):**	**GPS:**

1. Background Information (Demographics)

b. Ward (County Assembly)	
c. Name (Optional)	
d. Gender M= Male; F=Female)	**[ ]**
e. Age (please tick appropriately)	25 – 34 years **[ ];** 35 – 44 years [**];** 45 – 54 years **[ ];** 55-64 years **[ ]**
f. Family/Household size	
g. Level of education (Please tick the appropriate answer)	No education **[ ];** Primary education **[ ]** Secondary education **[ ];** Post-secondary education **[ ]** Other education (Please specify): …….
h. Occupation (Please tick the appropriate answer)	Farmer **[ ];** Employment **[ ];** Casual Labourer **[ ];** Business **[ ]** Other (please specify): …….
i. Average monthly income for the farmer	**KES …….**
j. Average monthly income from all the members of the household combined	**KES ……..**
Average expenses on farming	(i). Crop production Monthly: KES …… or Annually: KES …….. (ii). Livestock production Monthly: KES …… or Annually: KES ……..

1.0 Climate Information

1.1 Perception of climate change/variability by farmer experience

(The data obtained here will be corroborated with the climate data from KMD)

Variable	**Observed changes over time (Years)**				
Temperature	Period (years)	Increased	Decreased	No change	Don't know
	1-5	**[ ]**	**[ ]**	**[ ]**	**[ ]**
	5-10	**[ ]**	**[ ]**	**[ ]**	**[ ]**
	10-15	**[ ]**	**[ ]**	**[ ]**	**[ ]**
	>15	**[ ]**	**[ ]**	**[ ]**	**[ ]**
Rainfall	Period (years)	Increased	Decreased	No change	Don't know
	0-5	**[ ]**	**[ ]**	**[ ]**	**[ ]**
	5-10	**[ ]**	**[ ]**	**[ ]**	**[ ]**
	10-15	**[ ]**	**[ ]**	**[ ]**	**[ ]**
	>15	**[ ]**	**[ ]**	**[ ]**	**[ ]**

1.2 Climate-related shocks experienced by farmers over the last 1-15 years.

Level of severity (1=none; 2=moderate; 3=severe); Frequency (1=once, 2= twice, >3= high)

Shocks experienced in the last 1-15 years				
Climatic shock	Tick appropriately	Period (years)	Severity	Frequency
(a) Drought	**[ ]**	0-5		
		5-10		
		10-15		
		>15		
(b) Flood	**[ ]**	0-5		
		5-10		
		10-15		
		>15		
(c) Erratic rainfall	**[ ]**	0-5		
		5-10		
		10-15		
		>15		
(d) Hailstorm	**[ ]**	0-5		
		5-10		
		10-15		
		>15		
(e) Fires outbreak	**[ ]**	0-5		
		5-10		
		10-15		
		>15		

1.3 How did the farmer cope with the climate-related shocks?

Measures employed (please tick appropriately)			
Did nothing	**[ ]**	Sought off-farm employment	**[ ]**
Sold livestock	**[ ]**	Bought food	**[ ]**
Sold assets	**[ ]**	Ate less	**[ ]**
Borrowed from friends or relatives	**[ ]**	Ate different foods	**[ ]**
Borrowed from the bank	**[ ]**	Others (specify)	
Received food aid	**[ ]**		

2.0 Agricultural information

2.1 Farming activities

2.1.1 Cropping production

Specific crop	**Land coverage (ha)**	**Current average annual yields (kg)**	
Maize (specify the variety, if possible):			
Sorghum			
Finger millet			
Wheat			
Beans			
Pigeon peas			
Cow peas			
Fruits			
Vegetables (Kales, cabbages, tomatoes, etc.)			
Others(s) (Please specify)			

2.1.2 Livestock production

Livestock type	**Current population, yields (kg) (*where applicable*), & other relevant information**
Cattle	
Goats	
Sheep	
Donkeys	
Bees	
Fish	
Other(s) (Please specify)	

2.2 Overall performance of crop production by farmer experience in Trans-Mara East

(The data obtained here shall be processed and compared with climate data of the study area)

Crop	**Observed changes over time (Years)**				
Maize	Period (years)	Increased	Decreased	No change	Don't know
	1-5	**[ ]**	**[ ]**	**[ ]**	**[ ]**
	5-10	**[ ]**	**[ ]**	**[ ]**	**[ ]**
	10-15	**[ ]**	**[ ]**	**[ ]**	**[ ]**
	>15	**[ ]**	**[ ]**	**[ ]**	**[ ]**
Sorghum	Period (years)	Increased	Decreased	No change	Don't know
	0-5	**[ ]**	**[ ]**	**[ ]**	**[ ]**
	5-10	**[ ]**	**[ ]**	**[ ]**	**[ ]**
	10-15	**[ ]**	**[ ]**	**[ ]**	**[ ]**
	>15	**[ ]**	**[ ]**	**[ ]**	**[ ]**
Finger millet	Period (years)	Increased	Decreased	No change	Don't know
	0-5	**[ ]**	**[ ]**	**[ ]**	**[ ]**
	5-10	**[ ]**	**[ ]**	**[ ]**	**[ ]**
	10-15	**[ ]**	**[ ]**	**[ ]**	**[ ]**
	>15	**[ ]**	**[ ]**	**[ ]**	**[ ]**
Beans	Period (years)	Increased	Decreased	No change	Don't know
	0-5	**[ ]**	**[ ]**	**[ ]**	**[ ]**
	5-10	**[ ]**	**[ ]**	**[ ]**	**[ ]**
	10-15	**[ ]**	**[ ]**	**[ ]**	**[ ]**
	>15	**[ ]**	**[ ]**	**[ ]**	**[ ]**
Vegetables	Period (years)	Increased	Decreased	No change	Don't know
	0-5	**[ ]**	**[ ]**	**[ ]**	**[ ]**
	5-10	**[ ]**	**[ ]**	**[ ]**	**[ ]**
	10-15	**[ ]**	**[ ]**	**[ ]**	**[ ]**
	>15	**[ ]**	**[ ]**	**[ ]**	**[ ]**
Fruit crops	Period (years)	Increased	Decreased	No change	Don't know
	0-5	**[ ]**	**[ ]**	**[ ]**	**[ ]**
	5-10	**[ ]**	**[ ]**	**[ ]**	**[ ]**
	10-15	**[ ]**	**[ ]**	**[ ]**	**[ ]**
	>15	**[ ]**	**[ ]**	**[ ]**	**[ ]**
Others (Specify)	Period (years)	Increased	Decreased	No change	Don't know
	0-5	**[ ]**	**[ ]**	**[ ]**	**[ ]**
	5-10	**[ ]**	**[ ]**	**[ ]**	**[ ]**
	10-15	**[ ]**	**[ ]**	**[ ]**	**[ ]**
	>15	**[ ]**	**[ ]**	**[ ]**	**[ ]**

2.3 Overall performance of livestock production (milk, meat/live weight, and other products) by farmer experience in Trans-Mara East

(The data obtained here shall be processed and compared with climate data of the study area)

Crop	**Observed changes over time (Years)**				
Cattle	Period (years)	Increased	Decreased	No change	Don't know
	1-5	**[ ]**	**[ ]**	**[ ]**	**[ ]**
	5-10	**[ ]**	**[ ]**	**[ ]**	**[ ]**
	10-15	**[ ]**	**[ ]**	**[ ]**	**[ ]**
	>15	**[ ]**	**[ ]**	**[ ]**	**[ ]**
Goats	Period (years)	Increased	Decreased	No change	Don't know
	0-5	**[ ]**	**[ ]**	**[ ]**	**[ ]**
	5-10	**[ ]**	**[ ]**	**[ ]**	**[ ]**
	10-15	**[ ]**	**[ ]**	**[ ]**	**[ ]**
	>15	**[ ]**	**[ ]**	**[ ]**	**[ ]**
Sheep	Period (years)	Increased	Decreased	No change	Don't know
	0-5	**[ ]**	**[ ]**	**[ ]**	**[ ]**
	5-10	**[ ]**	**[ ]**	**[ ]**	**[ ]**
	10-15	**[ ]**	**[ ]**	**[ ]**	**[ ]**
	>15	**[ ]**	**[ ]**	**[ ]**	**[ ]**
Poultry	Period (years)	Increased	Decreased	No change	Don't know
	0-5	**[ ]**	**[ ]**	**[ ]**	**[ ]**
	5-10	**[ ]**	**[ ]**	**[ ]**	**[ ]**
	10-15	**[ ]**	**[ ]**	**[ ]**	**[ ]**
	>15	**[ ]**	**[ ]**	**[ ]**	**[ ]**
Others (specify):	Period (years)	Increased	Decreased	No change	Don't know
	0-5	**[ ]**	**[ ]**	**[ ]**	**[ ]**
	5-10	**[ ]**	**[ ]**	**[ ]**	**[ ]**
	10-15	**[ ]**	**[ ]**	**[ ]**	**[ ]**
	>15	**[ ]**	**[ ]**	**[ ]**	**[ ]**
Fruit crops	Period (years)	Increased	Decreased	No change	Don't know
	0-5	**[ ]**	**[ ]**	**[ ]**	**[ ]**
	5-10	**[ ]**	**[ ]**	**[ ]**	**[ ]**
	10-15	**[ ]**	**[ ]**	**[ ]**	**[ ]**
	>15	**[ ]**	**[ ]**	**[ ]**	**[ ]**
Others (Specify)	Period (years)	Increased	Decreased	No change	Don't know
	0-5	**[ ]**	**[ ]**	**[ ]**	**[ ]**
	5-10	**[ ]**	**[ ]**	**[ ]**	**[ ]**
	10-15	**[ ]**	**[ ]**	**[ ]**	**[ ]**
	>15	**[ ]**	**[ ]**	**[ ]**	**[ ]**

2.4 Level of severity of shortage of livestock feed

In which month(s) do you often experience shortages of the animals' feed?

(Level of severity: 1=none; 2=moderate; 3=severe)

	Animals and Level of feed shortage severity										
	Cattle			**Goats**			**Sheep**			**Others** (Please Specify)		
Month	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Jan												
Feb												
Mar												
Apr												
May												
Jun												
Jul												
Aug												
Sep												
Oct												
Nov												
Dec												

2.5 Reasons for the enhanced/depressed output in both the crops and animal feed resources

(Please tick appropriately)

Phenomenon	Tick if agreeing	Phenomenon	Tick if agreeing
(a) Drought	**[ ]**	(f) Technology	**[ ]**
(b) Climate change	**[ ]**	(g) Flood	**[ ]**
(c) Land use change	**[ ]**	(h) Lack of awareness	**[ ]**
(d) Overgrazing	**[ ]**	(i) Subdivision of land	**[ ]**
(e) Charcoal burning	**[ ]**	(j) Others (specify):	

2.6 Farmers' adaptation to climate changes

(Key adaptation strategies for livestock and crop production)

Livestock adaptation measures employed by the farmer (please tick appropriately)			
Mix crop and livestock production	**[ ]**	Change of planting seasons	**[ ]**
Destocking	**[ ]**	Change animal breeds	**[ ]**
Diversify/changes/supplement livestock feeds	**[ ]**	Move animals to alternative sites	**[ ]**
Change of crop varieties	**[ ]**	Others (specify):	

2.7 Desired adaptations

Adaptation measures (please tick appropriately)			
Irrigation (simple to advanced)	**[ ]**	Plant fast maturing crop variety	**[ ]**
Afforestation/agroforestry	**[ ]**	Change animal breeds	**[ ]**
Change of crop type	**[ ]**	Seek off-farm employment	**[ ]**
Plant drought resistant crop varieties	**[ ]**	Buy climate-tolerant inputs	**[ ]**
Build a water harvesting scheme	**[ ]**	Increase the number of livestock	**[ ]**
Change fertilizer application	**[ ]**	Others (specify):	

2.8 Change of crop varieties and animal breeds

Constraint (Please tick appropriately)			
Lack of money	**[ ]**	Lack of market access	**[ ]**
Lack of credit	**[ ]**	Lack of inputs	**[ ]**
Lack of access to land	**[ ]**	Other (Please specify)	

2.9 Increase the size of the herd and arable land

Constraint (Please tick appropriately)			
Lack of money	**[ ]**	Lack of inputs	**[ ]**
Lack of credit	**[ ]**	Other (Please specify)	
Lack of water	**[ ]**		

3.0 Key source (s) of income

(Please tick appropriately & specify the average earnings p.a.)

Source of income		**Tick**	**Average Annual Earnings (**KES**)**
Agriculture	Crop farming	**[ ]**	
	Livestock farming	**[ ]**	
Business	Fulltime (Commercial)	**[ ]**	
	Part-time (Retail)	**[ ]**	
Employment	Fulltime (Permanent & pensionable)	**[ ]**	
	Part-time (temporary/contractual)	**[ ]**	
Other (Please specify):			

4.0 Land ownership

Status of land ownership (Please tick appropriately)		**Means of acquisition/access rights**	**For how long** (years)
Do you own (all of) your current *shamba (s)*?	Yes [ ]	Inheritance [ ]; Size (ha): ……..	
		Purchasing [ ]; Size (ha): ……..	
		Donation [ ]; Size (ha): ……..	
		Other (please specify):	
	No [ ]	Leasing/Renting [ ] Size of the leased land (hectares): [……....] Annual lease/rent rates (KES): [……]	
		Other (please specify):	

5.0 Source(s) of information on modern (sustainable) farming practices

(Please rank them according to their 'dominance'; 1=highest 'dominance'; 10=least 'dominance')

Source	**Rank** (e.g. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10)
Internet	
Newspapers	
Television (TV)	
Radio	
Indigenous knowledge	
Extension officers (Government/NGOs)	
Public *barazas* (e.g. MCA's/Chiefs' meetings; Schools' parents' meetings; or any other formal non-religious gathering)	
Religious gatherings	
Just intuition	
Others (Please specify)	

6.0 What type of information and/or support (from any of the stakeholders in the sector) do you think would be helpful to you, particularly in enhancing the productivity of your farming activities?
(*Beginning with crops…then livestock*)?

a. Crop production

……
……
……

b. Livestock production

……
……
……

7.0 What would be your key recommendation(s) to the government/ policymakers concerning the current state of your farming and the prevailing climatic situations?

……
……
……
……
……

8.0 Kindly let's know if you have any other information which you think would be good to share with us before we end the session?

……
……
……

Thank you very much for your time and cooperation

Appendix 2: Semi-structured interview

(Targeting the key informants)

1. Personal Information

1.1.Name…….

1.2.Position…….

1.3.Contact details…….

2. Information on Climate Change

Generally, what can you say about Kenya's climate? Are we experiencing any Climate Change? Kindly explain

3. Performance in the smallholder farming enterprises

3.1. How would you describe the current smallholder farming practices in Trans-Mara East? How about in the past? How has been the performance of farming in this area, to as far as you can remember?

3.2. Based on the scenarios you have explained above, what do you think is/are the main factor(s) behind these situations? Can these be attributed the individual farmers, our policies or institutions?

3.3. At your level as an organization/institution, what are you doing about the situation of this smallholder farming, considering its crucial role, the overall performance and the prevailing climatic situations?

4. Impacts of climate change and variability on smallholder farming

4.1. Based on your observations, both at individual and organizational/institutional levels, has the performance of smallholders'output been affected by climate change? If yes, to what extent?

4.2. What aspects of climate change and variability are chiefly attributed to the inconsistencies, or otherwise, in the smallholder farming performances in the area? Can these be put on scale/quantified? What are the key constraints and/ or opportunities related to these?

4.3. In your own view, how are these variances affecting the livelihoods of the smallholder farmers in the sub-County? (In terms of income for their daily demands, their food, etc.)

5. Climate change awareness, coping and adaptation

5.1. In your opinion, would you say people in rural areas are aware of climate change? Why do you say so?

5.2. Are there any deliberate efforts to enlighten the smallholder farmers in the sub-County on climate change? Please explain, citing the specific actors involved.

5.3. Which specific roles do you have, as an organization/institution/ or department, in ensuring the adoption of climate change adaptation and coping measures among the farmers? Any measures to enhance the performance in the performance of their enterprises?

5.4. How has been the government's response to smallholders' situations in this area? Starting with the County government? How about the National government?

6. Finally, what would be your parting shot on this critical subject?

Thank you very much for your time, Sir/Madam, despite your busy schedule.