SMALL-SCALE FARMERS' ADAPTATION TO CLIMATE VARIABILITY IN MANGA, NYAMIRA COUNTY, KENYA

BY

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JUNE 2023

DECLARATION

Declaration by the candidate:

“This project proposal is my original work and has not been presented for award of degree at any university.”

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DEDICATION

I dedicate this project to my parents Josiah Bosire Nyamiaka and Pherus Kemunto Bosire, and daughter Lexie Liege Kemunto. Thank your for your support and God bless you all.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS AND ACRONYMS

CI	Coefficient of interval
CV	Coefficient of Variance
EWS	Early Warning Systems
FAO	Food Agricultural Organization
GHGs	Green House Gases
GST	Global Service Temperature
IHO	International Hydrographic Organization
IPCC	Intergovernmental Panel for Climate Change
NCCRS	National Climate Change Response Strategy
OR	Odds Ratio
RCMRD	Regional Centre for Mapping of Resources for Development
SD	Standard Deviation
SPSS	Statistical Package for Social Sciences
UNFCCC	United Nations Framework Convention for Climate Change

ABSTRACT

Agriculture is among the most vulnerable sectors to climate variability effects globally. This stems from climate variability extremes that paralyze farming systems and affect the socioeconomic status of farmers. As the population surges, climatic changes continue to impair food security. This has created a variable demand for climate adaptation strategies towards small-scale farming. This study therefore aimed to assess small-scale farmers' adaptation strategies to climate variability in Manga Sub-County, Nyamira County. The specific objectives were: to determine small-scale farmers' adaptation strategies to climate variability effects; to assess the climate variability trend (rainfall and temperature) in the years 1991–2021 in Manga Sub-County; to assess the dissemination of climate variability adaptation strategies information to small-scale farmers; and to examine perceptions of small-scale farmers on climate variability effects in Manga Sub-County, Nyamira County. A mixed-method research design was used where both qualitative and quantitative data were collected. Questionnaires and interviews were the primary data collection tools. The sample size of 198 was derived through the application of the Naissuma sampling formula that determined the infinite sample, where different sampling techniques, such as purposive sampling and systematic sampling, were used. Raw data was coded in excel sheets and analyzed through SPSS. The results show that the annual rainfall ($y = -2.199x + 2088.2$, $R^2 = 0.0096$) and annual average maximum temperature ($y = 0.0186x + 25.528$, $R^2 = 0.249$) have retrospectively increased overtime through a simple regression model. On average, Manga Sub-County had an annual average temperature of 25.5^0C. Use of mixed cropping (n = 196, 96.45%) and rainwater harvesting (n = 192, 97.46%) were the most preferred adaptation strategies. The least preferred adaptation strategies as non-adaptors were greenhouse technology (n = 182, 92.39%) and use of climate index insurance (n = 181, 91.88%). In addition, the small-scale farmers perceived the notable climate variability effects with a strong agreed tally of (n = 130, 65.66%). Use of radio (94.21%) was the main source of climate variability information. From the findings, the study recommends the development of early warning systems (EWS) by the environmental department in collaboration with NEMA county office in Nyamira County to give accurate weather and climatic prediction trends and the establishment of proper climate communication pathways and channels to embed small-scale farmers with adequate weather and climate information to enable better adaptation.

CHAPTER ONE: INTRODUCTION

1.1 Background information

Food insecurity is a massive global challenge because of the surging population of the planet and is the main problem for the climate change-prone poorer world (Hossain *et al.*, 2018). Food security exists when all people, at all times have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and health life (World Food Summit 1996 report). Food security has become a great concern in today's era. Concepts of food security have evolved in the last thirty years to reflect changes in official policy thinking (clay, 2002; Heidhues *et al*, 2004). The term first originated in the mid-1970s, when the World Food Conference (1974) defined food security in terms of food supply – assuming the availability and price stability of basic foodstuffs at the international and national levels.

The world population kicks 7.4 billion with growth rate of up to 33% by 2050 to reach 9.9 billion (population reference bureau). Agriculture as the main source of food to feed the huge population has been undergoing various constraints resulted by desertification, industrialization, climate change, poor policies and legal actions guarding food storage and distribution worldwide. About 795 million people are undernourished globally, down 167 million over the last decade and 216 million less than in 1990 – 92. The decline is more pronounced in developing regions, despite significant population growth. In recent years, progress has been hindered by slower and less inclusive economic growth as well as political instability in some developing regions such as central Africa and western Asia. Population Reference Bureau (PRB)'s projections show Africa's population will reach 2.5 billion by 2050, while the number of people in USA will rise by only 223 million to 1.2 billion. Asia will gain about 900 million to 5.3 billion, while Europe registers a decline from 740 million to 728 million. Oceania (which includes Australia and New Zealand) would rise from 40 million to 60 million. With this global population exponential growth; great pressure is being placed on arable land, water, energy and biological resources to provide an adequate supply of food while maintaining the integrity of our ecosystem. According to the World Bank and the United Nations, from 1 to 2 billion humans are now malnourished, indicating a combination of insufficient food, low incomes and inadequate distribution of food. This is the largest number of hungry human ever recorded in history. Countries that have failed to reach the international hunger targets, natural and human induced disasters or political instability have resulted in protracted crises with increased vulnerability and food insecurity in large part of the population. In such contexts, measures to protects vulnerable population groups and improve livelihoods have been difficult to implement or ineffective.

Extreme weather and temperature conditions are likely going to shift because of global warming. Climate variability refers to the variations in the mean state and other statistics like standard deviations and the occurrence of extremes of the climate on all temporal and spatial scales beyond that of individual weather events (UNEP, 2001). Climate variability can occur due to internal or external anthropogenic forcing. It has significant impacts on current agricultural processes and smallholder populations. The two main restricting factors in the optimization of agricultural output in the tropical regions are temperature and precipitation. These climatic extremes have indeed been found since the 1950s, but it is still nearly impossible to determine if they are a product of anthropogenic effects or not.

In Africa, agriculture accounts for over 50% of the job market (Yeboah & Jayne, 2018). Just like in Asia, environmental instability and transition continue to impede agricultural production in Africa as well. Agriculture is the major cause of economic earning in Kenya. The sector contributes 24% of the Gross Domestic Product (GDP) and 27% of GDP indirectly through linkage with manufacturing, distribution and other service related sectors. Approximately, 45% of government revenue is derived from agriculture and the sectors contribute over 75% of industrial raw materials and more than 50% of export earnings (Food security report prepared by Kenya Agricultural Research Institute). It also provides jobs that contribute to approximately 24% of economic stability (Mutunga *et al.*, 2018 and Kogo *et al.*, 2020). However, with projected climate vagaries, this contribution could plummet in the next decades as the agricultural sector is already feeling the effects of climate variability. The Intergovernmental Panel for Climate Change (IPCC) asserts that coupled climate variability effects could worsen if global emissions continue to pile up in the atmosphere (Berg, 2019). This further erodes the already plunging agricultural sector. Although the exact existence and magnitude of such adjustments remain unclear, Kenya's most recent climate change forecasts suggest that temperatures would rise by approximately 1°C to 2°C, coupled with moderate and seasonally variable (5–10%) rainfall, by the mid-century.

Nyamira County, like other counties in Kenya from previous studies (Innocent, 2017 & Wamalwa, 2017), has been identified among the counties that climate extremes have injected agricultural losses. This stems from limited access to information on climate variability in agriculture to small-scale farmers. Existing climate smart agriculture technologies through training have transformed farming resilience to environmental changes in Europe, Asia, Africa and Southern America. In Kenya, Climate Smart Agriculture (CSA) was launched and yet the information is yet to be channeled to impact climate change adaptation strategies for small-scale farmers at large (Chesterman & Neely, 2015). This study therefore aims to assess how small-scale farmers are addressing climate variability effects and the probable adaptation strategies they use in Manga Sub-County, Nyamira County, Kenya.

1.2 Problem statement

Climate variability and its accrued effects remain a threat to the global agricultural sector. This poses a threat to food security as farming systems continue to be impacted. In Kenya, agriculture contributes approximately 24% of the Gross Domestic Product (GDP) (Kogo *et al.,* 2020). However, this potential that is tapped both on a large scale and on a small scale is vulnerable to climate variability. The uncertainties proliferated by recurring imbalances in rainfall and temperature are a concern to farmers worldwide, including in Kenya.

Smallholder agriculture in East Africa is synonymous with poor productivity, stemming from several climatically related causes (Pereira, 2017). This varies from erratic rainfall, to soil infertility, to weak agronomic methods, undeveloped marketing networks, and lack of access to required agricultural inputs. These issues are specifically related to food shortages and the low quality of life of the area's farmers. Facing water and nutritional shortages, rural farmers are continually on the verge of poverty and food instability. There is a need for farmers to learn about climate adaptation strategies like mixed farming, green house technology, rainwater harvesting, use of organic manure, and use of indexed-based agricultural insurance.

Even with existing climate-smart techniques for mitigating and adapting to climate shocks, farmers are still under-informed about proper climate variability adaptation strategies. Climate extremes continue to be felt across all counties in Kenya, frustrating small-scale farmers that depend on rainfall for small-scale farming. In Nyamira County, climate variability effects are evident. A study by Ngare *et al. (*2016) found that in the past 30 years (1988–2017) there were changes in climate variability trends. For instance, there were rainfall anomalies and the temperature had increased by approximately +0.5°C, with a notable effect on agricultural production. This study therefore needed to be conducted with urgency among small-scale farmers in Manga Sub-County to ascertain their adaptation strategies for climate shocks in farming.

1.3 Research questions

The following were study research questions:

1. How has climate varied in the years 1992-2021 in Manga Sub- County, Nyamira County?
2. What are small-scale farmers' adaptation strategies to climate variability effects in Manga Sub- County, Nyamira County?
3. How is climate variability adaptation strategies information disseminated to small scale farmers in Manga Sub-County, Nyamira County?
4. How do small scale farmers' perception toward climate change influence choice of adaptation strategy in Manga, Nyamira County?

1.4 General objective

The general objective was to assess small-scale farmers' adaptation strategies on climate variability in Nyamira County.

1.4.1 Research objectives

The following were research objectives:

1. To analyze climate variability trend (rainfall and temperature) in the years 1991-2021 in Manga Sub - County, Nyamira County.

2. To establish small-scale farmers' adaptation strategies to climate variability effects in Manga Sub- County, Nyamira County.

3. To determine the dissemination of climate variability adaptation strategies information to small scale farmers in Manga Sub-County, Nyamira County.

4. To examine how small-scale farmers' perception toward climate change influences choice of adaptation strategy in Manga Sub-County, Nyamira County.

1.5 Research hypotheses

$\mathbf{H_{01}}$There is no significant climate variation in Manga Sub- County, Nyamira County.

1.6 Justification of the study

The overarching climate variability effects have crippled farming in Kenya's agriculture sector (Herrero *et al.*, 2010). Farmers are yet to be educated on proper climate variability adaptation strategies to mitigate its shocks. This study was anchored on knowledge and information dissemination to small-scale farmers in Manga Sub-County in Nyamira County, Kenya, which is experiencing climate variability vulnerability effects. The study aimed to create discourse on the agricultural sector at county and national levels on small-scale farmers that depend on rain fed agriculture. The findings could inform appropriate adaptation strategies to create resilience in agriculture and directly benefit small-scale farmers.

1.7 Scope of the study

This study was conducted in Manga Sub- County (0.3730° S, 34.5730° E). The Sub-County forms part of Nyamira County that is approximately 912.5Km^2. Small-scale farmers will be sampled to ascertain their climate variability adaptation strategies information approaches. The study sought to assess the climate variability trend, climate variability adaptation strategies and perceptions of small-scale farmers on climate variability in Nyamira County.

1.8 Conceptual framework

This study was pegged to three categories of research variables, guided by the study objectives (Fig.1.1). The independent variables, climate variability, socioeconomic characteristics, perceptions, and risk, are the foundation of the study and are moderated by intervening variables. The dependent variables, small-scale farming and climate adaptation strategies, are influenced by the outcome of independent variables. Their outcome is either direct or indirect and affects their stability in adjusting to climate variability indicators (rainfall and temperature) on their farming systems and adjusting to ramified environmental shocks.

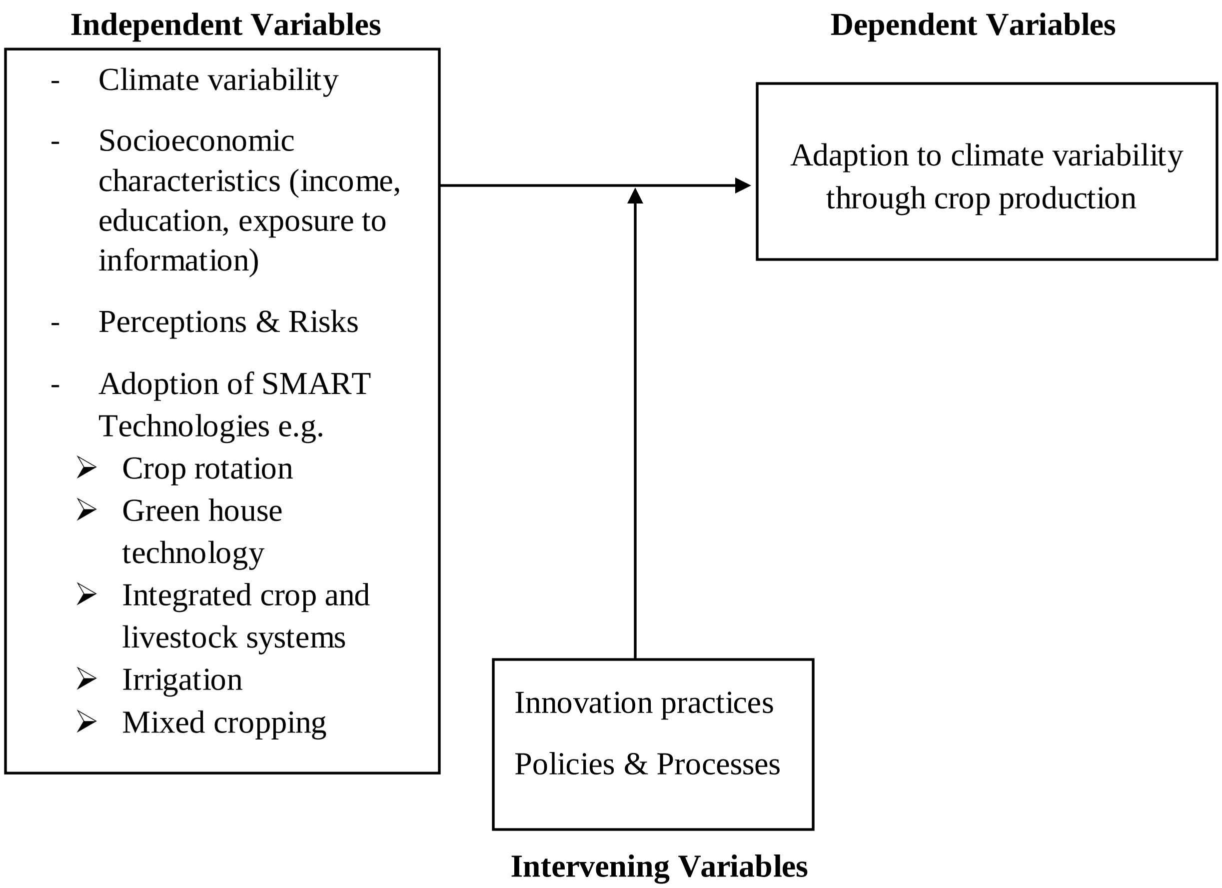

Figure 1.1: Conceptual Framework

1.9 Operationalization of terms

Adaptation	The state or ability to adjust to an external change (Pisor and Jones, 2020).
Climate Change	Long-term modeled changes in the climate system driven by natural forcing on human induced activities (Werndl, 2016).

Climate Variability	Statistical shift in temperature or rainfall caused by external forcing (Ghil and Lucarini, 2020).
Dissemination	A pathway or medium that information or knowledge is able to be channeled down to the target audience.
Small-Scale farming	Agricultural activity done at limited local scale on small parcels of lands (Borychowski, 2020)

CHAPTER TWO: LITERATURE

2.1. Overview

This Chapter is a summary and an evaluation of the current state of knowledge about climate variability and small scale farmers' adaptation. It covers global and regional climate variability trends, various climate adaptation strategies applied and the information gaps.

2.2 Global climate variability

International Panel on Climate Change (IPCC) estimates that the global surface temperature (GST) has increased by approximately 0.6 degrees Celsius since the mid-19th century, attributed to greenhouse gases (GHGs) and induced climate variability shocks (iCVS) (Masson-Delmotte *et al.,* 2018). Climate variability has been defined as shifts occurring on timescales as short as a month, as long as a season, and as long as a year (IPCC, 2014; Ngare *et al.*, 2020). The severe consequences of climate change have become more evident. The situation is triggering both a rise in the number of natural hazards and long-term social and economic implications (Dallmann & Millock, 2017). The most recently published evaluation report addresses the difference in how the environment will impact migration, but it is difficult to measure how many people may migrate (IPCC, 2014). Climate change may have specific direct consequences, such as decreased agricultural production, deteriorating health, an increased mortality rate, capital loss, and damage to social practices, but it may also have a negative impact on the environment and society.

Africa, like any other continent, is climate variability sensitive as climatic extremes are felt, affecting the socioeconomic wellbeing of the human population. The United Nations Convention on Climate Change (2019) report indicates that, in the worst possible situation, a yield loss of 13 percent for West and Central Africa, 11 percent for Northern Africa, and 8 percent for East Africa is expected by 2050. Sorghum and millet are predicted to be the most resistant, with a 5% and 8% yield decline by 2050 owing to their greater heat tolerance, and rice and wheat are projected to lose 12% and 21% of their yields (Scambos & Stammerjohn, 2020).

2.2.1 Temperature and rainfall variations in Africa's Sahel

The rainfall in the Sahel is influenced by globalization flow of the Hadley cell as well as the continental regional monsoon cycle, according to the International Hydrological Organization (IHO). Increased global warming increases the equilibrium temperature of the tropics' atmosphere and decreases the upwelling of the Hadley circulation, which both contribute to global warming (Nicholson, 2018). The warmth of the Sahara and the adjacent waters shifts the composition and location of the surface circulation and creates more extreme natural convection systems that influence seasonal rainfall. The mechanisms underlying reported inter-annual and multidecadal fluctuations. That was the primary forcing of the 1970s and 1980s droughts owing to the cooling of the oceans. There has been a rise in the average daily high temperature along with an improvement in the average daily minimum temperature during some seasons. A similar inter-annual variation in rainfall patterns correlates with the human-induced impact (Biasutti, 2019). Uncertainty about potential rainfall forecasts is usually anticipated because of "small-scale" circulations across the ground. Data is required to give a more valuable projection of rainfall shifts, extending beyond the overall amount to metrics of intra-seasonal dynamics and the probability of severe events, and evidence should be given by climatologists and stakeholders throughout the time of uncertainty.

In recent decades, the volume of rainfall has dramatically declined in the Sahel region, and the change is predicted to continue for years to come (Nicholson *et al.,* 2018; Ngare *et al.,* 2020). The majority of climate scientists agree that there has been an unmistakable human influence on recent climate change. 2019 was the third warmest year on record in the Sahel region of Africa, with temperatures 0.5°C–0.6°C above the 1981–2010 long mean (IPCC, 2019 & Yamanoshita, 2019).

Temperature and rainfall are two main indices of the environment in Africa and both have an impact on African communities on a continuous basis. Agriculture and water supplies are adversely affected by improvements in these two variables. Agriculture is essential in many African nations and provides a large portion of their gross domestic product. Rain-fed cropping is very susceptible to both temperature and precipitation shifts. Changes in the environment are impacting the wellbeing of people all over Africa. A big entry point for analyzing the status of the African environment is by tracking the two indices.

2.3 Farming and perceptions on climate change

Farmers' responses to climate shocks have a significant impact on how they adjust to the changing climate. Farmers probably do not have a good attitude towards climate change, and their news services are not reliable enough (Dubey *et al.,* 2017). Is it feasible for farmers to detect the danger of extreme weather events? It is doubtful because of many factors. As far as climate change is concerned, it is a long-term issue that will require long-term planning as opposed to a short-term situation. Secondly, they depend on their memory from previous climatic seasons. Climate change is one of the processes that cannot be perceived by the naked eye. Scientists have been seeking to figure out how growers will grasp and view how climate change works (Hasan & Kumar, 2019). Researchers prefer using the phrase "climate variability" rather than "climate change" in an effort to avoid being sued, misunderstood, but still referring to the same concept or phenomenon.

Climate change appears to have more negative consequences than positive effects (IPCC, 2014). Climate variability and extreme events severely affect farmers' eagerness and capacity to adjust their agricultural systems. Innovation in adaptation policy necessitates an awareness of how climate change attitudes, information resulting from adaptation and their drivers change. Notwithstanding a vast field of knowledge in both advanced and least-developed countries, many serious questions remain unanswered. Recently, according to Elahi *et al. (*2018), they highlighted the significance of farm level access to meteorological data, agriculture extension and credit to local adaptation measures and promotion of adaptive capacity. By adjusting their techniques, farmers can lower their economic losses and reap great benefits. In Africa, the agricultural sector remains the bedrock of livelihood (Abdi *et al.,* 2018).

Studies into the potential consequences of climate change also found that farmers could not respond to new developments in the landscape. This is because climate change impacts are based on location and time frames. For instance, certain people assume that global climate change is happening, but the effects on them are occurring somewhere, well on the horizon, or both (Pedersen & Nielsen, 2014). Farmers are comfortable with annual shifts in temperature, but the need and extent of farmers' adaptation are projected to accelerate. Despite the predominant or adverse climate crisis on agriculture in Africa, the largest portion of adaptation would rely on the farmers' independent adaptive activities that the FAO (2016) describes as the continuous application of farmers' current resources and information (Woods *et al.,* 2017).

2.4 Small-scale agricultural adaptation strategies

The worldwide environmental problem is climate change and has greatly expanded its effect on farming practices in developed countries. Identifying how farmers view and respond to climate change is highly critical for adopting effective agriculture and food protection policies. Small-scale farmers can use different adaptation strategies (Table 2.1)

Table 2.1: Climate adaptation strategies

Crop rotation
Green house technology
Integrated crop and livestock systems
Irrigation
Mixed cropping
Planting of cover crops
Practicing Intercropping
Rain water harvesting
Using Index-based agricultural insurance
Reseeding, control of weeds
Use of organic manure
Shift of planting dates
Use of herbicides

Adopted and modified from, Masud *et al.,* 2017

Adaptation relates to mitigating the detrimental consequences of climate change that could potentially improve resistance or minimize sensitivity to climate change. This refers to a systematic response package designed to counteract negative environmental consequences for a country's climate adaptation strategies (Masud *et al*., 2017). When it comes to the agricultural sector, climate change adaptation designs are critical in the current atmosphere change scenario. Farmers' willingness to take climate change into consideration is a critical precondition for successful adaptation. Alam and colleagues (2013), on the other hand, claim that the vast majority of Malaysian farmers are slow to recognize the dangers of climate change. Rice farmers, in particular, are particularly vulnerable to these temperature threats and are ill-equipped to deal with them. Farmers, on the other hand, must have a good understanding of climate change in order to implement effective adaptation methods and techniques (Somda *et al*., 2017). It is important to see the climate change threat background in defining hurdles and the necessary adaptation strategies in order to develop a policy structure to tackle climate change.

2.5 Dissemination of climate variability information in farming

Farming is the main industry in many sub-Saharan African nations. The agrarian system is mostly monopolized by small scale farmers, the majority of whom reside in semi-arid regions. They often suffer from powerful weather events, such as inadequate rainfall, floods, and extreme temperature fluctuations, and in addition they are vulnerable to pest and disease incidences, which often result in severe crop and livestock losses. These farmers are at risk of being affected by climate variability and changes; since majority of small-scale farmers lack access to reliable and actionable climate variability information hence farmers don't take full advantage of potential climate information. Climate variability information is a key input for farmers' adaptation to climate variability and change. Providing climate services such as climate variability information to farmers in underdeveloped countries can play a key role in making these vulnerable populations more resilient to climate variability (Huysen *et al.*, 2018).

According to Tall *et al.* (2014), research has shown that for sustainable goal 13: climate action to be achieved in Africa; there should be provision of climate information services to the most susceptible groups and or countries to build on resilience as soon as possible. Study by Tall *et al*. (2014), has aided in the establishment and production of climate services programs in majority of developing countries such as Kenya, hence facilitating the adaptation of climate variability and change. And yet tall works has enthused meteorological services to take initiative in their states to implement the climate services at national level.

2.5.1 Significance of climate variability knowledge in small-scale farming

From time-to-time, climatic variability has impacted the production capacity of the country, leading to hunger. At present, Kenya is experiencing several severe climatic conditions, including droughts, floods, and economic recession (Orindi & Ochieng, 2005). Major climatic instability and change in Kenya directly affect farming productivity and food security given that the majority of Kenya's population live in rural areas and depend on farming for their livelihoods. The main problem with rain-fed agriculture is that it makes it much more difficult to produce crops. According to Nhemachena and Chikwizira (2010), the poor in the developing world face many risks due to climatic and environmental changes. Such as poverty, sickness, inaccessibility of land, and high illiteracy are among their socio-economic vulnerabilities. Therefore, this demands clear response strategies in response to the threats of climate variability and change.

According to Wambua (2019), recognizing the challenges of climate variability, the Kenyan government has officially established the National Climate Change Response Strategy (NCCRS), whose objective is to mitigate the effects of climate change. NCCRS is meant to work towards strengthening national responses to adjusting and mitigating against a changing climate, taking into account the state's vulnerability to the consequences of climate change. Environmental protection has been established as one of the major national priorities in Kenya Vision 2030 and under its National Climate Change Act of 2016 (GoK, 2016). Besides identifying irrigation as a way of managing climatic changes and variation, the government invested in a major irrigation project in the Tana River region in the coastal area in 2014.

2.6 Research knowledge gaps

Smallholder agriculture in East Africa is synonymous with poor productivity, stemming from several climate variability causes affecting agricultural production (Pereira, 2017). This stems from unpredictable rainfall and changes in temperature that hinders farming systems.

Dissemination of climate variability information has not been channeled effectively even with existing media. This derails small-scale farmers' proper planning and switching to climate-smart adaptation strategies (Huysen *et al.,* 2018). Review studies (Wamalwa, 2017;

Ngare *et al.,* 2020) have shown significant climatic changes globally and in Kenya that keep accruing overtime if climate action is not taken.

According to the IPCC (2018), different regions are experiencing erratic rainfall and temperature changes, affecting food security in different regions across the globe. In Nyamira County, climate variability has taken center stage, affecting farmers across all its sub-counties (Innocent, 2017).

Still there exists overarching adaptation barrier towards climate change in Kenya hampering small scale farming (Mazud *et al.,* 2017). These include limited access to credit facilities, unpredictable weather, land size and cost of farm equipment.

CHAPTER THREE: METHODOLOGY

3.1 Overview

This chapter explains various methodologies that were used in gathering data and analysis which are relevant to the research. The methodologies will include areas such as the location of the study, research design, sampling and sample size, types of data, data collection method and its analysis. It also covers research tool validity, its reliability and pre-testing.

3.2 Study area

This study was conducted in Manga, Nyamira County, Kenya. The study area covered approximately 912.5 Km^{2}at a geographical location at 34°52'0" E to 34°57'30E and 0°48'30" S to 0°37'30" S. The bordering Sub-counties are; Gachuba and Kemera. Refer to Figure 3.1. From the National Population Census (2019), Manga Sub-County has approximately a total of 75,996 people. The County has approximately 21,000 small-scale farmers (Nyamira County official website).

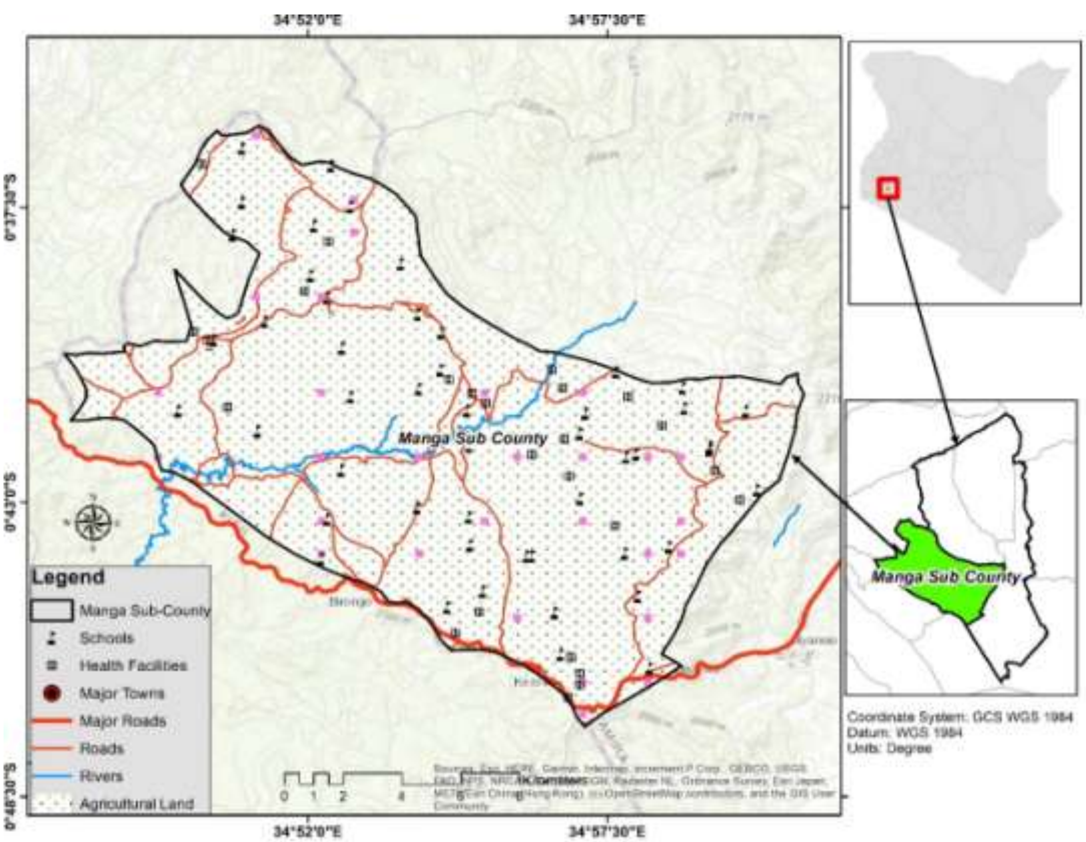

Figure 3.1: Area map source: Adopted from RCMRD, 2021

Topographically, the area is covered with gentle slopes that are covered with dark loamy soils from basement and sandy soils at the top of hills. The vegetation cover has been degraded with farming activities where dominant blue gums have been planted. The major economic activity is farming that is done largely on substance and small-scale levels. The agricultural yields are sold by the farmers at nearby trading selling centers.

3.3 Research design

This research took a combined method research design where, both quantitative and qualitative research designs were applied. Qualitative design focused on obtaining data through open-ended and conversational communication such as interviews while quantitative design aimed at discovering how many people think, act or feel in a specific way (Alves *et al.*, 2020)

3.4 Sample size

The target population for the study was made of small-scale farmers in Manga Sub-County. Naissuma sampling formula (2000) was used to determine the appropriate sample where households' heads shall participate in the answering of the questionnaires.

$(n) = (NCv^2) / [Cv^2 + (N-1) e^2$

Where: N = Number of populations,

CV = Coefficient of Variation (0.5) and

e = Tolerance at desired level of confidence (0.05) at 95% confidence level.

Therefore, $n = 165{,}594 (0.5^2) / [0.52 + (21000) 0.05^2] = 198$

3.4.1 Sampling procedure

The following sampling techniques facilitated the activities to undertake this study.

a) Systematic Random sampling – this sampling technique aided the sampling of household that are practicing small scale farming in the sub-county.

b) Purposive sampling – this technique targeted the key informants who are professionals in the agricultural sector, environment and meteorology to latitude their views on climate variability effects. Additionally, field officers were also interviewed while undertaking the study.

3.5 Data collection

The study used both primary and secondary data from the field and existing research reports. Primary data involved use of questionnaires and interview facilitated by the researcher. To obtain secondary data, climate variability data was sought from the Kenya Meteorological Department, other valuable secondary data was obtained from reports, published journals and national and county published document relevant to the study.

3.6 Data analysis

The data analysis was done using Statistical Package for Social Sciences (SPSS) to obtain descriptive data. To ascertain the relevance of the study, hypotheses were tested using inferential statistics. To ascertain the influence factors that influence farmer's choice of adaptation strategy, Ordinal Ratio (OR1) and Coefficient Interval (CI) were used as a fit model. According to Muzamhindo (2015), this model was important as it takes into account the relationship between research variables. Finally, analyzed data was presented using graphs, tables and charts

3.7 Validity

Research tool validity was done with the guidance of the supervisors from Kenyatta University to ascertain how well the data collection tools collects data and covers the actual area of research (Ghauri and Gronhaug, 2005). It's basically the measure of what is intended to be measured, the relevance of the tools and their research potential.

3.8 Reliability

Through Cronbach's Alpha technique, to demonstrate that tests and scales that have been constructed or adopted for research project are fit for purpose. The premise for conducting reliability tests is that there will always be a degree of random error in the administration of measurement scales. Therefore, reliability is a statistical measure of how reproducible the instrument's data are' (Utwin 1995) and can be equated with stability, consistency and dependability (Polit & Hungler 1995).

The reliability of research tools was ascertained if they met the minimum requirement of 70%.

3.9. Pretesting

The researcher made pre-visits to the field to test the research tools. In order to pin point problem areas, reduce measurement areas, reduce respondent burden, determine whether or not respondents are interpreting questions correctly and ensure that the order of questions is not influencing the way a respondent answers. Questionnaire items were adjusted aftermath to suit responses. This was to avoid biases and distortion of information.

3.10 Ethical consideration

The researcher was cleared by Kenyatta University ethical unit at the school of postgraduate to show authenticity of the study. This acted as a point of references to the respondents pertaining to the study.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 Overview

This chapter gives an in-depth discussion of results that the study looked into. The results are discussed according to the objectives that looked into the farming strategies of small-scale farmers on climate mitigation and adaptation in Manga, Nyamira County in Kenya. Different analytical approaches that involved descriptive and parametric tests are shown in the study.

4.2 Demographic characteristics of respondents

The farmers' demographic characteristics were based according to their age, education level, income levels, marital status, the detailed demographic characteristics of respondents is discussed in Tables; 4.1, 4.2, 4.3, 4.4 and 4.5 respectively.

4.2.1 Age of the respondents

Results in Table 4.1 show the age of the respondents during the survey. The age ranges were; 18-30, 31-45, 46-60 and 60 years and above that categorized the small-scale farmers in Manga, Nyamira County. A total of 198 farmers were sampled. From the results, most of the farmers 35.35% (n=70) were in the age bracket of 31-45years. Those in the age range of 18-30 years and above 60 years had tally of 18.69%. Small scale farmers in age range of 46-60 years came second in response with 27.27% (n=54).

Table 4.1: Age of the Respondents

Age	Frequency (n)	Percentage (%)
30 years and below	37	18.69
31 - 45 years	70	35.35
46 - 60 years	54	27.27
Above 60 years	37	18.69
Totals	**198**	**100**

The results therefore show variations in age distribution among the household heads in Manga. According to Feyrer (2007) and Prem *et al.* (2017), age is important in classification of different population respondents while undertaking data collection because age difference lead to different perception and application of adaptation strategies.

4.2.2 Education level of the respondents

From the results in Table 4.2 indicates the education level of the respondents in the time of the study. The level of education was classified into four categories namely: Informal/no formal education, primary level, secondary level and tertiary level of small-scale farmers in Manga, Nyamira County.

Table 4.2: Education Level of the Respondent

Education	Frequency	Percentage (%)
No formal education	16	8.08
Primary Level	69	34.85
Secondary Level	96	48.48
Tertiary Level	17	8.59
Totals	**198**	**100**

A total of 198 small scale farmers were sampled and the results were represented as above seen (table 4.2). Results shows that majority of farmer’s education level was secondary level with 48.48% (n=98). The no formal education recorded the least of 8.08% (n=16). Primary level was the second highest educational level among the sampled farmer with 34.85% (n=69). From the 198 total sampled tertiary level had 8.59% (n=17). For that reason, education level of the respondent indicates variation in distribution of education in Manga, Nyamira County. This affected the choice of an adaptation strategy method because some need knowledge to apply them for example greenhouse technology. Education level is significant during data collection as it acts as an indicator of comprehension of respondent on the concept and also gives accurate information (Istiyono *et al.,* 2020).

4.2.3 Income level of the respondents per month

The result in table 4.3 displays the income level of the small-scale farmers in Manga, Nyamira County. The income ranges from below Kshs 20,000, Kshs 20,000 - 40,000, and above Kshs 40,000. In addition, Kshs 40,000 in Manga, Nyamira County record the least with 2.02% (n=4) slightly followed by income range Kshs 20,000-40,000 with 18.18% (n=36) of the total. Form the result, majority of small-scale farmers fall under the category below Kshs 20,000 with 79.80% (n=158). The total number of small-scale farmers that were sampled was 198(n). This result shows uneven distribution of income of the household breadwinner in Manga, Nyamira, and County and with the result reveal majority of small-scale farmers live below Kshs 20,000. According to Benavides *et al*. (2021), income level of respondent is crucial as it helps to understand different adaptation strategies require different amount of funds to apply or set up.

Table 4.3: Income of the Respondents per month

Income	Frequency	Percentage (%)
Below Kshs 20,000	158	79.80
Kshs 20,000 - Kshs 40,000	36	18.18
Above Kshs 40,000	4	2.02
Totals	**198**	**100**

4.2.4 Gender of the respondents

Results in table 4.4 shows gender of the small-scale farmers in Manga, Nyamira County (respondents). From the responses, the total sample was 198 respondents. From the analysis, out of the total 198 respondents, all respondents (n=198) responded to the questionnaire; where 42.42% (n=84) were male. Also, of the 198 (N) respondent 57.58% (n=114) where female. Therefore, female is dominant with a higher percentage of 15.16% response to that of the male counterparts. This could be the reason that female gender is more involved in small scale farming as compared to males. Study, Schmidt (2020) gender enhances in categorizing the respondent for different responses for comparison purposes.

Table 4.4: Gender of the Respondents

Gender	Frequency	Percentage (%)
Male	84	42.42
Female	114	57.58
Total	**198**	**100**

4.2.5 Marital status of the respondents

The table 4.5 shows marital status of the respondent in the sub county of study. A total of 198 small scale farmers were interviewed during the survey. Of the total 198, 92.93% (n=184) were the married and 7.07% (n=14) fall in the category of the unmarried respondents. From the result of the study, it indicates that over 50% of the respondents are married and small-scale famers see Table 4.5. According to Nwosu *et al*. (2021) that marital status is important in data collection as it aids accurate collection of data and also for comparison purposes.

Table 4.5: Marital Status of the Respondents

Marital Status	Frequency	Percentage (%)
Married	184	92.93
Not Married	14	7.07
Total	**198**	**100**

4.3 Climate variability trend in Manga Sub-County, Nyamira County

4.3.1 Descriptive average monthly rainfall

The minimum and maximum average monthly rainfalls are clearly shown in Appendix III. This table contains descriptive statistics that include the kurtosis, the coefficient of variance, the mean, the standard deviation, and the mean of the distribution. It can be seen in this table that the high and low correlations of standard deviation (SD) as derived from the mean are represented by the coefficient of variance (CV). On average, January CV was the highest with 68.20 with the standard deviation of 72.26 whereas May averages had the least CV of 25.68 and with standard deviation of 67.06. In comparison with their distribution from the mean, months with high CV relations is more likely to vary from the mean and those with least CV are less likely to vary from the mean. With a kurtosis of 0.99 1.75, the monthly rainfall average was unevenly distributed, indicating a diverse distribution of monthly average rainfall, as indicated by the dispersion of kurtosis and skewness of the monthly rainfall average. Despite this, even when positive skewness was detected, the degree of two-tailed was neither highly significant on the left nor highly significant on the right. The left skewness (+ve) was at 0.99, while the right skewness (+ve) was at 1.75, transversely in the trend over the past decade, respectively. The calculated skewness displays a scale of 0.33 to 1.30, evident that the distribution was right tailed (positive) Rainfall disparity assist as long-term factor to foresee the past, present and future for climate related prognoses. Furthermore, rainfall plays a significant role in determining the extent to which climate change variation has occurred in a particularly area (Innocent, 2017). Refer to Appendix III for the average monthly rainfall data between 1990 and 2019.

4.3.2 Descriptive average minimum temperature

The table (refer to Appendix III) indicates the descriptive statistics of monthly minimum temperature averagely between the year 1990 and 2019. The spread, trend and distribution of the minimum temperatures in the table are resolute by measures of central tendency and dispersion. The standard deviation quotients that are derived from the mean of the distribution indicate consistency variants.

In November, the month with the lowest CV (1.98), there is less separation from the average (15.41). In April, the most consistent deviations from the mean were observed with a CV of 3.46 and SD of 0.55, in contrast to the consistency deviations from the mean in November, which were 0.31. The calculated skewness exhibits a scale of -1.31to 0.15, marks that the dispersal was left tailed (negative skewness). Nevertheless, the perceived kurtosis in table shows that August had the least coefficient of kurtosis of -0.15 and November with the highest coefficient of kurtosis of 2.19. Although the highest reading of CK was less than 3(<3) hence, the observation of a platykurtic distribution. The detected negative and positive extremes of minimum temperature annually were less. According to

Djaman *et al*. (2020) that average minimum temperature showed increase by about 69% with a variation of 0.1 to 8^0C over the last century.

4.3.3 Descriptive average maximum temperature

The concise figures style was used to objectively assess the distribution and trends of the maximum temperature in Manga, Nyamira County. Distinct methods were used to define the computed data on the Table (refer to Appendix III) that include measures of dispersion and measures of central tendency. On average, February had the highest mean of 27.67 of the maximum temperature whereas June had the least average mean of 24.80. The average mean range across the trend is 2.87, thus illustrating evenly distributed of average mean of maximum temperature. The highest witnessed coefficient of variance was 4.53 and the lowest coefficient of variance being 1.80 months of March and May respectively. From this finding May with CV of 1.80 has low degree of variation from mean (u=25.20) as equated to march with CV of 4.53 with (u=27.18) showing high degree of variation from the mean.

The coefficient of kurtosis displayed a range of -0.23 to 0.92, indicating that the distribution was right tailed in this case study (positive skewed). The skewed values range from -0.41 to 0.92, and they show a normal distribution, despite the high right tailed intensity trend in the data. The highest positive skew mark was achieved with a right inclined skewness of 0.92 degrees. When comparing the right and left sides, the centrosymmetric skewness was no longer in the right side. As a result, the maximum temperature was ascetically distributed across the asymmetrical skewness range of 1, -1, or 0.5, -0.5 degrees Celsius (Doane and Seward, 2011).

Figure 4.1 shows average monthly precipitation of Manga Nyamira County between (1990 and 2019). From the research, different observations were made on precipitation in the three decades. The highest monthly received precipitations in the area were April, May, November and March. In the month of April and May, the monthly average precipitation was 251.5mm being the months with the highest recorded monthly precipitation in the past three decades. Another month with higher precipitation was recorded in November with precipitation average of 200mm; March emerged with an average of 118mm being lower than November, making it the third highest precipitation monthly in year between 1990 and 2019.

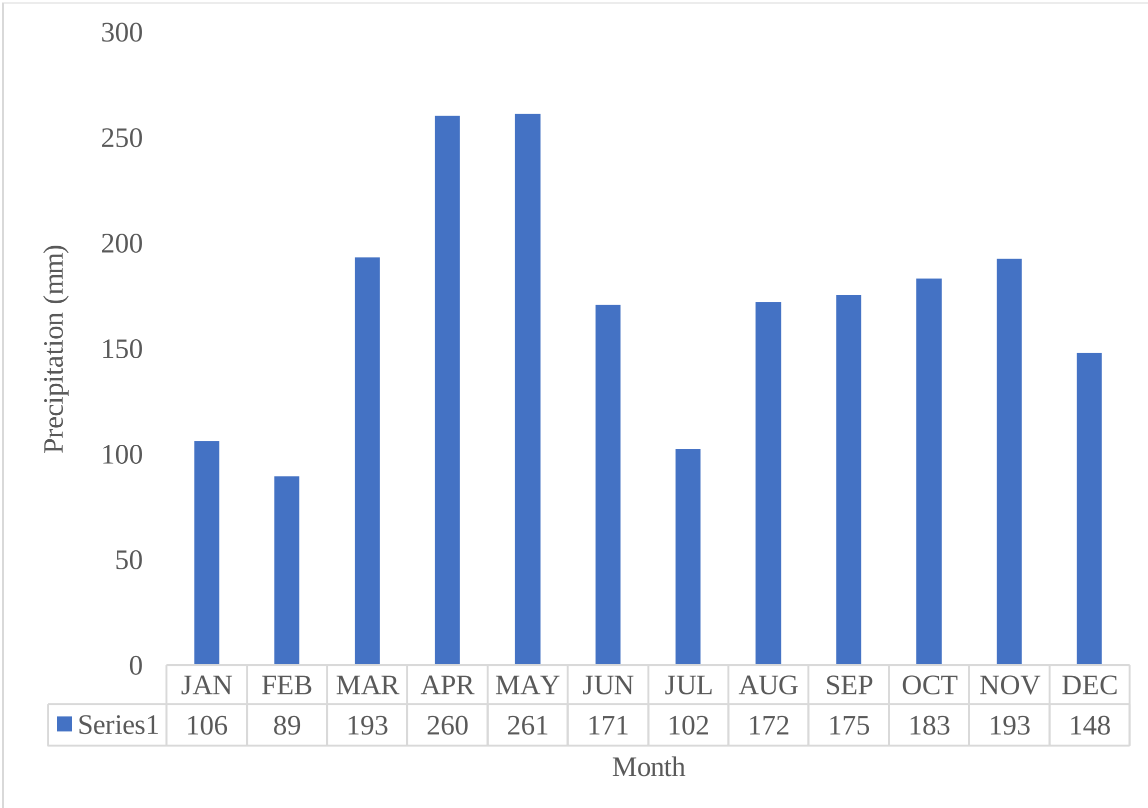

Figure 4.1: Average monthly precipitation of Manga in Nyamira County (1990-2019)

February had the lowest average precipitation of 95mm for the past twenty years. Associating the lowest and the highest precipitation monthly between 1990 and 2019, the monthly precipitation range was 156.5mm (251.5-95.0). From the findings, there was a constant precipitation increase from month of August to November precipitation monthly averages. Nevertheless, with all this escalating precipitation pattern across the four months (August, September, October and November); there was notable relentless precipitation decline trend between April, May, June and July. The observation made of average monthly precipitation over the past three decades might be influenced by changes in climate in Manga, Nyamira County.

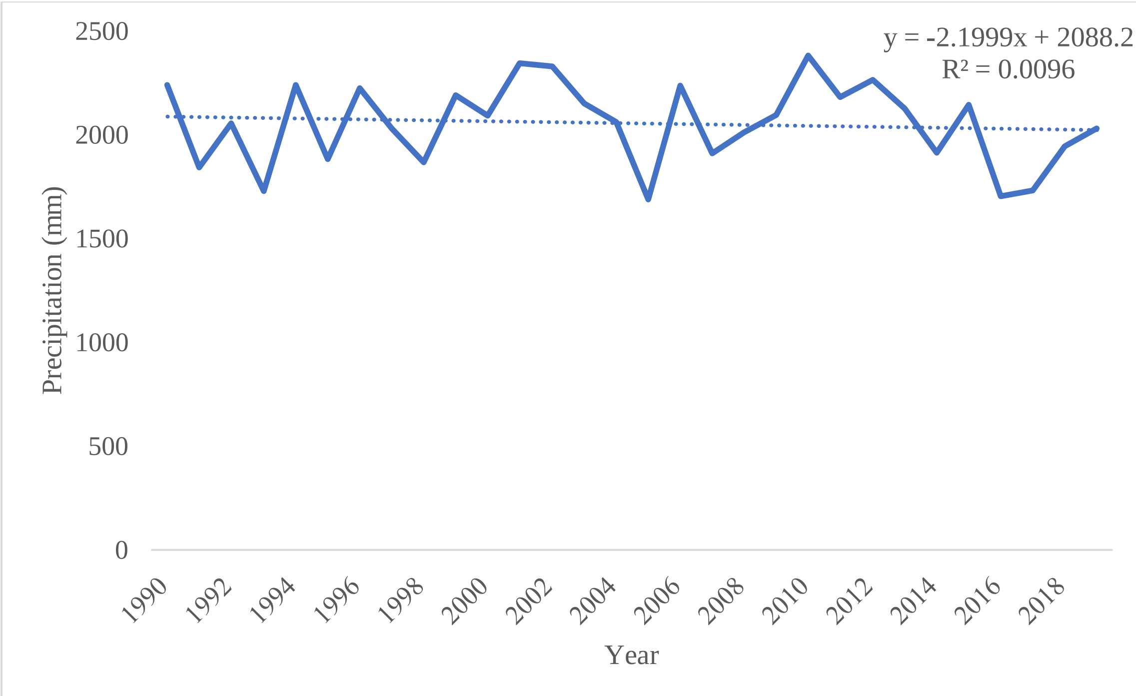

Figure 4.2: Total yearly precipitation for Manga, Nyamira County (1990-2019)

Figure 4.2 illustrates the linear regression of total yearly precipitation between years 1990-2018. The Figure represents trend of yearly precipitation with fewer extremes of between 2400mm and 1600mm in lower side. Across the pattern (figure 4.2), climate unevenness in total annual precipitation increased its lowest and highest peak in the years 2005 and 2011 respectively. The least recorded yearly precipitation of 1600mm in 2005 as compared to 1700mm in the year 1994 which was greater by 100mm. Over the years the total annually precipitation of Manga, Nyamira County have been decreasing drastically with the recent recording of 2000mm in the year 2019, evident that change in climate aspects has been experienced in the county in the year (1990- 2019). According to the total annual precipitation (Figure 4.2), the range is found to be low, ranging between 2400 and 1600mm (800mm). The linear precipitation shows a decrease in total yearly precipitation between 1990 and 2019 ($y = -2.1999x+2088.2$, $R^2 = 0.0096$), which is consistent with the linear precipitation. Also used is precipitation data from the selected circle headquarters, Nyamira, over a 30-year period to understand normal, deficit, excess, and seasonal precipitation in the selected circle headquarters (Arvind *et al*., 2017).

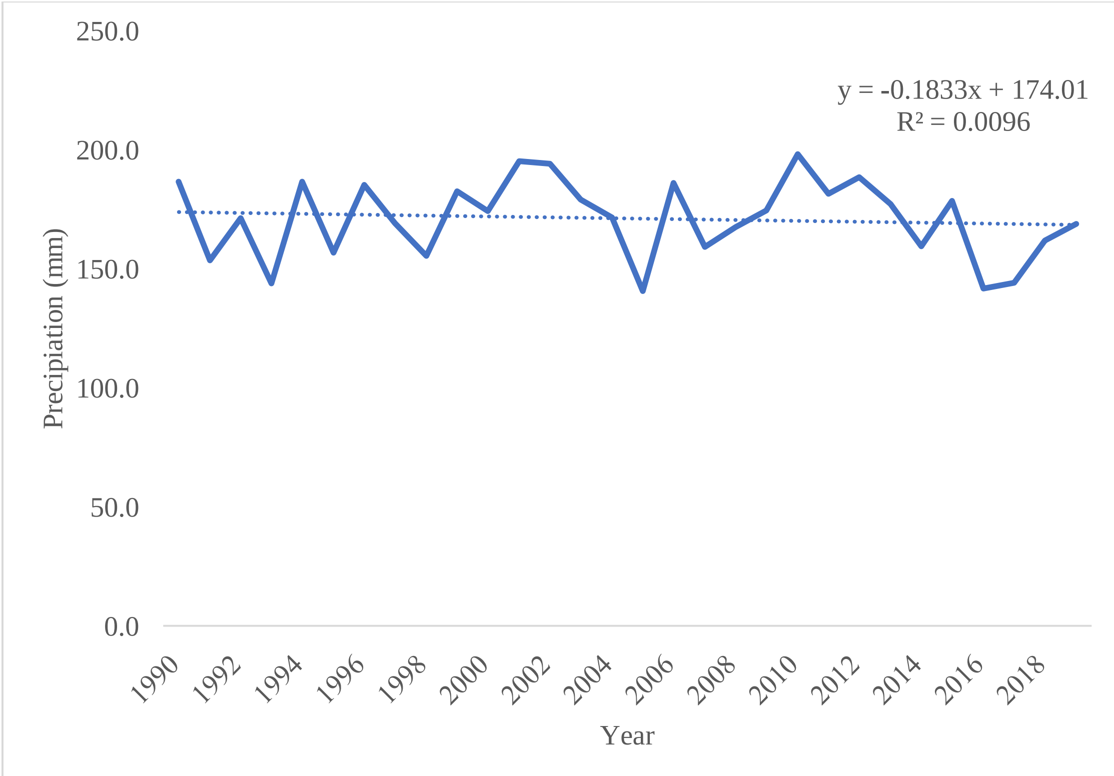

Figure 4.3: Average yearly precipitation of Nyamira County

Throughout the trend in the figure (4.3) uncertainties in climate has affected the average yearly precipitation in Nyamira County. The linear average annually precipitation showcase decline in annual average precipitation between 1990 to 2019 ($y = -0.1883x+174.01$, $R^2 = 0.0096$). Average annual precipitation has displayed high and low points in the years 2011 and 1994 with recording of 200mm and 149mm respectively. In the years 2001 and 2002 with equal average yearly precipitation of 199mm which is the second highest average annual precipitation in Manga area. This indicates that average annually precipitation was declining across the trend thus climate variations were felt in the between (1990-2019) period. Therefore, the analysis of average annual precipitation figure (4.3), the difference is witnessed to be low 51mm (200-149mm) over the past 30years.

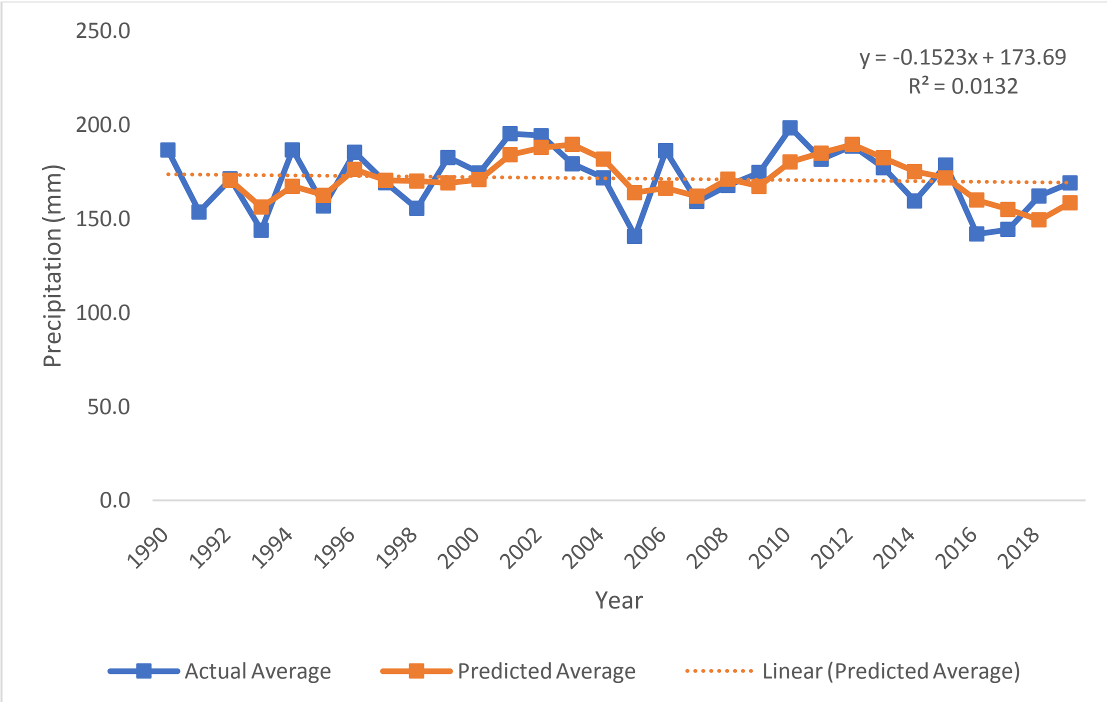

Figure 4.4: Three year moving average for the average annual precipitation

Figure 4.4 show the actual average and predicted average annual precipitation in Manga, Nyamira County. The linear precipitation reveals decline of both actual and predicted average precipitation between 1990 and 2019 ($y = -0.1523x + 173.69$, $R^2=0.0132$), evident that there was a constant predicted average precipitation across the years (1997, 1998, 1999, 2000 and 2001) of 180mm annually. Yet in the same years (1997, 1998, 1999, 2000 and 2001) the actual average annual precipitation revealed different recording of 180mm, 160mm, 150mm, 170mm and 190 mm respectively. From the research finding, 2010 had the highest actual average annual precipitation of 210mm whereas the years 2003 and 2013 highest predicted average annual precipitation was 200mm showcasing a range of 10mm in the 3-year moving average for the average annual precipitation between the years 1990 to 2019. Across the trend the linear predicted average was 180 mm annually however, due to the climate variation the trend showed increase and decrease in both actual and predicted average annual precipitation. The year of 2005 showed the least recorded actual average annual precipitation of 130mm whereas the least recorded predicted average annual precipitation was year 2018 with 150mm, evident that the actual average was less than predicted average by 20 (Zhang *et al.*, 2016).

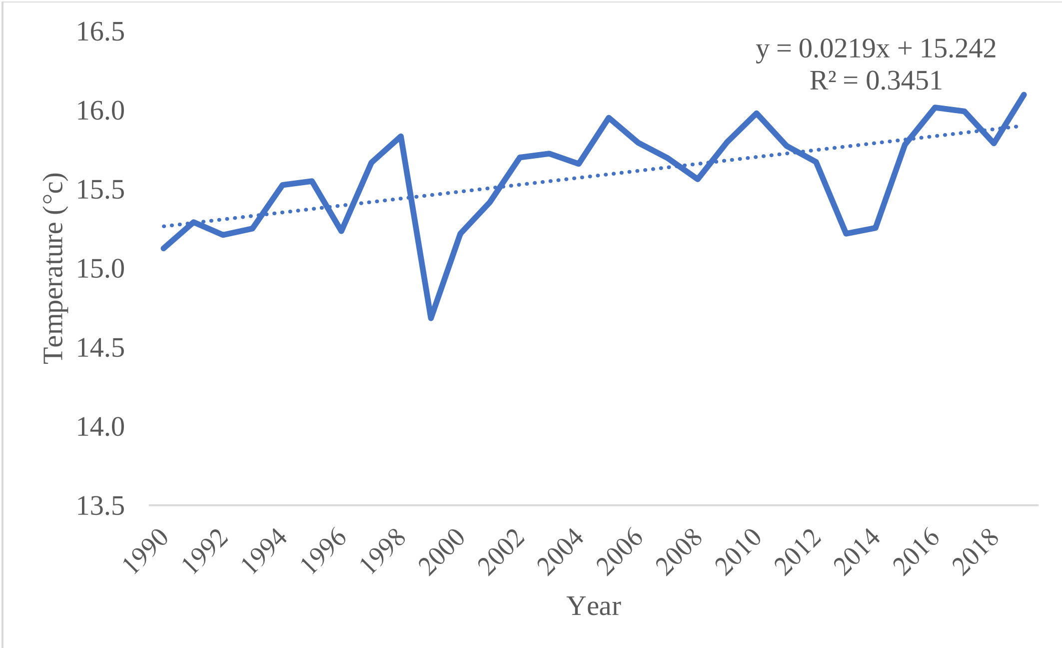

Figure 4.5: Average annual minimum temperature between 1990 and 2019

The average annual minimum temperatures have been shown in figure 4.5 for Manga. From the analysis the long run average annual minimum temperature, 2000 had the least average of 14.5^{0}C below the linear long-term average annual minimum temperature in 15.1^{0}C. It was slightly followed by the years 2013 and 2014 with an average minimum temperature of 15^{0}C, these were the years with the lowest average minimum temperature annually in the past three decades. The year's 2019 and2016 had the highest average annual minimum temperature 2019 had 16.3^{0}C with 2016 recording 16.1^{0}C respectively. From the findings years 2006 and 2010 both shared average annual minimum temperature of 16.0^{0}C. Some years had similar average annual minimum temperature of the annual long run average of 15.1^{0}C. The years 1997, 1999, 2015 and 2017 has an alike average annual minimum temperature of 15.1^{0}C similar to the average annual minimum temperature for the past three decades (1990 to 2019). The highest minimum annual average was indicated in the years 2019, 2016 and 2010 with temperature of 16.3^{0}C, 16.1^{0}C and 16.0^{0}C respectively.

The linear average annual minimum temperature showcased an increase in annual average minimum temperature across the trend between1990 to 2019 ($y = 0.0219x+15.242$, R^2 = 0.3451). As per Sonali and Kumar (2013), the observable upward and downward variances that could ultimately led to extreme ends in minimum temperature are both significant. From the above predictions, the average warming in Manga, Nyamira County is within $+0.2^0$C and $+0.5^0$C evident that temperature variation of Manga is positively backing to general global warming.

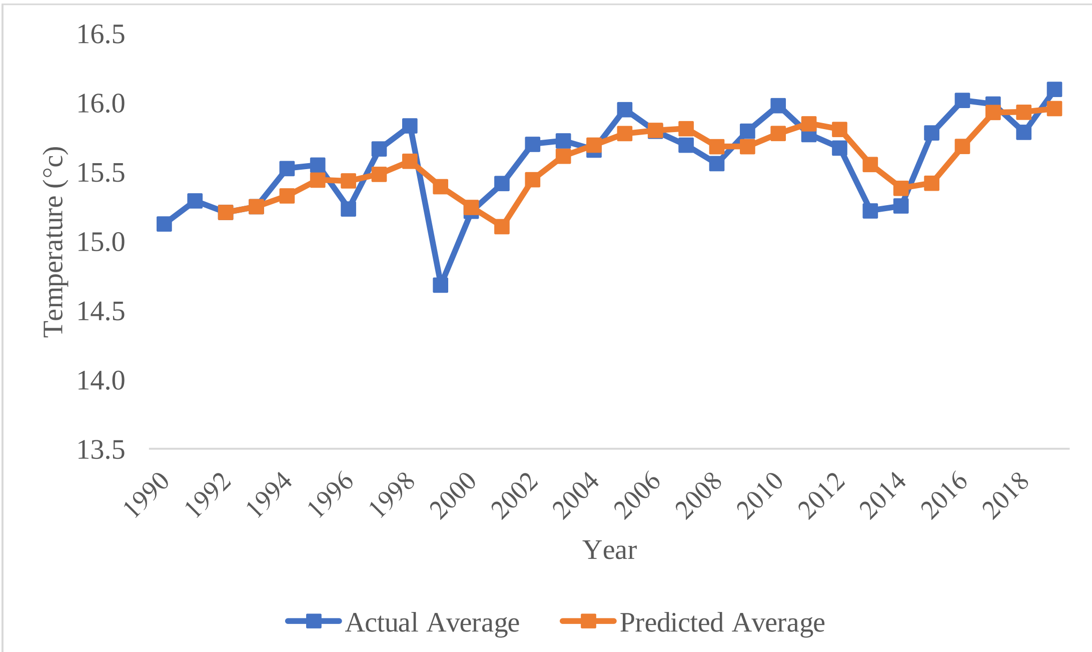

Figure 4.6: Minimum temperature 3-year moving average

Figure 4.6: indicates minimum temperature 3-year moving average (between 1990 and 2019) in Manga area in the past two decades. The findings show that actual average and predicted average tend to take different shifts. As from 1990 up to 1999 the actual average shows fluctuation with slight increase and decrease in minimum temperature 3-year moving average. Nonetheless the trend indicates decline in minimum temperature between 2000, 2001 and 2002. From the analysis for actual average, 2019 was the year that recorded the highest minimum temperature of 16.2^0C with the least recorded actual average minimum temperature of 14.5^0C in the year 1999.

Yet the predicted average minimum temperature revealed that the highest recorded minimum temperature was less with $<0.2^0$C with record of 16.0^0C in the year 2019 from the actual average minimum temperature same year (2019). However, the lowest recorded predicted average minimum indicates an increase by 1.5^0C (>1.5) with a recording of

15.0^0C in 2001 from the actual average minimum temperature of 14.5^0C in the year 1999. From the research findings, the highest and least records for both actual and predicted average showcase a range of 1.70C (16.2- 14.5^0C) and 1.00C (16.0-15.0^0C) respectively across the trend between year 1990 and 2019.

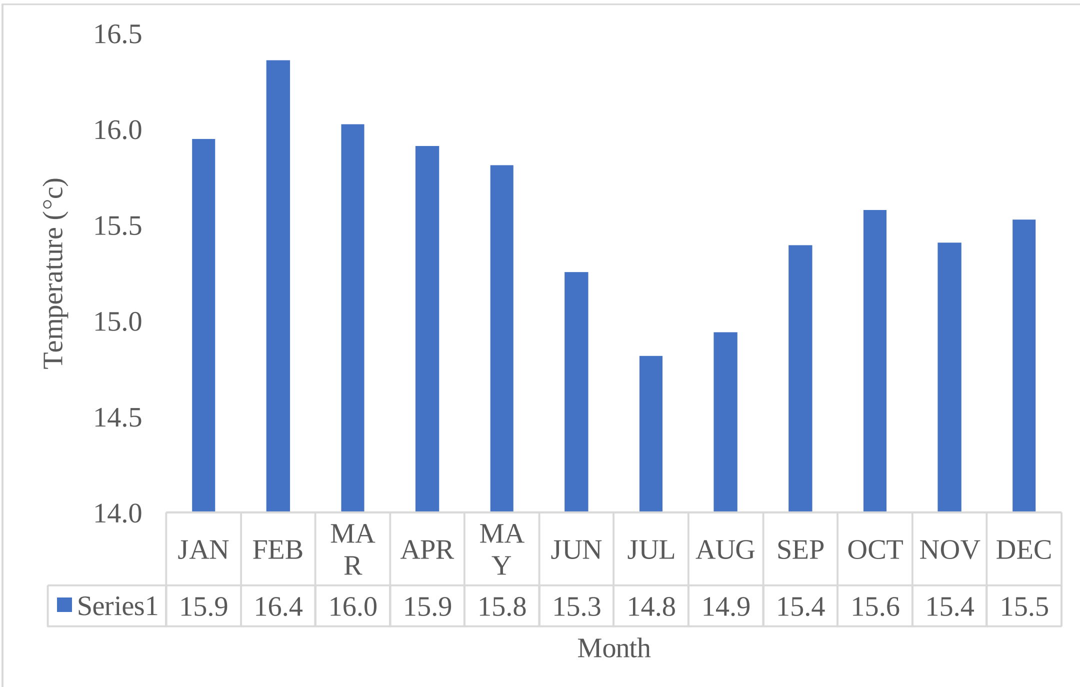

Figure 4.7: Average monthly minimum temperature between 1990 and 2019

Figure 4.7 illustrates the average monthly minimum temperature in the past three decades (between 1990 and 2019). The lowest minimum monthly temperatures from the above analysis were in the month of June, July, August and September between 1990 and 2019. It is observed as well that four distinct months slightly higher minimum temperature has same average temperature, January and April shows similar average monthly minimum temperature of 15.9^0C also September and November indicated similar temperature recording of 15.5^0C with a range of 1.1^0C and 0.7^0C respectively from the lowest average monthly minimum temperature recorded in July. The month of February had the highest average monthly minimum temperature record between 1990 and 2019 with record of 16.4^0C; this evident throughout the trend as show in figure.

Different observation on increase and decrease in the monthly average temperature between 1990 and 2019 were made. For instance, in the months February, March, April, May and June. Nevertheless, there were other observations of change in temperature where they indicated increase in minimum average monthly temperature. For example, in the month of July, August, September and October. Consequently, this increase and decrease in temperature evident on the figure 4.7 could be as a result of climate variation in Manga area, Nyamira County. From the analysis, the range was 1.6^0C ($16.4-14.8^0$C), indicating and increase in minimum monthly average temperature ($>1.6^0$C) over the past 30 years (Tokarska *et al.*, 2019).

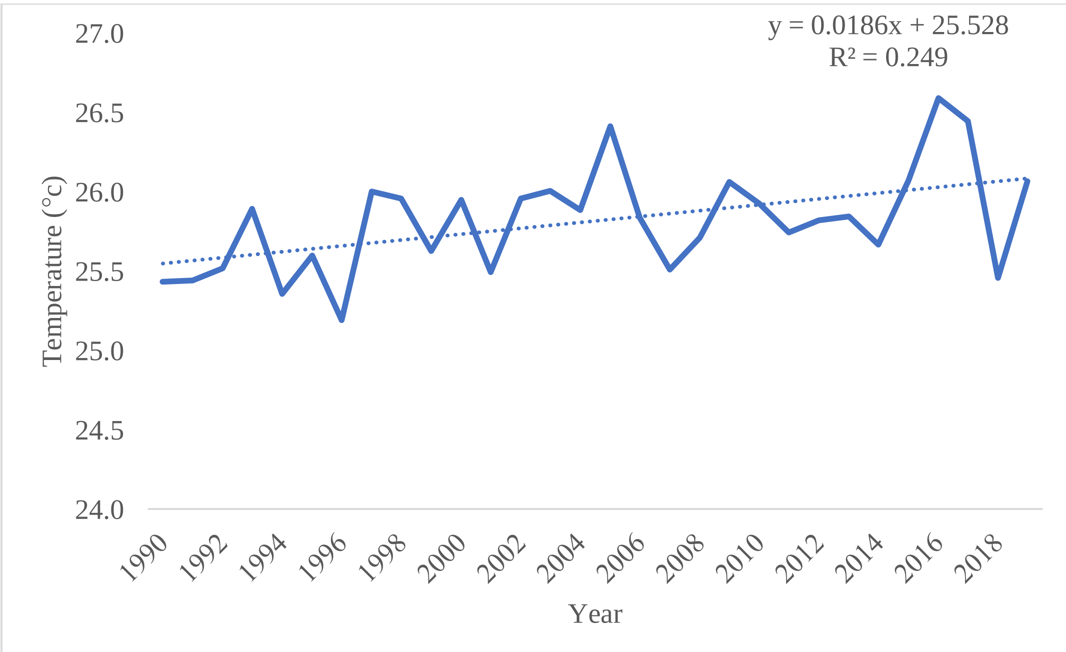

Figure 4.8: Average annual maximum temperature between 1990 and 2019

Figure 4.8 demonstrates average annual maximum temperature of Manga, Nyamira County with average of 25.5^0C. The linear trend of annual temperature shows a monotonic character (y= 0.0186x + 25.528, R^2= 0.249). Between 1990 and 2019, anomalies in both the upward and downward direction were observed, and it is possible that these anomalies will cause extremes in annual maximum temperature. The findings show that the highest temperature was experienced in the year 2016 with a record of 26.6^0C. This exceeded the normal average annual maximum temperature with an increase of about $+1.1^0$C over the past 30 years. From the analysis the long run, between the years 1997-1998, 2001-2003, 2004-2006, 2010 and 2016 and 2017, it indicates that the most of average annual maximum temperature experienced were above the linear temperature of 25.5^{0}C over the past three decades.

The lowest average annual maximum temperature was evident among different years with 1996 top on the list with a reading of 25.0^{0}C. It was followed by 2018 with temperature recording of 25.3^{0}C. This is evident that both lowest recorded temperature with a decline from the linear trend maximum temperature of about <0.5^{0}C and <0.2^{0}C respectively between the years 1990 and 2019. There were significant annual temperature fluctuations between 2012 and 2017 where in this year the average annual maximum temperature amplified by +0.9^{0}C (26.4- 25.5^{0}C). Furthermore, there were years that shared same average annual maximum temperature. For example, 2010-2019 and 1990-1991 had 26.0^{0}C and 25.4^{0}C respectively over the past 30 years. Across the trend, temperature had rose by 1^{0}C, see (figure 4.8).

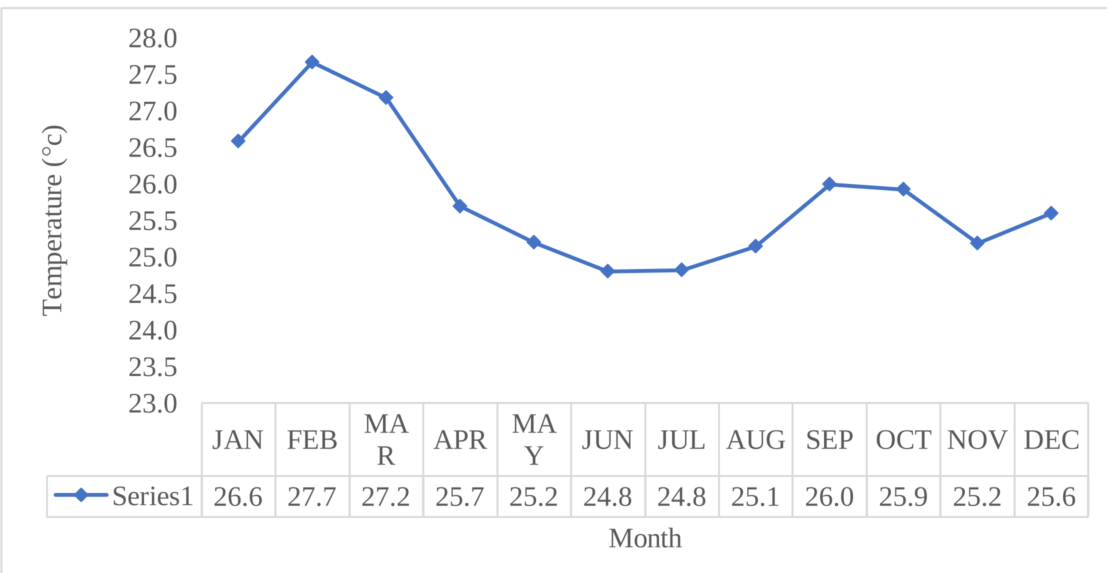

Figure 4.9: Average monthly maximum temperature between 1990 and 2019

Figure 4.9 shows the average monthly maximum temperature in the past three decades (between 1990 and 2019) of Nyamira County. The lowest maximum monthly temperatures from the above analysis were in the month of June and July with a reading of 24.9^{0}C and 25^{0}C respectively between 1990 and 2019. It is observed as well that four distinct months slightly higher maximum temperature has same average temperature, April and December shows similar average monthly maximum temperature of 25.6^0C and also May and August indicated similar temperature recording of 25.3^0C with a range of 0.7^0C and 0.4^0C respectively from the lowest average monthly maximum temperature recorded in June (24.9^0C). The month of February had the highest average monthly maximum temperature between 1990 and 2019 with record of 27.5^0C; this evident throughout the trend as show in figure 4.9.

Different observation on increase and decrease in the monthly average temperature between 1990 and 2019 were made. For instance, between the month of February and June. Nevertheless, there were additional observations of change in temperature where they showed increase in maximum average monthly temperature. For example, in the month of July, August and September. Subsequently, this increase and decrease in temperature evident on the figure 4.9 could be as a result of climate variation in Manga. From the analysis, the range was 3^0C ($27.5\text{-}24.5^0C$). This alludes with Eresanya *et al*. (2018), study showing an increase in average monthly maximum temperature by about $+3^0C$ in the past 30 years.

4.4 Small-scale farmers' adaptation strategies to climate variability effects

The second objective of the study sought to establish small-scale farmers' adaptation strategies to climate variability effects in Manga, Nyamira County. Results in Table 4.6 show different adaptation strategies small-holder farmers use to respond to climate change shocks in the area. Rain water harvesting was most preferred by adaptors 97.46% (n = 192), with mixed cropping 96.45% (n = 196) as the second most preferred strategy. Other adaptation strategies with over 85% used by the farmers were: use of organic manure 89.34% (n = 176); practicing intercropping 93.45% (n = 184); integrated crop and livestock systems 92.39% (n = 182); and crop rotation 87.31% (n = 172). A study by Ngare *et al*. (2017) found mixed cropping as an ideal climate variability adaptation strategy for small-holder farmers in Nyamira County. In addition, this was alluded to by Innocent Ngare (2017) in the same region.

The noted non-adaptors' climate adaptation strategies were greenhouse technology 92.39% (n = 182), using index-based agricultural insurance 91.88% (n = 181), and irrigation 66.5%

(n = 131). The results there indicate that modern agricultural technology like greenhouses has little preference among the farmers. In addition, the penetration of climate risk response through insuring crops from possible hydro meteorological disasters like hail stones that affect crops has not been taken up. According to Ngare *et al.* (2020) and Malhi *et al.* (2021), climate change impacts have heightened in the tropics, affecting agricultural production. However, farmers should leverage climate insurance and inculcate climate-smart agriculture practices (Vyas *et al.*, 2021).

Table 4.6: Climate Change Adaptation Strategies Used by Farmers

Adaptation Strategies	Adaptors		Non-adaptors		Total	
	n	%	n	%	N	%
Crop rotation	172	87.31	25	12.69	197	100
Green house technology	15	7.61	182	92.39	197	100
Integrated crop and livestock systems	182	92.39	15	7.61	197	100
Irrigation	66	33.5	131	66.5	197	100
Mixed Cropping	190	96.45	7	3.55	197	100
Planting of cover crops	158	80.2	39	19.8	197	100
Practicing Intercropping	184	93.4	13	6.6	197	100
Rain water harvesting	192	97.46	5	2.54	197	100
Using Index-based agricultural insurance	16	8.12	181	91.88	197	100
Reseeding, control of weeds	127	64.47	70	35.53	197	100
Use of organic manure	176	89.34	21	10.66	197	100
Shift of planting dates	141	71.57	56	28.43	197	100
Use of herbicides	101	51.27	96	48.73	197	100

4.4.1 Model fitting factors that influence the choice of adaptation strategy

Modeling the factors that influenced the choice of an adaptation strategy by small scale farmers of the outcomes (non-adaptors and adaptors) were constructed on four major positive and negative influential adaptation strategies from the total 13 assesses strategies in Manga, Nyamira County (Table 4.9). The four no-adaptors and adaptor factors were; green technology, mixed cropping, rain harvesting and using agricultural insurance.

4.4.2 Green technology

The UN Environment Programme has defined green economy as one that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities. In its simplest expression, a green economy can be considered as one that is low in carbon, resource efficient and socially inclusive.

Results in Table 4.7 show non-adaptors factors that influence the outcome of green technology preference.

Table 4.7: Non-adaptors influence on green economy

Characteristic	OR1	95% CI1	p-value
Gender			
Female	—	—	
Male	0.80	0.24, 2.80	0.7
Marital status			
Married	—	—	
Not Married	0.49	0.02, 4.15	0.6
Education Level			
No formal education	—	—	
Primary Level	7,554,536	0.00, NA	>0.9
Secondary Level	6,014,080	0.00, NA	>0.9
Tertiary Level	6,334,356	0.00, NA	>0.9
Occupation			
Agribusiness	—	—	
Any other business	0.00		>0.9
Income			
Above Kshs 40,000	—	—	
Below Kshs 20,000	0.03	0.00, 0.36	0.010
Kshs 20,000 - Kshs 40,000	0.02	0.00, 0.26	0.009
Age class			
18 - 30 years	—	—	
31 - 45 years	0.26	0.05, 1.24	0.10
46 - 60 years	0.15	0.01, 0.95	0.060
Above 60 years	0.52	0.08, 2.87	0.5
Climate trend	1.45	0.65, 4.19	0.4
Farmers cv perception	0.83	0.04, 37.2	>0.9
Farmers cv effects perception	10.5	0.26, 1,282	0.3

OR = Odds Ratio, CI = Confidence Interval

From the fitting model (OR1), Climate trend influenced their approach towards cropping. The model odds of association of Farmers CV perception (OR 0.02, 95% CI: 0.00 - 0.26) at a significance (p=0.009) with a no association outcome (OR=1) of small-scale farmers' choice on green technology adaptation strategy. Therefore, from the fitting model factors, income level was a determinant on the choice of green technology strategy.

4.4.3 Mixed cropping

Results in Table 4.8 show adaptors factors that influence the outcome of mixed cropping to their preference by the small-scale farmers. From the fitting model (OR1), Climate trend influenced their approach towards cropping. The model odds of association of Farmers CV perception (OR 1.07, 95% CI: 0.03 -30.1) at a statistical significance (p=0.9) with a great association higher outcome (OR>1) of small-scale farmers' choice on mixed cropping adaptation strategy. Therefore, from the fitting model factors, climate trend was a determinant on the choice of mixed cropping strategy by the farmers.

Table 4.8: Adaptors influence on mixed cropping

Characteristic	OR1	95% CI1	p-value
Gender			
Female	—	—	
Male	0.66	0.09, 4.16	0.7
Marital status			
Married	—	—	
Not Married	112,664,098	0.00, NA	>0.9
Education			
No formal education	—	—	
Primary Level	0.00		>0.9
Secondary Level	0.00		>0.9
Tertiary Level	0.00		>0.9
Occupation			
Agribusiness	—	—	
Business	65,763,062	0.00, NA	>0.9
Income			
Above Kshs 40,000	—	—	
Below Kshs 20,000	0.00		>0.9
Kshs 20,000 - Kshs 40,000	0.00		>0.9
Age class			
18 - 30 years	—	—	
31 - 45 years	4.93	0.57, 57.7	0.2
46 - 60 years	4.24	0.38, 66.0	0.3
Above 60 years	26,927,624	0.00, NA	>0.9
Climate trend	0.47	0.02, 2.62	0.5
Farmers CV perception	15.3	0.47, 734	0.14
Farmers CV effects perception	1.07	0.03, 30.1	>0.9

OR = Odds Ratio, CI = Confidence Interval

4.4.4 Rain harvesting

Results in Table 4.9 show adaptors factors that influence the outcome of rain water harvesting preference.

Table 4.9: Adaptors influence on rain water harvesting

Characteristic	OR1	95% CI1	p-value
Gender			
Female	—	—	
Male	0.33	0.01, 2.810.4	
Marital status			
Married	—	—	
Not Married	17,394,482	0.00, NA	>0.9
Education			
No formal education	—	—	
Primary Level	0.00		>0.9
Secondary Level	7.64	0.00, 204	>0.9
Tertiary Level	0.00		>0.9
Occupation			
Agribusiness	—	—	
Business	144,073,362	0.00, NA	>0.9
Income			
Above Kshs 40,000	—	—	
Below Kshs 20,000	0.00		>0.9
Kshs 20,000 - Kshs 40,000	0.00		>0.9
Age class			
18 - 30 years	—	—	
31 - 45 years	0.63	0.02, 10.30.8	
46 - 60 years	1.49	0.04, 33.30.8	
Above 60 years	36,483,561	0.00, NA	>0.9
Climate trend	0.90	0.07, 3.78>0.9	
Farmers cv perception	1.68	0.03, 79.50.8	
Farmers cv effects perception	4.30	0.09, 188	0.4

1OR = Odds Ratio, CI = Confidence Interval

From the fitting model (OR1), Climate trend (OR 0.09, 95% CI: 0.07- 3.78) influenced highly (OR>1) their approach towards rain harvesting. The model odds of association of Farmers CV perception (OR 1.68, 95% CI: 0.03 – 79.5) at a significance (p=0.08) with a no association outcome (OR=1) of small-scale farmers' choice on rain harvesting. Therefore, from the fitting model factors, secondary education (OR 7.64, 95% CI: 0.00 – 204) influenced farmers' choice of rain harvesting climate variability strategy.

4.4.5 Using agricultural insurance

Results in Table 4.10 show non-adaptors factors that influence the outcome of using agricultural insurance preference.

Table 4.10: Non-adaptors influence on using agricultural insurance

Characteristic	OR1	95% CI1	p-value
Gender			
Female	—	—	
Male	1.70	0.51, 6.41	0.4
Marital status			
Married	—	—	
Not Married	0.69	0.03, 5.99	0.8
Education Level			
No formal education	—	—	
Primary Level	0.05	0.00, 0.57	0.019
Secondary Level	0.16	0.02, 1.39	0.10
Tertiary Level	0.39	0.03, 4.63	0.5
Occupation			
Agribusiness	—	—	
Business	0.00		>0.9
Income Level			
Above Kshs 40,000	—	—	
Below Kshs 20,000	2,970,869	0.00, NA	>0.9
Kshs 20,000 - Kshs 40,000	1,290,144	0.00, NA	>0.9
Age class			
18 - 30 years	—	—	
31 - 45 years	1.31	0.29, 6.63	0.7
46 - 60 years	0.55	0.08, 3.44	0.5
Above 60 years	0.29	0.02, 2.57	0.3
Climate trend	0.66	0.35, 1.24	0.2
Farmers cv perception	4.52	0.20, 213	0.4
Farmers cv effects perception	2.19	0.11, 98.7	0.6

1OR = Odds Ratio, CI = Confidence Interval

From the fitting model (OR1), occupation level (OR 0.00, 95%, CI, NA) influenced their approach towards no preferring agricultural insurance. This can be attributed with lack of Coefficient Interval (CI). However, they had a statistical significance of (p = 0.9) which was highly influential (OR>1). Therefore, from the fitting model factors, occupational level was a determinant on the choice of green technology strategy.

4.5 Dissemination of climate variability adaptations strategies information

The third objective was to ascertain the dissemination of information on climate variability adaptation strategies to small-scale farmers in Nyamira County. The farmers were asked if, indeed, they had obtained climate variability and how is it affecting them. A total of (N = 198) farmers responded. The results are shown in Table 4.11. The results show, 95.96% (n = 190) of the small-scale farmers had obtained climate variability adaptation strategy information. Only 4.04% (n=8) of the farmers had no information about climate variability (Table 4.11).

Table 4.11: Accessing Information on Climate Variability

Access info	Frequency (f)	Percentage (%)
No	8	4.04
Yes	190	95.96
Total	**198**	**100%**

The ways farmers obtain climate information are shown in Table 4.12. The common sources were radio, television, local communication, the internet, and the use of agricultural extension officers. Most farmers indicated that use of radio 94.21% (n =179). The second most common source of information was from local community communication 47.89% (n = 91). The internet 96.84% (n = 184) and agricultural extension officers 97.89% (n = 189) were the least reliable sources of information for the farmers. Apparently, in the current information and technology (IT) era, the internet is a major source of information supported by human personnel. These two sources had little influence in the area (Table 4.12). Studies (von Braun *et al.*, 2021; Ristaino*et al.*, 2021) suggest that farmers should give priority to internet access and use it to obtain current and emerging global information on research, climate change, and agricultural production.

Table 4.12: Sources of information on climate variability

Source of Information	Access		Non Access		Total	
	n	%	n	%	N	%
Radio	179	94.21	11	5.79	190	100
Television	110	57.89	80	42.11	190	100
Local Community Communication	99	52.11	91	47.89	190	100
Internet	6	3.16	184	96.84	190	100
Agricultural Extension Officers	4	2.11	186	97.89	190	100

4.6 Small-Scale farmers' perception towards climate change influences choice of adaptation strategy.

Perception is psychological processes through the experience gained by the five senses, individuals can process responses into positive or negative perceptions. Obtaining responses is obtained through the stages of selection, interpretation, and reaction (Erin, & Maharani, 2018).

The fourth objective of the study was to assess small-scale farmers' perceptions of climate variability effects in Manga sub-county, Nyamira County. The small-scale farmers were asked how they perceived climate variability effects in the region and their statements were ranked on a scale (Table 4.13).

Table 4.13: Perceptions of Small-Scale Farmers on Climate Variability Effects

	Agree		Strongly Agree		Total	
Perceived statements	n	%	n	%	n	%
Has caused decline in my farm production	45	22.73	153	77.27	198	100
Has become a serious problem	45	22.73	153	77.27	198	100
Has brought unpredictable weather patterns	43	21.72	155	78.28	198	100
Is negatively affecting our agricultural sector	44	22.22	154	77.78	198	100

Results in Table 4.13 show four perceived statements if the farmers agreed or strongly agreed with them. Among the four statements, the leading one was that climate variability has brought unpredictable weather patterns 78.28% (n = 155). The second most felt and perceived effect was that climate variability was negatively affecting the agricultural sector

77.78% (n = 154). On whether climate variability was impacting farm production and had become a serious problem, all the farmers strongly agreed, with a percentage tally of 77.27%.

These findings (Table 4.13) agree with that of Kangai *et al.* (2021) on small-scale farmers in Embu, Eastern Kenya, where the author emphasizes the need to adapt to climate-resilient agricultural systems to curb climate variability shocks. The same has been alluded to by Rabach *et al*. (2020) through transitions to agro forestry systems in conventional agriculture that sequester carbon emissions from the atmosphere.

4.6.1 Perception on climate variability trend

The perceptions of the climate variability trend were constructed along with rainfall amount, rainfall intensity, and temperature (Table 4.14). These responses were ranked depending on the small-scale farmers' responses in Manga, Nyamira County.

Table 4.14: Perception of Climate Trend Variability

Weather Conditions	Decreased		Significantly decreased		Remained the same		Significantly increased		Increased		Total	
	n	%	n	%	N	%	n	%	n	%	N	%
Rainfall Amount	28	14.14	0	0	1	0.51	130	65.66	39	19.7	198	100
Rainfall Intensity	25	12.63	6	3.03	0	0	87	43.94	80	40.4	198	100
Temperature	3	1.52	1	0.51	8	4.04	123	62.12	63	31.82	198	100

The results showed that the majority of respondents 65.66% (n = 130) felt rainfall had significantly increased in the Manga area. The other perceived aspect was the significant increase in temperature in the area 62.12% (n = 123). These findings support the claim of Oluwatimilehin and Ayanlade (2021), on the effect of climate variability on temperature in different agricultural ecological zones in Nigeria. In addition, Mairura *et al.* (2021) mention perceived determinants of climate variability with a focus on rainfall and temperature among small-scale farmers in the central highlands of Kenya.

4.7 Hypotheses testing

H_{01} There is no climate variation in Manga Sub- County, Nyamira County.

To test if there was any significant climate variation in Manga Sub-County, the Mann Kendall test for trend was performed on both the rainfall and temperature data. A time series plot was generated a long side the test statistic result for reassertion of the test results.

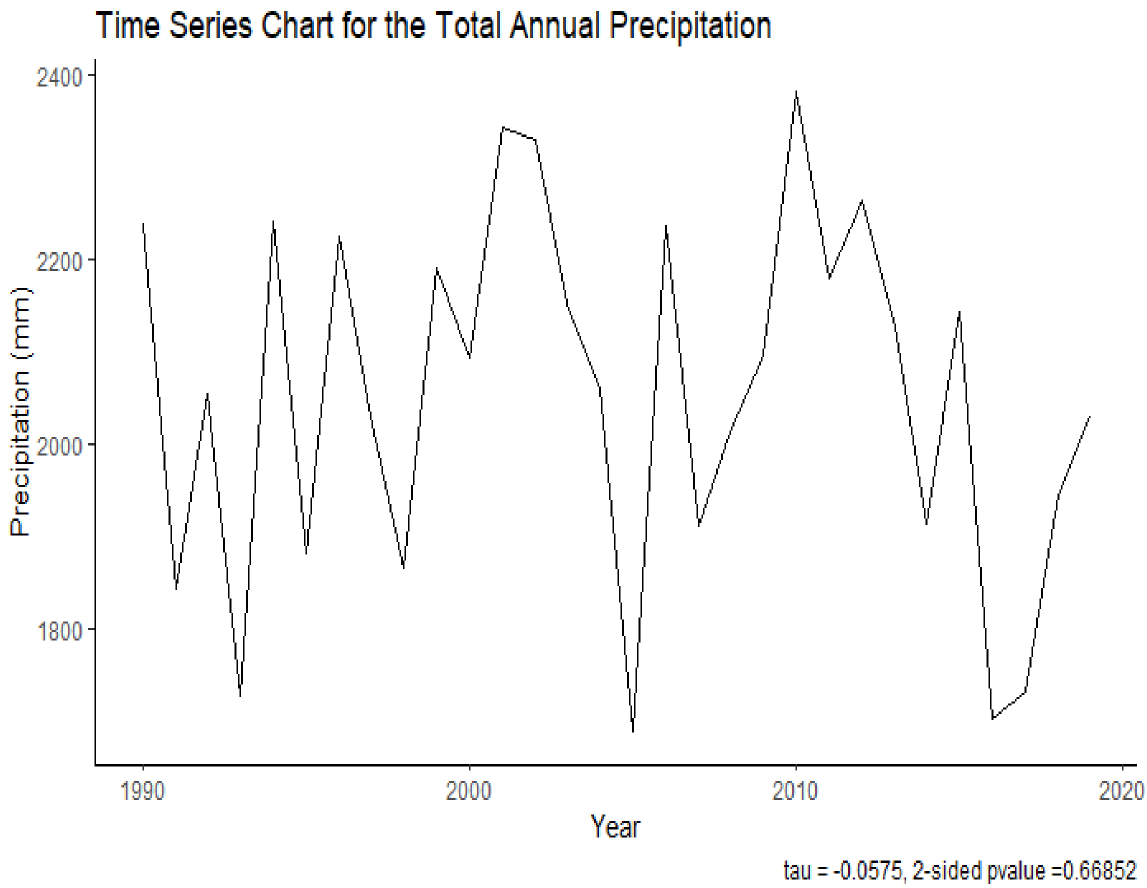

Figure 4.10: Hypothesis results annual precipitation

As seen in the figure 4.10, the results of the Mann Kendall test on the trend of Annual precipitation in Manga between 1990 and 2019 shows a tau value of -0.0575 with an associated p-value of 0.6685. Given that the obtained p-value was greater than 0.05, these results indicate that there is no significant trend present in this data. This implies that the annual precipitation in Manga Sub- County has not significantly changed in the selected 30-year period.

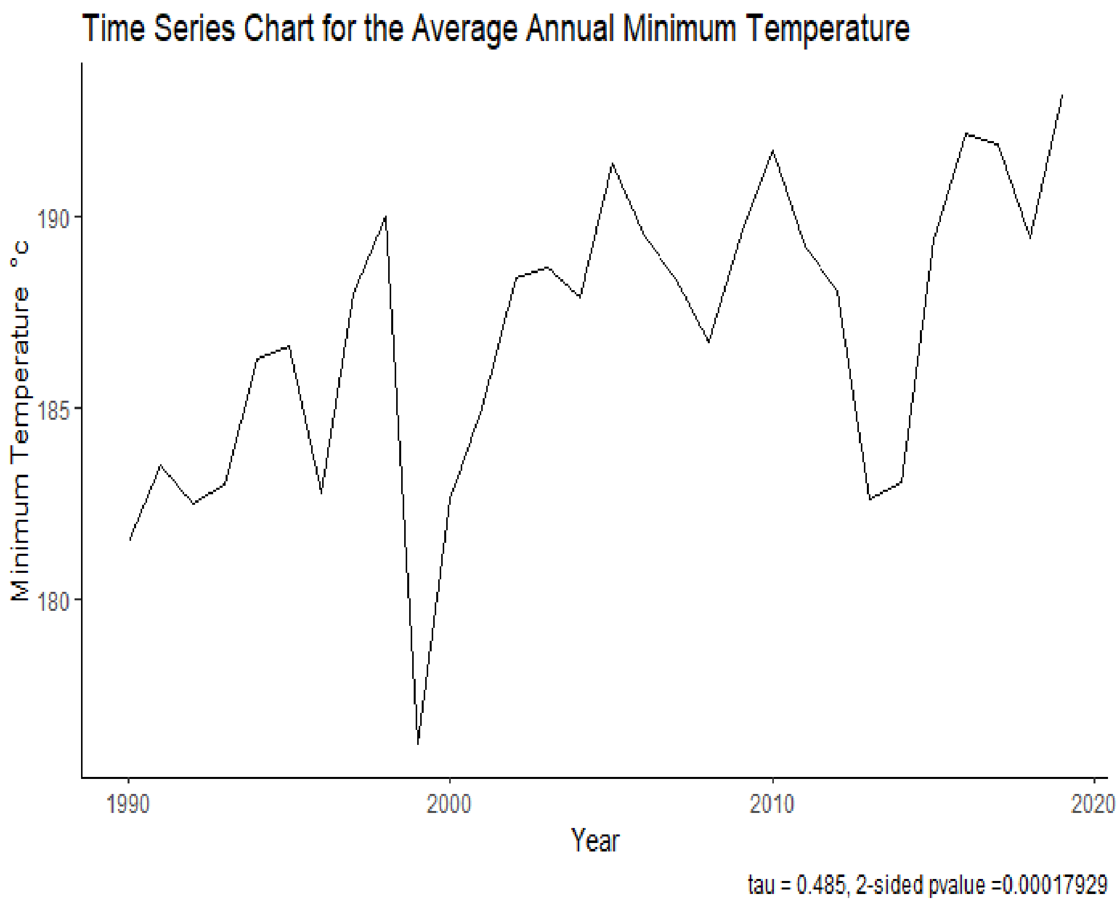

Figure 4.11: Hypothesis results annual maximum temperature

The obtained test statistic for the Mann Kendall test, as shown in the above figure 4.11 for the average annual minimum temperature of Manga Sub- County, is 0.485 with an associated p-value of 0.0002. Based on these results, it can be concluded that there is a significant trend present. This implies that the minimum temperature in Manga Sub-County has been significantly changing over the selected 30-year period. Also, given that the tau value is positive, it indicates that the minimum temperature has been increasing over time in Manga Sub-country for the selected period of time.

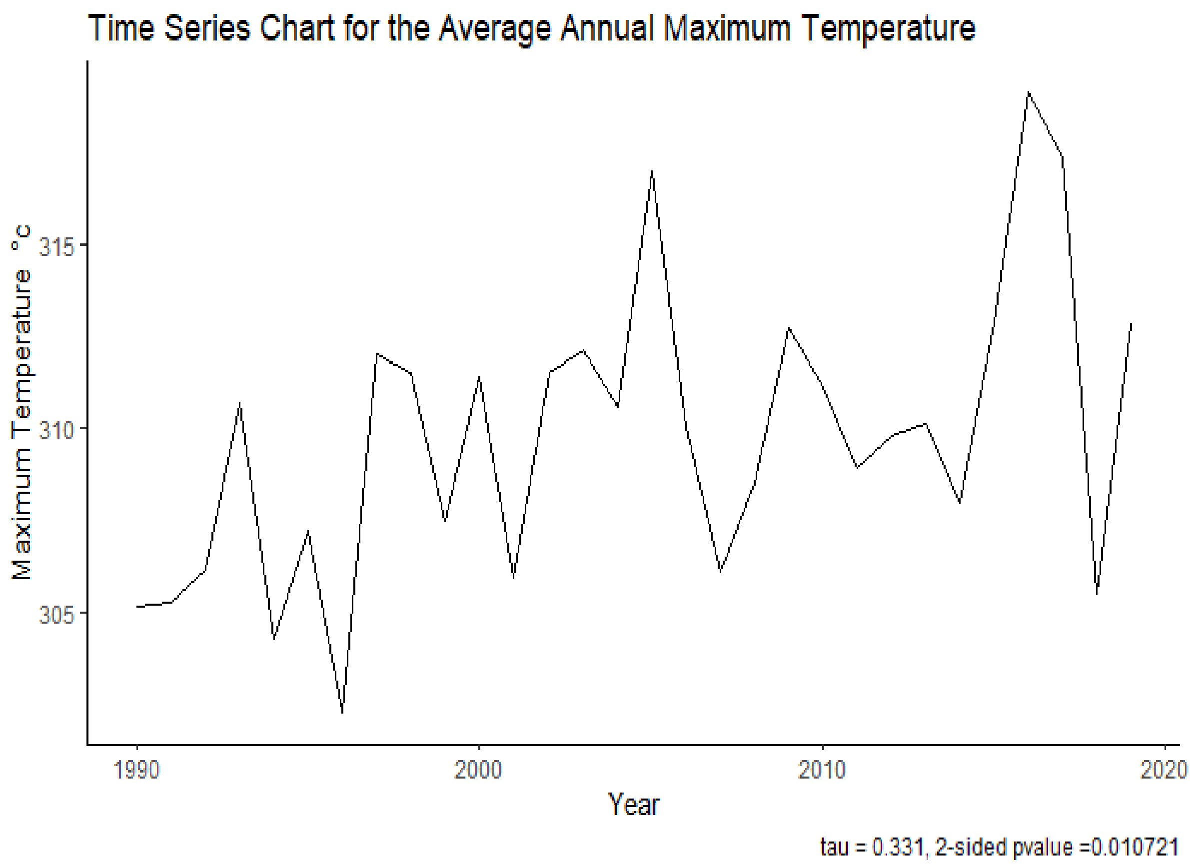

Figure 4.12 Hypothesis results annual maximum temperature

On performing the Mann Kendall test on the annual maximum temperature, a tau value of 0.331 with an associated p-value of 0.0107 was obtained. These results indicate that there was a significant trend in the data, and given that the tau value was positive, the trend was increasing over time. Therefore, it can be concluded that the annual maximum temperature in Manga Sub-County has been significantly increasing over time between the years 1990 and 2019.

In a nutshell, the above trend analyses indicate that there is some statistically significant variation in climate in Manga Sub - County. According to the findings, these variations are witnessed in both the minimum and the maximum temperature rise. However, the annual precipitation in this region does not indicate any climatic variation.

Table 4.15: Hypothesis testing

Source of information		Income			Test Statistic
		Below Kshs 20,000	Kshs 20,000 - Kshs 40,000	Above Kshs 40,000	
Radio	Yes	144 (75.79%)	2 (1.05%)	0 (0.00%)	$\chi^2 = 0.2527$
	No	9 (4.74%)	31 (16.32%)	4 (2.11%)	p = 0.8813
Television	Yes	64 (33.68%)	21 (11.05%)	0 (0.00%)	$\chi^2 = 5.951$
	No	89 (46.84%)	12 (6.32%)	4 (2.11%)	p = 0.0510
Local Community Communication	Yes	62 (32.63%)	25 (13.16%)	0 (0.00%)	$\chi^2 = 17.949$
	No	91 (47.89%)	8 (4.21%)	4 (2.11%)	p = 0.0001
Internet	Yes	3 (1.58%)	1 (0.53%)	2 (1.05%)	$\chi^2 = 29.418$
	No	150 (78.95%)	32 (16.84%)	2 (1.05%)	p = 0.0000
Agricultural Extension Officers	Yes	3 (1.58%)	1 (0.53%)	0 (0.00%)	$\chi^2 = 0.2385$
	No	150 (78.95%)	32 (16.84%)	4 (2.11%)	p = 0.8876

As seen in the table above, the use of radio ($\chi^2 = 0.2527, \mathrm{p} = 0.8813$) and agriculture extension officer, ($\chi^2 = 0.2385, \mathrm{p} = 0.8876$) as the source of climate variability information does not depend on the financial status of the farmers. Nonetheless, the findings show that the use of television ($\chi^2 = 5.951, \mathrm{p} = 0.0510$), local community communication ($\chi^2 = 17.949, \mathrm{p} = 0.0001$) and internet ($\chi^2 = 29.418, \mathrm{p} = 0.0000$) are significantly influenced by the income level of the farmers. More farmers belonging to the higher income levels tend to use television, local community communication, and the internet as their source of climate variability information than farmers in the lower income levels. Therefore, it can be deduced that some of the sources of information on climate variability depend on the income level of the farmers for example internet.

CHAPTER FIVE: SUMMARY, CONCLUSIONS AND RECOMMENDATION

5.1 Overview

This chapter is a summary of the research findings from the study. The results, conclusions and recommendations have been presented, anchored along with the research objectives.

5.2 Summary of results

This study was conducted in Manga Sub-County, Nyamira County, Kenya, where small-scale farmers were assessed to determine their climate variability adaptation strategies in farming. Demographically, the male respondents were slightly higher compared to their female counterparts in the survey. From the income levels of farmers, the majority had an income range of Kshs 20,000 and below from their farming proceeds annually. The study also finds that the majority of the farmers serving as household heads were married, with a few not married. As per the respondents' educational levels, a large proportion of farmers had attained secondary education, with very few having a tertiary level of education. The age range of respondents had slight variations, with those between the ages of 31 and 45 having a slighter dominance compared to other age ranges.

The first objective of the study looked into the climate variability trend in Manga Sub-County in Nyamira County. To determine trend behavior, a 30-year retrospective analysis of rainfall and temperature was performed. In modeling the rainfall trend across the years, rainfall was unevenly distributed with a diverse monthly average rainfall distribution as depicted by the kurtosis level of skewness. The results show that the months of April and May had the highest monthly average precipitation compared to other months between 1990 and 2019 in Manga Sub-County. From the total yearly precipitation of Manga, the trend of rainfall was slightly decreasing over time in the area. In addition, the average annual minimum temperatures from the simple linear regression have increased over time. The area recorded an increase in $0.5^{o}C$ in temperature. This was similar to the average annual maximum temperature increasing gradually, even with the observed monotonic character. Between 1990 and 2019, the observed upward and downward abnormalities that could cause extremes in annual maximum temperature.

The second objective established small-scale farmers' adaptation strategies to climate variability effects in Manga Sub-County, Nyamira County. The results show that among the adaptation strategies the farmers used, rainfall harvesting was the most preferred adaptation strategy, followed by mixed cropping as compared to other adaptation strategies. It was also noted that the leading non-adapter strategies to respond to climate shocks were the use of greenhouse technology at 92.4% and using index-based agricultural insurance at 91.9%. The leading adopted strategy was rainfall harvest at 97.4%. This clearly shows that the farmers had not really leveraged the climate-smart agricultural approach where use of modern technology and provision of farmer incentives through insurance on climate losses is important.

The third objective looked into how the dissemination of climate variability adaptation strategies information to small-scale farmers was done in Manga, Nyamira County. The majority of the farmers alluded that they were receiving climate variability information in the sub-county. That is 96% access climate variability information. The primary source of information was radios at 94.2%, with a minor contribution from local community communication. The results also found that the internet and agricultural extension officers were the least sourced sources of climate information in the area at 3.16% and 2.11% respectively.

Finally, the fourth objective investigated small-scale farmers' perceptions of climate variability effects in Manga sub-county. Small-scale farmers strongly agreed that climate variability had brought about unpredictable weather patterns. In addition, 77% of the farmers indicated that climate variability was indeed negatively affecting their agricultural sector, caused decline in food production and is a serious problem. Furthermore, the majority of the small-scale farmers perceived that rainfall and temperature had significantly changed in Manga Sub-County.

5.3 Conclusion

There was evident of temperature increase of 0.5^0 C and decline in rainfall. Also, there is experienced unpredicted weather patterns. If this situation remains constant the is a likelihood of intense drought, water scarcity, heat waves, increase in pests and diseases, decline in biodiversity and generally affect agricultural production

The farmers had adapted strategies to cope with climate variability. They had developed some resilience to climate change and were getting direct and indirect benefits from the strategies applied.

Majority of the farmers had access to adaptation strategies' information at 96%. The main source of information was radios. However, farmers were also getting climate change information from other sources such as; television, local community members, internet and agro-extension officers. With climate change information, the respondents are likely to continue to adapt to climate change.

Small-scale farmers strongly agreed that climate variability had brought about unpredictable weather patterns. The climate variability was negatively affecting their agricultural sector, caused decline in food production and is a serious problem. It can therefore be concluded that the farmers in the study area are more likely to adapt to climate change by taking up various strategies to raise crop productivity.

Climate variability shocks will continue to wreck agricultural potential areas that support subsistence farming, especially in the Manga region. I have witnessed unprecedented rainfall and temperature variations that affect crop production. This clearly is in line with the current increase in global temperatures that shows no relentless slow down if global emissions don't subside, thus frustrating farmers. In addition, small-scale farmers, especially in rural areas, have not been exposed to adequate climate smart agriculture techniques to adapt holistically to the changing climate and unpredictable weather patterns. A similar scenario in Manga Sub-County

The world is transitioning to a modernized agriculture that is climate resilient and socioeconomically lucrative. The farmers in Nyamira County, in the Manga area, still need adequate training and information to catch up with this current unfolding in agriculture. The use of green economy techniques to revolutionize agriculture and the use of climate insurance to mitigate climate shocks and risks is paramount in the current modernized world. Finally, there is a need to develop a realistic early warning system not only in modernized areas but also in rural areas where agricultural activities are dominant. This will establish realistic climate communication pathways and channels on which farmers can rely on as the seasons change.

5.4 Recommendations

1. Due to observed increase in temperature over the 30 years' period and slight decline in rainfall there is need for mitigation and measures such as planting of trees and rural community education. This should be done by the National government, County Government, in schools and individual farms. The Ministry of Education should include climate change topics in the curriculum to create more awareness to all school and college students.
2. The Ministries of Environment, Climate Change and Forestry (MECCF), and ministry of Agriculture should promote awareness climate change and the need to adopt strategies that can create resilience as far as food production is concerned. The MECCF, NGOs and CBOs should also promote afforestation and re-afforestation to enhance climate change adaptation.
3. The ministry of Agriculture through extension officers, NGOs and other relevant bodies should use radio, Television and internet to promote SMART strategies that can raise crop production when adopted by farmers.
4. The positive perception or climate variability by respondents should be exploited by the County Government to influence the local community members in the study area to collaborate with all institutions dissemination technologies on climate change variability adoption and mitigation.

5.5 Areas for further research

1. A study to be conducted on the significance of Early Warning Systems on small-scale farmer productivity index at Manga Sub-County.
2. Research to be conducted on the uptake on climate finance insurance at the rural small-holder farmers to ascertain its significance to climate change mitigation and risk management.

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APPENDICES

Appendix I - Survey questionnaire

No………………………………………………………...   Date…………………………

Location Coordinate…………………………………………….

Introduction

My name is Isaac Bosire a postgraduate candidate with Reg. No. N50/CTY/PT/32804/2015 from the school of Environmental Studies, Kenyatta University. I'm undertaking my master's research on "*Small-Scale Farmers' Adaptation to Climate Variability in Manga Sub-County, Nyamira County, Kenya*"**.** I kindly request your cooperation and participation to my research questionnaire. Your details will be kept anonymous and purposely for academic purposes. Kindly tick or circle where appropriate.

<u>BIODATA</u>

1. Name…………………………………………………………...
2. Gender
    a) Male
    b) Female
3. Education Level
    a) No formal education
    b) Primary
    c) Secondary
    d) Bachelors
    e) Masters
    f) PhD

4. Occupation

    a) Student

    b) Farmer

    c) Formal employment

    d) Business

    e) Any other

5. Age group (years)

    a) 20-30

    b) 30-40

    c) 50-60

    d) 60>

6. Kindly circle your monthly income level from any of the choices. (KSH)

    a) 10000-20000

    b) 30000-40000

    c) 50000-60000

    d) 60000 >

<u>OBJECTIVE 1 - Small-Scale Farmers Adaptation Strategies to Climate Variability Effects</u>

7. What are some of climate variability adaptation strategies do you use in your farm? Circle where appropriate.

    a) Crop rotation

    b) Green house technology

    c) Integrated crop and livestock systems

    d) Irrigation

e) Mixed cropping

f) Planting of cover crops

g) Practicing Intercropping

h) Rain water harvesting

i) Using Index-based agricultural insurance

j) Reseeding, control of weeds

k) Use of organic manure

l) Shift of planting dates

m) Use of herbicides

8. Kindly rank the effectiveness of following climate variability adaptation strategies. 1-5 (1 being with lowest effectiveness and 5 with most effectiveness) in reference to number 7 above. One is the least effective and five is the most effective.

Statement		Responses				
		1	2	3	4	5
a)	Crop rotation					
b)	Green house technology					
c)	Integrated crop and livestock systems					
d)	Irrigation					
e)	Mixed cropping					
e)	Mixed cropping					
f)	Planting of cover crops					
g)	Practicing Intercropping					
h)	Rain water harvesting					
i)	Using Index-based agricultural insurance					
j)	Reseeding, control of weeds					
k)	Use of organic manure					

l)	Shift of planting dates					
m)	Use of herbicides					

9. What are some of the barriers towards appropriate adaptation of all strategies climate variability in your farm? Circle where appropriate.

    a) No appropriate adaptation strategies
    b) Lack of adequate climate smart information
    c) Accessibility to credit and farm climate smart loans
    d) Irregularity or limited agricultural extension services
    e) Limited accessibility to water resources
    f) Soil infertility
    g) Limited accessibility to agricultural subsidies
    h) State of unpredictable weather
    i) Limited farm land size
    j) Expensive farm inputs
    k) Limited access to linked agriculture markets
    l) Shortage of labor force.

<u>OBJECTIVE 2 –Climate Variability Trend</u>

10. Are you aware of climate variability impact on small scale farming in your area?

    a) Yes
    b) No
    c) Not sure

11. How do you perceive climate variability vulnerability in Manga Sub-County?

Statement	SD 1	D 2	N 3	A 4	SA 5
Rainfall has declined					
Temperatures are increasing					
Water sources are drying					
Climate variability has affected small-scale farming yield					
Rainfall patterns have become unpredictable					
New Agricultural diseases are emerging					

D-Disagree, N-Neutral, A-Agree, SA-Strongly agree

<u>OBJECTIVE 3 - Dissemination of Climate Variability Adaptation Strategies Information to Small Scale Farmers</u>

12. How do you get climate variability information?

    a) Radio
    b) Television
    c) Internet
    d) Local community communication
    e) Agricultural extension officers

13. Do you feel satisfied with the information provided on your choice for climate variability information?

    a) Yes
    b) No
    c) Not certain

Kindly explain briefly your answer?..

....

....

....

<u>OBJECTIVE 4 - Perceptions of Small-Scale Farmers on Climate Variability Effects</u>

14. How do you perceive climate variability in your area?

    a) Climate variability is directly affecting my farming

    b) Climate variability has become a serious problem

    c) Climate variability has brought unpredictable weather patterns

    d) Climate variability is affecting our agricultural sector

15. Kindly rank your responses. SD-Strongly disagree, D-Disagree, N-Neutral, A-Agree, SA-Strongly agree

Statement	SD 1	D 2	N 3	A 4	SA 5
a) Climate variability is directly affecting my farming					
b) Climate variability has become a serious problem					
c) Climate variability has brought unpredictable weather patterns					
d) Climate variability is affecting our agricultural sector					

Appendix II - Interview guide

My name is Isaac Bosire a postgraduate candidate with Reg. No. N50/CTY/PT/32804/2015 from the school of Environmental Studies, Kenyatta University. I'm undertaking my master's research on "*Small-Scale Farmers' Adaptation to Climate Variability in Manga Sub-County, Nyamira County, Kenya*"**.** I kindly request your cooperation and participation to my research interview. Your details will be kept anonymous and purposely for academic purposes.

1. Name..
2. Education level...
3. Gender……………
4. What is your designation……………………………………………
5. What are some of the strategies your department is advocating to farmers to use towards climate variability effects on small-scale farming?..
6. How often do you engage farmers on climate change issues?
7. Do you have support kitty that helps farmers on climate variability adaptation?
8. Does the county have a plan have any climate change action plan with the guide from the national level to mitigate climate change effects in agriculture?

Thank you for your time.

Appendix III:

Rainfall amounts received and temperature for the study area in the period 1990 – 2019.

Average monthly rainfall between year 1990 and 2019

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Mean	105.95	89.39	193.27	260.35	261.11	170.82	102.43	171.79	175.27	183.06	192.62	148.02
s.e	13.19	9.60	14.21	12.99	12.24	9.92	7.21	12.00	13.48	13.48	15.26	14.67
Median	88.60	80.00	176.50	248.75	245.95	176.50	102.30	158.45	170.75	182.45	163.05	125.66
Mode	-	80.80	-	204.10	-	-	86.10	-	-	-	-	-
SD	72.26	52.61	77.82	71.12	67.06	54.35	39.47	65.73	73.83	73.85	83.58	80.33
SV	5221	2767	6056	5058	4497	2953	1557	4320	5451	5453	6986	6452
Kurtosis	0.85	0.99	-0.84	0.18	-0.08	-0.73	1.43	3.83	1.75	-0.58	-0.28	0.22
Skewness	1.08	1.19	0.50	0.64	0.39	0.33	0.58	1.30	0.72	0.37	0.71	0.72
Range	278.40	212.50	271.10	286.30	302.10	191.10	192.60	330.60	345.40	278.70	325.80	335.48
Minimum	6.50	5.90	86.50	139.20	118.50	90.60	21.60	66.70	31.10	65.80	72.60	29.92
Maximum	284.90	218.40	357.60	425.50	420.60	281.70	214.20	397.30	376.50	344.50	398.40	365.40
CI (95%)	26.98	19.64	29.06	26.56	25.04	20.29	14.74	24.54	27.57	27.57	31.21	30.00
CV	68.20	58.85	40.27	27.32	25.68	31.81	38.53	38.26	42.13	40.34	43.39	54.27

(SD)Standard Deviation, (S.E) Standard Error, (SV) Sample Variance, (CI) Coefficient of interval, (CV) Coefficient of variance

Average minimum temperature for 30 years

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Mean	15.95	16.36	16.03	15.91	15.81	15.25	14.82	14.94	15.39	15.58	15.41	15.53
s.e	0.09	0.10	0.10	0.10	0.08	0.08	0.08	0.06	0.07	0.08	0.06	0.06
Median	15.97	16.34	16.06	15.84	15.80	15.19	14.80	15.00	15.40	15.65	15.44	15.60
Mode	15.20	15.80	15.60	15.60	15.60	14.90	14.70	14.70	15.40	15.80	15.40	15.70
SD	0.49	0.55	0.53	0.55	0.46	0.43	0.45	0.32	0.36	0.42	0.31	0.34
SV	0.24	0.30	0.28	0.30	0.21	0.18	0.20	0.10	0.13	0.17	0.09	0.12
Kurtosis	-0.33	-1.05	0.90	-0.18	0.23	0.30	0.66	-0.15	0.50	1.32	2.19	1.35
Skewness	-0.19	0.31	-0.28	0.15	-0.30	0.34	-0.75	-0.62	-0.63	-1.12	-1.31	-1.00
Range	2.00	1.80	2.59	2.30	1.98	1.94	1.98	1.28	1.53	1.82	1.34	1.48
Minimum	14.90	15.50	14.60	14.70	14.70	14.30	13.60	14.20	14.40	14.40	14.50	14.60
Maximum	16.90	17.30	17.19	17.00	16.68	16.24	15.58	15.48	15.93	16.22	15.84	16.08
CI (95%)	0.18	0.21	0.20	0.21	0.17	0.16	0.17	0.12	0.14	0.16	0.11	0.13
CV	3.05	3.37	3.30	3.46	2.90	2.81	3.06	2.12	2.36	2.67	1.98	2.21

SD: standard deviation, s.e: Std E: Standard error, SV: sample variance, CI: coefficient of interval, CV: coefficient of variance

Average maximum temperature for 30 years

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Mean	26.58	27.67	27.18	25.69	25.20	24.80	24.82	25.14	25.99	25.92	25.19	25.60
s.e	0.20	0.23	0.23	0.16	0.08	0.10	0.12	0.10	0.15	0.12	0.14	0.17
Median	26.70	27.66	27.25	25.55	25.25	24.83	24.73	25.08	25.93	25.90	25.13	25.46
Mode	26.40	26.50	27.30	25.30	25.20	25.00	24.90	24.60	26.20	25.90	25.00	25.50
SD	1.07	1.24	1.23	0.88	0.45	0.54	0.65	0.57	0.84	0.64	0.78	0.95
SV	1.15	1.53	1.52	0.77	0.21	0.29	0.43	0.33	0.71	0.41	0.61	0.89
Kurtosis	0.85	-0.50	-0.44	0.44	-0.23	-0.51	-1.04	0.01	4.87	0.21	-0.37	0.43
Skewness	-0.41	-0.23	-0.29	0.13	-0.30	0.03	0.26	0.63	0.16	0.34	-0.35	0.92
Range	4.92	4.80	4.70	4.26	1.89	2.25	2.13	2.36	5.20	2.60	2.93	3.80
Minimum	24.12	24.90	24.70	23.59	24.27	23.70	23.80	24.10	23.40	24.70	23.60	24.12
Maximum	29.04	29.70	29.40	27.84	26.16	25.95	25.93	26.46	28.60	27.30	26.53	27.92
CI (95.0%)	0.40	0.46	0.46	0.33	0.17	0.20	0.24	0.21	0.31	0.24	0.29	0.35
CV	4.04	4.48	4.53	3.42	1.80	2.19	2.64	2.28	3.24	2.48	3.10	3.69

SD: standard deviation, s.e: Std E: standard error, SV: sample variance, CI: coefficient of interval, CV: coefficient variance