CLIMATE VARIABILITY AND POVERTY NEXUS IN KENYA
(1986-2020)

BY

CINDY MWENDERANI

A RESEARCH PROJECT SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF ARTS IN ECONOMICS OF THE UNIVERSITY OF NAIROBI

NOVEMBER 2021

DECLARATION

This thesis is my original work and has not been presented for a degree award in any other university.

Sign…………………………………Date…………23rd November 2021…………………………………………..

Cindy Sandra Mwenderani X50/13539/2018

This project has been submitted for examination with my approval as University Supervisor:

Sign ……………………………….. Date…December 7, 2021…………………………………....

Prof. Richard Mbithi Mulwa

SCHOOL OF ECONOMICS, UNIVERSITY OF NAIROBI

DEDICATIONS

I dedicate this paper to my beloved parents, Elizabeth Rose Mang’ong’o and Joshua Onyango and siblings, Ian Nyakwaka and Allan Mang’ong’o. Thank you for your support and prayers

ACKNOWLEDGEMENT

I take this opportunity to thank Almighty God for the gift of life that has enabled me to accomplish this task.

I also recognise the contribution of my dedicated supervisor Prof. Richard Mbithi Mulwa. Sir, without your timely suggestions and keen eye for details, this work would have not been possible. It has been a great privilege working under your guidance and supervision. I also recognise University of Nairobi for admitting and sponsoring me to study MA Economics in the great institution.

I appreciate the love and support accorded to me by my beloved family. Thank you for your concern and constantly encouraging me to push through to get this work complete.

I thank my friends, Beryl, Phelgon and Sarah for providing emotional support during the entire research period.

To my classmates, Winnie, Sellah and Rose, I appreciate your assistance and peer review you provided towards the completion of this research paper. God bless you all.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS AND ACRONYMS

ARDL	:	Autoregressive Distributed lags
CBK	:	Central Banks of Kenya
FGD	:	Focus Group discussion
GDP	:	Gross domestic Product
IMF	:	International Monetary Fund
MDGs	:	Millennium Development Goals
NPEP	:	National Poverty Eradication Plan
OLS	:	ordinary least squares
PRSP	:	Poverty Reduction Strategy Paper
SSA	:	Sub-Saharan Africa
SDGs	:	Sustainable Development Goals
VAR	:	Vector Auto regression
VEC	:	Vector Error Correction

ABSTRACT

The study had sought to examine the impact of climate variability on poverty in Kenya. Specific objectives included to examine the effect of climate variability and other covariates on poverty in Kenya. To establish the mediating effect of economic growth on the relationship between climate variability and poverty. To examine the direction of causality between climate variability and poverty. The study adopted Keynesian theory, Fosu Growth-Poverty Model and Vulnerability Frameworks. The diagnostic research design was adopted examine the causal effect link between climate variability and poverty levels in Kenya. ARDL model and Error Correction model was adopted. The Error Correction term allowed for detection of short run and long run casual relationships and captures the long run adjustment of the cointegrated variables. The study further adopted pairwise granger causality test to examine the direction of causation between climate variability and poverty. The study results revealed that climate variability and other covariates explained poverty to a major extent as depicted by adjusted R^2 of 0.9663 and 0.9419 for the consumption per capita and head count ratio models. Further, widespread climate shock occurrence and rainfall variability had a significant effect on consumption per capita and head count ratio measures of poverty. The study thus accepted the alternative hypothesis that climate variability has a significant effect on poverty in Kenya. Regarding the mediating effect of economic growth on the relationship between climate variability and poverty, it was established that economic growth mediated the relationship between climate variability (Rainfall variability and climate shock) and poverty in Kenya. The alternative hypothesis that economic growth mediates the relationship between climate variability and poverty in Kenya was thus accepted. Finally, regarding the direction of causality between climate variability and poverty in Kenya. The study revealed that poverty granger caused temperature variability. The study therefore concludes there is unidirectional causality between climate variability and poverty in Kenya running from poverty to climate variability. The study thus rejected the hypotheses that climate variability granger causes poverty in Kenya. The study recommended that government should focus on alleviating poverty in a bid to control climate change by raising minimum wages and investing in the Agricultural sector which is the main source of livelihood of poor communities. The government should continue implementing tax policies that hurt the poor masses less to help in redistribution of resources to the poor. Additionally, the government should invest in pro poor projects. Policies that encourage economic growth can help minimise the negative impacts of

climate variability on the poor masses. The government should also come up with policies of import minimization to reduce imported inflation that hurt the poor. Further, cost push inflation resulting from wage demands by the lowly paid workers should attract policy from the government inform of having peaceful labour relations in the country.

CHAPTER ONE: INTRODUCTION

1.1. Background of the Study

Climate variability is one of the most complicated and uncertain environmental challenge the world is experiencing currently. In the last few decades, the world has experienced oscillation between flooding and drought with the amount and distribution of the same also changing greatly with serious impacts on the population. The changing trends of weather patterns and associated events are deviating greatly from the expected situation with fewer cold days and nights and warmers and more frequent hot days and nights (IPCC, 2017). Additionally, most countries are also experiencing heavy precipitation and associated events leading to dare consequences on the general population. The dynamics of weather patterns including temperature and rainfall have affected agricultural production, increased prevalence diseases and pests, increased soil degradation and flooding of farms. Moreover, areas affected by high temperatures and drought have become known for having idle unproductive land and low animal production (Wossen & Berger, 2015).

Climate variability effect could be seen in declining agricultural production and productivity, increased pest and diseases in human, crop, and animals, decline in food security, unemployment, and poverty (Okonkwo, Arua & Agbo, 2015). Climate variability is a serious threat facing the world with its impacts in various fronts including social, economic, and environmental impacts (Wheeler & Von Braun, 2013). Additionally, climate variability is affecting the biodiversity, services of the ecosystem and livelihood of the minority forest dependent population in less developed countries of the world. Climate variability is rendering the population of the developing nations especially the poorest section of such societies. The poorest population of the developing nations are greatly affected given that majority of the poor in such countries are dependent on climate sensitive economic activities including forestry, crop growing, animal rearing, fishing, hunting among other natural resource extraction. Moreover, such population are derailed by backwards technology, low skilled human capital that limits their capacity to invest in risk reduction and adaptation to changing climate (Leichenko & Silva, 2014).

Ecosystems, people, and societies globally are at the mercy of climate variability however, the level of vulnerability to climatic changes varies in various places. The variability in climate is usually accompanied by and interacts with other factors leading to heightened risks especially due low level of preparedness among most of the population to combat or adapt to such changes. (Casillas & Kammen, 2010). Climate events accompanying climate variability are most likely to lead to emerging inequalities in the distribution of wealth and income at the household level. Uitto (2016) noted that market-oriented avenues for regenerating assets destroyed by climatic events among the poor members of the societies is usually limited thus there is growing urgency for assistance programs to such communities. Karfakis, Lipper, and Smulders (2012) revealed that nations depending on primary extractive sectors including crop production, animals rearing, fishing and forestry are vulnerable climatic changes leading to increasing poverty. Therefore, areas with high dependence on agriculture and local food production and with fewer alternatives for protecting themselves against climate variability and associated events find themselves vulnerable are easily overtaken by poverty (Gondhalekar & Ramsauer, 2017).

1.1.1 Climate Variability Trends in Kenya

Climate variability is a quantification of the frequency and magnitude of changes in climate variables over a specified period. Climate variability is the annual fluctuation of climatic conditions around mean value (Otieno, 2019). Even though there are numerous climate variables, rainfall and temperature are the most critical components of climate variability especially regarding food production. The range and intensity of temperature and rainfall values are critical to food production in any country (Thurlow, Zhu & Diao, 2012). The climatic condition in Kenya varies across regions with most areas at the sea level altitude experiencing high temperatures while highlands areas experience low temperatures. The mean rainfall per year varies from below 250 mm in the arid and semi-arid areas to above 2,000 mm in the highland areas. Kenya’s land area is about 580,367 km^2 with only 12 per cent of the land being considered high potential for agriculture. Additionally, only about 6 per cent of the land mass in Kenya considered moderately useful for animal husbandry (Government of Kenya, 2016).

In Kenyan setting, development of agriculture sector is dependent on climate that is considered a critical natural resource (Bryan, Ringler, Okoba, Koo, Herrero & Silvestri, 2011). The main driver of Kenya’s economy is Agriculture that is in turn dependent on rainfall. Agriculture is critical to the livelihood of most Kenyans especially the rural population (Ray, Gerber, MacDonald & West, 2015). Agriculture is a significant contributor to the gross domestic product of Kenya, rural employment generation and foreign exchange earner. Additionally, agriculture provides food security to both rural and urban population. Even with the critical position occupied by agriculture in Kenya's economy, in the last 30 years, the position of agriculture as a component of gross products has continued to fall in comparison to other sectors of the economy (Dillon, McGee and Oseni (2014). Climate variability has been a leading factor leading to fall in agricultural output in addition to other factors including population growth, poor initial resource endowments and disease infestation that is related to climate variability (Thornton, Ericksen, Herrero & Challinor, 2014).

Presently, climate variability has attracted attention due to its effects on the lives and livelihood of most Kenyans. From 1990 to 2000, the mean climate Δ was about 0.150 c; however, in the last ten years from 2001 to 2012 the mean climate change has shifted to 4.10 c (Republic of Kenya, 2010). The change in mean climatic conditions has been due to rise in frequency and intensity of extreme climate events accompanying climate variability including serious drought floods. Additionally, climate variability has been causing havoc in development planning including MDGs and SDGs that are aimed at meeting economic and human development aspirations of Kenya (Mburu, Kungu & Muriuki, 2015). Moreover, in the last ten years, the intensity and frequency of malnutrition diseases and hunger has been on the rise significantly given that food security has not been at par with population growth rate in Kenya. Additionally, food insecurity has resulted to food poverty (Mburu, Kungu & Muriuki, 2015).

Climatic condition of frequent rise in drought situation leads to reduced food supply resulting to food poverty. Fiyaz et al. (2020) noted that animal rearing done in the arid and semi-arid areas that are prone to serious droughts leads to death of livestock due starvation. Livestock disease out-break such as Rift Valley Fever are common in periods of heavy rainfall and high temperatures. Further, the death of livestock due to starvation and diseases lead to loss of valuable asset stock owned by pastoralist communities hence their source of livelihood is impacted adversely (Ochieng, Kirimi & Mathenge, 2016).

1.1.2 Poverty Trends in Kenya

Poverty is a multi-dimensional concept. It does not just involve material or income lack. The other dimensions include health, education and living standards. One of the measures which have been used in literature is per capita consumption. However, this measure has been criticized in literature since it is a general measure of welfare. Another measure is the head count ratio defined as the number proportion of the total population that is living below the poverty line.

Measuring poverty in Kenya has been inconsistent. For the past 20 or so years, there have only been about four surveys. For the period between 1992 and 2006, poverty has been high ranging over 40 percent. In the year 2006, Kenya's poverty level was 46 percent (Kenya Integrated Household Budget Survey, KIHBS, 2005/2006). Poverty has remained above the 40 percent mark since 2006 and the latest estimates by the World Bank (World Bank, 2013) show that poverty stands at between 38 percent and 43 percent. The poverty level in Kenya is often made worse by income inequalities experienced across population characteristics. Even though various strategies and efforts have been put in place in combatting poverty, the level of poverty remains high. Such efforts have included the National Poverty Eradication Plan (NPEP) for 1999-2005 and the Poverty Reduction Strategy Paper (PRSP) for 2001- 2004 (Republic of Kenya, 2001).

In these plans, the state promised to eradicate poverty by 2015 by growing the economic performance, adopting the International Development Goals, and shifting resources to pro-poor programs (Republic of Kenya, 2001). The Millennium Development Goals (MDGs) signed into in the year 2000 and ended in 2015 and were also targeting eradication of extreme poverty and were succeeded by Sustainable Development Goals. Beyond the efforts of the government, there has been other stakeholders involved in poverty eradication especial development partners (Ronge et al., 2002). The development partners that have played critical role in fighting poverty in Kenya includes the United Nation office for projects services, IMF, and the World Bank. Even with these efforts by Kenyan government and development partners, policy makers are still faced with the unresolved question how to eradicate poverty and why various efforts have proved futile?

1.1.3 Climate Variability and Poverty

In early empirical studies, Udry (1996) examined the causal effect relationship between climate variability and poverty. The study noted that exogenous variables like climate variability have a significant effect on poverty vulnerability. Karfakis, Lipper, and Smulders (2012) revealed that developing nations that depends greatly on agricultural sectors such pastoralism, crop production, fishing, are heavily affected environmental evets accompanying environmental variability strikes. The study further revealed that areas that depend on rain fed agriculture are affected adversely by environmental variability with food security falling. Moreover, food insecurity leads to food poverty and malnutrition (Thornton, Ericksen, Herrero & Challinor, 2014).

In examining the effect of climate variability on poverty, one common channel is through effect of climate variability on key rural assets majorly via land prices (Hansen et al. 2019). Such kind of analysis is based on the reasoning that in condition of profit optimization by the farmer, the prices of parcels of land are directly related with revenues expected from the land. Moreover, climate variability acts a constraint on the agricultural out and associated revenues hence further impacting adversely on land prices. Following same line of though, Bakshi, Nawrotzki, Donato, and Lelis, (2019) noted that agricultural production in Brazil may decline by eighteen percent in the next ten years give the high intensity and frequency of environmental changes being experienced. The abnormally varying temperatures and rainfall is rendering most parts of Brazil inhabitable for livestock and crops production.

Another group of studies have tended to examine the direct effect of climate variability on poverty vulnerability by choosing a measure of welfare and then then examining how climate variability affects household welfare through its impact on family income. Household welfare measures that are impacted on directly by climate variability includes household income, household consumption, and health-related indicators among others. The severity of the impact is a function of returns to assets, location, diversification level and maintenance of expenditures levels (Hansen et al., 2019). Randell & Gray, (2016) adopted comparative welfare model to examine the impact of climate variability on income poverty with the study revealing that areas with high levels of poverty were those areas that had lower welfare levels. Studies belonging to the two approaches of examining the effect of climate variability on poverty levels have tended to show that there is a long-term association between climate variability and poverty vulnerability with climate variability reinforcing rural poverty.

1.2 Statement of the Problem

The crop yield from selected SSA African counties including Kenya has been declining steadily with the income from crops estimated to decline by 90 percent at the end of 2100 (IPCC, 2017). The decline in agricultural output has been associated with various factors including climate variability. Moreover, it has been estimated that temperatures in Kenya will rise by between 1-2.5^{0}C at the end of 2030, this paints gloomy picture for the Vision 2030 (IPCC, 2017). Additionally, it is estimated that due to changing temperatures and rainfall, there will be changes in seasons, increased outbreak of crop and animal diseases and poor crop productivity. The changes are expected to impact adversely on food security and poverty. Currently, about 18 % of

Kenyans live below poverty line with majority of that number being food poor (Njoya & Seetaram, 2018). Climate variability that is inversely related with food poverty is expected to affect most Kenyans who reside in the rural areas and depending on rain fed agriculture (KARI, 2016). Empirical findings predicts that recurring climate shocks may make poverty situation even worse thereby keeping the poor masses in poverty and pulling others into poverty especially in rural setting (Phiri, Morgenroth & Xu, 2019).

Studies have examined the association between climate variability and poverty at the global stage and locally. Azzarri and Signorelli (2019) while examining the effect of weather shocks and climate variables on poverty level revealed that people living in humid areas also had high level of economic welfare while areas experiencing drought were associated with low welfare standards. In Ethiopia and Ghana, Wossen, Berger, Haile and Troost (2018) examined the causal effect link between household incomes, food security, climate change and price variability revealing that climate and price fluctuations had an adverse effect on income and food security. Ademe, Kassel, Goshu and Mwanjalolo, (2017) examined the impact of climatic fluctuations among small-scale farmers. The study revealed that increased rainfall for crop production holding temperature constant result led to fall in household income. Additionally, increases in temperatures when rainfall was held constant also lead to falling crop production. In Kenya, Ofulla et al. (2016) examined the association between climatic events and health and economic outcomes. The study revealed that the adverse climatic conditions affected the livelihood of vulnerable members of the population. Kagunyu (2014) evaluated the impact of climate variability on people's livelihood coping strategies in Borana Kenya. The results revealed that climate variability has an inverse effect on livelihood including livestock deaths, food insecurity, and poverty among other impacts.

Most of the studies examined have been in other countries with few studies existing locally. Additionally, majority of studies tends to be based on household level data analysis and regional level data analysis with few macro level data analysis. The study therefore sought to bridge the gap in literature by examining the effect of climate variability on poverty based on macro level data analysis. The study was done with a view of policy recommendations regarding adaptation strategies and level of support needed in Kenya to cushion the most vulnerable.

1.3 Objectives of the Study

1.3.1 General Objective

To examine the impact of climate variability on poverty in Kenya.

1.3.2 Specific Objectives

1. To examine the effect of climate variability and other covariates on poverty in Kenya
2. To establish the mediating effect of economic growth on the relationship between climate variability and poverty.
3. To examine the direction of causality between climate variability and poverty

1.4 Hypotheses of the Study

H_{a1}: Climate variability has a significant effect on poverty in Kenya

Ha_2: Economic growth mediates the relationship between climate variability and poverty in Kenya

Ha_3: Climate variability has a granger causality effect on poverty in Kenya.

1.5 Justification of the Study

Variability in climatic conditions has proved problematic when it comes to development planning and fight against poverty. The study is necessary since poverty alleviation is among several Governments' concerns today. Indeed, there is need to tackle poverty through policies that focus specifically on its main determinants and Climate variability is a determinant of concern in this study. This research is motivated by the need to identify how climate variability contributes to poverty such that Government of Kenya can identify climate variability elasticity of poverty to enable the designing of specific strategies of reduction of poverty through climate mitigation policies aimed at reducing vulnerability of the most members of the society.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

The chapter examines the literature review including the theoretical literature and empirical literature.

2.2 Theoretical Literature

Theoretical literature has tended to focus on direct and indirect channels by which climate variability make the poor worse off or expose people to poverty. The study was based on Keynesian theory, Fosu Growth-Poverty Model and Vulnerability Frameworks

2.2.1 Keynesian Theory

This theory revolves around the idea that poverty in an economy is caused by both market distortions and underdevelopment in various areas. This theory was formulated by Keynes (1936) who believed that market forces could promote economic growth and in turn was able to eradicate poverty. Based on this belief, Keynes justified government's interventions at macroeconomic level especially in handling involuntary unemployment. From a liberal perspective, poverty is defined as the misfortune of a small group of people who cannot work even if they wished to work. Consequently, governments should regulate as opposed to impose its rule on poverty reduction (Bradshaw et. al., 2000).

While economic growth may be critical in reducing absolute poverty by simply raising income levels, the relative benefits of relative poverty especially those relating to expansion in economic activities are only applicable so long as increases in income levels is accompanied by reduction in inequalities in income distribution (Granville and Mallick, 2006). In this respect, wage growths especially wage for agricultural employee accompanied by GDP growth may force relative poverty to reduce (Dickens and Ellwood, 2001). According to the theory, poverty levels may persist and even grow even when economic growth is recorded so long as deprived people are not included in the growth wagon (Dickens and Ellwood, 2001).

In line with the argument above, Keynesian theory is of great importance in analysing the indirect effect of climate vulnerability on poverty through economic growth. The theory presumes that economic growth leads to development that in turn leads to poverty eradication. Economic growth resulting has the tendency to improve per capita income of the population that results in reduced poverty levels. By extension, Economic growth results from various sectors of the economy including agricultural sector that is majorly affected by climate variability. A slump in economic growth due to unfavourable climate variability would therefore gravitate the poverty condition especially the rural poverty. Additionally, an expanding economy through economic growth also leads to reduced unemployment that enables households to afford basic goods needed to support life. By extension, the theory implies that economic growth originating from favourable agricultural production, which is a function of climate variability, leads to reduced unemployment for the agricultural labour that in turn reduces their poverty status.

2.2.2 Fosu Growth-Poverty Model

Fosu (2008) explains that poverty is a function of economic growth, income inequality and a core set of control variables including population, inflation, trade openness. Fosu explains that a person is poor when their level of disposable income cannot afford them basic needs in each place. Additionally, Fosu (2008) stated that the lower the level of income, the high chance that an individual's income will not afford them the basic needs hence exposing them to poverty. Fosu while borrowing from Dollar and Kraay (2002), expressed a poverty as function of income and that the relationship was inverse where falling level of income was associated with rising level of poverty. Further, per capita income was used to capture economic development. Further, just like Dollar and Kraay (2002), Fosu added inequality to the poverty function where the association between poverty and income inequality was direct and that equitable income distribution was accompanied by falling poverty levels. Poverty was therefore a function of both income and inequality Dollar and Kraay (2002) had initially proposed that all members of the population benefited equitably from income such that there was no special role of inequality in the poverty function. However, later, the model was improved to include inequality given the unequal nature of the society especially in the distribution of wealth and income.

The model analyzes the indirect effect of climate variability on poverty through economic growth. Climate variability can affect poverty through its impacts on economic growth that in turn affects poverty. Empirical studies have revealed that slow growth in economies of most African states can be explained by low levels of rainfall being experienced (Wossen & Berger, 2015, Brown et al., 2011). Additionally, high and fluctuating temperatures in the last half of twentieth century may be the culprit as regards to slow rate of economic growth in most African countries that depends substantially on agriculture (Auci & Coromaldi, 2020). In a study in

Africa, Gohar and Cashman (2016) revealed that there was drop in average income for every unit increase in global warming in the long run. The fall in income due to increased global warming had would have significant effect on poverty rates. Fosu (2008) models revealed that poverty is affected by economic growth and inequality. Therefore, by extension any factor affecting economic growth rate like climate variability would therefore affect poverty through economic growth rate.

2.2.3 Climate-Poverty Vulnerability Frameworks

The most outstanding vulnerability framework scholars include Hallegatte et al. (2014). Vulnerability frameworks also referred to as indirect channels that theorised that the association between climate variability and poverty is complex and is influenced by other variables exiting at the individual, household, regional and macro level. This factors that influences the interaction between climate variability risk exposure and poverty vulnerability may include individual decision-making, socio economic factors, governance, and other factors. Indirect channels studies reveal that climate variability influences factors that are known or thought to impact on poverty level. Vulnerability frameworks further hold that climate variability affects poverty indirectly through asset channel, productivity channel and economic growth channel.

The first channel through which climate variability is linked indirectly to poverty is through the assets. Climate variability impacts on assets and returns expected from assets. Further climate variability impacts on the capability of the household to accumulate capital. Leichenko, O'Brien (2008) revealed that climate variability might lead to loss of valuable assets. For instance, natural climatic related events like flooding and drought can destroy assets like crops, livestock, and dwelling places. Household assets that are less portable and transferrable and are not diversified are highly exposed to climatic events given that adaptation may need large outlays of investment for recovery and regeneration of lost assists (Jones, Samman & Vinck, 2018; Weldearegay & Tedla, 2018). Further, expected climate variation exposers may become disincentive to commutation of valuable assets. The loss of assets to climate exposers and disinterest to cumulate valuable assets may render the population depending on the assets to vicious cycle of poverty (Herrera, Ruben & Dijkstra, 2018; Wossen & Berger, 2015).

The next channel through which climate variability affects poverty vulnerability is through productivity. Climate variability has been found to influence poverty by impacting on the productivity of sectors such as agriculture thus further impacts on land pieces and returns and agricultural labour and wages hence income of the household (Herrera, Ruben & Dijkstra, 2018). The impact of climate variability on income generated in the agricultural sector as well as associated wages further impacts on the poor. Climate variability that lowers the productivity in the agricultural sector including crop and livestock production also leads to poverty, as the household in the rural sectors do not get enough income when agricultural output is exchanged in the market. Additionally, labour employed in the agricultural sector may experience declining wage income due to low productivity in the agriculture sectors. The effect of climate variability on agricultural production leads to declining family income thereby exposing them to poverty (Arshad et al, 2017; Hayes & Knox-Hayes, 2014).

The final channel by which climate variability impact on poverty is through economic growth. Studies have revealed that slow growth in economies of most African states can be explained by low levels of rainfall being experienced (Wossen & Berger, 2015, Brown et al., 2011). Additionally, high, and fluctuating temperatures in the last half of twentieth century may be the culprit as regards to slow rate of economic growth in most African countries that depends substantially on agriculture (Auci & Coromaldi, 2020). In a study in Africa, Gohar and Cashman (2016) revealed that there was drop in average income for every unit increase in global warming in the long run. The fall in income due to increased global warming had would have significant effect on poverty rates. Fosu (2008) models revealed that poverty is affected by economic growth and inequality. Therefore, by extension any factor affecting economic growth rate like climate variability would therefore affect poverty through economic growth rate.

2.3 Empirical Review

Empirical literature has examined the nexus between climate variability and poverty. Azzarri and Signorelli (2019) evaluated the factors affecting poverty in SSA with the study focusing on the effect of weather shocks and climate variables on poverty level measured by per capita expenditure. The research was based on twenty-four SSA countries with geospatial agro based information combined with household consumption surveys. The study was based household level and regional level analysis. The study adopted linear models to examine household level data and spatial models to analyse geospatial regional data. The analysis models controlled confounding factors such as demographic, socio-economic, and geographic factors. The study revealed that people living in humid areas also had high level of economic welfare while areas experiencing drought were associated low welfare standards. Additionally, climatic shocks like flooding were related to decline in per capita consumption and increased food poverty. However, the effect heat shocks, and rainfall shortages were not conclusive.

In another study in Ethiopia and Ghana, Wossen, Berger, Haile and Troost (2018) examined the causal effect link between household incomes, food security, climate change and price variability. The research used an agent-based modelling method to establish the effect climate and price changes on poverty under different states of adaptation and coping strategies. The research revealed that climate and price fluctuations had an adverse effect on income and food security. The study revealed that mechanism of coping at the individual and facility level were adequate hence the need for policy on coping by the government. Additionally, coping strategies including a mix of credit provision, firm inputs were effective in reducing the adverse effect of climate and price changes.

In a study by Ademe, Kassa, Goshu, & Mwanjalolo, (2017), the impact of climatic conditions fluctuations was examined among small-scale farmers. The research used unbalanced panel data due to missing data for some years. The data collected was longitudinal covering the period between 1994 to 2014. The panel data model was fixed effect regression in nature. The study revealed that increased rainfall for crop production holding temperature constant result led to fall in household income. Additionally, increases in temperatures when rainfall was held constant also lead to falling crop production. Further, the study revealed that when increase in temperature and rainfall at the same led to increased crop production. Moreover, other variables such as frost, storm, and flood and rainfall unreliability affected crop production adversely.

In a study in Zmanbia, Thurlow, Zhu & Diao (2012) examined the association between climate variability, anthropogenic climate changes and aggregate agricultural sector output. The research used Standard econometric methods and hydrological-crop models to examine the effect of current climatic changes and future expected changes in climate resulting from human activities and agricultural output. The confounding factors such as uncertainty were controlled with the research revealing that climate variability leads to reduction in GDP bringing the population into poverty. The relationship between climate variability and GDP was greatest and adverse during weather shocks such as drought. The study concluded that the current climate variability is a single most significant determinant of economic development.

Singh et al. (2017) examined the association between climate variability and adaptation to climate evets in India. The study used quasi panel data among 136 farmers who were participated FGD and interview. Women farmers noted that climate variability affected collection, harvesting and storage of crop production. Men farmers on the other hand noted that climate variability affected hunting and marketing of agricultural production. Additionally, the study revealed that well off members of the population were better in adapting to climate change compared to poor members of the society given that they could take advantage of firm mechanization and latest technology to compensate for climate variability. The study further revealed that wealthy people tended to be men who were able to adapt to climatic changes through.

Herrera, Ruben and Dijkstra (2018) examined the causal effect link between vulnerability to poverty and climate evets exposures in Nicaragua. Per capita consumption of the household was used to measure poverty variability with climate variables measured in various regions. , regional and climate characteristics. OLS and Hierarchical Models were adopted with the results revealing inverse causal effect link between per capita consumption and climate variability. Further, the study revealed inverse relationship between temperature variability and per capita consumption of the households. Rainfall variability also had a significant influence on household per capita consumption.

A critical literature review by Leichenko and Silva (2014) examined studies relating climate variability and poverty. The study literature revealed that poverty status was multidimensional and dynamic in nature. Additionally, the research revealed that poverty status was influenced by macro, regional, household, and individual factors. The specific factors included socioeconomic, environmental, political, historical, individual and community variables. Climate condition was therefore not eh sole factor influencing poverty with climate variability interacting with other variables mentioned in determining poverty situation. The research also revealed that climate variability could influence poverty directly or indirectly.

In Kenya, Ofulla et al. (2016) examined the association between climatic events and health and economic outcomes. Four hundred and eighty respondents were selected from various regions. The regions were segregated into six clusters depending on prevailing local climate. The study subjects were interviewed. The study examined the causal link between study variables using Chi-square and odds ratio. The study revealed that there was a significant association between prevalence of diseases like Malaria and climatic conditions. Further, the research showed that the adverse climatic conditions affected the livelihood of vulnerable members of the population.

Adebayo, Yahaya and Mohammed (2018) evaluated the causal effect link between climate variability and livelihood of communities around Kamuku National Park (KNP) Birni-Gwari, Kaduna State, Nigeria. Structured questionnaire filled by household heads. The qualitative and quantitative information about socioeconomic components from household survey as related to the topic was summarized and analysed using descriptive statistical tools. The result reveal that majority of the respondent had little knowledge on the cause of climate variability. They were however aware of the changes in climatic variables of their areas in terms of changes in rainfall and temperature pattern and intensity. The Communities perceived decline in agricultural production as a major impact of climate variability. Other impacts perceived are shortage of water for irrigation, household and animal consumption, cases of diseases in human, plant and animals, decrease in soil fertility and migration of youths.

2.4 Chapter Summary

The chapter examines the literature review including the theoretical literature and empirical literature. The empirical literature presented past studies done in relations to temperature variability and poverty with majority of studies being based on household level data analysis. The theoretical literature has examined the Keynesian theory, Fosu growth-poverty model and vulnerability frameworks and their link with the association between climate variability and poverty levels. The Keynesian theory has established that income level resulting from economic growth leads to poverty reduction. Fosu growth-poverty model has revealed that economic growth and income inequality have a direct impact on poverty levels. Finally, the vulnerability frameworks have shown that climate variability affects poverty through channels including assets, productivity, and economic growth. The empirical literature has examined various past studies on the causal effect link between climate variability and poverty both globally and locally.

CHAPTER THREE: METHODOLOGY

3.1 Chapter Overview

The chapter presents the methodology of the study including research design, theoretical framework, empirical framework, data measurement, diagnostic tests, model estimation and data sources.

3.2 Research Design

The research employed diagnostic research design to examine the causal effect link between climate variability and poverty levels in Kenya. Further, the study adopted to design as it sought to analyse the frequency with which climatic variables occur and their effect on poverty. Time series data was collected on each variable to test hypothesis and achieve research objectives. Further, the research was based on secondary annual data collected between 1986-2019 for all the variables. A multivariate time series regression models was adopted to capture the casual effect link and direction of causation between climate variability, other confounding variables, and poverty in Kenya.

3.3 Theoretical Framework

The study was broadly be based on vulnerability frameworks. Under the vulnerability frameworks, the study focused on the effect of climate variability through socio economic conditions including economic growth, income inequality, inflation, and population. The study was thus based on two models, with the first model examining effect of socio-economic factors including income inequality, economic growth, inflation, and population on poverty with climate variability excluded. The second model will examine the effect of socio-economic factors and climate variability on poverty. The first model will build on growth-poverty model variants by Dollar and Kraay, 2002 and Fosu, 2008, that explains that poverty is a function of economic growth, income inequality and a core set of control variables including population, inflation, trade openness. The second model will be based on the first baseline model augmented with indicators of climate variability.

3.3 Empirical Framework/Model Specification

In deciding on the model specification, the study will borrow from Fosu (2008) and Dollar and Kraay (2002). Fosu explains that a person is poor when their level of disposable income cannot afford them basic needs in each place. Additionally, Fosu (2008) stated that the lower the level of income, the high chance that an individual's income will not afford them the basic needs hence exposing them to poverty. Fosu while borrowing from Dollar and Kraay (2002), expressed a poverty is a function of income and that the relationship was inverse where falling level of income was associated with rising level of poverty. Further, per capita income was used to capture economic development. Further, just like Dollar and Kraay (2002), Fosu (2008) added inequality to the poverty function where the association between poverty and income inequality was direct and that equitable income distribution was accompanied by falling poverty levels. Based on Dollar and Kraay (2002) and Fosu (2008) a simple model specification is given in equation (1).

$$P_{OV} = \beta_o + \beta_1 gdp + \beta_2 gini \quad (1)$$

Where Pov captures poverty rate, gdp measures national income, gini measures inequality. All the variables are expressed in logarithm. The responsiveness of poverty to income and inequality is captured by β_1 and β_2 respectively.

The growth of population (Pop) was to be introduced into the estimation model to measure the effect of demographic variables on poverty. Additionally, Inflation (INF) was also added to control for the macroeconomic environment of the country as heightened inflation makes people worse off hence they cannot afford the same basket of goods they were buying before inflation. The model in equation (1) is further expanded to equation (2).

$$\mathrm{P_{OV}} = \beta_0 + \beta_1 \mathrm{gdp} + \beta_2 \mathrm{gini} + \beta_3 \mathrm{INF} + \beta_4\, Pop \quad (2)$$

Following on vulnerability frameworks that examine effect climate variability on poverty through socio economic factors, effect of climate variability is then introduced in the poverty function in equation (3). The effect of climate variability was examined directly and indirectly through economic growth and climate shocks. Climate variability has been found in the empirical literature to be impact on poverty through growth where increased climates shocks and variability affect agricultural output that in turn leads to poverty level especially rural poverty. Climate variability comprising of proxies including climate variability (temperature and rainfall variability) and climate shocks (countrywide droughts and flooding) are introduced into equation (2) to generate equation (3).

$P_{ov} = \beta_0 + \beta_1 TV + \beta_2 RfV + \beta_3 gdp + \beta_4 gini + \beta_5 INF + \beta_6 Pop + \beta_7 DummyCS$ .... (3)

Model in equation (3) was presented in econometric form as equation (4) by introducing the error term and time factor.

$\ln P_{ov} = \beta_0 + \beta_1 \ln TV + \beta_2 \ln RfV + \beta_3 \ln gdppca + \beta_4 \ln gini + \beta_5 \ln INF + \beta_6 lnPop + \beta_7 DummyCS$

.... (4)

Where Pov = Poverty; TV= temperature Variability;

RfV= Rainfall Variability;

gini = Gini coefficient is proxy for Income Inequality;

gdp= Gross Domestic Product is proxy for economic growth;

INF = Annual Inflation in percentage;

Pop = Population;

Dummy CS = Dummy for country wide climate shocks given by 1 for climate shock year and 0 for non-climate shock year;

ln = Natural Logarithm;

β_0 = intercept term;

β_1, β_2, β_3, β_4, β_5, β_6 and β_7= parameter estimates;

ε = error Term.

Further to examine the mediating effect of economic growth on the relationship between climate variability and poverty, the study adopted model in equation (4) and model in equation (5). Model in equation (5) had the economic growth proxy removed.

$\ln P_{ov} = \beta_0 + \beta_1 \ln TV + \beta_2 \ln RfV + \beta_3 \ln gini + \beta_4 \ln INF + \beta_5 lnPop + \beta_6 DummyCS$ .... (5)

Testing the mediation involved estimating model in equation (5) that had no mediator variable (gdppca) and then estimating the model in equation (4) where economic growth was included.

3.5 Variable Definition and Measurement

Table 1: Measurement of Study Variables

Variable	Notation	Definition and Measurement	Expected Sign		Source
Dependent Variable			HCR	CPC	
Poverty	POV	Head count Ratio is proportion of the total population that is living below the poverty line.			Ali and Thorbecke (2000)
		Per capita consumption is the value of all goods and services purchased by households divided by population.			(Odhiambo, 2009).
Climate Variability	TV	The temperature variability are deviations from the expected annual temperature.	+	-	Otieno (2019)
	RfV	The rainfall variability are deviations from the expected annual rainfall.			Otieno (2019)
Income Inequality	gini	GINI coefficient	+	-	Dollar and Kraay (2002)
Gross Domestic Product per capita	gdppca	Gross domestic product is the proxy for total product of a country capturing economic growth.	-	+	
Inflation	INF	Inflation is the continuous increment in price levels of goods and services over a certain time (Annual)	+	-	Dollar and Kraay (2002)

Climate shocks	Dummy CS	Dummy for country wide climate shocks given by 1 for climate shock years and 0 for non climate shock years	+	-	Otieno (2019)

3.6 Diagnostic Testing

Diagnostic test was used to establish the robustness of the model in estimating the parameters. The major diagnostic test when estimating using multivariate time series data tests includes normality, serial correlation and heteroscedasticity test. To test for normality, Jarque-Bera statistics was used to determine whether the residual variances are normally distributed. Serial correlation tests are done to examine whether there exist correlation between the residuals across time. Test of heteroscedasticity is also conducted and this is to determine whether the error terms have equal variances or not. Heteroscedasticity is present if the variances are not constant. A part from the normal tests of assumption of classical least squares, time series data also involves other tests including optimal lags, unit roots test and cointegration test.

3.6.1 Optimal Lags

Before running the model, it will be critical to establish the optimal lag length. The study adopted Schwarz Information Criterion, Hannan-Quinn Criterion and Akaike Information Criterion to determine the optimal lag length of the variables. The over estimation of the lags may lead to over fitting the model resulting to standard error terms with exaggerated means while underestimation of the lags may lead to auto correlated standard errors. Thus, it is critical to establish the optimal lag lengths.

3.6.2 Unit Roots Test

The study carried out unit roots test to evaluate the existence of unit' roots in the variables of the study. Existence of Unit roots or lack of stationarity leads to spurious regression. The study adopted Augmented Dickey Fuller Test (ADF) (Dickey and Fuller, 1979). The null hypothesis for unit roots is that variables are not stationery. The p-value generated in the ADF test should be less than either, 0.01%, 0.05% or 0.1% levels of significance depending on level of significance chosen in the study. If the data does not have unit roots, then ordinary least squares regression can be adopted to estimate the parameters however, presence of unit roots would yield misleading coefficients hence Autoregressive lagged model ARDL, or VAR model may be adopted. The study finally Autoregressive Distributed Lag Model (ARDL) given that some variables did not have unit roots at levels while others had unit roots at levels. VAR was disqualified because it is suitable where variables are integrated of order 1(1) only.

3.6.3 Cointegration Analysis

Cointegration analysis is a long-run concept that shows that group of variables move together. The idea behind Cointegration is that although macro-economic variables may trend together overtime, groups of variables may drift together. Given that some variables were not stationary, the normal OLS model was dropped, and the study should proceed with cointegration analysis. Cointegration tests are used to establish the existence of long run relationship among study variables. The study adopted Cointegration tests are used to establish the existence of long run relationship among study variables. The ARDL bounds test for cointegration was conducted. The test is based on null hypothesis that there is no significant long turn relationship among study variables. The study should fail to reject the hypothesis when F statistic is lower than F-critical in line with 1(0) integrations otherwise F - statistic greater than F-critical in line with 1(1) integrations should lead to rejection of null hypothesis.

3.7 Estimation Technique

In cases where the variables do not have unit roots, then ordinary least squares regression (OLS) is to be used to estimate parameters, however in the presence of unit roots in levels for some variables at levels means that OLS would lead to spurious regression hence ARDL model was adopted. Further, after carrying cointegration, Error Correction Model within the ARDL framework was adopted. The Error Correction term allows for detection of short run and long run casual relationships and captures the long run adjustment of the cointegrated variables. The study adopted Microsoft excel and STATA version 15 software for the purpose of analysis.

3.8 Sources of Data

The study used annual secondary time series data between 1986 to 2020. Data on GDP, GINI coefficient, Population and inflation were extracted from World Bank database and harmonized with the data extracted from KNBS and CBK to ensure the data is correct. Data on climate variability including temperatures, rainfall and climate shocks were obtained from the database of meteorological department of Kenya.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 Introduction

The chapter presents the data analysis and discussion on the effect of climate variability on poverty levels in Kenya. The chapter presents the descriptive analysis, diagnostic tests and inferential analysis based on VAR model.

4.2 Descriptive Analysis

Descriptive analysis involved the generation of descriptive statistics including skewness, Kurtosis, mean and standard deviation. The findings presented in Table 2 reveals that the variables were generally normally distributed given skewness values closure to zero (0) and kurtosis values closure to three (3). Further, the Jarque-Bera test showed that most of the variables had p-values greater than 0.05 level of significance normality of residuals is expected in the regression analysis.

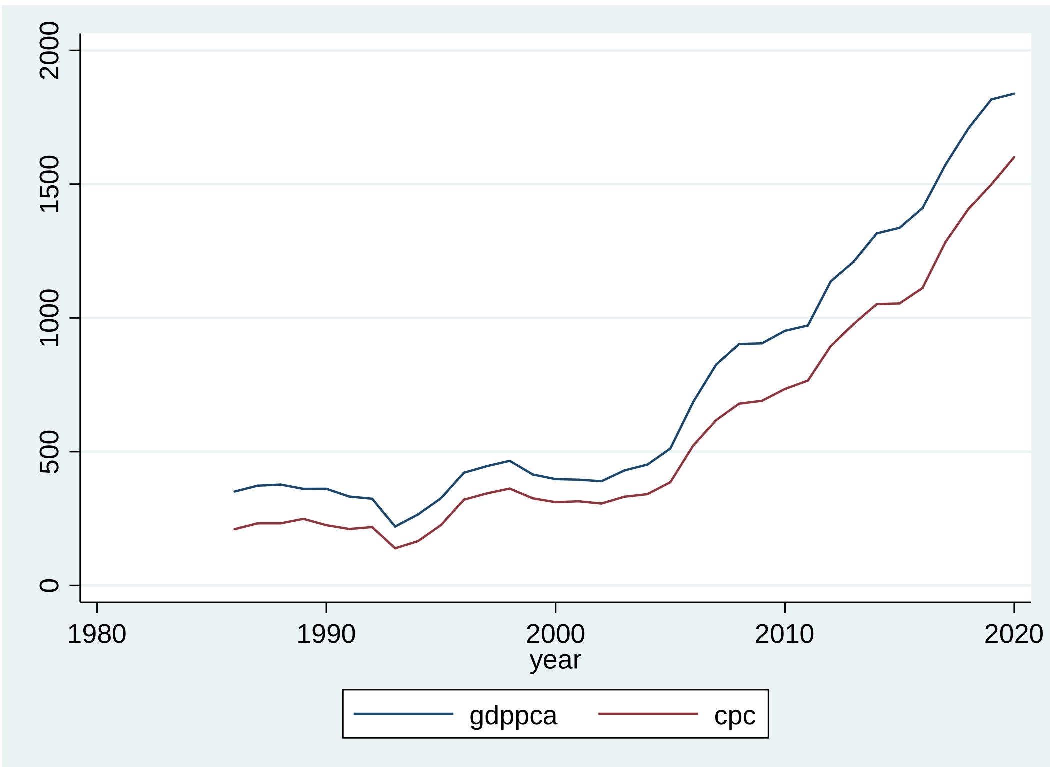
Table 2: Summary of Descriptive Statistics

	LnCPC	Lngini	LnHCR	INF	TV	RfV	Lngdppca
Skewness	0.296	0.848	0.405	2.044	0.964	1.948	0.387
Kurtosis	1.805	2.728	2.341	7.655	4.027	6.873	1.747
Variance	0.499	0.003	0.049	0.008	0.008	1766.084	0.396
Mean	6.119	4.077	3.895	0.113	0.121	48.821	6.420
Std. Deviation	0.707	0.518	0.221	0.090	0.091	42.025	0.629
Observations	35	34	34	35	35	35	35

Note: consumption per capita (CPC), income distribution (gini), Head count ratio (HCR), inflation (INF), Temperature variability (TV), Rainfall Variability (RfV), Gross domestic product per capita (gdppca). Ln is the natural logarithm.

4.3 Trend Analysis

The study examined the trend movement of various macroeconomic variables that were adopted in the study. The findings are presented in figures [1-4]. Figure 1 presents the co-movements of consumption per capita and gross domestic product per capita. The consumption per capita and gross domestic product per capita have been moving together in the study period from 1986-2020. The two macroeconomic aggregates have been or a raising trend throughout the study period with cyclic variation along the trend. The consumption per capita is a component of per capita income that is spent by households on final products within a country.



Note: Consumption per Capita (CPC), Gross domestic product per capita (gdppca)

Figure 1: Movement of Consumption per Capita and Gross domestic product per capita

The study also evaluated the co-movement between gini coefficient and Head Count Ratio (HCR). The findings are presented in figure 2 where anytime the gini coefficient rises, the poverty measured by head count ratio also rises (1986-1992 and 1994-2006). Further, anytime the gini coefficient falls, poverty levels also fall (1992-1994 and 2006-2020). Generally, poverty has been reacting to income inequality.

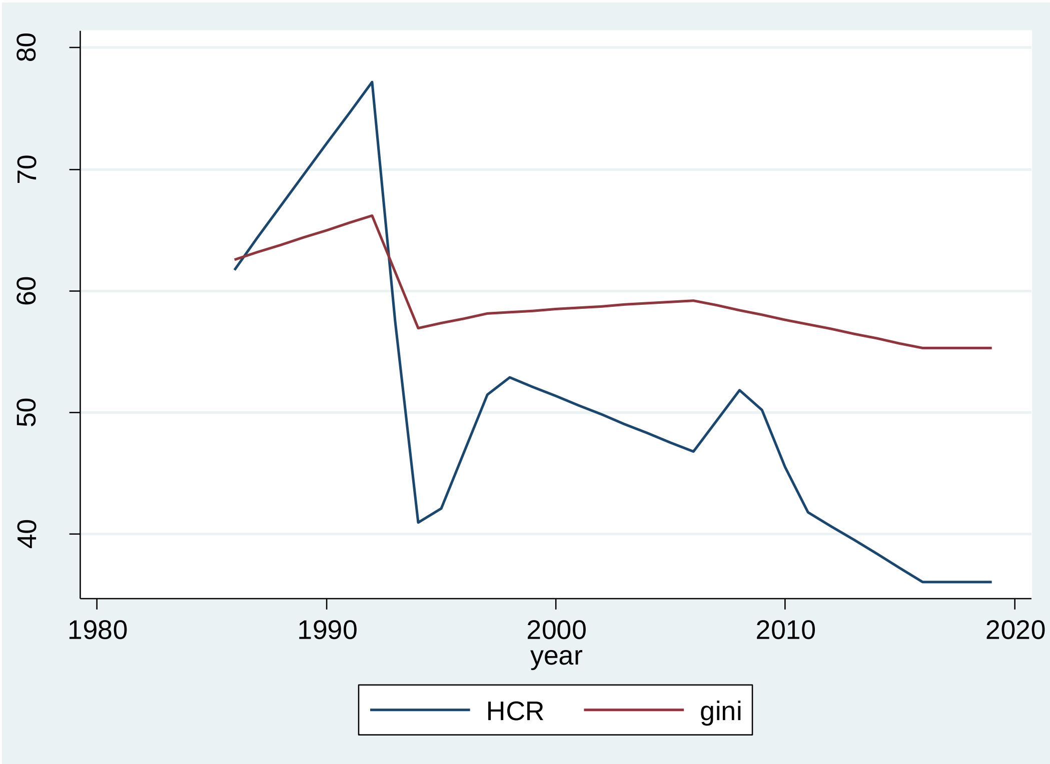


Figure 2: Movement of income inequality and head count ratio

The study also examined the movement in annual mean temperature around the century mean temperature (25.09^{0}C). The trend shown in figure 3 revealed that annual mean temperature was below the century mean temperature from 1986- 2001. The annual temperature then begun rising above the mean century temperature from 2001 onwards with annual temperatures sometimes going beyond the century mean temperature depicting increased temperature variability.

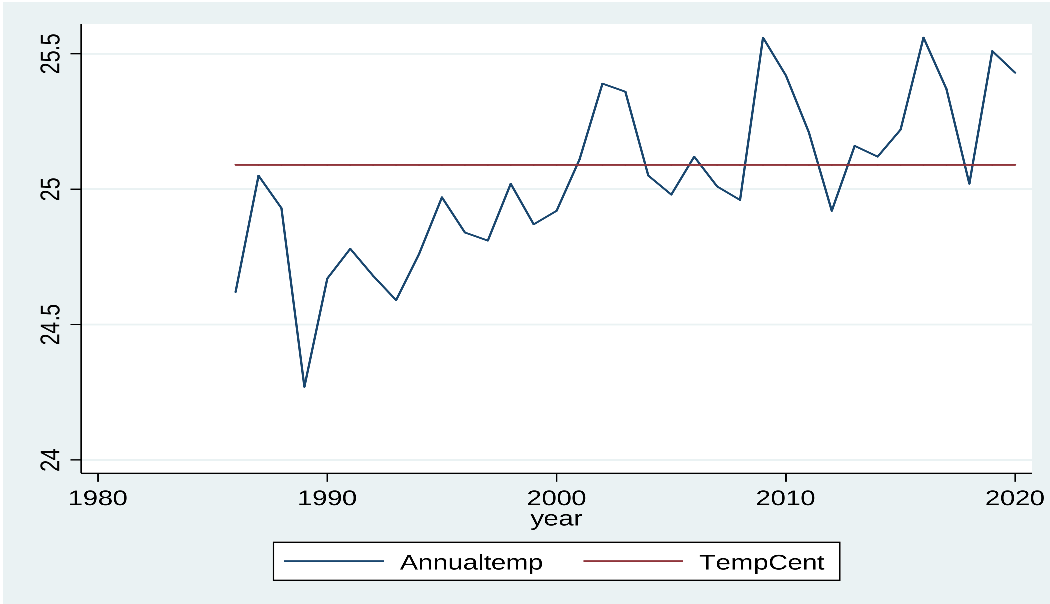


Figure 3: Movement of Annual Mean Temperature around Century Mean Temperature

The annual Rainfall versus century Rainfall was also examined using trend analysis. The study findings are presented in figure 4. The figure reveals that annual rainfall was oscillating along the century mean rainfall (699.1 mm) from 1986 to 2016 depicting rainfall variation. After 2015, the mean annual rainfall has been above the century mean rainfall. The swings of annual rainfall below the century mean rainfall depicts insufficient rainfall or drought while annual rainfall above the century mean rainfall depicts adequate rainfall or floods.

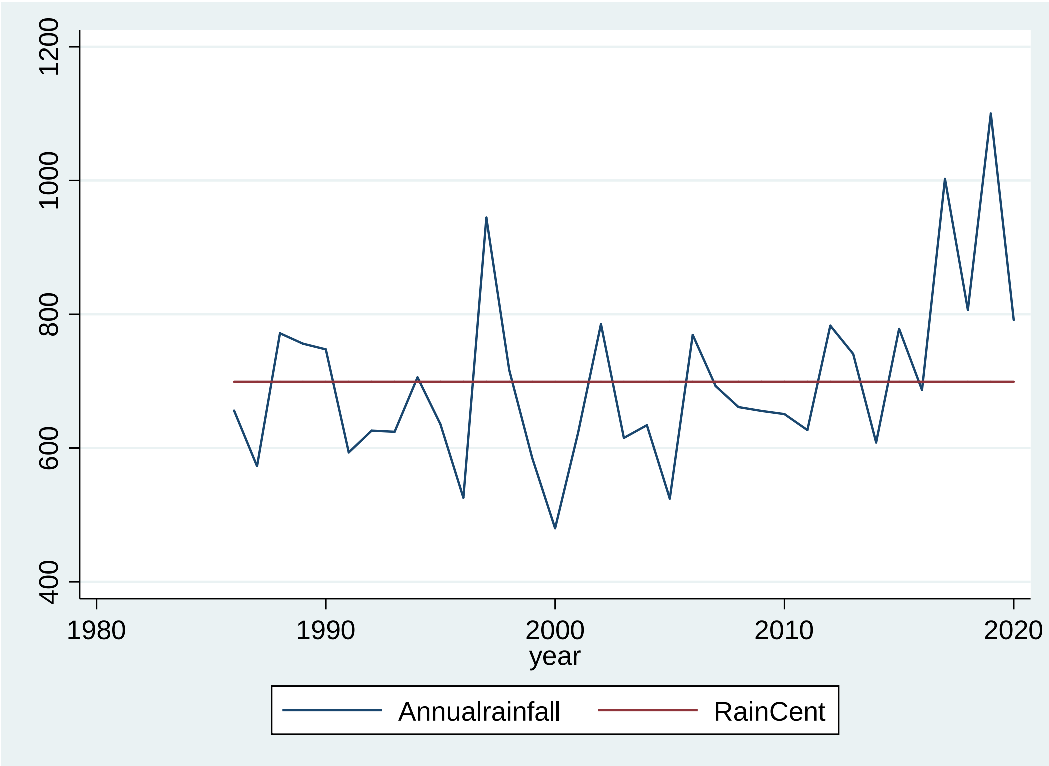


Figure 4: Movement of annual mean rainfall around century mean rainfall.

The study finally examined the movement of inflation measured by consumer price index from 1986 to 2020. The findings are presented in figure 5 where inflation rate was very high between 1986 to 1995. After 1995 the inflation rate begun falling only rising later between 2007-2009 around the period Kenya experienced very serious post-election violence.

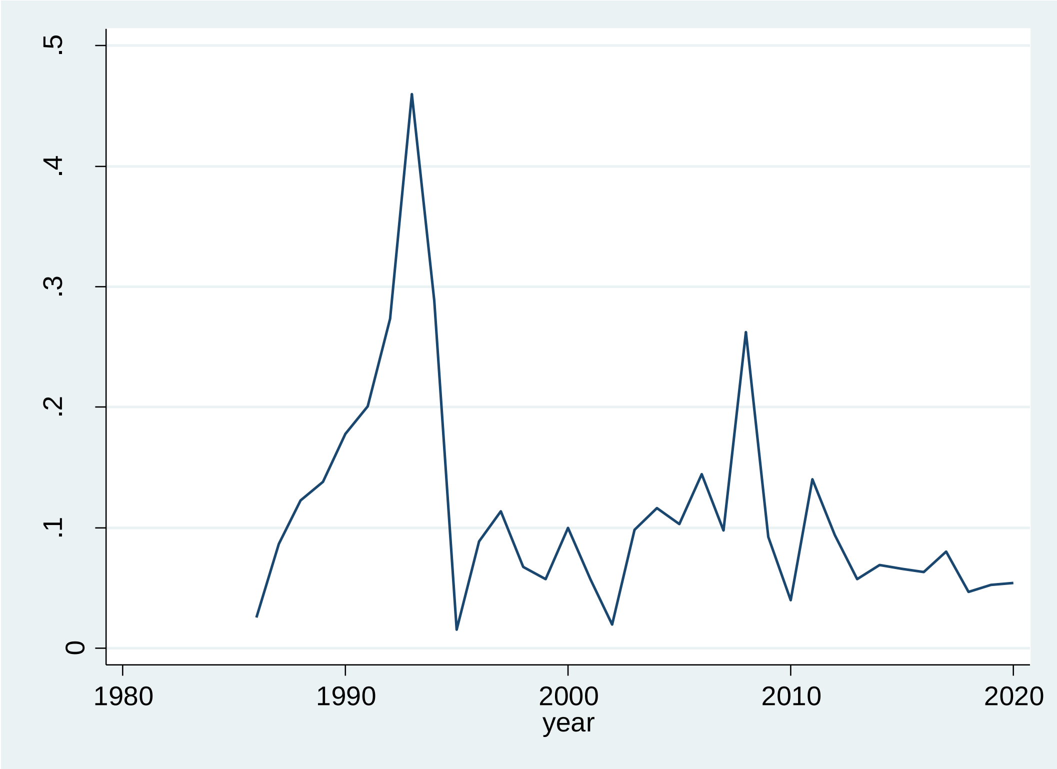


Figure 5: Movement of Inflation Rate Measured by Consumer Price Index

4.4 Diagnostic Test

Diagnostic test was carried out to establish the robustness of the model in estimating the parameters. To settle on the most appropriate estimation model, the study optimal lag test, unit roots test and cointegration test.

4.4.1 Multicollinearity

Multicollinearity was examined based on pairwise Pearson correlation. High correlation among explanatory variables themselves and with the residual term would lead to inflated coefficient of determination. The findings are presented in Table 3.

Table 3: Pairwise Correlation Coefficients

	Lngdppca	Lngini	INF	TV	RfV	CS
Lngdppca	1	-0.703	-0.476	-0.176	0.219	-0.201
Lngini	-0.703	1	0.428	0.354	-0.234	-0.009
INF	-0.476	0.428	1	0.269	-0.171	0.140
TV	-0.176	0.354	0.269	1	0.034	-0.090
RfV	0.219	-0.234	-0.171	0.034	1	0.094
CS	-0.201	-0.009	0.140	-0.090	0.094	1

Note: income distribution (gini), inflation (INF), Temperature variability (TV), Rainfall Variability (RfV), Gross domestic product per capita (gdppca). Ln is the natural logarithm.

The Table 3 shows that multicollinearity was not a major problem given that the explanatory variables adopted in the study did not present close to perfect correlation among themselves. This implies that the coefficient of determination was not inflated. The study dropped the variable population because it was highly correlated with gross domestic product per capital (gdppca) given that gdppca is derived by dividing gross domestic product with total population.

4.4.2 Lag order Selection

The examination of the order of lags to be adopted for each variable and for the models was critical given the long time series data that was used. Establishing the optimal lag was important before unit roots tests could be carried out. Using the wrong lag length could give incorrect stationarity results by depicting presence of unit root when it is non-existent and vice versa. The tests for optimal lag length were conducted including Fixed Prediction Error (FPE), Akaike Information Criteria (AIC), Hannan and Quinn Information Criteria (HQIC) and Schwarz‘ Bayesian Information Criteria (SBIC). The results presented in Table 4 shows that the variables had different optimal lags. Rainfall variability (RfV) and climate shocks (CS) had an optimal lag length of zero. Inflation (INF) and consumption per capita (CPC) had optimal lag of one. gini coefficient (gini), temperature variation (TV) and head count ratio (HCR) had optimal lag length of three while gross domestic product per capita had optimal lag length of four.

Table 4: Optimal Lag Section

Variable	Lags	FPE	AIC	HQIC	SBIC
INF	1	.006948*	-2.13163*	-2.10148*	-2.03912*
Lngini	3	.000313*	-5.23443*	-5.17466*	-5.04761*
Lngdppca	4	.016335*	-1.2794*	-1.204	-1.04811
LnCPC	1	.02242*	-.960118*	-.92996*	-.867603*
LnHCR	3	.005429*	-2.37976*	-2.31999*	-2.19293*
TV	3	.005132*	-2.43575*	-2.37543	-2.25071
RfV	0	2011.48*	10.4445*	10.4596*	10.4907*
CS	0	.25307*	1.46376*	1.47884*	1.51002*

Note: Gini coefficient (gini), inflation (INF), Population (POP), Temperature Variability (TV), Rainfall Variability (RfV), Gross domestic product per capita (gdppca), Consumption per capita (CPC), head count Ratio (HCR). Ln is the natural logarithm.

4.4.3 Unit Roots Test

The existence of unit roots was examined based on Augmented Dickey Fuller tests. The adoption of OLS models requires that variables have a constant mean, variance and that the covariance between the values of two time periods is zero. If the condition does not hold, then regression tends to be spurious. The results presented in Table 5 showed that some variables had unit roots at levels hence OLS models could not be adopted given its spurious nature when variables have unit roots. The study therefore rejected OLS model and settled on Autoregressive Distributed Lag Model (ARDL). ARDL is suitable where variables are either 1(0), that is, stationary at level or 1(1), integrated of order 1 or a combination of both. VAR and VECM are suitable where variables are integrated at order 1. The study thus settled on ARDL estimation method.

Table 5: Augmented Dickey-Fuller Test for Unit Roots

		At levels		At first Difference		Order of integration
Variable	Lags	Trend and Intercept	Constant	Trend and Intercept	Constant	
INF	1	-3.709**	-3.039**	-	-	I (0)
lngini	3	-2.917	-1.851	-3.501***	-3.506**	I (1)
Lngdppca	0	-2.034	0.536	-4.346*	-4.189*	I (1)
LnHCR	3	-3.180	-1.427	-3.877**	-3.970*	I (1)
LnCPC	1	-3.042	0.067	-3.646**	-3.543**	I (1)
TV	3	-2.086	-2.496	-3.854**	-3.681**	I (1)
RfV	0	-5.798*	-5.667*	-	-	I (0)
CS	0	-5.023*	-5.071*	-	-	I (0)

*, ** ,***indicates rejection of the null hypothesis of non-stationarity at 1% ,5% and 10% significance levels respectively.

4.4.4 Cointegration Test

Cointegration analysis is a long-run concept that shows that group of variables move together. The idea behind Cointegration is that although macro-economic variables may trend together overtime, groups of variables may drift together. Cointegration tests are used to establish the existence of long run relationship among study variables. The ARDL bounds test for cointegration was conducted and the results are indicated in Table 6.

Table 6: ARDL bounds test for Cointegration

	F-statistic	bounds critical value at 10%		bounds critical value at 5%		bounds critical value at 2.5%		bounds critical value at 1%	
		I (0)	I (1)	I (0)	I (1)	I (0)	I (1)	I (0)	I (1)
Model 1(consumption per capita)	5.130	2.12	3.23	2.45	3.61	2.75	3.99	3.15	4.43
Model 2(head count ratio)	7.294								
Cointegration Status	Presence of cointegration								

The results in Table 5 revealed that there was cointegrating equations given that the f-statistic was greater than bounds critical values at 5% level of significance for model 1 and 2. The f-statistic was greater than bounds critical values for 1(1) integrations bounds. The study thus concluded that there was presence of cointegrating equations hence error correction model was run to bridge the short run and the long-run relationship.

4.6. Effect of Climate Variability and Other Covariates on Poverty

This research adopted Autoregressive Distributed Lag (ARDL) Model in the evaluation of the effect of climate variability (TV, RfV and CS) and other covariates (POP, gini, gdppca and INF) on poverty measured by consumption per capita (CPC) and head count ratio (HCR). The first objective of the study sought to examine the effect of effect of climate variability (TV, RfV and CS) and other covariates (POP, gini, gdppca and INF) on poverty measured by consumption per capita (CPC) and head count ratio (HCR). The ARDL model adopted lagged dependent variable (HCR and CPC) and this had the potential causing serial correlation or heteroscedasticity leading to misleading parameter estimates (Gujarati and Porter, 2009). The Table 7 presents the serial correlation test based on Breusch-Godfrey Serial Correlation LM Test where the p-values were greater than 0.01 level of significance (p-value = 0.5413 and 0.5638) hence the study concluded that there was no problem of serial correlation hence ARDL model was adopted.

Table 7: Breusch-Godfrey Serial Correlation LM Test

Consumption Per capita Model			
F-statistic	1.227	Prob.	0.5413
Head count ratio Model			
F-statistic	1.146	Prob.	0.5638

The study also evaluated the presence of heteroscedasticity given that model with heteroscedasticity leads to spurious regression. Heteroscedasticity is null hypothesis that there is a constant finite variance of the error terms. The study adopted Breusch-Pagan / Cook-Weisberg test for heteroskedasticity test as presented in Table 8 where the p-values were greater than 0.05 level of significance (p-value = 0.4239 & 0.6871) hence the study concluded that there was homoscedasticity implying constant finite variances of the residuals hence ARDL model could be adopted for estimating the coefficients of the models.

Table 8: Breusch-Pagan-Godfrey Test of heteroscedasticity

Consumption Per Capita Model			
F-statistic	0.64	Prob.	0.4239
Head Count Ratio Model			
F-statistic	0.16	Prob.	0.6871

The stability of the poverty models (consumption per capita and Head count Ratio) were tested based on graphical plot of the cusum of squares presented in Figures 8 and 9. The cusum of squares ought not to cross the 5% significance level. The graphs showed that the parameters in the Consumption per capita and head count ratio models were stable. The cusum plot was within the 95% confidence band around the null.

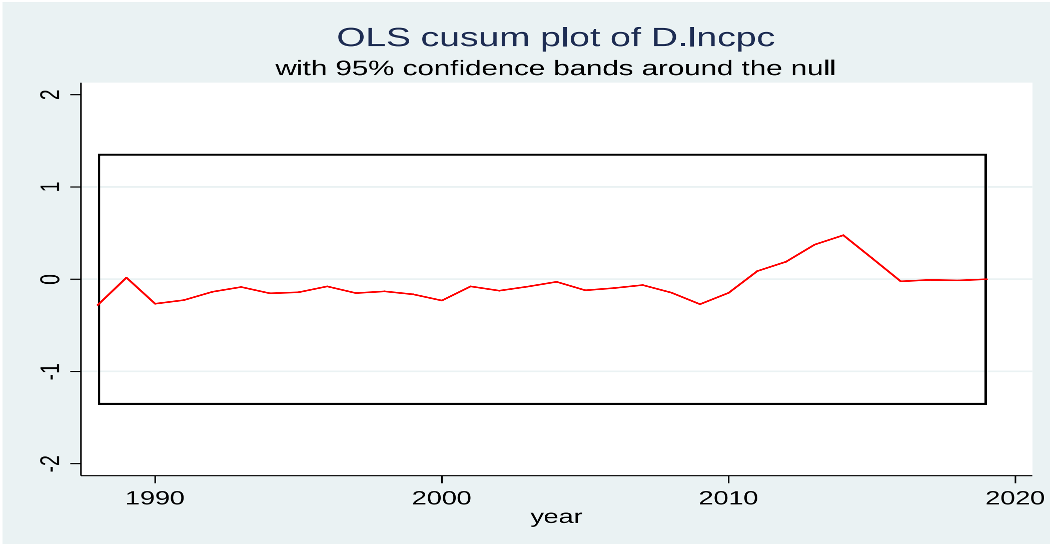


Figure 6: Plot of the cusum of squares for Consumption Per Capita Model

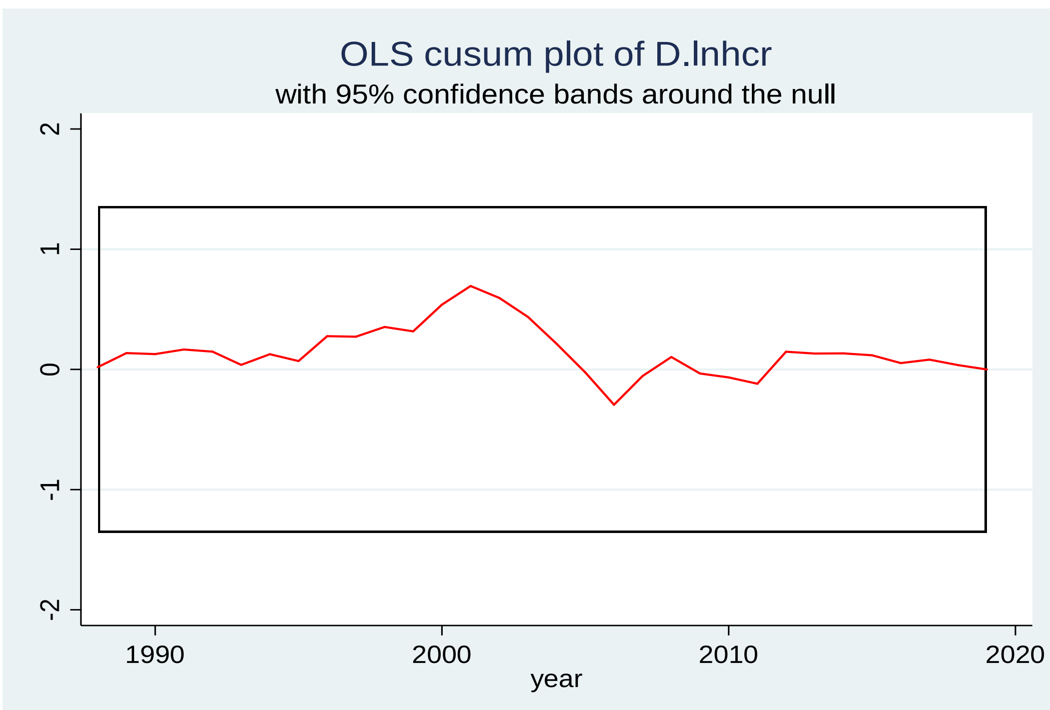


Figure 7: Plot of the cusum of squares for Head Count Ratio Model

4.6.1 Error Correction Models

The study had earlier revealed the presence of cointegration hence leading to the estimation of the error correction models based on differenced explanatory and dependent variables to bridge the long-run and short-run relationships.

Given that the ARDL model did not suffer from the problem of heteroscedasticity, serial correlation and the models stable, this implied that the study could continue with the ARDL model in estimating parameters. The study then adopted AIC lag selection criterion. The findings of the long-run models of two poverty level indicators are presented in Tables 9 and 10.

Table 9: Long-run Estimates of the Consumption per capita Model

Dependent Variable = ln of consumption per capita (lnCPC)	**long run coefficients, t-statistic and p-values**			
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**p value****
CS	0.049	0.029	1.710	0.104
TV	0.029	0.168	0.170	0.864
RfV	-0.000	0.000	-0.910	0.372
INF	0.458	0.294	1.560	0.135
lngini	-2.353*	0.622	-3.780	0.001
lngdppca	0.989*	0.028	35.680	0.000
Adjusted Coefficient	-0.053*	(0.000)		
R-squared	0.9793			
Adjusted R-squared	0.9663			
Log likelihood	79.8474			
Root MSE	0.0259			

* indicates 1% significance level

The model of poverty measured by consumption per capita presented in Table 9 had an adjustment coefficient of -0.053 that is significant at 1% significance level indicating that there is a long run convergence among the variables. The adjusted R^2 of 0.9663 implying a satisfactory goodness of fit of the model since 96.6% of the variations in consumption per capita were explained by the explanatory variables in the model.

Further, among the variables measuring climate variability (TV, RfV and CS), the study revealed that long run climate shock and temperature variability had a positive but not statistically significant effect on poverty rate measured by consumption per capita at 95% confidence level. Occurrence climate shocks and temperature variability leads to increased consumption per capita by 0.049% and 0.029% respectively. The positive effect implies that widespread climate shocks and temperature variability which are usually drought condition are usually felt in terms of increased prices of agricultural commodities. Kenya being an economy dominated by agriculture, climate shocks like drought affects agricultural output hence driving prices of commodities like maize up. The increased food prices imply food inflation such that household must spend more than normal on food commodities and reduce their savings. The effect of rainfall variability on consumption per capita was negative increased rainfall variability beyond the century mean rainfall is often associated with bumper harvest leading to reduced food inflation hence reduced household consumption especially on food products. This finding conflicted with Wossen, Berger, Haile and Troost (2018) who established that climate and price fluctuations had an adverse effect on income and food security

Regarding the effect of the other covariates (gdppca, gini and Inflation), gross domestic product per capita and Gini coefficient had a significant long run effect on consumption per capita. The effect of current values on gross domestic product per capita on consumption per capita was positive and significant. A one percent increase in current time gross domestic product per capita leads to increase in current period consumption per capita by 0.989%. This implies that increased current gross domestic product per capita leads to increased income of the household as entrepreneurs or labourers which can thus be spent on consumption of final goods in an economy depicting improved living standards. The results in line with Fosu growth-poverty nexus model. Fosu (2008) stated that the lower the level of income, the high chance that an individual's income will not afford them the basic needs hence exposing them to poverty.

Gini coefficient had a significant effect on consumption per capita. A one percent increase in lag one gini coefficient leads to reduction in consumption per capita by 2.3 %. Increasing gini coefficient implies increased income inequality leading to reduced available income for consumption purposes by the poor masses in Kenya. The effect of Inflation on consumption per capita was positive implying that increased inflation is also associated with increased monetary consumption per capita and that 1% increase in inflation leads to increased consumption per capita by 0.458%.

Table 10: Long run Estimates of the Head Count Ratio Model

Dependent Variable = ln of Head Count Ratio (lnHCR)	**long run coefficients, t-statistic and p-values**			
Variable	**Coefficient**	**Std. Error**	**t-statistic**	**p-value***
CS	-0.001	0.037	-0.030	0.977
TV	-0.063	0.106	-0.600	0.558
RfV	-0.001**	0.000	-3.110	0.006
INF	1.158**	0.379	3.050	0.007
lngini	1.704**	0.617	2.760	0.013
lngdppca	-0.113*	0.025	-4.450	0.000
Adjustment coefficient	-0.057	(0.000)		
R-squared	0.9663			
Adjusted R-squared	0.9419			
Log likelihood	86.5289			
Root MSE	0.022			

*,** indicates 1% and 5% significance levels

The model of poverty measured by head count ratio presented in Table 10 had an adjustment coefficient -0.057 that is significant at 1% significance level indicating that there is a long run convergence among the variables. The adjusted R^2 of 0.9419 implying a satisfactory goodness of fit of the model since 94.2% of the variations in head count ratio was explained by the explanatory variables in the model.

Further, among the variables measuring climate variability (TV, RfV and CS), the study revealed that rainfall variability had a significant effect on current head count ratio. A 1% rainfall variability leads to reduced head count ratio by 0.001% implying that increased rainfall variability especially above the century mean rainfall level is often associated with bumper harvest leading to increased agricultural output and reduced poverty measured by head count ratio. The effect of temperature variability and climate shock did not have significant effect on head count ratio. The finding agrees with Ademe, Kassa, Goshu, & Mwanjalolo, (2017) that revealed that when increase in temperature and rainfall at the same led to increased crop production. This finding conflicted with Wossen, Berger, Haile and Troost (2018) who established that climate and price fluctuations had an adverse effect on income and food security.

Among the other covariates (gdppca, INF and gini), gross domestic product per capita, gini coefficient and inflation had a significant effect on head count ratio as measure of poverty. 1% increase in current gini coefficient led to 1.704 % increase in current head count ratio implying that increased income inequality makes the poor mases worse off as they do not het their fair share of income hence they live below the national poverty line. The finding agrees with Dollar and Kraay (2002) and Fosu (2008) who added inequality to the poverty function and that the association between poverty and income inequality was direct and that equitable income distribution was accompanied by falling poverty levels. The study also established that inflation had a significant effect on head count ratio with 1 % increase in inflation leading to rising current head count ratio by 1.158 %. Inflation erodes the purchasing power of the households especially the poor masses hence driving them into poverty. Finally, a 1% increase in gross domestic product per capita lead to reduced head count ratio by 0.113%. Increased gross domestic product per capita should lead to reduced poverty especially if the income is fairly distributed. The finding is consisted with Keynes (1936) who believed that market forces could promote economic growth and in turn was able to eradicate poverty.

Table 11 and 12 presents short run estimates of consumption per capita and head count ratio models. The short run variables were in differenced form while the long run variables were at levels form.

Table 11: Short Run Estimates of Consumption Per Capita Model

Dependent Variable = DlnCPC	**Short run coefficients**			
Explanatory Variables	Coef.	Std.Err.	t	P value
D.lncpc (-1)	-0.050	0.043	-1.160	0.259
D.CS	-0.025**	0.011	-2.310	0.032
D.TV	0.109**	0.059	1.850	0.080
D.lngini	2.786**	0.838	3.320	0.004
D.lngdppca	0.446**	0.140	3.190	0.005
ECM (-1)	-0.530*	0.103	-5.150	0.000

*,** indicates 1% and 5% significance levels

The later D means difference while ln is natural logarithm. The estimated consumption per capita model presented in Table 11. The effect differenced lagged one consumption per capita had a negative but not statistically significant effect on current consumption per capita. Further, the short run effects of climate shocks on differenced consumption per capita was significant.

An occurrence of climate shock in the short run leads to reduced consumption per capita by 0.025 % implying that occurrence of widespread climate shocks leads to reduced consumption per capita in monetary terms. Climate shock especially those related to drought may affect availability of certain crops and output of agriculture therefore leading reduced consumption per capita. Further, reduced agricultural output may lead to reduced consumption per capita for the population that is employed in the agricultural sector as their income is negatively affected. The effect of temperature variability was positive but not statistically significant. The findings agree with Azzarri and Signorelli (2019) that climatic shocks like flooding were related to decline in per capita consumption and increased food poverty. Ofulla et al. (2016) also revealed adverse climatic conditions affected the livelihood of vulnerable members of the population.

A one percent increase in gross domestic product per capita led to 0.446% increase in consumption per capita. Increased gross domestic product per capita means increased per capita income hence improved consumption per capita. A one percent increase in gini leads to increased consumption per capita by 2.786 % contrary to theory. Finally, the error correction coefficient was negative and significant. The value of -0.530 showed that after disequilibrium or shock in the system, it takes about two years for to system be restored to long –run equilibrium.

Table 12:Short Run Estimates of Head Count Ratio Model

Dependent Variable = DlnHCR	**Short run coefficients**			
Explanatory Variables	Coef.	Std.Err.	t	P>t
DlnHCR (-1)	0.574*	0.100	5.740	0.000
D.CS	-0.021	0.017	-1.260	0.224
D.CS (-1)	-0.021**	0.011	-1.990	0.062
D. RfV	0.0004**	0.0001	2.830	0.011
D. INF	-0.412*	0.098	-4.220	0.001
D.lngini	4.336*	0.796	5.440	0.000
ECM (-1)	-0.573*	0.107	-5.350	0.000

*,** indicates 1% and 5% significance levels

The estimated head count ratio model presented in Table 12 showed that the short run effects of lagged head count ratio on current head count ratio was positive and statistically significant. A 1% increase in differenced lagged head count ratio leads to 0.574% increase incurrent head count ratio which is in line with vicious cycle of poverty. Regarding climate variability variables, rainfall variability had a significant effect on head count ratio and that 1% increase in rainfall variability was associated with 0.0004% increase in head count ratio. Rainfall variability especially below mean century rainfall may lead to reduced agricultural output resulting to increased poverty measured by head count ratio. Increased rainfall variability hurts agricultural output that the poor masses depend on in Kenya. This reduces their earning below the national poverty line hence more people falling into poverty as measured by head count ratio. The effect of climate shock on headcount ratio was negative and not statistically significant. The finding is supported by Adebayo, Yahaya and Mohammed (2018) that showed that changes in climatic variables in terms of changes in rainfall and temperature pattern and intensity led to decline in agricultural production. Leichenko, O'Brien (2008) also revealed that natural climatic related events like flooding and drought can destroy assets like crops, livestock, and dwelling places.

The study also revealed that a one percent increase in gini coefficient leads to increased head count ratio by 4.336 %. This implies that increasing gini coefficient means that income is unfairly distributed hence the poor masses do not get their fair share national income pushing them into poverty as measured by head count ratio. The finding is consistent with Dollar and Kraay (2002) that added inequality to the poverty function where the association between poverty and income inequality was direct and that equitable income distribution was accompanied by falling poverty levels. The research also revealed that a 1% increase inflation leads to reduced head count ratio by -0.412 % contrary to theoretical expectation. Finally, the error correction term had a negative and significant coefficient of -0.573. This implied that when there is a shock in the system, it takes about 2 years for the whole disequilibrium to be adjusted to the long-run equilibrium.

4.7 Mediating Effect of Economic Growth on the Relationship between Climate Variability and Poverty

The study sought to establish the mediating effect of economic growth on the relationship between climate variability and poverty. The first models under each dependent variable had all the other variables except economic growth while the second models under each dependent variable included the mediating variable economic growth as presented in Table 13.

Table 13: Economic Growth on the Relationship between Climate Variability and Poverty

Long Run	**Consumption Per Capita**		**Head Count Ratio**	
Variable	**lnCPC(model without lngdppca)**	**lnCPC(model with lngdppca)**	**lnHRC (model without lngdppca)**	**lnHCR(model with lngdppca)**
lngini	-34.557** (10.439)	-2.353* (0.622)	4.042* (0.619)	1.704** (0.617)
INF	16.189** (7.743)	0.458 (.293701)	0.092 (0.433)	1.158** (0.379)
lngdppca	-	0.989* (.0277)	-	-0.113* (0.025)
TV	-0.211 (2.103)	.0292 (0.168)	-0.162 (0.189)	-0.063 (0.106)
RfV	-0.003 (0.004)	-0.000 (0.000)	-0.000 (-0.000)	-0.001** (0.000)
CS	-0.714*** (0.398)	.0492 (0.029)	0.0146 (0.0313)	-0.001 (0.037)
Adjusted R^2	0.4548	0.9663	0.9096	0.9419

Short Run	Consumption Per Capita		Head Count Ratio	
Variable	**lnCPC(model without lngdppca)**	**lnCPC(model with lngdppca)**	**lnHRC (model without lngdppca)**	**lnHCR(model with lngdppca)**
D.lngini	11.083* (2.884)	2.79** (0.838)	2.821* (0.928)	4.336* (0.796)
D.INF	-0.854** (0.336)	-	-	-0.412* (0.098)
D.CS	-	-0.025 ** (.0108)	-	-0.021 (0.017)
D.CS (-1)				-0.021** (0.011)
D.RfV	-	-	-	0.001** (0.000)
D.TV		0.109** (0.059)		
D. lngdppca	-	0.446** (0.140)	-	-

*, **,*** indicates 1%, 5% and 10% significance levels

In the long run relationship, climate variability proxies (TV and RfV) did not have statistically significant effect on poverty measured by consumption per capita before mediation and after mediation by gross domestic product per capita. However, climate shock (CS) and temperature variability (TV) had a significant effect before mediation in the long run before mediation and only had a significant relation in the short run relationship after mediation hence it can be concluded that economic growth mediated the relationship between climate variability (CS and TV) and consumption per capita in the short run period. Regarding the head count ratio as a measure of poverty, in the long run relationship, climate variability proxies (TV, CS and RfV) did not have statistically significant effect on head count ratio, however when gross domestic product per capita was added to the model, rainfall variability had a significant effect head count ratio. It can thus be concluded that economic growth mediated the relationship between climate variability (Rainfall variability) and poverty in the long run. The finding agrees with Leichenko and Silva (2014) who showed that climate variability could influence poverty directly or indirectly through economic growth and other factors.

In the short run period, climate variability proxies did not have a significant effect on head count ratio measure of poverty. However, after mediation by the addition of gross domestic product per capita into the model, climate shocks and rainfall variability had a significant effect on poverty measured by head count ratio. It can thus be concluded that economic growth mediated the relationship between climate variability (climate shock and temperature variability) and poverty measured by head count ratio in the short run. The finding is in line with climate-poverty vulnerability frameworks by Hallegatte et al. (2014). Vulnerability frameworks hold that climate variability affects poverty indirectly through economic growth channel. Slow growth in economies of most African states can be explained by low levels of rainfall being experienced (Wossen & Berger, 2015, Brown et al., 2011). In a study in Zambia, Thurlow, Zhu & Diao (2012) concluded that the current climate variability is a single most significant determinant of economic growth and development.

4.8 Direction of Causation

The study also sought to establish the direction of causality between climate variability and poverty. The study estimated a VAR model of the climate variability variables and poverty measures, ran stationarity tests, lag length selection test and pairwise granger causality tests and the results are presented in Table 14, 15 and 16. The granger causality test was based on null hypotheses of no significant causation.

4.8.1 Unit Roots Test

Augmented Dickey fuller test was used to test for stationarity. Since the data series are of different order of integration, then by time series stationarity properties, the linear combination of the series in the regression analysis was at I (1) which is the highest order of integration.

Table 14: Augmented Dickey-Fuller Test for Unit Roots

Variable	At levels	At first Difference	Order of integration
LnHCR	-0.949	-3.419**	I (1)
LnCPC	0.371	-4.356*	I (1)
TV	-4.644*	-	I (0)
RfV	-5.667*	-	I (0)
CS	-5.071*	-	I (0)

*, **, indicates rejection of the null hypothesis of non-stationarity at 1% and 5% significance levels respectively**.**

4.8.2 Lag Order Selection

Table 15: Lag Order Selection- Consumption Per Capita

	Consumption Per Capita				**Head Count Ratio**			
Lags	**FPE**	**AIC**	**HQIC**	**SBIC**	**FPE**	**AIC**	**HQIC**	**SBIC**
0	0.4110	10.4624	10.5231*	10.6456*	0.1360	9.3563	9.4166	9.5413*
1	0.3532	10.3005	10.6042	11.2166	0.1058	9.0944	9.3960	10.0195
2	0.3290*	10.1776*	10.7242	11.8265	0.0804*	8.7624*	9.3053*	10.4277

The examination of the order of lags to be adopted for the model revealed that optimal lag to be used was lag 2 based on the AIC criterion for both models measuring poverty by consumption per capita and head count ratio.

4.8.3 VAR Stability Conditions

The stability of the VAR model was tested, and the results showed that all the eigenvalues lie inside the unit circle hence both VAR models satisfy the stability condition

Table 16: Eigenvalue Stability Condition

Consumption Per Capita		Head Count Ratio	
Eigenvalue	Modulus	Eigenvalue	Modulus
-.3055217 + .5764369i	.652398	.3282682 + .6222954i	.703571
-.3055217 - .5764369i	.652398	.3282682 - .6222954i	.703571
-.07404301 + .6381877i	.642469	-.266649 + .6380059i	.691486
-.07404301 - .6381877i	.642469	-.266649 + .6380059i	.691486
-.5088219 + .2073227i	.549438	-.1120199 + .6395845i	.64932
-.5088219 - .2073227i	.549438	-.1120199 + .6395845i	.64932
.112565 + .3369632i	.355268	-.4909178 + .2219175i	.538746
.112565 - .3369632i	.355268	-.4909178 + .2219175i	.538746

4.8.4 Autocorrelation Test

The two models have no autocorrelation since the null hypothesis of no autocorrelation at lag order two was rejected as the p values are greater than 0.05.

Table 17: Langrange Multiplier Test

	Consumption Per Capita		Head Count Ratio	
Lag	**F-Statistic**	**Prob**	**F-Statistic**	**Prob**
1	17.6837	0.34274	18.1323	0.31620
2	12.2985	0.72319	13.4656	0.63846

4.8.5 Causality Test

Table 18: Pairwise Granger Causality Tests- Consumption Per Capita Model

Null Hypothesis:	F-Statistic	Prob.
TV does not Granger Cause lnCPC	1.9263	0.405
lnCPC does not Granger Cause TV	4.2819	0.118
RfV does not Granger Cause lnCPC	1.9787	0.372
lnCPC does not Granger Cause RfV	1.1001	0.577
CS does not Granger Cause lnCPC	1.8059	0.405
lnCPC does not Granger Cause CS	0.6873	0.709

The study revealed further that climate variables (temperature variability, rainfall variability and climate shocks) do not cause poverty as measured by consumption per capita and poverty measured by consumption per capita does not cause climate variability. This is because the probabilities are more than 5% hence, we cannot reject the null hypothesis of no causation.

Table 19: Pairwise Granger Causality Test – Head Count Ratio Model

Null Hypothesis:	F-Statistic	Prob.
TV does not Granger Cause lnHCR	0.1358	0.934
lnHCR does not Granger Cause TV	6.7442	0.022
RfV does not Granger Cause lnHCR	0.0779	0.962
lnHCR does not Granger Cause RFV	2.7899	0.248
CS does not Granger Cause lnHCR	2.8593	0.239
lnHCR does not Granger Cause CS	3.6705	0.160

Table 16 revealed that poverty measured by head count ratio granger caused temperature variability. The study therefore concludes there is unidirectional causation running from poverty to climate variability through temperature variability. Poor nations like Kenya are experiencing more climate variability due to economic activities that the poor masses get involved in. The poor masses get involved in economic activities that leads to environmental degradation like deforestation for tree harvesting, charcoal burning and farming in water a catchment tower. The destruction of water towers leads to increased climate variability.

CHAPTER FIVE: SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

The chapter presents the study summary, conclusion, recommendations, limitations, and areas for further research.

5.2 Summary and Conclusion

5.2.1 Effect of Climate Variability and Other Covariates on Poverty

The first objective of this study was to determine the effect of climate variability and other covariates on poverty. The study used three indicators on climate variability including climate shock, temperature variability and rainfall variability. The other covariates included gross domestic product per capita, gini coefficient and inflation. The study also adopted consumption per capita and headcount ratio as proxies of poverty to determine this relationship. The study adopted ARDL and Error correction model to analyse this relationship and several diagnostic tests were also carried out.

The study results based on consumption per capita measure of poverty revealed that climate variability and other covariates explained poverty to a major extent as depicted by adjusted R^2 of 0.9663 implying 96.6% of the variations in consumption per capita were explained by the explanatory variables in the model. Further, among the variables measuring climate variability (TV, RfV and CS), the study revealed widespread climate shock occurrence leads to reduced consumption per capita in the short run period. Climate shock especially those related to drought may lead to reduced agricultural output that may further lead to reduced consumption per capita for the population that is employed in the agricultural sector as their income is negatively affected. The alternative hypothesis that climate variability has a significant effect on poverty in Kenya was thus accepted.

Regarding the effect of the other covariates (gdppca, gini and Inflation), gross domestic product per capita and gini coefficient had a significant long run and short run effect on consumption per capita. The effect gross domestic product per capita on consumption per capita was positive and significant both in the short run and long run period. This implies that increased gross domestic product per capita leads to increased income of the household as entrepreneurs or labourers which can thus be spent on consumption of final goods in an economy depicting improved living standards. Gini coefficient had a significant effect on consumption per capita and that the effect was negative in the long run period where increasing gini coefficient implies increased income inequality leading to reduced available income for consumption purposes by the poor masses in Kenya. However, in the short run period, increased gini led to increased consumption per capita.

The results using head count ratio as measure of poverty also supported the significant effect of climate variability and other covariates on poverty in Kenya as depicted by adjusted R^2 of 0.9419 implying 94.2 percent of the variations in head count ratio was explained by the explanatory variables in the model. Further, among the variables measuring climate variability (TV, RfV and CS), rainfall variability had a significant effect on current head count ratio both in the long run and short run period. In the long run period, rainfall variability leads to reduced head count ratio implying that increased rainfall variability especially above the century mean rainfall level is often associated with bumper harvest leading to increased agricultural output and reduced poverty measured by head count ratio. However, in the short run period, rainfall variability led to increased poverty as measured by head count ratio. Rainfall variability especially below mean century rainfall may lead to reduced agricultural output resulting to increased poverty measured by head count ratio. Increased rainfall variability hurts agricultural output that the poor masses depend on in Kenya. This reduces their earning below the national poverty line hence more people falling into poverty as measured by head count ratio.

Increase in gini led to increase in head count ratio in the long run and short run period implying that increased income inequality makes the poor mases worse off as they do not get their fair share of national income hence, they live below the national poverty line. Inflation had a significant effect poverty measured by head count ratio both in the short run and long period. In the long run period, increased inflation led to rising head count ratio given that inflation erodes the purchasing power of the households especially the poor masses hence driving them into poverty. However, in the short run period, increase inflation leads to reduced head count ratio contrary to theoretical expectation. Finally, increased gross domestic product per capita lead to reduced head count ratio in the long run period. Increased gross domestic product per capita should lead to reduced poverty especially if the income is fairly distributed.

5.2.2 Mediating effect of economic growth on the relationship between climate variability and poverty.

The study sought to establish the mediating effect of economic growth on the relationship between climate variability and poverty. Based on poverty measured by consumption per capita, in the long run period, rainfall and temperature did not have statistically significant effect on poverty before and after introduction of gross domestic product per capita. However, climate shocks had a significant effect on per capita consumption before introduction of gross domestic product per capita in the long run. In the short run period climate shocks and temperature variability had a significant effect after introduction of gross product per capita hence it can be concluded that economic growth mediated the relationship between climate variability (climate shock) and consumption per capita in the short run period. Regarding the head count ratio as a measure of poverty, in the long run, climate variability proxies did not have statistically significant effect on head count ratio model, however when gross domestic product per capita was added to the model, rainfall variability had a significant effect head count ratio. It can thus be concluded that economic growth mediated the relationship between climate variability (Rainfall variability) and poverty in the long run. In the short run period, climate variability proxies did not have a significant effect on head count ratio measure of poverty. However, after the addition of gross domestic product per capita into the model, climate shocks and rainfall variability had a significant effect on poverty measured by head count ratio. It can thus be concluded that economic growth mediated the relationship between climate variability (climate shock and temperature variability) and poverty measured by head count ratio. The alternative hypothesis that economic growth mediates the relationship between climate variability and poverty in Kenya was thus accepted.

5.2.3 Direction of Causality between Climate Variability and Poverty

The final objective sought to establish the direction of causality between climate variability and poverty in Kenya. The study revealed that none of the climate variability proxies granger caused poverty measured by consumption per capita at two lagged variables

Based on head count ratio as a measure of poverty, the study revealed that poverty granger caused temperature variability. The study therefore concludes there is unidirectional causation running from poverty to climate variability through temperature variability The study thus rejected the hypotheses that climate variability granger causes poverty in Kenya.

5.3 Policy Recommendations

Given that poverty as measured by head count ratio leads to increased climate variability as measured the government should come up with policy measures for combating poverty when looking into solutions to climate change. The government ought to raise minimum wages and create jobs by mainly investing in Agriculture which is the main source of livelihood for the poor communities. Further, given that increase in gini led to increase in head count ratio in the long run and short run period, the government should continue enforcing policies that encouraging equitable distribution of income. The government should continue implementing tax policies that hurt the poor masses less to help in redistribution of resources to the poor.

Additionally, the government should invest in pro poor projects. Increased gross domestic product per capita lead to reduced poverty measured by head count ratio and consumption per capita. The government should continue policies that promote growth. Policies that raise growth such as an enabling macroeconomic environment need to be put in place too. Policies that encourage economic growth can help minimise the negative impacts of climate variability on the poor masses. The government should also come up with policies of stabilising general prices given that increased inflation led to rising poverty level. Policies of import minimization should be encouraged to reduce imported inflation that hurt the poor. Further, cost push inflation resulting from wage demands by the lowly paid workers should attract policy from the government inform of having peaceful labour relations in the country.

5.4 Limitations of the Study

The major limitation of the research was data scarcity. For instance, poverty data is wanting in all African countries and Kenya is not an exception. However, this data limitation was addressed by using linear extrapolation and interpolation based on gini coefficient data for filling gaps in data. It is believed that this data is reliable and policy recommendations can be made from the results of the data.

5.5 Areas for Further Research

It is necessary to conduct thresholds effects especially for climate variability indicators to establish the level at which climate variability indicators affect poverty. This is critical for control policies. Additionally, other proxies of poverty that depicts severity and depth of poverty for robustness are important. Scanty literature exist in other measures of poverty in empirical research and the relationship may not be fully understood.

The results obtained from the granger causality test that climate variability does not cause poverty was contrary to what was expected. In developing countries, Kenya included, it has often been seen that whenever there is adverse climate variability, poverty tends to be rampant. These contrary results might have been caused by the limitations in data availability and as such, further research should design a different method of collecting data and focus on analysing the direction of causality between climate variability and poverty.

REFERENCES

Adebayo, I., Yahaya, T., & Mohammed, B. (2018). Impact of Climate Variability on Livelihood of Communities in Kamuku National Park, Birnin-Gwari, Kaduna State. *Ethiopian Journal of Environmental Studies & Management*, *11*(4).

Ademe, A. S., Kassa, B., Goshu, D., & Mwanjalolo, M. (2017). Effect of Climate Variability on Crop Income in Central Ethiopia. *Turkish Journal of Agriculture-Food Science and Technology*, *5*(12), 1536-1543.

Ali, A. A. G., & Thorbecke, E. (2000). The state and path of poverty in Sub-Saharan Africa: some preliminary results. *Journal of African Economies*, *9*(Supplement_1), 9-40.

Arshad, M., Kächele, H., Krupnik, T. J., Amjath-Babu, T. S., Aravindakshan, S., Abbas, A. & Müller, K. (2017). Climate variability, farmland value, and farmers' perceptions of climate change: implications for adaptation in rural Pakistan. *International Journal of Sustainable Development & World Ecology*, *24*(6), 532-544.

Asfaw, S., & Maggio, G. (2018). Gender, weather shocks and welfare: Evidence from Malawi. *The Journal of Development Studies*, *54*(2), 271-291.

Auci, S., & Coromaldi, M. (2020). Climate variability and agricultural production efficiency: evidence from Ethiopian farmers. *International Journal of Environmental Studies*, 1-20.

Azzarri, C., & Signorelli, S. (2020). Climate and poverty in Africa South of the Sahara. *World development*, *125*, 104691.

Bakshi, B., Nawrotzki, R. J., Donato, J. R., & Lelis, L. S. (2019). Exploring the link between climate variability and mortality in Sub-Saharan Africa. *International Journal of Environment and Sustainable Development*, *18*(2), 206-237.

Barbier, E. B., & Hochard, J. P. (2018). Land degradation and poverty. *Nature Sustainability*, *1*(11), 623-631.

Bhattacharjee, K., & Behera, B. (2018). Determinants of household vulnerability and adaptation to floods: Empirical evidence from the Indian State of West Bengal. *International journal of disaster risk reduction*, *31*, 758-769.

Birthal, P. S., Negi, D. S., Kumar, S., Aggarwal, S., Suresh, A., & Khan, M. (2014). How sensitive is Indian agriculture to climate change?. *Indian Journal of Agricultural Economics*, *69*(902-2016-68357), 474-487.

Bohra-Mishra, P., Oppenheimer, M., Cai, R., Feng, S., & Licker, R. (2017). Climate variability and migration in the Philippines. *Population and environment*, *38*(3), 286-308.

Bouzarovski, S., & Tirado Herrero, S. (2017). The energy divide: Integrating energy transitions, regional inequalities and poverty trends in the European Union. *European Urban and Regional Studies*, *24*(1), 69-86.

Bryan, E., Ringler, C., Okoba, B., Koo, J., Herrero, M., & Silvestri, S. (2011). *Agricultural management for climate change adaptation, greenhouse gas mitigation, and agricultural productivity: Insights from Kenya* (No. 1098). International Food Policy Research Institute (IFPRI).

Casillas, C. E., & Kammen, D. M. (2010). The energy-poverty-climate nexus. *Science*, *330*(6008), 1181-1182.

Dallmann, I., & Millock, K. (2017). Climate variability and inter-state migration in india. *CESifo Economic Studies*, *63*(4), 560-594.

Dickey, D. A., & Fuller, W. A. (1979). Distribution of the estimators for autoregressive time series with a unit root. *Journal of the American statistical association*, *74*(366a), 427-431.

Dillon, A., McGee, K., & Oseni, G. (2014). *Agricultural production, dietary diversity, and climate variability*. The World Bank.

Dollar, D., & Kraay, A. (2002). Growth is Good for the Poor. *Journal of economic growth*, *7*(3), 195-225.

Fiyaz, R. A., Ajay, B. C., Ramya, K. T., Kumar, J. A., Sundaram, R. M., & Rao, L. S. (2020). Speed Breeding: Methods and Applications. In *Accelerated Plant Breeding, Volume 1* (pp. 31-49). Springer, Cham.

Fosu, A. K. (2008). Inequality and the growth–poverty nexus: specification empirics using African data. *Applied Economics Letters*, *15*(7), 563-566.

Gray, C., & Wise, E. (2016). Country-specific effects of climate variability on human migration. Climatic change, 135(3-4), 555-568.Gondhalekar, D., & Ramsauer, T. (2017). Nexus city: operationalizing the urban water-energy-food nexus for climate change adaptation in Munich, Germany. *Urban Climate*, *19*, 28-40.

Ghosh, M., & Ghosal, S. (2020). Determinants of household livelihood vulnerabilities to climate change in the himalayan foothills of West Bengal, India. *International Journal of Disaster Risk Reduction*, 101706.

Gohar, A. A., & Cashman, A. (2016). A methodology to assess the impact of climate variability and change on water resources, food security and economic welfare. *Agricultural Systems*, *147*, 51-64.

Hallegatte, S., Bangalore, M., Bonzanigo, L., Fay, M., Narloch, U., Rozenberg, J., & Vogt-Schilb, A. (2014). *Climate change and poverty—an analytical framework*. The World Bank.

Hansen, J., Hellin, J., Rosenstock, T., Fisher, E., Cairns, J., Stirling, C., ... & Campbell, B. (2019). Climate risk management and rural poverty reduction. *Agricultural Systems*, *172*, 28-46.

Hayes, J., & Knox-Hayes, J. (2014). Security in climate change discourse: analyzing the divergence between US and EU approaches to policy. *Global Environmental Politics*, *14*(2), 82-101.

Headey, D. D. (2016). *Food prices and poverty*. The World Bank.

Herrera, C., Ruben, R., & Dijkstra, G. (2018). Climate variability and vulnerability to poverty in Nicaragua. *Journal of Environmental Economics and Policy*, *7*(3), 324-344.

Herrero, S. T. (2017). Energy poverty indicators: A critical review of methods. *Indoor and Built Environment*, *26*(7), 1018-1031.

Hong, Z., & Sun, Y. (2020). Power, capital, and the poverty of farmers' land rights in China. *Land Use Policy*, *92*, 104471.

Intergovernmental Panel on Climate Change (2017) Climate Change -The Physical science Basis; Fourth Assessment Report of the Intergovernmental Panel on Climate Change; Cambridge University Press: Cambridge, UK.

Ivanic, M., & Martin, W. (2014). *Short-and long-run impacts of food price changes on poverty*. The World Bank.

Johansen, S. (1988). Statistical analysis of cointegration vectors. Journal of economic dynamics and control, 12(2-3), 231-254.

Jones, L., Samman, E., & Vinck, P. (2018). Subjective measures of household resilience to climate variability and change. *Ecology and Society*, *23*(1).

Kabubo-Mariara, Jane, and Millicent Kabara, (2015). "Environment for Development."#

Kaczan, D. J., & Orgill-Meyer, J. (2020). The impact of climate change on migration: a synthesis of recent empirical insights. *Climatic Change*, *158*(3), 281-300.

Karfakis, P., Lipper, L., & Smulders, M. (2012). The assessment of the socioeconomic impacts of climate change at household level and policy implications. In *Building resilience for adaptation to climate change in the agriculture sector. Proceedings of a Joint FAO/OECD Workshop, Rome, Italy, 23-24 April 2012* (pp. 133-150). Food and Agriculture Organization of the United Nations (FAO).

Koubi, V., Bernauer, T., Kalbhenn, A., & Spilker, G. (2012). Climate variability, economic growth, and civil conflict. *Journal of peace research*, *49*(1), 113-127.

Leichenko, R., & O'Brien, K. (2008). *Environmental change and globalization: double exposures*. Oxford University Press.

Leichenko, R., & Silva, J. A. (2014). Climate change and poverty: vulnerability, impacts, and alleviation strategies. *Wiley Interdisciplinary Reviews: Climate Change*, *5*(4), 539-556.

Liu, Y., & Wang, Y. (2019). Rural land engineering and poverty alleviation: Lessons from typical regions in China. *Journal of Geographical Sciences*, *29*(5), 643-657.

Malpeli, K. C., Weiskopf, S. R., Thompson, L., & Hardy, A. R. (2020). What are the effects of climate variability and change on ungulate life-histories, population dynamics, and migration in North America? A systematic map protocol. *Environmental Evidence*, *9*(1), 1-9.

Mburu, B. K., Kungu, J. B., and Muriuki, J. N. (2015). Climate Change adaptation strategies by small-scale farmers in Kenya: Kenyatta University, NairobiKenya.

Njoya, E. T., & Seetaram, N. (2018). Tourism contribution to poverty alleviation in Kenya: A dynamic computable general equilibrium analysis. *Journal of Travel Research*, *57*(4), 513-524.

Ochieng, J., Kirimi, L., & Mathenge, M. (2016). Effects of climate variability and change on agricultural production: The case of small scale farmers in Kenya. *NJAS-Wageningen Journal of Life Sciences*, *77*, 71-78.

Odhiambo, N. M. (2009). Finance-growth-poverty nexus in South Africa: A dynamic causality linkage. *The Journal of Socio-Economics*, *38*(2), 320-325.

Ofulla, A. V. O., Gichere, S. K., Olado, G. O., Abuom, P. O., Anyona, D. N., Othero, D. M., ... & Owuor, P. O. (2016). Effects of regional climate variability on the prevalence of diseases and their economic impacts on households in the Lake Victoria basin of Western Kenya. *International Journal of Global Warming*, *10*(1-3), 332-353.

Okonkwo, E. A., Arua, R. N., & Agbo, F. U. (2015). Effects of climate variability on the choices of livelihood among farm households in Anambra State, Nigeria. *African journal of agricultural research*, *10*(44), 4134-4141.

Okushima, S. (2017). Gauging energy poverty: A multidimensional approach. *Energy*, *137*, 1159-1166.

Otieno, N.(2019). Effect of climate change on agricultural productivity in Kenya. Unpublished Masters Thesis, Kenyatta University.

Phiri, D., Morgenroth, J., & Xu, C. (2019). Long-term land cover change in Zambia: An assessment of driving factors. *Science of The Total Environment*, *697*, 134206.

Ponnampalam, E. N., Dunshea, F. R., & Warner, R. D. (2020). Use of lucerne hay in ruminant feeds to improve animal productivity, meat nutritional value and meat preservation under a more variable climate. *Meat Science*, *170*, 108235.

Randell, H., & Gray, C. (2016). Climate variability and educational attainment: Evidence from rural Ethiopia. *Global environmental change*, *41*, 111-123.

Ray, D. K., Gerber, J. S., MacDonald, G. K., & West, P. C. (2015). Climate variation explains a third of global crop yield variability. *Nature communications*, *6*(1), 1-9.

Republic of Kenya (2001), Poverty Reduction Strategy Paper, 2001-2004. Nairobi: Ministry of Finance and Planning. June, 2001

Singh, R. K., Zander, K. K., Kumar, S., Singh, A., Sheoran, P., Kumar, A., ... & Padung, E. (2017). Perceptions of climate variability and livelihood adaptations relating to gender and wealth among the Adi community of the Eastern Indian Himalayas. *Applied Geography*, *86*, 41-52.

Teklewold, H., Mekonnen, A., & Kohlin, G. (2019). Climate change adaptation: a study of multiple climate-smart practices in the Nile Basin of Ethiopia. *Climate and Development*, *11*(2), 180-192.

Thiede, B., Gray, C., & Mueller, V. (2016). Climate variability and inter-provincial migration in South America, 1970–2011. *Global Environmental Change*, *41*, 228-240.

Thornton, P. K., Ericksen, P. J., Herrero, M., & Challinor, A. J. (2014). Climate variability and vulnerability to climate change: a review. *Global change biology*, *20*(11), 3313-3328.

Thurlow, J., Zhu, T., & Diao, X. (2012). Current climate variability and future climate change: estimated growth and poverty impacts for Zambia. *Review of Development Economics*, *16*(3), 394-411.

Udry, C. (1996). Gender, agricultural production, and the theory of the household. *Journal of political Economy*, *104*(5), 1010-1046.

Uitto, J. I. (2016). The Environment-poverty Nexus in Evaluation: Implications for the Sustainable Development Goals. Global Policy, 7(3), 441-447.

Weldearegay, S. K., & Tedla, D. G. (2018). Impact of climate variability on household food availability in Tigray, Ethiopia. *Agriculture & Food Security*, *7*(1), 6.

Wheeler, T., and Von Braun, J. (2013). Climate change impacts on global food security. Science, 341 (6145), 508-513.

Wossen, T., & Berger, T. (2015). Climate variability, food security and poverty: Agent-based assessment of policy options for farm households in Northern Ghana. *Environmental Science & Policy*, *47*, 95-107.

Wossen, T., Berger, T., Haile, M. G., & Troost, C. (2018). Impacts of climate variability and food price volatility on household income and food security of farm households in East and West Africa. *Agricultural systems*, *163*, 7-15.