UNIVERSITY OF GHANA

CLIMATE CHANGE AND INCOME INEQUALITY IN AFRICA

BY

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DECLARATION

I, Sylvana Poziema Zuanah, do hereby declare that this thesis has not been documented for the presentation in this or any other University. I, therefore, declare that this thesis is my own work and all references have been duly acknowledged. I take sole responsibility for any shortcomings that may be found in this thesis.

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Sylvana Poziema Zuanah   Date

CERTIFICATION

I hereby certify that this thesis was supervised in accordance with procedures laid down by the University of Ghana.

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Date

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Date

DEDICATION

I dedicate this research work to my family and loved ones.

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LIST OF ABBREVIATIONS

AfDB	African Development Bank
AGRA	Alliance for a Green Revolution in Africa
ASEAN	Association of Southeast Asian Nations
EPIC	Erosion Productivity Impact Calculator
FAO	Food and Agriculture Organization
GDP	Goss Domestic Product
GMM	Generalized Method of Moments
IPCC	Intergovernmental Panel on Climate Change
MDGs	Millennium Development Goals
ND-GAIN	Notre Dame Global Adaptation Index
NEPAD	New Partnership for Africa's Development
NOAA	National Oceanic and Atmospheric Administration
OECD	Organisation for Economic Co-operation and Development
SDGs	Sustainable Development Goals
SSA	Sub-Saharan Africa
UNDESA	United Nations Department of Economic and Social Affairs
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
WDI	World Development Indicators

ABSTRACT

Policymakers and governments have raised concerns about the rate at which global climate change is occurring. The adverse impact of climate change on the environment and ecosystems has necessitated the formulation of mechanisms to address its effects. Empirical evidence has shown that climate change greatly affects health, water and food supply, and economic growth in Africa. However, given the emerging nature of climate change studies, little research has examined its impact on income inequality in Africa. This study therefore sought to examine the effects of climate change on income inequality in Africa and determine how climate adaptative capacity moderates such effects.

The study used the two-step System Generalized Method of Moments (GMM) estimator to analyse secondary data for 37 African countries from 1995 to 2015. Using temperature change anomaly and Carbon dioxide as measures for climate change, the study found that rising temperatures have a negative and significant relationship with income inequality. The study also found agricultural productivity to be the main channel through which climate change affects inequality in Africa. As crop and livestock productivity decreases, income inequality in Africa increases. In examining the moderating role of adaptive capacity in the climate change and income inequality nexus, the study found that, Africa's adaptive capacity does not moderate the threat of climate change on income inequality.

The study recommends that adaptation efforts should be channelled specifically to the agricultural sector, particularly the poor small-scale farmers who are affected by the negative consequences of climate change in order to reduce the disparity in income distribution in Africa.

Keywords: Adaptive Capacity, Africa, Climate Change, Agriculture, Income Inequality

CHAPTER ONE

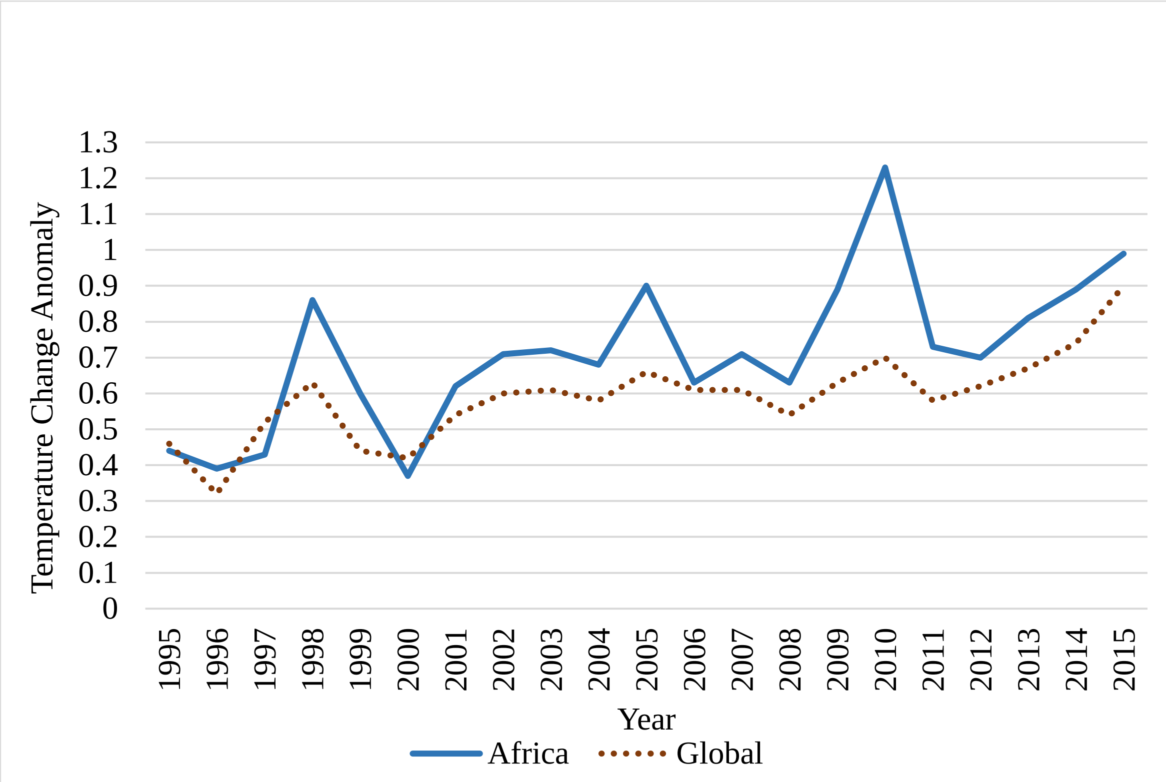
INTRODUCTION

1.1 Background of Study

The recent change in climate has become a global threat, making it an existential issue to be confronted by both developing and developed economies. Some researchers argue that climate change is largely induced by human activities such as the combustion of fossil fuel, deforestation, vegetation burning, population and economic growth (Höök & Tang, 2013; Peterson, Connolley, & Fleck, 2008; IPCC, 2007; Denton, 2002; Arrhenius, 1895). The major indicators of climate change include temperature change anomaly which is a deviation from expected average temperatures, precipitation and carbon dioxide emissions (Hatfield *et al.*, 2018; World Meteorological Organization, 2017).

Annual global temperatures in particular have risen in recent times and global temperature anomalies have been reported to increase every three years since the dawn of the twenty-first century (Global Climate Report, 2017). Climate change has been a peculiar issue of concern in Africa because the warmest temperatures that have occurred on the globe have been recorded in the region (NOAA, 2019a). In recent times, temperature change anomalies in Africa have risen above the average global temperature change anomaly. As shown in Figure 1.1, the years 1995, 1997 and 2000 were the only periods that had global temperature change anomaly exceeding that of Africa within a 21-year period. These temperatures in Africa have therefore consistently been warmer than the expected global averages. The highest temperature change anomaly in Africa occurred in 2010 at 1.23°C, exceeding the global temperature anomaly (of 0.70°C) by 0.53°C (NOAA, 2019a).

Figure 1.1 Temperature Change Anomalies for Africa and the World, 1995 – 2015



Source: National Oceanic & Atmospheric Administration (NOAA, 2019a).

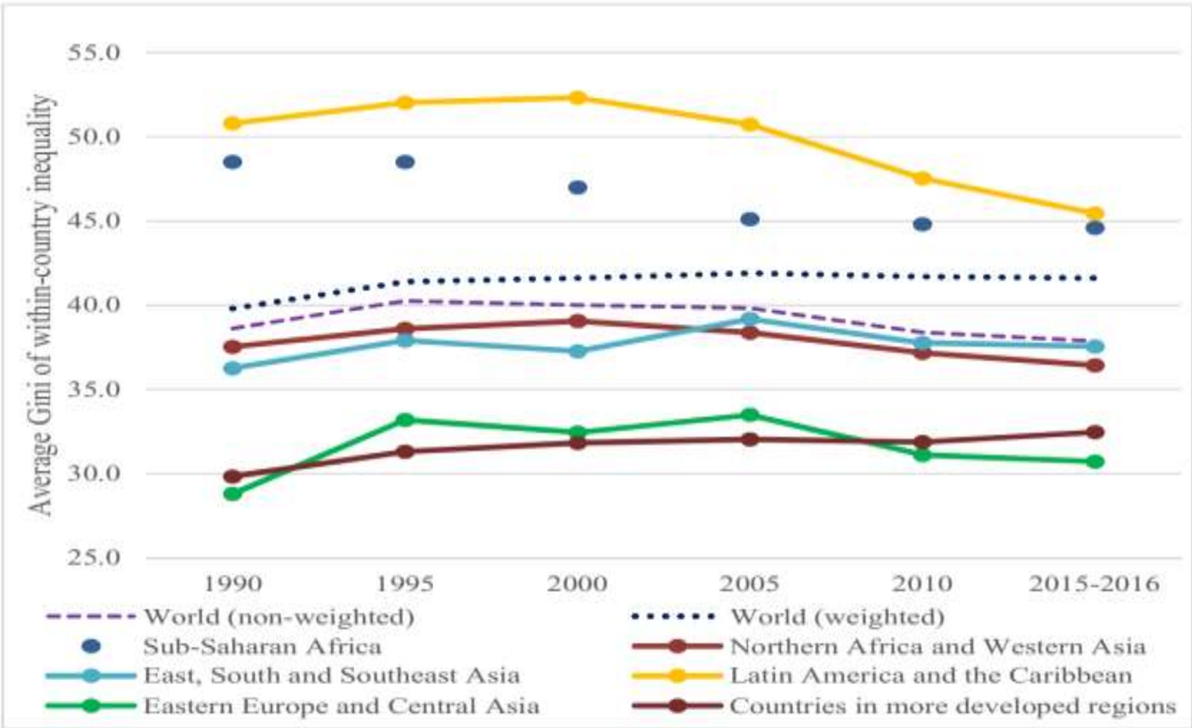
The implication of climate change is the negative impact it has on natural systems which in turn affects human welfare. Less Developed Countries (LDCs) have been found to suffer the most from the negative impact of climate change due to their greater dependence on agriculture for livelihood (Welborn, 2018; Hallegatte *et al.*, 2016; IPCC, 2014). Researchers have found evidence that climate change leads to a reduction in crop yield, health problems, reduced productivity, and water insecurity (Macpherson, 2013; Mckibben, 2009; Rosenzweig & Parry, 1994). In order to adapt to the negative consequences of climate change, countries need to build strong adaptive capacities mostly in the form of resources, technology and institutions.

While richer economies have the capability and resources to adapt and cope with damages caused by climate change, developing countries may be severely affected in the event of extreme weather shocks. In order to help the vulnerable build resilience to destructions caused by climate change, international organizations and developed nations have made commitments to channel funds to augment the adaptive capacity and resilience of those affected. The adaptive capacity is an indication of a country's ability rebound from the damaging effects of climate change. The World Bank intends to provide funding of about $200 billion between the period of 2021 and 2025 to help the world's poorest build resilience to climate change (World Bank, 2018).

The negative consequences of climate change on Africa tends to be immense due to its reliance on agriculture. Agriculture is the primary occupation in Africa and employs the majority of the population, especially the poor in rural communities. Since earnings of the poor are largely sourced from the agricultural sector, climate change potentially widens the income distribution gap between agriculture and non-agriculture workers. Income inequality refers to the disparity in the distribution of income among a population. Latin America and the Caribbean has persistently recorded the highest income inequality in the world, but this has declined since the year 2000 as shown in Figure 1.2. Similarly, income inequality appears to be reducing from the year 2005 to 2016 in East, South and Southeast Asia, Eastern Europe and Central Asia. However, the trend for sub-Saharan Africa depicts a decline in inequality between the period 1995 and 2005 and then stabilized at an average rate of about 45 percent until 2016. Africa remains the second most unequal regions in the world even though policies such as the sustainable Development Goals (SDGs) have been implemented by the United Nations (Odusola, Cornia, Bhorat, & Conceição, 2017).

Examining climate change in light of income inequality becomes essential because inequality undermines the efforts of the poor in escaping hunger and poverty (Oxfam, 2014). Efforts to reduce poverty in developing economies is hampered and rendered ineffective in the face of persisting inequality. Drawing the link between climate change and income inequality is also important because it provides a potential explanation for the persistently high level of inequality in Africa in recent years. The global rise in temperature anomalies and carbon emissions have also necessitated the implementation of adaptation mechanisms and mitigation strategies to contain the fallout of climate change.

Figure 1.2 Trends in Income Inequality by Region, 1990-2016



Source: UNDESA (2019), Calculations based on data from UNU-WIDER's World Income Inequality Database, version 4 and the World Development Indicators Databank

1.2 Problem Statement

Climate change has become a topical issue because of the implications it has on human existence. Scholars have emphasized the impact of climate change on health, water security, economic growth, poverty and crop production (Dell, Jones, & Olken, 2013; Hope, 2009; Collier, Conway & Venables, 2008; Thornton *et al.*, 2008; Adams, 1989). Adverse climate change impact on crop yields and livestock production have been experienced in tropical climate zones such as Africa, South America and South – East Asia where temperatures are consistently high (Ncube, Anyanwu, & Hausken, 2014; Barrios, Ouattara, & Strobl, 2008; Maddison, 2007; Jones & Thornton, 2003; Rosenzweig & Parry, 1994).

The significance of agriculture in African economies cannot be overlooked; it is the key to solving poverty and economic growth issues in Africa (NEPAD, 2013). The agriculture sector employs about 70% of Africans in smallholder farming and contributes more than 50% to GDP in some countries in the region (AGRA, 2017). Despite the critical role of the agriculture sector in providing food security, boosting growth and reducing poverty, Africa's per capita agricultural productivity has not progressed in the past few decades (UNDP, 2008). A contributory factor to this stagnating growth in productivity is the change in rainfall patterns and rising temperatures. Odusola and Abidoye (2015) found that changes in temperature and rainfall patterns significantly affect agricultural productivity in Africa. They established that a 1˚C increase in temperature results in a 1.58 percentage points decline in economic growth. In order to adapt to the adverse impacts of climate change, countries need to build strong adaptive capacities mostly in the form of resources, technology and institutions. Countries in Africa are considered to be highly vulnerable to climate change due to their limited capacity to respond to climate-related shocks (Stern, 2006).

The adverse effects of climate change on Africa's agriculture, has potentially reduced the income of agricultural workers because of low farm outputs. This tends to increase the disparity in income distribution between agricultural workers who are mostly the poor in rural areas and non-agricultural workers. This disparity in income distribution between the rich and the poor has significantly remained high despite efforts to make income shares more equitable through policies such as the Sustainable Development Goals (Shimeles & Nabassaga, 2018).

Empirically, researchers have shown that high income inequality in Africa is influenced by the level of Africa's development, population growth, level of education, natural resource rents, domestic investments, government consumption expenditure, trade openness, foreign investments, among others (Shimeles & Nabassaga, 2018; Anyanwu, 2016; Mallaye, Timba & Yogo, 2015; Gyimah-Brempong, 2003). Extant literature on income inequality has focused on the economic, political and social factors that affect income distribution. Few empirical studies have however been done to show the possible impacts of environmental factors such as climate on the distribution of income in Africa. Among such studies is the work of Diffenbaugh and Burke (2019) who investigated the effect of global warming on the trends and development in economic inequality across countries. They used historical and natural climate models to generate a measure for temperature for different countries and found that, increase in economic inequalities are largely as a result of human-induced climate change. Their study also measured economic inequality as the population-weighted percentiles of per capita GDP distribution. This study differs from their work in that, the Gini coefficient, which is arguably the most appropriate measure for inequality, is used to empirically examine the relationship between climate change and income inequality in Africa. This research further seeks to investigate the role of Africa's adaptive capacity in moderating the impact of climate change on income inequality.

1.3 Research Objectives

The primary objective of this study is to understand the link between climate change and income inequality in Africa. Specifically, the study seeks

1. To examine the impact of climate change on the distribution of income in Africa.

2. To determine the mediating effect of agricultural productivity on the relationship between climate change and income inequality in Africa.

3. To understand how climate adaptive capacity moderates the relationship between climate change and income inequality in Africa.

1.4 Significance of the Study

Analysing the impact of climate change on income inequality provides a means of determining the most effective ways of promoting policies and actions that reduce the negative impacts of climate change. This study is extremely important because policymakers have channelled efforts to help highly vulnerable countries cope with and recover from the adverse outcomes of climate change. The Climate adaptation funds are meant to help countries boost their adaptive capacities and to enforce strategies to withstand climate impacts. If a stronger adaptive capacity would indeed lessen the impact of climate change, then it would have some implications for income inequality reduction. This would provide a basis for strengthening the allocation of climate funds to the most vulnerable sectors of a countries.

Practitioners will find this study useful by providing guidelines to governments and various stakeholder organizations that are keen on dealing with climate change threats by way of increasing resilience and mitigating GHG emissions. The adverse effects of climate change will be emphasized in light of income inequality. This would speed up the establishment of measures that are needed to make the society more equal. Such efforts include ensuring that emission laws are adhered by both developed and developing economies and also, channelling funds to the most climate-affected employment sectors to help reduce income inequality.

This study is also relevant because given the emerging nature of both climate change and income inequality studies, little literature exists with regards to drawing a link between these two phenomena. The study therefore contributes to the limited body of knowledge in the inequality literature by empirically establishing a relationship between climate change and income inequality.

1.5 Limitation of the Study

This research examines the link between climate change and income inequality in Africa, and how adaptation to changing climate moderates this relationship. The study is restricted to 37 out of 54 African countries which were selected due to data availability problems. The results obtained from this study may therefore not be a true representation of the entire African case, and may also not be applicable to other non-African nations.

The impact of climate change is better assessed over a considerably long period of time (usually over 30 years). The study examined the impact of climate change over a twenty-one-year period (1995-2015). Unavailability of data for key variables used in the study accounted for the shorter study period. This is comparatively a shorter time period to conclude on the consequences of climate change on income inequality.

1.6 Organisation of the Study

The study is presented in five chapters. The first chapter provides an overview and background to the study, and also outlines the objectives and significance of the research. Chapter Two extensively examines empirical and theoretical literature on climate change and the distribution of income as well as the linkages between them. Chapter Three shows the methods used for the collection and estimation of data as well as the procedures used for the data analysis. The fourth chapter discusses the findings of the study and their relationship with related works done on the subject of income inequality and climate change. The last chapter provides the summary, conclusion, and some implications and recommendations for the formulation of policy and further research.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Most climate change studies have revealed the adverse impacts it has on human existence. Greater concerns have been raised on the potential impacts it would have on the world in few decades to come. The changing climatic systems have proven to be disadvantageous to economic growth, agricultural productivity, health and political stability. Concerned organizations, governments and individuals have therefore amassed efforts to help control the factors that cause climate change, and have also sought to provide funds for the most affected societies. Examining the consequences of changing weather patterns on present existence is essential for formulating and implementing mechanisms that minimize any potential future impact. This chapter therefore seeks to review the studies done on climate change and its impacts on economic systems, with particular focus on income inequality.

2.2 Income inequality

Inequality is a multidimensional concept (has dimensions of wealth, income, consumption, opportunities) that has different approaches to its measurement. According to Cowell (1995) inequality is an obvious deviation from an elementary idea of equality – the fact that two or more numbers are equal in size. The focus of this research is the income distribution dimension of inequality.

Income inequality refers to the disparity in the distribution of income and achievements among people. Income inequality goes beyond distributional discrepancies to include the denial of fair enjoyment of rights and freedoms (UNICEF & UN Women, 2013). Income inequality mostly leads to other multiple forms of inequalities (such as social, opportunity) associated particularly with marginalized groups due to disabilities, gender, race or ethnicity (Kabeer, 2010). Recent literature show that the various forms of inequalities are interdependent on each other. For instance, Income inequality inhibits equal opportunities for individuals to succeed in life and at the same time, inequality in opportunities result in income inequality (UNDP, 2013).

It has become necessary to give attention to the issue of income inequality because it negatively affects poverty reduction measures and stifles progress towards the attainment of SDGs. Fosu (2017) found that unequal income distribution weakens the poverty-reducing tendency of economic growth in developing countries. Inequality also has the potential of inhibiting economic growth (Ncube *et al.*, 2014; Okojie & Shimeles, 2006; Persson & Tabellini, 1994) and stability since the views of the poor and marginalized are often not represented (Dabla-Norris, Kochhar, Suphaphiphat, Ricka, & Tsounta, 2015). Conflicts and political instability may arise because of damaged trust and social cohesion because of unfair income distribution. These conflicts ultimately affect people's happiness, discourage investments and hurt growth (Anyanwu, 2016).

Researchers have expressed different views on the factors the influence income distribution. The lack of unanimity of views has been linked to the fact that income distribution is an outcome of economic processes and issues (Bigsten, 1983). In order to devise inequality-reducing strategies, it is essential to comprehend the causes of such income disparities within and among countries. The forces that drive inequality are generally classified as political, economic and demographic factors (Milanovic, 2016). These forces include technological change, civil conflicts and war, domestic investment, education, globalization and economic development.

2.3 Drivers of Income Inequality

2.3.1 Past Income Inequality Levels

The lagged value of income inequality usually is expected to influence subsequent levels of inequality. This driver of current income inequality values provides evidence that income inequality has the tendency to persist over time. Some scholars have empirically shown that income inequality changes slowly over time and thus, is not characterised by rapid change (Anyanwu, 2016; Mahmood, Noor, & Law, 2014; Bahmani-oskooee *et al.*., 2008; Gupta, Davoodi, & Alonso-Terme, 1998). Gupta *et al.*(1998) included the lagged values of income inequality in establishing the link between corruption and unequal income distribution, in order to control for possible omission of essential variables. The current levels of income inequality have therefore been suggested to be influenced by past levels of income inequality. This is an indication that the relationship between current and past income distribution levels is positive.

2.3.2 Economic Development Levels

At initial stages of a nation's development, income inequality increases, moves to a peak as the economy further grows, and then declines with higher levels of economic development (Kuznets, 1955). Kuznets (1955) argued that at the initial stages where an economy is largely agrarian, income inequality is usually low. However, as nations economically advance towards secondary and tertiary sectors, income inequality levels rise. Finally, when a country has reached a stage of high economic development, income inequality then tends to reduce as the economy grows. This indicates that GDP per capita will have a positive relationship with income inequality for developing economies, but show a negative relationship with inequality when GDP per capita is sufficiently high as with developed countries. Empirical evidence on the hypothesized inverted-U relationship between unequal income distribution and economic development has been provided for OECD nations (Alderson & Nielsen, 2002), the United

States of America (Dincer & Gunalp, 2012), ASEAN-5 economies (Seneviratne & Sun, 2013), and West Africa (Anyanwu, 2016).

While most studies have confirmed the Kuznets hypothesis in the economic growth and income inequality relationship, some have found no evidence of its existence. Harris (1993) provided evidence that the Kuznets inverted U-shaped theory has become U-shaped in the US and hence, the hypothesis does not hold anymore. Ram (1991) confirmed this finding by showing that the inverted-U hypothesis was contradictory to the actual relationship between economic development and income distribution. New evidence on the relationship between economic development and income inequality emphasize that, the validity of Kuznets hypothesis is potentially flawed (Hossain, 2013).

Alessina and Perotti (1993) highlighted some mechanisms through which unequal income distribution affects development of economies. They argued that this type of inequality insights rent-seeking behaviour and indulgence in illegal activities by the poor, which discourages investments and hence, economic growth. Also, they were of the view that unequal income distribution induces the poor who mostly comprise the majority of the people to enforce fairer redistribution of income by voting for higher taxation. Higher tax rates reduce after-tax marginal product of capital which further reduces the speed at which capital is accumulated and thus, decreases economic growth. Income inequality also affects growth through the stability channel, which suggests that a large proportion of poor citizens demand radical changes that lead to violence, instability and ultimately affect investment opportunities.

2.3.3 Domestic Investment

The relationship between domestic investment (gross capital formation) and income inequality has been found to be negative in Korea (Lee, Kim, & Cin, 2013) and in Pakistan (Chaudhry & Imran, 2013). This relationship occurs when an increase in capital investments (in infrastructure and industries) offers more people jobs, and in turn increases the proportion of income earners. This consequently leads to a decrease in income inequality in the country.

On the contrary, Anyanwu (2016) found that increasing domestic investment in West Africa by a one percentage point would increase income inequality by 0.08 percentage point. Also, Székely and Sámano (2012) found no significant link between the two variables in Latin America.

2.3.4 Democracy

There is both empirical and theoretical evidence to show that income distribution and democracy are related. The empirical evidence on democracy and income distribution studies are mixed; some researchers have found the relationship to be positive (see Lee, 2005; Balcazar, 2016; Islam, 2016), negative (Amendola, Easaw, & Savoia, 2013; Ahmad, 2017) and others have found no link between them (Timmons, 2010; Acemoglu, Naidu, Restrepo & Robinson, 2015). Reuveny and Lee (2003) have argued that democracy ensures the adoption of better redistributive measures such as progressive taxation, welfare spending and minimum wage legislation. Gradstein and Milanovic (2004) also highlighted that fair income distribution usually exists in countries that are highly democratized as opposed to autocratic countries. This view supports the median voter theory which suggests that if median income falls below the mean income, median voters would impose higher taxation on the rich and choose to redistribute income.

Literature further suggests that restrictions on voters' rights have led to high levels of income inequality while democratization has improved the distribution of income. This indicates that an inverse relationship exists between income distribution and various measures of democracy. However, Acemoglu *et al.*(2015) propose a contrary view where democracy may actually worsen income inequality. They posit that this can occur when governments invest in obtaining de facto power and recompense the loss of de jure power by restricting income redistribution in order to satisfy their interests.

2.3.5 Natural Resources

The abundance of natural resources is a major driver of income distribution. Literature suggest that resource rents tend to widen the disparity in the distribution of income (Auty, 2004; Stevens, 2003; Fields, 1989). High income inequality levels in Latin America and sub-Saharan Africa have been attributed to the abundance of natural resources in those regions (Mckay *et al.*, 2003). A study by Buccellato and Alessandrini (2009) confirmed that a positive relationship exists between natural resources rents and income inequality, particularly for ores and metals .

A major channel through which natural resources affect income inequality has been identified to be rentierism. Auty (2004) indicates that reliance on natural resourses worsens the income disparity between the rich and the poor by creating rents that are easily captured by people in power. He further agrued that the ruling elite channel efforts into imeediately capturing most of the gains from rent extraction without considering the longterm advantages of competitive investments. Moreover, over dependence on natural resources also indirectly increases inequality by constraining the emergence of industralization. Leamer *et al.*(1999) argued that manufacturing enhances fairer income distribution by increasing the demand for human capital which results in an increase in the wages of unskilled labour. This tends to suggest that over reliance on natural resources will retard the development of other sectors of the economy and widen the income gap among the various sectoral workers.

In spite of the findings that show that the abundance of natural resources in an economy exacerbates income inequality, Mallaye *et al.*(2015) found the relationship between oil resources and income distribution in developing countries to be negative. Anyanwu (2016) corroborates this finding in a study on African economies. This indicates that countries that are able to effectively manage their natural resources ensure equal benefits to the people through the provision of basic infrastructure, the creation of jobs, among others.

2.3.6 Trade Openness

Evidence on the existing relationship between the trade openness and income inequality remain inconclusive. The effects of trade openness on the distribution of income tends to differ between developed and developing nations (Polpibulaya, 2015). Polpibulaya (2015) showed that the relationship between inequality and trade openness could turn out to be positive or negative for countries at different stages of development. Developed economies that are open to trade tend to reap the benefits that comes with it due to the high level of technological progress, large skilled labour and a better government whereas the opposite is true for developing nations. By implication, for the full benefits of trade openness to be realized there is need for the aforementioned conditions to be realized. For developing countries trade openness may lead to unemployment, the shutdown of indigenous firms that are unable to compete with foreign firms which ultimately leads to lower wages. Anderson (2005) has demonstrated that an increase in the openness of trade has adverse effects on income distribution of developing nations through assets, spatial and gender inequality. Dollar and Kraay (2004) investigated the effects of globalization on inequality and poverty and found a strong negative relationship; globalization accelerates growth and reduces poverty in countries that are least developed. However, trade liberalization is not always likely to yield benefits as shown by empirical evidence. Thus, the evidence provided suggests that there is a tendency for poverty to prevail in least developed countries that exhibit a high level of openness to trade.

2.3.7 Population Growth

Population growth has been associated with income inequality and has been regarded as a contributing factor to the worsening inequality gap. It is widely considered that population growth stifles the increase in social infrastructure, decrease the income earned per person, and puts pressure on available natural resources, which lead to excess labour and unemployment (Rodgers, 1983). Rodgers (1983) has attributed the distribution of income to a number of reasons. According to the author, population growth widens the income gap when increases in labour outstrips available land size and the remuneration paid to labour force tend to reduce due to cheap labour relative to land and capital. He also indicated that the primary channel through which population growth affects income distribution is the ownership of land. Population growth promotes unequal distribution of land which further worsens the population of people who are landless. Rougoor and Marrewijk (2015) also showed that income inequality is affected by population growth through dependency ratio. This occurs when rapid growth of population is connected with higher youth dependency ratio, culminating the lag in economic growth. Nonetheless, Campante and Do (2007) have argued that countries that are densely populated experience less inequality by using a distributional channel. They indicated that when the population that demand for a different government is larger, relative to the total population, income distribution tends to be fair.

2.3.8 Foreign Direct Investment (FDI) Inflows

The IMF defines Foreign Direct Investment as an investment made in an economy by a non-resident who is a direct investor with the intention of sustaining a lasting relationship. Foreign Direct investment spans the initial investment made in the setting up of an enterprise as well as other capital transactions that goes into the establishment of the enterprises. These investments are so called if they reach a 10% threshold. Evidence suggests that FDI promotes economic growth, capital growth, productivity growth, and income distribution. In respect of income inequality, FDI has proven to be relevant in enhancing fair income distribution (Mah, 2012; Lipsey & Sjoholm, 2004). The positive impact of FDI on the distribution of income is realized through capital inflows and wage premium offered by foreign firms (Jensen & Rosas, 2007). te Velde (2003) draws on the works of other researchers and concludes on three kinds of channels through which FDI affects income inequality; technological transfers, knowledge transfer and the "composition effect". te Velde (2003) also finds empirically that an increase in FDI in Latin America reduces the income gap in the region. In as much as FDI has positive implications for the distribution of income, the positive effects tend to differ across sector – primary sector, manufacturing sector and services industry, with the manufacturing and services sector demonstrating a significant impact from FDI.

Whiles this may be true, other works suggest the existence of a positive relationship between FDI and Inequality, particularly in emerging economies (Sturm & De Haan, 2015; Jaumotte, Lall, & Papageorgiou, 2013; IMF, 2007; Behrman, Birdsall, & Szekely, 2003). These researchers have argued that, FDI inflows from developed nations to emerging economies has the possibility of increasing the relative demand for skilled labour which causes income inequality to increase.

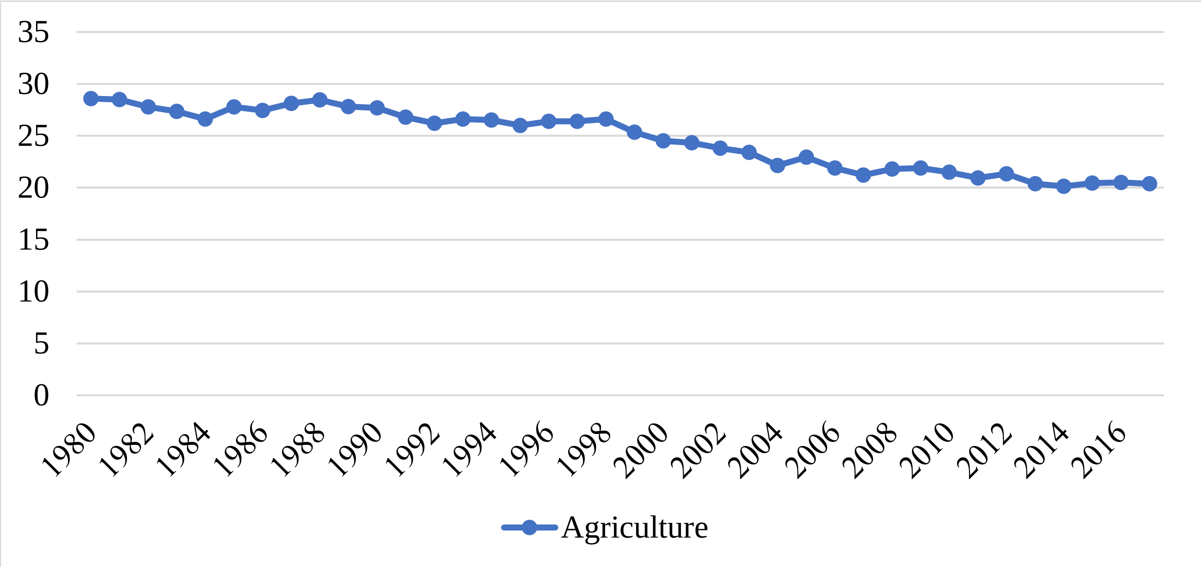
2.4 Conceptual Framework

Literature on the the linkages between climate change and inequalities has been shown to have some defects (Islam & Winkel, 2017). One of such defects is the absence of a unifying conceptual framework. This is corroborated by the IPCC (2014) Assessment Report 5 (AR5) which shows that there is no single conceptual framework to explain the complex relationship between climate change and inequality. Evidence suggests that there is a vicious cycle between the climate change and inequality through three main ways namely exposure, susceptibility and adaptive capacity. The framework underlying this study conceptualizes the relationship between climate change and income inequality as one that occurs through agriculture. Since climate change reduces agricultural productivity and hence agricultural income, the income gap between agricultural and non-agricultural workers potentially widens. The study therefore suggests that the main transmission channel between climate change and income inequality is agricultural productivity. This proposition is largely grounded on the fact that the informal sector (mostly agriculture and manufacturing) employs the greatest proportion of the people in Africa.

The agricultural sector of African countries like Mozambique, Guinea, Madagascar, Ethiopia and Uganda employs over 70% of the people who are mostly found in rural settlements (Gollin, 2010). This sector contributed about 17.5 percent to Africa's total GDP value in 2015, and over 30 percent to GDP in countries like Chad, Ethiopia, Kenya, Togo, Sierra Leone and Burkina Faso (Odusola, 2017). The agricultural sector contributes significantly to the growth of economies and the living conditions of people, especially the poor in rural communities (Alagidede *et al.*, 2016). An increase in economic growth has implication for standards of living, inclusive growth and income inequality. This emphasizes the fact that adverse climate change impacts which affect agricultural productivity, ultimately affect the distribution of income among the populace.

Agriculture in Africa has improved in the past few decades not due to increased agricultural productivity or better farm management mechanisms, but because of the intensification of fallowing systems, cultivation of uncultivated arable farm lands, and the expansion of farm lands (Odusola, 2017; Odusola, 2014). Despite the argument that agriculture has improved, the share of agriculture in Africa's GDP reduced by about 8.2 percentage points – from 28.6 percent in 1980 to 20.4 percent in 2017 as shown by Figure 2.1. This indicates that the value additions by agriculture to GDP in Africa has constantly reduced over the past few decades, potentially because of reduced crop yields or decreasing agricultural commodity prices. This further suggests that farmers, particularly those in rural Africa, suffer such income losses which can largely attributed to inadequate mechanized system of irrigation, droughts and desertification, changes in rainfall patterns, among other factors.

Figure 2. 1 Agriculture Sector Value Added (% GDP)



Source: World Development Indicators (Accessed: March, 2019)

2.5 Climate Change

Climate change refers to the variations in the average weather and seasonal patterns over a long period, usually over a decade. Humans and ecosystems depend on and are affected by climate patterns in aspects of existence such as food supply, water availability and health risks. Understanding climate change requires the integration of disciplines such as chemistry, geography, politics, biology and economics due to its complexity. There is so much controversy about the existence and causes of climate change. While some people deny the existence of climate change, a growing body of literature suggests that it is largely induced by human activities. For instance, Denton (2002) is of the view that climate change is as a consequence of anthropogenic factors such as fossil fuel and vegetation burning, deforestation, population growth and industrialization. Scientists have also reported that the rate at which global temperatures are increasing cannot simply be explained by natural variations (Lott, Christidis, & Stott, 2013; Barnett *et al.*, 2005; Adger, Saleemul, Brown, Conway, & Hulme, 2003; Alley *et al.*, 2003). The Intergovernmental Panel on Climate Change (IPCC), the UN's body that deals with climate issues, also reports that the rapid warming on the globe is attributable to human activity (IPCC, 2014).

Human economic activities produce greenhouse gases (GHG) as by-products that trap heat which would normally be reversed back into the atmosphere. The most destructive of such gases is carbon dioxide from fossil fuel combustion, vehicles, factories and power plants. Other greenhouse gases include nitrogen oxide and methane, which is produced from decaying garbage, mining operations, and rice paddies. Climate Change is usually manifested through happenings such as changes in cloud cover and precipitation, increases in average temperatures, increases in greenhouse gas emissions, melting glaciers and snow cover, and rising sea levels.

Recent years have recorded the warmest average temperatures and highest atmospheric carbon dioxide concentrations. The fast-rising average annual temperatures rose by 0.94°C in 2016 as the highest in the world's history (NOAA, 2019a). This trend has been projected by the IPCC to continue and increase by 3°C in the year 2100 (IPCC, 2014). Urgent measures need to be implemented to reduce the susceptibility of countries, especially developing countries, to the rapidly changing climate. Hence, the implementation of mitigation and adaptation mechanisms requires both national and global efforts since vulnerability is not only climate-dependent but also dependent on policy and development strategies.

2.5.1 Impact of Climate Change

Millions of people around the globe have suffered losses and destruction because of the effects of climate change. These impacts have necessitated the formulation of strategies to prevent further damages from escalating. While most nations acknowledge the harm caused by climate change and are willing to contribute their quotas to fight it, other governments have over the years shown lower commitment levels. For instance, the United States' President, Donald Trump has expressed his doubts about the existence of climate change and has withdrawn from the Paris Agreement (BBC, 2018). Contrary to the views of the United States, the total cost of climate change would equal at least 5 to 20% of the world's GDP yearly and perpetually (Stern, 2008).

An important thing to know about climate change impact is that they are irreversible. The irreversibility of the effects of human actions on the environment makes mitigation and adaptation strategies in addressing climate change all the more important. Changing weather patterns are a threat to the basic needs of life such as food supply, water availability, healthy living and the environment (Odusola & Abidoye, 2015; Dell, Jones & Olken 2012), particularly in low-income economies that contribute little to greenhouse emissions (IPCC, 2014). The main channel through which climate change affects developing countries is through agriculture (Mideksa, 2010; Guiteras, 2007; Kurukulasuriya *et al.*, 2006), industrial productivity (Mehic, 2018), political stability and aggregate investment (Dell, Jones, & Olken, 2008), and health (IPCC, 2014, 2007; Jankowska, Lopez-Carr, Funk, Husak, & Chafe, 2012; Tol, 2011).

2.5.2 Climate Change in Africa

Africa bears the brunt of negative climate change outcomes as suggested by many researchers and reports by climate change experts. Climate change is a peculiar subject of interest in Africa because of the weather dependent nature of most economic activities in the region. Agriculture still remains the biggest economic activity in Africa, employing about 70% of the people and contributing more than 50 per cent to GDP in some countries (AGRA, 2017). Subsistence farmers in sub-Saharan Africa who rely on rainfall for agricultural productivity are gradually experiencing the effects of weather pattern variations through declining crop yields.

Inadequate resources to cope with the adverse outcomes of the changing weather patterns makes Africa highly vulnerable to the effects of climate change. Africa is also characterised by high incidence of poverty, high illiteracy rates, inadequate and poor access to infrastructure, low technology and information, and degrading ecosystems which are DE-contributors to adaptive capacity (UNFCCC, 2007). Rapid population growth, deforestation and desertification, as well as the degrading nature of lands in Africa also have the potential of increasing risks associated with climate change. Some countries in the region are reported to have the most unstable seasonal climates in the universe. It has also been estimated that about a third Africans live in low rainfall zones and are exposed to droughts.

There is evidence to prove that temperatures in Africa are rapidly rising above average global temperatures. The average annual temperature in Africa in 2016 was the highest at 1.23°C, and exceeded global temperature change by 0.29°C (NOAA, 2019a). Christensen *et al.*(2007) posit that Africa is expected to record severe drought and flooding in some few decades to come due to global warming. Water scarcity and possible conflicts are also predicted to increase as almost all river basins in Africa are cross boundary (de Wit & Stankiewicz, 2011). Furthermore, rising temperatures exposure Africa to diseases like malaria, diarrhoea and tuberculosis (Guernier, Hochberg, & Guégan, 2004) and reduce life expectancy due to increased infectious diseases, hunger and malnutrition (WHO, 2004).

Climate-driven droughts have also led to mass migration of people (Fleming, 2019) and conflicts, especially in the horn of Africa where close to 13 million inhabitants face food shortages (Welborn, 2018). IPCC (2007, p. 449) also indicated that over 50% of Africa's ecosystems, habitats and species are endangered by changes in climate and has led to the migration of species and loss of habitat.

A report by the National Communications (2018) highlighted that countries along the coast of Gulf of Guinea, The Gambia, Senegal, Southern Africa, and Northern African countries around the Nile Delta risk being affected by future sea level. Moreover, in countries like Ghana and Gambia where a high percentage of the populace resident along coastal zones, relatively small sea level rises would be disastrous for these economies.

2.6 Empirical Review of Literature

2.6.1 Climate change and Economic Growth

Existing studies on the link between climate change and growth provide mixed results. While rising temperatures has been found to be beneficial (increasing economic growth) for countries in temperate zones where low crop productivity has been attributed to extremely cold weathers, emerging economies in tropical and sub-tropical regions have negatively been affected by climate change (Diffenbaugh & Burke, 2019; Parry, Rosenzweig, Iglesias, Livermore & Fischer, 2004; Rosenzweig & Parry, 1994). Bruckner and Ciccone (2011) attribute low incomes in sub-Saharan Africa to negative rainfall shocks while Hsiang and Jina (2014) found that GDP growth rates declined by 1.3 percentage points in some selected countries because of tropical cyclones (during 1950-2008).

Odusola and Abidoye (2015) also examined the impact of temperature and rainfall changes on economic growth and established that a 1˚C increase in temperature yields a 1.58 percentage points decline in economic growth. Fankhauser and Tol (2005) also corroborates the negative effects climate change has on growth by demonstrating that climate change leads to a reduction in investment, which in turn has implications for consumption and production output in the future. They also emphasized that high temperatures slow down labour productivity by reducing rate of learning and increasing climate-related health problems. In the presence of the aforementioned, low output resulting from climate change affects human capital accumulation and investment which in turn decreases future productivity.

Similarly, Alagidede and Adu (2014) show that the relationship between climate change and growth in sub-Saharan Africa is linear and monotonically decreases at a constant. This is due to the fact that temperatures in most sub-Saharan African countries exceed the threshold that exposes countries to decreasing income per capita. On the contrary, Alagidede, Adu and Frimpong (2016) by using a nonparametric approach, found an intrinsically nonlinear relationship between real per capita income and temperature. However, the study found that temperatures above 24.9°C would have a negative impact on SSA's economic performance.

Dell *et al.*(2008) found that high temperature levels in poorer countries have a greater impact on growth rates than on output levels through channels such as agriculture and industry, aggregate investments and political stability. In a related study, Dell *et al.*(2009) showed that as temperatures increased by one degree Celsius, the per capita output of countries significantly decreased by 8.9 percentage points. The authors however highlighted that about 50 per cent of the adverse short-run impact of rising temperatures could be reduced by long-run adaptation mechanisms. Even though they showed that the relationship between rising temperatures and GDP is negative, they did not attempt to provide any linkages to poverty levels and inequality. Empirical studies on climate variability impacts have generally proven that unusual temperatures, precipitation and other extreme weather conditions have economic implications for affected systems (Dell *et al.*, 2014).

2.6.2 Climate Change and Health

Extremely high temperatures have the potential of increasing health risks and mortality rates in affected regions (Scovronick *et al.*, 2018; Egondi *et al.*, 2012; Azongo, Awine, Wak, Binka, & Oduro, 2012; Diboulo *et al.*, 2012). The mortality cases can be traced to the increase in disease carrying insects, particularly mosquitoes. In Eastern Africa for example, the cases of malaria have increased in recent times because of warming temperatures (IPCC, 2014). Field *et al.*(2014) attribute increases in water-borne and vector-borne diseases in Eastern and Central Africa to heavy rainfalls. Such diseases include leishmaniasis, schistosomiasis, meningococcal meningitis and rift valley fever (RVF) endemics which usually occur in the Horn of Africa (Nguku *et al.*, 2010; Anyamba *et al.*, 2009).

Denman *et al.*(2007) highlight that climate change influences air pollution and aids the dispersion of pollutants in the atmosphere. Such atmospheric concentrations potentially affect human health when land cover and surface temperatures deplete the ozone layer over Africa (Zeng, Pyle, & Young, 2008; Stevenson *et al.*, 2006). The work capacity of labour is compromised by abnormally high temperatures and this is a peculiar issue in Africa because of the proportion of agricultural employees.

2.6.3 Climate Change and Agriculture

Extant literature has provided empirical evidence on the negative impact of climate change on crop yields and livestock productivity (Ncube *et al.*, 2014; Muller, Cramer, Hare, & Lotze-Campen, 2011; Thornton, Jones, Ericksen, & Challinor, 2011; Parry *et al.*, 2004; Rosenzweig & Parry, 1994). Li *et al.* (2015) found that the effects of precipitation and temperature changes on maize production in the United States differed from that of China – differences exist among regions and countries. They also examined the potential influence of economic and technological measures on lessening the adverse effects of high temperatures on crop yield and found that, a decrease in supply of crops causes the price of such crops to rise, incentivize farmers to produce more, which ultimately increase yields. Similarly, Jones and Thornton (2003) used the third order Markov rainfall model to forecast daily temperature and its impact on maize production and found that, overall maize production would reduce by 10% in Latin American and Africa in the year 2055.

Rosenzweig and Parry (1994) examined the link between world food prices, world hunger and climate change. They showed that a large gap exists in the climate agricultural impacts on advanced and less advanced countries in Latin American and Africa. Moreover, the study provided evidence to support the varying geographical impact of changing weather patterns on agriculture; climate change is beneficial to countries in temperate zones but extremely disadvantageous for countries in the tropical and sub-tropical zones. Barrios, Ouattara and Strobl (2008) also showed that total agricultural productivity declines in sub-Saharan Africa at a quicker pace than in other African countries.

Furthermore, Adejuwon (2006) showed that crop production in Nigeria would initially increase in the twenty-first century but quickly decline because of abnormal temperatures, radiation and carbon concentration. The case of South Africa is no different as output from agriculture decreases as climatic conditions worsen beyond expectations (Ncube *et al.*, 2014).

A study by Maddison (2007) also argued that productivity losses in countries like Niger and Burkina Faso would increase by 19.9% and 30.5% respectively even when adaptation strategies are completely in place. However, the findings were based on the Ricardian approach that uses the perceived value of each farmer's land rather than the observed value of the owner's property.

Irrespective of the fact that climate change adversely affects crop production in Africa, there are other factors like low investments, inadequate irrigation schemes, and lack of access to agricultural services which affect agricultural development in developing countries (Calzadilla *et al.*, 2013).

2.6.4 Climate Change and Poverty

Climate threats associated with water shortages, food security and adverse health implications made the achievement of the MDGs particularly difficult. The consequence of climate change on health, agriculture and water have the potential of increasing poverty in developing regions of the world (Stern, 2008) and adversely affecting human development (Hughes *et al.*, 2012; UNECA, 2010). According to Leichenko and Silva (2014), studying the linkages between poverty and climate change has many dimensions, and varies from one context to another.

Researchers have used various methodologies to examine the impact of climate change on poverty within and across countries; (Gentle & Maraseni, 2012; Skoufias, Rabassa, Olivieri, & Brahmbhatt, 2011; Brainard, Jones, & Purvis, 2009; Somanathan & Somanathan, 2009; Paavola, 2008). Skoufias *et al.*(2011) used economic growth models to make projections about the future path of climate change impact on poverty and found continual growth of an economy will generally accelerate poverty reduction despite the negative impact of climate change on poverty.

The various channels through which climate change affects poverty include assets, productivity, commodity prices and opportunities (Hallegatte *et al.*, 2016). In as much as literature has focused on poverty-related effects of climate change on economies and individuals, little research has examined the effects of climate change on inequality, which potentially exacerbates poverty.

2.6.5 Climate Change and Inequality

Much attention has been given to melting glaciers, the extinction of polar bears and penguins and melting ice caps. However, there is little effort dedicated to the documentation and discussion of the relationship between climate change and income inequality, which leaves a lot of work to be done. This section reviews studies that have been done to link climate change and inequality. In an investigation by Diffenbaugh and Burke (2019) to ascertain how global warming has affected recent trends and development in economic inequality across countries, they find that there is a high probability that climate change as a result of human activities contributes to increased economic inequalities among countries. Economic inequality is used in a much broader sense than income inequality because it captures the causal influences on individual well-being beyond incomes and commodity holding (Sen, 1997). Diffenbaugh and Burke (2019) measure economic inequality as the population-weighted percentiles of per capita GDP distribution. Islam and Winkel (2017) on the other hand examines the relationship between climate change and "within-country inequality" which is generally referred to as social inequality. The concept of social inequality discussed in their paper is a multi-dimensional one with most of the evidence pertaining to income inequality. In their work they provide evidence that shows that this relationship is characterized by a vicious cycle where initial inequality causes vulnerable groups to suffer disproportionately to the negative impacts of climate change resulting in subsequent inequality. Their study also establishes that climate change aggravates income inequality through three main channels namely; (a) increase in the exposure of the disadvantaged groups to the adverse effects of climate change; (b) increase in their susceptibility to damage caused by climate change; and (c) decrease in their ability to cope and recover from the damage suffered.

Also, Skoufias (2012) demonstrates that climate change impacts the poor more than the rich hence, it tends to be more regressive. In the overall assessment reports of the impact of climate change on inequality by the IPCC (2014), they conclude that climate change exercebates inequality. They show that socially disadvantaged people suffer disproportionately based on gender, age, race, class, indigeneity and disability and are particularly affected negatively by climate hazards. That is, climate change adaptation expenditure tends to be driven by wealth (Georgeson et al., 2016). The effects of inequality can be transmitted through the political channel which deals with the reduction of private resources available to disadvantaged groups or through the economic channel which deals with the state power (Islam & Winkel, 2017).

2.7 Adaptive Capacity

Adaptive capacity is the ability of a system to adjust to climate variability and extremes, to lessen possible damages, take advantage of opportunities, or cope with the negative outcome of climate change (IPCC, 2014). The aim of adaptive capacity is to respond or alter to better suit climatic variations and their impacts. Smit and Wandel (2006) argue that adaptive capacity is associated with a long-term ability to withstand climate stress as against 'ability to cope' which represents the shorter-term ability of a system to respond to climate shocks. Adaptive capacity essentially, shapes how a system can promote, stimulate, dampen or exaggerate adaptation strategies and has implications for sustainable growth and development (Burton *et al.*, 2003; Brooks and Adger, 2005; Lebel *et al.*, 2006). This is an indication that the effectiveness of adaptation funds and options is greatly influenced by the adaptive capacity of an economy, which tends to vary from one system to another and even within systems (Adger *et al.*, 2007). In India for example, farmers respond differently to climate change; while some are capable of coping with changing conditions, others are unable to do same because of economic and technological differences (O'Brien *et al.*, 2004).

2.7.1 Factors that Influence Adaptive Capacity

The adaptive capacity of a country positively impacts its ability to cope with climate shocks and extremes to enhance sustainable growth and development by augmenting the nation's adaptation options (Brooks & Adger, 2005). The ability to adapt to changes in the climate is based firstly on the level of human development known as generic factors and secondly, based on impact-specific factors that are concerned with specific climate risks. Adger *et al.* (2007) identified some of these factors to include education, health, governance, knowledge, infrastructure and economic resources. Asante *et al.* (2012) argue that the different determining factors of adaptive capacity are interdependent on each other and hence adaptive capacity is a mix of all generic and impact-specific factors.

Even though no economy is immune to climate change shocks, advanced countries are better positioned to recover rapidly from weather shocks. On the contrary, emerging economies are highly vulnerable to climate impacts because of their low adaptive capacities (UNFCCC, 2007). This low capacity to cope with climate stress emanates from the fact that these countries are economically weak. The poorer a country is, the less likely its ability to adapt to climate change because of limited resources (such as financial and capital assets) and institutions (Engle, 2011). Lower adaptive capacity is evidenced by less government spending, weak governance and uneven income distribution (Fankhauser and McDermott, 2013). Even though economic resources are necessary for adaptation to climate change in less developed nations, the availability of those resources will not necessarily make countries resilient, unless specific individuals and groups are entitled to those resources (Adger *et al.*, 2003).

The link between education and adaptive capacity is such that an individual's formal education level affects his ability to personally adapt to climate shocks (Wamsler *et al.*, 2012). On a national level also, Skidmore and Toya (2005) found that countries that generally have more highly educated people stand the chance of suffering less impacts from climate-related disasters. The argument for this outcome is that as more people attain formal educational status, they become more aware of and appreciate the measures instituted by governments and organizations to deal with changing weather conditions. Education of females in particular has the potential of neutralizing the climate impacts on the society (Blankespoor *et al.*, 2010).

Moreover, the existence of physical infrastructure like schools, hospitals, water, electricity and other technological infrastructure enhances the adaptive capacity of countries. Adger and Kelly (1999) highlight that the availability of communication infrastructure is vital for the dissemination of adaptation strategy information among people. Also, the use of technology to engineer climate resilient seedlings that have the ability to withstand harsh weather conditions improves the agricultural productivity of small farm holders (Nantui *et al.*, 2012). The presence of adequate infrastructure in highly vulnerable areas puts the society in a better position to manage and build resilience to climate variations (Nakhooda and Watson, 2016). Hence, infrastructural and technological development helps to boost the ability of countries to cope with climate risks and ultimately reduce climate vulnerability.

The place of institutions in strengthening the capacity of nations to deal with adverse consequences of climate change cannot be neglected. O'Riordan and Jordan (1999) argue that adaptive capacity is enhanced when institutions ensure that everything is rightly held together. The intervention of institutions ease access to important adaptation resources is gained by individuals and communities. The level of responsiveness of communities to climate change therefore lies with the effectiveness of their formal and informal institutions as suggested by Yaro *et al.* (2014). Ahmed *et al.* (1999) attribute difficulties in coping with climate risks to institutional deficiencies and Huq *et al.* (1999) also link Bangladesh's vulnerability to climate change (food insecurity, poor settlement, endangered human life) to institutional constraints. Engle and Lamos (2010) argue that governance and institutions are essential in the climate change discussion because democratic institutions are more likely to increase adaptive capacity when the people who matter most participate in decision making processes.

2.7.2 Adaptive Capacity in Africa

Adaptive capacity is generally low in Africa because of low levels of development and increasing populations. The region is characterised by extreme poverty, inadequate infrastructure and weak state capacity which make Africans extremely susceptible to climate change (Welborn, 2018). In recent times, the number of people without access to safe water and the number of people in poverty is continuously increasing. About two-thirds (643 million) of Africans are extremely poor and live on less than $1.90 daily (Brookings Institution, 2018). This number is projected to increase by the year 2040 owing to natural disasters, rising temperatures and conflicts. In particular, West Africa has the largest proportion of people living in extreme poverty and is highly susceptible to climate change impacts than all other regions. The poverty levels in Africa undermine the region's capacity to adapt to the rapidly changing weather patterns.

Growing urban populations in coastal areas increase risks of loss of lives through flooding, increase migration and conflicts, and exacerbate food insecurity due to reduced agricultural productivity. In order to meet the demands of rapidly growing populations especially in Eastern Africa, dependence on international organizations and governments for food, medical care and other basic supplies will intensify in the foreseeable future (Welborn, 2018).

The adaptive capacity of Africa is weakened by the poor state of economies in the region. The nature of institutions makes it challenging to identify climate-related hazards, formulate and implement adaptation strategies across highly vulnerable regions. The mobilization of revenues by governments in sub-Saharan Africa average about one-fifth of its GDP and one-fifth of these government revenues come from foreign aid receipts. This implies that the ability of Africa to mobilize resources is weak and requires developing (Hughes *et al.*, 2012). Moreover, Africa's government effectiveness score of 1.7 out of 5 (World Bank, 2015) indicates that domestic governments in Africa struggle to effectively use these resources.

2.8 Chapter Summary

This section provided theoretical and empirical evidence on climate change, income inequality and climate adaptation in Africa. Review of empirical literature showed that climate change effects could be adverse or favourable. The existing evidence for Africa showed that the region is highly susceptible to rising temperatures due to the region's dependence on Agriculture. Recent research has focused mainly on the various determining factors of inequality, as well as the impact of climate change on specific sectors such as agriculture, health, economic growth, poverty and labour output.

However, with regards to the impact of climate change on income inequality, no empirical work has been carried out on Africa. Given the persistent nature of income inequality in Africa, coupled with the rise in climate-related occurrences, this study would help explain why inequality in Africa is not declining compared to other regions. The study would also fill the literature gap by providing empirical evidence on the link between income distribution and climate change in Africa.

The adaptive capacity of Africa has proven to be weak, owing to inadequate infrastructure, poor institutional quality and low economic resources. For adaptation measures to effectively reduce risks associated with climate change, economies need to strengthen their capacities to withstand such climate variabilities.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter of the study presents the procedures used to achieve the research objectives. Specifically, it highlights the various tools and methods used to show how climate change is related to income inequality. This section provides guidance and explanations with regards to the mode of data collection, the methods of analysis, and statistical inferences that helped to achieve the objectives. The research methodology will comprise the research design, data sources, sample size, explanatory and outcome variables, data analysis models and procedures.

3.2 Research Design

The processes used to obtain proposed research outcomes are mostly influenced by the research design. The design of a study generally provides a guide to answering the research questions. According to Bryman (2012), research design is a framework for obtaining and analysing data in a research. The essential components of the design are the data collection and analysis approach, and the strategies adopted for the research. This study uses a quantitative research methodology to analyse and interpret the data used.

The quantitative research approach helps to collect, investigate and predict the relationships between variables (Creswell, 2009). Bryman and Bell (2015) define this research approach as "entailing the collection of numerical data and exhibiting the view of relationship between theory and research as deductive, a predilection of natural science approach, and as having as objectivist conception of social reality". This research method essentially examines the relationships between numerical variables through the use of statistical methods.

Dudovskiy (2016) is of the view that quantitative research methodology provides clear answers to research questions by the use of structured data collection approaches from well-defined data sources. This method, he stated, also helps to generalize the findings of a study using a relatively large sample size. We objectively select countries in Africa for the study to help verify insights about the impact of climate change and adaptation efforts, and to help suggest a course of action. The adoption of a quantitative research method is therefore appropriate for this study as we seek to analyse and interpret numerical data on income inequality and climate change.

3.3 Data Availability and Sources

The study uses panel data which comprises both time series and cross-country data to capture variations across countries and over time. The empirical analysis of the potential effect of climate change on unequal income distribution and the moderating role of adaptive capacity was based on 37 African countries. Selected countries were based on the availability of data. The countries used are: Algeria, Angola, Benin, Botswana, Burkina Faso, Cameroon, Central African Republic, Chad, Comoros, Congo, Côte D'Ivoire, Egypt, Ethiopia, Gambia, Ghana, Guinea, Guinea Bissau, Kenya, Liberia, Madagascar, Malawi, Mali, Mauritania, Morocco, Mozambique, Namibia, Nigeria, Senegal, Sierra Leone, South Africa, Swaziland, Tanzania, Togo, Tunisia, Uganda, Zambia, Zimbabwe. These countries provide a good representation of the entire continent because nations from the various regional blocks of Africa – North, South, East and West, are incorporated in the study.

Data used in the study was restricted to the period 1995 to 2015 (21 years) because data was largely available for this period. All data were collected from secondary sources. Income inequality data, proxied by the Gini coefficient, was obtained from the Standardized World

Income Inequality Database (SWIID) developed by Solt (2018). This database makes available consistent and balanced inequality data that enhances comparisons across time and countries. It standardizes data from the UNU-WIDER, the World Bank, Eurostat, the World Bank's PolvcalNet and other income databases by using missing data-imputation algorithm approach. Climate change data was proxied by temperature change anomaly and carbon dioxide emissions which were obtained from the Food and Agriculture Organization (FAO) and the World Development Indicators (WDI) database respectively. We also obtained data for adaptive capacity from the Notre-Dame Global Adaptation Index (ND-GAIN). Polity2 and civil conflicts data were obtained from Marshall's Polity IV Project (2018). Data for all other control variables were obtained from the WDI.

3.4 Econometric Technique

Dynamic panel regression models are constructed to estimate data with smaller time periods and larger cross-sectional observations, mostly at firm and country levels. They are most useful when the outcome variable in a model is dynamic and is influenced by on its own previous realizations; the independent variables are not strictly exogenous; autocorrelation and heteroscedasticity are present (Roodman, 2009).

Income inequality is persistent in nature and changes slowly, thus, inequality in the past period is likely to influence present values (Anyanwu, 2016). To help control for important variables that may be omitted in our estimation, the lagged value of the Gini index is included as a regressor. The lagged inequality variable is included in the model estimation because the present outcome variable of interest is affected by its past realizations. The lagged Gini coefficient is also used as an 'internal instrument' (from an existing econometric model) to control the endogenous relationship between the regressors and error term (Roodman, 2009). The general dynamic panel regression estimator is specified as:

$$\mathcal{Y}_{it} = \alpha\mathcal{Y}_{it-1} + \beta' X_{it} + \eta_i + \lambda_t + \varepsilon_{it} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots \text{(1)}$$

$$i = 1, \dots, N, t = 1, \dots, T$$

where η_i denotes the unobserved individual-specific heterogeneity, λ_t denotes the unobserved time effects, α is the coefficient of the lagged dependent variable and β' represents the coefficients of the regressors and ε_{it} is the idiosyncratic error term. This general model encompasses other specifications such as distributed lag or first-differenced specifications. The individual specific effect η_i is mostly considered to be correlated with the explanatory and the lagged outcome variables. The potential correlation between a regressor and the error term leads to the endogeneity problem. This endogeneity problem can yield inconsistent estimates when the ordinary least squares and other static estimators are used for estimating the model. To deal with possible endogeneity of some variables, the Generalized Method of Moments (GMM) estimator is used for the estimation. This model deals with endogeneity by subtracting the previous data values from its present values (transforms the data). An alternative to the GMM estimator is the fixed effects estimator which also has the potential of dealing with endogeneity problem in panel data estimation. There are two major types of the GMM dynamic panel estimator – difference GMM and system GMM.

The difference GMM by Arellano and Bond (1991) transforms all explanatory variables by differencing to remove fixed effects. Their model tests for autocorrelation in linear GMM panel regressions when lagged variables are used in the model. In this GMM model, the lagged dependent variables in levels are used as instruments for the first-differenced lagged variable. Differencing the variables can be complex and can generate invalid estimates (Roodman, 2009). Adequate information on the first differences may not be provided by the lagged dependent variable. Arellano-Bover (1995) and Blundell-Bond (1998) designed the system GMM model to control for this shortfall. The system GMM makes a supplementary assumption that the first differences are correlated with the fixed effects by building two equations; the original and transformed equations (Roodman, 2009). The system GMM also controls for the potential sample biases and asymptotic imprecision associated with the difference estimator (Blundell and Bond, 1998).

System GMM has two variants; the one-step system and two-step system GMM. This study employed the two-step model because it improves efficiency by using the residuals from the one-step analysis. The system GMM approach is used for two reasons. First, system GMM improves efficiency by producing better and consistent estimates than static models, accounted for by orthogonality conditions imposed on the lagged variables and the error term (Arellano and Bond, 1991; Arellano and Bover, 1995). Second, the system GMM (specifically two-step) model also controls the problem of endogeneity, autocorrelation and heteroscedasticity (Blundell and Bond, 1998).

Moreover, two assumptions underpin the use of the system GMM estimator: no serial autocorrelation exist in the error terms, and the model instruments are valid. Consequently, we test the hypothesis of no second-order serial correlation to show the consistency of the estimates using the Arellano-Bond autocorrelation test. We also use the Hansen test of overidentifying restrictions to prove that the instruments used in the estimation are valid.

3.4.1 Measuring climate change and income inequality

The dynamic nature of income inequality requires estimation with a dynamic regression model that provides consistent results. The two-step system GMM model is used to analyse the impact of climate change on income distribution in Africa. This estimator deals with the problem of omitted variable biases that occur with panel regression analysis. Also, the system GMM estimator employs additional moment conditions that accurately work for non-stationary data (Blundell and Bond, 1998). The empirical models are therefore specified as;

$$Gini_{it} = \beta Gini_{it-1} + \gamma_1 temp_{it} + \gamma_2 agric_{it} + \gamma_3 lgdppc_{it} + \gamma_4 pop_{it} + \gamma_5 gcf_{it} + \gamma_6 fdi_{it} + \gamma_7 res_{it} + \gamma_8 pol_{it} + \gamma_9 trdop_{it} + \rho_i + \theta_t + \mu_{it} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots.. (2)$$

$$Gini_{it} = \alpha Gini_{it-1} + \delta_1 CO_{2_{it}} + \delta_2 agric_{it} + \delta_3 lgdppc_{it} + \delta_4 pop_{it} + \delta_5 gcf_{it} + \delta_6 fdi_{it} + \delta_7 res_{it} + \delta_8 pol_{it} + \delta_9 trdop_{it} + \omega_i + \varphi_t + \varepsilon_{it} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots.\dots (3)$$

where *i* denotes the country and *t*, the year. $Gini_{it}$ is our measure of income inequality which is the outcome variable, and $Gini_{it-1}$ is the observation in the same country in the previous year, included as an explanatory variable. *Temp* and CO_2 represent temperature change anomaly and carbon dioxide emissions respectively; they are both used as measures of climate change (FAO, 2018). We include the log of GDP per capita (*lgdppc*) as a measure of economic development; *agric* denotes agricultural productivity; *pop* represents the rate of population growth; *gcf* denotes gross capital formation (% GDP) which is included as a measure of domestic investments; *pol* represents polity2 index, which measures democracy and autocracy; *res* represents gains from natural resource; and *trdop* denotes trade openness.

3.4.2 Measuring the Role of Adaptative Capacity in Climate Change and Inequality Nexus

To estimate the moderating role of adaptive capacity on the relationship between climate change and income distribution, we specify our model as follows;

$$Gini_{it} = \vartheta Gini_{it-1} + \phi_1 temp_{it} + \phi_2 adpc_{it} + \phi_3 temp_{it} * adpc_{it} + \sum_{n=1}^{8} \Omega_n X_{it}^n + \eta_i + \sigma_t + \xi_{it} \quad (4)$$

$$Gini_{it} = \lambda Gini_{it-1} + \pi_1 CO_{2_{it}} + \pi_2 adpc_{it} + \pi_3 CO_{2_{it}} * adpc_{it} + \sum_{n=1}^{8} \Phi_n Z_{it}^n + \chi_i + \tau_t + \psi_{it} \quad (5)$$

where *adpc* is our measure of adaptive capacity in a country. Adaptive capacity represents the potential of countries to cope with the adverse consequences of climate change on income inequality. The strategies that are formulated by policymakers and governments to help countries cope with the negative effects of climate change are expected to reduce the unequal distribution of income. X_{it} and Z_{it} are vectors which represent the control variables that affect the association between income inequality and climate change. The parameters of the control variables are also represented by Ω_n and Φ_n in equations (4) and (5) respectively. The same control variables used in equations (2) and (3) – GDP per capita, democracy, civil conflicts and gross capital formation are used in estimating equations (4) and (5).

3.4.3 Dependent Variable

The outcome variable used in the study is income inequality. The indicator for this variable the Gini coefficient which ranges from 0 (complete equality) to 100 (complete inequality). Countries with indices closer to zero are more equal than those with estimates closer to one hundred. The Gini index used for the study was developed by the SWIID and provides complete and consistent data on income inequality for almost all countries in the world. The Gini index is measured from gross or net income computations with data per capita or data per household (Solt, 2016). This study used the gross household income Gini coefficient data for 37 countries in Africa.

3.4.4 Independent Variables

Temperature change anomalies is denoted by *temp* and is measured in degree Celsius for each meteorological year. Temperature change anomaly represents the difference between the long-term average temperatures (from 1951 to 1980 as the baseline) and the current period's temperature. Hence it is the difference between the temperatures that are currently recorded and the average temperatures that are expected to be recorded. A negative temperature change anomaly is an indication of a cooler temperature than expected while a positive anomaly shows that temperatures were warmer than the expected average. The use of temperature anomalies presents more accurate information for analysis than actual temperatures because it minimizes problems associated with the addition or removal of stations from the monitoring network (NOAA, 2019b). Rising temperatures are expected to have a negative correlation with the distribution of income in Africa especially in agriculturally dominated regions of the continent.

Carbon dioxide emissions, CO_2 is measured in metric tons per capita. $CO_2$is one of most studied greenhouse gases that has damaging implications on the environment. Scholars have attributed rising GHG emissions to the industrial revolution, population growth, and dependence on non-renewable energy such as fossil fuels. We use this measure of climate change as a test for robustness in determining the interrelation between climate change and inequality. We have a positive a priori expectation about carbon dioxide emissions and the Gini coefficient.

3.4.5 Control Variables

The control variables used in the equations are informed by recent income inequality literature on Africa (AfDB, 2017; Anyanwu, 2016; Mallaye *et al.*, 2015). The income inequality studies identified the past values of income inequality, education, economic development, population growth, domestic investment, foreign direct investment, natural resource rents and personal remittances as primary drivers of uneven income distribution. The variables are added to the model to know whether the effect of climate change would hold even after accounting for the impacts of other income inequality covariates.

Income inequality changes slowly because of its degree of inertia and its current value is thus influenced by past levels of inequality (Anyanwu, 2016). Most empirical studies have shown that the link between current and past income inequality levels is positive (Anyanwu, 2016; Mahmood *et al.*, 2014; Dincer & Gunalp, 2008). We therefore include the lagged values of the Gini coefficient as a control variable in our regression estimation to validate the persistence of income inequality in Africa.

The *'agric'* variable, which represents agricultural productivity, is included as a mediating variable between climate change and income inequality. Since most Africans are engaged in agriculture, a decrease in crop and livestock yields attributable to climate change causes a disparity in income distribution between agriculture and non-agriculture workers. Mediating variables serve as the channel through which causal effects operate (Hayes, 2018, p. 112). To establish mediation, we first include inequality as the outcome variable and climate change indicator as the main regressor. The study then introduced agriculture in addition to climate change as regressors on the outcome variable, income inequality. To show that agriculture fully mediates the climate change-inequality nexus, the impact of climate change on income inequality when agriculture is controlled for should be insignificant as suggested by Baron and

Kenny (1986). On the other hand, partial mediation would occur when the impact of climate change on inequality is simply reduced after agriculture is controlled for (Baron & Kenny, 1986).

The level of a nation's development, which is measured by GDP per capita (*gdppc*), affects the distribution of income in that country. According to Kuznets (1955), growth of a country initially increases unequal income distribution, gets to a peak, and then eventually declines. We therefore expected that as countries in Africa developed economically, the inequality gap would widen, as confirmation of the positive association between development and income inequality.

Domestic investment spending as denoted by *'gcf'*, is negatively correlated with income distribution because more spending implies increasing job opportunities and earnings for the poor as well. This leads to a distribution of income that ropes in individuals at the lower socioeconomic sectors of the economy. We also include FDI net inflows (% GDP) and personal remittances as measures of financial globalization with significant impact on income inequality. Both economic globalization indicators are anticipated to have a positive relation with income inequality. The increase in income levels of recipient households cause income inequality gaps to widen.

The rate of population growth denoted by *'pop'* affects income distribution through the supply of labour which in turn affects the income and wages of such workers. A rapidly growing economy was hypothesized to raise income inequality levels due to the declining wages of excess labour demanded. Demographic factors such as population have the tendency of worsening inequality when countries in their developing stages become socially heterogenous because of the inability to evenly diffuse technology into their systems (Anyanwu, 2016).

Natural resources abundance *'res'* significantly affects income distribution by reducing possible rents in economies where the governments have the capability of redistributing profits towards the lower income groups. We therefore expected African nations with abundant natural resources to have lower levels of uneven income distributions as found by Mallaye *et al.* (2015) and Anyanwu (2016).

The influence of political regimes on income distribution is measured by polity2 index represented as *'pol'* and it ranges from -10 (highest autocracy) to 10 (highest democracy). Countries with high democratization should have better income redistribution that results in income inequality reduction.

The adaptive capacity index *'adpc'* measures the damage reducing potential of a country and its ability to adjust to the adverse impacts of climate events. The index is between 0 and 1, and the higher the adaptive capacity index of a country, the better its resilience to damaging climate disruptions.

Table 3.1 Indicators, Descriptions and Sources

Indicator	Description	Source
Gini Coefficient	An indicator of income inequality that ranges from 0 to 100. The index is based on the disposable household consumption income that is standardized using a Bayesian approach. The observations are collected from the OECD Income Distribution Database, Eurostat, World Bank, World Bank's PovcalNet, national statistical offices worldwide among others.	Standardized World Income Inequality Database
Temperature Change Anomaly	An indicator for climate change that is measured in degree Celsius. The anomaly shows the difference between observed average expected temperature and the actual temperature recorded in a country.	Food and Agriculture Organization
Carbon dioxide Emissions	This is an alternative indicator of climate change, measure in metric tons per capita. The higher the CO_2 emission, the greater the chances of climatic hazard occurrence.	World Development Indicators

Agricultural Productivity	An index is constructed from data on livestock yield and crop yield, measured as harvested production per unit of harvested area.	Food and Agriculture Organization
Gross Domestic Product per capita	Nominal value additions by domestic producers plus taxes on products minus all subsidies as a ratio of population. Data are based on PPP constant at 2011 international dollars which gives equal purchasing power over GDP as the U.S. dollar's in the U.S.	World Development Indicators
Population Growth	Annual rate at which the number of all residents, regardless of citizenship, increases. The yearly rate is the exponential growth rate of midyear population from the previous year to the current year.	World Development Indicators
Gross Capital Formation	An indicator for domestic investment comprising outflows that increase fixed assets such as roads, hospitals, schools, industries; and net changes in inventories of goods and WIP for production and sales. This is expressed as a percentage of a county's total GDP.	World Development Indicators
FDI Inflows	Total equity capital as well as short and long-term capital, and reinvestment of earnings. They represent the difference between new investment inflows and disinvestment, expressed as a percentage of GDP.	World Development Indicators
Natural Resources	Represents total oil, natural gas, mineral, coal and forest rents, expressed as a percentage of GDP. The estimates are based on methods described in "The Changing Wealth of Nations 2018: Building a Sustainable Future" (Lange *et al.*, 2018)	World Development Indicators
Polity2	Composite indicator for democracy and autocracy, suitable for time-series analysis which records democratic and autocratic regimes at various times. It ranges from -10 (strongly autocratic) to 10 (strongly democratic). The composite value is obtained from competitiveness of political participation, openness of executive recruitments among others.	Marshall's Polity IV Project
Trade Openness	Total imports and exports expressed as a ratio of GDP. Imports denote total value of goods and services received from other countries. Exports represent the value of all goods and services provided to other countries. All variables are measured in current U.S. Dollars.	World Development Indicators
Adaptive Capacity	A composite index that indicates the readiness (social, economic, governance), as well as the sectoral measures to cope with adverse climate change outcomes (see Table 3.2)	Notre Dame Global Adaptation Initiative

Table 3.2 Adaptive Capacity Components

Description	Component	Sources
Food	Agriculture capacity (fertilizer, irrigation, pesticide, tractor use) and child malnutrition	FAOSTAT, World Development Indicators
Water	Access to good drinking water and dam capacity	World Development Indicators
Health	Medical staff per 1000 people (physicians, nurses and midwives) and access to improved sanitation amenities	World Development Indicators
Eco-system Services	Protected biomes and engagement in international environmental conventions	Environmental Treaties & Resource indicators, Environmental Performance index
Human Habitat	Trade Quality and transport-related infrastructure and Paved roads	World Development Indicators
Infrastructure	Electricity access and disaster preparedness	World Development Indicators
Economic Readiness	Doing business indicators	Doing Business Index
Governance Readiness	Regulatory quality, control of corruption, rule of law, political stability	World Governance Indicators
Social Readiness	Education, ICT infrastructure (phone suscriptions, broadband internet suscription),	World Development Indicators

3.5 Generating an Index for Agricultural Productivity

Agriculture is a potential channel through which climate change affects income inequality in Africa because rising temperatures have been found to affect this sector. In order to measure and control for agricultural productivity, the study generates an index from Principal Component Analysis (PCA) using key measures of crop and livestock yields from the FAO. Yields on over 170 crops, expressed in hectograms per hectare, are broadly classified under cereals, vegetables, roots and tubers, fruit crops, oil crops and pulses. The yields on livestock are also classified as meat products, milk and eggs production. However, due to the unavailability of data for some of the yields on livestock, the study only included total milk and eggs productivity in generating the index.

PCA is a statistical tool that is used to reduce data and create aggregate indices from large data sets. This technique also produces eigenvectors that help understand the underlying composition of the data. PCA transforms potentially correlated variables with shared attribute into a set of uncorrelated variables that capture the variations in a dataset (Abson, Dougill, & Stringer, 2012).

As a result of PCA, linear combinations of variables (known as principal components) weighted by their contribution to the explanation of variations in the data set are generated. The first principal component (PC_1) mostly captures a greater part of the variations in the data set and provides much information than the other components. Each of the subsequent principal components account for the remaining variations which are orthogonal to each other. Abson *et al.*(2012) indicate that the orthogonality in PCA means that the variations explained by the previous component is removed and the remaining variation is accounted for by the next principal component.

The factor loadings for the various variables used in the construction of a single score show the level of importance of each variable in the construction of the index for agriculture. The factor loadings also present the correlation between the variables and the principal component that are aggregated. Therefore, based on the factor laoding scores of the first prinicipal component, an agriculture index is generated and used in addition to other variables for the regression estimation.

3.6 Statistical Tests

3.6.1 Hansen Tests

The system Generalized Method of Moments includes additional instruments to improve the consistency of estimates in the model. The aim of conducting the Hansen (1982) test of overidentifying restrictions is to show the validity of the additional moment instruments. The null hypothesis for this test is that 'all the restrictions of overidentification are valid' and the vector moments are randomly distributed around zero. It is mostly difficult to detect invalid instruments when the model is exactly identified. Hence, testing for the joint validity of moment conditions requires a model that is overidentified. The test statistic for overidentifying restrictions has a degree of freedom that is equal to the level of overidentification.

The Sargan test is very similar to the Hansen test but is more appropriate for one-step estimations. However, if the errors are non-spherical as in a robust one-step GMM, the Sargan test is inconsistent. The Hansen test is thus superior for overidentification tests in a two-step GMM estimation. The Hansen (1982) test also tests the validity of moment conditions with a test statistic for overidentifying restrictions, which is made feasible by substituting estimates. These tests are mostly feasible when there are enough instruments or moment conditions in a dynamic regression model. We therefore test the instruments to know whether they are independent of the error term.

The statistic reported for this test is the χ^2 and we fail to reject the null hypothesis if the probability obtained is greater or equal to 0.05. We conclude that overidentification does not exist and all the instruments for the estimation are valid. Nevertheless, if the likelihood is close to 1, then the asymptotic properties of the test have not been applied and requires that we reject the null hypothesis as we would if the probability was lower than 0.05 (Roodman, 2009). The recommended range for the probability of χ^2 should be $0.05 \leq P(\chi^2) < 0.80$.

3.6.2 Arellano-Bond Autocorrelation Test

One assumption of the system GMM dynamic model is the condition of 'no serial autocorrelation' in the error terms. This test is carried out to confirm that the past error terms are uncorrelated with the current error term. To confirm non-existence of autocorrelation in the errors, we expect the probability of the AR (2) to be insignificant at 5%. However, AR (1) would normally be significant at 5%. The error terms are not autocorrelated if we reject the null hypothesis when the probability is greater than 0.05. Nonetheless, autocorrelation exists where we reject the H_0 if the probability of the statistic is less than 5%.

3.7 Limitations

Analysing income inequality in Africa has been challenging over the years due to the inconsistent and limited nature of data (Bourguignon & Morrisson, 2002; Palma, 2011). The irregular intervals within which data are made available also reduce data comparability (Devarajan, 2013). This has resulted in varying arguments about the trend of inequality in Africa. (Sala-i-Martin & Pinkovskiy, 2010) are of the view that income inequality in Africa is declining while (Palma, 2011) shows that unequal income distribution has been increasing across the African region.

The GMM estimator mostly supports estimations with a larger cross section and a shorter time period. Our model used data for 37 countries over a period of 21 years. Limitations arise with the estimation of panels with extended time periods and fewer individual observations (called 'long panels'). Such situations require several adjustments to estimate models properly and to address the issues that arise from overidentification of the model by restriction in the use lagged regressors and a step by step incorporation of the independent variables in levels and differences (Labra & Torrecillas, 2018).

CHAPTER FOUR

DATA ANALYSIS AND DISCUSSION OF RESULTS

4.1 Introduction

This chapter of the study presents an analysis of the data, findings and interpretation of the results obtained from examining the variables considered for the study across Africa. The section provides the descriptive statistics of the variables employed. It also shows an analysis of climate change impacts on income inequality, and the role of adaptive capacity in the climate change and income inequality relationship.

4.2 Summary Statistics

4.2.1 Descriptive Statistics

The summary of descriptive statistics for the variables used in the analysis are presented in Table 4.1. The average Gini coefficient in Africa is 49.49. Generally, countries that recorded high income inequality levels in Africa include Namibia, South Africa, Botswana, and Comoros. Taking into consideration the time period used for the study, Namibia recorded the highest Gini coefficient of 72.1 in 1995. Although over 70% of the citizens are involved in rural agriculture production with few people relying on the formal economy for livelihood, agriculture accounts for 7.1% of GDP while services sector account for 56.9% of GDP (FAO, 2019a). The countries with the least income inequalities include Ethiopia, Algeria and Tanzania. Ethiopia recorded the least Gini coefficient of 36 in 2004. Ethiopia is among the best performing countries in Africa with an average growth rate of 11% over the last few years, and ranks among the top ten countries that have the largest absolute gains in HDI (FAO, 2019b).

The average temperature change anomaly among African countries was 0.812°C and the highest temperature change anomaly of 2.329°C occurred in Egypt in the year 2010. The landscape of Egypt is characterised by extreme aridity with most of its inhabitants living along the Nile Valley and Delta. Kenya recorded the least temperature change anomaly of -0.26°C, an indication that the country was colder in the year 2005 than in 2015 when a temperature anomaly of 1.089°C was recorded.

The average domestic investment as measured by gross capital formation was approximately 20% of GDP over the period of study. Domestic investments in Chad was the highest at 61.47% of GDP in 2005 and in 1999, the lowest investments of 0.293% occurred in Sierra Leone. Sierra Leone's gross capital formation significantly reduced in the late 20th century potentially due to the civil war caused by political clashes to overthrow the ruling government that began in 1991 and ended in 2002. Similarly, the Angola conflicts in 2002 resulted in a negative FDI inflows (% of GDP) of 6.055 per cent, the minimum during the study period. The highest FDI inflows, 159.7 per cent of GDP was however recorded in Liberia in the year 2010.

On the average, natural resource rents in Africa was about 13 per cent of GDP which indicates that natural resources contribute significantly to the GDP of Africa. The highest natural resources rent was recorded to be 80.63 per cent of GDP in Liberia in the year 1995 and the least resource rents of 0.307 per cent occurred in Morocco in 1996.

Trade Openness averaged 68.4% of GDP over the period of study, suggesting that African countries took advantage of trade opportunities with among countries in the region, and countries in other continents as well. This shows that the region is highly engaged in international trade and globalization. While Liberia traded the most with other countries in the year 2007 (at 311.4 % of GDP), trade openness of Nigeria was the least at about 21% of the country's GDP.

The average population growth rate in Africa was 2.424% over the period of study. Liberia's population increased rapidly in the year 1998 at the highest rate of 7.85% while a decline in population was reported in Sierra Leone (-0.206%) in 1995.

Table 4.1 Descriptive Statistics

Variables	Observations	Mean	Standard Deviation	Min	Max
Gini Coefficient	622	49.490	7.912	36.000	72.100
Temperature Change Anomaly	754	0.812	0.375	-0.260	2.329
CO_2 Emissions	740	0.391	0.277	0.032	1.639
Agricultural Productivity	740	0.000	1.988	-1.929	9.545
Log GDP per capita	777	7.780	0.838	5.511	9.675
Population Growth	776	2.424	0.877	-0.206	7.850
Gross Capital Formation	752	20.370	9.323	0.293	61.470
Foreign Direct Investment	774	4.613	12.340	-6.055	159.700
Natural Resource Rents	777	13.080	12.640	0.307	80.630
Polity2	777	1.147	5.039	-9.000	9.000
Trade Openness	772	68.400	0.335	21.440	311.400
Adaptive Capacity	777	0.682	0.108	0.359	0.892
Number of Countries	37	37	37	37	37

The region recorded an average Polity2 index of 1.147 with a deviation of 5.039. Highly democratic countries in Africa include; South Africa, Senegal, Comoros, Ghana and Kenya. Swaziland was the most autocratic country in Africa with the least Polity2 value of -9. Other countries that have autocratic political regimes in Africa include the Republic of Congo, the Gambia, Egypt, Morocco and Mauritania.

The average adaptive capacity of Africa which signifies the ability of the region to cope with climate-related risks was 0.670. Egypt had the lowest ability and resources (index of 0.359) to cope with climate change in 2012, while Chad had the highest adaptive capacity index of 0.892 in 1995.

4.2.2 Correlation Matrix

Table 4.2 presents the correlation among all variables used in the analysis. The correlation matrix shows the direction and strength of the linear association among all the variables. It is however noted that the correlation between the variables does not suggest causality. The Gini index is positively corelated with CO_2 emission, GDP per capita and trade openness but negatively correlated with temperature anomaly, natural resource rents, agricultural productivity and adaptive capacity.

The correlation matrix helps to detect the problem of multicollinearity which occurs when variables are strongly correlated with each other and can lead to inaccurate estimation results. It has been suggested that multicollinearity exists when the correlation between two regressors is very high, usually in excess of 0.8 (Gujarati & Porter, 2009, p. 338). Multicollinearity is therefore not evident from the correlation matrix, indicating that the no variable employed could inflate the standard errors, weaken statistical power and lead to biased estimates.

4.2.3 Variance Inflation Factor (VIF)

The VIF is also used as an indicator of multicollinearity; the larger its value, the more collinear the variables would be. The rule of thumb is that, if the VIF exceeds 10 then the variable is considered to be highly collinear (Kleinbaum, Kupper, & Muller, 1988, p. 210). High multicollinearity may however not suggest that standard errors and variances would be high.

The VIF of the variables used are presented in Appendix 2. The result shows that, all the variables have VIFs between 1.12 and 3.56 which emphasizes that none of the variables exhibits multicollinearity.

Table 4.2 **Correlation Matrix**

	Gini	*Temp anomaly*	*CO_2 emission*	*Agric*	*GDP per capita*	*Population growth*	*Capital formation*	*FDI inflows*	*Natural Resource*	*Polity2*	*Trade openness*	*Adaptive capacity*
Gini	1											
Temp anomaly	-0.336	1										
CO_2 emission	0.084	0.185	1									
Agric	-0.099	0.100	0.434	1								
GDP per capita	0.350	0.167	0.361	0.525	1							
pop	-0.172	-0.135	-0.492	-0.347	-0.457	1						
Capital formation	-0.024	0.170	0.055	0.069	0.325	-0.015	1					
FDI inflows	-0.045	-0.059	-0.026	-0.079	-0.078	0.157	0.270	1				
Natural Resource	-0.266	0.041	-0.126	-0.132	-0.133	0.339	-0.002	0.304	1			
Polity2	0.372	-0.154	0.126	-0.008	-0.07	-0.04	-0.004	0.039	-0.124	1		
Trade openness	0.197	-0.015	0.058	-0.113	0.320	-0.061	0.350	0.330	0.215	-0.080	1	
Adaptive capacity	-0.153	-0.200	-0.4136	-0.704	-0.717	0.397	-0.219	0.074	0.303	0.108	-0.085	1

4.3 Principal Component Analysis (PCA) Results

The study used PCA to construct an aggregate index for agricultural productivity which was included as a control variable in the analysis. The agriculture index, denoted by *'agric'* is an important variable that is controlled for, in the examination of the relationship between climate change and income inequality. In generating the agriculture index, the study employed the factor loadings of the variables that reported the highest correlation with the first principal component (PC_1). The factor loadings, which represent the correlation between each variable and the principal component is presented in Appendix 1.

The primary criterion for the selection of a principal component is when the eigen value is greater than 1. The first, second and third principal components has eigen values that were greater than 1. However, the first principal component (PC_1) was used because it produced the highest eigenvalue of 3.952 and accounted for the greatest variation in the variables (value of 0.439).

4.4 Relationship Between Climate Change and Income Inequality

Regression results on the relationship between climate change and income inequality are presented in Table 4.3. The estimation results were produced by the two-step system GMM estimator because it corrects standard errors which otherwise would be downward biased; provides small-sample adjustments; and transforms orthogonal deviations to maintain the size of panels with gaps (Roodman, 2009). Two indicators of climate change are separately used for the estimations – Temperature change anomaly and Carbon dioxide emissions.

4.4.1 Temperature change anomaly

The p-values of the Hansen test for Model 1 (0.672) and Model 2 (0.783) show that the instruments used for the estimations are valid. The Arellano-Bond autocorrelation (AR) tests also indicate that no autocorrelation exists in the error terms; the p-values for the AR (2) test of both models are 0.400 and 0.474.

The coefficient of temperature change anomaly is positive and significant in Model 1, indicating that higher temperatures worsen income inequality. The results show that when temperature anomaly increases by 1°C, income inequality worsens by 0.254 percentage points in Africa. It is worth noting however that, the increase in income inequality that is caused by rising temperatures is only by a small magnitude.

Nonetheless, when agricultural productivity is included in Model 2 estimation as a potential channel through which climate change affects inequality, the coefficient of temperature change anomaly becomes insignificant. The coefficient of agriculture is negative and significant and shows that when agricultural productivity reduces by a one percentage point, income inequality increases by 0.186 percentage points. The results show that agriculture is indeed a channel through which climate change affects income inequality in Africa. This is because, the relationship between climate change and income inequality is entirely accounted for (full mediation) by agriculture (Hayes, 2018).

4.4.2 Carbon dioxide emissions

The p-values of the Hansen test for Model 3 (0.372) and Model 4 (0.471) show that the instruments used for the estimations are valid. Also, the p-values of the Arellano-Bond autocorrelation (AR) tests for the Models 3 and 4 are 0.410 and 0.508 respectively. The p-values show that no autocorrelation exists in the errors.

The coefficient of CO_2 emissions, which is another indicator for climate change, is significantly positive in Model 3. When CO_2 emissions increase by one metric ton per capita, income inequality in Africa increases by 0.799 percentage points. Moreover, when agriculture is controlled for in Model 4, the coefficient of CO_2 emissions is positive and significant but affects income inequality by a lower magnitude compared to that of Model 3. An increase in CO_2 emissions by one metric ton per capita leads to an increase in income inequality by 0.766 percentage points.

The relationship between agricultural productivity and income inequality is also negative but insignificant in Model 4. Unlike the findings in Model 2 where the coefficient of agricultural productivity was significantly negative, the coefficient of agricultural productivity in Model 4 was not significant because agricultural productivity depends more on temperature than on CO_2 emissions.

4.4.3 Other control variables

Interpretation of the coefficients of the control variables is based on the results from the estimations of Model 2 and Model 4 when agriculture is also included as a mediating variable. The coefficient of the GDP per capita is positive and significant in both models. When economic growth in Africa improves by one percentage point, unequal income distribution among households worsens by 1.194 and 0.489 percentage points in Model 2 and Model 4 respectively. This means that as most African countries develop their economies through industrialization and a shift from less productive to more productive economic sectors, income inequalities among households increase. This result is consistent with the findings of Anyanwu (2016) whose study focused on identifying the drivers of income inequality in Africa.

The results also show that the relationship between population growth and income inequality is positive and significant in Model 4. A one percent increase in population growth exacerbates income distribution by 0.691. Higher population growth rates tend to increase the demand for food and jobs and potentially limit resources available for consumption by households. Our results validate the findings of Anyanwu (2016) and Shimeles and Nabassaga (2018) in related income inequality studies for Africa.

Gross capital formation has a negative relationship with income inequality but is significant only in model 4. The income disparity between the poor and rich decreases by 0.014 percentage points when gross capital formation increases by a one percentage point. This indicates that increasing domestic investments in infrastructure and other fixed assets enhances even distribution of income between the rich and the poor through the creation of jobs and the provision of basic amenities. This confirms the findings of Lee *et al.* (2013) and Chaudhry and Imran (2013) where a negative relationship is found to exist between inequality and gross capital formation.

The results also show that the relationship between natural resource rents and income inequality is negative. The study finds that a one percentage point increase in gains from natural resources significantly reduces income inequality by 0.029 percentage points in Africa as shown by Model 4. This finding is consistent with that of Mallaye *et al.*(2015) who found a negative relationship between income inequality and oil rents in developing countries in the short run. On the contrary, some studies found a positive relationship between resources rents and income inequality due to the resource curse effect which enhances the extortion of profits and creates a rentier economy that inhibits even income redistribution (Anyanwu, 2016; Buccellato & Alessandrini, 2009).

Openness of trade is also shown to have a significantly negative link with income inequality. This study found that a one percentage point increase in trade openness reduces income inequality by 1.861 percentage points in Africa as shown by the results in Model 2. This finding is in support of the findings of Dollar and Kraay (2004) who found that globalisation reduces poverty, enhances growth, and improves income distribution in developing countries.

Table 4. 3 Regression Results for Climate Change Impact on Income Inequality

Variables	Model (1)	Model (2)	Model (3)	Model (4)
Lagged Gini Coefficient	1.079***	1.071***	0.995***	0.991***
	(0.035)	(0.061)	(0.021)	(0.020)
Temperature Change Anomaly	0.294*	0.131		
	(0.153)	(0.199)		
CO_2 Emissions			0.799**	0.766**
			(0.389)	(0.352)
Agricultural Productivity		-0.186*		-0.030
		(0.105)		(0.046)
Log GDP per capita	0.589	1.194**	0.423***	0.489***
	(0.412)	(0.481)	(0.152)	(0.171)
Population Growth	0.238	0.284	0.737**	0.691*
	(0.281)	(0.409)	(0.328)	(0.344)
Gross Capital Formation	-0.005	-0.015	-0.012*	-0.014*
	(0.015)	(0.017)	(0.006)	(0.008)
Foreign Direct Investment	0.018**	0.032**	0.031	0.043
	(0.008)	(0.013)	(0.030)	(0.043)
Natural Resource Rents	0.012	0.016	-0.026***	-0.029***
	(0.013)	(0.018)	(0.007)	(0.007)
Polity2	-0.044	-0.045	-0.009	-0.008
	(0.029)	(0.031)	(0.021)	(0.022)
Trade Openness	-1.137*	-1.861**	-0.167	-0.295
	(0.567)	(0.870)	(0.283)	(0.413)
Constant	-8.682**	-12.41**	-4.695**	-4.765**
	(3.475)	(5.600)	(2.259)	(2.129)
Observations	544	544	556	556
Number of countries	37	37	37	37
Number of instruments	33	33	33	33
AR (2)	-0.84	-0.72	0.82	0.66
p-value	(0.400)	(0.474)	(0.410)	(0.508)
Hansen statistic	19.50	16.64	24.59	21.81
p-value	(0.672)	(0.783)	(0.372)	(0.471)
F Statistic	513.09	330.19	2135.94	2246.61
p-value	(0.000)	(0.000)	(0.000)	(0.000)

The standard errors are reported in brackets. *, ** and *** represent statistically significant at 10%, 5% and 1% levels respectively.

The coefficient of FDI inflows is positive and significant only in Model 2 which indicates that, income inequality increases by 0.032 percentage points when FDI inflows to Africa increases by a one percentage point. The results highlight that, as foreign firms and institutions invest new capital in the African economy, overall income is unequally distributed across the various economic classes of the people and validates the findings of Behrman *et al.* (2003) in Latin America.

4.5 The Role of Adaptive Capacity in the Climate Change and Income Inequality Nexus

The Adaptative capacity indices of African countries are included in the regression estimation to determine how the relationship between climate change and income inequality in Africa would be moderated. We interact adaptive capacity with the main regressors that is, temperature change anomaly and CO_2 emissions and present the results in Table 4.4. Model 5 shows the results for examining the role of adaptive capacity in the relationship between temperature change anomaly and income inequality, while Model 6 presents the outcome for carbon emissions and income inequality.

The results show that the coefficient of the interactive term between adaptive capacity and each of the climate change indicators is insignificant. This means that Africa's adaptive capacity does not play a role in the relationship between climate change and income distribution; income inequality is still affected by rising temperatures and carbon emissions given the current adaptive capacity of Africa. Because the coefficient of the interaction term (between temperature change anomaly and income inequality) is interpreted together with the coefficient of temperature change anomaly, the results show that income inequality is worsened by rising temperature irrespective of adaptive capacity. This can largely be attributed to the weak state of adaptive capacity in Africa which makes the region highly vulnerable to the adverse consequences of climate change which in this case, includes income inequality.

Table 4.4 Role of Adaptive Capacity in the Climate Change and Income Inequality Nexus

VARIABLES	Model (5)	Model (6)
Lagged Gini Coefficient	1.001***	0.995***
	(0.032)	(0.030)
Temperature Change Anomaly	0.229*	
	(0.114)	
CO_2 Emissions		0.830*
		(0.450)
Adaptive Capacity* Temperature Change	0.055	
	(0.059)	
Adaptive Capacity* CO_2 Emissions		0.037
		(0.124)
Adaptive Capacity	6.542***	1.728
	(2.224)	(1.821)
Agricultural Productivity	0.100	0.034
	(0.103)	(0.064)
Log GDP per capita	1.210***	0.538**
	(0.411)	(0.261)
Population Growth	0.597***	0.726***
	(0.201)	(0.249)
Gross Capital Formation	-0.035***	-0.011
	(0.011)	(0.011)
Foreign Direct Investment	0.007	0.021
	(0.015)	(0.030)
Natural Resource Rents	-0.032***	-0.026**
	(0.012)	(0.010)
Polity2	-0.012	-0.008
	(0.039)	(0.025)
Trade Openness	1.163	-0.092
	(0.984)	(0.283)
Constant	-15.34***	-6.774**
	(3.744)	(2.948)
Observations	544	556
Number of countries	37	37
Number of instruments	33	33
AR (2)	-1.27	0.80
p-value	(0.204)	(0.427)
Hansen statistic	13.38	16.86
p-value	(0.895)	(0.662)
F Statistic	226.32	1187.82
p-value	(0.000)	(0.000)

The standard errors are reported in brackets. *, ** and *** represent statistically significant at 10%, 5% and 1% levels respectively.

The results for the control variables show that, the level of Africa's economic development as well as its population growth rate significantly increase unequal income distribution in the region. The coefficients of both variables are positive and significant in both Models 5 and 6. In Model 5 for instance, a one percentage point increase in economic growth increases the disparity in income distribution by 1.21 percentage points. Also, a one percentage increase in the rate of population growth worsens income inequality by 0.597 percentage points.

Gross capital formation has a negative and significant impact on income inequality but only in Model 5. An increase in domestic investment by one percentage point reduces the disparity in income distribution in Africa by 0.035 percentage points. The coefficient of natural resource rents is also negative and significant in both Models; an increase in resource rents by one percent, decreases income inequality by 0.032 percentage points in Model 5 and by 0.026 percentage points in Model 6.

4.6 Discussion of the Findings

Rising temperatures in Africa have largely been attributed to climate change, which is the variations in the weather patterns over an extended period of time. Climate change adversely affects agriculture, health, economic growth and ecosystems in the region. Africa's agriculture depends greatly on the climate (rainfall and temperature) for growth and sustainability, and is also the primary sector that employs the majority of Africans. Due to the weather-dependent nature of agriculture in Africa, a change in rainfall patterns and higher temperatures negatively affects agriculture. The poor, who are largely employed by the agricultural sector lose income in the case of extreme weather events, further culminating in the widening of the income inequality gap.

Given the aforementioned, the a priori expectation of the study was that, a reduction in crop production due to climate change would further exacerbate income inequality. The study confirms this negative relationship between agricultural productivity and income distribution by demonstrating that decreasing crop and livestock production in Africa results in a significant increase in income inequality.

The results of the study also provide evidence that increases in Carbon dioxide emissions significantly cause income disparities among households in the region through agriculture, which was a partial mediator. This highlights the fact that agriculture may not be the only means by which climate change affects income inequality even though controlling for agriculture showed a significant impact between inequality and agricultural productivity.

In order for a country to deal with the damaging impacts of climate change, there is the need to build a strong adaptive capacity (resources and institutions to enhance ability to adjust to climate change). The higher the adaptive capacity of countries, the better chances they have at rebounding from extreme weather shocks and events. The results of the study showed that Africa's adaptive capacity does not significantly reduce the adverse impact climate change has on income inequality in the region. This could be explained by the current state of Africa's adaptive capacity. Most African countries are highly characterised by low economic development, high incidence of poverty, poor institutions and poor educational quality.

The role of adaptive capacity in the climate-inequality nexus is particularly essential because the effectiveness of adaptation efforts depends on the quality of a country's adaptive capacity. For instance, if a country has poor institutional quality (an indication of low adaptive capacity), there is the tendency that, funds that are meant to enhance climate adaptation strategies would be mismanaged. Nevertheless, countries that are least capable of coping with the adverse impact of climate change need support in the form of resources from organizations and governments. In order to reduce the income distribution gap that is attributable to climate change, adaptation funds would have to be channelled to the sectors that need support the most, specifically the agricultural sectors of African economies.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This concluding chapter of the study summarizes the findings obtained from the study. It draws conclusion from the summary findings, and also gives suggestions for further research and for policy formulation and implementation.

5.2 Summary

This study sought to examine the relationship between climate and income inequality in Africa, a region where the disparity in income distribution has been persistently high over the past few decades. The study also analysed the potential impact of adaptive capacity on the relationship between climate change and income inequality in Africa. Using thirty-seven (37) African countries because of data availability constraints, the study employed data from the WDI, FAO and ND-GAIN for the analysis. The GMM dynamic regression model was used to determine the impact of climate change on income inequality.

Firstly, results from the study showed that climate change, proxied by temperature change anomaly and carbon dioxide emissions has a negative effect on the level of income inequality in Africa. The study also found agricultural productivity to be the primary channel through which the impact of climate change is transmitted to income inequality in Africa. The results of the study also highlighted that, a decrease in agricultural productivity which is attributable to climate change, leads to an increase in income inequality among households in the region.

Secondly, the study highlighted that Africa's adaptive capacity generally plays no significant role in moderating the negative effect of climate change on income distribution. Rising temperatures and carbon emissions still contribute to unequal income distribution in Africa because of the region's inability to adapt to and cope with the negative consequences of climate change. This is attributable to the low level of adaptive capacity in Africa which has the potential of making adaptation strategies less effective.

5.3 Conclusion

Climate change significantly worsens the disparity in income distribution between the rich and the poor in Africa. This possibly contributes to persisting income inequality in the region despite the implementation of policies such as SDGs that are aimed at closing the income gap between the rich and poor. Workers in the informal agriculture sector, which is the largest employer of Africans, suffer income losses because of rising temperatures and carbon emissions. This poses threat to fair income distribution as shown by the study. To curtail such negative consequences of climate change, mitigation strategies are required for countries, especially the highly vulnerable ones that are under the threat of suffering losses. However, adaptive capacity in Africa has been found to be low which suggests that Africa is unable to do much to cope with climate risks and improve income distribution.

Low adaptive capacity in Africa, characterized by insufficient resources as well as poor institutional and educational quality, did not reduce the adverse consequences of climate change on income inequality. Although the study found no significant impact of adaptative capacity on the nexus between climate change and income distribution, the importance of climate adaptation efforts cannot be neglected. The results of the study also highlight the essence of taking advantage of opportunities that strengthen policies targeted towards enhancing agricultural productivity. In the context of the study, channelling climate adaptation funds to small-scale farmers in Africa will have positive implications for income inequality reduction.

5.4 Recommendations

5.4.1 Policy Recommendation

This study recommends that efforts aimed at helping developing nations cope with the negative impact of climate change should be geared towards enhancing agricultural productivity. This would shield small scale farmers from the negative impact of climate change and would ultimately culminate in productivity and income increase. This would again help bridge the income gap between households engaged in agriculture and those in the non-agricultural sectors.

Moreover, since the low state of Africa's adaptive capacity does not moderate the current impact of climate change on inequality, policymakers should give greater attention to strengthening climate mitigation mechanisms which limit greenhouse gas emissions, as a mean of slowing down the rate at which climate change is occurring.

5.4.2 Further Research Recommendation

Given the insignificant role of adaptive capacity on income inequality in this study, future research could focus on providing an in-depth investigation into adaptive capacity's role on income inequality. Further studies could determine the relevant components of adaptive capacity, culminating in the reconstitution of the components that yield the desired outcomes in reducing income inequality. This could help policy makers know the appropriate destinations to channel adaptation funds and strategies in order to improve income distribution among people.

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APPENDICES

Appendix 1: Principal Component Analysis

Number of observations: 740
Number of components: 9
Trace: 9
Period: 1995-2015

Component	Eigenvalue	Difference	Proportion	Cumulative
1	3.9518	2.6129	0.4391	0.4391
2	1.3388	0.0971	0.1488	0.5878
3	1.2417	0.5364	0.1380	0.7258
4	0.7053	0.0361	0.0784	0.8042
5	0.6692	0.2859	0.0744	0.8785
6	0.3833	0.0260	0.0426	0.9211
7	0.3573	0.1391	0.0397	0.9608
8	0.2182	0.0839	0.0242	0.9851
9	0.1343	…	0.0149	1

Eigenvectors (loadings):

Variable	Comp1	Comp2	Comp3	Comp4	Comp5	Comp6	Comp7	Comp8	Comp9
Cereals Total	0.410	0.328	-0.259	-0.002	-0.160	-0.023	-0.174	-0.127	-0.765
Fruit Primary	0.379	-0.176	-0.003	0.326	-0.587	-0.273	0.021	-0.439	0.327
Oil crops Cake	0.390	-0.079	0.075	-0.094	0.631	0.110	-0.374	-0.495	0.181
Oil crops Oil Equivalent	0.082	0.565	0.455	0.546	0.243	-0.079	0.322	-0.007	0.010
Pulses Total	0.347	0.338	-0.427	0.145	-0.047	0.316	-0.215	0.463	0.447
Root & Tuber	0.248	-0.575	0.272	0.452	0.084	0.035	-0.243	0.451	-0.245
Vegetables	0.396	-0.253	-0.080	-0.137	0.069	0.439	0.743	-0.033	-0.060
Eggs Primary	0.400	0.032	0.086	-0.415	0.141	-0.696	0.152	0.348	0.099
Milk Total	0.177	0.165	0.671	-0.414	-0.373	0.359	-0.212	0.072	0.043

Appendix 2: Variance Inflation Factor

Variable	VIF	1/VIF
Adaptive Capacity	3.56	0.280759
GDP per Capita	2.9	0.345093
Agric Productivity	2.43	0.412203
Population	1.71	0.584183
Trade Openness	1.62	0.617774
CO2 Emission	1.57	0.635102
Resource Rents	1.52	0.656896
Gross Capital	1.37	0.728138
Foreign Direct Investment	1.36	0.736212
Temp Anomaly	1.16	0.860254
Polity2	1.12	0.889154
Mean VIF	1.85	