UNIVERSITY OF CAPE COAST

# ENERGY CONSUMPTION, INSTITUTIONS AND ENVIRONMENTAL QUALITY IN SUB-SAHARAN AFRICA

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# ENERGY CONSUMPTION, INSTITUTIONS AND ENVIRONMENTAL QUALITY IN SUB-SAHARAN AFRICA

BY

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# DECLARATION

**Candidate's Declaration**

I hereby declare that this thesis is the result of my original work and that no part of it has been published or presented for another degree in this university or elsewhere.

Signature………………………………. Date………………………………

Candidate's Name: Kwabena Boakye-Mensah

**Supervisors' Declaration**

We hereby declare that the preparation and presentation of the thesis were supervised in accordance with the guidelines on supervision of thesis laid down by the University of Cape Coast.

Signature………………………………. Date………………………………

Principal Supervisor's Name: Mr. Kwabena Nkansah Darfor

Signature………………………………. Date………………………………

Co-Supervisor's Name: Dr. Francis Taale

## ABSTRACT

Efficient use of renewable energy is critical for ensuring high economic growth and competition. However, the adoption and use of renewable energy alone may not be a sufficient means of ensuring environmental sustainability. By utilising the system Generalised Method of Moments technique on a balanced panel dataset of 26 sub-Saharan African countries from 2002 to 2016, the study investigated the effect of disaggregated energy consumption and institutional quality on environmental quality. The results of this study indicate that while non-renewable energy consumption degrades the environment, renewable energy consumption enhances the quality of the environment. The study also discovers that a lower tax burden and improvement in government integrity lead to higher environmental quality given the consumption of renewable energy. From the moderating effect of energy consumption and institutional quality, more secured property rights and improvement in government integrity significantly moderate the effect of non-renewable energy consumption on environmental quality while a lower tax burden moderates the effect of renewable energy consumption on environmental quality. The study recommends that to reduce carbon-induced emissions, governments and policymakers need to commit to renewable energy development while implementing a flexible tax system, securing property rights, and maintaining strong state integrity.

## KEYWORDS

Environmental Quality

Institutional Quality

Non-Renewable Energy Consumption

Renewable Energy Consumption

Sub-Saharan Africa

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# DEDICATION

To my parents

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| | |
|---|---|
| AR (2) | Arellano-Bond Test for Serial Correlation |
| ARDL | Autoregressive Distributive Lag |
| ASEAN | Association of Southeast Asian Nations |
| BRICS | Brazil, Russia, India, China and South Africa |
| CIS | Commonwealth of Independent States |
| COP26 | Conference of Parties (26) |
| COVID-19 | Coronavirus disease 19 |
| $CO_2$ | Carbon Dioxide |
| EC | Energy Consumption |
| EEA | European Environment Agency |
| EIA | Energy Information Administration |
| EKC | Environmental Kuznets Curve |
| FDI | Foreign Direct Investment |
| GDP | Gross Domestic Product |
| GFCF | Gross Fixed Capital Formation |
| GHG | Greenhouse gas |
| GMM | Generalised Method of Moments |
| GOV. INT. | Government Integrity |
| Gt | Gigatonnes |
| IEA | International Energy Agency |
| INSQ | Institutional Quality |
| IPAT | Impact of Population, Affluence and Technology |
| IPCC | Intergovernmental Panel on Climate Change |
| LUCF | Land Use Change and Forestry |

| | |
|---|---|
| MEA | Millennium Ecosystem Assessment |
| NREC | Non-renewable Energy Consumption |
| PROP RIG | Property Rights |
| REC | Renewable Energy Consumption |
| RGDPPC | Real Gross Domestic Product per capita |
| SDG | Sustainable Development Goal |
| STRIPAT | Stochastic Impacts by Regression on Population, Affluence and Technology |
| SSA | Sub-Saharan Africa |
| TAXB | Tax Burden |
| TOT | Trade Openness |
| UNEP | United Nations Environmental Programme |
| UNEP-IRP | United Nations Environmental Programme-International Resource Programme |
| UNFCCC | United Nations Framework Conference on Climate Change |
| URBAN | Urbanisation |
| WDI | World Development Indicators |

# CHAPTER ONE

# INTRODUCTION

## Background to the study

Energy resources, both renewable and non-renewable, are essential to all aspects of life. Consequently, energy is regarded as an integral part of the sustainable livelihood of several economies in the world. Without energy, most of the activities of life that enhance economic growth will be difficult to successfully carry out (Ramchandra & Boucar, 2011). The achievement of economic development is linked to the efficient use of energy (Balitskiy, Bilan, Strielkowski & Štreimikienė, 2016).

Rapid population growth and rising living standards across the globe are causing energy demand to increase. At the same time, many countries are struggling to provide sustainable amounts of energy to meet the rising demand for it (Edenhofer et al., 2011). For instance, despite the efforts of many developing economies to generate power that will enhance economic growth, energy supply is yet to be consistent and reliable (Ahuja & Tatsutani, 2009). Load shedding, inadequate energy supply, and frequent power outages have been the major bane of the Nigerian economy for several decades (Asumadu-Sarkodie & Owusu, 2016). The inability of these countries to provide reliable, efficient, and sustainable energy to their citizens has necessitated a rise in demand for unclean energy sources such as firewood, and charcoal, thus polluting the environment.

Despite the immense contribution of energy to socio-economic development, unregulated energy consumption is recognised to cause environmental degradation (Taale & Kyeremeh, 2016). Energy is widely recognised as a significant factor in climate change and is responsible for around two-thirds of the world's total greenhouse gas emissions (European Environment Agency [EEA], 2017). The expansion of the economy is stimulated by higher energy use. Nevertheless, higher energy use results in the production of more greenhouse gas (GHG) emissions (Khan et al., 2014). Energy consumption remains a key facilitator of global environmental pollution (Al-Mulali, Tang & Ozturk, 2015). Globalisation has hastened these changes, ensuring that the choices of one nation are greatly felt in many others. High energy consumption is also noted to have a lot of harmful effects on human life (Burger, DeLong & Hamilton, 2011).

Rapid socioeconomic development contributes to higher energy use and pollution emissions (Jian, Fan, He, Xiong & Shen, 2019). Carbon dioxide emissions from fossil fuel combustion essentially drive global climate change (Wang & Wang, 2015). The use of fossil fuels for electricity generation has aggravated environmental degradation in almost all parts of the world (Menyah & Wolde-Rufael, 2010). In particular, the little attention paid to environmental management in developing and newly industrialised economies has exacerbated the relationship between high energy consumption and environmental quality. As these economies continue to consume more energy, the nature of the environment is affected by the release of greenhouse gases that affect the quality of air and natural resources.

Research carried out by the Intergovernmental Panel on Climate Change (2007) predicts a catastrophic average global temperature rise in the next 100 years. According to this assessment, a further increase in temperature could be detrimental to the ecosystem and could cause sea levels to rise.

Available data from the International Monetary Fund projects a 3 percent mean global increase in gross domestic product between 2015 and 2040. During this period, the projected increases in world energy consumption are expected to reach a staggering 21 percent in 2040 (Osaki, 2019). About a 90 percent increase in $CO_2$ emissions was recorded globally. Out of this, 78 percent of total GHGs were accounted for by fossil fuel emissions and industrial processes (Intercontinental Panel on Climate Change [IPCC], 2014). Volcovici (2013) estimates $CO_2$ emissions from energy-related activities in developing economies to be 127 percent higher than those in developed economies by 2040.

Hove, Ngwerume, and Muchemwa (2013) reveal that nearly all nations in sub-Saharan Africa are at a pivotal point of their development, characterised by rising environmental pollution and increasing levels of urbanisation. These developments have the potential to weaken food production systems and intensify conflicts as well as undermine efforts and gains in growth and poverty reduction (Hogarth, Haywood & Whitley, 2015). Available evidence shows that about 56 percent of total emissions recorded in Africa come from agriculture, energy, forestry, and land use in the sub-Saharan region (Osman-Elasha & Fernández de Velasco, 2020). Further to the probable increases in population and expansion of the economy, greenhouse gases in sub-Saharan Africa are predicted to increase rapidly, largely due to a rise in consumption of fossil fuels and deforestation (World Bank, 2010).

Due to the difficulty of trading off economic growth for environmental improvement, it is important to find a balance between the two. The race to achieve already set climate change targets, therefore, demands that nations regularly review their greenhouse gas emission reduction portfolios to ensure effective management (Fawcett et al., 2015). As the clock ticks down to 2030, the key target year of the Paris Agreement, there is a growing consensus among major countries to accelerate efforts to decarbonise their economies (Kirton, Warren & Rapson, 2021).

The United Nations Environmental Programme emphasises the need to decouple resources to achieve sustainable consumption and production patterns geared towards a greener and equitable global economy (Carlsen, 2021). Climate change and energy security have currently become the primary concerns of most nations in the world (González-González et al., 2018). Given that carbon dioxide emissions drive climate change, achieving Sustainable Development Goal 13 of combating climate change and its impacts might be a difficult task especially for developing economies like Africa (Kyte & Forum, 2014).

Various policies and programmes have been designed to ensure sustainable economic development, one such policy being the Sustainable Development Goals aimed at achieving a global objective of having access to modern, cost-effective, reliable and sustainable energy (Santika, Urmee, Simsek, Bahri & Anisuzzaman, 2020). Efforts to meet the global objective of having access to cleaner forms of energy have resulted in the formulation of various policies relating to how the environment can be protected. To further the goals of the United Nations Framework Convention on Climate Change (UNFCCC) of 1992, the parties to the Kyoto Protocol have agreed to implement a range of measures to reduce emission levels to a point that lessens the likelihood of catastrophic weather occurrences brought on by climate change. The policy mandates an average emission reduction of 5% from developed nations (Tiwari, 2011). The most recent of such policies is the Conference of the Parties 26 (COP26) which is aimed at empowering the world to achieve net-zero emissions. The COP26 project is a United Nations climate change conference geared toward reducing greenhouse gas emissions to a point where global warming will be kept under 1.5 degrees (Shuckburgh et al., 2020). Although most of the policies implemented have to some extent aided in ensuring environmental protection, pollution remains on the rise.

Adoption and use of cleaner energy sources are deemed to be an important avenue through which improved environmental quality can be attained (Ozturk & Bilgili, 2015). The energy industry is instrumental in both economic growth and poverty reduction. As such, countries could make good use of energy by implementing an energy production policy and a shift towards clean and renewable energy (Zhu, Duan, Guo & Yu, 2016). The availability of more efficient forms of renewable energy technologies in recent times has now created the platform for African policy makers and business communities to enhance economic growth and innovation.

In most developing economies, the aspirations to alleviate poverty have been sought through rapid economic growth, perhaps with no regard to environmental maintenance. The rapid economic growth achieved has been made partly possible through increased energy use without recourse to the quality of the form of energy used in the growth drive. This feeds into poor environmental quality, which potentially affects human health and by extension, welfare. Until mitigating measures are taken, the aim of alleviating poverty through rapid economic growth might lead to more and more emissions being generated. Is it possible then, to consume these less expensive, more readily available, but environmentally damaging sources of non-renewable energy while mitigating their environmental impact? How do we balance energy use with environmental stewardship?

It may be difficult to hope for a sustainable level of development without effective governance and higher-quality institutions (Hope & Kempe, 2020). Institutions may be thought of as a set of rights, laws, and administrative processes that occur at different levels in society, each of which places a greater focus on environmental conditions and resource regimes. Most developing economies are characterised by weak institutional settings, long procedural delays, and an erratic investment structure that makes it difficult to mitigate environmental impacts (Bellakhal, Ben Kheder & Haffoudhi, 2019). It is estimated that developing nations lose an amount of $1.26 trillion annually due to corruption, bribery, embezzlement, and tax evasion (Lazarus, 2020). As part of achieving its Sustainable Development Goal 16, the United Nations Development Programme has set up targets to ensure the development of effective, accountable, and transparent institutions at every level. This is to assist in extending and strengthening the involvement of developing nations in institutions of global governance, as well as making sure that laws and policies that are in no way discriminatory are put in place for sustainable development (Lazarus, 2020).

Green growth can either be enhanced or hampered by the nature of laws and the level of enforcement agencies that are present in an economy. Quality institutions can also ensure compliance with established environmental standards (Nguyen, Schinckus, Nguyen & Su, 2018).

Interventions from institutions can stimulate sustainable economic growth by ensuring environmental improvements through proper legislation (Ali, Zeqiraj & Lin, 2019). Higher-quality institutions could pave way for corruption to be eradicated, the rule of law to be effectively enforced, accountability to be ensured, and improved monetary and environmental policy management to be achieved (Sherani, 2017).

**Statement of the problem**

Although energy consumption has aided the development of several nations over the years, such development has come at an enormous cost to the environment. Unregulated energy consumption is believed to bring about poorer environmental quality, especially in countries with weak institutions to ensure that environmental regulations are implemented and respected. Generally, in poor countries, people tend to focus more on their higher incomes and the cost of living than on improving the quality of the environment. It is believed that with energy being a key ingredient in development, many governments intervene in the energy market by exercising control over the supply of energy, manipulating energy demand, restricting competition using feed-in-tariffs, engaging in preferential tax treatment, establishing renewable energy quotas, setting up trade barriers and other regulatory structures, as well as investing in targeted stimulus programmes.

The profit-seeking actions of these governments are believed to essentially increase access to or perhaps reduce the price of politically preferred energy sources while increasing the price of other energy sources. By making available large volumes of the cheaper conventional energy fuels, the quality of the environment is threatened by potential emissions. Over the past century, fossil fuel use has resulted in large-scale environmental shifts on a global scale. Because of the magnitude of these reforms, strategies for promoting sustainable development and eradicating poverty may now include both mitigation and adaptation. It is believed that to foster a transition toward an effective allocation of environmental resources, well-established institutions with higher quality must be present to serve as a check against inefficient resource management. Effective monitoring of energy use by various institutions may ensure that the resources marked out to regulate related environmental problems are channelled into realising other paramount economic objectives.

The study adds to the existing literature by looking at the effect of disaggregated energy consumption to know the specific effect each of these components has on environmental quality in the presence of institutions.

**Purpose of the study**

The purpose of this study is to examine the effect of disaggregated energy consumption and institutional quality on environmental quality in sub-Saharan Africa.

**Objectives of the study**

1. Examine the effect of disaggregated energy consumption on environmental quality in sub-Saharan Africa
2. Investigate the effect of institutional quality on environmental quality in sub-Saharan Africa
3. Examine the moderating effect of institutional quality on disaggregated energy consumption and environmental quality in sub-Saharan Africa

**Hypotheses of the study**

The hypotheses of the study are as follows:

1. $H_0$ : Disaggregated energy consumption does not affect environmental quality in sub-Saharan Africa

   $H_1$ : Disaggregated energy consumption affects environmental quality in sub-Saharan Africa

2. $H_0$ : Institutional quality does not affect environmental quality in sub-Saharan Africa

   $H_1$ : Institutional quality affects environmental quality in sub-Saharan Africa

3. $H_0$ : Institutional quality moderates the effect of disaggregated energy consumption on environmental quality in sub-Saharan Africa

   $H_1$ : Institutional quality does not moderate the effect of disaggregated energy consumption on environmental quality in sub-Saharan Africa

**Significance of the study**

Results and findings from this study highlight the effect of disaggregated energy consumption on the environment. These findings provide an insight into the need to incorporate quality and effective institutional management as a way of ensuring efficient energy use and environmental sustainability. The results also inform the government and other stakeholders of the need to further intensify efforts in the transition toward cleaner energy. It also helps inform policymakers on the measures that could be put in place to ensure sustainable energy use. The findings from the study also contribute to existing theory and academic discourse on energy efficiency and environmental governance.

**Delimitation of the study**

This study focused on the role of institutions in the relationship between disaggregated energy consumption and environmental quality in 26 sub-Saharan African countries. The study was conducted for a 15-year period due to data unavailability before 2002 and after 2016.

**Limitation of the study**

Sub-Saharan Africa has different demographic, social, and economic characteristics. Categorising the region as a block implies overlooking some of these individual heterogeneities among these nations.

**Definition of terms**

**Energy consumption**: In analysing the effect of disaggregated energy consumption, the study employed annual data from World Development Indicators (WDI). The study utilised energy use in kilogrammes of oil equivalent per capita to measure non-renewable energy and renewable energy consumption as a percentage of total final energy consumption to measure renewable energy.

**Institutional quality**: Institutional quality captures the degree of economic freedom underlying three components ranging from property rights, tax burden, and government integrity. Data for institutional quality was sourced from the Heritage Foundation.

**Environmental quality**: Environmental quality is defined by carbon dioxide emissions in metric tonnes per capita. Data for environmental quality was sourced from WDI.

**Organisation of the study**

The study is organised into five chapters. The first chapter constitutes the introduction to the study, the background, statement of the problem, purpose, objectives, study hypotheses, significance, delimitation, limitation, the definition of terms, and the organisation of the study. A review of related literature is discussed and presented in Chapter Two. The third chapter discusses the methods employed in the research. It focuses on the study area, the study design, research approach, data collection techniques, analysis of data, and appropriate estimation techniques applied in the study. Research results are analysed in Chapter Four. Chapter Five summarises the study and draws conclusions and recommendations based on the results. It also suggests areas for further studies. The next chapter reviews related literature on energy consumption, institutions and environmental quality.

# CHAPTER TWO

# LITERATURE REVIEW

## Introduction

This chapter reviews related literature. It is composed of three sections. Section One provides an overview of energy and environmental issues in Africa and around the world. Section Two discusses some theoretical foundations on energy, institutions, and the environment. The third section highlights some empirical studies relating to energy consumption, institutions, and environmental quality. The chapter concludes with a synthesis of the reviewed literature and a summary of the entire chapter.

## Overview of global energy consumption and environmental issues

Energy consumption is generally considered a prerequisite for economic growth and, thus constitutes one of the fundamental aspects of the growth of a nation. Fossil fuels remain the world's principal energy source. Around 85 percent of cumulative energy needs are accounted for through the use of fossil fuels. Industrialisation, transportation, and electrification among others that essentially propels the growth of an economy are mostly powered by fossil fuel combustion (Sen & Ganguly, 2017).

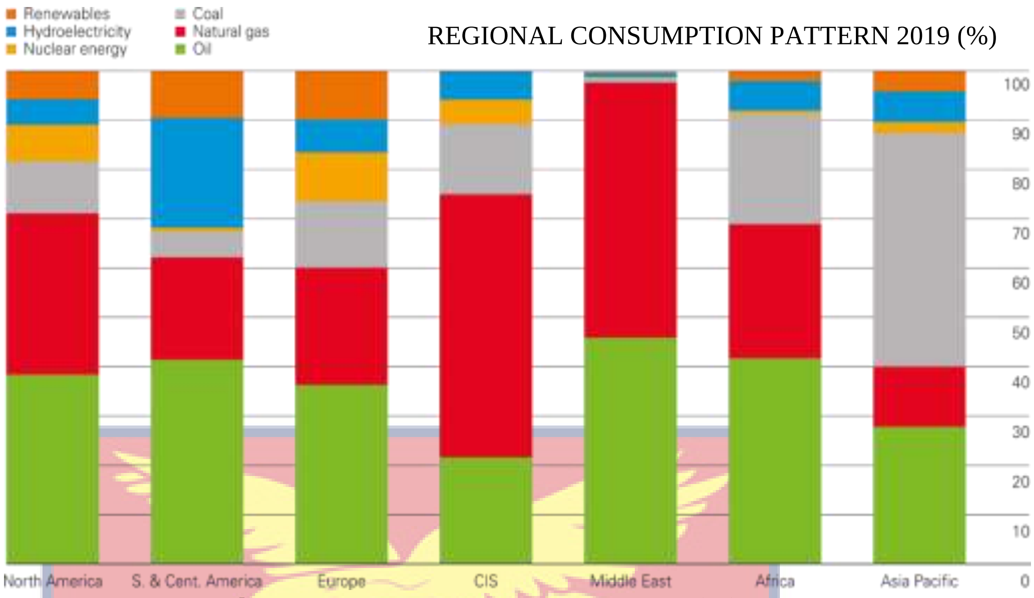


*Figure 1*: Regional energy consumption pattern 2019 (%)
Source: Looney (2020)

The regional energy consumption pattern of the world in 2019 is illustrated in Figure 1. From the graph, it is evident that the Middle East heavily relies on oil as its major energy source with about 46 percent of the continent's total energy sourced from it. The Commonwealth of Independent States (CIS), however, depends on natural gas as the major source of energy fuel. It constitutes about 52 percent of the total energy consumed in the region. Coal is the dominant source of energy used in the Pacific region of Asia and makes up about 47 percent of the entire energy mix of the continent.

Southern and Central America use the highest amount of hydroelectricity. It constitutes around 22 percent of the total energy sources consumed in the region. The consumption of renewables remains particularly low in all these regions. Nonetheless, there have been considerable improvements in the use of renewables in both Europe and America. The share of renewables constitutes around 10 percent of their total energy mix. Aside from the Middle East and America, Africa is the next continent that heavily relies on oil as its source of energy fuel. Oil constitutes around 42 percent of its total energy mix.

These energy sources have considerably aided the development of these economies. Notwithstanding, this expansion path has produced harmful by-products which are currently limiting the scope of economic growth (Beach & Hanlon, 2017). Amidst the continued global production and consumption of energy, there have been severe environmental impacts caused by greenhouse gas emissions. The International Energy Agency (2021) estimated a relatively stable fuel-induced emission at 34.2 $GtCO_{2eq}$ in 2019 after peaking at 34.3Gt in 2018. Further reports also indicated a significant 5.8% reduction in global $CO_2$ emissions resulting from low energy demand due to the COVID-19 policies. The United Nations Environmental Programme stresses that regardless of a reduction in GHGs due to the COVID-19 lockdown policies, the world is on course for a temperature rise of more than 3°C; a number that exceeds that of the Paris Agreement (United in Science Report, 2021).

In 2016, atmospheric concentrations of $CO_2$ emissions surpassed their threshold level of 400 parts per million. At the present growth rate, $CO_2$ levels are projected to hit 500 parts per million within the next half-century putting the world on the path to experiencing temperature boosts of perhaps more than 3°C (Jones, 2017). Current research conducted revealed that developing countries would be accountable for the majority of the increases in energy use in the coming decades. There is a cause for concern by the mere fact that most of these economies are characterised by low energy efficiency and increasing levels of energy-related emissions (Wolfram, Shelef & Gertler, 2012).

This situation has necessitated the adoption and implementation of policies and mechanisms to help sustain and enhance the current civilisation. Efficient energy use is a way through which economies can grow while ensuring environmental sustainability. Commercial expansion of power generation systems and the adoption of modern energy are some of the means through which energy can be used efficiently. Most non-renewables are undeveloped and as such efforts and resources should be channelled towards their development.

The balance in the coming years of economic and environmental compatibility will very much depend on the level of emissions within the environment. Consequently, reductions in these emissions would be essential to help reduce the harmful effects of climate change (Brown, Bischof-Niemz, Blok, Breyer, Lund, & Mathiesen, 2018). Given this, a transition to modern energy has now become a paramount challenge for economies in their quest to achieve cleaner growth (Bhattacharya, Awaworyi-Churchill & Paramati, 2017).

**Overview of energy consumption and environmental quality in Africa**

Africa has matured to become one of the leading powerhouses in world oil and gas markets. According to Dale (2019), reports from the British Petroleum statistical review indicate that primary energy consumption of Africa recently fell by 6.7 percent. This unprecedented decline was the continent's first recorded fall in energy consumption since 1991. This was brought about by the coronavirus pandemic. Africa also recorded a sharp decline of 9 percent in its per capita energy consumption compared to the global average of 5 percent. The continent experienced significant growth of

10.9 percent in its renewable energy generation. Out of the total energy consumption, 39 percent comes from the consumption of oil. This is followed by 30 percent natural gas, 22 percent coal, 6.8 percent hydro, 2 percent renewables, 1 percent wind, 0.7 percent nuclear, 0.6 percent solar, and 0.4 percent of other renewables (Looney, 2020).

Notwithstanding, with increasing urbanisation and a growing urge for non-renewables, the projected growth in oil demand for Africa now far exceeds that of most of the fast-growing economies. Fossil fuels account for roughly half of Africa's overall primary energy supply and one-third of the amount of energy the region consumes (Marais, Silvern, Vodonos, Dupin, Bockarie, Mickley & Schwartz, 2019). Regardless of its extensive energy resources, Africa continues to face significant energy issues. Some of these challenges include limited access to cleaner energy, inadequate energy infrastructure, inefficient energy use, and weak institutional and technical expertise to efficiently utilise available resources. The situation has slowed down economic growth and contributed to poverty in Africa.

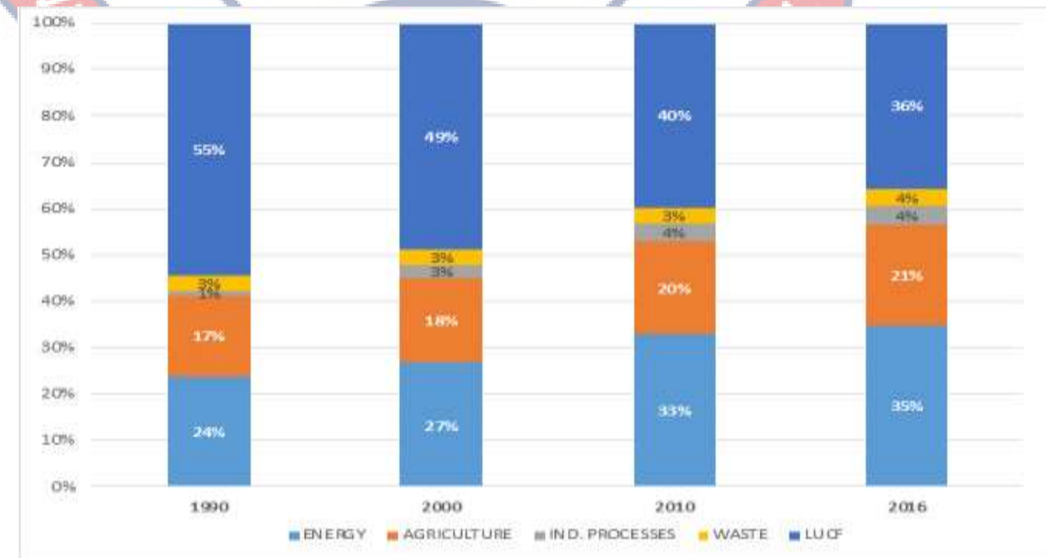


*Figure 2*: Evolution of Africa’s greenhouse gas emissions by sector 1990 – 2016
Source : Osman-Elasha & Fernández de Velasco (2020)

The evolution of Africa's GHGs within the various sectors of the economy from the period 1990 to 2016 is illustrated in Figure 2. It is observed from Figure 2 that land use change and forestry (LUCF) have historically contributed to the low quality of the African environment. The cause for concern is that energy-related greenhouse gas emissions keep on rising at alarming rates. The recorded figure for total carbon dioxide emissions of Africa from energy during this period was 1.2 billion tonnes representing 3.7 percent of the world's total (Looney, 2020).

The harmful effects of energy-related GHG emissions have heightened the concern about energy efficiency and how energy-related greenhouse gas emissions might be minimised to protect the environment. Given how much GHG emissions contribute to global warming, their continued release poses a threat to the environmental resource base. Reductions in these emissions would therefore be critical to ensuring environmental sustainability in Africa.

**Overview of energy consumption and environmental quality in sub-Saharan Africa**

Sub-Saharan Africa is endowed with over half of the oil and gas reserves on the African continent. The region accounts for about 60 percent of primary energy demand, with bioenergy being the dominant primary energy source. The portion of energy supply from modern renewables constitutes only about 10 percent. The lower supply of modern energy has been largely due to the vast untapped renewable energy potential in the region. One challenge Africa faces as a continent is an access to clean and efficient energy. Like several other developing economies, most nations in sub-Saharan Africa rely mostly on fossil fuels. Consequently, the region has been engulfed by higher air pollution and numerous resource challenges. Poor air quality forms the genesis of respiratory diseases like tuberculosis, asthma, and respiratory cancer among others (Jary, Simpson, Havens, Manda, Pope, Bruce & Mortimer, 2016). For instance, it is estimated that around 49,000 premature deaths occur in Africa every year due to urban outdoor air pollution (Schwela, 2012).

Based on data gathered in 2018, the region's energy-related $CO_2$ emissions were reported to be around 0.8Gt, making up for about 2 percent of global energy-related $CO_2$ emissions. Given that the primary energy supply is expected to surge in the future, these emissions are predicted to go up to around 0.97Gt in 2050 (Global Carbon Atlas, 2019). At present, only a smaller portion (around 4%) of world $CO_2$ emissions is produced in Africa. However, how Africa is developing could see the continent become a big emitter (Goldstone, 2021).

With increased fuel and energy usage, Africa's $CO_2$ emission per person has been expanding at a considerably quicker rate compared to the continent's population. The continent of Africa saw a 14-fold increase in its recorded $CO_2$ emissions between 1950 and 2016. Africa is currently home to over 1.3 billion people; a figure expected to more than double by the year 2060, reaching around 3 billion people. If by that date $CO_2$ emissions per capita were to just climb to the level that they are in India now, Africa's overall $CO_2$ production would quadruple to 5.8 gigatonnes annually, which is virtually an identical amount as the emissions that the United States produces today (Goldstone, 2021).

It is important to emphasise that the sub-Saharan African region is working to improve its environmental situation. This process has been facilitated by rapid advancements in the market development of energy-efficient technologies. The gradual incorporation of renewables in the energy mix has induced a substantial decline in the demand for unclean energy. Changes in storage and advancement in energy efficiency have also enhanced the energy situation in the region. The availability of decarbonised transport options means fewer fumes and cleaner air quality. Cleaner technology possibilities are fast being embraced and implemented.

Blimpo and Cosgrove-Davies (2019) reveal that investments in off-grid solar enterprises in SSA and other nations substantially increased to more than US$200 million between 2013 and 2016. Nonetheless, this rapid expansion only accounted for a small percentage of the investments required to make a significant impact on the regional energy marketplace. Energy efficiency is accompanied by a variety of economic and environmental benefits in both advanced and emerging economies (Popkova & Sergi, 2021). In the upcoming years, developing countries will be accountable for a chunk of the rise in energy demand. High energy use would be necessary to sustain the growth required to alleviate poverty. Nonetheless, if countries continue to depend on fossil fuels to satisfy this energy need, the world would be at risk of catastrophic climate change (United Nations Environmental Programme [UNEP], 2020).

Climate change and how its effects can be mitigated have become paramount due to increasing global environmental challenges. Some researchers have attempted to discuss both political and economic ways of reducing the effects of climate change. Consequently, most studies have focused largely on the underlying drivers of $CO_2$ emissions. The reason is that carbon dioxide emissions constitute the major leading pollutant on a global scale and as such, contribute significantly to changes in the climate. This study is inspired by a similar motivation and structured in a way that incorporates the roles institutions play in ensuring sound environmental quality.

**The recent development of economic freedom (institutional quality) and interrelationships with energy consumption and environmental quality**

The role of market structures in establishing an incentive system under which economic agents can operate and thus, resulting in efficient allocation of resources is termed economic freedom. It could also be defined as the legal right of a person or nation to manage his or her labour and property. Several studies have firmly established the positive link between economic freedom and economic growth (Hussein & Haque, 2016; Brkić, Gradojević & Ignjatijević, 2020). However, the link between economic freedom and environmental quality is still up for debate (Stroup, 2003).

Contrary to the central idea of a free market system where unregulated markets are thought to deliver the most effective outcomes for society and the economy as a whole, legislative strategies intended to combat climate change have regulatory ramifications (Rossen, Dunlop & Lawrence, 2015). Research has also distinguished the ideology of state interventionism, which emphasises the importance of governmental regulations in offering protection to the environment (Joshi, 2018). Considering the contradictory findings of these empirical studies, there is no generally accepted view as there still exists an ongoing debate on whether or not economic freedom ensures environmental quality.

It is believed that the principles of the free market that have opened the path to economic prosperity can also help protect the environment more pragmatically. Economic freedom offers protection to the environment by strengthening environmental stewardship. Environmental protection tends to be generally higher in nations with more economic independence than in economies with more intrusive, government-directed environmental governance (Kim & Bond, 2021).

Property rights, open markets, and a vibrant private sector are all considered vital economic structures that could affect environmental outcomes. Undesirable government legislation is believed to forestall agreements between those who profit from and those who are harmed by polluting activities. In the end, an effective allocation of the right to environmental resources is not achieved, resulting in inefficient levels of pollution. Bureaucratic inefficiency, lobbying, and the proliferation of state-owned corporations could impede a nation’s ability to successfully enhance the quality of its environment (Kim & Bond, 2021).

The most significant advancements in clean energy usage and energy efficiency have not happened from government command and control but as a result of advances in economic freedom. These achievements have been realised due to enhanced regulatory efficiency, secure property rights, market openness in the private sector, and higher levels of dynamic trade. The World Trade Organisation, in one of its conferences, emphasised the importance of trade openness in strengthening efforts geared towards mitigation and adaptation to climate change. Encouraging efficient global resource allocation, boosting living standards, and enhancing access to quality environmental products and services are considered some of the means through which trade has enhanced the quality of the environment (Kim & Bond, 2021).

Based on the models proposed by climate scientists concerning an inevitable global temperature rise of three degrees Celsius, even if carbon dioxide emissions were to be cut to zero, it would only have a minimal effect on global warming. Nevertheless, this would come at a huge cost to society. The burden of cost on society would stifle economic growth which constitutes an important factor for maintaining a cleaner environment. The financial capacity of individuals and economies to adequately cater to the environment largely depends on how well an economy grows. Though human activity directly affects climate change, big climate policies implemented by the government bring economic pain and very little environmental gain (Kim & Bond, 2021).

Lowering taxes and removing regulatory impediments to energy innovation constitute ways through which governments can preserve the economy. Some states, for instance, generate clean, inexpensive natural gas, but heavy restrictions and litigation prohibit pipelines from being built to transport the gas to other areas of the country. A recent article by Lo (2021) highlights the decision of 20 counties including Canada, the United States, most of Western Europe, six African countries, the World Bank as well as 5 development banks at COP26 to stop approving unabated gas fuels by the end of 2022. He further explains that the decision was met by a series of opposition and pleas. One such was made by the foreign minister of Nigeria, Geoffrey Onyeama, who voiced his concern and hinted at the implications taking such a stance will have on other African countries that see gas as a transition fuel in their quest towards net zero emissions.

Moreover, competition between electricity markets can make way for customers to purchase 100 percent renewable energy if they so want. Fixing a dysfunctional regulatory framework will enable the development of new, creative commercial nuclear technology. This is how clean energy can be attained. It is how economies can keep growing and, ultimately, how a cleaner environment can be achieved (Kim & Bond, 2021).

By merging economic freedom with environmental performance, the study highlights the regulatory role, which constitutes a finite measure in promoting economic development (Duval & Furceri, 2018). The conceptual framework associated with these interactions offers a methodological foundation for determining the significance of economic freedom in guaranteeing environmental sustainability.

**Review of theoretical literature**

**Theory of environmental governance**

Environmental governance could be defined as the interconnected structures and actor-networks that exist at every level of society, established to guide societies on how to adapt to and reduce the effect of environmental change (Biermann et al., 2009). Environmental policy has for a long time been viewed as the responsibility of government authorities (Fiorino, 2001). Recently, communities, individuals, non-governmental organisations, and corporations have all been included in discussions about environmental policy and management.

Many people today believe that "free market competition" is more efficient compared to "government regulation" of the economy. Although the traditional "command and control" methods of management may have been quite effective in guaranteeing a steady flow of ecosystem services, such achievement has only come at a huge cost to society and the environment. While social costs are associated with issues of compliance, enforcement, and conflict, environmental costs greatly interfere with the regulation and provision of ecosystem services (Millennium Ecosystem Assessment [MEA], 2005).

Being the founder of economic liberalism, Smith (2010) championed the right of individuals to freely make economic choices in a thoroughly competitive market. Such an economic structure that arose out of the necessity to guard against abuse of political authority has persisted and now dominates the economy of the 21st century (Marjanović, 2010). There was a common belief that society is made up of people who want to fulfil their private desires, while the government existed to preserve constitutionally guaranteed human rights (Clark, 1998). The explicit opponents of state interventionism advocated for absolute liberalisation, unrestricted circulation of goods, individuals, and resources in international flows, lower taxation for the wealthy, tax exemption for the poor, and privatisation of the public sector (Marjanović, 2010). These, as well as fiscal discipline, interest rate, and exchange rate freedom, general market reform, private property rights protection, and foreign direct investment, are some of the characteristics of the Washington Consensus on Economic Policy, which is currently being utilised in most economies around the world (Marjanović, 2010).

The concept of global governance may presently be understood in the best possible way not just by looking at what governments do, but also as a mix of what states, civil society and markets do or not.

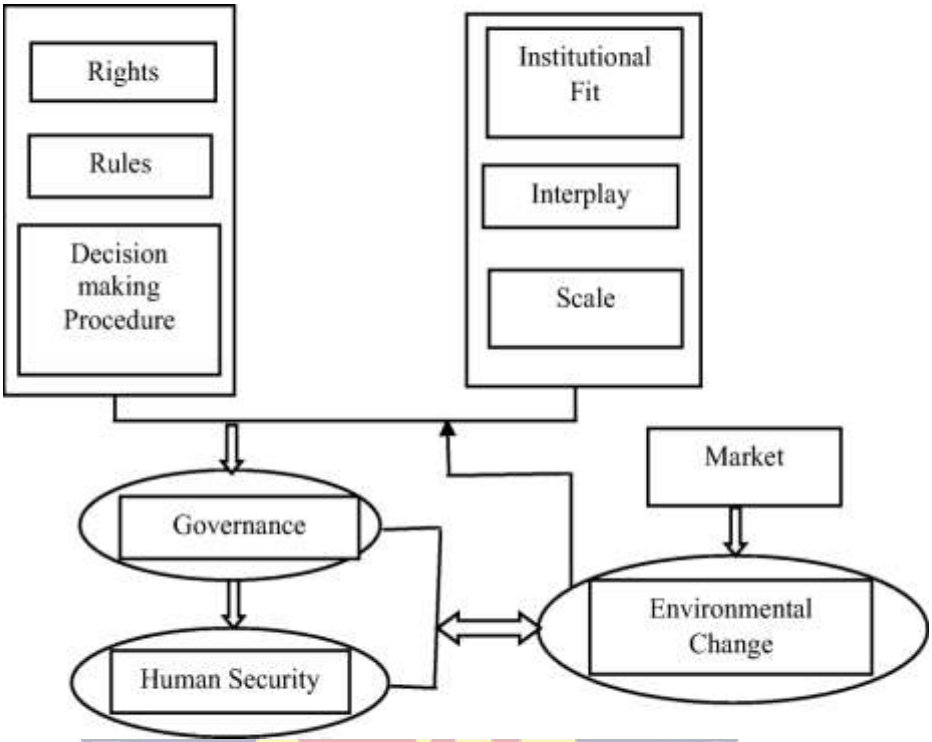


*Figure 3*: Conceptual framework of institutions and environmental quality
Source: Egbetokun and Ogundipe (2016)

Policymakers have established a range of systems of rights and obligations as well as relevant decision-making mechanisms in international environmental policy to solve global environmental challenges in the most efficient manner (Carter, 2013). A social practice emerges as a result of the collection of these rights, rules, and decision-making processes. Participants in the social practice are given roles within the practice, and interactions between those who occupy these positions are governed by these procedures (Young, 2008).

Ignoring the wishes, needs, fears, and worries of various actors during decision-making procedures may give rise to ill-advised choices and poor governance which may undermine a country's economic and social progress, leading to poverty, corruption, and higher unemployment. Government, communities, and individuals must therefore make smart choices to achieve effective governance. Good governance creates well-governed societies, communities, and nations that respect and protect people's rights. Such nations are better positioned to eradicate poverty, end violence, safeguard the environment, and achieve social and economic progress and development (Grenade, 2013).

Studies on fit investigate a wide range of different ways in which ecosystems and institutions might interact. They emphasise the need to establish a general theory of human-environment relationships to create appropriate institutions to tackle a given environmental problem (DeSombre, 2003). Institutional interplay presents an opportunity to control the interaction between institutions to achieve mutual benefits. Sections on interplay claim that national or international institutions are better at understanding the dynamics of large-scale ecosystems compared to local organisations, and that they are also more inclined to commercialise nature (DeSombre, 2003). Discussions on scale offer support to the view that while it may be difficult to ramp up knowledge about local institutions to generate solutions for global challenges, it is essential to assess and understand how local and global institutions complement each other (DeSombre, 2003).

The concept of human security has extended traditional conceptions of security far above sovereignty, nationalism, militarism, and conflict resolution to encompass a myriad of different challenges faced by individuals and communities (Shani, 2007). The connection between the environment and human security sheds light on two concepts (Detraz, 2009). The first, environmental conflict, relates to a competition over the available resource (Detraz, 2009). The concept of environmental conflict, as envisioned by Kaplan, is reflective of conventional ideas of security in which protecting the environment is seen as a legitimate objective of national security. The second concept, environmental security, centres on the impact of environmental change on people (Detraz, 2009). It highlights the impact of environmental degradation and natural disasters. Climate change, forest degradation, and resource depletion constitute a host of environmental challenges the world faces presently (Barnett, 2007).

**Free market environmentalism**

Free-market environmentalism describes environmentalism as the study of human relationships and their interactions with their environment (Huerta de Soto, 2009). The theory of free market environmentalism emphasises markets, property rights, and the rule of law as a solution to environmental problems. Advocates of free market environmentalism hold the view that low market regulation, protection of property rights, and higher economic growth offer more to environmental protection than government regulation (Andersen & Leal, 2001).

Property rights and other economic institutions have long been recognised as important in reducing emissions. Coase (1960) argued that in situations where there are no transaction costs, secured property rights would often lead to the correction of negative externalities. The cardinal insight of the Coase theorem is that with secure property rights, effective legal enforcement of contracts, and low transaction costs, people or even countries can bargain over externalities to generate Pareto improvements. This will happen when people who profit from and are harmed by polluting activities bargain until a fair allocation of the right to the resource is reached. Without secure property rights, such an agreement would be highly unlikely.

Coase (1960) also proposed that while assuming the absence of transaction costs will not truly make them disappear, the cost of settling disputes can be outrageously expensive. To foster a transition toward an effective allocation of environmental resources, well-established institutions that make it much simpler to settle disputes must be present. Panayotou (1993) suggested that emerging economies could reduce their environmental impact by removing market-distorting policies, ensuring strong property rights, and internalising any resulting externalities.

For proponents of free-market environmentalism, there are three major flaws in government-regulated environmental policies. The first problem is that government-planned economic policies make accurate forecasting impossible. When a person's private property rights are clearly defined, he or she has a legal basis for taking action against others who breach such rights, such as through a lawsuit (Andersen et al., 1990; Rothbard, 1982; Reimers, 2019). Humans are unable to act rationally when property rights are violated because the disruption of essential information and price signals prevents them from doing so. This means that the most extreme environmentalists cannot guarantee that their centrally planned initiatives would not bring more harm to the environment than they already have (Huerta de Soto, 2009).

Second, when governments officially declare natural resources to be public property, it hinders economic forecasting and discourages entrepreneuri al initiatives (Huerta de Soto, 2009). Being the engine of the market economy, entrepreneurs use price signals to make more environmentally sound decisions and distribute resources more effectively than governments do through central planning (Von Mises, 1996; Foss & Klein, 2012).

Third, government action and legislation can give rise to zero-sum games, whereas market cooperation may provide a more effective means of addressing these issues. Voluntary agreements and individual initiatives are hindered by governmental orders. Inefficient resource distribution occurs as a result of ineffective public management. Frequent government intervention and regulation policies prevent agents from internalising the costs and benefits of environmentally-related production. (Huerta de Soto, 2009; Boettke et al., 2015; Boettke, 2018).

Free market environmentalists propose that establishing and enforcing tradeable property rights could be a viable solution to resolving environmental issues. However, while markets are efficient in allocating resources, they are not capable of determining issues like equitable income distribution or the ideal size of the economy for the environment. "Free market environmentalism" may be the best answer to some environmental concerns. For instance, it can promote energy efficiency through market mechanisms (Eckersley, 1993).

As a way of internalising environmental externalities and ensuring better allocation of resources, free market environmentalists advocate for voluntary transactions between the owners of private property rights. Since governments are inefficient, it is preferable for private entities to own, control, and manage environmental goods and services such as energy, wood, water, national parks and wastes (Eckersley, 1993).

**The IPAT model**

Ehrlich and Holdren (1972) used this model to provide a simple theoretical framework to examine the 'multiplying' effect of population (P), affluence (A), and technology (T) on the environment. Simply put, the model was proposed to examine the determinants of environmental impact (I).

$$I = P \times A \times T \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Population growth is one factor that exacerbates environmental degradation. The rate of emissions is influenced by the size and growth of the population. This is because population growth induces higher consumption levels which are generally met by higher production levels in an economy. Production activities generate residual waste products which pollute the environment and consequently degrade natural resources. The exponential growth of the population is emphasised by Ehrlich and Holdren. They show, in a paper published in 1974, that population growth works as a multiplier for negative effects of human activity on the environment, such that even if only one of the IPAT elements rises significantly, it is the cumulative effect of all the factors that result in a significant influence on the environment (Chertow, 2000). Affluence refers to an economic activity per person. It is measured by GDP per capita. Affluence constitutes a per capita measure of wealth, consumption, or production.

Technology is defined as the efficiency with which production occurs. It has the potential to be beneficial and detrimental to the environment. Technological innovation has been and will continue to be a significant driver of global environmental changes (Segars, 2018). Nonetheless, technologies have frequently resulted in unintended outcomes. Energy consumption is considered to increase the temperature of the earth through the emission of harmful gases (Menyah & Wolde-Rufael, 2010). The burning of fossil fuels increases pollution levels. Existing scientific studies of technology issues do not often reflect the significant rebound effects of technologies (Chitnis, Sorrell, Druckman, Firth & Jackson, 2013). However, issues of technology now take centre stage in modern theories of growth (Romer, 1994; Zenghelis, 2011).

The IPAT identity has been successful for many reasons, including its ease of use and adaptability to different ecological contexts. The application of the IPAT equation in studies on energy-related carbon emissions may prove to be IPAT's most lasting legacy. This is especially true of research on climate change. Such formulations are stated as (Holdren, 2000):

$$Energy\ Use = Population \times \frac{GDP}{person} \times \frac{energy}{GDP} \ldots\ldots (2)$$

$$Carbon\ emissions = Population \times \frac{GDP}{person} \times carbon\ energy \ldots.. (3)$$

There have been some other helpful elaborations that have been done to the identity. The earliest illustration of this concept is found in the Kaya identity, which accounts for $CO_2$ emissions by multiplying the amount of $CO_2$ produced per unit of energy by the amount of energy used per unit of GDP (Kaya, 1990). This consideration of technology helps one grasp the differences between energy efficiency technologies such as enhanced energy-efficient refrigerators and low carbon energy sources such as solar photovoltaics.

The second example of IPAT elaboration is a more extensive breakdown by industry sector, fuel type, by material class among others. This specific form of analysis is currently commonly utilised (Ang, 2004; O'Mahony et al. 2012). A "master equation" that is directly built upon the

IPAT identity may be found in the recently developed discipline of industrial ecology. The master equation views technology not just as a significant driver or cause of environmental deterioration, but also as a possible source of remedy (Graedel & Allenby, 1995). However, to the best of our knowledge, the master equation has not established a forecasting model for technological advancement. Dietz and Rosa (1994), who named their approach STIRPAT and introduced some more constants that allowed the basic variables to be raised to powers, are credited with the fourth example of extension. This extension makes the relationship more amenable to statistical analysis. Their equation reads as follows:

$$I = aP^{b}A^{c}T^{d}e\ldots\ldots (4)$$

Where *a-d* denotes parameters estimated using standard statistical techniques and *e* is the error term.

**Review of related empirical studies**

An uninterrupted supply of energy is needed to achieve sustainable economic growth. As a result, there is the need to ensure efficient use and regulation of these energy sources in a way that would ensure their continued availability both in the present and in the future. Without a constant supply of energy, production processes, as well as modernisation, would be impeded. Carbon dioxide emissions are regarded as one of the most essential measures of the quality of the environment and as such have been used by most researchers in an attempt to establish the relationship the environment has with other macroeconomic variables. As a way of finding out the gap in our literature, the study reviews a few works that have been done on energy, economic growth, institutional quality, and environmental quality.

**Studies on the relationship between energy consumption and environmental quality**

Ozturk (2015) employed the panel co-integration technique on data gathered from a panel of six economically diversified economies to inquire into how energy consumption and air pollution affected climate change from 1990 to 2012. Findings revealed that energy use and air quality have a direct influence on the climate. The results of the study reveal that higher energy consumption induces higher greenhouse gas emissions. However, results from fixed and random effect estimations indicate that these indicators of air quality have a weakened effect on the climate.

Dong, Sun, and Hochman (2017) examined the impact of the consumption of natural gas and renewables on environmental sustainability. Findings from the study confirm the existence of the EKC hypothesis for BRICS economies. The causality analysis which was carried out in the study also confirms the feedback mechanism among the variables.

Mert and Bolük (2016) analysed data from 16 European nations from 1990 to 2008 to find out how energy consumption affects environmental quality. By applying OLS and the fixed effect approach, results from the study indicated that renewable and non-renewable energy contributes to the release of greenhouse gas emissions. However, renewable energy induces lower levels of emissions.

A study conducted by Paramati, Sinha, and Dogan (2017) portrayed a direct link between renewable energy and economic growth in developing countries. The study which was examined from 1991 to 2012 also reveals an inverse relationship between renewable energy and carbon dioxide emissions.

As a result, the study encourages the use of more renewable energy in the present grid system to ensure effective environmental management.

Using panel data from 24 African countries, Asongu, El Montasser, and Toumi (2016) studied the relationships that exist between energy consumption, $CO_2$ emissions, and economic growth based on an ARDL technique. Findings from the study confirm a significant relationship between energy consumption, $CO_2$ emissions, and economic growth. Other results show a significant negative short-run error correction model with a value less than one.

Alam, Murad, Noman, and Ozturk (2016) found out that higher income and energy consumption stimulates $CO_2$ emissions. Based on the ARDL bound test, the study reveals a significant positive link between $CO_2$ emissions and population growth for India and Brazil. To confirm the EKC hypothesis, tests carried out show that a rise in income levels in Brazil, China, and Indonesia lowers carbon dioxide emissions.

Sinha, Shahbaz, and Balsalobre (2017) sought to examine the impact of the EKC hypothesis on $CO_2$ emissions using disaggregated forms of energy across 11 economies. The study, which was conducted for 25 years, reveals an N-shaped relationship between economic growth and environmental degradation across these economies.

**Studies on the relationship between institutions and environmental quality**

Lau, Choong, and Eng (2014) carried out a study on the impact of institutional quality and $CO_2$ emissions on economic growth in Malaysia from 1984 to 2008. By employing the bound testing approach, the study revealed a significant direct effect of institutional quality, carbon emissions, and exports on economic growth. With the interaction between $CO_2$ emissions and institutional quality, the result discovered a positive effect on economic growth. The results from this study indicate that quality institutions could effectively work to enhance environmental improvement through the reduction of $CO_2$ emissions.

**General determinants of environmental quality**

Pao and Tsai (2011) carried out a study to analyse the impact of economic growth and financial development on the environment across BRICS economies from 1980 to 2007. The results from a panel co-integration reveal a bi-causal link between $CO_2$ emissions and FDI. Other findings also indicate a causal relationship between output and FDI in the long run.

Ponce de Leon Barido and Marshall (2014) applied the fixed and random effect methods to investigate how urbanisation and environmental policy affect $CO_2$ emissions in 80 countries. By conducting this research from the period 1983 to 2005, findings from this study indicated that on average, a one percent growth in the urban population could induce a 0.95 percent increase in the amount of carbon dioxide emissions.

Further research conducted by Ali, Abdul-Rahim, and Ribadu (2017) reveals a negative impact of urbanisation on carbon dioxide emissions in Singapore. Nonetheless, economic growth leads to further environmental deterioration.

Balibey (2015) also attempted to assess the EKC hypothesis for Turkey from 1974 to 2011. By employing the Johansen co-integration and the vector auto-regression model, the study ascertained a positive impact of FDI and economic growth on $CO_2$ emissions.

**Chapter summary and synthesis of the literature**

This chapter presented literature on energy use in the world, Africa, and sub-Saharan Africa, particularly highlighting the dangers that higher energy consumption brings to the environment. It also covered some theoretical literature and empirical studies relating to energy, institutions, economic growth, and environmental quality. The researcher searched for relevant related materials, including articles, journals, reports, and working papers on energy consumption, institutions, and environmental quality. All references in related studies were assessed to verify that most of the literature for this study was captured. Nonetheless, it must be pointed out that the literature list presented in this study is non-exhaustive. Although the focus of the study was on Africa, literature on European and other non-African nations was also considered to capture other relevant variables within the context of the study.

Among the studies that were reviewed, the majority of them focused on multiple countries from different continents. The remaining studies were conducted in either specific countries or regions worldwide. The Autoregressive Distributive Lag technique and the Panel co-integration approach were the most dominantly used methods. In regards to the link between the variables that were used in these studies, the relationship between energy consumption and environmental quality was not entirely negative or positive. In almost all the countries and regional blocks studied, evidence of both positive and negative relationships between energy consumption and environmental quality has been documented. In this regard, no universal generalisation has been made regarding the exact relationship. More than half of the analysed papers used $CO_2$ emissions to measure environmental quality. Most of the research conducted discovered that a country or region's economic growth had a significant impact on environmental quality.

In summary, it should be said that although empirical studies on the environment and issues relating to pollution are extensive, a significant number of works examining environmental relationships have ignored the importance of institutions (Paramati, Sinha & Dogan, 2017; Shahbaz, Sbia, Hamdi & Ozturk, 2014; Asongu, El Montasser & Toumi, 2016). Being a new and different approach to existing studies, the lack of research in this area necessitates further insight.

It is the argument of this study that institutional quality which is measured as economic freedom has a decisive role to play in enhancing environmental quality. Despite sometimes acknowledging this inescapable, causal connection, most researchers have failed to account for the role of institutions in their explanatory models. When assessing environmental outcomes, property rights, open markets, and a thriving private sector are believed to be key economic institutions to consider, and as such, failure to incorporate them might lead to inconsistent results.

As a way of filling the gap that exists in the literature, the study employs several sparsely institutional factors including property rights, tax burden, and government integrity to assess the link between energy consumption and environmental quality in SSA. The next chapter focuses on the methodological section of the study.

# CHAPTER THREE

# RESEARCH METHODS

## Introduction

This chapter discusses the methods employed in the study. The chapter highlights the steps and procedures that guided the study in addressing its objectives. The chapter is structured into three sections. The chapter begins with an explanation of the research philosophy, design, and approach. The first section features the specification of the empirical model. The type and sources of data with their descriptions are highlighted in the second section of the chapter. Section Three looks at the technique and procedures used in the estimation process as well as diagnostic tests associated with the results. The third section ends with the chapter summary.

## Research Philosophy

Research is an inquiry into a phenomenon that involves collecting, analysing, and interpreting data to determine the causes and effects of social events. The theoretical framework that governs this process is referred to as a research paradigm (Babbie, 2005; Kuhn, 1962). Simply put, a research paradigm provides an overall framework through which reality is viewed, the elements it contains, and the kind of abstractions that can be deduced from them.

It should be emphasised that although several paradigms have been highlighted in the literature, Della Porta and Keating (2008) and Guba and Lincoln (1994) argue that positivism, postpositivism, constructivism, and critical theory remain the only ones that compete for recognition as "paradigms of choice" in guiding social science research. Galliers (1991) maintains that there are two main dimensions in the tradition of science: positivism and postpositivism. While positivism admits knowledge about the real world to be limited and relative, postpositivism holds onto the assertion that reality can only be achieved and fully understood through subjective interpretation (Patton, 2002).

Positivism describes epistemologies that seek to objectively measure, analyse and forecast social events by highlighting regularities and causal links between them (Babbie, 2005; Creswell, 2003). The positivist philosophy assumes that society can be scientifically studied and knowledge can be objectively discovered. Alternatively put, the positivist paradigm asserts the view that in the social sciences, the researcher can be separated from the object of his or her research and as such, observes it in a neutral and value-free manner.

Advocates of this philosophy believe that society can be studied and understood logically and rationally. Positivists also believe that a phenomenon can only be clearly understood if it is free from personal emotions and can be scientifically validated through empirically verifiable and repeated methods of inquiry. Since this philosophy suits the study and is widely used in the literature, the study adopted the positivist research philosophy.

**Research approach**

Three forms of research approaches have been identified in the literature. These include quantitative, qualitative, and mixed methods (Creswell, 2014). The principal focus of qualitative research is to explore and discover the reality. As a result, induction rather than theory testing is more frequently relied upon in the quest to discover the truth. Unlike the qualitative approach to research, the quantitative research approach more often than not depends on existing data to test for hypothetical propositions.

Quantitative research is defined as a systematic inquiry into a phenomenon that involves the collection of quantifiable data and the use of statistical methods to test the relationships between and among variables in an objective manner (Babbie, 2010). Like in quasi-experimental research design, the quantitative approach to research also takes the positivist paradigm as its starting point. Given its extensive use in the literature and its suitability for quantitative-based studies, the study employed a quantitative research approach to achieving its research objectives.

**Research design**

Research design constitutes a framework of methods or techniques used in the research process. There exist four types of research designs. These include Descriptive, Correlational, Quasi-Experimental and Experimental research designs. While the descriptive research design seeks to describe a phenomenon, correlational research allows the researcher to establish a relationship between closely related variables or topics. The quasi-experimental research design, on the other hand, aims to establish a cause-and-effect relationship between a dependent and an explanatory variable.

Naturally, the descriptive and correlational research designs are based on the constructivist paradigm, while the experimental research designs follow the positivist philosophy. The quasi-experimental research design is based on the positivist view of the received model, which rests on the formulation and verification of theoretical hypotheses using empirically verifiable estimation techniques. Based on its extensive use in the literature and its suitability for the study, the quasi-experimental research design was chosen.

**Theoretical model specification**

The IPAT model is a simple framework that assesses the environmental impact (I) of population (P), affluence (A), and technology (T) on the environment.

$$I = P \times A \times T \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{ (5)}$$

In the context of this study, we expressed I as environmental quality, P as urbanisation (URBAN), A as real per capita GDP, and T as energy consumption. Trade openness (TOT) and foreign direct inflows (FDI) which ensures energy is not wasted are also considered key proxies. The quality of the institutions (INSQ) is important because it provides enforcement, prevents bad practices, and establishes property rights, which guarantees the ownership and prevents public misappropriation of resources. The IPAT model is augmented to incorporate some institutional variables as a proxy for behavioural factors accordingly. Using appropriate proxies, equation (5) is transformed as:

$$I = f(URBAN \times RGDPPC \times EC \times TOT \times FDI \times INSQ) \ldots\ldots \text{ (6)}$$

**Specification of the empirical model**

A wide array of literature has adopted the IPAT model to ascertain the effect economic variables have on the environment (Dietz & Rosa, 1994; Schulze, 2002; Naqvi & Rehm, 2014). Following Begum, Sohag, Abdullah, and Jaafar (2015) and Yeh and Liao (2017), the study applied the IPAT model to investigate the effect of disaggregated energy consumption and institutions on environmental quality. First, energy consumption is defined as a function of institutional quality and other exogenous factors (EX1).

$EC = f(INSQ, EX1)$……… (7)

Environmental quality is also defined as a function of energy consumption (EC) and other variables such as production technologies (EX2):

$CO_2\text{E} = f(EC, EX2)$……… (8)

Finally, by substituting Eq. (7) into Eq. (8), the following relationship is obtained:

$CO_2\text{E} = g(EC, INSQ, EX1, EX2)$……… (9)

To obtain the first and second objectives of the study, which seeks to examine the effect of disaggregated energy consumption and institutional quality on the quality of the environment, the equations are stated as:

$$CO_2\text{E}_{i,t} = \beta_0 + \beta_1 CO_2\text{E}_{i,t-1} + \beta_2 NREC_{i,t} + \beta_3 INSQ_{i,t} + \beta_4 EG_{i,t} + \beta_5 \boldsymbol{X}_{i,t} + \omega_t + \gamma_i + \varepsilon_{i,t} \quad i = 1,2,3,\dots,26 \quad t = 1,2,3,\dots 15 \text{ ………. (10)}$$

$$CO_2\text{E}_{i,t} = \beta_0 + \beta_1 CO_2\text{E}_{i,t-1} + \beta_2 REC_{i,t} + \beta_3 INSQ_{i,t} + \beta_4 EG_{i,t} + \beta_5 \boldsymbol{X}_{i,t} + \omega_t + \gamma_i + \varepsilon_{i,t} \quad i = 1,2,3,\dots,26 \quad t = 1,2,3,\dots 15 \text{ ………. (11)}$$

Where $CO_2E$ represents environmental quality. $CO_2\text{E}_{i,t-1}$ denotes the lagged dependent variable of $CO_2$ emissions, $NREC$ represents non-renewable energy consumption, $REC$ is renewable energy consumption, $EG$ represents economic growth, $INSQ$ represents institutional variables consisting of indicators such as property rights, tax burden, and government integrity, $X$ represents a vector of other control variables including trade openness, urbanisation, foreign direct investment and gross fixed capital formation. $\beta_0$ represents the constant term and $\beta_0, \beta_1, \beta_2, \beta_3, \beta_4 . \beta_4, \beta_5, \beta_6$ represent the parameters or coefficient of interest. $\varepsilon$ is the error term whilst $i$ and $t$ represents individual country and time respectively.

In achieving the third objective which seeks to investigate the moderating effect of institutional quality on disaggregated energy consumption and environmental quality, the study first examines the joint effect of institutional quality and disaggregated energy consumption on environmental quality. This is to help ascertain the instantaneous rate of change in environmental quality related to changes in renewable and non-renewable energy consumption. The equations are then specified as:

$$CO_2E_{i,t} = \beta_0 + \beta_1 CO_2E_{i,t-1} + \beta_2 NREC_{i,t} + \beta_3 INSQ_{i,t} + \beta_4 EG_{i,t} + \beta_5 \boldsymbol{X}_{i,t} + \beta_6 (NREC_{i,t} * INSQ_{i,t}) + \omega_t + \gamma_i + \varepsilon_{i,t} \quad i = 1,2,3,\ldots,26 \quad t = 1,2,3,\ldots 15 \quad \ldots\ldots\ldots\ldots (12)$$

$$CO_2E_{i,t} = \beta_0 + \beta_1 CO_2E_{i,t-1} + \beta_2 REC_{i,t} + \beta_3 INSQ_{i,t} + \beta_4 EG_{i,t} + \beta_5 \boldsymbol{X}_{i,t} + \beta_6 (REC_{i,t} * INSQ_{i,t}) + \omega_t + \gamma_i + \varepsilon_{i,t} \quad i = 1,2,3,\ldots,26 \quad t = 1,2,3,\ldots 15 \quad \ldots\ldots\ldots\ldots (13)$$

$NREC * INSQ$ denotes the interaction term of non-renewable energy consumption and institutional quality while $REC * INSQ$ represents the interaction term of renewable energy consumption and institutional quality respectively. $\omega_t$ indicates time-specific fixed effects while $\gamma_i$ indicates individual country-specific effects.

The interaction alone does not adequately cater to the moderating effect of institutional quality and energy consumption on environmental quality. The study, therefore, analyses the moderating effect of institutional quality and energy consumption on environmental quality by calculating the marginal effects at the means of the institutional variables.

$$\frac{\Delta CO_2E_{i,t}}{\Delta EC_{i,t}} = \beta_2 + \beta_3\overline{INST}\ldots\ldots\ldots\ldots\ldots (14)$$

Where $\beta_2$ represents the coefficient of the energy consumption. $\beta_3$ denotes the coefficient of the interacted term of energy consumption and institutional quality and $\overline{INST}$ is the mean of the institutional quality variable.

**Sources of data**

A panel annual data series from 2002 to 2016 was used for the study. The data series were sourced from WDI and the Heritage Foundation (Economic Freedom). It should be noted that only 26 countries from the sub-Saharan African region were selected as a result of data unavailability.

**Definition and measurement of variables**

The variables employed for the analysis are described as follows:

**Carbon dioxide emissions**: The dependent variable for the study is carbon dioxide emissions per capita. This measure is consistent with Aboagye (2019) and Ali, Zeqiraj, and Lin (2019). Carbon dioxide effectively captures most of the environmental conditions in an economy. It is regarded as one of the catalysts of environmental pollution which adversely affects the quality of the environment. This harmful gas enters the atmosphere through energy use and other chemical reactions (Intercontinental Panel on Climate Change [IPCC], 2013).

**Energy Consumption**: Fossil fuels sit at the core of the debate on climate change for the simple reason that burning these fuels leaves in their wake massive amounts of carbon dioxide. Collectively, fossil fuels account for almost 56.6 percent of the greenhouse gas emissions around the world (Sen & Ganguly, 2017). However, new forms of energy are being adopted as a way of protecting the environment. The study, therefore, investigates the link between disaggregated forms of energy and environmental quality. The measures employed in the study were energy use in kilogrammes of oil equivalent per capita and renewable energy consumption as a percentage of total final energy consumption. These measures are in line with Jian, Fan, He, Xiong, and Shen (2019).

**Economic Growth**: This occurs when there is a rise in the production of goods and services and a simultaneous rise in income levels over time. Economic growth is believed to negatively affect the quality of the environment by propelling faster rates of exploitation of natural resources. Following Zhu, Duan, Guo, and Yu (2016), the study used real GDP per capita to measure economic growth.

**Trade Openness**: Trade openness can be defined as the degree to which a nation is open to participating in international trade. It is expected that trade openness would have a direct effect on the environment. Trade openness is measured by total trade as a percentage of GDP. This is in line with Chen, Jiang, and Kitila (2021).

**Foreign Direct Investment**: It refers to a form of cross-border investment where a citizen of one nation has authority over a company and the administration of that company in another nation. Several nations have become "pollution havens" as a result of their decision to relax environmental restrictions to increase foreign direct investment. These countries have become the most attractive hosts of FDI due to their abundant natural resources, cheap labour costs, and lax environmental regulations. Ultimately, resources are carelessly destroyed and the environment is polluted with no regard for it. The study measures FDI as the net inflows of investment as a percentage of GDP.

Zhu, Duan, Guo, and Yu (2016) justify the inclusion of FDI. FDI is expected to have a negative relationship with the environment.

**Urbanisation**: Urbanisation refers to the process by which large numbers of people become concentrated in relatively smaller areas. Urbanisation induces higher demand for and consumption of resources such as food, water, air, fossil fuels, and minerals, among others. Higher consumption of these resources leads to the mass generation of waste products and other harmful pollutants. Following Dash et al. (2020), the study uses the annual growth rate of the urban population as a proxy for measuring urbanisation. It is expected that growth in urban centres will lead to more environmental pollution.

**Gross Fixed Capital Formation**: Land upgrades, factory, equipment acquisitions, construction of bridges, highways, and commercial and industrial facilities all contribute to GFCF. The extraction and refinement of resources including biomass, fossil fuels, metals, and non-metallic minerals all contribute to climate change (Hertwich, 2021; United Nations Environmental Programme-International Resource Programme [UNEP-IRP], 2019). The approach taken by Lee (2005), Soytas and Sari (2009), and Narayan and Smyth (2008) in the energy literature is followed, and GFCF is used as a substitute for capital stock. The study measures GFCF as gross fixed capital formation as a percentage of GDP. The study expects that increases in fixed capital will lead to a fall in the quality of the environment.

**Institutional variables**

Institutional quality, as used in the study, captures the degree of economic freedom underlying three basic components, ranging from property rights, tax burden, and government integrity. The measurement of economic freedom used in this study is based on the index developed by the Heritage Foundation. Personal choice, voluntary exchange, freedom to compete in markets, and protection of private property constitute the basic elements of economic freedom. Following the collection of data for more than 180 economies, statistical procedures were employed to assign each country a component rating between 0 and 100. With a total of twelve measures, the economic freedom index has been grouped under four broad headings. These include the rule of law (property rights, government integrity), regulatory efficiency, open markets, and government size or limited government (tax burden). A higher component rating, particularly one that is closer to the hundredth position on the scale, is indicative of institutions more consistent with economic freedom (The Heritage Foundation, 2022).

Governments need to engage in certain activities while refraining from others to get a higher ranking on the economic freedom index. By creating a stable monetary environment, allowing individuals to choose for themselves, ensuring lower taxes, ensuring private sector development, and refraining from creating barriers to both domestic and international trade, governments boost their chances of getting a higher score of economic freedom (The Heritage Foundation, 2022).

**Property Rights**: Property rights refer to the legal right to the ownership and use of resources. Legal protection of private property is a prerequisite for the business environment as it fosters innovation, promotes entrepreneurship, and, thus leads to improved environmental health. The property rights indicator measures how well the government protects the rights of citizens to own, use, and inherit private property. It examines the independence of the judiciary, provides checks against judicial corruption, and monitors issues that relate to contract enforcement (Cabello, Ruiz & Pérez-Gladish, 2021).

Markets perform their function effectively only when property rights are well-defined, enforced, and tradable. When property rights are not properly defined or defended, the fault may not lie with the non-existent market but instead, with the governments that failed to protect citizens against rights violations by others in society. When a property is not protected from loss, environmental harm occurs. Equitable administration of private contracts helps to ensure fairness and integrity in the marketplace (Cabello, Ruiz & Pérez-Gladish, 2021).

This component's score is calculated by taking the average of the scores for three sub-factors; risk of expropriation, respect for intellectual property rights as well as the quality of contract enforcement, property rights, and law enforcement, each of which carry equal weight. This is done using the equation:

$$Subfactor\_score_i = \frac{100 * Subfactor_{Max} - Subfactor_i}{(Subfactor_{Max} - Subfactor_{Min})^2} \text{.........} \quad (15)$$

Where $Subfactor_i$ denotes the original data for the country $i$ and $Subfactor_{Max}$ and $Subfactor_{Min}$ represent the upper and lower bounds for the corresponding data set. $Subfactor\_score_i$ denotes the computed sub-factor score for country *i*.

Following Brkić, Gradojević, and Ignjatijević (2020), the study uses the property rights index constructed by the Heritage Foundation. The index is graded on a scale of 0 to 100 with a higher value reflecting a country with secured private ownership. A lower value represents a country where there are a greater number of state-owned properties, expropriation, a corrupt judicial system, and ineffective enforcement of private property. It is expected that a more secure property rights system will induce a higher environmental quality.

**Tax Burden (Fiscal Freedom)**: Tax Burden is a measure of the tax burden imposed by the government. The Heritage Foundation's economic freedom uses the tax burden index to assess the level of fiscal freedom in a country. Fiscal freedom refers to the degree of freedom individuals in an economy have from the tax burden placed on them by the government. Taxation and borrowing are used by governments to place fiscal constraints on economic growth. Economic freedom is maximised by governments that enable individuals and corporations to retain a greater portion of their profits and resources for their good and use. Higher government profits or capital lowers the individual's capacity for productive success. Higher tax rates make it more difficult for businesses to pursue their interests in the economy, thereby lowering total private-sector investment (Cabello, Ruiz & Pérez-Gladish, 2021).

The tax burden index, previously known as the fiscal freedom index does not provide a complete picture of the tax burden because it excludes payroll, sales, excise tax, tariffs, and value-added tax. Tax burden as measured by the Heritage Foundation constitutes the amount of corporate and income tax. It incorporates the top marginal tax rates on individual and corporate income and the total tax burden as a percentage of GDP. A quadratic cost function is employed for this computation of the tax burden index.

$$Tax\_Burden_{ij} = 100 - \alpha(Factor_{ij})^2 \ldots\ldots\ldots\ldots (16)$$

Where $Tax\_Burden_{ij}$ is fiscal freedom in country $i$ for factor $j$, while $Factor_{ij}$ is the value of factor in country $i$ for factor $j$. $\alpha$ is a coefficient set equal to 0.03. The score for each component is computed individually on a scale of 100 points, and the average is used to determine the fiscal freedom subindices.

In line with Brkić, Gradojević, and Ignjatijević (2020), the study adopts the tax burden index constructed by the Heritage Foundation. It is graded on a scale of 0 to 100. Countries that impose higher taxes are more likely to have a lower score (closer to 0) while countries that ensure individuals have higher freedom in regards to the tax burden placed on them are likely to have a higher score (closer to 100). Higher fiscal freedom is expected to have a positive impact on the environment.

**Government Integrity**: Differences in social and cultural norms create differences in perceptions of attitudes or behaviour. Corrupt practices in one location may represent conventional relations in other areas. Small unofficial rewards to service providers or state authorities, for instance, may be seen as a common form of allowance, a bonus for exceptional service, or a dishonest form of extortion. Bribery, nepotism, cronyism, patronage, embezzlement, and graft are even more concerning forms of institutional misconduct by government institutions. Though not all of these activities are criminal in every culture or situation, these practices erode the integrity of government. They tend to be incompatible with the ideals of fair and equitable treatment which are central components of an economically stable society (Cabello, Ruiz & Pérez-Gladish, 2021).

The sub-index of "freedom from corruption" was created from Transparency International's Corruption Perceptions Index. The Corruption Perception Index is a 10-point scale with 0 signifying a highly corrupt government. The resultant index is multiplied by 10 to get the "freedom from corruption" sub-index. A nation with a score of 7.5 will have a "freedom from corruption" score of 75. The equation for the computation is stated as:

$$Subfactor\_score_i = \frac{100 * Subfactor_{Max} - Subfactor_i}{(Subfactor_{Max} - Subfactor_{Min})^3} \ldots\ldots\ldots (17)$$

Where $Subfactor_i$ denotes the original data for the country $i$ and $Subfactor_{Max}$ and $Subfactor_{Min}$ represent the upper and lower bounds for the corresponding data set. $Subfactor\_score_i$ denotes the computed sub-factor score for country $i$.

Following the study by Brkić, Gradojević, and Ignjatijević (2020), the present study uses the government integrity index constructed by the Heritage Foundation. It is graded on a scale of 0 to 100 with 0 being the weakest and 100, being the strongest. It is expected that having the most integrity will lead to better environmental quality.

**Table 1: Variables and data sources**

| Variable | Description | Source |
|---|---|---|
| Environmental Quality | $CO_2$ emissions (metric tonnes per capita) | WDI |
| Non-renewable Energy Consumption | Energy use (kg oil equivalent per capita) | WDI |
| Renewable Energy Consumption | Renewable Energy Consumption (% of total final energy consumption) | WDI |
| Economic growth | Real GDP per capita in constant 2010 US$ | WDI |
| Property rights | The property rights indicator assesses people's ability to own private property protected by state laws (0-100). | Heritage Foundation |
| Tax burden (Fiscal freedom) | It captures the top marginal tax rates on individual and corporate income and the total tax burden as a percentage of GDP (0-100) | Heritage Foundation |
| Government Integrity | It assesses the presence of corruption within the judicial and administrative systems and among government officials (0-100). | Heritage Foundation |
| Urbanisation | Urban population (annual % growth) | WDI |
| Trade Openness | Sum of imports and exports as a % of GDP | WDI |
| Foreign Direct Investment | Net inflows of investment as a % of GDP | WDI |
| Gross Fixed Capital Formation | Gross Fixed Capital Formation (% of GDP) | WDI |

Source: Boakye-Mensah (2021)

**Analytical models**

After a comprehensive review of related literature, a dynamic panel economic model was adopted and used to address the objectives of the study. The section discusses the system Generalised Method of Moments technique used to examine the effect of energy consumption and institutions on environmental quality in line with the three objectives of the study.

**Estimation procedure**

Performing panel analysis involves the use of two techniques, namely the static panel and dynamic panel regression models. The static panel model consists of fixed and random effects. In general, fixed effect panel regression is used to model time-varying predictors of time-varying outcomes. The random effect panel regression works the same way as fixed effect panel regression. However, the random effect panel regression assumes that there exist between-case or subject differences in the outcome that should be included in the model. The dynamic panel model is used to remove unobserved country-specific heterogeneities. It is most suitable when the dependent variable depends on its past realisations.

Three types of dynamic regression techniques have been identified in the literature. These include the Generalised Method of Moments (GMM), Two-stage Least Square technique, and Instrumental Variable approach. Carbon dioxide emission per capita was employed as the dependent variable in the model. According to the theory of non-uniformly mixing flow pollutants, carbon emissions can persist over time. As a result, the previous year's emissions of carbon dioxide will likely affect the current year. With a potential correlation between the lagged dependent variable and the error term in the model, an estimation technique that could take care of issues of endogeneity and country-specific heterogeneities was required. In all, a total of 26 countries for 15 years were used in the study.

The GMM estimator is an estimation technique that is capable of addressing all forms of endogeneity issues, omitted variable bias, measurement errors, and generating effective internal instruments (Levine, Loayza & Beck, 2000). The Generalised Method of Moments comes in two forms. These include the Difference and the System Generalised Method of Moments. The Difference GMM as specified by Arellano and Bond (1991) corrects endogeneity by transforming all regressors through differencing. The system GMM, however, deals with endogeneity issues by introducing more instruments to dramatically improve the efficiency of the estimator (Arellano & Bover, 1995; Blundell & Bond, 1998). Arellano and Bond (1991) maintain that the difference transformation has a weakness. While subtracting the previous observations from the contemporaneous ones, the gaps in an already unbalanced panel are further magnified. The system GMM corrects this weakness by using orthogonal deviations. It minimises data loss by subtracting the average of all future available observations of a variable (Arellano & Bover, 1995; Blundell & Bond, 1998).

According to Arellano and Bond (1991), Arellano and Bover (1995), and Blundell and Bond (2000), the first difference in the equation will remove the constant term and the country-specific unobserved effects. This is done to eliminate all unobserved heterogeneities. Equations (10) and (11) are transformed to obtain equations (18) and (19).

$$CO_2\mathrm{E}_{i,t} - CO_2\mathrm{E}_{i,t-1} = (\beta_0 - \beta_0) + \beta_1(CO_2\mathrm{E}_{i,t-1} - CO_2\mathrm{E}_{i,t-2}) + \beta_2(NREC_{i,t} - NREC_{i,t-1}) + \beta_3(INSQ_{i,t} - INSQ_{i,t-1}) + \beta_4(\mathbf{X}_{i,t} - \mathbf{X}_{i,t-1}) + (\gamma_i - \gamma_i) + (\omega_t - \omega_{t-1}) + (\varepsilon_{i,t} - \varepsilon_{i,t-1}) \quad i = 1,2,3,\dots,26 \quad t = 1,2,3,\dots 15 \dots\dots\dots (18)$$

$$CO_2\mathrm{E}_{i,t} - CO_2\mathrm{E}_{i,t-1} = (\beta_0 - \beta_0) + \beta_1(CO_2\mathrm{E}_{i,t-1} - CO_2\mathrm{E}_{i,t-2}) + \beta_2(REC_{i,t} - REC_{i,t-1}) + \beta_3(INSQ_{i,t} - INSQ_{i,t-1}) + \beta_4(\mathbf{X}_{i,t} - \mathbf{X}_{i,t-1}) +$$

$(\gamma_i - \gamma_i) + (\omega_t - \omega_{t-1}) + (\varepsilon_{i,t} - \varepsilon_{i,t-1}) \quad i = 1,2,3, \dots ,26 \quad t = 1,2,3, \dots 15 \dots\dots\dots (19)$

By eliminating the constant terms and individual country-specific unobserved heterogeneities, we obtain equations (20) and (21)

$$CO_2E_{i,t} - CO_2E_{i,t-1} = \beta_1(CO_2E_{i,t-1} - CO_2E_{i,t-2}) + \beta_2(NREC_{i,t} - NREC_{i,t-1}) + \beta_3(INSQ_{i,t} - INSQ_{i,t-1}) + \beta_4(\mathbf{X}_{i,t} - \mathbf{X}_{i,t-1}) + (\omega_t - \omega_{t-1}) + (\varepsilon_{i,t} - \varepsilon_{i,t-1}) \quad i = 1,2,3, \dots ,26 \quad t = 1,2,3, \dots ,15 \dots\dots\dots (20)$$

$$CO_2E_{i,t} - CO_2E_{i,t-1} = \beta_1(CO_2E_{i,t-1} - CO_2E_{i,t-2}) + \beta_2(REC_{i,t} - REC_{i,t-1}) + \beta_3(INSQ_{i,t} - INSQ_{i,t-1}) + \beta_4(\mathbf{X}_{i,t} - \mathbf{X}_{i,t-1}) + (\omega_t - \omega_{t-1}) + (\varepsilon_{i,t} - \varepsilon_{i,t-1}) \quad i = 1,2,3, \dots ,26 \quad t = 1,2,3, \dots ,15 \dots\dots\dots (21)$$

Equations (20) and (21) are then rewritten as:

$$\Delta CO_2E_{i,t} = \beta_1(\Delta CO_2E_{i,t-1}) + \beta_2(\Delta NREC_{i,t}) + \beta_2(\Delta INSQ_{i,t}) + \beta_3(\mathbf{\Delta X}_{i,t}) + \Delta\omega_t + \Delta\varepsilon_{i,t} \quad i = 1,2,3, \dots 26 \quad t = 1,2,3, \dots ,15 \dots\dots\dots\dots (22)$$

$$\Delta CO_2E_{i,t} = \beta_1(\Delta CO_2E_{i,t-1}) + \beta_2(\Delta REC_{i,t}) + \beta_2(\Delta INSQ_{i,t}) + \beta_3(\mathbf{\Delta X}_{i,t}) + \Delta\omega_t + \Delta\varepsilon_{i,t} \quad i = 1,2,3, \dots 26 \quad t = 1,2,3, \dots ,15 \dots\dots\dots\dots (23)$$

The constant term and country-specific unobserved heterogeneity are effectively dealt with by taking the first difference in equations (10) and (11). However, doing so creates another problem known as endogeneity bias since the new error term $(\varepsilon_{i,t} - \varepsilon_{i,t-1})$ in equations (18) and (19) becomes correlated with $CO_2E_{i,t-1} - CO_2E_{i,t-2}$. Furthermore, all other independent variables become correlated with the lagged error term $\varepsilon_{i,t-1}$. To overcome this problem, the difference GMM estimator allows us to use lag values of the independent variables as instruments. For this to be possible, the instruments and error terms should not be serially correlated and the independent variables should be weakly exogenous.

$E[CO_2\mathrm{E}_{i,t-s}, \ (\varepsilon_{i,t} - \varepsilon_{i,t-1})] = 0 \ for \ all \ s \geq 2; \quad t = 3, \dots, 18$……… (24)

$E[\boldsymbol{X}_{i,t-s}, \ (\varepsilon_{i,t} - \varepsilon_{i,t-1})] = 0 \ for \ all \ s \geq 2; \quad t = 3, \dots, 18$……….. (25)

Given that the difference GMM suffers from weak instrumentation, Arellano and Bover (1995) and Blundell and Bond (2000) propose an estimator that allows us to combine a system of equations into differences and levels. In this case, the system GMM estimator is proposed as a more efficient estimator. Validating instruments require that there should be no correlation between the country-specific effects and the difference in the variables. This requires the fufillment of an additional moment condition for the level equation.

$E[CO_2\mathrm{E}_{i,t-s} - CO_2\mathrm{E}_{i,t-s-1}) \ (\gamma_i + \varepsilon_{i,t-1})] = 0 \ for \ all \ s = 1; t = 3, \dots, 15$ ……… (26)

$E[\boldsymbol{X}_{i,t-s} - \boldsymbol{X}_{i,t-s-1})(\gamma_i + \varepsilon_{i,t-1})] = 0 \ for \ s = 1; \quad t = 3, \dots, 15$……… (27)

Choosing between a difference GMM and a system GMM estimation technique requires an initial pooled OLS model estimation. A subsequent estimation is conducted on the same model using the fixed effect approach. A comparison is done between the coefficients or parameters of the lag-dependent variable in the two estimated models. Difference GMM estimation is then carried out. A lower difference GMM estimate compared to the fixed effect estimate signifies a downward biased difference GMM estimate as a result of weak instrumentation. In such a situation, a system GMM estimator is preferred (Blundell, Bond & Windmeijer, 2001).

Having satisfied the conditions stated above, the system GMM technique is employed to achieve the objectives of the study. The empirical models for examining the effect of energy consumption and institutional quality on environmental quality using the system GMM estimator are specified as:

$$\Delta CO_2\mathrm{E}_{i,t} = \beta_1(\Delta CO_2\mathrm{E}_{i,t-1}) + \beta_2(\Delta NREC_{i,t}) + \beta_3(\Delta INSQ_{i,t}) + \beta_4(\mathbf{\Delta X}_{i,t}) + \Delta\omega_t + \Delta\varepsilon_{i,t} \quad i = 1,2,3,\ldots 26 \quad t = 1,2,3,\ldots 15 \ldots\ldots. \quad (28)$$

$$\Delta CO_2\mathrm{E}_{i,t} = \beta_1(\Delta CO_2\mathrm{E}_{i,t-1}) + \beta_2(\Delta REC_{i,t}) + \beta_3(\Delta INSQ_{i,t}) + \beta_4(\mathbf{\Delta X}_{i,t}) + \Delta\omega_t + \Delta\varepsilon_{i,t} \quad i = 1,2,3,\ldots 26 \quad t = 1,2,3,\ldots 15 \ldots\ldots. \quad (29)$$

In investigating the moderating effect of institutional quality on energy consumption and environmental quality, the empirical model for estimation using the system GMM estimator becomes:

$$\Delta CO_2\mathrm{E}_{i,t} = \beta_1(\Delta CO_2\mathrm{E}_{i,t-1}) + \beta_2(\Delta NREC_{i,t}) + \beta_3(\Delta INSQ_{i,t}) + \beta_4(\Delta NREC_{i,t} * \Delta INSQ_{i,t}) + \beta_5(\mathbf{\Delta X}_{i,t}) + \Delta\omega_t + \Delta\,\varepsilon_{i,t} \quad i = 1,2,3,\ldots 26 \quad t = 1,2,3,\ldots,15 \ldots\ldots\ldots\ldots \quad (30)$$

$$\Delta CO_2\mathrm{E}_{i,t} = \beta_1(\Delta CO_2\mathrm{E}_{i,t-1}) + \beta_2(\Delta REC_{i,t}) + \beta_3(\Delta INSQ_{i,t}) + \beta_4(\Delta REC_{i,t} * \Delta INSQ_{i,t}) + \beta_5(\mathbf{\Delta X}_{i,t}) + \Delta\omega_t + \Delta\,\varepsilon_{i,t} \quad i = 1,2,3,\ldots 26 \quad t = 1,2,3,\ldots,15 \ldots\ldots\ldots\ldots \quad (31)$$

**Model diagnostic tests**

The system GMM estimator is considered valid and consistent if the error term does not suffer from serial correlation and the instruments are valid.

**Hansen test for over-identifying restrictions**

Arellano and Bond (1991), Arellano and Bover (1995), and Blundell and Bond (1998) proposed that the instruments used for the analysis must be valid for results to be consistent. For this to happen, the instrumented variables must be exogenous and uncorrelated with the error term.

**Arellano-Bond test for serial correlation**

This test enables us to assess the assumption that errors present in the first difference regression do not suffer from serial correlation.

**Chapter Summary**

This chapter discussed the methodological frameworks that were used in achieving the objectives of the study. It also touched on the appropriate research philosophy, design, and approach and stressed the importance of using the positivist approach. The chapter also justified the choice of both the dependent and independent variables. The chapter ended by looking at the estimation techniques employed in finding the relationship between energy consumption, institutions, and environmental quality. Some diagnostic tests employed in the study were also presented in the final section. The next chapter discusses the estimated empirical results obtained in the study.

# CHAPTER FOUR

# RESULTS AND DISCUSSIONS

## Introduction

This chapter discusses the estimated empirical relationship between energy consumption, institutions, and environmental quality. The chapter is organised into four sections. Section One presents the descriptive and correlation statistics of the variables employed in the study. The second and third section discusses the estimated empirical findings. Specifically, the second section discusses the effect of disaggregated energy consumption and institutions on the quality of the environment while the moderating role of institutions in the link between disaggregated energy consumption and environmental quality is discussed in the third section. The fourth section summarises the chapter.

## Descriptive statistics

The descriptive statistics of the variables employed for the analysis in this chapter are presented in Table 2.

**Table 2: Summary statistics of variables employed for the analysis**

| Variable | Mean | Std. Dev. | Minimum | Maximum | Skewness |
|---|---|---|---|---|---|
| $CO_2$EMPC | 1.385 | 2.286 | 0.021 | 11.204 | 2.689 |
| NREC | 682.222 | 662.539 | 9.548 | 3129.079 | 2.011 |
| REC | 61.820 | 26.881 | 5.352 | 98.270 | -0.550 |
| EG | 31.132 | 37.569 | 1.128 | 259.882 | 2.557 |
| URBAN | 3.721 | 1.374 | -0.224 | 7.510 | -0.658 |
| TOT | 77.565 | 30.887 | 20.723 | 161.894 | 0.603 |
| FDI | 4.253 | 5.275 | -5.208 | 39.456 | 3.104 |
| GFCF | 24.276 | 9.849 | 2.000 | 79.462 | 1.223 |
| PROP. RIG | 35.286 | 16.726 | 5 | 75 | 0.553 |
| TAXB | 72.860 | 9.869 | 41.1 | 97.8 | -0.412 |
| GOV. INT | 29.793 | 12.586 | 10 | 73.3 | 0.938 |

Note: Std. Dev. represents standard deviation.
Source: Boakye-Mensah (2021)

The mean of carbon dioxide emissions per capita is 1.385. It ranges from 0.021 and 11.204. It has a standard variation of 2.286 and mirrors a positively skewed distribution. The mean energy use in kilogrammes of oil equivalent is 682.222. It has a maximum value of 3129.079 and a minimum value of 9.548. Renewable energy consumption records a mean of 61.820. It has a standard deviation of 26.881 and mirrors a negatively skewed distribution. Economic growth which is proxied by real gross domestic product per capita records a mean of 31.132. The average dispersion of the observation from the mean is 37.569. It mirrors a positively skewed distribution. In regards to the institutional variables, property rights have a mean of 35.286. With a standard deviation of 16.726, the variable mimics a normally skewed distribution. Ranging from 41.1 to 97.8, tax burden possesses an average of 72.860. It also mirrors a normally skewed distribution. Government integrity has a mean of 29.793 and ranges from 10 and 73.3. It has a standard deviation of 12.586 and it mirrors a normally skewed distribution.

**Correlation analysis**

The correlation between the variables employed in the study is presented in Table 3. Carbon dioxide emission per capita is positively correlated with non-renewable energy consumption, economic growth, trade openness, gross fixed capital formation, and foreign direct investment. This demonstrates that an increase in any of these variables could lead to a fall in environmental quality. The negative correlation between Renewable energy consumption and carbon dioxide emissions per capita implies any increase in renewable energy consumption could cause the quality of the environment to improve.

**Table 3: Pairwise correlation matrix**

| VAR | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) $CO_2$EMPC | 1 | | | | | | | | | | |
| (2) NREC | 0.815*** | 1 | | | | | | | | | |
| (3) REC | -0.659*** | -0.356*** | 1 | | | | | | | | |
| (4) EG | 0.809*** | 0.634*** | -0.652*** | 1 | | | | | | | |
| (5) URBAN | -0.020 | -0.061 | 0.250*** | 0.093 | 1 | | | | | | |
| (6) TOT | 0.258*** | 0.084 | -0.477*** | 0.385*** | -0.226*** | 1 | | | | | |
| (7) FDI | 0.014 | -0.058 | 0.001 | 0.098 | 0.175*** | 0.297*** | 1 | | | | |
| (8) GFCF | 0.100*** | 0.045 | -0.185*** | 0.158*** | 0.233*** | 0.351*** | 0.399*** | 1 | | | |
| (9) PROP. RIG | 0.228*** | 0.175*** | -0.497*** | 0.276*** | -0.350*** | 0.194*** | -0.061*** | 0.110*** | 1 | | |
| (10) TAXB | 0.095 | 0.034 | -0.137*** | 0.114*** | 0.176*** | -0.174*** | 0.011 | 0.056 | 0.116*** | 1 | |
| (11) GOV. INT. | 0.246*** | 0.250*** | -0.515*** | 0.248*** | -0.450*** | 0.205*** | -0.022 | 0.155*** | 0.731*** | 0.111*** | 1 |

Note: ***$p < 0.01$ indicates significance at 1%.
Source: Boakye-Mensah (2021)

**Results of the regression analysis**

This section presents and discusses the results from the Generalised Methods of Moments estimation. Table 4 assesses the effect of disaggregated energy consumption and institutional quality on environmental quality. Similarly, Table 5 presents the results of the joint effect of institutional quality and non-renewable energy consumption on environmental quality while Table 6 discusses the results of the joint effect of institutional quality and renewable energy consumption on environmental quality. The moderating role of institutional quality in the relationship between energy consumption and environmental quality is presented and discussed in Table 7.

**Table 4: Results of the effect of disaggregated energy consumption and institutional quality on environmental quality**

| Variables | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| $CO_2$EMPC (-1) | 0.985** | 0.467*** | 0.931*** | 0.965** | 0.892*** | 0.917*** |
| | (0.361) | (0.069) | (0.037) | (0.432) | (0.077) | (0.125) |
| NREC | 0.002** | 0.001*** | 0.000** | | | |
| | (0.001) | (0.000) | (0.000) | | | |
| REC | | | | -0.077*** | -0.006** | -0.014* |
| | | | | (0.020) | (0.003) | (0.008) |
| EG | -0.015 | 0.003 | 0.005*** | -0.024* | 0.006* | 0.001 |
| | (0.018) | (0.006) | (0.002) | (0.012) | (0.003) | (0.004) |
| URBAN | 0.850** | 0.552** | -0.052** | 0.705*** | 0.178* | -0.280** |
| | (0.338) | (0.209) | (0.025) | (0.239) | (0.100) | (0.135) |
| TOT | -0.058** | 0.015** | -0.007*** | -0.092* | -0.003 | -0.012** |
| | (0.024) | (0.007) | (0.002) | (0.050) | (0.002) | (0.004) |
| FDI | 0.163* | 0.125 | 0.013 | 0.152*** | 0.008 | 0.144** |
| | (0.081) | (0.075) | (0.012) | (0.048) | (0.011) | (0.055) |
| GFCF | -0.072 | -0.057** | 0.003 | -0.085 | -0.007 | -0.012 |
| | (0.062) | (0.023) | (0.004) | (0.068) | (0.007) | (0.017) |
| PROP. RIG. | 0.095*** | | | 0.114* | | |
| | (0.032) | | | (0.060) | | |
| TAX BURD | | 0.094*** | | | -0.026* | |
| | | (0.023) | | | (0.013) | |
| GOV. INT | | | 0.008** | | | -0.028* |
| | | | (0.003) | | | (0.016) |

| | | | | | | |
|---|---|---|---|---|---|---|
| CONSTANT | -1.635 | -9.455*** | 0.364 | 3.706 | 1.876 | 3.420*** |
| | (1.533) | (2.297) | (0.216) | (0.411) | (1.220) | (0.999) |
| **Diagnostics** | | | | | | |
| F stat | 303.39 | 234.27 | 2884.64 | 75.48 | 7521.72 | 440.62 |
| Prob > F | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| AR (1) | 0.020 | 0.016 | 0.181 | 0.088 | 0.170 | 0.034 |
| AR (2) | 0.473 | 0.865 | 0.102 | 0.839 | 0.155 | 0.336 |
| Hansen test | 0.318 | 0.200 | 0.183 | 0.622 | 0.374 | 0.267 |
| No. of Obs. | 390 | 390 | 390 | 390 | 390 | 390 |
| Number of c_id | 26 | 26 | 26 | 26 | 26 | 26 |

Note robust standard error option used; Standard errors in parentheses; *p< 0.1, **p< 0.05, ***p< 0.01 indicates significance at 10%, 5% and 1% respectively. The estimation was done using xtabond2 command Stata.

Source: Boakye-Mensah (2021)

The regression results of the effect of disaggregated energy consumption and institutional quality on environmental quality are presented in Table 4. Here, six sets of results are offered and presented in columns. The first three models consider non-renewable energy consumption as the only source of energy resource. Specifically, Model 1 shows the results of the effect of property rights on environmental quality. The second model presents the results of the effect of tax burden on the quality of the environment while Model 3 considers the effect of government integrity on environmental quality. Similarly, the subsequent models (4, 5, and 6) in Table 4 present the effect of institutional quality (property rights, tax burden, and government integrity) on environmental quality, with renewable energy as the only energy resource. Table 4 also presents the results of the effect of some control variables (economic growth, urbanisation, trade openness, FDI, GFCF) on environmental quality. The significant lag values of carbon dioxide emissions per capita in all the models suggest that the current period's emissions are positively influenced by those of the previous periods. The situation, therefore, warrants the need to specify a dynamic model.

**Effect of disaggregated energy consumption on environmental quality**

In the first three models, Non-renewable energy was found to have statistically significant positive coefficients. The results suggest that an increase in non-renewable energy consumption induces a fall in environmental quality. A possible explanation for this result is that the use of energy is very essential in production. As such countries rely on energy sources to propel economic growth. However, the consumption of energy tends to pollute the environment. Most pollution occurs as a result of the high consumption of fossil fuels. Combustion and consumption of fossil fuels release carbon dioxide, thus causing damage to the environment and human health. These findings are similar to that of Shafiei and Salim (2014), who discovered that higher fossil energy consumption resulted in increased $CO_2$ emissions in OECD countries. In a similar study conducted in European countries, Dogan and Seker (2016) observed that non-renewable energy consumption induces higher $CO_2$ emissions.

Renewable energy consumption had negative coefficients and the results were found to be statistically significant in Models 4, 5, and 6. The results suggest that increasing renewable energy demand enhances environmental sustainability. The use of renewable energy results in fewer natural resource extraction rates and higher rates of replenishment. Given the minimal pollution levels of renewable energy, clean technology for production is assured. This can help achieve a cleaner and healthier environment. Liu, Zhang, and Bae (2017) discovered that renewable energy use adversely affects carbon dioxide emissions in four ASEAN countries. The findings are also consistent with Bilgili, Kocak, and Bulut (2016) who found that renewable energy has a negative and substantial effect on $CO_2$ emissions.

**Effect of institutional quality on environmental quality**

Property rights were found to have a statistically significant positive coefficient in both Models 1 and 4. The results suggest that more secured property rights lead to lower levels of environmental quality. A possible intuition behind this result could be that property rights have not been properly assigned and as such there may be potential issues of market failures. There could also possibly be an inefficient use of renewable energy and the desired controls that should be in place to ensure that the right environmental standards set are met are not being followed. Efficient assignment of property rights demands that there is enforceability. However, the enforceability of property rights is an issue in developing countries due to the weak nature of existing laws. This makes it difficult to tell which agent has the right to pollute or not. The actions of agents create externalities and the right institutional frameworks that are in place to monitor such actions are weak and cannot enforce these laws. This in effect induces lower levels of environmental quality.

While the burden of tax was revealed to have a statistically significant positive coefficient in Model 2 where only non-renewable energy was included in the model, the variable was discovered to have a significant negative influence on carbon dioxide emissions in Model 5 where only renewable energy resources were consumed. The higher mean of tax burden, per its definition in the study, seems to suggest higher levels of fiscal freedom. This by intuition would suppose lower environmental quality because lower income and corporate tax imply higher disposable income and increased capacity to innovate.

However, in sub-Saharan Africa, general income levels are low. 2018 figures project around 433 million Africans live in extreme poverty (Schoch & Lakner, 2020). Due to this reason, tax concessions and tax-free holidays do not have any substantial impact on our purchasing power. Given the low level of income, countries lack the financial capital to go in for cleaner forms of energy. Though property rights and other institutional environments might be in place, the limited financial muscles necessitate countries to flout some environmental regulations and, thus demand cheaper forms of energy which leads to poor environmental quality. The situation however changes when there are tax concessions on renewables. Tax reductions induce higher purchasing power and the benefits that modern renewables bring entice people to go in for them.

Government integrity was also found to have a statistically significant positive influence on $CO_2$ emissions with the inclusion of only non-renewable energy in the model. This suggests that an improvement in the integrity of the government induces a fall in the quality of the environment. However, in instances where only renewable energy is considered as the only source, any improvement in government integrity leads to higher environmental quality. Lower incomes ensure higher demand for affordable non-renewable fuels. The level of development of these sub-Saharan economies is at a pace where each country cannot solely rely on efficient renewable and non-renewable forms of energy. Countries in the sub-region are heavily dependent on imported non-renewable energy sources for their energy sector. This cripples the ability of regulatory bodies to effectively enhance the quality of the environment. However, the higher consumption of renewables ensures positive trickle-down effects on the environment. This coupled with effective supervision and management by regulatory bodies produces an environment of better quality.

**Effect of control variables on environmental quality**

Economic growth was discovered to have a significant direct effect on $CO_2$ emissions. The result as indicated in Model 3 suggests that a US dollar increase in real GDP per capita leads to a 0.005 increase in carbon dioxide emissions per capita respectively. The result obtained implies that an increase in the growth of an economy reduces the quality of the environment. Since growth in an economy necessitates an expansion of production, energy use increases along with growth. Consequently, the by-products of energy consumption release harmful pollutants into the atmosphere, thereby reducing environmental quality. This result is in line with Omri (2013) and Fodha and Zaghdoud (2010). However, economic growth does not always lead to negative environmental outcomes. Economies that are wealthier and environmentally conscious can adopt cleaner energy with lower polluting technologies which essentially mitigates environmental pollution. This is confirmed by the statistically significant negative coefficient of Economic growth in Model 4. The result is consistent with Pao and Tsai (2010) and Farhani and Shahbaz (2014).

Results obtained in Models 1, 2, 4, and 5 suggest that increases in urbanisation lead to a reduction in the quality of the environment. These results could be attributed to the urban heat island effect. In urban areas, people tend to own and rely on modern gadgets (cars, air conditioners, etc.), which are most energy intensive. Generally, urban areas tend to be warmer due to the constant emission of thermal heat and the densely built-up nature of settlements. As a result, as countries become urbanised, the quality of their environment tends to go down. All these play a decisive role in worsening the quality of the environment. The results obtained are in line with Wemegah, Yamba, Aryee, Sam & Amekudzi (2020).

Urbanisation was also revealed to have a negative influence on $CO_2$ emissions in Models 3 and 6. The results obtained suggest that the growth of the urban population leads to lower levels of environmental damage. This result is against expectations. However, it does not imply that the result is completely out of space. It is believed that as countries become urbanised, the quality of their environment tends to deteriorate. However, if the people living in these urban areas are wealthy and environmentally conscious, they will put pressure on the government to develop mechanisms and implement measures that will help ensure sound environmental quality. Urban population growth could provide an avenue to boost individuals' well-being while reducing their ecological footprints.

Lifestyle choices, enhanced governance, awareness and education programmes, infrastructure and service availability, as well as technological progressions, are some of the ways through which growing cities could contribute towards environmental sustainability. Small and medium cities have an essential role to play because they act as a bridge that connects rural and urban populations (United Nations Settlement Programme, 2015b). The results are consistent with Ali, Abdul-Rahim, and Ribadu (2017) who discovered a negative impact of urbanisation on $CO_2$ emissions in Singapore.

Another variable that was found to have a significant positive influence on $CO_2$ emissions per capita was Foreign Direct Investment. The results as indicated in Models 1, 4, and 6 imply that any increase in foreign direct investment will lead to a fall in the quality of the environment. Several nations have become "pollution havens" as a result of their decision to relax environmental restrictions to increase foreign direct investment. Ultimately, resources are carelessly destroyed and the environment is polluted with no regard for it. The results are consistent with the earlier study by Kivyiro and Arminen (2014).

The coefficient of Trade was discovered to be positive and statistically significant. The result as indicated in Model 2 suggests that opening up the economy to trade leads to poor environmental quality. A possible rationale behind this result is that the lower incomes of some nations encourage heavy reliance on coal-powered and other fossil fuel technologies. This induces large imports of dirty and affordable sources of energy fuels. Higher levels of specialisation in high pollutant commodities in these regions to meet their domestic needs also create a lot of environmental problems. Essandoh, Islam, and Kakinaka (2020) finds trade to be correlated with carbon emissions; an increase in export brings about higher carbon emissions while a rise in import lowers carbon emissions. The result is in line with Jalil and Feridun (2011), Shahbaz, Loganathan, Muzaffar, Ahmed and Jabran (2016) as well as Mutascu (2018).

Further results shown in Models 1, 3, 4, and 6 suggest that an increase in trade brings considerable benefits to the environment. The rationale behind this result is that encouraging the use of renewable energy through trade exposes an economy to the efficient use of energy resources and better environmental management. In certain instances, countries relocate their dirty industries to emerging economies with rather lenient or non-existent environmental regulations. This way, the countries in question are rid of industrial pollution and its effects. These findings are in line with Lv and Xu (2019).

**Table 5: Results of the joint effect of non-renewable energy consumption and institutional quality on environmental quality**

| Variables | (7) | (8) | (9) |
|---|---|---|---|
| $CO_2$EMPC (-1) | 0.956*** | 0.883*** | 0.405*** |
| | (0.121) | (0.043) | (0.142) |
| NREC | -0.001** | -0.006** | 0.002*** |
| | (0.000) | (0.003) | (0.001) |
| EG | -0.004 | 0.006 | 0.020*** |
| | (0.006) | (0.005) | (0.004) |
| URBAN | 0.034 | -0.021 | 0.279 |
| | (0.107) | (0.082) | (0.353) |
| TOT | -0.003 | -0.009 | 0.000 |
| | (0.004) | (0.006) | (0.005) |
| FDI | 0.150*** | 0.087*** | -0.006 |
| | (0.039) | (0.031) | (0.013) |
| GFCF | -0.051* | -0.028 | -0.023 |
| | (0.027) | (0.024) | (0.021) |
| PROP. RIG. | 0.031** | | |
| | (0.014) | | |
| NREC*PROP. RIG. | -0.000** | | |
| | (0.000) | | |
| TAX BURD | | -0.085* | |
| | | (0.046) | |
| NREC*TAX BURD | | 0.000** | |
| | | (0.000) | |
| GOV. INT | | | 0.0923* |
| | | | (0.046) |
| NREC*GOV. INT. | | | -0.000** |
| | | | (0.000) |
| CONSTANT | -0.387 | 6.830* | -3.175 |
| | (0.605) | (3.850) | (2.125) |
| **Diagnostics** | | | |
| F stat | 3585.78 | 2210.71 | 320.72 |
| Prob > F | 0.000 | 0.000 | 0.000 |
| AR (1) | 0.036 | 0.086 | 0.122 |
| AR (2) | 0.256 | 0.225 | 0.523 |
| Hansen test | 0.195 | 0.542 | 0.288 |
| No. of obs. | 390 | 390 | 390 |
| Number of c_id | 26 | 26 | 26 |

Note robust standard error option used; Standard errors in parentheses; *p< 0.1, **p< 0.05, ***p< 0.01 indicates significance at 10%, 5% and 1% respectively.
Source: Boakye-Mensah (2021)

The results of the joint effect of institutional quality and non-renewable energy consumption on environmental quality are presented in Table 5. The models in Table 5 illustrate the instantaneous rate of change in $C0_2$ emissions related to changes in non-renewable energy consumption in the presence of institutional variables.

The interaction of non-renewable energy with property rights was revealed to have a statistically significant negative coefficient. The result indicates that with more secured property rights, consumption of non-renewable energy brings environmental benefits. The results seem to suggest that secured property rights along with non-renewable energy use are efficient in protecting the environment. This may be possible due to the various policies put in place by governments and the kind of attention being paid to the non-renewable energy sector to limit its negative environmental impacts. Enforceability of the law when it comes to the non-renewable sector seems to be more stringent compared to the other sectors. In these circumstances, the proper incentives exist to promote the effective management of natural resources and safeguard the environment. Without private ownership in the means of production of fossil fuels and other polluting technologies, malinvestments in the energy sector may occur, causing wastage and shortages. The past years of non-renewable energy use have brought several harmful effects on the environment and as such, governments and policymakers have become more environmentally conscious. Particular attention is being paid to issues of property rights to ensure that polluters are held accountable for their actions.

Unlike the previous case where more secured property rights ensure the consumption of non-renewable energy produces better environmental outcomes, ensuring a lower tax burden while consuming higher non-renewable energy worsens the quality of the environment. Theoretically, disposable incomes increase when tax on real incomes falls. The lower the incidence of tax on consumers of non-renewable energy, the higher the amount of non-renewable energy that may be consumed. In an economy where there is heavy reliance on fossil fuels and other polluting energy technologies, frequent tax concessions and tax-free holidays may negatively affect the quality of the environment.

The coefficient of the interacted term of non-renewable energy consumption and government integrity was also discovered to be negative. The result signifies that a well-functioning government with an improved level of integrity considerably improves the quality of the environment. When non-polluting energy fuels are effectively managed and controlled by concerning regulatory bodies, their capacities to harm the environment may be lowered.

**Table 6: Results of the joint effect of renewable energy consumption and institutional quality on environmental quality**

| Variables | (10) | (11) | (12) |
|---|---|---|---|
| $CO_2$EMPC (-1) | 0.868*** | 0.746** | 0.983*** |
| | (0.100) | (0.312) | (0.079) |
| REC | -0.019** | 0.183 | -0.075** |
| | (0.007) | (0.141) | (0.029) |
| EG | 0.009 | -0.012 | 0.009** |
| | (0.005) | (0.009) | (0.003) |
| URBAN | -0.142** | 0.419*** | -0.135 |
| | (0.059) | (0.137) | (0.105) |
| TOT | 0.000 | -0.019 | -0.003 |
| | (0.005) | (0.012) | (0.004) |
| FDI | 0.008 | 0.153** | 0.012 |
| | (0.008) | (0.067) | (0.015) |
| GFCF | -0.002 | -0.082 | -0.013 |
| | (0.007) | (0.054) | (0.012) |
| PROP. RIG. | -0.027*** | | |
| | (0.009) | | |
| REC*PROP. RIG. | 0.001** | | |
| | (0.000) | | |
| TAX BURD. | | 0.104** | |
| | | (0.039) | |
| REC*TAX BURD | | -0.003* | |
| | | (0.002) | |
| GOV. INT. | | | -0.089** |
| | | | (0.036) |
| REC*GOV. INT. | | | 0.003** |
| | | | (0.001) |
| CONSTANT | 1.318*** | -2.286 | 3.975*** |
| | (0.261) | (3.174) | (1.239) |
| **Diagnostics** | | | |
| F stat | 1128.24 | 439.46 | 186.76 |
| Prob > F | 0.000 | 0.000 | 0.000 |
| AR (1) | 0.175 | 0.032 | 0.149 |
| AR (2) | 0.116 | 0.150 | 0.227 |
| Hansen test | 0.246 | 0.277 | 0.168 |
| No. of obs. | 390 | 390 | 390 |
| Number of c_id | 26 | 26 | 26 |

Note robust standard error option used; Standard errors in parentheses; *p< 0.1, **p< 0.05, ***p< 0.01 indicates significance at 10%, 5% and 1% respectively.
Source: Boakye-Mensah (2021)

The results of the joint effect of institutional quality and energy consumption on environmental quality are presented in Table 6. The models in the Table 6 illustrate the instantaneous rate of change in $C0_2$ emissions related to changes in non-renewable energy consumption in the presence of institutional variables.

Results from Table 6 show a significant positive relationship between the interacted term of renewable energy consumption and property rights on carbon dioxide emissions. The results seem to suggest that secured property rights along with renewable energy use do not lead to efficient environmental protection. The result is backed by Locke (2013) who found that Africa is typically characterised by unequal asset and property distribution. Consequently, a rise in property rights could deepen the degree of inequality and hamper renewable energy usage. Lower renewable energy use could consequently affect the quality of the environment.

However, an increase in the consumption of renewable energy coupled with a lower burden of tax burden will lead to an improvement in environmental quality. The result seems to suggest that giving out frequent tax concessions and tax-free holidays coupled with the consumption of renewable energy will likely induce higher environmental gains. Fiscal incentives are the most prevalent instrument used by the government to ensure green energy transformation. Tax incentives could efficiently resolve issues related to the green economy and change in consumer behaviour if they are adequately backed by other useful policy instruments.

Several African governments have implemented laws and policies on tax incentives for renewable energy (Mukami, 2021). For instance, investors in energy projects that amount to a minimum of 25 megawatts are granted a seven-year tax holiday by Rwandan Investment Code provided such investment reaches a minimum of 50 million USD and at least 30% of it exists in the form of equity (Africa Clean Energy, 2021). Such policies aid renewable energy development which creates positive environmental impacts.

The coefficient of the interacted term of renewable energy consumption and government integrity was also revealed to be positive and statistically significant. The result implies that interaction between renewable energy consumption and government integrity leads to higher levels of carbon dioxide emissions and thus, a fall in the quality of the environment.

Since the values obtained from AR (2) and Hansen tests were all not significant, the study concluded that the results in the models are valid and consistent.

**Moderating effect of institutional quality on disaggregated energy consumption and environmental quality**

The inclusion of the interacted terms of disaggregated energy consumption and institutional quality in Models 7 to 12 does not adequately explain the moderating effect of institutional quality on disaggregated energy consumption and environmental quality. To establish the moderating effect, the study calculates the marginal effects of renewable and non-renewable energy consumption on environmental quality at the means of the institutional variables.

Finding the moderating role of property rights in the non-renewable energy-environmental quality relationship gives:

$$\frac{\Delta CO_2\mathrm{E}_{i,t}}{\Delta NREC_{i,t}} = \beta_2 + \beta_3\overline{PROP}$$

Substituting the mean of property rights from the descriptive statistics gives:

$$\frac{\Delta CO_2\mathrm{E}_{i,t}}{\Delta NREC_{i,t}} = -0.001+ [(-0.00001)\ (35.286)]$$

$$\frac{\Delta CO_2E_{i,t}}{\Delta NREC_{i,t}} = -0.001$$

Assessing the moderating role of tax burden in the non-renewable energy-environmental quality relationship gives:

$$\frac{\Delta CO_2E_{i,t}}{\Delta NREC_{i,t}} = \beta_2 + \beta_3\overline{TAXB}$$

Placing the mean of tax burden from the descriptive statistics gives:

$$\frac{\Delta CO_2E_{i,t}}{\Delta NREC_{i,t}} = -0.006 + [(0.0001)\ (72.860)]$$

$$\frac{\Delta CO_2E_{i,t}}{\Delta NREC_{i,t}} = 0.013$$

Finding the moderating role of government integrity in the non-renewable energy-environmental quality relationship gives:

$$\frac{\Delta CO_2E_{i,t}}{\Delta NREC_{i,t}} = \beta_2 + \beta_3\overline{GOVINT}$$

Substituting the mean of government integrity from the descriptive statistics gives:

$$\frac{\Delta CO_2E_{i,t}}{\Delta NREC_{i,t}} = 0.002 + [(-0.0001)\ (29.793)]$$

$$\frac{\Delta CO_2E_{i,t}}{\Delta NREC_{i,t}} = -0.001$$

Assessing the moderating role of property rights in the renewable energy-environmental quality relationship gives:

$$\frac{\Delta CO_2E_{i,t}}{\Delta REC_{i,t}} = \beta_2 + \beta_3\overline{PROP}$$

Placing the mean of property rights from the descriptive statistics gives:

$$\frac{\Delta CO_2E_{i,t}}{\Delta REC_{i,t}} = -0.019 + [(0.001)\ (35.286)]$$

$$\frac{\Delta CO_2E_{i,t}}{\Delta REC_{i,t}} = 0.016$$

Finding the moderating role of tax burden in the renewable energy-environmental quality relationship gives:

$$\frac{\Delta CO_2 E_{i,t}}{\Delta REC_{i,t}} = \beta_2 + \beta_3 \overline{TAXB}$$

Substituting the mean value of tax burden from the descriptive statistics gives:

$$\frac{\Delta CO_2 E_{i,t}}{\Delta REC_{i,t}} = 0.183 + [(-0.003)\ (72.860)]$$

$$\frac{\Delta CO_2 E_{i,t}}{\Delta REC_{i,t}} = -0.036$$

Finding the moderating role of government integrity in the renewable energy-environmental quality relationship gives:

$$\frac{\Delta CO_2 E_{i,t}}{\Delta REC_{i,t}} = \beta_2 + \beta_3 \overline{GOVINT}$$

Placing the mean value of government integrity from the descriptive statistics gives:

$$\frac{\Delta CO_2 E_{i,t}}{\Delta REC_{i,t}} = -0.075 + [(0.003)\ (29.793)]$$

$$\frac{\Delta CO_2 E_{i,t}}{\Delta REC_{i,t}} = 0.014$$

**Table 7: Results of the moderating effect of institutional quality on disaggregated energy consumption and environmental quality**

| **Variables** | **Non-renewable energy consumption (Marginal Effects)** | **Renewable energy consumption (Marginal effects)** |
|---|---|---|
| NREC*PROP | -0.001 | |
| REC*PROP | | 0.016 |
| NREC*TAXB | 0.013 | |
| REC*TAXB | | -0.036 |
| NREC*GOVINT | -0.001 | |
| REC*GOVINT | | 0.014 |

Source: Boakye-Mensah (2021)

The results presented in Table 7 illustrate how institutions moderate the effect of disaggregated energy consumption on environmental quality. The results show that on average, with more secured property rights, an increase in the consumption of non-renewable energy leads to higher environmental quality. The result suggests that ensuring property rights are properly assigned and well protected could generate a positive effect of non-renewable energy consumption on environmental quality. Further results indicate that, on average, even with a lower burden of tax, an increase in non-renewable energy consumption induces higher carbon dioxide emissions per capita. This presupposes that ease of tax burden does not bring positive environmental outcomes in regards to non-renewable energy consumption. Other results in Table 7 also indicate that with government integrity, an increase in non-renewable energy consumption reduces carbon dioxide emissions. This implies that improving the integrity of government can generate positive environmental outcomes given the consumption of non-renewable energy consumption.

Further results from Table 7 indicate that, with more secured property rights, an increase in renewable energy consumption leads to higher carbon dioxide emissions per capita. However, tax burden enhances the effect of renewable energy consumption on environmental quality. The result suggests that ensuring a lower burden of tax will likely bring about positive environmental outcomes given the consumption of renewable energy. Other results in Table 7 also suggest that, with government integrity, an increase in renewable energy consumption induces higher levels of carbon dioxide emissions per capita.

**Model Diagnostics**

In all the models, the values for AR (2) were not significant. Therefore, the study failed to reject the null and concluded that there is no second-order serial correlation between the error terms. The values for the Hansen overidentification tests were also not significant and so the study failed to reject the null hypothesis that the instrumented variables are exogenous. Hence, the models and instruments were deemed valid and consistent.

**Chapter Summary**

The chapter presented the descriptive statistics and correlation analysis of the variables employed in the study. This was followed by a discussion of the results obtained from the GMM estimation technique. The first objective sought to examine the effect of disaggregated energy consumption on environmental quality. The results indicate that while non-renewable energy consumption leads to higher environmental damages, an increase in the consumption of renewable energy enhances the quality of the environment. The second objective sought to examine the effect of institutional quality on environmental quality. The results show that ease of tax burden and improvement in government integrity leads to higher environmental quality given the consumption of renewable energy.

The third objective sought to assess how institutional quality moderates the effects of disaggregated energy consumption on environmental quality within the region. The results indicate that secured property rights and government integrity positively moderate the effect of non-renewable energy consumption on environmental quality. A lower tax burden also positively moderates the effect of renewable energy consumption on environmental quality. The next chapter of this study covers the concluding section of the study.

# CHAPTER FIVE

# SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

## Introduction

This chapter discusses the summary, conclusions, and recommendations made from the study. The chapter is organised into three sections. Section One provides a summary of the entire study. The summary section presents an overview of the problem, objectives, and research methods used in the study. The second section highlights some conclusions based on the results obtained from the study. The third section presents policies and recommendations to relevant authorities based on the findings of the study. This section also points out some limitations and suggests possible areas for further research.

## Summary

The study sought to examine the effect of disaggregated energy consumption and institutions on environmental quality. The findings from the study indicate that in sub-Saharan Africa, the consumption of non-renewable energy leads to higher environmental damage. In contradiction, higher consumption of renewable energy enhances the quality of the environment. A lower burden of tax leads to higher environmental quality given the consumption of renewable energy. Likewise, higher government integrity leads to higher environmental quality given the consumption of renewable energy. From the interaction between disaggregated energy consumption and institutional quality, findings from the study indicate that more secured property rights along with non-renewable energy consumption generate positive environmental outcomes. Similarly, improvement in government integrity along with the consumption of non-renewable energy leads to higher environmental quality. As such property rights and government integrity positively moderate the effect of non-renewable energy consumption on environmental quality. A lower burden of tax along with the consumption of renewable energy ensures better environmental quality. Tax burden also positively moderates the effect of renewable energy consumption on environmental quality.

**Conclusions**

Energy has evolved into an essential commodity without which the smooth running of an economy would be compromised. Developing economies are facing the challenge of overcoming energy shortages and meeting energy demand. At the same time, environmental degradation seems to undermine such efforts toward sustainable development. Given this, steps are being taken to raise awareness of the usefulness and environmental compatibility of renewable energy. The study employed the system Generalised Methods of Moments approach on 26 sub-Saharan African countries for 15 years. The dataset for the study was obtained from WDI and the Heritage Foundation.

The conclusions from the study indicated that while consumption of non-renewable energy exacerbates environmental degradation, increases in renewable energy consumption enhance the quality of the environment. The study also discovers that a lower burden of tax and improvement in government integrity along with the consumption of renewable energy leads to positive environmental outcomes. Ensuring proper property rights protection in regards to non-renewable energy consumption generates positive environmental outcomes. Consumption of non-renewable energy induces positive environmental outcomes given an improvement in government integrity. A lower tax burden also enhances the effect of renewable energy consumption on environmental quality.

Hence, further secured property rights and improvement in the integrity of the government can considerably minimise negative environmental impacts. Also, attention should be given to how the burden of tax (income and corporate) can be lowered to remove regulatory impediments to energy innovation within the sub-Saharan African region.

**Recommendations**

The reduction of emissions is a major problem for today's environmental protection and development strategies. Clean energy is crucial, particularly for developing countries, due to its significant benefits to both humans and the ecosystem. Renewable energy is recognised as an accepted set of energy options with the potential of providing cost-effective, reliable low-carbon energy with very minimal health implications. The ideal solution to environmental problems caused by the release of energy-related carbon dioxide gases would be to formulate and implement more diversified energy policies. This may be accomplished by enacting appropriate laws that encourage the use of environmentally friendly green energy sources. Adoption and use of renewable energy such as hydropower, biofuel, and biomass as an alternative to the readily available non-renewable energy sources could provide an avenue to offer protection to the environment without affecting economic activities.

Regulatory bodies such as the Ministry of Energy and Petroleum (Ghana), Ministry of Power (Nigeria), Ministry of Petroleum, Energy and Renewable Energy (Cote d'Ivoire), Ministry of Energy and Power Development (Zimbabwe), Department of State for Petroleum, Energy and Mineral Resources (The Gambia), Ministry of Energy and Water (Angola), Ministry of Mines and Energy (Togo), Ministry of Energy and Public Utilities (Mauritius) and their counterparts in other sub-Saharan African countries are urged to implement policies towards abatement of environmental pollution from non-renewable energy sources. This could be done through the improvement and expansion of energy systems through private sector partnerships. The institutional environment and human resource capacity could also be strengthened by enhancing innovations in renewable energy technology solutions and implementing policies for the development of renewable energy and energy efficiency sectors.

The Energy Commission of Ghana and Nigeria, Electricity Supply Commission of South Africa, Regulatory Authority for the electricity sector of Togo, Electricity Sector Regulatory Agency of Cameroon, and other key energy stakeholders are also encouraged to incorporate mechanisms aimed at promoting renewable energy usage. This could be done by offering grants and loans to investors in renewable energy. Frequent tax concessions and tax-free holidays could also assist in fostering investment in the renewable energy sector. This can enhance renewable energy development and in essence, lower the demand for non-renewable energy in sub-Saharan Africa.

A lower burden of tax and favourable tax regimes can be directly granted to projects and organisations fostering access to clean energy. They can take the form of abatement or exemption of income taxes, value-added tax, or customs duties. However, activities that pollute the environment cannot be overlooked. The imposition of a carbon tax on excessive usage of unclean fuels and allocation of proceeds into proper procurement of renewable energy can ensure efficient competition between renewables and non-renewables. Implementation of a carbon tax has generally been successful in high-income energy markets. Notwithstanding, high-income countries are a poor proxy for the relatively lower-income sub-Saharan African countries. Around 83 percent of the sub-Saharan African population rely on traditional fuels for domestic and other uses (Lawrie, Szpotowicz & Occhiali, 2021). Introducing a carbon tax could have serious economic implications on growth and development. As a result, African fiscal policymakers need to consider their limited firepower while exploring the opportunities carbon tax represents.

Secured property rights ensure that parties can bargain with one another to find the cheapest option to correct the externality. In instances where there are no pollution rights, efficient negotiation on pollution abatement would not be possible. As such agents who are not held accountable for their actions would conveniently pollute with no regard for the environment. This can undermine efforts aimed at protecting the environment. Effective environmental protection can therefore be guaranteed if authorities and policymakers step up their efforts to ensure that property rights are secured and properly defined in a manner that would protect the owners of these properties while holding external users responsible for their actions. Effective property rights management could also create an enabling environment for innovation and investment.

Higher levels of government integrity could avert the degrading environmental effects of non-renewable energy consumption. Ensuring public trust in politicians, irregular payments and bribes, transparency of government policymaking, absence of corruption and civil service transparency are some of the means through which integrity of government can be upheld. These are compatible with the ideals of fair and equitable treatment which constitute the central ingredients of an economically stable society. Strengthening government integrity entails the development of a good regulatory framework for attaining higher environmental performance and efficiently minimising the effects of energy consumption on the environment.

**Areas for further research**

Notwithstanding the relevance and timeliness of this study, some limitations are identified and avenues for further research are proposed. The study was conducted on a short panel and hence may not have taken care of individual heterogeneities which need a longer timespan to be completely addressed. The study employed secondary data in its analysis. Since the data was not collected by the researcher himself, several issues regarding data measurement and approximations remain unsolved and contentious. Carbon dioxide is generally considered a dominant pollutant across the globe. However, other variables such as forest depletion, methane gas, sulphur dioxide, nitrogen dioxide, and adjusted national savings, can potentially harm the environment. Although the study emphasises the General Method of Moment technique as being the most appropriate, several others, including the two-stage Least Squared technique could also be employed in the estimation process.

Much as these limitations are genuine and can pose quality problems to any study of this nature, their combined effect is negligible as far as the validity of the results of this study is concerned. Further research on environmental relationships could incorporate some of these variables as a measure of environmental quality. Other estimation techniques in issues relating to the environment could also be explored.

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# APPENDICES

A: List of countries used for the study

| | | | | |
|---|---|---|---|---|
| Angola | Democratic Republic of Congo | Ghana | Niger | Zambia |
| Benin | Ethiopia | Lesotho | Nigeria | Zimbabwe |
| Botswana | Equatorial Guinea | Kenya | Senegal | |
| Cameroon | Republic of Congo | Mauritius | South Africa | |
| Cape Verde | Gabon | Mozambique | Tanzania | |
| Cote d'Ivoire | The Gambia | Namibia | Togo | |