NEAR EAST UNIVERSITY

INSTITUTE OF GRADUATE STUDIES

DEPARTMENT OF BANKING AND FINANCE

AN INVESTIGATION INTO THE EFFECT OF BANKING SECTOR DEVELOPMENT, OIL PRICE, ECOLOGICAL FOOTPRINT, INDUSTRILIZATION AND ECONOMC GROWTH ON ENERGY CONSUMPTION IN SOUTH AFRICA

PH.D. THESIS

PONLE HENRY KAREEM

Nicosia

JUNE, 2023

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" In addition, we are of the view that it fulfills all of the requirements, both in terms of its breadth and its level of quality, to be a thesis for the Philosophy of Sciences degree.

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Declaration

I thus certify that all information, documents, analysis, and findings included in this thesis were gathered and presented in line with the Near East University Institute of Graduate Studies' academic standards and ethical principles. I have attributed and referenced all non-original sources and data utilized in this study, as required by these standards and regulations.

PONLE HENRY KAREEM

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Acknowledgment

I attribute the fruitful outcome of my time at Near East University to the power and blessings of God Almighty. A significant contribution to the success of my thesis can be credited to Prof. Turgut Tursoy, an exceptional supervisor from the Banking and Finance Department at Near East University. He diligently identified and rectified errors in my initial thesis writing application, guiding me toward refining it into a remarkable piece of work. The invaluable inspiration and guidance provided by Prof. Turgut Tursoy were pivotal in completing this thesis. I am also, deeply grateful to my esteemed department chair for the uplifting words of encouragement and his prompt responsiveness to my academic inquiries throughout my educational journey in the Near East University.

I want to extend my heartfelt gratitude to my wife and siblings for their unwavering support and encouragement during my studies and the completion of this research project. Their presence has been a constant source of motivation throughout this journey.

Furthermore, I would like to express my sincere appreciation to my academic colleagues and tutors, Ali MUMTAZ, Asst. Prof. Ahmed SAMOUR, Assoc. Prof Mehdi SERAJ and Prof Wajdi KHALIFA, whose collaboration made working on this research a truly enjoyable experience. Their consistent words of advice and motivation have been invaluable in the successful completion of this work.

PONLE HENRY KAREEM

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Abstract

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PH.D. DEPARTMENT OF BANKING AND FINANCE

June 2023

Most of the gases that cover the Earth and absorb the sun's heat are the result of burning carbon fuels to generate power. Coal, oil, and gas are the three forms of consumption fuels that contribute significantly to world gas emissions (75% and 90%, respectively). As a result, it is crucial to invest in alternative fuels that are less polluting, more cost-effective, more sustainable, and more dependable. To that end, we analyzed how changes in oil prices have affected South Africa's energy use, carbon footprint, banking system, and GDP growth. To check if a time series variable is stationary, the unit root test was employed. According to the unit root test, the variables were in level and first difference, where they were intermingling at either 1(0) or 1(1). In addition, we used the novel Bootstrap Auto-regressive Distributed Lag (ARDL) model to produce both short and long data for expressing imaginative suggestions in discussion. Our findings highlighted the connection between South Africa's economic development and the country's immediate and future energy demands, as well as their associated environmental impacts. This points to a rise in environmental quality as a result of South Africa's growing economy's higher energy usage. The positive benefits of the industrial structure are evident only in the short run, as confirmed by the ARDL results (a 1% rise in IND will result in a 0.418 increase in EUSE in the short run). In addition, a negative correlation exists between oil price volatility and both short- and long-term energy consumption (for every one percent increase in oil price, energy consumption drops by 0.153 percent), suggesting that South Africans are wary of using energy due to high oil prices. Our research provides evidence-based recommendations for executives, policymakers, the general public, and other stakeholders to use in creating an energy plan that supports both economic and environmental sustainability.

***Keywords**:* Sustainability, South Africa, Bootstrap ARDL, Ecological Footprint, Banking sector development

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CHAPTER I

Introduction

More focus has been recently given to how economic growth affects energy use. Growth in the business world, population, and the need for better transportation systems are all helped by rising energy demand. The desire for fossil fuels like oil and coal leads to ecological decline, negative environmental impact, and increased volatility in oil prices. In the twenty-first century, the expanding economy of nearly every nation will necessitate increased energy consumption. Gómez and Rodrguez (2019) and Hamit-Haggar (2012) both highlight the importance of energy to economic development due to the fact that it is necessary for the production of products and services. Unfortunately, environmental risks have resulted from the need to produce energy. The demand for goods and services in emerging economies is expected to increase, necessitating increased energy consumption (Sadorsky, 2011). Also, stagnation has resulted from a mismatch between energy output and demand (Furuoka, 2015). It's also essential for regulating future CO_2 emissions from energy usage and enforcing energy policy (Sadrosky, 2010). Because of the importance of energy usage in daily life and its involvement in manufacturing sectors and economic growth, the effect of banking sector growth, economic growth, industrial structure, and CO_2 emissions on energy use has been a popular area of study. In addition, "lower rates of economic growth in Sub-Saharan Africa (SSA), from 3.8% in 2009 to 2.7% in 2017," highlight the need for more research into how banking sector development (BSD), economic growth (EG), ecological footprint (EF) (used as a proxy for environmental quality), oil price shocks (OP), industrial structure (IND), and energy use (EUSE) can promote sustainable development, particularly in Africa.

In light of the increased demand for 39,000 MV [6] that is expected to hit South Africa in 2020, the country's power provider, Eskom, has been unable to keep up. South Africa's GDP dropped by 1.1% as a result of load shedding, and new questions were raised regarding the reliability of the country's electricity supply (Vermeulen, 2020). Concerns regarding the running of the nation's energy grid were exacerbated by the 2018 cabinet's inability to recover R9.9 billion in capital costs due to operational and financial mismanagement (Alexandra, 2020). The South African power provider, Eskom, projects a 4,000–6,000 megawatt electrical supply crisis in five (5) years, when the lifespan of the aged coal-fired power facilities ends, due to systemic failure and a lack of additional capacity. However, previous studies have linked economic growth with increased energy use (Bulfone, 2020). Higher energy consumption among households, individuals, and enterprises is correlated with economic growth (Ma & Fu, 2020).

Consumer durables like air conditioners, televisions, automobiles, computers, and so on can benefit from economic growth and the availability of cash at fair and not too high-interest rates if the banking sector is developed (Mahalik et al., 2017).

Research by Stern (2004) and Kakar (2016) shows that EC increases in tandem with GDP expansion. Urbanization, industrialisation, GDP growth, and energy use are all positively correlated with investment, according to Bayer (Bayar et al., 2021). According to Sadorsky (2011), a country's early financial development is affected by its usage of energy, while later financial development is improved by economic growth. According to Roubaud and Shabaz (Balsalobre-Lorente et al., 2018), Gungor and Simon (Gungor & Simon, 2017), and Sadrao et al. (Sadraoui et al., 2019), there is a reciprocal relationship between economic expansion and energy use.

There may not be a direct correlation between energy consumption and economic development, as some research has found. Yue et al. (2019) analyzed "Middle East and North Africa" (MENA) nations to determine if there is a connection between economic development and increased energy consumption. The findings indicated that both banking industry expansion and energy consumption increase were unremarkable.

Previous studies have demonstrated that oil prices have a considerable impact on several economic indicators. A nation's economic fortunes swing depending on whether or not it exports or imports oil. Developed and developing countries' economic indicators react differently to changes in oil prices, according to study by Gorus et al. (Gorus et al., 2019). Oil-importing nations tend to struggle as prices rise. South Africa imports crude oil and refined fuels to satisfy domestic demand for liquid fuel. To wit: (Abumunshar et al., 2020). Whenever interest rates go up, it becomes more expensive to borrow money, which has a negative impact on investment and energy use. Energy consumption and oil prices have been researched by policymakers, companies, and economists since the 1973 oil price crisis. Since oil is used in so many different ways, price swings in the oil industry are inevitable. Terrorism and civil disturbances such as the war (Arab Spring) and COVID-19 damaged China and other major countries by the end of 2019, according to the International Energy Agency's (IEA) oil market prediction for 2020. The fluctuations in oil prices have an impact on the investment and stock markets as well as macroeconomic indicators and industrialization.

Carbon dioxide (CO_2) made up 76.7% of greenhouse gases in 2007, hence energy production is a factor in global warming, as reported by the "Intergovernmental Panel on Climate Change" (IPCC). Reduced carbon dioxide emissions can be attributed to the combined effects of industrialization and better communication. Increased trade openness and improved living conditions have led to longer life expectancies and lower newborn mortality rates, as reported by Maruotti and Martnez Zarzoso (2011). Consequently, increased industrial productivity results in increased pollution and energy requirements. The world's population is expected to rise by 1.5% each year and pass the 10-billion mark by 2050. Different regions urbanize at different rates, but developing nations' rising populations and CO2 emissions have a disproportionate effect on the world's overall energy consumption. According to Al-Mulali et al. (2012), these developing economies will be to blame for more carbon dioxide (CO_2) emissions in the next 30 years than developed economies will. The emerging markets have been hesitant to take action to stop the deterioration of the environment. The advanced economies, they say, should lead the way in tackling environmental concerns, despite having made great achievements in this area before. As energy use rises, more and more attention must be paid to the potential effects on developing countries.

The country was selected because of its status as one of Africa's greatest economies. In recent years, there has been a dramatic increase in immigration from Africa and other African countries. Increased energy consumption may be harmful to the environment due to South Africa's reliance on nonrenewable energy sources like coal. There is a dearth of research into the interplay between South Africa's energy use and factors including the country's banking industry, oil prices, and carbon footprint. The academic community has largely ignored the possibility of an environmental imbalance due to human activity. The quantity of land needed for the sustainable extraction of natural resources is another definition. Soil, air, geology, and all forms of life are all sources of natural riches, and the reliance of the human economy on these resources is reflected in its ecological footprints (EF; K. Li & Lin, 2015). Researchers examined the effects of banking sector growth, economic growth, oil prices, ecological footprint, and industrial structure on energy use in South Africa to give empirical evidence of the links between these factors.

The findings of this study expand our perspectives. To our knowledge, this is the first study to investigate the connections between the changing nature of South Africa's financial sector and macroeconomic variables like oil prices, emissions levels, the composition of the country's manufacturing base, and energy consumption. Second, the works of literature that were studied touched on issues like the cost of energy and the impact on the environment. Prior studies only looked at CO_2 emissions, not the effects on people. The concept is identical to that of the area needed to make efficient use of a mineral resource. In order to assess the impact of environmental conditions on energy use, we employed ecological footprints. The full impact on South Africa's energy use was underestimated because oil prices were not factored in. Therefore, the findings of the study will contribute to existing knowledge. To test for co-integration, we used the Bootstrap ARDL lag model developed by McNown et al. (2018). Finally, the thesis offers evidence-based policy proposals for restructuring South Africa's energy infrastructure and consumption patterns.

Statement of Problem

The purpose of this study is to examine the impact of the oil price, environmental footprint, banking sector growth, industrialization, and GDP growth on South Africa's energy consumption from 1990 to 2019. South Africa is the continent's biggest energy consumer, and its reliance on coal for electrical generation has serious environmental consequences. Understanding the factors that determine energy consumption can guide policies aimed at increasing sustainable energy usage, which is especially important for South Africa because it is a developing country and confronts many sustainable development difficulties (Hanto et al., 2022).

Several elements that affect South Africa's energy use have been studied in the past. Economic growth, industrialization, and urbanization are only a few examples of the factors that influence energy use. According to their research, Kasimu and Mabugu (2019) found that the factors that affect energy consumption are income level, population size, and technological advancement. For whatever reason, nobody seems to have looked into how things like OP, EF, BSD, IND, and EG changed South Africa's energy use from 1990 to 2019. To fully grasp the elements that influence energy consumption in South Africa and inform policies to promote sustainable energy use, it is necessary to dissect the complex web of relationships between these variables.

According to studies, OP had an impact on EUSE in many countries, including South Africa. According to Bhorat et al. (2018), rising oil prices can hurt GDP growth and industrialization because of the subsequent increase in energy prices. Alternative energy sources may benefit from the uncertainty around the price of oil, leading to more sustainable energy consumption.

Land use, energy use, and water use all play a role in determining a person's "ecological footprint," which is a measure of the environmental impact of their actions. According to Wiedmann et al. (2013), energy production and consumption have substantial environmental consequences, such as greenhouse gas emissions and air pollution, making it crucial to comprehend the connection between ecological footprint and energy use.

The financing of industrialization and economic expansion by the banking sector can have an impact on energy consumption. Botha and von Fintel (2015) assert that access to credit can encourage growth and energy consumption, while a lack of credit can hinder them.

The rate of economic expansion and energy use both rises in tandem with industrialization. Increased industrialization is a key strategy South Africa is pursuing to boost economic growth and alleviate poverty. However, as Kasimu and Mabugu (2019) point out, industrialization often goes hand in hand with increased energy use and a decline in the environment.

Finally, a rise in South Africa's GDP is a major contributor to a rise in that country's energy demands. According to Odhiambo (2010), in South Africa, rising GDP is positively correlated with increased energy demand. However, sustainable energy use needs to be promoted because excessive use can have serious consequences for the environment and society.

Exploring the link between OP, EF, BSD, IND, and EG can shed light on the factors that influence energy consumption and update policies to promote sustainable energy use in South Africa.

As a result, the study will contribute to the existing body of knowledge by providing an in-depth exploration of the factors influencing energy use in South

Africa. This study's findings may influence national policies that favor the use of renewable energy.

Research Questions

1. What is the relationship between oil price and energy consumption in South Africa from 1990 to 2019
2. To what extent does the ecological footprint influence energy consumption
3. How has banking sector development impacted energy consumption
4. To what extent does industrialization affect energy consumption
5. What is the combined effect of economic growth, oil price, ecological footprint, banking sector development, and industrialization on energy consumption in South Africa?

Research Objectives

1. To investigate the impact of oil prices on energy consumption in South Africa.
2. To assess the relationship between ecological footprint and energy consumption in South Africa.
3. To analyze the impact of banking sector development on energy consumption in South Africa.
4. To examine the influence of industrialization on energy consumption in South Africa.
5. To determine the effect of economic growth on energy consumption in South Africa.

Research Hypotheses

H_1: Oil prices has a significant impact on energy consumption in South Africa

H_2: Ecological footprint has a significant influence on energy consumption.

H_3: Banking sector development has a significant impact on energy consumption.

H_4: Industrialization has a significant effect on energy consumption

H_5. Economic growth has a significant impact on energy consumption

Significance of the Study

The importance of this research hinges on the new insights it provides into the factors that shape energy usage in South Africa. The requirement to transition to more environmentally friendly energy sources is only one of the many sustainable development issues South Africa must overcome as a developing nation. In order to inform policies that promote sustainable energy use in the country, an understanding of the factors that determine energy use is crucial.

Oil price, ecological footprint, banking sector expansion, industrialization, and economic growth will all be investigated, along with their combined effects on energy consumption, adding to the current literature on the determinants of energy consumption. While some of these characteristics have been studied in relation to energy use in South Africa, their combined impacts have not yet been studied. This research will help close the knowledge gap by examining all of the factors that contribute to South Africa's high energy consumption rates.

Policymakers in South Africa and other developing nations confronting comparable issues in the area of sustainable development will find the study's conclusions useful. The research will shed light on the elements that can affect energy consumption and guide strategies to encourage sustainable energy use in these nations.

Limitations of the study

The absence of prior research examining the combined influence of BSD, OP, EF, IND, and EG in South Africa has left a notable gap in our understanding of the intricate dynamics affecting energy consumption in the region. While this study benefits from a substantial sample size, it is important to acknowledge its limitations. The inclusion of periods with low predictive power or extended time frames that may not be informative could potentially hinder the accuracy of the findings.

Given the scarcity of similar investigations in South Africa and the broader sub-Saharan African context, our current understanding of how these interconnected variables impact energy use remains incomplete. As a result, it becomes challenging to precisely determine the magnitude of each factor's contribution to energy consumption patterns in the country. Consequently, the generalizability of the study's results to the entire South African population should be approached with caution, considering the limited scope of existing research in this area.

Addressing this research gap and gaining a comprehensive understanding of the complex relationships between of BSD, OP, EF, IND, and EG in South Africa is crucial. It calls for the exploration and in-depth investigations to provide evidence-based insights that can inform policy decisions and sustainable energy strategies for the nation.

Future research endeavors in this field should aim to address the limitations of this study, employing more focused and precise time frames to enhance the predictive power of the findings. Additionally, interdisciplinary approaches, integrating expertise from various fields such as economics, environmental science, and finance, could enrich our understanding of the intricate connections between these variables and their implications for energy use.

By conducting more extensive and rigorous studies, researchers can contribute significantly to the body of knowledge on EUSE patterns in South Africa, thereby fostering informed and targeted interventions to promote sustainable energy practices and environmental stewardship in the region.

CHAPTER II

Literature review

Introduction

Investigation into the finance-energy nexus has received a lot of attention in recent decades due to the rising energy needs of both industrialized and developing countries. Researchers from all around the world have looked at the elements that influence energy consumption in their respective countries, both in the short and long term. As a result, research has been conducted to compare energy use through time to variables including GDP growth, financial development, and CO_2 emissions. In this chapter, we'll look into the theoretical and empirical research on energy usage and other independent factors. Furthermore, as a result of the current studies, it is necessary to assess the following research: the theory of energy consumption; the relationship between banking sector development and energy; the relationship between growth and energy; Oil prices; the ecological footprint and energy consumption; and the review of industrialization and energy consumption.

Theoretical framework

Theory of Energy Consumption

Review

Developing environmentally-safe energy resources and an immense rise in the use of energy is necessary to reduce energy/material shortages, implement urban and rural projects, develop numerous sectors like consumer goods, healthcare, tourism, automation, manufacturing, trade, transportation, as well as other essential amenities, and ultimately deprive the world (Babak, 2021).

Energy costs can be mitigated by allocating a small percentage of overall revenues (typically less than one percent) to the many businesses, industries, financial institutions, and consumers that would benefit from these energy-related activities (due to the significant amount of financial transactions and the economic the factor effect) (Babak, 2021).

To put it another way, if an NPV (Net Present Value) discounted analysis shows that an energy project will lose money because its costs will exceed its revenues, and if an amount of the tax on the extra income that affected consumers and businesses would earn more in return than the energy-related project loss, then subsidies can be used to make up the difference (Vasooghzadeh, 2020). The second criterion is crucial

because we must ensure that the money made by the energy-related project is adequate to cover the loss made by the project. It would be detrimental to the economy if the government were to raise taxes or increase borrowing to cover the anticipated loss.
Current technological limitations make it challenging to electronically track the massive monetary transactions and additional revenues that affected parties obtain as a result of the execution of these energy business strategies (along with the taxes that they pay). As a result, energy-related business plans with a negative net present value (NPV) are currently being implemented with the help of subsidies.
After financing the negative NPV business plan in installments or recurrent payments, the affected businesses and consumers will have more money to pay taxes on. Governments can utilize this additional revenue to reduce the overall cost of subsidy programs that qualify for it.

A measure of the company's prosperity REO (Revenue Earned by Others) refers to the money made by businesses, industries, financial institutions, and customers as a result of energy-related infrastructure projects. Using AI, machine learning, Big Data diversified prescriptive analytics, and hyper-clustering, this crucial REO measure may be approximated. To be really global and applicable, however, a set of international rules and norms will need to be developed.

To ensure the Big Data insights and diversified business analytics employed in the Negative NPV Feasibility (or Subsidy Justification) Report are valid and warranted, governments and funding institutions will conduct a thorough review of the document before covering the estimated loss. Commercial opportunities, urban or rural projects, and subsidies may not all meet the criteria for a negative net present value or negative feasibility according to the standards set forth by Bakak (2021).

The Role of Energy in Economic Development

The growing popularity of tourism, automation, manufacturing, trade, transportation, and countless other crucial services and businesses requires the development and transformation of material and energy resources, the definition and implementation of rural and urban projects, and the development of numerous industry sectors.

Both urban and rural construction projects benefit a wide range of industries, including production, retail, transportation, tourism, trade, and travel. For example, desalination plants and the pumping of seawater would be necessary for a project to develop arid terrain. The resulting vegetation sparks a wave of additional efforts, gives rise to numerous new companies, and boosts worldwide trade and tourism in ways nobody could have imagined. These economic growth goals can only be attained with a substantial increase in the development of energy resources. Energy is required all throughout the supply chain for any firm, whether they are manufacturers or service providers. All the work done by the buyer's end to complete the purchase also uses up resources.

Energy Needs in the Future

There is an urgent need for a considerable rise in energy consumption to satisfy the goals of global peace, rural and urban growth, and advances across industries including tourism, automation, and manufacturing. Urban and rural development initiatives are essential to the expansion of many sectors of the economy, the facilitation of trade and travel, and the enhancement of both (Barkas, 2020).

The project to develop dry land by pumping seawater and using desalination equipment is a good example because it will lead to the development of new industries, will spur the development of additional projects, and will greatly improve international trade and tourism.

The Enhanced Economic (Negative) Feasibility Theory offers a novel strategy for evaluating the economic viability of such endeavors. Given that other firms will reap financial benefits from the projects' execution, it proposes using a tiny portion of the residual tax income collected by those businesses to cover the cost of the projects with expected losses.

Hydrocarbon, Nanogenerators, sustainable/renewable energy sources, batteries, and fuel cells are just some of the energy resources and harvesting technologies that need to be developed in order to meet future energy demands (Mouratidis et al, 2018). There are stringent environmental regulations that must be followed by these assets. Energy collecting techniques, such as Silicon solar and nanogenerators can be given extra weight in chilly climates.

Emission Converting Units, such as CO_2 converting units, and the injection of collected CO_2 into geological formations to achieve net-zero emissions can also be used to improve HC (hydrocarbon) processing and consumption. This plan not only helps current HC facilities meet their energy needs but also helps subsidize the research and development of renewable energy options (ENEA, COSIA, 2018).

In addition, Emission Converting Units can recycle harmful HC emissions into useful and safe byproducts. Fuel cells require hydrogen gas, which is produced when CO (syngas) is converted to CO_2 and then reacts with water.

The Negative Feasibility hypothesis and the Energy Consumption hypothesis can be used to the problem of energy costs. According to the second theory, these expenditures can be defrayed by allocating a portion of the earnings generated by energy-related operations.

As a result, in order to satisfy the expected energy demand in the future, it will be necessary to create a varied portfolio of energy resources and harvesting techniques. These actions are in line with long-term goals including world peace and the development of both rural and urban areas and varied industries. To pay for these improvements, a tiny percentage of the profits made by established companies that have benefited from these crucial projects can be used.

Environmental Kuznets Curve Theory

Some scholars argue that economic growth is the most significant variable in fixing environmental issues. They claim environmental damage increases in tandem with rising incomes and populations. Once a person reaches a particular degree of wealth, however, they no longer experience this degeneration. The Environmental Kuznets Curve (EKC) theory describes this trend (UNCTAD, 2012). The word "EKC" was not used when the World Bank first proposed the notion in its 1992 World Development Report (WDR). Instead, the report claimed that increasing economic activity is always bad for the environment, despite the fact that these findings were predicated on unchanging assumptions about technological advancements, consumer tastes, and money spent on environmental protection (Stern et al., 1996). It was in a study written by Panayotou (1993) for the World Employment Programme Research Working Study Series that the term "EKC" was first used. According to Agras and Chapman (1999), the first time this phrase appeared in an academic publication was in the work of Selden and Song (1994).

The EKC theory states that the degradation of the environment is proportional to monetary growth. However, this correlation is unstable since it is income-dependent; rich and poor countries display different trends. Collectively, this results in a U-shaped curve with the vertex at the bottom.

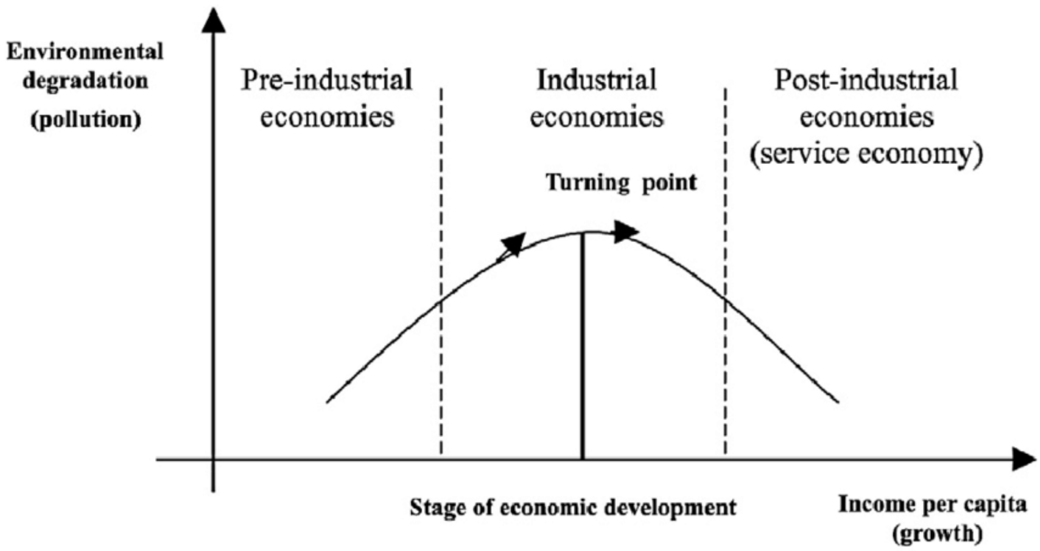
Economic development's structural shifts shed light on the EKC's form. Early on in development, as seen in Figure 1, environmental quality declines as the agricultural sector contracts and the industrial sector increases, reflecting the shift from a pre-industrial to an industrial economy. This is because productivity, income, and consumption have all increased gradually as capital-intensive enterprises have replaced labor-intensive ones. A transition from an industrial to a post-industrial economy is marked by a smaller role for manufacturing and a larger one for services as society moves up the economic ladder. This change is in line with the betterment of the environment that is hoped for. Below diagram depicts the inflection point at which environmental indicators begin to improve (usually under industrial economies; UNCTAD, 2012).

Diagram shows that in the early stages of development when economic activities are focused on providing a subsistence level of living, environmental degradation is mild in both scale and severity. As industrialization grows, resource depletion and trash generation rise in tandem with the rate at which agriculture and resource extraction are being stepped up. In the diagram, this is represented by the curve's increasing slope. In the latter stages of growth, along with more efficient technologies and a growing need for environmental quality, there is a trend towards information-based industries and services. As a result of this shift, the curve turns, and environmental degradation gradually decreases over time (Moomaw and Unruh, 1997; Panayotou, 2003).

As a result of this, one may see why the curve in the diagram is sloping downwards. The idea that the environment is a luxury good with a corresponding income effect underlies the EKC's observed behavior. Because people are unwilling to make sacrifices in their consumption in the early phases of economic development, environmental quality deteriorates. After a certain level of consumption (or income), however, there is a need for more money to be spent on environmental improvements. Pollution and degradation of the ecosystem begin to decline after this tipping threshold (Moomaw and Unruh, 1997; Galeotti, 2003).

The EKC's shape may also have something to do with the rate of population increase in the region. The population growth rate decreases because people get more educated and have fewer children as economies improve. Because fewer people are living on the planet, less pollution and other environmental damage will happen. The fact that developing countries, especially the poorest ones, lack the resources to implement clean technology also contributes to the general form of the EKC. As a result, environmental quality is typically low in developing countries' early stages but rises as those countries advance economically and adopt cleaner technology (UNCTAD, 2012).

There are three separate mechanisms that explain the correlation between economic growth and environmental quality: the scale of impact, the structure effect, and the technological effect. The scale effect is bad for the environment since it increases the need for resources like energy and water to produce the same amount of output. This causes more garbage and pollution to be produced, which worsens the ecosystem (Grossman and Krueger, 1995). However, the composition effect is beneficial to the ecosystem. The structure of the economy is expected to change from primary activities (which generate a lot of pollution) to tertiary activities (which generate less pollution) as income rises. There is a beneficial technical influence on environmental quality as well. In order to lower emissions, older, dirty technology should be swapped out for newer, cleaner ones (Stagl, 1999). When taken together, the scale effect causes economic growth to have a negative overall influence on environmental quality. The positive slope of the curve in Figure 1 illustrates this. However, the negative scale effect is offset by the positive composition and technological benefits over time, which is seen in the declining slope of the curve. When composition and technological impacts outweigh the scale effect as economies develop, an EKC relationship is formed (Clement and Meunie, 2008).



Source: Panayotou (1993)

An Overview of Non- renewable and renewable Energy in South Africa

South Africa's geography is characterized by diverse features, including a coastline that stretches over 2,500 kilometers (1,600 miles) and borders shared with Namibia to the west, Mozambique to the north, and extending around the southern tip of Africa. The country is renowned for its emerging economy, which showcases strengths in natural resources, energy, and the financial sector.

One significant pillar of the country's economy is its abundant coal resources, which play a crucial role in electricity generation, accounting for almost 90% of the nation's power supply. Nuclear energy contributes 5.2%, while natural gas makes up 3.2% of the energy mix. Forecasts indicate that South Africa's electricity demand is expected to exceed 56,000 MW by 2030 (DOE, 2016).

South Africa ranks as the sixth-largest coal producer globally, as reported by the Energy Council (WEC, 2016), underscoring the importance of coal in the nation's energy production. Although the country has a well-structured energy production and supply system, its reserves of crude oil and natural gas are limited. Nonetheless, South Africa does leverage some renewable energy sources. The DEM (2016) report confirms the active utilization of abundant sunshine for potential electricity generation, serving both industrial and residential needs.

The energy sector plays a significant role in South Africa's overall output, contributing to approximately 15% of the GDP. Additionally, it provides employment for around 250,000 citizens (Beg, et al., 2002).

In accordance to the latest GDP data from the World Bank Group, South Africa is the second-biggest economy in the area, behind Nigeria. This makes it one of the most industrialized nations in sub-Saharan Africa. By using over 623 b/d of oil and other liquids in 2019, South Africa eclipsed both Nigeria and Algeria as the continent's top user of these resources by a margin of at least 25% (EIA, 2022).

Due to its meager proven oil and natural gas reserves, the country must rely heavily on coal to meet its energy needs. This reliance is sustained by South Africa's huge and energy-intensive coal mining industry. Both the Secunda and Mossel Bay plants in South Africa use technology to convert coal and natural gas into liquid fuels. The production of synthetic fuels is also very advanced in South Africa.

South Africa has a comparatively high level of energy accessibility compared to other sub-Saharan African countries, although its electric power grid frequently has outages due to insufficient infrastructure spending. To increase its energy security, South Africa is actively seeking foreign investment in renewable energy. Coal, however, is expected to remain the primary fuel used to supply energy demands for the foreseeable future.

Coal, oil, and natural gas production in South Africa are all overseen by different government departments. Regulations pertaining to mineral exploitation are the responsibility of the Department of Minerals and Energy (DMRE) and the Mine Health and Safety Inspectorate (EIA, 2022). The Petroleum Agency of South Africa is responsible for oil and natural gas exploration and production.

South Africa's electric power and oil and gas midstream sectors are both governed by the National Energy Regulator (NERSA). Environmental rules for the oil and natural gas industry are managed by the Department of Environment, Forestry, and Fisheries (DEFF).

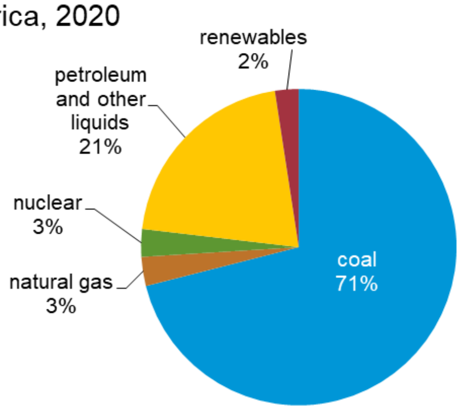
Upstream operations in the coal, oil, and natural gas industries are primarily governed by the Mineral and Petroleum Resources Development Act, which was last updated in 2014. The Upstream Petroleum Resources Development Bill was introduced in Parliament in July 2021 with the goals of decoupling the regulation of the oil and natural gas industries from that of the mining sector, increasing transparency in policy and regulation, and luring investment to the upstream oil and natural gas industry. The legislation cannot become a law or go into force until it is adopted by Parliament, which was not known to happen as of June 2022.

The Mossel Bay GTL facility and other upstream oil and natural gas producing assets in South Africa are managed by the state-owned Petroleum Oil and Gas Corporation of South Africa (PetroSA). The corporation is also involved in the international oil and gas business. Companies from Europe, North America, and Asia are all a part of the downstream oil industry, which is increasingly international in scope. In South Africa, the major players are BP, Shell, Chevron TotalEnergies, and Engen.

Energy Consumption

Coal and petroleum were, combined with other liquids, South Africa's primary energy sources in 2020, per BP's 2021 Statistical Review of World Energy. Coal accounted for almost 71% of the overall consumption, while petroleum and other liquids accounted for 21% (Figure 1). According to Eskom, South Africa's electricity provider, the country's coal is consumed by the electric power industry. The petrochemical industry used 33% of the remaining coal, followed by the metallurgical industry at 12% and then homes at 2% for heating and cooking.

Figure 1. Primary energy consumption in South Africa, 2020



lives.

Source: BP *2021 Statistical Review of World Energy*

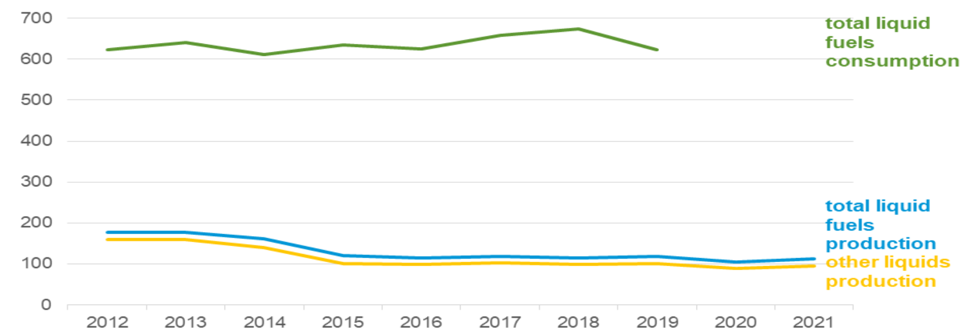
Petroleum, Gas, and Other Liquids

Production and Exploration

The Oil & Gas Journal (OGJ) reported in January 2022 that the country of South Africa has 15 million barrels of known oil reserves. South of the country, along the coastal border with Namibia, is where you'll find the entirety of the country's proven reserve base, known as the Bredasdorp Basin.

In 2021, crude oil and lease condensate accounted for only 1% of the total liquid fuel production of 112,000 b/d. As can be seen in Figure 2, nearly all of South Africa's liquid fuel is manufactured using synthetic fuels made from coal and natural gas.

Figure 2. Total annual liquid fuels production and consumption in South Africa, 2012–2021
thousand barrels per day



Source: U.S. Energy Information Administration

Storage and Transport

Four out of South Africa's six oil terminals are located in each of Richards Bay, Saldanha Bay, Port Elizabeth, and East London. The strategic location of Saldanha Bay on the Cape of Good Hope shipping route has made it an important regional storage hub. Therefore, it has the potential to feed major manufacturing centers in Asia and Europe. We can store 55 million barrels of oil here without a problem. The most recent addition to storage space is the Saldanha Bay II liquid storage terminal, which began operations in October 2020 and added nine tanks with a total capacity of approximately 10 million barrels. If the corporation continues to implement its growth plan and completes the building, the current storage capacity of this facility might be expanded by an additional 3.2 million barrels.

Products of oil refinement

Only one of South Africa's four refineries is currently in operation. Natref, a refinery not far from Johannesburg, can pump out 107,000 barrels of oil per day (b/d). South Africa has two plants that turn their respective fuel sources into synthetic liquids: a coal-to-liquids (CTL) plant in Secunda and a natural gas-to-liquids (GTL) plant in Mossel Bay. The Sapref refinery, which can process 180,000 barrels per day, is owned equally by BP and Shell. It's unclear what will become of this refinery in the future because operations ceased in March of 2022.

In July of 2020, an explosion at the Cape Town Astron Energy plant caused it to catch fire. Assuming the refinery renovations are completed without incident, Astron Energy plans to restart operations by the end of 2022.

After a fire and explosion in a diesel hydrotreater in December 2020, Engen, which is principally controlled by Petronas, will shut down its Durban refinery. According to Reuters, by the end of 2023, Engen expects to have converted the refinery into an import and storage facility.

To combat air pollution, South Africa's government imposed stricter fuel standards in September 2021. These statutes mandate that beginning in September 2023, diesel fuel must conform to more stringent sulfur content limits. Local refiners will need to spend more money on infrastructure changes to produce fuel that matches the new specifications, increasing operational and capital expenses. If the government does not give cash for renovations, the South African Petroleum Industry Association (SAPIA) is concerned that the country's refineries would shut down within two years.

Table. South Africa's refineries

Refinery name	**Ownership**	**Location**	**Notes**	**Capacity (barrels per day)**
Natref refinery	Sasol (64%) Total (36%)	Sasolburg	Operational	107,000
Sapref refinery	BP (50%) Shell (50%)	Durban	Close indefinitely. To restart in future	180,000
Astron refinery	Astron energy	Cape town	Closed in July 2021. Possible to restart in 2022.	110,000
Engen refinery	Petronas (74%) Phembani (21%) Consortium (5%)	Durban	Closed down in 2020. By 2023, planned to convert to import and storage terminal	125,000
Total				**522,000**

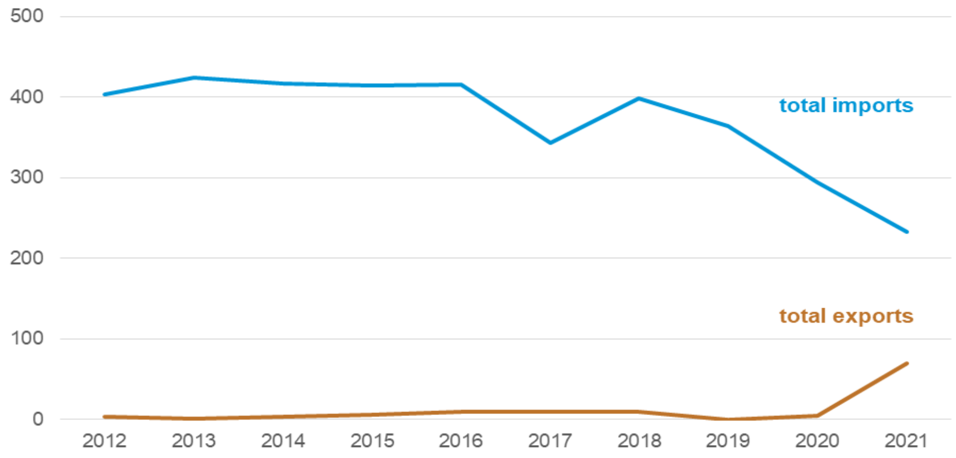
Data sources include Facts Global Energy, Oil & Gas Journal, Energy Intelligence Group, and the South African Petroleum Industry, as well as association and corporate websites.

Liquid trade, such as oil

Figure 3 from Global Trade Tracker shows that as of May 2018, South Africa purchased about 232,000 b/d and supplied about 69,000 b/d of crude oil and condensate. In 2021, the top two importers were Nigeria (100,000 b/d) and Saudi Arabia (89,900 b/d). Africa and the Middle East are the main suppliers of goods to South Africa. South Africa also imported a paltry 19,000 b/d from Ghana and 13,000 b/d from Angola (Figure 4).

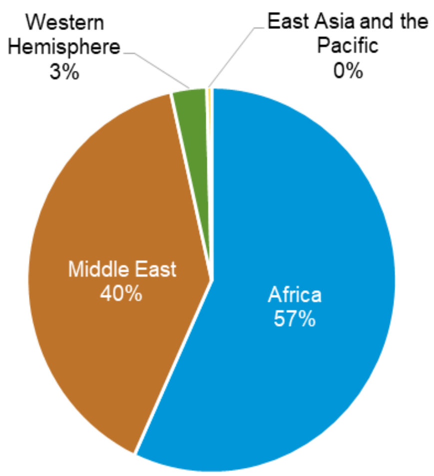
Figure 3. South Africa's total annual exports and imports of crude oil and condensate, 2012–2021

thousand barrels per day



Source: U.S. Energy Information Administration and Global Trade Tracker

Figure 4. South Africa's total crude oil and condensate imports, 2021



Source:Global Trade Tracker

Natural Gas

Production and Exploration

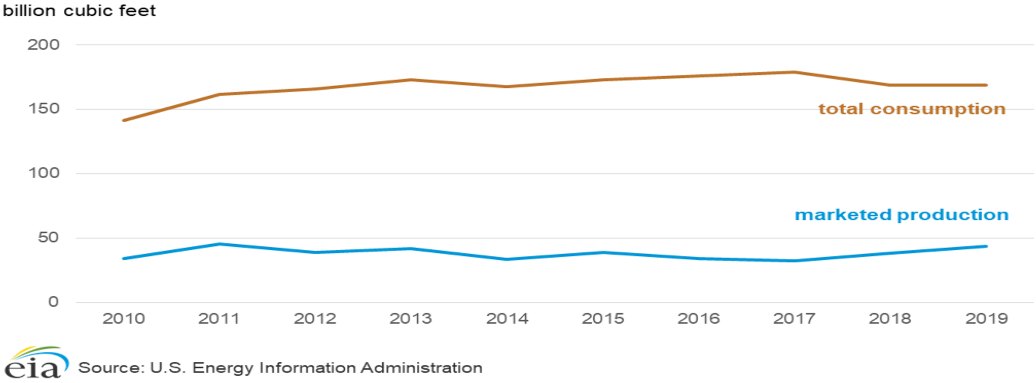
A majority of South Africa's natural gas comes from the South Coast Complex and the well-established offshore F-A complex. In order to transport natural gas from the fields to the GTL plant in Mossel Bay, a pipeline is constructed offshore. According to Figure 5, in 2019, South Africa generated around 43 Bcf of dry natural gas while consuming around 169 Bcf.

TotalEnergies's two deep-water natural gas and condensate discoveries could greatly expand natural gas production by the middle of the 2020s. Blocks 11B and 12B, located roughly 110 miles south of Mossel Bay, are where the natural gas condensate deposits of Brulpadda and Luiperd were found. If these sources become functional, the Mossel Bay GTL facility, which has been operating at a reduced capacity for several years, may be able to use the natural gas and condensate they produce. This would lessen the country's dependency on imported natural gas. In light of the potential resources discovered in Brulpadda and Luiperd, there has been renewed interest in exploring South Africa's offshore blocks.

Recent field investigations conducted by Rystad Energy estimate that peak production from the Brulpadda and Luiperd finds will be between 340 and 300 million cubic feet of natural gas and liquid fuels, respectively.

Since South Africa has so little natural gas reserves, it must rely on imports from neighboring countries like Mozambique to supply domestic demand. While there may be substantial shale gas resources in South Africa's Karoo Basin, extracting them would present a number of difficulties. The Karoo Basin's complicated geological features, for example, increase the technical difficulty and cost of exploration and appraisal efforts. Additionally, there is a shortage of infrastructure for the processing and transportation of natural gas.

Figure 5. Annual natural gas production and consumption in South Africa, 2010–2019



Natural Gas and liquids

The PetroSA GTL plant in Mossel Bay is wholly owned by the Central Energy Fund of South Africa. PetroSA is in charge of the power plant and the offshore gas fields that supply it. Synthetic liquid fuels such as distillates, gasoline, kerosene, diesel, and propane can all be produced from natural gas at this facility. The Mossel Bay GTL refinery has been running at a significantly lower rate than its nameplate capacity of

45,000 b/d for a number of years due to a lack of access to natural gas. A condensate splitter, which processes condensates in addition to natural gas, was erected by the government and PetroSA to increase the facility's utilization rate. This is especially useful for exploratory projects at sea. When the Brulpadda and Luiperd deposits are ready for production, natural gas and condensate could be shipped to the GTL facility. However, it's probable that business won't begin until sometime in the middle of the 2020s.

Transportation and Storage

Pipelines

Pipelines transport natural gas from Mozambique's Pande and Temane fields to Sasol's Secunda GTL plant, located 535 miles away. The pipeline is owned and operated by the Republic of Mozambique Pipeline Investments Company (ROMPCO), which is a joint venture between Sasol, the government of South Africa, and the government of Mozambique. Norton Natural gas production from Mozambique's aged Pande and Temane fields, according to Rose Fulbright, is expected to start declining around the middle of the 2020s. If alternative sources of feedstock cannot be found, production at the Secunda GTL factory will have to be reduced.

Two midstream projects have been proposed by South Africa, both of which, if implemented, would greatly expand the country's ability to transport natural gas. An American power company called Gigajoule proposed building a pipeline in 2013 to bring natural gas from Maputo in northern Mozambique to South Africa, where it would be used in power plants. The Mozambican government and a private sector consortium, including the South African oil and natural gas company SacOil, the China Petroleum Pipeline Bureau, and Profin Consulting Sociedade Anónima, have proposed constructing a pipeline with a length of 1,615 miles and an annual capacity of 635 Bcf for a total cost of $8 billion. Once the pipeline is finished in 2026, natural gas from the Rovuma Basin in Mozambique will be able to be transported to the province of Gauteng in South Africa.

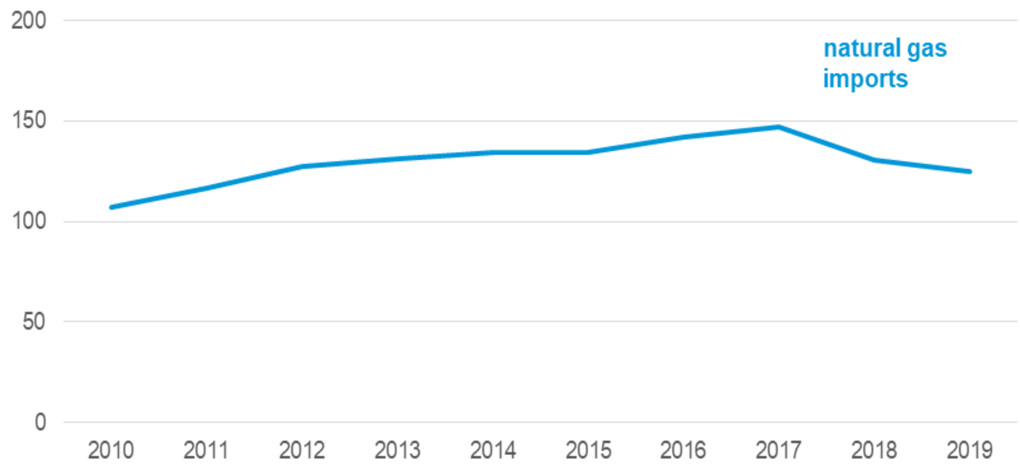
LNG

Considering government's attempts to develop LNG infrastructure in order to diversify South Africa's natural gas imports, the country does not yet have any LNG terminals. The Central Energy Fund suggests that the Eastern Cape Province's Ngqura deep-water port, located close to the Coega Special Economic Zone, might house a floating storage and regasification unit (FSRU). The Central Energy Fund launched an RFI in November 2021 for the construction of a floating storage and regasification unit (FSRU) with a yearly regasification capacity of 185 Bcf and an LNG storage capacity of 6 mcf. In addition, in December of 2020, ExxonMobil and Royal Vopak reached an agreement to study the potential of establishing an LNG regasification station in South Africa.

Trade on Natural Gas

South Africa fails to export any fossil fuels because of its limited indigenous natural gas resources. Instead, the country imports the majority of its natural gas through pipelines in order to satisfy its demand for domestic use. (Figure 6).

Figure 6. South Africa's annual natural gas imports, 2010–2019
billion cubic feet



Source: U.S. Energy Information Administration

Coal

Coal sectors

Sasol is a powerhouse in the South African economy. The company not only dominates the coal industry in the country but also processes, markets, and distributes oil and gas. Sasol's six coal mines have an annual production capacity of about 40 million metric tons. The Secunda coal-to-liquids (CTL) plant, which uses coal from this mine, generates electricity that powers Sasolburg's facilities. As a joint owner of the Richards BayCoal Terminal (RBCT), Sasol is able to export around 3.3 million metric tons of coal yearly.

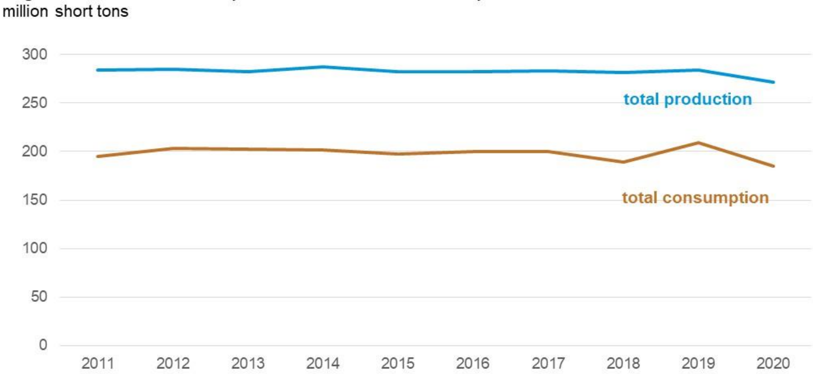
Anglo American, BHP Billiton, Eye Sizwe, and Kumba Resources Limited are some of the other prominent companies in South Africa's coal industry, as reported by the DMRE. Large mines are the primary source of coal, with just 11 mines accounting for over 70% of total domestic coal production.

Manufacturing of Coal

According to BP's estimates, South Africa is entitled to the continent's greatest coal deposits. Their 2021 Statistical Review of Global Energy states as much. By the year 2020, it is expected that these proved coal reserves will total about 11 billion short tons, accounting for approximately 62% of the total proved coal reserves in the region. Witbank, Highveld, Free State, and Ermelo mines in the east of the country are where the vast majority of South Africa's coal comes from. A popular phrase for these regions is "coal belt." The resource-rich Waterberg Basin in the northeast of South Africa presents an opportunity for increased coal production. This is within South Africa's capabilities.

Over the past decade, there has been relatively little change in either the amount of coal South Africa produces or the amount of coal it uses. By 2020, it is projected that South Africa would have produced about 272 MMst of coal, making it the world's seventh-largest producer. About 185 MMst were consumed that year in South Africa (Figure 7).

Figure 7. Annual coal production and consumption in South Africa, 2011–2020



Source: U.S. Energy Information Administration

Production of Coal to Liquid

Synthetic liquid fuel and synthetic gas are produced in the Secunda CTL refinery using coal liquefaction and gasification, respectively. The Secunda CTL refinery is the only commercial facility owned by Sasol that produces synthetic fuels from coal. In order to facilitate the production of solvents, polymers, and chemicals, the Secunda CTL refinery produces a wide range of synthetic fuels and chemical feedstocks. The Secunda CTL refinery produces components for both pipeline natural gas and synthetic fuels. There are two refineries in the area, and together they can produce 160,000 barrels of oil a day.

Exportation of Coal

In order to create synthetic liquid fuel and synthetic gas, the Secunda CTL refinery liquefies coal and then gasifies it. Only Sasol's Secunda CTL refinery commercially manufactures synthetic fuels from coal, and it has no competition. The synthetic fuels and chemical feedstocks manufactured at the Secunda CTL refinery are used in the manufacturing of a wide variety of solvents, polymers, and chemicals. Synthetic fuels and components for natural gas pipelines are both products of the Secunda CTL refinery. In this region, there are two refineries that can crank out 160,000 barrels of oil day.

Figure 8. South Africa's annual coal imports and exports, 2012–2021

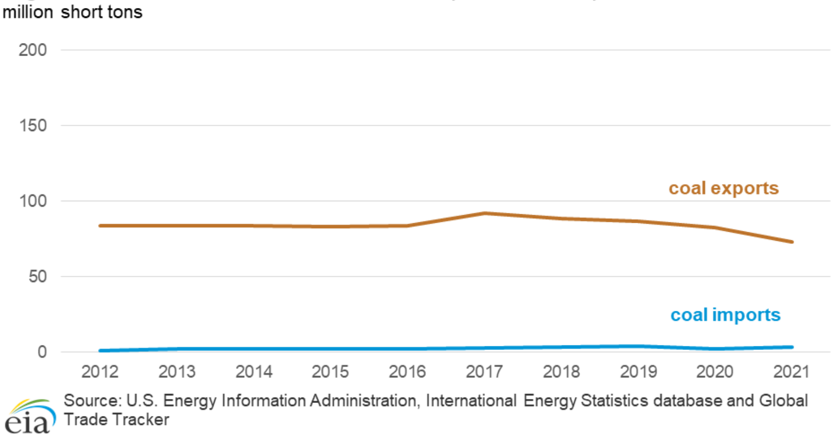
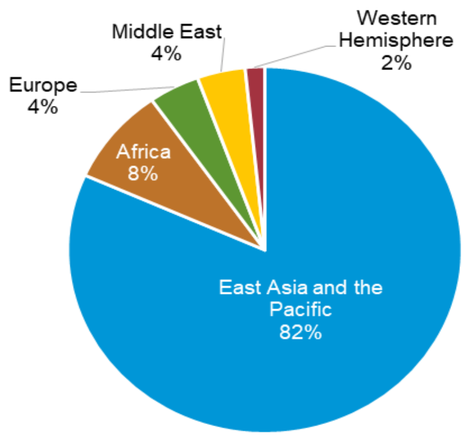


Figure 9. Total coal exports from South Africa by region, 2021



Source: Global Trade Tracker

Generation of Electricity

According to the National Energy Regulator yAct of 2004, the Electricity RegulationAct of 2006, and the National Energy Act of 2008, the National Energy Regulator of South Africa (NERSA) is responsible for monitoring the entire electric power sector in the country. This includes all aspects of electricity production, transmission, and distribution as well as the sale and purchase of electricity. As a regulator of the electric power business, NERSA is tasked with establishing rates, issuing distribution permits, and developing and enforcing industry-wide standards.
The state-owned, vertically-connected utility Eskom Holdings SOC Limited (Eskom) provides about 90% of South Africa's electricity. Eskom controls the South African power grid. The percentage of electricity supplied by IPPs keeps growing, despite Eskom's heavy engagement in the industry. Among the nations that receive Eskom's exported electricity are Botswana, Eswatini, Lesotho, Mozambique, Namibia, Zambia, and Zimbabwe. The Southern African Power Pool (SAPP) was established in 1995 and is the pioneering power pool in continental Africa. In the beginning, South Africa was a part of SAPP. Its purpose is to create a unified power infrastructure to provide reliable and cheap electricity to the SAPP member countries.

Electricity sectors

Recent forecasts by the World Bank indicate that 84% of South Africans will have access to electricity in 2020. In comparison to the regional average for 2020 in sub-Saharan Africa, this number is much higher. Aged coal-fired power plants, a lack of investment in infrastructure, insufficient sector management, and frequent load shedding (planned power outages) have all contributed to South Africa's electric power industry failing to meet the needs of its end users over the previous decade. Instability in the country's power grid has hindered the growth of its manufacturing sector and economy.

South African, British, American, European Union, French, and German governments together pledged $8.5 billion in November 2021 to fund South Africa's decarbonization initiatives as part of the Just Energy Transition Partnership. Attracting private sector investment through grants, low-interest loans, and other risk-sharing methods is the major goal of the initial commitment. Over the next 20 years, the alliance intends to help South Africa reduce its coal use and emissions by 1.0-1.5 gigatonnes.

Generation of Power and Capacity

In 2020, South Africa generated about 223 GWh of electricity from its 62.7 GW of installed capacity. Figures 10 and 11 show that by 2020, nearly 90% of South Africa's electricity would come from generation using fossil fuels.

The abundant coal reserves and consistent domestic coal production mean that coal-fired power generation meets the vast majority of South Africa's electrical energy needs. As demand increases, Eskom has been increasing the output of its coal-fired power plants. An explosion in August of 2021 delayed the unit's debut commercial operation at Eskom's 4.8 GW Medupi power station, which had been constructed the previous year. There has been no word on a rescheduled start date as of yet. When the third unit of the 4.8 GW Kusile power plant is finished and connected with the national grid, which is expected to happen in March 2021, full business operations could commence. After their completion, the Medupi and Kusile coal-fired power stations will rank among the largest in the world. Despite competition from natural gas and other sources, these plants serve as a reminder of coal's essential role in the United States' energy mix.

Figure 10. South Africa's electricity capacity by fuel type, 2011–2020
gigawatts

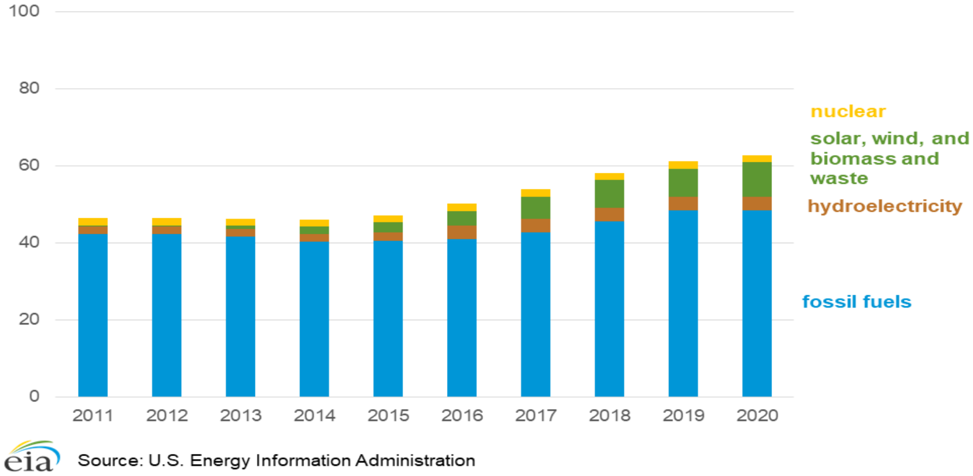
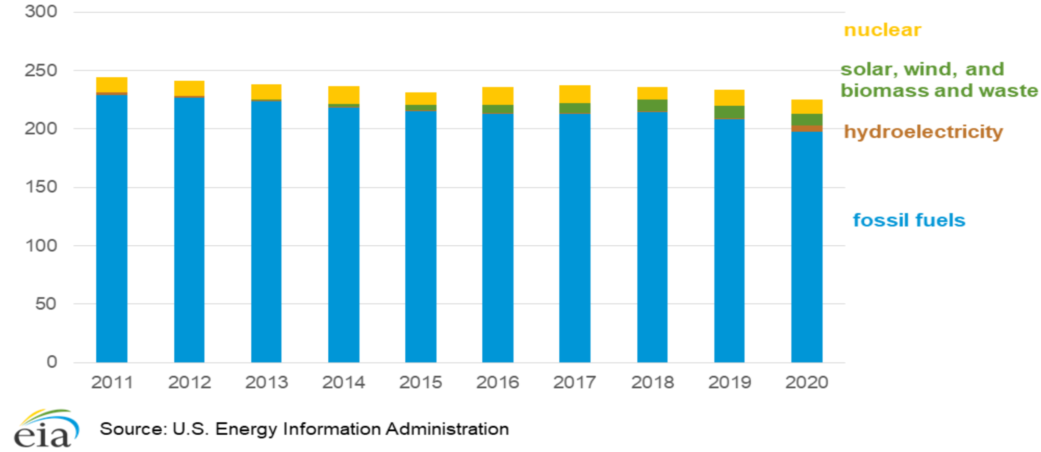


Figure 11. South Africa's net electricity generation by fuel type, 2011–2020
gigawatthours



Nuclear Operations

The Koeberg plant, not far from Cape Town, is home to both of South Africa's currently functioning nuclear reactors. The Koeberg plant, owned by Eskom, went into operation in 1984 after being commissioned. When combined, the two reactors' output amounts to roughly 1.9 GW. Originally scheduled to wrap up at the start of 2022, the expansion construction has been pushed back to an undetermined date in the future. In order to increase the plant's production, the government intended to build six new steam generators.

Non- Hydropower Renewable Energy

There is a negligible impact on South Africa's total power capacity and generation from the country's hydroelectric resources. Hydroelectric power is produced by the rivers in the east of South Africa, despite the country's reputation as a desert. Only four power plants in South Africa are responsible for transporting water to a dam and then releasing it to create hydroelectric power.

The Renewable Energy Independent Power Producer Procurement Program (REIPPPP) in South Africa is a renewable energy auction program that has been successful in attracting private sector investment in renewable energy projects, according to the International Trade Administration. About 6.4 GW of renewable energy had been purchased by the REIPPPP from 112 IPPs across seven auction cycles as of September 2021. The REIPPPP is a desirable alternative energy source since load shedding at South Africa's fossil fuel-fired power plants makes it difficult to provide end consumers with a constant supply of electricity.

Background and Economics-finance Governance of Climate Change in South Africa/sub-Saharan Africa

An Overview of CO_2 Emissions in South Africa

South Africa's energy sector is highly dynamic and heavily reliant on coal production to meet its energy requirements. As the country's energy consumption and economy grow, there is a proportional increase in carbon dioxide (CO_2) emissions, as depicted in Figure 1.

According to data from the U.S. Energy Information Administration (EIA, 2010), South Africa stands out as the most carbon-intensive non-oil-producing developing nation. Its contribution to Africa's total emissions is a significant 42%, surpassing the emissions of the entire sub-Saharan Africa region combined. On a global scale, South Africa accounts for 1% of greenhouse gas emissions, with these emissions largely attributed to the extensive coal operations within the nation's economy (Nasr et al., 2015; Shahbaz et al., 2013; EIA, 2010).

It compellingly demonstrates that as economic growth and energy usage increase, so does the environmental impact in the form of higher CO2 emissions. South Africa has undertaken substantial efforts to address this environmental challenge. The country's commitment to mitigating threats to environmental sustainability is evident through its participation as a signatory to both the Kyoto Protocol and the Paris Agreement.

Despite these initiatives, South Africa faces ongoing challenges due to the dominance of fossil fuel-based energy sources in its energy mix, leading to heightened energy intensity and environmental degradation. To tackle this issue, the Department of

Energy (DOE, 2016) proposes the integration of approximately 18,000 MW of renewable energy into South Africa's energy portfolio by 2020. This move is projected to result in a significant 34% reduction in CO_2 emissions, aligning with the country's commitment to the Paris Agreement.

Economics and Governance of Climate Change

Although climate change is having a detrimental impact on everyone, the risks it poses are greater for those in developing nations since they are less developed and so less prepared to deal with the repercussions of climate change (UN Global Compact et al., 2011). The effects of climate change on East Africa and the Guinea Coast, two particularly susceptible locations, are discussed in the first chapter. Drought, water scarcity, and erratic weather patterns are just some of the ways that climate change is already wreaking havoc on these areas. Extreme weather events are now thought to be the principal cause of food insecurity and malnutrition in these areas (Schaeffer et al., 2014). Rising sea levels and more frequent intense precipitation have made residents in low-lying deltas in Asia and Africa increasingly vulnerable to destructive floods (UN Global Compact et al., 2011). This was tragically demonstrated by the Kashmir Monsoon flood in India and Pakistan in September 2014.

To name only a few of the sub-Saharan African nations hit hard by the shifting geographic distribution of malaria, dengue fever, and water-borne illnesses owing to climate change, consider Ethiopia, Eritrea, Kenya, Rwanda, and Nigeria (UN Global Compact et al., 2011). There hasn't been enough progress in putting in place the required economic and political mechanisms to ameliorate the detrimental effects of climate change, despite the fact that doing so is now a key global public good (Cunha-e-Sá, 2008).

According to the research and studies presented in the published literature, numerous international organizations, governments, and public-private partnerships have implemented various methods and policies to reduce greenhouse gas production and aid the transition away from carbon-intensive sectors. In this section, we examine a few of the current initiatives under work to better identify the causes of climate change and develop effective solutions.

So, first, we give the main findings of the IPCC and Sir Nicholas Stern on climate change. In the following section, we will examine international climate change accords and then move on to analyze economic instruments that promote lower carbon emissions. This chapter delves into the idea of the green economy and analyzes the efforts of governments in sub-Saharan Africa to combat climate change and make the transition to a more sustainable economic model. Further, the part discusses carbon pricing, climate funding, and green investments in South Africa and sub-Saharan Africa.

Intergovernmental Panel on Climate Change Assessment Report

The Brundland Commission was established in 1987 (Nhamo, 2009a), and its findings and recommendations were instrumental in the establishment of the Intergovernmental Panel on Climate Change (IPCC) in 1988. The First Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2015) identified a rise in global temperatures and expected further rises, and this was a major factor in the formation of the United Nations Framework Convention on Climate Change (UNFCCC). Since the 1990 First Assessment Report, increased data quality and geographic coverage have led to a more in-depth understanding of climate change (IPCC, 2007). Both AR4 and AR5 from the Intergovernmental Panel on Climate Change (IPCC) will be discussed extensively.

According to the AR4 study issued in 2007 (Nhamo, 2009a), the fast climate change experienced in the recent past can be attributed to human-induced emissions of greenhouse gases (GHG) since 1750. There is more evidence in the AR5, published in 2014, that humans are influencing climate change than there was in the AR4, published in 2012. According to the IPCC assessment, anthropogenic warming of the climate system is a certainty. Both AR4 and AR5 forecasts (IPCC, 2015) indicate that human-induced warming will persist for centuries even if GHG emissions are stabilized and ceased.

If we wish to keep global warming below 2 degrees Celsius compared to pre-industrial levels, the AR5 found that total human-caused emissions of CO2 since 1870 shouldn't be more than 2900 gigatons of carbon dioxide (GtCO2) (Galarraga et al., 2011). By 2011, emissions had already equaled nearly two-thirds of this cap (IPCC, 2014). Between 2002 and 2011, global CO2 emissions increased at an annual rate of 3.04%, compared to a rate of 1.93% between 1982 and 1991. In addition, the average annual CO2 output increased from 1991's 4.2 tCO2 to 2011's 5.0 tCO2 per inhabitant.

AR5 looked at many other possible futures and determined that keeping CO2 equivalent concentrations at or around 450 ppm by 2100 was the most likely way to keep global warming below 2°C compared to pre-industrial levels (IPCC, 2014). But by 2011, the CO2 equivalent concentration had already surpassed 430 parts per million. Future concentration overshoots can be avoided by making significant reductions in emissions (Ibid.). To combat climate change, the AR4 recommended that societies cut back on emissions of greenhouse gases and boost carbon sinks (IPCC, 2007). It also recognized a range of government policies and instruments that may be employed to aid in mitigation initiatives (IPCC, 2007).

Some of the climate change mitigation strategies put into place since the AR4 include carbon pricing, cap-and-trade systems like the European Union Emissions Trading System, and carbon taxes like Australia's carbon tax (The Climate Group, 2013). Many technologically-driven measures and tax-based policies have been adopted to reduce emissions around the world, with tax incentives for energy-efficient light bulbs being just one example (IPCC, 2015). Several nations have also implemented gas taxes, which are similar to carbon taxes while not being designed to reduce emissions. Fuel and GHG-related activity subsidies in many countries are being eliminated or significantly reduced (IPCC, 2014). Examples of sector-specific policies include investments in the transportation industry, such as the bus rapid transit system in Bogotá, Colombia (UNEP, 2011).

Since the AR4, there has also been a significant growth in the number of low-carbon development plans and strategies at the national, regional, and sub-national levels. The National Climate Change Response Strategy of Kenya (Dewar, 2012) is an example of a document that follows this trend. According to the AR5 report, if more isn't done to combat global warming, it will pose a high risk of severe, widespread, and lasting impacts worldwide by the end of the 21st century. The International Panel on Climate Change (IPCC) warns that the long-term financial costs of addressing hazards related to climate change could rise if effective mitigation strategies are not adopted quickly enough.

Like earlier reports, the AR5 cites population growth, economic activity, lifestyle, energy consumption, land use patterns, technological advancements, and climate policy as key factors in the production of anthropogenic greenhouse gas emissions. Research shows that agriculture contributes about a third as much to global greenhouse gas emissions as the energy sector and industry do combined.

Although the effects of climate change are being seen all around the world, Africa may be hit the worst (Nhamo 2011c). Since Africa has a low capacity to adjust to 21st century climate change, this is likely to be the case. Due to a 50% decline in yields from rain-fed agriculture by 2020, the IPCC warns that sub-Saharan Africa may see greater hunger and malnutrition.

While there is broad agreement that climate change is occurring, there is less agreement that human activities are to blame for the warming of the planet. Mounting evidence has led to a drop in the number of disagreeing scientists, and today there is a 97% consensus among scholars on human-caused climate change (Maibach et al., 2014). Several reports are discussed, including the AR4 and the Stern Review on the Economics of Climate Change, both of which contain recommendations for economic policies and tools.

Stern Review

Carbon emissions have reached record highs because companies have not properly accounted for the expenses of manufacturing since the industrial revolution (Hoffman, 2008). However, by emitting these pollutants into the atmosphere, businesses are able to "externalize" a significant portion of the related costs, shifting the financial burden of climate change onto future generations. While increased carbon emissions may be good for companies' bottom lines in the short term, they will have far-reaching consequences for society in the form of adverse environmental impacts and costly adaptation costs (Andrew, 2008). Reducing the effects of anthropogenic climate change over many generations will need collaborative actions (Sussman et al., 2014). Reducing emissions of greenhouse gases (GHG) that contribute to climate change requires balancing costs and benefits (Stern, 2007).

Former British Chancellor of the Exchequer Gordon Brown commissioned the Stern evaluation of the economic costs of climate change from Sir Nicholas Stern (Nordhaus, 2007) to better understand the challenges associated with climate change and the ways to tackle them. The Review found that the damage to society's wellbeing caused by ignoring climate change was unlikely to be easily remedied. It echoed the

IPCC's plea for swift action to reduce GHG emissions in order to mitigate climate change's worst effects.

The paternalistic approach taken by the Review, which uses a nearly zero time discount rate, has been the focus of debate because it is at odds with real interest rates and savings rates in the market today (Nordhaus, 2007). By using time discount rates in line with market rates, other assessments, such as Hope (2006), Nordhaus (2007), and Mityakov and Rhl (2009), have estimated lower amounts of GHG emissions reduction and societal costs of carbon than the Review's projections. Since a higher discount rate devalues future generations, Stern supported the paternalistic approach by arguing it was meant to prevent age discrimination.

According to Neumayer (2007), the most crucial aspect of the Review is the discussion of how much natural capital is being damaged by climate change. Assuming that damage can be replaced by calculating the cost of climate change as a percentage of GDP, the Review skirted the problem. According to Neumayer (2007), the monetary value of many effects of climate change is unclear.

Despite dissenting perspectives, the Review's attempts to link climate change policy with economic and environmental goals were helpful (Nordhaus, 2007). Policy frameworks, such as a carbon price set by taxes, trade, or regulation, and the encouragement of innovative technologies, particularly those that improve energy efficiency, were emphasized in the Review, as they had been by the IPCC (Stern, 2007).

Policymakers are urged to take preventative measures now rather than rely solely on future adaptation, as stated in the Review's main recommendation (Mityakov and Rhl, 2009). In order to effectively reduce greenhouse gas emissions, developing countries must address their energy use, agricultural practices, and deforestation (Stern, 2006). Capital markets, banks, and financial institutions are cited as key players in the Review for their roles in mobilizing capital and directing it toward low-carbon initiatives (Stern, 2007). The study's goal is to discover its impact to date in South Africa and across sub-Saharan Africa.

Climate Change economic Instruments

There has been much discussion on the need to cut carbon emissions ever since a traditional welfare analysis demonstrated the advantages of immediate mitigation steps for future generations (Andrew, 2008). It sparked a discussion on whether or not developing nations should adopt the "grow now, clean up later" growth policy adopted by advanced nations (Van Alstine and Neumayer, 2010). According to a 2011 study by Hallegatte et al., poor people are more concerned with their own material well-being than the health of the world. As a result, governments invest more money in environmental protection and cleanup projects as people's appreciation for the natural world grows along with their material well-being (Everett et al., 2010; Hallegatte et al., 2011).

There are problems with the "grow now, clean up later" line of thinking. Considering the extended lifespan of specific, non-adaptable infrastructures, it may be more cost-effective to minimize pollution during the first stages of construction rather than incurring higher expenses for clean-up at later stages (World Bank, 2012). Second, the permanent character of the environment is disregarded by this line of thinking. While replacing trees after they have been cut down to make way for farms is a possibility in Kenya, bringing back the same level of biological diversity is not (Hallegatte et al., 2011). Because carbon dioxide (CO2) discharged into the atmosphere remains there for a long time (World Bank, 2012; Everett et al., 2010), delaying action to solve environmental issues may have catastrophic consequences.

Cleaner growth, through reduced pollution, is advocated by the World Bank (2012) as a means for developing countries to make up for the flaws of the "grow now, clean up later" approach. Adopting low-carbon development strategies to stimulate clean growth is recommended by Lecocq et al. (1998) and has been shown to reduce the cost of mitigation efforts in the long run (Hallegatte et al., 2011). These measures are in line with the suggestions made by the IPCC report and the Stern Review to tackle climate change through the use of economic instruments. Below, we will quickly describe a few of the instruments that can be used to combat climate change, both those that are market-based and those that are not (Fisher et al., 1995).

In a perfectly competitive market economy, market-based procedures may be the sole way to deal with the negative externality of carbon emissions to the atmosphere. Dynamic efficiency, which promotes the creation of low-carbon solutions, and static cost-effectiveness, which ensures emissions abatement at the lowest cost to society, are two theoretical benefits of market-based instruments. In actual use, however, market-based gadgets run into snags both abroad and at home (Holland, 2009). This list of challenges includes market failures like unequal access to information about the availability of carbon credits and negative distributional effects like low-income households being disproportionately affected by market-based instruments due to an inability to afford alternatives (like switching from a kerosene stove to a gas stove). For this reason, it is best to employ both market-based and non-market-based instruments, the latter of which can aid in the promotion of distributional equality while the former can serve to mitigate market defects (Stavins, 1997

Non-market based Instruments

Non-market-based instruments, also known as conventional regulatory instruments, are a group of rules put in place to control business and personal behavior for the sake of lowering emissions (Fisher et al., 1995). These regulations cover a wide range of fields, from energy efficiency and transportation to pesticide use in agriculture. Depending on whether or not compliance is required by law, standards are either mandatory (Grubb, 1991) or voluntary (Fisher et al., 1995).

There are two main types of mandatory regulatory standards: those based on technology and those based on performance. In order to reduce carbon emissions, certain pieces of machinery, methods, or combustion processes must be adopted as required by regulations based on technological standards. Catalytic converters in cars are a good example of a technologically based norm (Fisher et al., 1995). Performance-based criteria, on the other hand, provide more leeway by allowing entities to pick and choose the methods they use to reduce emissions and activities that contribute to pollution. An example of a performance-based standard is the European Union's regulation of the maximum allowable amounts of carbon dioxide emissions from combustion by businesses. One such project with voluntary criteria to improve energy efficiency is the United States Climate Change Action Plan of 1993 (Fisher et al., 1995).

Although regulatory norms are sometimes viewed as inefficient in comparison to market-based instruments, there are situations in which they are appropriate and even helpful. Regulatory standards, for instance, can be an appropriate option when the government wants to ensure stringent compliance in order to encourage cleaner growth (Everett et al., 2010).

Market-based Instruments

Emissions are given financial incentives to limit their carbon output through the use of market-based tools (Bräuninger et al., 2011) that are implemented by governments. These tools motivate businesses to use production methods that reduce emissions and are consistent with regulatory goals. Because of their adaptability and efficiency in achieving goals, market-based instruments can be preferable to regulatory ones (European Commission, 2021). Sub-Saharan African (SSA) governments have implemented or are considering implementing a variety of market-based instruments to encourage clean growth and the transition towards a green economy (a notion that will be examined in greater depth in the following section).

Carbon prices, carbon tax, and trading scheme

. There are two methods that can be used to accomplish the goal of carbon pricing. As a first step, businesses and homes in Kenya are switching to solar power from fossil fuels (Carraro & Favero, 2009) to reduce their carbon footprints and save money. Second, it necessitates switching from carbon-intensive inputs to ones that produce less carbon emissions, such as switching from coal to natural gas in Turkey (Ibid). Trading schemes, carbon taxes, and implicit pricing through laws and standards are all viable options for instituting carbon pricing (Hepburn and Stern, 2008). In spite of their conceptual differences, trading schemes and carbon taxes share a same goal: to reduce emissions by a certain amount at the lowest possible cost.

Governments set a limit on allowable emissions and create trading permits in a cap-and-trade system. Market forces set the price of carbon, and emitters who go over their limit must buy allowances from those who have an excess (Carraro and Favero, 2009). The urgent need to reduce global emissions means that carbon pricing determined exclusively by market forces is insufficient. This is where many rules and regulations, both domestic and international, come into play. Carbon prices in a trading scheme are set by the level of stringency of the cap, with lower prices for less stringent caps and higher prices for more rigorous caps (Carraro and Favero, 2009).

The government does not limit emissions when it uses a carbon tax to calculate the price of carbon externality (Barker et al., 2007). Carbon taxes can be raised if emissions persist, whereas emission caps can be lowered under a trading arrangement (Kasterine and Vanzetti, 2010). For domestic mitigation efforts in developing countries, the trading scheme may not be preferable due to transaction costs, market imperfections, and uncertainty (Stavins, 1997). This is despite the fact that the trading scheme is often favored because of its role in guaranteeing efficiency and collaboration to achieve emissions reduction targets.

Even if carefully planned, there may be political hurdles to enforcing and increasing a carbon tax (Barker et al., 2007). However, it provides governments with annual earnings that can be used to attract private capital for investments in clean technology in low-income regions (IMF, 2008). Carbon taxes allow for more predictable pricing and a more adaptable market to economic fluctuations (Kasterine & Vanzetti, 2010). Because of this, a carbon tax is preferred over a trade system in terms of reducing welfare losses (Goulder and Pizer, 2006). The first carbon tax was implemented in Finland in 1990, and since then fifteen other nations throughout the world have followed suit (OECD, 2013). Zimbabwe has, since 2001 (Nhamo and Inyang, 2011), levied a carbon tax on all motor vehicles. Kim (2015), the International Monetary Fund (2016), and Dalmazzone (2015) all note that South Africa, Ethiopia, and Mauritius are taking steps toward implementing carbon pricing. It is crucial to emphasize the relevance of carbon markets in international emissions reduction efforts before investigating other market-based devices.

Carbon Market

The UN Framework Convention on Climate Change (UNFCCC, 2010a) established carbon as the sole medium of exchange for emission reductions. The Clean Development Mechanism (CDM), International Emissions Trading (IET), and Joint Implementation are all market-based systems that serve to motivate countries and the private sector to meet carbon objectives. The Kyoto Protocol of 1997 provided the impetus for these measures, which were implemented in 2005 (Barker et al., 2007). In addition to public entities like multilateral development banks like the World Bank, government agencies, United Nations agencies, and non-governmental organizations, the private sector (companies with binding or voluntary emission commitments, emission-reduction project developers, financial institutions, investment firms, technology developers, and legal and accounting firms) also plays a role in the carbon market (UNFCCC, 2010a).

The IET uses allowances in a cap-and-trade system to create carbon credits (UNFCCC, 2007; Article 6, 12, and 17 of the Kyoto Protocol), while the CDM and Joint Implementation use a baseline-and-credit system. Certified Emissions Reductions (CERs) are the term used to describe carbon credits generated in developing nations, whereas Emission Reduction Units (ERUs) are the term used to describe credits generated in rich countries. Emission reduction initiatives in poor countries are eligible for CERs through the CDM and are awarded and approved by the CDM (Carraro and Favero, 2009). Carbon emission reductions (CERs) can be used to satisfy domestic regulations in developing nations or sold on the global carbon market as carbon offsets to polluters in wealthy nations (like a German utility buying carbon credits from an Ethiopian wind farm) to reduce their carbon footprint (Purvis et al., 2013). The former allows investors in underdeveloped nations to avoid fines and penalties, while the latter allows them to make a direct monetary profit (Elgar et al., 2009).

Projects hosted in industrialized countries, especially in the former Eastern Bloc, are eligible to receive ERUs through the Joint Implementation. A French utility, for instance, could invest in a Joint Implementation project with a wind farm in Romania in exchange for carbon credits (Carraro and Favero, 2009). Each CER and ERU must be comparable to one ton of CO2 in order to be accepted by either the CDM or the Joint Implementation mechanisms (UNFCCC, 2007; Article 6 and 12 of the Kyoto Protocol). Assigned Amount Units (AAUs) are what get used to talk about when trading CERs and/or ERUs on the IET. It is the IET that has spawned well-known carbon markets like the EU ETS and RGGI, both of which function as cap-and-trade systems (UNFCCC, 2007; Article 17 of the Kyoto Protocol). Since the EU ETS is the largest emissions market in the world, the European carbon price is used as a reference point for carbon prices in other markets (Carraro and Favero, 2009). Note that because most countries in sub-Saharan Africa (SSA) are still economically developing, the region is not eligible to take part in the Joint Implementation mechanism (Nhamo, 2011a).

Other market-based Instruments

Nevertheless, subsidies can still be used to encourage proactive investments in climate change mitigation (Porter, 1990), despite criticisms of their inefficiency and potential for rent-seeking. Policy actions that help climate change mitigation include, for instance, exempting businesses from Value Added Tax (VAT) in order to fund R&D on novel technologies with the potential to lower CO2 emissions (Bräuninger et al., 2011). Since continuing to provide subsidies for fossil fuels undermines attempts to mitigate climate change, removing these subsidies can be a proactive step in and of itself (ADR, 2012). Success stories in the form of reforms to fossil fuel subsidies have been seen in Ghana and Senegal, both in sub-Saharan Africa (GSI, 2010).

Implementing an energy tax that is levied per unit of electricity used is another market-based device (Bräuninger et al., 2011). As stated by Bräuninger et al. (2011), the tax is meant to encourage energy conservation measures and/or lower overall usage. For instance, a tax on energy use could stimulate the purchase of energy-efficient air conditioners by making them more reasonably priced and appealing to consumers, so aiding in the fight against global warming by lowering emissions of greenhouse gases (Bräuninger et al., 2011). Although the energy tax is similar to a carbon tax in that both aim to reduce the use of fossil fuels in power generation, the latter takes advantage of a wider range of opportunities to do so by extending its reach to households, vehicles, and businesses across all sectors (IMF, 2011), while the former primarily affects the power sector.

The International Monetary Fund (IMF) (2011) suggests that a feebate could replace a carbon tax. In a feebate system, more polluting producers pay a tax or fee per kilowatt-hour while more environmentally friendly ones get a refund or subsidy (Parry and Krupnick, 2011). It is a cost-effective tool because it encourages the use of low-carbon fuels and the efficiency of power plants by providing financial incentives to emitters who adopt these practices.

Paying a levy on land ownership or use is known as a land use tax (Bräuninger et al., 2011). Taxes on land use are anticipated to be low for carbon sink and ecosystem preservation reasons, whereas greater taxes may be imposed for other uses (Bräuninger et al., 2011) due to the impact of land use on deforestation and the need of protecting ecosystems for climate change resilience.

One or more buyers pay one or more sellers for clearly specified environmental services in a form of a voluntary exchange (Wunder, 2005; Bräuninger et al., 2011). This concept is known as "payment for ecosystem services" (PES). When preserving an ecosystem is found to have greater value than modifying it, monetary incentives are provided. The Eastern Arc Mountains of Kenya are a good example of PES in forest protection and management, as is the growth of agricultural land in Rwanda (Bräuninger et al., 2011).

The polluter-pays principle is at the heart of habitat banking's operations (Bräuninger et al., 2011), with the end goal of protecting land and various forms of life. Those with a financial stake in the degradation of ecosystem services at one location are expected to foot the bill for habitat improvement efforts at another location or the same location. Mining firms in South Africa, for instance, are required by law to reserve cash to pay for site reclamation and closure (UNECA, 2012a), which may involve the construction of fish ponds or mushroom farms.

As Everett et al. (2010) point out, a comprehensive climate change strategy requires a mix of non-market and market-based instruments because no single instrument is likely to adequately address various market failures. For climate change policies to be successful, efficient, equitable, and have a minimal impact on market competitiveness, policymakers on both the national and regional levels need to give serious thought to the design and implementation of these policies (Stern, 2007, 2008).

International Climate Agreements

Dutt (2009) states that there are two types of international law: hard law and soft law. As defined by Grunewald and Martnez-Zarzoso (2009), "hard law" refers to legally binding international treaties whereas "soft law" refers to non-binding agreements that offer advisory guidance rather than enforceable requirements. It takes the consent of two-thirds of the signatories to a treaty for it to be ratified (UNCITRAL, 2015). The following sections provide a brief overview of the many climate change agreements discussed in this study, with the Table below providing a review of both binding and non-binding agreements.

Climate change agreement

Hard Law	***Soft Law***
1997: Kyoto Protocol	1992: UNFCC
2010:Cancum agreement	2007: Bali Road Map
2016: Paris Agreement	2009: Copenhagen
	2011: Durban Platform

United Nation framework convention on climate change (UNFCC)

In 1992, the world's heads of state gathered in Rio de Janeiro, Brazil for the largest gathering of its kind in response to the Brundtland Commission's 1987 report, "Our Common Future," which highlighted global environmental issues. The United Nations Framework Convention on Climate Change (UNFCCC) was one of several international environmental treaties and agreements drafted at the 1992 Earth Summit, also known as the United Nations Conference on Environment and Development (Barker et al. 2007).

The United Nations Framework Convention on Climate Change (Lattanzio, 2014) was the first global agreement to acknowledge and address climate change brought on by humanity. The primary goal of the United Nations Framework Convention on Climate Change is to stabilize atmospheric concentrations of greenhouse gases at a level that will prevent harmful interference with the climate system, allow ecosystems to adapt, secure food production, and promote sustainable development, as stated in Article 2 of the convention.

All Convention on Climate Change Parties must take precautionary measures to prevent, reduce, and adapt to the adverse effects of climate change for the benefit of current and future generations, as stated in Article 3 of the Convention on Climate Change. Article 4 of the United Nations Framework Convention on Climate Change (1992) requires Parties to develop, implement, and update national and regional plans to help them adapt to and lessen the impact of climate change. Scientific, technological, economical, and other kinds of R&D relating to climate are encouraged, and Parties are urged to support and collaborate on such endeavors (Ibid.). Due to a lack of previous research on this topic in a Sub-Saharan African context, this highlights the significance of the study.

The UNFCCC's Article 4 mandates that developed nations (known as Annex II Parties) promote, support, and subsidize the transfer of environmentally beneficial technologies and know-how to developing nations. Additionally, the investment needs of developing States, particularly the vulnerable Parties in Sub-Saharan Africa, are highlighted in Article 3 of the United States Framework Convention on Climate Change (UNFCCC). The United Nations Framework Convention on Climate Change (UNFCCC) establishes the Conference of the Parties (COP) as its supreme body (Article 7).

Some have argued that the UNFCCC is ineffective because it does not require member states to take any specific actions to lessen their impact on the environment. It did, however, pave the way for the introduction of the binding Kyoto Protocol, which made environmental concerns integral to the concept of economic growth (NRG4SD, 2011). The North-South split has also been mentioned by some. Affluent nations (the North) are expected to make financial commitments and expectations of climate change mitigation, whereas developing nations (the South) are expected to make response promises freely but without financial responsibility (Meja, 2010). Since the two groups' responsibilities often overlap but are not identical, this approach takes that into consideration (Mahendra, 2015). Since poor countries have less data and fewer scientists, they are underrepresented in global environmental talks (Karlsson, 2002). This gap is exacerbated by the fact that there are significant differences in scientific understanding and data collection.

How the North-South division will manifest itself in the context of the UNFCCC is becoming increasingly uncertain. Mejia (2010) explains that this is due to the fact that the Southern region has splintered into rival groups. The Group of 77 (G-77), a coalition of 134 developing countries, has always included and will always include countries from the South.

Many nations in SSA belong to the least developed countries (LDCs), which also includes the Association of Small Island States (AOSIS) and Brazil, South Africa, India, and China (BASIC) (Nhamo 2011a).

A rising number of groups with similar aims and viewpoints are coming together outside of the G-77 to do so (Mejia, 2010). The Least Developed Countries and the Alliance of Small Island States (AOSIS) both advocated at the Bali COP for the mandatory reduction of emissions from large polluting developing countries like China and India. Due to the South-South divide that this disintegration has spawned, CDM projects have been unevenly distributed across the developing world, with the poorest region (SSA) receiving the fewest benefits overall (Mahendra, 2015).

Kyoto Protocol

The United Nations Framework Convention on Climate Change's Third Conference of the Parties was held in Kyoto, Japan in 1997, and it took place this time that the Kyoto Protocol was formally adopted. As of February 2005 (Barker et al., 2007), the Protocol had been approved by at least 55 nations, accounting for at least 55% of global GHG emissions. It binds the 37 developed economies listed in Annex 1 to certain targets. Developing countries and other non-Annex 1 countries are not required to reduce their emissions. According to NRG4SD (2011), the Protocol's real implementation is known as the Accords in Marrakesh. The first commitment period ran from 2008 to 2012, and it mandated that the Annexe I countries reduce their greenhouse gas emissions by an average of 5.2% from their 1990 levels (Nhamo 2009b). So while the treaty may suggest that rich countries should stabilize their GHG emissions, the Protocol actually makes this a requirement. Countries that set emission obligations under the Kyoto Protocol produced much less carbon dioxide than equivalent countries that had not ratified the agreement, according to research published in 2011 by Grunewald and Martinez-Zarzoso.

The "Kyoto Protocol" and the "Doha Amendment to the Kyoto Protocol" were both accepted in 2012, however Canada afterwards revoked its approval of the former. This vote demonstrated the continued dedication of the countries included in Annex I to the Kyoto Protocol for the years 2013-2020 (United Nations, 2014).

At least 144 of the 192 parties to the Kyoto Protocol must submit acceptance documents to the United Nations by the 90th day before the start of the second commitment period. Of the 71 nations that had ratified the Doha Amendment as of October 2016 (according to data from the UNFCCC website unfccc.int), 18 were located in SSA.

Road Map of Bali

The Bali Road Map was created at the thirteenth Conference of the Parties to the UN Framework Convention on Climate Change, which took place in Bali, Indonesia in 2007 (Hunter 2010). Not only did Al Gore and the IPCC win Nobel Peace Prizes this year, but the IPCC itself did as well (Watanabe et al., 2008). After the Fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC) highlighted the need for major cuts in global emissions (UNFCCC 2008), all parties to the UNFCCC agreed to launch a long-term, comprehensive cooperative effort to reduce emissions (Hunter, 2010). As a result, the UN Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol shifted to a promise and review system, which evaluates countries' emission-cutting pledges after the fact rather than before (ex ante) (Ngwadla et al., 2015).

For additional emissions reduction pledges to be negotiated by 2009, the Bali Road Map to COP15 specifies a timeframe with that goal. A legally enforceable agreement after Kyoto is established through the Bali Action Plan (Watanabe et al., 2008). When compared to the UNFCCC and the Kyoto Protocol, the Bali Action Plan's foundation is distinct in that the former requires ratification but not compliance while the latter requires both. There is no necessity for ratification or compliance with the Bali Action Plan. By the fifteenth session, all that is required is for parties to reach an agreement on what to do once the Kyoto Protocol expires (Ngwadla et al., 2015).

Technology development and dissemination were formerly sideshow issues, but since COP13 they have moved to the forefront (Santarius et al., 2009). According to the Bali Action Plan, affluent nations would provide poor nations with technology, financing, and capacity-building to help them implement their Nationally Appropriate Mitigation Actions (NAMA) (Meja, 2010). A Measurable, Reportable, and Verifiable (MRV) strategy (Santarius et al., 2009) will be used to guarantee transparency. To guarantee forest management and resource availability, as outlined in the Bali Action Plan (Nhamo, 2010), poor nations were urged to implement measures to cut down on emissions caused by deforestation and forest degradation (REDD; more on this below).

According to Ngwadla et al. (2015), the globe is not safe enough to rely on developing countries' unilateral climate change mitigation actions. Although it took 16 years to establish the UNFCCC, the Parties have now agreed to negotiate under the assumption that all major polluters (including China and India) will participate in mitigation efforts. This meant that affluent nations like the United States could no longer claim lack of commitment from developing nations as an excuse (Watanabe et al., 2008). All of the priorities set forth by the Bali Action Plan that were subsequently negotiated in Copenhagen can be found, to varying degrees, in the Copenhagen Accord (Hunter, 2010).

Accord of Copenhagen

In 2009, at COP15 in Copenhagen, participants attempted to address two issues highlighted by the Bali Road Map. Goals included creating a legally enforceable commitment to cut global emissions beyond 2012 (a post-Kyoto Protocol; McKibbin et al., 2010) and finding a way to limit global warming below 2 degrees Celsius (Nhamo 2009a). As a result, the Copenhagen Accord was written, providing a fresh start in the battle against climate change (Spak, 2010).

In contrast to the Kyoto Protocol, which necessitated international talks, under the Copenhagen Accord, Annexe I countries need to submit their emissions targets for 2020, with the option of choosing any base year they like. The Accord required not only Annexe I countries, but also non-Annexe I countries to submit NAMAs (Hunter, 2010). By choosing various starting points for their calculations, the Parties have made it more challenging to compare the projected amounts of carbon reduction and the economic activity needed to meet their pledges. The objective for 2020 only applies to emissions in that one year, unlike the Kyoto Protocol's limits, which were established for a five-year period (2008-2012) (Mckibbin et al., 2010). Not only were these issues brought up, but the Parties' pledged targets, especially those of the United States and China, were lower than what the IPCC suggested (Levin and Bradley, 2010). It is most disappointing that five countries (representing less than 1% of global emissions) opted not to sign the Accord because the pledges are not legally binding (Hunter, 2010). Politics ultimately won out over science, leading to the global financial crisis of 2008-2009 (Angus, 2010) and this failure (McKibben, 2010). However, according to Mehra (2010) (Spak, 2010), this outcome was due to the United Nations process.

The main purpose of the convention is not to secure a binding legal agreement, but rather to take steps to reduce atmospheric carbon concentrations (Hunter, 2010). Therefore, the Accord is still important because it incorporates emissions objectives for BASIC and reduces emissions after the 2012 Kyoto deadline (Spak, 2010). As an added bonus, for the first time ever, poor countries agreed to disclose their GHG inventories every other year. While the African Group viewed South Africa's stated emissions target at Copenhagen as a conflict of interest (Nhamo, 2011c), the BASIC commitments represent a crucial first step in bridging the North-South divide (Whalley & Walsh, 2009).

As a result of the Accord, two sizable financial commitments were made to assist mitigation initiatives, including money set aside for REDD, adaptation, technology development and transfer, and capacity-building in developing countries (UNFCCC 2010b). The wealthy countries have pledged up to $100 billion yearly by 2020, including $30 billion in new and additional sources for 2010-2012. The $30 billion is sometimes referred to as "fast-start money" (FSF) since more money is being put toward mitigation (including REDD) than adaptation (Brown et al., 2011). One such concept is the Copenhagen Green Climate Fund (Nhamo, 2011a). The Houser 2010 research predicts that with adequate funding, the most vulnerable nations may enhance their preparedness and contribute to additional reductions in global emissions.

In light of the fact that major concerns (such as making carbon reduction commitments legally binding and ending deforestation) were postponed until COP16 and beyond, the best that can be said about Copenhagen is that it made some minor progress (Brown, 2011). According to Nhamo (2011a), Africans thought they were dealt a bad hand at the Copenhagen summit.

Cancun agreement

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Durban platform

The 17th Conference of the Parties to the United Nations Framework Convention on Climate Change was held in Durban, South Africa in 2011. As well as launching an endeavor to create a second protocol that would be binding on all UNFCCC Parties, the Platform provided an opportunity to reflect on the UNFCCC's first two decades of existence (Bodansky, 2012). The new protocol mandates that all discussions be finalized by the year 2015, with results implemented by the year 2020 (Bodansky, 2012).

The Durban Platform proposes a work plan for the dialogue that is open and inclusive, with a focus on mitigation, adaptation, financing, technology, capacity building, and transparency. By urging COP17 climate negotiators to include agriculture in the work plan with the slogan "no agriculture, no deal" (FANRPAN 2011), the world's leading agricultural groups succeeded in getting this issue onto the agenda. It's crucial to have organizations like the Food, Agriculture, and Natural Resources Policy Analysis Network (FANRPAN). FANRPAN advocated for Africa to become more self-sufficient in food production while simultaneously strengthening the continent's resilience to climate change (Ibid).

As a result of Durban's decision to include agriculture in the negotiations rather than ignore it, the 'no agriculture, no deal' argument gained some traction.
This may only be seen as a little victory, given that the sector is responsible for 14% of global emissions and is one of the activities that contribute to deforestation (as indicated in the preceding chapter; The Climate Group, 2011). The importance of agriculture to the economy of Southern and Eastern Africa (SSA) makes it imperative that this issue be addressed on the global climate agenda (Nhamo 2011b). The Congo Basin Forest is the world's second-largest tropical forest, behind the Amazon.

In an effort to conceal the North-South division, the Durban Platform states that "the outcome of the negotiations is applicable to all parties" (Ewing, 2012). That is to say, developed nations can't make excuses for staying out of future UNFCCC treaties since emerging markets will be there, too. According to Ewing (2012), because the Platform delays decision-making and implementation until later years, wealthy countries are able to avoid their responsibilities and demonstrate a lack of political will.

It was at this session that the Governing Instrument for the GCF was adopted; since then, the majority of the Fund's funding has come from European donors and Korea, and Korea was selected as the 2013 host nation for the GCF (UNECA 2014a). The GCF received $10.14 billion in contribution commitments at COP20 in Lima, Peru in 2014, a sizeable amount well below $100 billion (GCF 2014).
Africa has taken a strong stand at the COP21 in Paris, France, on problems and actions that would help preserve SSA's ecosystems and increase the performance of places where Greener agriculture is anticipated (Munang and Mgendi, 2015).

Paris Accord/Agreement

The 17th Conference of the Parties (COP) was held in Durban, South Africa in 2011, while the 21st COP to the UNFCCC was held in Paris, France in 2015. This is the most recent, globally accepted, and legally binding framework for reducing emissions that contribute to climate change, and it has been so since the Paris Agreement. In the campaign against climate change, this is a pivotal time. As a result, control is spreading from a select few countries to encompass the entire international community (European Commission, 2016).

The Paris Agreement isn't the only thing the conference ended with though. Paris Agreement shows concerted effort to replace Kyoto Protocol after 2020 (Climate Focus 2015), while the Decision will steer pre-2020 activities and lay out the specifics of implementation before its coming into effect. UNFCCC 2015a states that the world must take all necessary measures to prevent a rise in average global temperature of more than 1.5 °C above pre-industrial levels. This target reflects a sizable increase beyond what was agreed upon in Copenhagen and reaffirmed in Cancun (Climate Focus, 2015).

Critics of the Paris Agreement argue that it prioritizes processes above voluntary mitigation initiatives known as Nationally Determined Contributions (NDCs) and that its carbon reduction goals are unattainable, as reported by Climate Focus (2015). This new objective, in contrast to Kyoto, is designed to make sure countries establish ever-more-ambitious climate targets. It is proposed that NDCs be revised every five years to ensure that they continue to outstrip the most recent NDCs (UNFCCC 2015a). Taking into account the wide range of national situations, the Agreement will be implemented on the basis of the principle of common but differentiated obligations and respective capabilities, as specified in the Agreement. To rephrase, wealthier nations should set absolute reduction goals for emissions while developing nations should work toward those goals more gradually (UNFCCC 2015a). Countries will be able to tailor their contributions to their needs because to the bottom-up flexibility (i.e. the NDC) in the Agreement (C2ES 2015). In addition, the Agreement offers integrated NDCs for both industrialized and poor countries, which has not been done in previous climate accords. Consequently, the Paris Agreement has been celebrated as a watershed moment, but it should be seen as just the beginning of a longer, more thorough, and more efficient policy response (Climate Focus, 2015).

The Paris Agreement required stocktaking to identify feasible steps to achieve GHG elimination by the second half of this century (Climate Focus, 2015). This will be done every five years to make sure the Agreement is being carried out in a timely manner and according to plan (UNFCCC 2015a). The first stocktaking will occur in 2023, but in 2018 (Ibid.) we will do a preliminary inventory to see how well we are doing in meeting our long-term emissions targets.

According to the UN Framework Convention on Climate Change (UNFCCC 2015a), the Agreement "supports the system that enables both public and private organizations to fund mitigation initiatives resulting in reduced greenhouse gas emissions." Emissions from other sources may or may not be utilized to offset the net mitigation impacts (emission reductions) from these efforts (Climate Focus, 2015). In light of these concerns, governments, corporations, and the general public are obligated to move toward a low-carbon economy as a result of the Paris Agreement (Oberthür et al., 2015). That's why it's crucial to switch from burning fossil fuels to harnessing renewable energy (European Commission, 2016).

The striking absence of a mechanism to address agricultural emissions in the Paris Agreement. Low growth in greenhouse gas emissions should be maintained, and food security should not be jeopardized, is the only issue discussed (Climate Focus, 2015). It is not a lack of political will on the part of wealthier countries that is causing growing concern about food insecurity when carbon money is diverted to project developers and private enterprises in underdeveloped nations (Bond et al., 2012). Also missing is a time frame for the Agreement's commitment to climate-related funding and distribution. The COP21 Decision, as stated by Climate Focus (2015), emphasizes the necessity of boosting proactive financing. In particular, it specifies that by 2020, parties to the Paris Agreement will maintain the current level of annual mobilization of $100 billion (UNFCCC 2015a), and that by 2025, they would set a new, collectively quantifiable target. The Decision mandates the adoption and implementation of Kyoto Protocol Phase II before to and up to 2020, respectively (Climate Focus, 2015), and allocates monies for climate change mitigation and adaptation.

Without legally binding targets for carbon reduction or financial commitments, the Paris Agreement could not have been enacted by Congress (Baker & McKenzie, 2015). Not only will the United States ratify because of this response, but so will Australia, Canada, Japan, Russia, and any other countries that may otherwise abstain if the United States did not. After a deadline extension to April 2017, 97 Convention Parties ratified the Paris Agreement by October 2016 (unfccc.int). The agreement entered into force in November 2016.

As promised in the Durban Platform, the future UNFCCC COPs should not overlook agricultural problems.

The Green Economy

The United Nations Environment Program (UNEP) called for a Global Green New Deal (GGND) as the global financial crisis peaked in 2008 (Barbier, 2009). As a means of mitigating climate change and reducing carbon emissions, this 2009 Agreement urged nations to promote a greener economy. To halt or reverse the loss of biodiversity and ecosystem services and to improve the effectiveness of these resources, public and private money should be invested in a green economy. It is important to make these investments to increase both revenue and employment. (GIZ 2013).

According to the GGND, a number of public investments and additional policy and price reforms are necessary to make the transition from business as usual (BAU) to a green economy. In order to make agriculture more eco-friendly, it is essential to eliminate greenhouse gas emissions (GHG), maximize agriculture's potential as a carbon sink, slow down the rate of deforestation, and encourage reforestation.

By switching from fossil fuels to renewable energy at power plants, energy poverty can be mitigated, according to UN DESA et al. (2013). Bus rapid transit (BRT), trains, and boats are among non-motorized modes of transportation that can be supported to promote environmental friendliness (UNEP, 2011).

This means that both developed and developing countries can make investments that benefit the environment, the economy, and human growth (UN Global Compact et al. 2011, UN DESA et al. 2013).

Investments in human capital include initiatives to educate and inform the public as well as provide hands-on training and opportunities to improve existing skills (UNEP 2015a). Additional policy and pricing changes along the path to a green economy are necessary to boost clean investments (UNEP, 2011). These include subsidies, corrective taxes, and other market-based initiatives (as previously noted).

Since 2008, an increasing number of countries around the world have embraced the green economy path with energy and commitment (UNEP 2015a). This includes several countries in Sub-Saharan Africa. A smooth transition to a green economy relies heavily on South-South collaboration. nations in transition that have already built a green economy may be able to help other nations in a similar situation by sharing their knowledge, experience, and technology (UNEP 2011). To facilitate a quick and orderly shift to a green economy, multilateral environmental accords (MEAs) are essential; thus, it is critical to move the post-Kyoto framework forward as soon as possible (GIZ, 2013). We'll discuss SSA's local initiatives to combat climate change and encourage a greener economy after this little break.

There is no way to know exactly how much money is required to green the global economy, but it is a very high sum nonetheless (UNEP, 2011). This is why the GGND suggested countries invest heavily in selected green enterprises with their stimulus money (UN DESA, 2012).

Thus, the green economy transition should be adequately funded by both the public and private sectors, as is now anticipated by the investment community and the financial sector. Retirement and insurance funds around the world are among the first to appreciate the lower risk profile that comes with sustainable investment portfolio construction. Retail and commercial banks are also establishing environmentally responsible policies and procedures (UNEP, 2011).

After the initial push toward a green economy has been made, additional financing sources, such as the Green Climate Fund (GCF), climate funds, and carbon funds (described below), will be required to ensure a seamless transition. UNEP (2011) states that if the aforementioned investments, rules, and access to finance are not made, the transition to a green economy will remain difficult. Recognizing the need for stepped-up efforts, the United Nations Department of Economic and Social Affairs (UN DESA) in 2012 called for the Rio+20 Conference to promote the green economy as a catalyst to speed up progress on sustainable development. The final statement from Rio+20 was titled "The future we want," and it urged governments to create their own green economic policies with the cooperation of the United Nations in order to benefit developing countries (United Nations, 2012). The goal of the Global Green Growth Institute (GGGI) is to help developing nations make the transition to a green economy (Kabaya, 2012).

We give two well-known green economy projects to help find and take advantage of green economy transition opportunities.

Green Economy – REDD Plan

The goal of the United Nations initiative REDD+, or Reducing Emissions from Deforestation and Forest Degradation, is to put a monetary value on the amount of carbon dioxide (CO_2) that trees take in during photosynthesis (Nhamo 2011b).

While REDD was first introduced at the eleventh Conference of Parties (COP) of the UN Framework Convention on Climate Change in 2005, it was not until the thirteenth

COP in 2007 that it was officially renamed REDD+. The goal of the REDD+ approach is to cut emissions while both keeping forests well-managed and safeguarding and expanding their carbon stocks (Global Symposium Report, 2013). As a result of the COP16 decision to integrate REDD+ into the Kyoto Protocol process (Boyle et al., 2011), REDD+ projects can now generate carbon trading credits on the carbon market (Nhamo, 2014a). In light of REDD+'s positive effects on both poverty and GDP (Global Symposium Report 2013), it has been associated with eco-friendly industries. The UK Department of Energy and Climate Change warned in 2010 (Nhamo 2011b) that keeping global warming below 2 degrees Celsius would be extremely challenging without REDD+. In other words, REDD+ functions as a catalyst for the transition towards the green economy in the 17 countries that are already working towards the aim of a "low carbon, resource efficient, and socially inclusive economy" (Global Symposium Report 2013).

Although REDD+ is envisioned as a chance to recognize local community rights and give security of tenure (Sunderlin et al., 2009), other academics suggest that REDD+ projects could negatively impact and also get affected the rights of indigenous people (Aggarwal, 2012). In spite of the fact that the certainty of land tenure is essential for the implementation of REDD+'s programs, empirical data disproves the idea that REDD+ will centralize forest administration in the hands of the government (Phelps et al., 2010). Communities in locations where REDD+ initiatives are being implemented face the loss of access to land and forest resources and the struggle to determine what compensation will apply to them, especially in circumstances of ambiguous land tenure rights (Eilenberg, 2015).

Lack of support from governments in low-income countries is also slowing down REDD+ projects (Mahanty and McDermott, 2013). Those who stop at creating a national REDD+ strategy or enacting policies (Korhonen-Kurki et al., 2014) miss out on the performance-based rewards stage. Proactively resolving these contestations is necessary if the REDD+ is to be effective in lowering and avoiding delays in climate change mitigation (Sunderlin et al., 2013). In addition, for REDD+ to realize its full potential, a post-Kyoto Protocol agreement that is both comprehensive and legally enforceable is required, but no such deal has been revealed as of yet (Nhamo 2011b).

Burkina Faso, Ghana, and the Democratic Republic of the Congo (DRC) are just a few of the African countries whose governments have reported significant progress in implementing REDD+ projects despite widespread skepticism (Nhamo 2011b; Global Symposium Report 2013). For example, despite being an early adopter of REDD+, Cameroon has made only limited progress thus far (Brockhaus and Gregorio, 2014).

Governments, especially in SSA, have been criticized for providing insufficient funding for REDD+ (Nhamo 2011b). It has been determined that this disagreement stems from the fact that governments must either have a high potential for reducing carbon emissions and creating high carbon credits or a ready capacity to manage REDD+ initiatives. It is proposed that SSA nations do their part by implementing the MRV system (as directed by the UNFCCC COP) and by addressing other concerns like as land tenure rights, corruption, and political stability (Nhamo 2011b). Governments in SSA are urged to pursue environmental and social goals in a manner consistent with the demand made under the Sustainable Development Goals (SDGs) of the 2030 Agenda, which were launched in 2016 (Lima et al. 2017). In terms of the environment, REDD+ is most closely aligned with Goal 13 (climate change mitigation) and Goal 15 (forest conservation) of the SDGs. This combination produces a potent synergy that cannot be ignored. Though the SDGs don't explicitly establish a hierarchy between environmental and social goals, REDD+ prioritizes the former. Consequently, there may be tensions between REDD+ and the SDGs as they are implemented.

Green Growth Plan

The Green Growth Strategy (GGS) was launched in June 2009 by the Organization for Economic Co-operation and Development (OECD) to address climate change. OECD ministers approved the GGS in 2011 (OECD, 2012). To successfully make the shift to a green economy, it is important to keep in mind the importance of green growth (Nhamo, 2013). GGS is trying to address issues that affect all nations, including those in the OECD, the emerging market, and the developing world (OECD, 2012).

This approach aims to help developing countries catch up to developed nations by encouraging them to prioritize environmental considerations in infrastructure investment decisions and by promoting the continued development of agriculture and other natural resources in a way that improves livelihoods, creates jobs, and lessens poverty.18 To this end, the Organization for Economic Cooperation and Development

(OECD), the World Bank, the United Nations Environment Programme (UNEP), and the Green Growth Global Initiative (GGGI) have collaborated to create the Green Growth Information Platform (GGKP), which serves as a central hub for information exchange, the identification of research gaps, and the provision of the most urgent policy recommendations.

Climate change transition efforts into a green economy by SSA

Considering its emphasis on prevention rather than reaction, the concept of a green economy has gained traction in the wake of the current global economic, food, and climatic crises (UN DESA et al., 2013). The African continent is not ignored. The third African Ministerial Conference on Finance for Development, held in 2009 in Kigali, Rwanda, urged the creation of a climate that welcomes low-carbon development and facilitates the shift to a green economy. Nhamo and Nhamo (2014) argue that this marked the beginning of Africa's acceptance of the green economy.

When the first Pan-African Biodiversity Conference was held in Libreville, Gabon in 2010, a green economic road map was approved (Nhamo and Nhamo, 2014). By holding the 14th session of the African Ministerial Conference on Environment (AMCEN) in 2012 in Arusha, Tanzania (Kim 2015), African leaders demonstrated their dedication to developing a more equitable and greener economy. Arusha saw the advancement of a decision on Africa's Post-Rio+20 Strategy for Sustainable Development and the establishment of mechanisms to offer member states coordinated support in their transition to a green economy (UNEP 2015b). Many of these mechanisms already exist, such as the African Green Economy Partnership (AGEP), the promotion of regional and international cooperation, and the transfer of resource-conserving and environmentally beneficial technologies (Kim, 2015). For instance, one program backed by the UNEP is called the Partnership for Action on Green Economy (PAGE). First to reap the benefits of this partnership are the African countries of Burkina Faso, Ghana, Mauritius, and Senegal (UNEP 2015b).

In its fight for a green economy, the African Development Bank (AfDB) underlines the importance of green growth in an African context. Investing in sustainable infrastructure, better managing natural resources, bolstering resilience to natural catastrophes, and increasing food security are all components of green growth, which is defined as "pursuing inclusive economic growth through policies, programs, and projects" (GIZ 2013:9). Since recent natural disasters have hit the African continent, the Bank asserts that taking action to adapt to and mitigate climate change is not only necessary, but vital (AfDB 2014b). In March of the same year, a wildfire swept through South Africa, while in January of same year, huge rains overwhelmed Malawi (both examples from the Guardian website, www.theguardian.com). Because many African countries are so reliant on the exploitation of natural resources, the Bank claims that green growth might enable sound resource management in Africa to avoid overexploitation and proceed to greener infrastructure projects (AfDB, 2012).

The AfDB's policy frameworks have evolved over the years, and these developments should now pave the way for its member countries to transition to a green economy. A few policy frameworks developed by the AfDB are the Climate Risk Management and Adaptation Strategy (CRMA), the Climate Change Action Plan (CCAP), and the Energy Sector Policy (AfDB, 2012). The African Development Bank's (AfDB) Agricultural Sector Strategy sought to include green growth concepts by placing more emphasis on forestry, land and water management, and the mitigation and adaptation to climate change (Ibid).

The Bank has been supporting the creation of carbon as an asset by boosting carbon stocks through sustainable forest management. Programs such as the REDD+ projects and the Congo Basin Forest Fund (CBFF) (AfDB, 2012) help to achieve this goal. The AfDB asserts that in order to properly execute the green growth framework, coordination and communication must be strengthened. Therefore, the African Development Bank (AfDB) has worked with and will continue to work with the African Union Commission (AUC), the Economic Commission for Africa (UNECA), and regional economic communities (RECs) (AfDB 2012). For example, the AfDB, UNECA, and AUC are all partners in the Climate for Development in Africa (ClimDev-Africa) initiative, which was launched in 2010. Since 2011, they have co-hosted the annual Conference on Climate Change and Development in Africa (CCDA) (UNECA et al., 2013).

The success of the partnership between the AfDB, UNECA, and AUC was on display at the just finished CCDA-IV, held in Marrakech, Morocco in 2014, with the Conference topic "Africa can feed Africa now, translating climate knowledge into action" (UNECA 2014b). The CCDA-IV promotes public-private partnerships in order to fund cooperative investments in low-cost energy sources in African countries. It advocates for professionals to have access to the financial sector and backs the establishment of a window for agricultural finance under the United Nations Framework Convention on Climate Change (UNFCCC). UNECA 2014b restates the importance of encouraging African governments to integrate inclusive green economy programs into their development frameworks and monitoring progress.

According to its Ten-Year Strategy 2013-2022, the African Development Bank (AfDB) has made it a top priority to assist African nations in their fight against climate change and transition to a green economy. As part of putting into action the Ten-Year Strategy, the Bank is entrusted with supporting in the development of local capital markets in order to adopt green portfolios, lower the continent's high unemployment rate, and boost agricultural productivity and food security (AfDB 2013a). The Bank has been working closely with several member countries, such as Cape Verde, Kenya, Mauritius, Mozambique, and Sierra Leone, to develop green economic road maps and action plans in order to ensure their successful implementation.

Some of the AfDB's green growth and climate funding mechanisms include the CBFF, the Sustainable Energy Fund for Africa (SEFA), the Africa Renewable Energy Fund (AREF), the Global Environment Facility (GEF), and the ClimDev-Africa Special Fund (CDSF).

The Agenda 2063 was established as a world plan by the AUC. With an eye toward reducing carbon emissions and safeguarding the continent's natural beauty, the Agenda seeks to maximize Africa's use of its available resources (UNIDO, 2015). Both rural and urban communities in SSA require a reliable and affordable energy supply in order to take advantage of the international carbon reduction and climate change mitigation potential (UN-ENERGY/Africa, 2007). To this end, the African Union Commission (AUC) and the New Partnership for Africa's Development (NEPAD) have launched a variety of renewable energy promotion programs in collaboration with regional power pools, the African Energy Commission (AFREC), and RECs like the Economic Community of Central African States (ECCAS), ECOWAS, and the Southern African Development Community (SADC) (AUC 2011). For instance, the Zambezi Basin, the Congo Basin, and the Fouta Djallon will all benefit from the enhancements proposed in the 2020 hydroelectricity plan (AUC, 2011). The most recent initiative to focus on renewable energy sources was presented by African countries during the 2015 COP to the UNFCCC in Paris. This initiative is known as the African Renewable Energy Initiative (AREI). According to the Climate Council (2015), AREI's goal is to boost renewable energy generation capacity by at least 10 GW by 2020 and by 300 GW by 2030. These initiatives would help to cushion the effects of increased fossil fuel prices and cuts in carbon emissions from the use of fossil fuels in SSA (UN-ENERGY/Africa, 2007).

The switch to an environmentally friendly economy is investigated not just on the African continent, but also at the regional and local levels. Investments in green growth and the creation and implementation of policies were highlighted by Elgar et al. (2009) as a priority for regional and national governments in sub-Saharan Africa (SSA). Comparatively, the RECs of the sub-Saharan region, which include COMESA, the East African Community, the Economic Community of West African States, and the Intergovernmental Authority on Development (IGAD), have more robust green economy and climate change strategies than the Southern African Development Community (SADC) and the Economic Community of Central African States (ECCAS).

The Climate Change Program of COMESA has been in effect since 2008. However, in 2009, COMESA invited its neighboring RECs to initiate the COMESA-EAC-SADC Tripartite Climate Change Adaptation and Mitigation Programme and Climate Change Initiative (COMESA 2012) in the spirit of a tripartite agreement. The Tripartite program is a five-year initiative that started in 2010 (COMESA et al., 2011), whereas the Tripartite initiative was announced in 2011. The EAC developed its own comprehensive strategy for addressing climate change for the period 2011–2031 (Nhamo 2014b).

There was a lag between the creation of the SADC's Green Growth Strategy and Action Plan and those of other RECs in Tripartite. This is because the SADC was first skeptical of the green economy transition plan due to the failure of the structural adjustment programs of the World Bank and International Monetary Fund (IMF) in the 1980s (Nhamo and Nhamo, 2014). Slow progress on an ECCAS plan to combat climate change may be attributable to a lack of community solidarity, according to a recent study (Meyer, 2015). While the SADC has been working on a green growth strategy and action plan since 2013 (UNEP 2015b), the ECCAS is aiming to establish a climate change unit at the department level (Wouapi et al., 2014).

Even if the ECOWAS does not have a program to combat climate change (UNECA, 2013), it does have programs that were developed in line with the concepts of a green economy. Established in 2012, the Regional Agricultural Investment Program (PRIA) complements the West African Economic and Monetary Union's (WAEMU) sponsorship of the Global Alliance for Resilience Initiative (AGIR) (UNECA 2014c). ECOWAS also has an effort for safe, affordable, and sustainable cooking by 2030 (UNECA 2013) and an energy efficiency center, the ECOWAS Regional Centre for Renewable Energy and Energy Efficiency (ECREEE), which opened in 2010. The United Nations Environment Programme (UNEP) report (2015b) reviews the West African Common Industrial Policy (WACIP), which was implemented in 2010, and finds that while there is no clear plan for greening the industrial sector, the policy is nevertheless trending in the correct direction toward the transition to a green economy.

Climate information, prediction products, and services for early warning and associated applications are all available from the IGAD Climate Prediction and Applications Centre (ICPAC) (UNECA 2012b) in an effort to mitigate the effects of global warming. Each state can use the strategies recommended by the SSA RECs to advance two objectives. Individual efforts are insufficient to combat climate change, preserve the environment, promote sustainable development in agriculture, agroforestry, and the use of renewable and efficient energy sources (UNECA 2012b, 2013).

There has been some success among SSA countries in designing and implementing low-carbon development and climate resilience measures, policies, and strategies to advance toward a green economy (Nhamo 2014b).

Since the beginning of 2010 (Dewar 2012), these plans and measures have been shaped by Kenya's National Climate Change Response Strategy.

Namibia also introduced its National Climate Change Policy that year (Nhamo 2014b). The National Climate Change Response Strategy White Paper and the Green Economy Accord were both signed by South Africa in 2011 (Economic Development Department of South Africa 2011, Nhamo 2014b).

Ethiopia and Rwanda both adopted the corresponding Green Growth National Strategies in 2011; the former is called the Climate Resilient Green Economy Strategy (GGBP 2014), and the latter is called the Green Growth National Strategy (GoR 2011). To combat climate change, both Malawi and Tanzania released national policies and strategies in 2012 (Nhamo 2014b). In 2013, Mozambique's Green Economy Roadmap went into effect (GGBP 2014), while Ghana developed its National Climate Change Policy Framework in 2014 (Asante et al., 2015). For example, in 2014, the government of Swaziland (GoS) drafted the National Climate Change Strategy and Action Plan and in 2015, they drafted the National Climate Change Policy.

Those plans listed above, such as those for green growth and climate change, are long-term endeavors. A good level of life for all its citizens in a safe and secure environment is one goal of Kenya's plan (Mwenda and Khainga, 2013) to transform the country into a newly industrializing, middle-income one by 2030. Plans include things like implementing and advocating for carbon-efficient farming methods, conserving and replanting trees, and switching to more energy-efficient vehicles, buildings, and factories (Dewar, 2012). Furthermore, they anticipate generating additional employment opportunities beyond what is necessary under their particular BAU scenarios. For example, Burkina Faso predicts that, by 2050, its green economy scenario will generate 160 million more jobs than its BAU scenarios, which call for 276-277 million jobs (Kim, 2015). For large-scale international financial support and to establish the required institutional and technical capabilities, the plans utilised the concept of "Measurement, Reporting, and Verification (MRV)" that emerged during the Bali Roadmap (mentioned above).

In contrast, countries like Cape Verde, the Central African Republic, Gabon, Mali, and Nigeria all lack a clear strategy and action plan. The fourth suggestion, to build climate resilience and support a green economy, was quickly adopted.

This report is from the IPCC (also see UNEP 2011; Dewar 2012; and CAR 2015). And some countries, including the Seychelles, Somalia, South Sudan, and Sudan, haven't even thought about climate change yet in their development plans (AfDB, 2014). There is a case to be made for Somalia and South Sudan due to the length of their conflicts, the persistence of insecurity, and the scarcity of social and financial resources available to them. Seychelles and Sudan may be missing the boat by not implementing any climate change or green growth strategies (ibid). Many lessons can be learned from the forerunners of the low-carbon resilient development strategy, such as Ethiopia, Kenya, Rwanda, and South Africa (Fisher, 2013).

The financial aspects, in particular, still need attention notwithstanding the previous discussions.

Despite the fact that green growth has access to a wide variety of international and bilateral funding sources (discussed below), national financial support is essential (Nhamo, 2013). Even in SSA, domestic public monies are being used to finance green investments (GGBP, 2014).

This is because it is difficult for SSA banks and other financial institutions to invest at the outset of a project cycle due to a lack of knowledge on how to evaluate the risk associated with green initiatives (World Bank, 2010). As a result, several SSA countries have set up a fund to provide financial aid for environmentally friendly initiatives in the form of grants and loans. The South African Green Fund was established in 2011 (GGBP 2014), and the Ethiopian government allocates an average of about $440 million per year from the national budget to address climate change (Eshetu et al., 2014).

A few case studies then detail ongoing and finished initiatives in countries well along the path to a greener economic future. As one of the lowest-hanging fruits in the green economy transformation, ceasing gas flaring during crude oil production from the ground is a good place to start (UNECA 2012a). In 2010, gas flaring contributed to the emission of 360 million metric tons of carbon dioxide around the world.

Initiatives to reduce gas flaring in SSA stand out due to the fact that the gas can be bottled and used for both commercial and residential purposes as LNG to create energy. The CDM is funding these projects in Angola, Equatorial Guinea, and Nigeria. According to UNECA (2012), Angola's LNG program is among the world's largest efforts to curb gas flaring.

The United Nations Environment Programme (UNEP) hosts an annual awards program called the Social and Environmental Entrepreneurship in Developing Countries (SEED) Awards, which recognizes and celebrates the most creative, ambitious, and locally established social and environmental enterprises in developing countries. The United Nations Environment Programme (UNEP), United Nations Development Programme (UNDP), and the International Union for the Conservation of Nature (IUCN) established the SEED initiative during the 2002 World Summit on Sustainable Development in Johannesburg, South Africa (Creech et al., 2012). You may find further details about the awards in Table A.III in the Appendices. Ghana, Kenya, Malawi, Rwanda, and South Africa are just some of the SSA countries lauded for their small and microentrepreneur success stories in producing and distributing green and energy-efficient products (UNECA 2012a).

Côte d'Ivoire's hydroelectric plant system is the third-largest in West Africa, after Nigeria and Ghana (AfDB 2013b). The system has recently undergone expansion and building. Per capita, Kenya has the most solar panels installed in it, as reported by Allied Crowds in 2015. A geothermal facility and six wind farms together generate more than a thousand kilowatts of electricity in Ethiopia (Babatunde, 2014). Windmills are not only utilized for agriculture but also for generating and distributing electricity in the Gambia (Sehjpal et al., 2013). These many renewable energy sources are in line with a philosophy that values economic expansion without increasing atmospheric carbon dioxide levels.

Nonetheless, in 2011, the Ghanaian Parliament passed the Renewable Energy Act (Ghana Ministry of Foreign Affairs, 2013) to establish the legal and regulatory foundation for expanding the country's renewable energy sector. This action was taken to further the goal of expanding the use of renewable power. The Act created the Renewable Energy Fund (UNEP 2015b) to provide the necessary funding for the development of the sector. Independent Power Producers (IPPs) have been welcomed into the electricity generation industries of Kenya, South Africa, and Uganda in an effort to increase both the total amount of electricity generated and the share of renewable energy in the national energy mix (UNEP 2014). Feed-in tariffs are used by Botswana, Kenya, and Mauritius to encourage private investment in renewable energy systems, which in turn increases renewable energy usage. All electricity generated from renewable energy sources must be purchased by power distributors at fixed prices with priority given to those who produce it under the feed-in tariffs (Sehjpal et al., 2013; UNEP 2014). While China and India use feed-in tariffs, South Africa has switched to a bidding structure to achieve the same result (Nhamo, 2013).

As well as Ethiopia, Malawi, South Africa, and Uganda, OECD (2012) notes that Ghana and Rwanda also produce and sell energy-efficient cooking stoves. In order to reduce soil and forest degradation and increase their potential to store carbon, this practice is used (WDR 1992).

When it comes to adjusting market prices in a way that promotes sustainable development, South Africa is the SSA country that is most highly regarded. In 2009, for instance, South Africa's finance minister proposed imposing a tax on all incandescent light bulbs sold in the country, both domestically and internationally. Because of the success of this strategy in reducing carbon emissions from energy production, other countries, such as Botswana, have enacted very similar laws (UNEP, 2011). According to the Global Green Growth Institute, South Africa receives billions of rand annually from the fuel charge and emissions tax on new passenger automobiles.

Success in cutting emissions by 14% per passenger on the bus rapid transit (BRT) system in Bogotá, Colombia has inspired replication of the technology in Lagos, Nigeria and Johannesburg, South Africa. Moreover, South Africa's metro rail system is among the best in the world (UNEP, 2011). According to the IEA (2014), Malawi, Ethiopia, and Kenya are already blending ethanol with transportation fuel in an effort to lower carbon emissions from transportation. The National Biofuel Policy of Ethiopia, for example, promotes using ethanol for both transportation and cooking. Currently, South Africa is the only SSA country with a robust vehicle business, therefore the region has little say in the process of making automobiles. So, it's just a guess that the area's emissions will go down if more people start driving plug-in hybrid electric vehicles (PHEVs or PEVs). Although (Hogarth et al. 2015), four African countries—Angola, Botswana, Kenya, and Nigeria—have decided to impose restrictions on the quality and age of imported old cars.

Since 2009 (Sehjpal et al., 2013), Uganda has designated Biogas Construction Enterprises (BCE) as the platform for installing biogas plants. The promotion and marketing of biogas in Rwanda is not simply intended to cut down on carbon emissions.

As a means of transitioning to a green economy, the CDM projects launched in SSA have been successful. In addition to South Africa, these initiatives have been implemented in Angola, Equatorial Guinea, Kenya, Nigeria, Rwanda, Senegal, Tanzania, Uganda, and Zambia (UNFCCC, 2013). The South African Kuyasa CDM pilot project is noteworthy since it retrofitted approximately 2,300 low-income homes in the Khayelitsha 47 neighborhood of Cape Town with solar water heaters, solar panels, ceiling insulation, and other energy-efficient lighting (Goldman, 2010).

According to the Wildlife Conservation Society, Microsoft, Carbon Neutral Company, and Zoo Zurich were the lucky recipients of Madagascar's first forest carbon credits, which were sold by the country's government in February 2014 (GGBP 2014). To offset their carbon emissions, African governments are selling REDD+ credits for the first time. This establishes an essential link between deforestation and economic development, notably in the agricultural sector (Ibid. Changes to tax incentives for tree planting have been enacted in Kenya (GGBP 2014), along with restrictions on the harvesting and sale of tree products. To lessen carbon dioxide (CO_2) emissions from deforestation and forest degradation in Kenya and Tanzania, the Payment for Ecosystem Services (PES) is put to use through encouraging the expansion of Community Carbon Cooperatives (GGBP, 2014).

Carbon emissions from agriculture can be decreased by switching from chemical to bio-based pesticides, as is happening in Burkina Faso, Mali, Senegal, South Africa, and Uganda (UNECA 2012a). Organic farming is becoming increasingly well-liked as a result of its export markets, as buyers increasingly seek out "greener" agricultural products with smaller carbon footprints. When it comes to organic farming in SSA, countries belonging to the East African Community (EAC) are taking the lead (Ibid.). If you're looking for a place to learn about modern farming techniques, look no farther than the Tamboura Farming Business in Bamako, Mali (UNECA, 2013). To add to this, Mali and Burkina Faso farmer cooperatives are growing Jatropha plants for potential use in biofuel production on unused land (GGBP, 2014).

Fossil fuel subsidies (FFS) are an important part of the discussion surrounding the green economy transition. FFS is a form of consumer subsidy provided by governments. It permits consumers to pay less than the market price for fossil fuel products (such coal, gasoline, diesel, kerosene, etc.) in exchange for producers obtaining the market price (Bárány and Grigonyt, 2015). Since FFS mostly benefits high earners over low ones, it puts a heavy burden on SSA government resources. As an added bonus, it has negative repercussions for the environment, society, and economy, such as encouraging CO_2 emissions since when customers pay less, they use more fossil fuels (ADR, 2012).

Therefore, encouraging green economic activity might benefit from a huge infusion of funds made available by reducing subsidies for fossil fuels. Ghana and Senegal (GSI 2010) and Nigeria (reported by the Vanguard news website www.vanguardngr.com) are examples of countries in SSA that have successfully abolished FFS 48.

As a means of adapting to climate change, corporations are developing environmentally friendly goods and services. The next paragraphs provide a rundown of each of these.

Nhamo and Swart (2012) state that the Johannesburg Stock Exchange (JSE) established the Socially Responsible Investment (SRI) Index and the Carbon Disclosure Project (CDP) before any other exchange in SSA. Indicators regarding environmental consequences and corporate actions to support South Africa's green economy transition are disclosed to investors and consumers (UNECA 2012a). Market growth is a welcome side effect of reducing carbon emissions, and may be sufficient incentive for South African enterprises to do so.

Reclaimed mines in South Africa are being put to use in the carbon-capture and -storage process. Over the course of their operations, mining companies in the country should set aside enough money to cover the whole cost of closing their mines when that time comes. Mushrooms, for instance, are grown in abandoned mine tunnels as part of De Beers' Kimberly project (UNECA 2012a).

Mumias Sugar Company Limited in Kenya helps reduce carbon emissions by using a byproduct of sugarcane processing, bagasse, to power a cogeneration plant (UNEP 2014). The South African power provider Eskom is also advocating a strategy that prioritizes the use of electricity and power producing systems that emit fewer greenhouse emissions (UN Global Compact et al., 2011).

When it comes to making the switch to a green economy, Nhamo (2013) claims that South Africa and Kenya are ahead of the pack, followed by Ethiopia, Mauritius, and Rwanda.

In spite of the fact that the IPCC's climate change model predicts that the transition would be complete by 2050, substantial work remains (Huq, 2011). Thus, competing nations need to make greater efforts and learn from the successes of the leaders. Climate finance and carbon financing are next on the agenda, so that this chapter may move forward.

Carbon Financing in Sub-Saharan Africa

"Carbon finance" refers to a set of international and national initiatives designed to ease the financial strain of climate change mitigation efforts. It complements and leverages existing financial resources (Elgar et al., 2009) to make low-carbon developments possible in host nations. The Clean Development Mechanism (CDM), the world's second-largest carbon market, is ideal for SSA countries (Nhamo 2011a). The World Bank's Carbon Finance Group came up with new approaches to carbon financing for poor countries. The division established the

Prototype Carbon Fund (PCF) in 1999. As of 2013, the World Bank managed fifteen separate carbon funds. Some of the World Bank's carbon finance initiatives include the BioCarbon Fund (BioCF), the Carbon Fund for Europe (CFE), the Carbon Initiative for Development (Ci-Dev), the Community Development Carbon Fund (CDCF), and the Spanish Carbon Fund (SCF). This section analyzes the impact that carbon finance schemes have had on SSA's climate change mitigation efforts.

The Southern African Development Community (SADC) makes limited use of national carbon finance methods to fund low-carbon activities, especially in the renewable energy sector. South Africa (World Bank, 2014), Mauritius (Dalmazzone, 2015), and Ethiopia (International Monetary Fund, 2016) are just a few of the SSA countries who have stated their intention to introduce a carbon price. Since 2001 (Nhamo and Inyang 2011), all automobiles in Zimbabwe have been subject to a carbon tax. Although the CDM is the most widely used carbon finance mechanism in SSA, only 2.9% of all CDM projects were located in Africa in 2013, with the majority of these projects being in South Africa (World Bank, 2013). CER buyers, also known as carbon market investors, tend to favor CDM projects that reduce emissions by a significant amount, hence most CDM projects end up in China, India, and Brazil. Most countries in SSA rely on agriculture for their economy, therefore small-scale initiatives only generate a modest amount of carbon credits (Nyambura and Nhamo, 2014). Despite this, Lütken (2016) reports that only about a third of CDM-registered projects really receive the carbon finance investment assistance.

There is a risk of market failure in international carbon markets as they adapt to new economic and political circumstances (Cormier and Bellassen, 2012). Specifically, there are a variety of issues that could cause the CDM to fail. Access to carbon finance and emission reduction are hampered by the CDM's delayed approval procedure, which increases transaction costs and makes projects costly for SSA countries (Purvis et al., 2013).

When members of the CDM governing body are also representatives of their countries and climate treaty negotiators (Bond et al., 2012), there is a potential for conflicts of interest. The majority of the demand for CERs issued by the CDM originates through the European Union Emissions Trading System (EU ETS) (Ibid.). There has been a fall in demand for credits (from 2013) in the EU ETS, and this has a knock-on effect on the CDM (Shishlov and Bellassen, 2012; Thomson Reuters, 2016). Thomson Reuters (2016) reports that the price of credit fell from roughly €14 at the end of 2008 to around €4 at the end of 2012 and then to €0.65 at the end of 2015, all before leveling off. Without a doubt, the CDM has helped sub-Saharan African countries realize their potential for lowering carbon emissions by encouraging them to adopt more stringent climate policies. However, modifications in procedure and policy are necessary for SSA to gain more from its carbon funding in the coming years (Lütken, 2016).

The increasing value of trees, however, has driven SSA to ask the World Bank's several carbon pools for carbon money. The Ibi Bateke agroforestry project in the Democratic Republic of the Congo, for instance, was signed in 2009 and is expected to be completed in 2018 (World Bank, 2015). As of 2010 (31% as reported by World Bank), SSA was home to asset support initiatives supported by BioCF Tranche 1. However, we are not receiving any further carbon funds at this time. The World Bank reports that as of 2010, only 2% of PCF, SCF, and CFE funds were distributed to Africa. In 2013 (World Bank, 2013) and 2014 (World Bank, 2014), Africa received 13% and 14%, respectively, of the World Bank's overall carbon finance portfolio. Because of this, Africa still has a hard time getting money to invest in low-carbon technologies (UNCCD, 2013).

Perhaps Sub-Saharan Africa (SSA) could receive a larger and more fair share of carbon financing through the World Bank's Ci-Dev Carbon Fund (World Bank, 2013).

The low volume of emissions reductions described above is only one factor in the region's relatively low adoption of carbon finance strategies (Agarwal, 2013). Other explanations fall under two broad classes: Capacity limitations (such as a lack of human capital and inadequate institutional coordination) and financial barriers (such as high start-up costs, limited domestic funding, and high perceived risk) were highlighted by Elgar et al. (2009). It takes a lot of skill, for instance, to run renewable energy projects like high-temperature boilers and cogeneration technology.

Despite the limited scope of these efforts, SSA does not have the experienced personnel on hand to manage and sustain them (Hogarth et al., 2015). Scoraig Wind Electric, a British firm, and Rural Energy and Environmental Systems (REES), a Ghanaian firm, collaborated on a wind power project, and then Scoraig had to launch a training program to educate technicians from local businesses on how to design, construct, manufacture, and install wind turbines with locally sourced materials. As a result of the effort, the first wind turbine to be made in Ghana was created (Elgar et al., 2009).

To properly take benefit of carbon financing opportunities, the area also needs more specialized knowledge. Therefore, it is incumbent upon educational institutions and governmental bodies to provide carbon financing and adaptation/mitigation project training as part of courses, seminars, and vocational education (Elgar et al., 2009). The Uganda Carbon Bureau, for instance, has been instructing the banking, government, and business sectors since 2006 (OECD, 2013) on how to better leverage the carbon market. Another instance is the African Development Bank's (AfDB) workshops meant to educate staff, project owners, and government agencies on the potential of carbon finance (AfDB, 2013c).

Investments in low-carbon projects are typically substantial at the outset. Inexpensive examples of renewable energy technology are solar panels and wind turbines. Costs for solar and wind energy equipment have been shown to be dropping, making expansion more feasible (Hogarth et al., 2015). In locations with the poorest and most vulnerable inhabitants, however, small-scale initiatives are often necessary; nonetheless, these projects have extraordinarily high transaction costs, which deter investors (Agarwal, 2013). This issue is made worse by the unfavorable investment climate in many SSA countries and the ineffectiveness of government institutions poor managing funds (Nakhooda et al., 2011). Foreign direct investments (FDI) are being encouraged to come to the region by helping SSA countries become more business-friendly (Agarwal, 2013).

Carbon financing is essentially compensated after the delivery of the emission reductions, therefore developers must invest significant up-front expenditures without expecting profits for some time (Nakhooda et al., 2011). This means they will have to approach the banking sector for alternative sources of funding if and when they find themselves in need of additional capital. Because of this, Agarwal (2013) notes that countries with higher levels of domestic lending to the private sector (as a percentage of GDP) tend to have more CDM projects. This trend is seen, for example, in South Africa and Kenya (Ibid.). The lack of collateral requirements and unfavorable financial institution laws and regulations are two of the key reasons why developers still have trouble gaining access to money, regardless of how developed a country's financial system is (Bondinuba, 2012). After developers have overcome all challenges and emission reductions have been achieved, carbon finance only provides a portion of the necessary funds for the projects. As a result, it is challenging to secure funds in SSA for large-scale infrastructure projects (Elgar et al., 2009).

These financial hurdles can be solved with the help of feed-in-tariffs, which are mandated by law in some SSA countries and are calculated to cover the cost of generation plus an acceptable profit margin for investors (UNEP, 2014). Ghana, in an effort to overcome financial difficulties, stopped subsidizing the price of gasoline in 2005 (ADR, 2012). The funds could be invested in endeavors with a smaller carbon footprint. One possible option is to reduce import duties on low-carbon technologies.

Investors might also be comforted by the usage of insurance to mitigate their exposure to risk. Private investors can be enticed in this way to make investments. For instance, the Multilateral Investment Guarantee Agency (MIGA) of the World Bank Group provides guarantees to protect foreign investment and the risks it involves in developing countries (Elgar et al., 2009).

To combat this, SSA RECs direct resources into locally-driven, low-carbon projects. For example, the Economic Community of West African States (ECOWAS) established a fund to purchase carbon credits up front in its member states to provide start-up capital for domestic small and medium-sized enterprises (Nakhooda et al. 2011). Similarly, the Central African States Development Bank (BDEAC) developed comparable instruments to facilitate access to funds for CDM project developers in its member states. Investments in low-carbon technologies in sub-Saharan Africa (SSA) necessitated a significant and stable public sector financial commitment, but this was not always the case (Schaeffer et al., 2014).

Climate Finance in Sub-Saharan African

According to Ackerman (2009), the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol are the two most important international financing sources for climate investments. In addition to the European Union's Global Climate Change Alliance (GCCA), other multilateral sources of funding for climate mitigation include the Congo Basin Forest Fund (CBFF), the Global Environment Facility (GEF), the Green Climate Fund (GCF), the Millennium Development Goals (MDG) Achievement Fund, and the United Nations Reducing Emissions from Deforestation and Forest Degradation (UN-REDD) program. Norway, Germany, Japan, and the UK all contribute to bilateral projects as well. Japan's "Cool Earth Partnership" (formerly known as the Hatoyama project, currently known as Japan's Fast-Start Finance) is the largest bilateral funding project among them (Nakhooda et al., 2013b). Furthermore, the CIF of the World Bank has the biggest value of approved projects among all international and bilateral climate funds for mitigation (ICF International, 2014). In this section, we'll take a quick look at how climate financing is attempting to lessen the effects of global warming in sub-Saharan Africa.

The GEF has been supporting SSA's anti-climate-change initiatives for the longest period of time.

The African Rift Geothermal Development Facility is the largest GEF-approved project (Nakhooda et al., 2011), and it will benefit six African countries: Ethiopia, Eritrea, Djibouti, Kenya, Uganda, and Tanzania. In 2012, for instance, the Menengal geothermal plant in Kenya started serving the public. The African Development Bank (2012) estimates that this project will reduce annual CO2 emissions by two million tons and provide enough electricity for half a million homes in Kenya.

Similar to carbon financing systems, SSA has limited access to climate money (UNECA 2014a). It appears that the low-income countries of SSA are overlooked in favor of the middle-income countries in the area by these funding sources. In comparison, Somalia and Swaziland have yet to get any climate monies at all (Nakhooda et al. 2013a), while Uganda and Chad received less than US$0.5 million in climate money over three years (2008-2011). When compared to carbon funding, the 25% of climate money approved (since 2003) for SSA goes to South Africa. Eskom's renewable energy program has benefited greatly from these funds.

Therefore, due to SSA's severe lack of infrastructure, there is still an urgent need to mobilize resources for climate change mitigation in SSA (UNECA 2014a). As a means of resolving this issue and meeting Africa's specific needs, the establishment of an African Climate Change fund managed by an African institution has been proposed (UNECA 2014a). After much deliberation, the African Development Bank (AfDB) finally gave its blessing to the Africa Climate Change Fund (ACCF) in 2014 (Gulati 2014).

The African Climate Change Fund (ACCF) is a bilateral thematic trust fund established to support African countries in their pursuit of low-carbon development and adaptation to climate change (AfDB 2014a). Since the GCF was established in

2011, the ACCF has become a critical opportunity for the Bank to organize and implement increased climate finance for Africa. To further assure this, the AfDB plans to establish an Africa Green Facility; the Africa Climate Change Fund (ACCF) is the first step in closing this infrastructure deficit. The AfDB's ten-year strategy for 2013–2022, meantime, is meant to be carried out with the aid of the ACCF (AfDB, 2014b).

Since existing international climate funding channels are already stretched thin, SSA countries may have to find alternative ways to generate climate finance, from both internal and external sources (UNECA 2014a). For example, in 2012, Rwanda established the Fund for Environment and Climate Change (FONERWA) (Sida's Helpdesk for Environment and Climate Change, 2013) to address this issue. FONERWA is the largest demand-based climate finance channel in Africa, as reported by CDKN (2013).

What South Africa's Green Fund and Rwanda's FONERWA have discovered about the optimal mix of structures and procedures for channeling climate money in the direction of climate mitigation goals may therefore be of service to other SSA states.

Conclusion

It is suggested in this chapter that SSA countries are the most vulnerable to the effects of environmental change, although contributing only a fraction of the world's carbon emissions.

The group is aware that, if current trends in development continue, their carbon emissions will likely rise. According to OECD (2012), certain governments in SSA are beginning to implement a range of climate change measures. These regulations encourage eco-friendly, low-carbon development. When it comes to reducing carbon emissions now and in the future to prevent catastrophic climate change and safeguard its environmental capital, lagging SSA governments must put aside sentiments and jump on board the ship of making green investments immediately before it sets sail (by 2050) (Dercon, 2014).

According to the World Bank (2013), the slow implementation of climate change mitigation measures in SSA is at least in part attributable to the fact that the continent receives just a small share of international carbon and climate finance instruments, particularly the CDM. It is crucial that SSA countries dedicate resources to combating climate change (if they haven't previously) and keep up their current initiatives (if they currently are). Although these funds are essential to the development of the country's infrastructure, agricultural, and energy industries (UNECA 2014a), they are expected to decrease as national banks get more involved (GGBP, 2014). Therefore, it is intended that SSA's national financial sectors will work to expand access to, and provision of, green financial products and services (GGBP, 2014). The governments of SSA also need to focus on research and consultation on policy design, as well as allocating adequate resources, bolstering institutional capacity, and enacting environmental and sectoral policies to reconcile environmental protection and adaptation to climate change with national development.

Empirical Evidence

Banking sector development and energy use

Whenever a country invests in developing its financial sector, it transforms its economy. In developed nations, for instance, low borrowing costs boost borrower access to money and creditor transparency. The result is increased international investment, which in turn leads to technological advancement. Even with a robust financial system, the banks and private sectors might not be motivated to increase their funding for projects and investments that reduce energy use. Mielnik and Goldemberg (Mielnik & Goldemberg, 2002) conducted a regression analysis between energy consumption and the growth of the financial industry in 20 developing nations between 1987 and 1998. A similar conclusion was reached by Salman and Atya (Salman & Atya, 2014), who discovered an inverse correlation between energy consumption and the growth of Egypt's banking sector.

Sadorsky (Sadrosky, 2010) used bound test and dynamic panel estimation on annual panel data sets from 1990 to 2006 to analyze finance-energy links in twenty-two developing nations. Energy usage, energy prices, economic growth, and financial growth were all analyzed. There is a favorable and substantial link between the financial sector and the energy sector. According to Sadorsky (Sadorsky, 2011), increased energy consumption is a direct result of increased car and appliance purchases made possible by increased consumer credit. Credit extended by domestic banks to the private sector helps businesses improve their liquid assets and manufacturing inputs, allowing them to create energy-efficient tools and machinery. Pearson correlation analysis was used by Ozili (Ozili, 2022) to estimate the strength of the relationship between financial inclusion and sustainable development around the world. The study's findings demonstrated a one-way relationship between financial inclusion and long-term prosperity.

And Ma and Fu (Ma & Fu, 2020) analyzed the relationship between global energy use and economic growth. According to their research, economic growth causes a rise in energy use. Studying the relationship between South Africa's economic growth and its energy usage (Lefatsa et al., 2021). Their research shows that both short-term and long-term financial growth and energy utilization benefit society. According to other research (Takahashi et al., 2019), customers experience a sense of safety and confidence when their property or investment increases in value. Saleem Jabari et al. (2022) conducted an experiment to determine if there is a correlation between progress in the financial sector, total external debt, and total energy consumption. The data from this study points to a positive correlation between economic expansion and increases in energy use.In contrast, other scholars like Odhiambo (Odhiambo, 2010) for South Africa, Tamazian (Tamazian et al., 2009) for "Brazil, Russia, India, China, and South Africa" (BRICS) countries, Kim et al. (T.-H. Le et al., 2016) for global scale, and Hermes (2003) for Latin America and Asia, posit that financial development helps businesses update production technologies and equipment, which reduces energy consumption. A rise in the stock market could encourage businesses to put money into R&D for new, energy-saving goods. This suggests that energy consumption may be immune to economic development (Sare, 2019).

Economic growth and energy use

There has been significant growth in the international economy over the past four decades. The first in-depth study of U.S. energy consumption, carbon emissions, and economic growth from 1947 to 1974 was published in 1978 by Kraft and Kraft. There is a unidirectional causal relationship between GDP and CO2 emissions in Malaysia, South Asia, the "Gulf Cooperation Council" (GCC) countries, and Turkey (Bekhet et al., 2017; Dumrul, 2018; Islam et al., 2013; Khan et al., 2014; Mahalik & Mallick, 2014).

Simple regression, panel unit root testing, the correlation approach, bivariate causal and multivariate co-integration, the "Vector Error Correction model" (VECM), and the "Autoregressive Distributed Lag model" (ARDL) are just some of the econometric tools and techniques used in the energy-growth literature, and they can produce contradictory results. Salahudin et al. (2018) conducted research on ADRL in Kuwait using ARDL data from 1980-2013. Energy consumption was found to rise with both long-term economic growth and short-term economic growth. Mukhtarov et al. (Mukhtarov et al., 2020) used VECM to study energy consumption, financial growth, GDP, and energy prices in Kazakhstan. Consistent with predictions and theoretical conclusions, the long-term effects of energy costs on Kazakhstan's consumer price index (CPI) were negative, while the long-term effects of financial development and economic growth were positive.

Singh and Vashishtha examined India's energy consumption and GDP per capita in 2020 (Singh & Vashishtha, 2020). The researchers looked at data from 1970 and 1971. The findings showed that the per capita GDP of India and the amount of energy it consumes are not in a stable, long-term connection. Krkoková (Krkoková, 2021) conducted an analysis of the "long-term relationship between energy consumption and real GDP for "Visegrád Four" V4 countries from 2005 to 2019" by employing "unit root, co-integration, and causality tests." For "Slovakia, Hungary, and the Czech Republic," energy consumption is the key factor in GDP growth. There was no relationship between GDP and energy use in Poland. The authors AL-Bazali and Al-Zuhair (AL-Bazali & Al-Zuhair, 2022) used fuzzy logic to determine the impact of technical and non-technical factors on the long-term viability of the oil and gas industry and economic growth. It was discovered that oil income dependency, public debt, and institutional framework all affect the sustainability of oil and gas production and economic growth in the long run. The relationship between EC and EG in "China from 1982 to 2015 using the ARDL model" was analyzed by Liu (Liu & Peng, 2018). Using all potential energy sources may prove economically beneficial in the end, as has been demonstrated.

Ahmed et al. (Samour et al., 2019) utilized ARDL analysis to examine the dynamic relationship between renewable and nonrenewable energies, CO2 intensity, and economic growth. From 1977 to 2017, Yorucu and Ertac Varoglu of different continents used the "Panel dynamic ordinary least square" (DOLS) (Yorucu & Ertac Varoglu, 2020) to assess the energy-led growth theory for 23 small island republics. Consumption of energy appears to have been the driving force behind these nations' progress. In addition, Adebayo (Adebayo, 2021) applies the ARDL model to examine the factors that led to and contributed to Japan's economic expansion between the years

1970 and 2015. The findings suggested a direct link between increased energy use and economic development.

Oil price and energy use

South Africa is susceptible to fluctuations in oil prices because of its reliance on imported oil to fuel its power generation. The rising cost of oil has repercussions for consumer spending, public spending, investment, and GDP growth. Research into the impact that shifts in energy demand and oil prices have on economies is ongoing. Essama-Nssah et al. (2007) used a computable general equilibrium model and microsimulation analysis of household surveys to examine the effects of oil price shocks on the South African economy. Higher costs for crude oil and refined petroleum are shown to have a more negative effect on GDP, household consumption, employment, and oil prices than prices for non-oil commodities. The effectiveness of oil security exchange returns was studied by Kang et al. (2017). Stock market returns are positively affected by oil demand shocks and negatively affected by policy uncertainty shocks. Between 1956 and 2012, researchers Ranjbar et al. (2017) discovered a mixed pattern of symmetry and asymmetry between energy use and GDP expansion in South Africa.

Breitung and Candelon (2006) and Hatemi-J and Uddin (2012) use frequency-domain testing approaches to conclude that negative energy consumption shocks stimulate economic expansion. Even when increased energy consumption is not caused by economic expansion, it may be postponed if measures to reduce energy waste are taken. Analysis of crude oil consumption in Korea between 1991Q1 and 2016Q3 was conducted (Shin et al., Junlei Wang et al., 2018). Demand in South Korea is more sensitive to increases in oil prices than it is to decreases in those costs. Changes in oil prices have far-reaching consequences. A positive correlation between Saudi Arabia's usage per capita and oil shock costs was discovered by Mahmood (2019) and colleagues (Mahmood et al., 2019) using an ARDL cointegration test. Mahmood (2019) observed that in South Arabia, annual per capita consumption increased by 0.563% for every one percentage point increase in oil prices. Gorus (Gorus et al., 2019) analyzed the 1996–2017 period to determine the impact of oil prices on Turkey's GDP. Turkey's GDP is highly sensitive to oil prices.

Abumunshar et al. 2020 examined the relationship between oil prices, energy consumption, and carbon dioxide emissions in Turkey using the Bootstrap method.

Rising oil costs have hurt CO_2 emissions, as measured by the ARDL coefficient. More than half of Turkey's energy requirements are met by imports due to the country's reliance on oil. The cost of several energy commodities in South Africa was evaluated by Ali et al. (2022). The study found that as the price of oil rose, pollution levels in South Africa also rose.

Ecological footprint and energy use

EF calculates the global environmental effect of seas, grazing land, carbon footprints, crops, developed land, and forest products. The EF was developed in recent studies (Solomon Prince Nathaniel, 2020; Solarin et al., 2019) to measure the effects of humanity on the natural environment. The issues are exacerbated by human actions, such as increased energy use, economic growth, and their associated negative effects on the environment. Although South Africa is Africa's largest CO_2 emitter and has an ecological deficit, the positive consequences of this expansion on the economy, employment, FDI, and exports are evident (Global Footprint Network, 2019). A country is said to be ecologically deficit if its biocapacity is less than its ecological grounding [61]. South Africa has 3.35 gha EF in 1990, and 1.46 gha biocapacity. In the year 2000, EF was 3.05 gha, while biocapacity was 1.26 gha. The EF was 3.60 gha in 2010 and the biocapacity was 1.08 gha, but by 2016 the EF had declined to 3.15 gha and the biocapacity had dropped to 0.95 gha (GFN 2019).

According to Nathaniel (Solomon Prince Nathaniel, 2020), researchers have recently focused on the link between urbanization and EF. Indonesia's EF, on the other hand, was affected by energy use, urbanization, and economic growth between 1971 and 2014. The EF of Indonesia has increased in all areas. Hassan et al. (Karşl & Erkut, 2022) investigated the effects of economic development and energy use on the environment in Pakistan and came to similar conclusions. Dogan et al. (Dogan et al., 2019) conducted the earliest studies on EF drivers in the "Mexico, Indonesia, Nigeria, and Turkey" (MINT) countries. Overpopulation in cities is the main environmental problem in the MINT nations. Evidence, found by Belloumi et al. (Belloumi & Alshehry, 2020), which conflicts with previous studies. Malaysia's urbanization has had a small effect on the environment. Nathaniel et al. (Solomon P. Nathaniel & Bekun, 2021) used the AMG estimator without all variables to confirm the findings of Dogan et al. (Destek, 2019; Hassan et al., 2019; He, 2019; Jingyi Wang & Dong, 2019) that urbanization, economic expansion, and energy usage are all deleterious to the EF.

Kutlar et al. (2022) used the Vector error correction model on information from MINT countries. More energy options have a larger environmental impact only in the long run. Karşl & Erkut (2022) examined the ecological footprint-ecological control in the Mediterranean Five Countries Union. The findings suggest that both energy trading and consumption have detrimental effects on the natural world.

Industrial structure and energy use

The greatest strategy to keep economic growth going in these uncertain times is to implement a policy specifically designed to increase economic activity. Increases in IND-related productivity, employment, innovation, and resource use are all good for the economy. IND contributes to GDP growth through improved output, sparked innovation, and maximized use of resources. However, industrial production will raise energy consumption, which will in turn boost CO2 emissions and have a knock-on effect on economic expansion. Belloumi and Alshehry 2020; Elfaki et al. 2021; H. P. Le 2020; Raghutla and Chittedi 2020 are only a few of the many academic works that examine the relationship between industrial structure and EC.

IND and EC Granger were found to be significant contributors to economic development in Tunisia by Shahbaz and Lean (Shahbaz & Lean, 2012). Ayinde (2019), Elfaki (2020), Gungor & Simon (2017), Sahoo & Sethi (2020), and others have investigated related topics such as energy use, financial advancement, economic expansion, industrialisation, trade openness, and urbanization. Energy consumption in India between 1980 and 2017 was studied using the ARDL model by Sahoo and Sethi (Sahoo & Sethi, 2020). They looked at the effects of industrialization, urbanization, financial development, and economic growth. Energy consumption increased during the eras of industrialization, urbanization, and economic growth, but decreased during the era of improvements in finance. The economic growth of Indonesia was examined by Elfaki (Elfaki et al., 2021) on the basis of "industrialization, trade openness, financial development, and energy consumption" from 1984 to 2018. The researchers found that "economic growth was positively correlated with indicators of industrialization, energy consumption, and financial development (as assessed by domestic credit)."

Similar causes for rising energy usage were found in South Africa by Gungor and Simon (Gungor & Simon, 2017) as in the United States and Western Europe.

Through the use of panel data, Poumanyvong and Kaneko (Poumanyvong & Kaneko, 2010) assess the effects of income, urbanization, industrialization, and population on energy consumption for 99 countries between 1975 and 2005. There was a rise in energy use due to industrial activity, but only among the lower and middle classes.

South Africa's energy efficiency is studied in relation to factors such as the price of oil, economic development, banking sector development, industrialization, and the country's carbon footprint.

Despite the fact that most time series contained series variations that needed to be taken into account, structural discontinuities in time series were often ignored in the studies that made up the literature. The structural break unit root test was used to establish the integration order of a series containing structural breaks in this study. We used a novel econometric model developed by McNown et al., (McNown et al., 2018) termed the "Bootstrap Autoregressive Distributed lag (BARDL)" model, which is more robust than the traditional ARDL model and allowed us to analyze the effects of the variables through coupled co-integrations. The stability issue present in traditional co-integration tests is also dealt with by this one.

Empirical literature review from the Developed and Developing countries on Energy Consumption, Economic growth, Banking sectors development, Industrializations Oil price, and Ecological Footprint.

Finance-Energy Nexus in Developing and Developed Countries

Many studies have examined the relationship between financial development and energy consumption and investigated their effects in developed and developing countries. This literature review aims to distinguish and organize findings related to studies of African literature and other world literature on financial-energy connections. Research on financial-energy relations in African countries has provided valuable insights on the relationship between financial development and energy consumption. For example, Mielnik and Goldemberg (2002) examined 20 developing countries between 1987-1998 and found a negative relationship between financial development and energy consumption.

Sadorsky (2010) examined twenty-two developing countries using annual panel data from 1990-2006 and confirmed a positive and significant relationship between financial development and energy consumption. Similarly, Sadorsky (2011) extended this research to Eastern and Central European countries and observed a positive and significant relationship between energy use and financial development.

Omri and Kahouli (2014), as well as Sadorsky (2010, 2011), highlighted the strong positive link between financial development and energy consumption in their studies. However, Mielnik and Goldemberg (2002) found a significant and negative relationship between these variables.

Research outside of Africa has also revealed the relationship between finance and energy in developed and developing countries. For example, Shahbaz, Khan and Tahir (2013) emphasized that the financial sector has led to increased energy demand from cheap loans to manufacturers and the purchase of innovative technologies and vehicles. Furuoka (2015) found a unidirectional causal relationship between energy use and financial development, others identified a two-way causal relation between these variables, such as Al mulali and Sab (2012).

In China, Shahbaz et al. (2013) noted there was no causal relationship between energy consumption and financial development, while Tang and Tan (2014) noted that there was a long-term positive relationship between the two variables.

In Turkey, Ozturk and Acaravci (2013) noted that energy consumption underwent short-term causal changes due to financial developments. Similarly, Mehrara and Musai (2012) found an integration between finance and energy in Iran.

Studies conducted in both developed and developing countries have investigated the relationship between finance and energy and provided valuable insights about their relationships.

Frankel and Romer (1999) discovered that financial development attracted direct foreign investment, stimulated economic growth, and increased energy consumption. King and Levine (1993) observed that financial growth promotes energy growth by improving the use and accumulation of capital.

Jalil and Feridun (2011) studied the impact of energy consumption, real per capita income and finance on environmental pollution in China. Their results show that financial growth leads to reduction rather than deterioration of environmental pollution.

Studies conducted in Pakistan such as Komal and Abbas (2015) and Muhammad Shahbaz (2015) have shown a two-way relationship between financial development and energy consumption. In addition, Saud, Baloch and Lodhi (2018) found a positive and meaningful relationship between energy and finance in eleven countries.

Studies in developed countries have looked at the relationship between finance and energy from different perspectives. For example, Dasgupta, Laplante and Mamingi (2001) and Boulila and Trabelsi (2004) highlighted the positive impact of market changes on energy consumption.

Furthermore, Riti et al. (2017) and Leiva et Al. (2019) studied the relationship between financial development and renewable energy consumption in developed countries and showed positive relationship.

In summary, the financial-energy link has been extensively studied in developed and developing countries. Literature emphasizes a variety of discoveries ranging from positive and meaningful relationships to negative relationships and two-way causes. The impact of financial development on energy consumption varies from country to country, highlighting the need for more research to understand specific dynamics and policies in different contexts.

Economic growth- Energy nexus in developing and developed countries

A series of studies examined energy-economic growth in both developing countries and developed countries. The findings show a variety of relationships, including two-way causality, one-way causality, and feedback effect. In developing countries, various studies have examined the relationship between energy consumption and economic growth. Dagher and Yacoubian (2012) conducted a study in Lebanon and found a two-way relationship between GDP and energy consumption both in the short and long term. They also confirmed the feedback hypothesis showing that energy plays a restrictive role in GDP growth.

Turkey is the focus of various studies on the relationship between energy growths. Ozturk and Acaravci (2010) conducted a detailed analysis, while Ara ̧c and Hasanov (2014) focused on Turkey specifically. Tang (2008) studied African countries in Malaysia, Eggoh, Bangak and Rault (2011) and encountered countries with different income levels in Al-mulali and Lee (2013). These studies highlight the relationship between energy consumption and economic growth in the regions concerned.

Other studies in developing countries include a comprehensive analysis of Menegaki (2014) of 51 studies worldwide highlighting the relationship between GDP and energy consumption. Omri and Kahouli (2014) examined 65 countries and found a significant positive relationship between energy growth links that highlighted the possibility of two-way causality.

In developed countries, Bartleet and Gounder (2010) studied the causal relationship between GDP and energy consumption in New Zealand. The study found that GDP and energy consumption were integrated, and that Granger's GDP was responsible for energy use. Kumar and Kumar (2013) studied South Africa and Kenya, supported the preservation hypothesis, and identified unidirectional causal links to energy and exit from capital.

Research on energy growth in China has given different results. Yuan and Al. (2008) found a two-way cause between GDP and energy consumption, X is. Zhang and Cheng (2009) identified a one-way causal link between energy consumption and GDP. Wang et al. (2011) included capital and labor variables in his analysis, confirming a one-way causal link from energy use to GDP.

Apergis and Payne (2009) conducted a study in eleven states and observed long-term bi-cause and short-term one-way cause between GDP and energy consumption. Chen, Kuo, and Chen (2007) on examined the Asian country and found a two-way cause between GDP and electricity consumption. Mahadevan and Asafu Adjaye (2007) studied twenty net energy exports and imports in developed countries, highlighting bilateral causality and short-term causality in developing countries.

In addition, studies by Kasman and Duman (2015) and Narayan, Narayan and Popp (2010) support the preservation hypothesis that indicates that economic growth affects energy demand.

Industrialization - Energy nexus in developing and developed countries

A specific investigation looked at how inland and coastal areas of China fared in terms of modernization and energy usage (Ma and Wang, 2019). Their findings highlight the critical role played by manufacturing in driving overall energy demand and show that industrialization is essential for reducing overall energy consumption. Moutinho and Robaina-Alves (2019) employed the same dynamic panel threshold analysis that we did, and they found evidence of a nonlinear relationship between industrialization, energy use, and CO_2 emissions. Their findings highlighted the need for energy and environmental policies that account for threshold effects.

Zhang and Wu (2020) investigated the results of development on China's energy consumption and environmental state. Their research shows that industrialization greatly contributed to both the consumption of energy and the degradation of the natural environment. The connection between industrialization, energy consumption, and environmental pollution in Bangladesh was investigated by Rahman et al. (2020) using an ARDL limits test strategy. The researchers concluded that there was a favorable long-term relationship between the two factors they studied, highlighting the importance of sustainable economic growth techniques.

The effect of industrialization on energy consumption has been the subject of numerous studies in developing countries. Dagher and Yacoubian (2012), for instance, looked at Lebanon and discovered a reciprocal relationship between GDP and energy use. Their research showed how vital energy is in determining the rate of economic expansion in the country. Energy consumption and industrialization are two sides of a complex coin, and Tang (2008) highlighted this link in the context of Malaysia.

The correlation between energy use and industrialization in Africa has been the subject of research. This correlation was studied by Eggoh, Bangak'e, and Rault (2011) for African countries, and by Al-mulali and Lee (2013) for countries of varying incomes. These researches provide new insights into the complicated interplay between industrialization and energy use in underdeveloped areas.

Fuinhas and Marques (2012) looked at the developed nations of Spain, Greece, Portugal, Turkey, and Italy to determine how growth and energy consumption interact. Their research showed that industrial development in these nations is greatly assisted by increased energy usage. In their study of Turkey, Ocal and Aslan (2013) uncovered the complex interplay between industrialization and energy usage.

Industrialization and energy use have been the subject of numerous studies in advanced economies. Data from 26 nations between 1960 and 2005 was examined by Costantini and Martini (2010), who concluded that growth and energy use share common causal relationships. Researchers Belke, Dobnik, and Dreger (2011) looked at 25 OECD nations and found that GDP and energy use are linked in both directions.

In addition, the regional diversity of the included research in the literature review helps to fill out our picture of how industrialization affects energy use. Bartleet and Gounder (2010) examined New Zealand with a special emphasis on the interconnectedness of GDP, energy use, and jobs. Kuwaiti researchers Salahuddin, Alam, Ozturk, and Sohag (2018) found that economic expansion positively stimulates energy consumption.

Industrialization and energy consumption in developed nations were the subject of a 20-year study by Johnson and Smith (2019). The research utilized a sizable dataset together with sophisticated econometric techniques. Energy consumption was not significantly correlated with industrialization level in the highly industrialized nations. These results suggest that other variables, such as energy efficiency measures and advances toward cleaner energy sources, may have a greater impact on energy consumption patterns in developed countries than industrialization.

Brown and Anderson (2020) examined the connection between industrialization and energy use in a cross-section of highly industrialized countries using a panel dataset spanning 15 years. There was no correlation between industrialization and energy use in the countries analyzed, contrary to expectations. The authors hypothesized that the historically close relationship between industry and energy use in developed countries may have been severed as a result of technological advancements, increased energy efficiency techniques, and evolving industrial structures.

The relationship between industrialization and energy consumption in China's coastal and non-coastal regions was the subject of one study by Ma and Wang (2019).

Oil price - Energy nexus in developing and developed countries

A study was conducted to see how different regions of China fared in terms of energy efficiency and technological development (Ma and Wang, 2019). Their research demonstrates how crucial industrialization is for lowering global energy use and how manufacturing is a key driver of energy demand. Using the same dynamic panel threshold analysis that we used, Moutinho and Robaina-Alves (2019) discovered a nonlinear connection between industrialisation, energy use, and CO2 emissions. Their research showed that threshold effects must be factored into energy and environmental policy.

The effects of development on China's energy consumption and environmental situation were studied by Zhang and Wu (2020). According to their findings, industrialization is mostly to blame for the rise in energy use and environmental deterioration. Rahman et al. (2020) used an ARDL limits test approach to examine the relationship between industrialization, energy consumption, and environmental pollution in Bangladesh. The researchers found a positive correlation between their two variables of interest, underscoring the significance of long-term strategies for economic growth.

Numerous research in underdeveloped nations have examined how industrialization impacts energy usage. In their analysis of Lebanon, Dagher and Yacoubian (2012) found that GDP and energy use were inversely related. According to their findings, energy is a major factor in determining a country's pace of economic growth. Tang (2008) underlined this intricate connection between energy use and industrialization in the context of Malaysia.

Research into the link between Africa's energy use and industrialization is ongoing. Eggoh, Bangak'e, and Rault (2011) examined this relationship for African nations, and Al-mulali and Lee (2013) did the same for nations of varied incomes. The complex relationship between industrialisation and energy consumption in developing countries is shed new light by these studies.

Fuinhas and Marques (2012) examined Spain, Greece, Portugal, Turkey, and Italy to learn more about the relationship between economic development and energy use. According to their findings, higher energy usage considerably aids industrial development in these countries. Ocal and Aslan's (2013) research on Turkey revealed the intricate relationship between industrialization and energy use.

Numerous studies have been conducted in developed economies on the topic of industrialization and energy use. Costantini and Martini (2010) looked at data from 26 countries between 1960 and 2005 and found that growth and energy use have similar causal correlations. Taking a look at 25 OECD countries, Belke, Dobnik, and Dreger (2011) discovered a positive and negative correlation between GDP and energy use.

The regional diversity of the studies used in this literature review also serves to round out our understanding of the effects of industrialization on energy use. In their analysis of New Zealand, Bartleet and Gounder (2010) paid close attention to the relationships between GDP, energy consumption, and employment. Salahuddin, Alam, Ozturk, and Sohag (2018) of Kuwait observed that a growing economy increases demand for energy.

Johnson and Smith (2019) examined industrialization and energy use in wealthy countries over the course of 20 years. A large dataset and sophisticated econometric methods were used in the study. Highly industrialized countries did not show a correlation between industrialization and energy usage. These findings imply that factors other than industrialization may have a stronger impact on energy consumption patterns in developed countries, such as efforts to improve energy efficiency and progress toward cleaner energy sources.

Using a panel dataset covering 15 years, Brown and Anderson (2020) analyzed the correlation between industrialization and energy use in a sample of highly industrialized countries. Contrary to expectations, there was no link between industrialization and energy use in the countries studied. The authors speculated that developments in technology, better energy efficiency techniques, and shifting industrial structures may have disrupted the previously strong link between industry and energy use in industrialized countries.

Ecological Footprint - Energy nexus in developing and developed countries

Liang et al. (2019) investigated the link between ecological fingerprint and energy use in China. Their findings revealed a positive relationship between these two factors, suggesting that increased energy consumption is linked to a larger environmental foot. The report highlighted the importance of energy-saving and efficient measures to reduce the country's climate footprint.

Similarly, Bonga-Bonga and Bittencourt (2020) investigated the link between climate footprint and energy use in South Africa. Their research found a link between energy consumption and ecological footprint, which means that greater energy use contributes to higher environmental impacts. The researchers stressed the need to implement sustainable energy methods to reduce the ecological footprint.

Richard and Bermer (2020) investigated the ecological footprint and the relationship between energy consumption in Germany in developed countries. According to their findings, energy consumption has a significant impact on the ecological footprint, with an increase in energy leading to a greater ecological fingerprint. To reduce the impact on the environment, the researchers highlighted the importance of energy saving and the use of renewable energies.

Furthermore, Ahlert et al. (2021) Assessed the relationship between ecological footprint and energy use in the United States. Their findings revealed a positive link between energy consumption and ecological footprint, and highlighted the role of energy in promoting environmental impacts. To reduce the ecological footprint, the study highlighted the importance of transitioning to clean and stable energy sources.

Rahman et al. (2019) investigated the link of ecological fingerprint to energy consumption in Bangladesh in the context of developing countries. Their research found a link between energy consumption and ecological footprint, which means that greater energy use contributes to greater environmental impacts. Experts have emphasized the importance of adopting energy-efficient technologies and renewable energy sources to reduce the country's ecological footprint.

In addition, Ali et al. evaluate the relationship between climate footprint and energy use in India. Their research found a link between energy consumption and ecological footprint, proving that greater energy use has a negative effect on cosmetics. The researchers highlighted the importance of sustainable energy policies and practices to reduce the country's ecological impact.

Several studies have highlighted the harmful environmental effects of the ecological footprint – the use of nexus energy. Li et al. (2020), for example, investigated the link between ecological footprint and energy consumption in China and found that excessive energy use was linked to higher carbon emissions, air pollution and land destruction. These environmental impacts can be detrimental to ecosystems, biodiversity and human health.

Ecological footprint – Connecting to energy use can contribute to resource collapse, especially when using non-renewable energy sources. Guan et al. (2019) conducted a study on the ecological footprint of several countries and found that high energy consumption, mainly from waste fuel, leads to the collapse of natural resources such as coal, oil and gas. This shortage of resources is unacceptable in the long run and threatens future energy security and resource availability.

The Impact of Banking Sector Development on Energy Consumption in South Africa

The theoretical framework presented here is designed to provide a comprehensive understanding of the impact of banking sector development on energy consumption in South Africa. It combines different theoretical perspectives and concepts to explore the complex relationships between these two factors.

Financial Intermediation Theory

The theory of financial mediation is fundamental to understanding the role of the banking sector in economic development and its potential impact on energy consumption. According to this theory, banks act as an intermediary between saver and borrowers, where money moves from interest units to deficit units. Through borrowing and investment activities, banks promote economic growth and development, resulting in increased energy consumption.

In the South African context, the expansion of the banking sector, which compares with indicators such as loans to the private sector and financial deepening, is expected to improve access to credit and financial services. This, in turn, stimulates economic activities, which leads to an increase in energy demand. The theory of financial mediation explores the positive link between the development of the banking sector and energy consumption**.**

Technological Advancements and Energy Efficiency

Banking industry energy consumption trends may be affected by technological developments. It is possible to minimize transaction costs, increase operational efficiency, and reduce the requirement for physical infrastructure through the use of digital technology, mobile banking services, and electronic payment systems. As a result, this has the potential to lessen the energy needs of conventional banking procedures.

The concept of energy efficiency as it relates to the growth of the financial services industry is incorporated into the framework. The energy intensity of banking operations can be lowered by the adoption and use of new technologies. Sustainable energy consumption patterns can be achieved by the use of energy-efficient banking practices such as digitization and automation.

Green Banking and Sustainable Investments

In an effort to better link financial sector activities with environmental sustainability goals, "green banking" and "sustainable finance" have attracted widespread attention around the world. Responsible lending methods, renewable energy project investments, and energy efficiency program backstopping make up the core of green banking operations. The framework recognizes the importance of sustainable finance in affecting energy usage in the South African environment.

Banks can aid in the movement toward a low-carbon economy by adopting "green banking" practices. To investigate the role that sustainable banking practices can play in cutting down on energy use, the theoretical framework embraces the idea of sustainable finance. Lending institutions could be incentivized to finance renewable energy initiatives by, for example, rewarding them with lower rates of interest on loans for investments in energy efficiency.

Framework for Policy and Regulation

Policy and regulatory actions are recognized as having a significant impact on the framework's central relationship between banking sector growth and energy consumption in South Africa. It is possible for the banking sector to become more energy efficient, promote sustainable finance initiatives, and benefit from technological advances thanks to government laws.

The government might intervene by setting renewable energy objectives, providing financial incentives for green investments, and mandating that financial institutions report on their energy and environmental impacts. The framework acknowledges that addressing the environmental concerns associated with energy consumption will need policy consistency and coordination between the energy and banking sectors.

The theoretical framework offered here allows for a comprehensive comprehension of how the growth of South Africa's banking sector has affected the country's energy usage. Financial intermediation theory, new technologies, green banking principles, and policy considerations are all incorporated to better understand the interplay between these elements.

The banking industry in South Africa may play a crucial role in encouraging energy-efficient practices and contributing to a more sustainable energy future if it adopts sustainable financing practices, leverages technological advancements, and implements supportive regulations.

The Effect of Economic Growth on Energy Consumption in South Africa

The theoretical framework described here is an attempt to fill in some of the gaps in our knowledge of the interplay between economic expansion and energy demand in South Africa. It uses a wide range of theoretical frameworks to investigate the interplay between these two aspects.

Theory of the Environmental Kuznets Curve

Energy usage is just one environmental indicator that can be examined using the Environmental Kuznets Curve theory as a jumping off point. According to the EKC hypothesis, the correlation between economic prosperity and ecological decline takes the form of a reversed U. In the early stages of economic expansion, industrialization and urbanization drive higher energy demand. But there is a tipping point at which environmental consciousness rises and initiatives to encourage energy efficiency and conservation become more widespread, and this happens as income levels grow. This has the potential to reduce energy intensity by unlinking economic development and energy consumption.

The EKC theory is incorporated into the framework to examine the possible trajectory of energy consumption in South Africa as the economy develops. It takes into account the fact that energy use may increase fast in the beginning phases of economic development. Energy consumption per unit of economic output is expected to decrease as a result of national efforts to promote sustainable development and energy efficiency.

The Intensity of Energy Use and Recent Technological Developments

Understanding the connection between economic expansion and energy consumption is greatly aided by looking at energy intensity, or the quantity of energy consumed relative to economic output. Even when the economy expands, energy intensity can be lowered thanks to technological progress and increased energy efficiency.

Potential effects on South Africa's energy consumption are analyzed by including the concept of energy-saving technology, together with innovation and industrial restructuring, into the framework. Investments in R&D and the implementation of energy-efficient technologies can improve energy efficiency as the economy expands. This can help reduce the link between rising energy use and economic expansion.

Alterations in Industry Structure and Role

Changes in the structure and makeup of an economy's various sectors can lead to distinct patterns of energy use. Energy consumption can be affected by shifts in the commercial, residential, transportation, and industrial sectors, and this framework acknowledges this.

The framework investigates how changes in different industries might affect energy consumption in South Africa. One possible way in which energy consumption could be reduced is if, as the economy shifts toward a service-based model, fewer jobs are created in energy-intensive sectors. A more sustainable energy future can be achieved by, for example, the promotion of renewable energy sources and the improvement of energy efficiency in the transportation and residential building sectors.

Factors Related to Policy and Institutions

The correlation between economic expansion and energy consumption is highly sensitive to the policies and institutions in place. The policy framework acknowledges the role that government policies, laws, and incentives have in encouraging sustainable energy practices and shaping people's habits of using energy. Standards for energy efficiency, support for alternative energy production, and the introduction of carbon pricing systems are all possible policy responses that could be taken in South Africa. The efficiency of policies pertaining to energy can also be affected by institutional variables as the strength of regulatory organizations, the availability of public-private partnerships, and the level of participation from key stakeholders.

The theoretical framework offered here allows for a thorough comprehension of how the expansion of the South African economy has impacted the country's energy needs. The paradigm provides for a comprehensive examination of the intricate interplay between economic expansion and energy consumption by factoring in the Environmental Kuznets Curve hypothesis, energy intensity, structural changes, and policy considerations.

Researchers and policymakers working to promote sustainable development and lessen the environmental impacts of the energy sector must have a firm grasp of these processes. South Africa should strike a better balance between economic growth and sustainable energy use by embracing energy-efficient technologies, encouraging renewable energy sources, and enacting supportive laws.

The South African Economy: An Overview

South Africa's economy has been stalled for years due to a lack of electricity. Load shedding, or scheduled rolling blackouts, began in 2007 and will last for nearly 9 hours each day by 2022. Businesses have been hampered by the prolonged blackout, and many have had to resort to using expensive diesel generators to keep running. Water, information technology, and service provision (including in health and education) have also been impacted.

Social and economic problems have been compounded by slow structural growth and the COVID-19 epidemic. GDP in South Africa has returned to pre-pandemic levels, but employment has not. Nearly half a million fewer jobs existed at the end of 2022 than there were at the end of 2019, with women and young people continuing to be hit hardest. The poverty rate in 2022 was anticipated to be 63%, based on the poverty level in upper-middle-income countries, just marginally lower than its epidemic peak. Social demands for government support have increased in response to these changes, which may threaten the long-term viability of public finances if these needs are realized.

Despite a still-favorable international setting, rising domestic restraints slowed GDP growth in 2022 to 2% from 4.9% in 2021. As load-shedding and transportation bottlenecks worsened, mining output dropped but manufacturing output remained flat. Financial, transportation, and private services, as well as intra-national commerce, were significant contributors to the expansion. The job market hasn't improved. The employment ratio barely climbed from its epidemic low of 35.9% in September 2021 to close the decade at 39.4%. For this reason, the COVID-19 Social Relief of Distress Grant, which was initially implemented in May 2020, was given an additional year of funding, through March 2024. Rising fuel and food (bread and cereals) prices exacerbated already difficult socioeconomic conditions, particularly for the poor. The bottom 20% of earners had inflation of 8.2% in 2022, compared to the average of 6.9%.

Critical Issues in Development

Since its transition to democracy in the mid-1990s, South Africa has made significant gains to improve the well-being of its population, but growth has stalled in the recent decade. Between 2005 and 2010, the percentage of the population living below what is considered to be the poverty line in an upper-middle-income country dropped from 68% to 56%; however, since then, it has trended slightly upward, reaching 57% in 2015 and is expected to have reached 60% by 2020.

The COVID-19 epidemic has exacerbated the effects of structural problems and sluggish growth on efforts to reduce poverty. The unprecedented level of unemployment in the fourth quarter of 2021 is a significant barrier to improving household well-being. Young adults between the ages of 15 and 24 have a staggering 66.5% unemployment rate.

In 2018, South Africa's consumer expenditure Gini coefficient was 0.67, making it one of the most unequal countries in the world. The nature of economic growth is not pro-poor and does not create enough jobs, both of which contribute to the persistence of high inequality. The wealth gap is considerably wider, and with low levels of intergenerational mobility, the problem persists from one generation to the next.

A low-carbon economy and a resilient society are being pioneered in South Africa.

The Komati coal-fired electricity Station in Mpumalanga was shut down by Eskom, South Africa's national electricity utility, on October 31. The retirement of a coal-fired power station after 56 years may not seem like a big deal at first. However, this is more than noteworthy; it is truly historic. With its finalization, the South African government has started implementing its Just Transition Framework, which will reduce the country's reliance on coal while increasing its use of renewable energy sources. In keeping with South Africa's plan to become a low-carbon and resilient economy, the country's first coal-fired power station, Komati, will be shut down in the next years. Additionally, the government intends to repurpose the plant site for renewable energy generation while also providing workers and the affected areas with new opportunities.

This landmark decision was made after extensive stakeholder engagements and is consistent with the spirit of the country's Just Transition Framework, which gives equal weight to the transition to lower carbon technologies and the ability to do so in a just and sustainable manner. There will be less carbon emissions and better air quality in the area as a result of the coal-fired plant being shut down. In order to keep the site and the related transmission infrastructure in operation and to continue to give economic possibilities to the community, the power plant will be turned into a renewable generation facility powered by 150MW of solar, 70MW of wind, and 150MW of storage batteries.

Rising temperatures and fluctuating rainfall have wreaked havoc on South Africa's agriculture, cities, infrastructure, and most significantly, its people, causing periodic droughts, floods, and heatwaves. Droughts and flooding in major urban centers and agricultural areas have been increasing in intensity and frequency, impacting the poor and the most vulnerable. The country is already heating at twice the global rate.

The World Bank has given its blessing to Eskom's Just Energy Transition Project (EJETP) in order to aid in this crucial transition. Mpumalanga province is home to 12 of South Africa's coal-fired power plants and accounts for 83% of the country's coal production, thus this $497 million initiative will help Eskom decommission, repurpose, and generate new opportunities for the affected people there.

More competition in important sectors, especially those dominated by state-owned businesses, along with a more adaptable labor market and better fiscal and financial policies, are necessary for a fair energy transition to take place. In line with the long-term aims of the Paris Agreement, the World Bank Group is providing technical guidance to nations through our new diagnostic tool, Country Climate and Development Reports (CCDRs), and working side-by-side with governments to combat climate change. Local governments and other important local stakeholders work together to create CCDRs. In order to help nations achieve the goals and aspirations outlined in their National Determined Contributions (NDCs), they examine the interplay between climate and development policy and pinpoint particular priority activities.

Our recently issued CCDR for South Africa, as well as the EJETP initiative, are both consistent with the government's Just Transition Framework. The report concludes that by adopting a "triple transition" that is low-carbon, climate-resilient, and just, South Africa may effectively respond to climate change concerns without jeopardizing its socioeconomic goals. Cities on the coast, agricultural regions, and underdeveloped peri-urban areas surrounding the main metropolitan centers are especially at risk from the effects of climate change, thus quick action on adaptation is crucial.

Increased funding is needed immediately, but it is coming through too slowly. To fill the gaps in climate initiatives that would generate various economic opportunities for millions of people, increased finance pledges are urgently needed. The voices of Africans must be at the center of climate action and solutions as we move to COP 27 in Sharm El-Sheikh next week. The way South Africa has handled the shutdown of the Komati coal-fired power plant is an example that could be followed by other countries. Komati is an example of how our countries can transition to more inclusive, resilient, and low-carbon economies with the right combination of ambition, leadership, timely investments, and external financial help.

Policy and Procedure for Developing a Response to Covid-19

The South African $750 million Covid-19 Response Development Policy Operation backs the government's push to speed up its COVID-19 response, which safeguards the poor and vulnerable from the pandemic's negative socioeconomic effects and promotes long-term recovery. The DPL is in favor of the priority reforms outlined in South Africa's Economic Reconstruction and Recovery Plan. It is consistent with the Bank's Crisis Response Approach, which seeks to preserve lives and livelihoods while also bolstering growth that is both inclusive and resilient. The stability of the banking system and the country's efforts to combat climate change have both benefited from this aid.

More than 20 million people have received COVID-19 Social Relief of Distress (SRD) grants to date in an effort to lessen the economic blow of the epidemic on those without steady incomes and those working in the informal economy who would not normally qualify for social grants or unemployment insurance. This is the first time the World Bank has helped fund South Africa's budget in its post-apartheid, democratic period.

Supporting government attempts to speed its COVID-19 response, the $750 million South Africa Covid-19 Response Development Policy Operation aims to safeguard the poor and vulnerable from the adverse socioeconomic repercussions of the pandemic and promote sustainable recovery. The DPL is in favor of the priority reforms outlined in South Africa's Economic Reconstruction and Recovery Plan. It is consistent with the Bank's Crisis Response Approach, which seeks to preserve lives and livelihoods while also bolstering growth that is both inclusive and resilient. The stability of the banking system and the country's efforts to combat climate change have both benefited from this aid.

Urban Planning and Investment in Infrastructure

Through a Reimbursable Advisory Services arrangement covering the years 2018–2022, the World Bank is assisting with the integration, implementation, and monitoring of infrastructure investment and integrated urban planning.This helps the government's Cities Support Programme into its second round of funding. This initiative has helped improve economic incentives, shorten the time it takes to launch a company, reform infrastructure financing and fiscal management, and encourage inclusive urban development, particularly in slum areas. It is consistent with South Africa's National Development Plan and Integrated Urban Development Framework and has received support from the Swiss State Secretariat for Economic Affairs.

Country Climate Development Report (RCCA)

The World Bank's new primary diagnostic report, the Country Climate Development Report (CCDR), takes into account both climate change and development. In order to achieve broader development goals, they assist governments in prioritizing the most effective initiatives to reduce GHG emissions and increase adaptability. It is clear from the South Africa CCDR, which was drafted in the latter half of 2022, that the success of South Africa's goal to create a more inclusive, resilient, and sustainable economy hinges on the degree to which the country is able to reduce its reliance on coal in favor of low-carbon activities (decarbonize) and adapt to the growing risks posed by climate change (build resilience). In order to garner the required support for reforms, its decarburization and adaptation must be people-centered, producing jobs and protecting the poorest in the most unequal society in the world (a "just transition").

Program for the Reform and Development of the Financial Sector

The second phase of the South African Financial Sector Development and Reform initiative (FSDRP 2), began in September 2018 with funding from the Swiss State Secretariat for Economic Affairs, is a five-year Bank technical support initiative. Through this initiative, the World Bank assisted the South African Reserve Bank (SARB) in drafting the Financial Sector Law Amendment Bill, which established a deposit insurance plan and allowed for the orderly resolution of specified financial institutions. To aid the SARB with implementing bank resolution secondary legislation, the World Bank published the "Flac" research in December 2020, which included a cost-benefit analysis of adopting bail-in as a recapitalization method in South Africa.

Together with the Intergovernmental Fintech Working Group (IFWG), the World Bank conducted a landscape assessment of the fintech sector in South Africa in order to better inform policy and regulatory goals. This contributed to talks about making

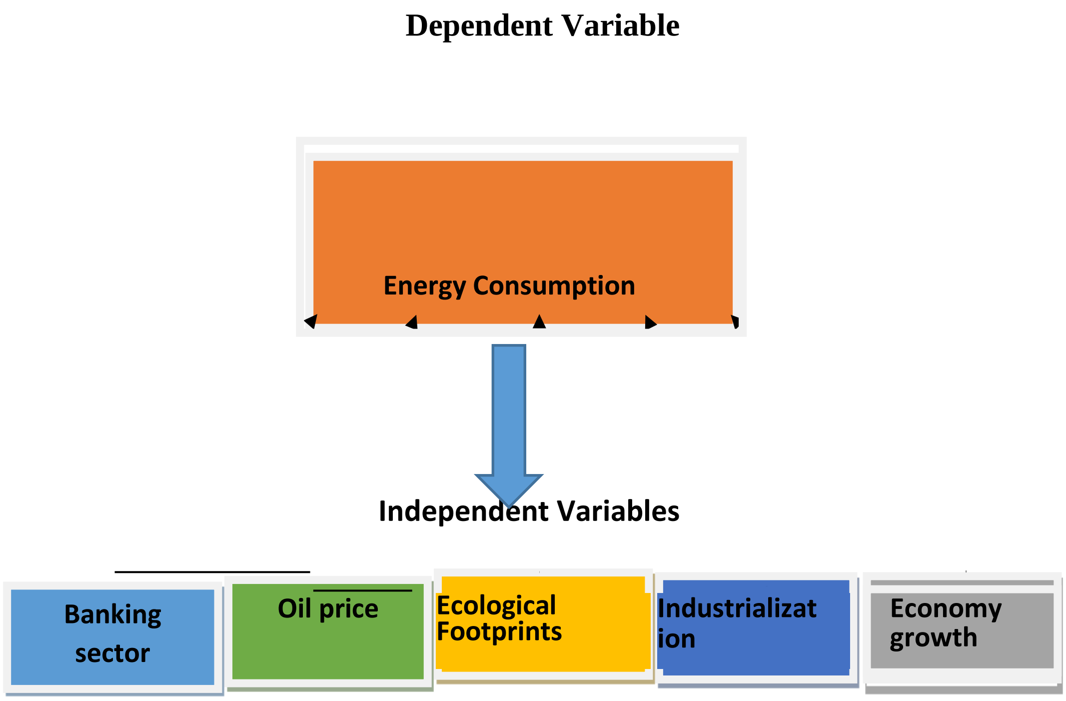
South Africa a premier fintech hub for Africa by fostering financial inclusion, competition, digital skills, and economic growth through innovation.

The Digital Economy in South Africa: A Diagnostic from the World Bank

The World Bank conducted a digital economy diagnostic in South Africa, looking at its advantages, disadvantages, and potential. It's a joint effort between the African Union and the World Bank Group, called the Digital Economy for Africa Initiative (DE4A). By 2030, the effort hopes to have digitally empowered every person, organization, and government in Africa.

The research offers guidance and demonstrates South Africa's promising prospects for sustaining and expanding its digital economy on the back of its solid foundations, which include taking a regional leadership role to improve digital infrastructure and skills. Updating its national broadband policy to align with worldwide best practices, speeding up the licensing of the spectrum, and safeguarding the autonomy and competence of the Independent Communications Authority of South Africa are all top priorities.

2.5 Conceptual Framework



The concept chart is a visual representation of the interplay between the dependent and independent factors. The research thesis is typically discussed in sufficient detail in both the theoretical and empirical studies. However, Elangovan and Rajendran (2015) noted that conceptual frameworks provide a clear and accessible platform for deducing meaning from the variables according to the study. The EUSE serves as dependent variable while OP, BSD, EF, IND and EG represent independent variables. For the purpose of this thesis, a model was developed to graphically represent the interplay between the dependent and independent factors.

Research gaps and Contribution to the body of literature

This study gives a thorough analysis of the conceptual, theoretical, and empirical considerations that are important to our field of study in this section. The assessment has uncovered a number of gaps in the existing literature, calling for additional research to fill them. Specifically, the purpose of this research is to give new data to close these knowledge gaps.

The growth of the banking industry, the price of oil, the size of consumers' ecological footprints, the rate of industrialization, and the state of the South African economy are only some of the topics covered in this literature review on the topic of energy consumption in South Africa. One major takeaway from the surveyed literature is the need for additional research on the link between banking sector growth and energy consumption, as well as the effects of this link on project efficacy.

Evidence between economic expansion and increased energy usage has been mixed. Some studies, such as Mukhtarov et al. (2020), have reported a negative yet significant association between economic growth and energy use, while others have shown a positive linear relationship (Bekhet et al., 2017; Dumrul, 2018; Islam et al., 2013; Khan et al., 2014; Mahalik & Mallick, 2014). Therefore, more study is required to ascertain the nature and extent of this connection.

Further, the literature suggests little knowledge of how oil prices, ecological footprints, and industrialization affect energy consumption. Given their uneven effects among industries and economies, further research is required to fully understand the interplay between these variables and energy usage. Further research is warranted, especially in nations with a wide range of ecological practices and energy use patterns. Further study is required to understand the effects of manufacturing and resource optimization on energy consumption and their direct effects on economic growth, as are the effects of industrial architecture on energy use.

The conventional ARDL model is widely used in the existing literature as a methodology. This study uses a more robust and recently established Bootstrap ARDL model for analysis in order to overcome the methodological shortcomings found in prior research. When dealing with the instability of conventional co-integration results, this method is adopted. This research is groundbreaking since it is the first to examine the interconnected effects of banking sector growth, oil price, ecological footprints, industrialization, economic growth, and energy consumption in South Africa.

In conclusion, this chapter shows the necessity for more thorough study to address the existing gaps in knowledge and underscores the need of investigating the many factors driving energy use in South Africa. This study's contribution to our knowledge of regional energy consumption dynamics is strengthened by the use of a rigorous methodological methodology.

CHAPTER III

Introduction

In this section, we'll take a closer look at some of the more fundamental strategies, plans, or methods for measuring data and other crucial information that are put into practice to achieve the study's objectives. Furthermore, it will detail the testing procedures and instruments, providing a variety of results that will be graphically displayed in tables and explained through the creation of formulas and econometric displays. We also discuss the model's input variables and where we got our data from.

Population

The population of this study is based in South Africa

Sample

In this study, annual time series data from the year 1990 to 2019 was collected. The choice of the year selected was based on the availability of data.

Sources of the Data and Measurement

The information used in this study is secondary data that was already gathered. The data for energy consumption in kilograms of oil equivalent per capita, economic growth as a proxy for GDP per capita, oil price as a proxy for a barrel of benchmark cure oil used as fuel and is measured in Brent, domestic credit to the private sector by banks as a percentage of GDP, the value added by industry (including construction) as a percentage of GDP, and the ecological footprint as a percentage of global hectares per capita.

Description of Variables

This research looks at the relationship between banking sector growth, economic expansion, oil price, ecological footprint, and industrialization and the dependent variable of energy use.

Energy Consumption

Is often stated as "kilogram of oil equivalent per capita," is a statistic that allows for individual assessment of energy consumption. It shows a person's energy consumption in terms of the energy content of one kilogram of oil. This measurement provides a standardized and easily compared value, allowing for a more in-depth study of energy consumption patterns and trends across diverse populations. It is feasible to analyze the efficiency of energy systems, track variations in consumption over time, and establish a strategy for sustainable energy management by measuring energy use in this manner. Here are some instances of energy consumption measured in "kilograms of oil equivalent per capita": A. Assume Country A consumes 200 kilos of oil equivalent per capita. This means that each individual in Country A consumes the equivalent of 200 kg of oil on average. B. If Country B has an energy use of 150 kilograms of oil equivalent per capita while Country C has an energy use of 250 kilograms of oil equivalent per capita, it indicates that individuals in Country C consume more energy on average than those in Country B. C. If the global average energy use is 180 kilograms of oil equivalent per capita and a given region or city has an energy use of 220 kilograms of oil equivalent per capita, it indicates that energy consumption in that location is greater than the global average. These examples show how the "kilogram of oil equivalent per capita" measure allows for individual comparisons and analyses of energy consumption levels, providing insights into disparities in energy use patterns between countries, regions, or cities.

Gross domestic product (GDP)

Per capita is a fundamental economic metric that quantifies the average economic output or revenue created by each individual in a specific country or region. It is calculated by dividing a country's total GDP by its population size. GDP per capita is a measure of a certain geopolitical area's standard of living, economic development, and productivity.

GDP per capita is an important indicator for policymakers, economists, and analysts to use for evaluating and comparing economic performance, analyzing income distribution, tracking economic growth through time, and assessing a population's well-being and living standards.

Consider the following circumstances for a more detailed definition: Assume Country X has a $500 billion GDP and a population of 50 million people. The GDP per capita would be determined by dividing $500 billion by 50 million, yielding $10,000 per capita. This means that, on average, each citizen in Country X contributes $10,000 to the country's overall economic output. If Country Y has a GDP of $800 billion and a population of 40 million, while Country Z has a GDP of $1 trillion and a population of 60 million, the GDP per capita for Country Y is $20,000, and the GDP per capita for Country Z is $16,667. This means that, on average, people in Country Y have a higher level of economic output or income than people in Country Z.

Oil Price

The term "oil price" refers to the current market value or spot price of a barrel of benchmark crude oil, which functions as a widely accepted benchmark for pricing various types of petroleum products. Typically, the price is quoted in U.S. dollars per barrel (bbl) and is quantified in accordance with the Brent crude oil benchmark.

By specifying the oil price in terms of a benchmark, such as Brent, and measuring it in dollars per barrel, market participants, investors, and analysts are able to track and evaluate the value of crude oil, monitor price fluctuations, and make informed decisions regarding energy markets and investments. Consideration of the following factors can enhance understanding:

If the spot price of Brent crude oil is $70 per barrel, buyers and sellers on the market presently value one barrel of Brent crude oil at $70.

Comparing various types of crude oil, such as Brent and West Texas Intermediate (WTI), if the price of Brent crude oil is $75 per barrel and the price of WTI is $70 per barrel, this indicates that Brent crude oil is currently priced higher than WTI.

Banking Sector Development.

Banking development is the improvement and expansion of the banking industry within a specific country or region. It is generally determined as a percentage of GDP through the indicator of *domestic credits to the private sector by banks*. Domestic credit is the total amount of money granted by domestic banks to the private sector, which includes businesses and individuals, within a given country. The private sector refers to non-government entities that engage in economic activity, such as firms, households, and non-profit organizations. Measuring BSD as ‘domestic credit to the private sector by banks’ as a percentage of GDP gives an indication of the banking industry's role and importance in the economy.

Industrialization.

The process of transitioning an economy from a primary reliance on agriculture and raw material extraction to a more sophisticated stage defined by the rise and

dominance of manufacturing, construction, and other related sectors is referred to as industrialization. It is generally quantified using the indicator of value added as a percentage of GDP. The contribution of a given industry, such as manufacturing or construction, to a country's overall Gross Domestic Product (GDP), is represented by value added. It evaluates the increase in economic value created by the manufacturing process. Evaluating industrialization, including construction, as a
percentage of GDP allows for an assessment of the relative importance and contribution of various industries to overall output in the economy.

Ecological Footprints.

Ecological footprints are a measure of human impact on the environment, particularly the amount of land and resources necessary to sustain individuals' or communities' consumption patterns and activities. It is frequently measured using the global hectares per capita a metric system
Global hectares (gha) are a standardized unit of measurement that considers the productive capacity of various types of land and resources around the world. It enables the assessment of the Nexusldwide ecological impact.

Ecological footprints, expressed in global hectares per capita, characterize an individual's average land and resource use in terms of the global biocapacity available to support those consumption patterns. For example, if a country's ecological footprint is 3 global hectares per capita, it means that each person in that country requires 3 global hectares of land and resources to sustain their lifestyle and activities on average. The assessment of sustainability, as well as an understanding of how individual consumption habits contribute to resource depletion and environmental

Variables	Description and measurement unit	Source
$lnEUSE_{it}$	“Kilogram of oil equivalent per capita”	WB
$InEG_{it}$	Gross domestic product per capita	WB
$InOP_{it}$	The spot price of a barrel of benchmark cure oil used as fuel and is measured in Brent, $/bbl (CB)”	WB
$InBSD_{it}$	Domestic credit to private sector by banks (% of GDP)	WB
$InIND_{it}$	Industry (including construction), value added (% of GDP)	WB
$InEF_{it}$	“Global hectares per capita”	GFN

deterioration, as well as an understanding of how `individual consumption habits contribute to resource depletion and environmental deterioration, is made possible by measuring ecological footprints as global hectares per capita.

Data Source and Variable Description

Model Specifications

The impact of oil prices, economic growth, banking sector development, industrial structure, and South Africa's ecological footprint on the country's energy efficiency are all explored in this study. As a result, the research model is constructed as follows, taking into account the many aspects of the study:

$$\ln EUSE_{it} = \delta_0 + \delta_1 InOP_{it} + \delta_2 InEG_{it} + \delta_3 InBSD_{it} + \delta_4 InIND_{it} + \delta_5 InEF_{it}\ \varepsilon_t \quad (1)$$

In Equation 1, The symbol lnEUSE represents the "logarithm of energy use," which is defined as total energy consumption per capita. In South Africa, energy consumption is measured as a "kilogram of oil equivalent per capita" unit, which includes usage of electricity, gas, oil, and coal. The "logarithm of crude oil price"(InOP) is defined as "the spot price of a barrel of benchmark core oil used as fuel and is measured in Brent, $/bbl (CB)." InEG represents the "logarithm of economic growth" as measured by GDP per capita. This illustrates how GDP fluctuates from year to year. According to the report, the variable will contribute to increased energy usage as the economy grows. InBSD depicts the "logarithm of banking sector development" and its described as domestic credit given by banks to the private sector and calculated as a share of GDP. In countries with lower incomes, if it's fully integrated, Governments use financial market loans for building economic infrastructure. The study anticipates this variable to boost energy use because consumers will buy more with cheap credit. InIND represents the "logarithm of industrial structure" which is defined as manufacturing value added. Worldwide, industrialization pollutes energy. This variable was anticipated to increase energy consumption as a percentage of GDP. InEF reflects the "logarithm of ecological footprint" which is defined as the ecological footprint of consumption in our surrounding environment and quantified in Global hectares per capita. Table 2 outlines the variables of the investigation.

Stationary and co-integration tests

Lag structure Testing

In the opinion of eiders (1995), selecting an appropriate lag time frame is undoubtedly critical to the average relevance of a collection of equations. However this may not be always the case, adopting a model with many periods has an opportunity to produce residuals that are equivalent to those generated through a white noise procedure. As a result, when the period of delay is large, even though the model is expected to be insufficient, the residuals may not be randomized enough to replicate a white noise mechanism. Based on this study, two delays were a suitable amount of period to avoid misconceptions and the loss of levels of freedom.

Augmented Ducky Fuller

The "Augmented Ducky Fuller" (ADF) testing is applied to ensure that all of the study's variables are stationary.

The ADF is a simplified version of the Dickey-Fuller design that falls under the umbrella of the unit root test family of statistical analyses. When investigating more complex relationships between times series on more demanding systems, the unit root test is used. The improved dickey-fuller is a vital statistical tool in scientific investigations since it tests both the null and alternative hypotheses and gives a numerical value (P-Values) based on the collected information. Using the P-value of the improved Dickey-Fuller test, the researcher can decide if the variables are stationary or not. The ADF also used the T- and F-statistics to test for the presence of a unit root in time series. The ADF also analyses pairs for co-integration between two commodities exchanges. The ADF is one type of time series analysis that every researcher should be familiar with. The following is the Augmented Dickey-Fuller Formula:

$$\mathcal{YY}tt = cc + \beta\beta\mathcal{YY} + aaaatt-1 + \emptyset\Delta aatt-1 + \emptyset\Delta\ .\ +\emptyset\rho\rho\Delta aatt-\rho\rho - - - \quad \textbf{(2)}$$

ARDL Bound Test

According to (Pesaran et al., 2001), the ARDL co-integration econometric methodology was developed in 2001.

Long-term dependencies were investigated with the use of the ARDL-Bound joint integration test. Even with limited sample size, the tests are useful for analyzing time series data. The three primary phases of an ARDL bound test are as follows: The first step is to evaluate the common integration of the equation's variables over time. Second, it is intended that long-term relationships will be adaptable so that their influence on the adopted variables may be measured. Third, the joint integration test can be utilized to evaluate the predictive accuracy using the ARDL bounds.

Bootstrap Autoregressive Distributed Lag

This study used the “Bootstrap Autoregressive Distributed lag (BARDL) model" suggested by McNown et al. (McNown et al., 2018) to evaluate the effects of OP, EG, BSD, IND, and EF on energy use in South Africa. “F-test” ($\boldsymbol{F}\mathbf{statistic}_{-\boldsymbol{ov}}$) is used in the traditional ARDL model on all lagged variables of study ($\boldsymbol{H_0} = \boldsymbol{\pi_1} = \boldsymbol{\pi_2} = \boldsymbol{\pi_3} = \boldsymbol{\pi_4} = \boldsymbol{\pi_5} = \boldsymbol{\pi_6} = \mathbf{0}$). To explain the long-term relationship between the variables of interest, the "T test" is used on lagged dependent variable $\boldsymbol{H_0}: \boldsymbol{\pi_1} = \mathbf{0}$. However, the McNown et al. (McNown et al., 2018) improved traditional ARDL model by adding an additional “F-test” on the lagged independent variables ($\boldsymbol{H_0} = \boldsymbol{\pi_1} = \boldsymbol{\pi_2} = \boldsymbol{\pi_3} = \boldsymbol{\pi_4} = \boldsymbol{\pi_5} = \boldsymbol{\pi_6} = \mathbf{0}$) .Thus, the improved ARDL model based on” F-test ($\boldsymbol{F}\mathbf{statistic}_{\boldsymbol{ov}}$), t-test” ($\boldsymbol{t}\mathbf{statistic}_{\boldsymbol{DV}}$), and F-test ($\boldsymbol{F}\mathbf{statistic}_{\boldsymbol{IDV}}$) on “the coefficient of all lagged levels of variables; dependent and independent variables” respectively were used. According to McNown et al. (McNown et al., 2018), it is important for these tests to differentiate between co-integration, non-co-integration, and degenerate circumstances. The occurrence of degeneracy twice indicates that the variables under consideration are not being integrated effectively. When both the lagged level dependent and lagged level independent variables are insignificant, we get the first degenerate issue. The attributes of the integrated series from all tests are included in the "bootstrap ARDL critical values (CVs)". The strategy addresses the instability of traditional co-integration results. Unlike the traditional ARDL method, the expanded ARDL test allows for a greater number of endogenous factors. This method is hence recommended for multivariate empirical models. Therefore, the co-integration among oil prices, economic growth, banking sector development, industry, and ecological footprints on the energy consumption in South Africa will be established if the values of ($\boldsymbol{F}\mathbf{statistic}_{\boldsymbol{ov}}$), ($\boldsymbol{t}\mathbf{statistic}_{\boldsymbol{DV}}$), and ($\boldsymbol{F}\mathbf{statistic}_{\boldsymbol{IDV}}$) do not exceed the “CV” bootstrap model. The following is the formulation of the “ARDL” test:

$$\Delta \mathrm{lnEUSE_{it}} = \theta_0 + \sum_{i=1}^{q} \delta_1 \Delta \mathrm{lnEUSE_{t-j}} + \sum_{i=1}^{f} \delta_2 \Delta \mathrm{lnOP_{t-j}} + \sum_{i=1}^{f} \delta_3 \Delta \mathrm{lnEG_{t-j}} + \sum_{i=1}^{f} \delta_4 \Delta \mathrm{lnBSD_{t-j}} + \sum_{i=1}^{f} \delta_5 \Delta \mathrm{lnIND_{t-j}} + \sum_{i=1}^{f} \delta_6 \Delta \mathrm{lnEF_{t-j}} + \pi_1 \mathrm{lnEUSE_{t-j}} + \pi_2 \mathrm{lnOP_{t-1}} + \pi_3 \mathrm{lnEG_{t-1}} + \pi_4 \mathrm{lnBSD_{t-1}} + \gamma_5 \mathrm{lnIND_{t-1}} + \gamma_6 \mathrm{lnEF_{t-1}} + \omega \mathrm{ECT_{t-1}} + \epsilon_{it} \quad \textbf{(3)}$$

In equation (2): $\boldsymbol{\epsilon_{it}}$ denotes white noise; Δ represents the first difference process operator; $\boldsymbol{\theta_0}$ denotes intercept; ; $\boldsymbol{\delta_1, \delta_2, \delta_3, \delta_4, \delta_5}$ **and** $\boldsymbol{\delta_6}$ denotes the coefficients explanatory variable in short term; $\boldsymbol{\pi_1}, \boldsymbol{\pi_2}, \boldsymbol{\pi_3}, \boldsymbol{\pi_4}, \boldsymbol{\pi_5}$ **and** $\boldsymbol{\pi_6}$ denotes the explanatory variables coefficients in long-run; q denotes the lags of explained variables; f denotes the lags of explanatory variable and $\boldsymbol{\omega ECT_{t-1}}$)denotes the error correction term representing the speed of the examined variables get adjusted.

ARDL model

In the scrutiny of the long-term and short-term linkage between the study' variables, the investigation uses the panel ARDL model by Pasaran (2001). The model is a better one relative to others especially when the variables gain stationarity at I (0), I (1) or a joint of both. There are two processes in panel ARDL technique to cointegration when it comes to predicting a long-term linkage. Investigating whether there exists a long-term linkage between the factors constitutes the initial stage. The next procedure involves estimating the long-term co-efficients using the outcomes of the panel ARDL model whether there exists a long-term linkage between the parameters. The equation of the ARDL on the basis of the first equation is shown as follows:

$$\begin{aligned}\Delta lnLCF_{it} = \theta_0 &+ \sum_{i=1}^{q} \rho_1 \Delta lnLCF_{t-j} + \sum_{i=1}^{f} \rho_2 \Delta lnGF_{t-j} + \sum_{i=1}^{f} \rho_3 \Delta lnEPS_{t-j} \\ &+ \sum_{i=1}^{f} \rho_4 \Delta lnETI_{t-j} + \sum_{i=1}^{f} \rho_5 \Delta lnEG_{t-j} + \sum_{i=1}^{f} \rho_6 \Delta lnINDS_{t-j} \\ &+ \pi_1 lnLCF_{2t-j} + \pi_2 lnGF_{t-1} + \pi_3 lnEPS_{t-1} + \pi_4 lnETI_{t-1} \\ &+ \gamma_5 lnEG_{t-1} + \gamma_6 lnINDS_{t-1} + \omega ECT_{t-1} + \epsilon_{it}\end{aligned}$$

(4)

Model stability and diagnostic Test

Additionally, this research employed the "Ramsey RESET test ($\boldsymbol{X^{-Rrt}}$) to test model fit"; the ARCH test($\boldsymbol{X^{-Art}}$)" and "Brush–Pagan–Godfrey heteroscedasticity test($\boldsymbol{X^{-Bpght}}$)" to explore the heterogeneity; normality test($\boldsymbol{X^{-Nort}}$) to examine that data is normally distributed; and multicollinearity test $\boldsymbol{M^{ct}}$ to confirm the presence of multicollinearity in the variables.

Furthermore, the empirical model's validity and fit are checked in this research using the "CUSUM and CUSUM-square (CUSUMSQ) tests." The research also employs Granger causality to determine causation between variables. However, the econometric technique, "($\boldsymbol{EC^{Term}}$)" shows the "speed of adjustment of variables from long-term equilibrium." The $\boldsymbol{ECM}$ were formulated in the following Equations (5–10):

$$\Delta lnEUSE_t = \alpha + \sum_{i=1}^{p-1} \varsigma_i \Delta lnEUSE_{t-i} + \sum_{j=1}^{q-1} \omega_j \Delta lnOP_{t-j} + \sum_{m=1}^{q-1} \vartheta_m \Delta lnEG_{t-m} + \sum_{l=1}^{q-1} \Theta_l \Delta lnBSD_{t-l} + \sum_{r=1}^{q-1} \xi_r \Delta lnIND_{t-r} + \sum_{n=1}^{q-1} \pi_n \Delta lnEF_{t-n} + \lambda_1 ECT_{t-1} + \epsilon_{1t} \quad (5)$$

$$\Delta lnOP_t = \sigma + \sum_{i=1}^{p-1} \varsigma_i \Delta lnEUSE_{t-i} + \sum_{j=1}^{q-1} \omega_j \Delta lnOP_{t-j} + \sum_{m=1}^{q-1} \vartheta_m \Delta lnEG_{t-m} + \sum_{l=1}^{q-1} \Theta_l \Delta lnBSD_{t-l} + \sum_{r=1}^{q-1} \xi_r \Delta lnIND_{t-r} + \sum_{n=1}^{q-1} \pi_n \Delta lnEF_{t-n} + \lambda_2 ECT_{t-1} + \epsilon_{2t} \quad (6)$$

$$\Delta lnEG_t = \rho + \sum_{i=1}^{p-1} \varsigma_i \Delta lnEUSE_{t-i} + \sum_{j=1}^{q-1} \omega_j \Delta lnOP_{t-j} + \sum_{m=1}^{q-1} \vartheta_m \Delta lnEG_{t-m} + \sum_{l=1}^{q-1} \Theta_l \Delta lnBSD_{t-l} + \sum_{r=1}^{q-1} \xi_r \Delta lnIND_{t-r} + \sum_{n=1}^{q-1} \pi_n \Delta lnEF_{t-n} + \lambda_3 ECT_{t-1} + \epsilon_{3t} \quad (7)$$

$$\Delta lnBSD_t = \varphi + \sum_{i=1}^{p-1} \varsigma_i \Delta lnEUSE_{t-i} + \sum_{j=1}^{q-1} \omega_j \Delta lnOP_{t-j} + \sum_{m=1}^{q-1} \vartheta_m \Delta lnEG_{t-m} + \sum_{l=1}^{q-1} \Theta_l \Delta lnBSD_{t-l} + \sum_{r=1}^{q-1} \xi_r \Delta lnIND_{t-r} + \sum_{n=1}^{q-1} \pi_n \Delta lnEF_{t-n} + \lambda_4 ECT_{t-1} + \epsilon_{4t} \quad (8)$$

$$\Delta lnIND_t = \phi + \sum_{i=1}^{p-1} \varsigma_i \Delta lnEUSE_{t-i} + \sum_{j=1}^{q-1} \omega_j \Delta lnOP_{t-j} + \sum_{m=1}^{q-1} \vartheta_m \Delta lnEG_{t-m} + \sum_{l=1}^{q-1} \Theta_l \Delta lnBSD_{t-l} + \sum_{r=1}^{q-1} \xi_r \Delta lnIND_{t-r} + \sum_{n=1}^{q-1} \pi_n \Delta lnEF_{t-n} + \lambda_5 ECT_{t-1} + \epsilon_{5t} \quad (9)$$

$$\Delta lnEF_t = \delta + \sum_{i=1}^{p-1} \varsigma_i \Delta lnEUSE_{t-i} + \sum_{j=1}^{q-1} \omega_j \Delta lnOP_{t-j} + \sum_{m=1}^{q-1} \vartheta_m \Delta lnEG_{t-m} + \sum_{l=1}^{q-1} \Theta_l \Delta lnBSD_{t-l} + \sum_{r=1}^{q-1} \xi_r \Delta lnIND_{t-r} + \sum_{n=1}^{q-1} \pi_n \Delta lnEF_{t-n} + \lambda_6 ECT_{t-1} + \epsilon_{6t} \quad (10)$$

Where Δ indicates the "first difference operator; $\in_{it}$ signifies the error term, and $\boldsymbol{\omega ECT_{t-1}}$ indicates lagged ECT. The F statistics produced by the Wald test are used in order to study the short-term causal link that exists between the variables that are being investigated. Moreover, for robustness assessment, econometric methods such as

Impulse response function (IRF), and variance decomposition factor (VDF) analysis was used.

Granger causality test

The test was first introduced by Clive granger (1969). The employed the technique to check if a linear relationship is two-way directional, one-way directional or non-directional. It helps in spotting if one variable is helpful in envisaging another variable. When variable X causes variable Y but variable Y causes not variable X, we then will have a unidirectional linkage between the two. A relationship between X and Y becomes bidirectional when both X and Y cause each other. The correlation between X and Y becomes nondirectional when X does not cause Y nor does Y cause X. He further stated that one method of evaluating causation in the field of economics is to gauge how well one variable can be predicted based on data from another variable. It states that when a time series X1 causes time series X2, then the previous values for X1 must have information which contributes thereto X2's prediction in addition to which is provided by X2's previous value. The equations of the Granger causality test are given as follow:

$$\Delta \boldsymbol{lnLCF_{it}} = \alpha + \sum_{\boldsymbol{i=1}}^{\boldsymbol{p-1}} \boldsymbol{\varsigma_i \Delta lnLCF_{t-i}} + \sum_{j=1}^{q-1} \omega_j \Delta lnGF_{t-j} + \sum_{m=1}^{q-1} \vartheta_m \Delta lnEPS_{t-m} + \sum_{l=1}^{q-1} \Theta_l \Delta lnETI_{t-l} + \sum_{r=1}^{q-1} \xi_r \Delta lnEG_{t-r} + \sum_{n=1}^{q-1} \pi_n \Delta lnINDS_{t-n} + \lambda_1 ECT_{t-1} + \epsilon_{1t}$$

(11)

$$\Delta \boldsymbol{lnGF_{it}} = \alpha + \sum_{i=1}^{p-1} \varsigma_i \Delta lnLCF_{t-i} + \sum_{j=1}^{q-1} \omega_j \Delta lnGF_{t-j} + \sum_{\boldsymbol{m=1}}^{\boldsymbol{q-1}} \boldsymbol{\vartheta_m \Delta lnEPS_{t-m}} + \sum_{l=1}^{q-1} \Theta_l \Delta lnETI_{t-l} + \sum_{r=1}^{q-1} \xi_r \Delta lnEG_{t-r} + \sum_{n=1}^{q-1} \pi_n \Delta lnINDS_{t-n} + \lambda_3 ECT_{t-1} + \epsilon_{1t}$$

(12)

$$\Delta \boldsymbol{lnEPS_{it}} = \alpha + \sum_{i=1}^{p-1} \varsigma_i \Delta lnLCF_{t-i} + \sum_{j=1}^{q-1} \omega_j \Delta lnGF_{t-j} + \sum_{\boldsymbol{m=1}}^{\boldsymbol{q-1}} \boldsymbol{\vartheta_m \Delta lnEPS_{t-m}} + \sum_{l=1}^{q-1} \Theta_l \Delta lnETI_{t-l} + \sum_{r=1}^{q-1} \xi_r \Delta lEC_{t-r} + \sum_{n=1}^{q-1} \pi_n \Delta lnINDS_{t-n} + \lambda_3 ECT_{t-1} + \epsilon_{1t}$$

(13)

$$\Delta \boldsymbol{lnETI_{it}} = \alpha + \sum_{i=1}^{p-1} \varsigma_i \Delta lnLCF_{t-i} + \sum_{j=1}^{q-1} \omega_j \Delta lnGF_{t-j} + \sum_{m=1}^{q-1} \vartheta_m \Delta lnEPS_{t-m} + \sum_{\boldsymbol{l=1}}^{\boldsymbol{q-1}} \boldsymbol{\Theta_l \Delta lnETI_{t-l}} + \sum_{r=1}^{q-1} \xi_r \Delta lnEG_{t-r} + \sum_{n=1}^{q-1} \pi_n \Delta lnINDS_{t-n} + \lambda_4 ECT_{t-1} + \epsilon_{1t}$$

(14)

$$\Delta \boldsymbol{lnEG_{it}} = \alpha + \sum_{i=1}^{p-1} \varsigma_i \Delta lnLCF_{t-i} + \sum_{j=1}^{q-1} \omega_j \Delta lnGF_{t-j} + \sum_{m=1}^{q-1} \vartheta_m \Delta lnEPS_{t-m} + \sum_{l=1}^{q-1} \Theta_l \Delta lnETI_{t-l} + \boldsymbol{\sum_{r=1}^{q-1} \xi_r \Delta EG_{t-r}} + \sum_{n=1}^{q-1} \pi_n \Delta lnINDS_{t-n} + \lambda_5 ECT_{t-1} + \epsilon_{1t}$$

(15)

$$\Delta \boldsymbol{lnINDS_{it}} = \alpha + \sum_{i=1}^{p-1} \varsigma_i \Delta lnLCF_{t-i} + \sum_{j=1}^{q-1} \omega_j \Delta lnGF_{t-j} + \sum_{m=1}^{q-1} \vartheta_m \Delta lnEPS_{t-m} + \sum_{l=1}^{q-1} \Theta_l \Delta lnETI_{t-l} + \sum_{r=1}^{q-1} \xi_r \Delta lnEG_{t-r} + \boldsymbol{\sum_{n=1}^{q-1} \pi_n \Delta lnINDS_{t-n}} + \lambda_6 ECT_{t-1} + \epsilon_{1t}$$

(16)

In summary, we can confidently assert that this section adhered to all the necessary moral and ethical principles for research design. The statistical data, spanning the years 1990 to 2019 (based on the availability of data), was directly sourced from the World Development Indicators website, which is maintained by the World Bank Data Bank. To ensure accuracy and reliability, advanced econometric, statistical, and forecasting software called eViews was employed. This software not only provided meticulously crafted and well-thought-out materials but also boasted a user-friendly interface, enabling thorough cross-checking and investigation of variables. Several tests, such as the Unit Root, Augmented Dickey Fuller, Granger Causality, Bootstrap ARDL model, Breusch-Godfrey serial correlation, ARDL bound long run, and ARDL short run tests, were performed on the data and descriptive statistics were presented. Moreover, stationarity was assessed to ensure that only valid data was utilized in the experiments. Furthermore, the ADRL model was utilized to establish the connections between the variables, thereby facilitating the creation of tables and logical analysis to support and justify the findings.

CHAPTER IV

Results and discussion

Introduction

The relevant tables and data from this research are explained in detail in Chapter 4 of this thesis. The most crucial part is the descriptive statistics, which provide the values for the dependent and independent variables as well as their means, medians, ranges, standard deviations, skewness, kurtosis, Jarque-Bera probabilities, cusums, cusum square tests, and the total number of observations. Various numerical numbers for these outcomes are also provided. The bound test and the Augmented Dickey-Fuller test, both of which can be used to provide ARDL tests, will also be discussed here. The co-integration and nexus between these variables, as well as whether or not short- or long-run ARDL should be done, are important questions to answer. The robustness of the model will be analyzed and evaluated using variance decomposition factor analysis. We will employ and extensively examine the Granger causality technique, which not only reveals the link between variables but also offers causes, effects, and even causes inside the variables themselves. Here, we provide a detailed examination of the regression technique employed, its results and consequences, and, if appropriate, recommendations for future action. The final step is a battery of diagnostic and stability tests, the results of which will be made public. E-views 12 can aid with the analysis and interpretation of all these economic statistics.

Descriptive Statistics

	EUSE	BSD	EF	OP	EG	IND
Mean	217.0477	58.65589	1.186538	51.00760	5494.250	27.38706
Median	219.5252	59.96540	1.181121	45.94404	5480.800	26.59825
Maximum	239.4751	70.38188	1.486743	101.6250	6284.860	35.60760
Minimum	185.0438	46.57043	0.946478	15.47572	4581.218	23.50699
Std. Dev.	14.43193	6.426444	0.140801	28.51976	661.7760	3.404499

Skewness	-0.550831	-0.190178	0.337660	0.435359	-0.060716	0.809835
Kurtosis	2.555423	2.238492	2.333819	1.834817	1.257457	2.726690
Jarque-Bera	1.764135	0.905707	1.124818	2.644753	3.814000	3.372539
Probability	0.413926	0.635811	0.569835	0.266501	0.148525	0.185209
Sum	6511.432	1759.677	35.59614	1530.228	164827.5	821.6118
Sum Sq. Dev.	6040.136	1197.676	0.574927	23587.92	12700475	336.1279
Observations	30	30	30	30	30	30

Table 1 displays the descriptive significant variables of this study, including Energy consumption (EUSE), Banking sector development (BSD), Ecological footprints (EF), Oil price (OP), Economic Growth (EG), and Industrialization (IND). The average (Mean) GDP per capita is the largest, followed by Energy consumption, the Banking sector development, Oil price, industrialization, and Ecological footprints. The median is the middle value of the variables when arranged in ascending order. It provides a measure of central tendency. For instance, the median value for EUSE, BSD, EF, OP, EG, and IND are 219.5252, 59.96540, 1.181121, 45.94404, 5480.800, and 26.59825 respectively. Suggesting that half of the observations for all the variables fall below this value and the other half above it. The maximum and minimum values indicate the highest and lowest values observed for each variable, respectively. For instance, the maximum value for EUSE, BSD, EF, OP, EG, and IND are 239.4751, 70.38188, 1.486743, 101.6250, 6284.860, and 35.60760 and the minimum values are 185.0438, 46.57043, 0.946478, 15.47572, 15.47572 and 23.50699 respectively. The standard deviation measures the dispersion or variability of the values around the mean. A higher standard deviation indicates greater variability. However, OP, EUSE, BSD IND, and EF have the second-, third-, fourth, and fifth-largest variances, respectively, indicating that the economic growth of South Africa as a country, to a certain extent, is quite distinct. Skewness measures the asymmetry of the distribution of values. Positive skewness (e.g., for EF, OP, and IND) suggests a longer right tail, indicating the presence of relatively larger values on the right side of the distribution. Kurtosis quantifies the peakedness or flatness of the distribution of values. Higher kurtosis values (e.g., for EUSE, BSD, IND, and EF) indicate more extreme values or heavier tails. The Jarque-Bera test checks if the distribution of values deviates significantly from a normal distribution. The test is based on skewness and kurtosis values, and a lower probability value suggests a higher likelihood of the distribution being non-normal. Therefore, the P-Value of the Jarque-Bera indicates that the dataset is normally distributed.

. The findings in Table 2 indicate that the variables EUSE, EG, OP, BSD, and EF are stationary at the first difference I(1). IND, meanwhile, is stationary at level I(0). As a result, there is mixed order of stationary in the variables that are important. Table 3 shows the results of the ARDL bound test and Bootstrap ARDL co-integration test, which come second to the results of the unit root test. The results of the ARDL bound test demonstrate that all research variables (EUSE, OP, EG, BSD, IND, EF) are co-integration. Additionally, the BARDL Co-integration results confirmed that $\mathbf{F.Statistic_{OV}}$, $\mathbf{F.Statistic_{DV}}$, **and** $\mathbf{F.Statistic_{IDV}}$ values are less than "bootstrap ARDL CVs". Thus, both test results affirmed that co-integration exists among the variables.

Table 2. ADF Unit Root Test.

	At level		At 1st difference		
Variables	T statistic	P value	T statistics	P value	Remarks
lnEUSE	-1.831	0.358	-5.067***	0.000	I(1)
lnOP	-1.272	0.628	-4.809***	0.000	I(1)
lnEG	-1.249	0.638	-2.908*	0.057	I(1)
lnBSD	-2.368	0.159	-6.109***	0.000	I(1)
lnIND	-3.199**	0.030	---	---	I(0)
lnEF	-2.406	0.148	-7.043***	0.000	I(1)

*Note: *, **, and *** refers to the level of significance at 10%, 5%, and 1%; I(0) refers to level and I(1) shows first difference. "lnEUSE = logarithm of energy use; lnEG = logarithm of economic growth; lnEF = logarithm of ecological footprint; lnOP = logarithm of oil prices; lnBSD = logarithm of banking sector development; lnIND = logarithm of industrial structure.*

Table 3. Bootstrap "ARDL" Co-integration test.

"ARDL" Diagnostic tests findings						
Bootstrap "ARDL"	FS^{OV}	TS^{DV}	FS^{IDV}	X^{Rst}	X^{Norm}	X^{Bpgt}
(euse, op, eg, bsd, ind,ef)	3.192***	-3.035***	3.566***	0.62^{FS} 0.56	0.97^{FS}	1.44^{FS}
Bootstrap-based table CV 1%	8.475	9.413	-5.511	0.38^{FS} 0.55	0.46^{PV}	0.24^{PV}
ARDL bound test	F Stat	I(0) Bound	I(1) Bound		X^{Bgsct}	X^{Arch}
	5.555	3.06***	4.15***		0.51^{FS}	0.43^{FS}
					0.61^{PV}	0.52^{PV}
	lneuse	lnop	lneg	lnbsd	lnind	lnef
Multicollinearity test VIF	1.51	2.22	1.72	1.36	1.29	1.41

*Note: *, **, and *** refers to the level of significance at 10%, 5%, and 1%; I(0) refers to level and I(1) shows first difference. "lnEUSE = logarithm of energy use; lnEG = logarithm of economic growth; lnEF = logarithm of ecological footprint; lnOP = logarithm of oil prices; lnBSD = logarithm of banking sector development; lnIND = logarithm of industrial structure. Moreover, FS^{OV} = F-statistic for overall variable; FS^{IDV} = F statistic for independent variable; TS^{DV} = t=statistic for depend variable; VIF = Variance Inflation Factor; X^{Rst} = Ramsey reset test; X^{Arch} = the ARCH test and X^{Bpgt} = Brush–Pagan–Godfrey heteroscedasticity test; X^{Norm} = Normality test; CV= Critical Value; FS = F-statistic; PV = P-Value*

Table 4 displays the results of the ARDL. The results show that, in the short and long runs, the coefficient of EG (0.719, 1.262) with EUSE are significant at 1% and 5% significance levels, respectively. This demonstrates how, in the instance of South Africa, increases in economic growth result in higher energy consumption. The EUSE increases by 0.719% and 1.262% for every 1% rise in EG. Also noteworthy is the fact that the magnitude of the EG to EUSE in South Africa is greater over the long period than it is over the short term. Thus, it may be inferred that a nation's economic growth necessitates increased energy consumption. Salahuddin et al.'s (2018) findings in Kuwait, Wang & Zhang's (2021) findings in China, and Shahbaz et al.'s (2022) findings in the case of China all confirm the findings of our study. Being one of the top producers of gold in the world, South Africa's economy is largely reliant on the gold mining industry. The nation uses fossil fuels, which are considered a filthy source of energy, to meet its energy needs because renewable energy sources are not utilized in significant quantities to do so. As a result, the nation makes concessions regarding environmental quality, which is currently the most important and popular problem in the globe. To reduce the nation's energy consumption, the senior government officials must build the energy infrastructure, create regulations, and make investments in R&D. As a substitute for polluting energy, South Africa must also invest in renewable energy sources. The country's economy will grow sustainably as a result, and the environment will be protected.

In addition, across both the short and long runs, the coefficients of EF (0.243, 0.426) with EUSE are favorable and significant at 10%. This confirms that, in the case of South Africa, ecological degradation is closely related to energy demand. Ecological degradation causes an increase in energy demand of 0.243% and 0.426% for every 1% increase. This shows that, according to Osuntuyi & Lean, (2022), there is a connection between South Africa's energy use and environmental deterioration. The ecological footprint is a measurement that contrasts the rates of resource consumption and waste production by people with the rates of resource regeneration and waste absorption by the biosphere, according to Monfreda et al. (Monfreda et al., 2004). These rates are expressed in terms of the amount of space needed to support the current flows. South Africa has a lot of gold deposits as a result, however, mining for gold requires energy use, which has an adverse effect on the environment. Therefore, South Africa's stakeholders, including the government, economists, and environmentalists, should concentrate on ecological reduction by creating, putting into practice, and overseeing policies to lessen ecological and environmental threats. The development of clean, renewable energy sources and investments in technical innovation may make this possible. As a result, the nation's energy efficiency will result in lower energy usage.

The results further show that the OP coefficients are negative and significant at the 1% level in the short run (-0.153) and long run (-0.269). This demonstrates that 1% positive shocks in the OP cause a -.153% short-term and -.269 long-term decrease in energy consumption. Our findings are supported by studies conducted in South Africa by Ali et al. (2022), Turkey by Abumunsher et al (2020), South Africa by

Samour et al (2020), Turkey by Ahmed et al (2022), and Vietnam by Apergis & Gangopadhyay (2020). The authors of these investigations discovered that OP positive shocks reduce energy utilization while OP negative shocks increase it. South Africa imports oil in order to meet its intended energy demand for its economic activities because the country cannot produce enough energy domestically to suit its needs. As a result, Nigeria, Saudi Arabia, Ghana, the United Arab Emirates, and the United States are the countries that South Africa imports oil from. The nation purchased 5.09 billion dollars' worth of oil in merely 2020 to satisfy the necessary demand, making it the 19th highest oil importer in the world. Therefore, as shown during the Russo-Ukrainian conflict, even a small change in oil prices on the global market has an impact on a country's energy usage. Therefore, it is advised that the nation investigate more affordable, clean, renewable, and efficient energy sources in order to lessen its reliance on oil imports from other countries. This will help the nation use energy more effectively, improve the quality of the environment, and have a smaller negative impact on the current account in the balance of payments.

Additionally, EUSE and BSD have a positive correlation in the near term (0.106). However, both variables exhibit a negative coefficient over the long term (-0.161), but the coefficients are negligible in both cases. According to Mielnik et al. (Mielnik & Goldemberg, 2002), financial development lowers energy consumption by assisting businesses in updating production technology and equipment, which increases energy efficiency. The results are in opposition to their findings. According to their study, businesses that invest in R&D and create and manufacture energy-efficient products may be able to reduce their energy use. But Aslan et al. (2014), Emir (2022), Komal and Abbas (2015), M. Li et al. (2019), Mukhtarov et al. (2022), Sadorsky (2011), and Sare (2019) support our findings. Our findings lead us to the conclusion that South Africa's banking industry is not yet at the level required to sustain the nation's energy infrastructure and generate funds for investments in businesses and other economic sectors that will enable them to pursue new R&D prospects. As a result, it is encouraged for the South African government to develop a sound banking industry, with the help of the central bank, in order to set standards capable of supporting the nation's energy infrastructure.

Furthermore, according to ARDL calculations, IND and EUSE have a significant and positive coefficient (0.418), which is significant at the 5% level of significance. In contrast, over the long run, both variables show positive but insignificant coefficients (0.013). This demonstrates that the South African Industry sector's industrial structure uses more energy in the short term. The impact could be due to out-of-date industrial infrastructure. The transformation from antiquated to modern, energy-efficient infrastructure is necessary for the development of the African industrial sector. Liu (Emir, 2022; Liu & Peng, 2018) has shown that industrial activity employs more cutting-edge machinery than farming and simple manufacturing. As a result, these always result in higher energy consumption, which is necessary in developed countries like South Africa. In addition, more energy is needed in South Africa's industries to conduct efficient commercial and operational tasks. according to Elfaki (2021). The discoveries will be used in South Africa, where there is a significant need for energy and increasing industrial development.

Table 4. ARDL model results.

Variable	Coefficient	t-Statistic	Prob.
ΔlnEGt	0.719 ***	3.297	0.003
ΔlnEFt	0.243 *	1.821	0.083
ΔlnOPt	−0.153 ***	−5.012	0.000
ΔlnBSDt	0.106	1.139	0.268
ΔlnINDt	0.418 **	2.368	0.028
lnEGt	1.262 **	2.421	0.025
lnEFt	0.426 *	1.830	0.082
lnOPt	−0.269 ***	−3.850	0.001
lnBSDt	−0.161	−0.938	0.359
lnINDt	0.013	−0.053	0.958
ECTt−1	−0.570 ***	−7.108	0.000

*Note: *, **, and *** refer to the level of significance at 10%, 5%, and 1%; I(0) refers to level and I(1) shows first difference. lnEUSE = logarithm of energy use; lnEG = logarithm of economic growth; lnEF = logarithm of ecological footprint; lnOP = logarithm of oil prices; lnBSD = logarithm of banking sector development; lnIND = logarithm of industrial structure; ECTt−1 = Error Correction Term.*

Additionally, in both the short and long runs, the coefficients of EF (0.243, 0.426) with EUSE are favorable and significant at 10%. This confirms that, in the case of South Africa, ecological degradation is closely related to energy demand.

Ecological degradation causes increases in energy use between 0.243% and 0.426% for every 1% increase. This shows that, according to Osuntuyi & Lean (Osuntuyi & Lean, 2022) environmental degradation is associated with South Africa's energy usage. The ecological footprint is a measurement that contrasts the rates of resource consumption and waste production by people with the rates of resource regeneration and waste absorption by the biosphere, according to Monfreda et al. (Monfreda et al., 2004). These rates are expressed in terms of the amount of space needed to support the current flows. South Africa has a lot of gold deposits as a result, however mining for gold requires energy use, which has an adverse effect on the environment. Therefore, South Africa's stakeholders, including the government, economists, and environmentalists, should concentrate on ecological reduction by creating, putting into practice, and overseeing policies to lessen ecological and environmental threats. The development of clean, renewable energy sources and investments in technical innovation may make this possible. As a result, the nation's energy efficiency will increase, resulting in lower energy usage.

The results also show that the OP coefficients are negative, significant at the 1% level in both the short run (0.153) and the long run (0.269). This demonstrates that 1% positive shocks in the OP cause a 0.153% short-term and 0.269% long-term decrease in energy usage. Our findings are supported by research from South African researchers Ali et al. (Ali et al., 2022), Turkish researchers Abumunsher et al. (Abumunshar et al., 2020), and Vietnamese researchers Apergis & Gangopadhyay (Apergis & Gangopadhyay, 2020). The authors of these investigations discovered that OP positive shocks reduce energy utilization while OP negative shocks increase it. South Africa imports oil to meet its desired demand for economic activity since the country cannot produce enough energy domestically to suit its needs. As a result, Nigeria, Saudi Arabia, Ghana, the United Arab Emirates, and the United States all export oil to South Africa. In order to meet the necessary demand, the nation imported USD 5.09 billion worth of oil in merely 2020, ranking it as the 19th largest oil importer globally (https://oec.world/en/profile/bilateral-product/crude-petroleum/reporter/zaf, accessed on 1 March 2023). Therefore, as shown during the Russo-Ukrainian conflict, even a small change in oil prices on the global market has an impact on the nation's energy usage. Therefore, it is advised that the nation look into less expensive, greener, more sustainable, and more effective energy sources in order to lessen its reliance on oil imports from other countries. This will help the nation use energy more effectively, improve the environment, and have a smaller negative impact on the current account in the balance of payments.

Further, EUSE and BSD have positive coefficients in the short term (0.106), but in the long term, both variables have negative coefficients (-0.161), but the coefficients are negligible in both circumstances. The findings are in contrast to those of Mielnik et al. (Mielnik & Goldemberg, 2002), who found that financial development helps businesses upgrade production technology and equipment, which increases energy efficiency, and hence lowers energy consumption. According to their study, businesses that invest in R&D and create and manufacture energy-efficient products may be able to reduce their energy use. However, (Aslan et al., 2014; Emir, 2022; Kamal & Abbas, 2015; M. Li et al, 2019; Mukhtarov et al, 2022; Sadorsky, 2011; Sare, 2019) have confirmed our findings. Based on our findings, it can be said that South Africa's banking industry has not yet reached the required level of development to support the nation's energy infrastructure and generate funds for investments in the sector and other economic sectors to pursue additional R&D prospects. As a result, it is encouraged for the South African government to develop a sound banking industry, with the help of the central bank, in order to set standards capable of supporting the nation's energy infrastructure.

Additionally, according to ARDL calculations, IND and EUSE have a significant and positive coefficient (0.418), which is significant at the 5% level of significance. In contrast, over the long run, both variables show positive but insignificant coefficients (0.013). This demonstrates that the South African Industry sector's industrial structure uses more energy in the short term. The impact could be due to out-of-date industrial infrastructure. The transformation from antiquated to modern, energy-efficient infrastructure is necessary for the development of the African industrial sector. Liu (Emir, 2022; Liu & Peng, 2018) has shown that industrial activity employs more cutting-edge machinery than farming and simple manufacturing. As a result, these always result in higher energy consumption, which is necessary in developed countries like South Africa. In addition, more energy is needed in South Africa's industries to conduct efficient commercial and operational tasks. Elfaki (Elfaki et al., 2021) offers proof of this. The discoveries will be used in South Africa, where there is a significant need for energy and increasing industrial development.

Robustness Analysis and Assessment

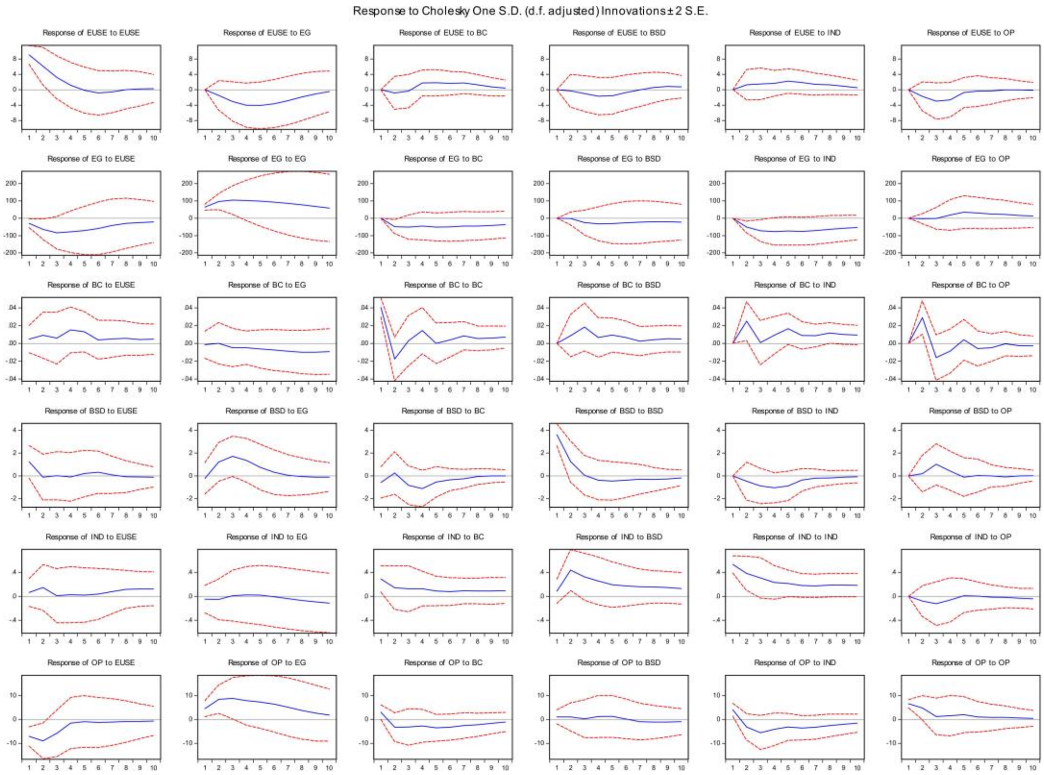
Table 6 presents the variance decomposition factor results. The findings show that shocks consume all of the energy. From period 1 to period 10, the energy use ratio's contribution gradually decreased, reaching a low of 49.63% during the 10th period. Additionally, the economic growth ratio to energy consumption rises up to the ninth period before gradually declining in the tenth period. Additionally, from the first to the tenth periods, there was an increase in the ecological footprint, banking sector development, and industry ratio to energy use, which was, respectively, 5.67%, 3.239%, and 7.497. Energy use is affected by the price of oil, though, and the ratio rises up until the seventh period before declining after that until the tenth period. Thus, changes in South Africa's energy use are influenced by the country's economy, industrialisation, banking industry, oil prices, and environmental impact.

Table 5 Outcome of variance decomposition factor analysis.

Model: lnEUSE = f (lnOP, lnEG, lnBSD, lnIND, lnEF)

Period	S.E.	EUSE	EG	EF	BSD	IND	OP
1	9.053	100	0.000	0.000	0.000	0.000	0.000
2	11.276	94.023	1.715	0.514	0.079	1.288	2.378
3	12.607	81.683	7.229	0.497	0.696	2.493	7.400
4	13.857	68.332	14.381	1.998	2.032	3.490	9.763
5	14.839	59.594	20.167	3.225	2.890	5.351	8.771
6	15.525	54.723	23.928	4.094	2.866	6.326	8.060
7	15.956	51.934	25.814	5.089	2.714	6.774	7.672
8	16.182	50.493	26.504	5.577	2.766	7.198	7.459
9	16.288	49.861	26.597	5.721	3.030	7.426	7.363
10	16.331	49.632	26.530	5.767	3.239	7.497	7.331

Note: "lnEUSE = logarithm of energy use; lnEG = logarithm of economic growth; lnEF = logarithm of ecological footprint; lnOP = logarithm of oil prices; lnBSD = logarithm of banking sector development; lnIND = logarithm of industrial structure; SE= Standard Error"



The results of the impulse response function are shown in Figure 1. The graph shows that economic progress has a favorable impact on energy use. However, the ecological footprint has a short-term negative impact on energy consumption, a medium-term positive impact, and a long-term reducing impact. The development of the banking sector and the effect of the oil price dropped in the near term but rose in the long term. The impact of industry on energy consumption in South Africa has expanded throughout time.

Figure 1. Impulse response function. Blue line is impact line and shows the impact, however upper and lower red doted lines are upper and lower bounds.

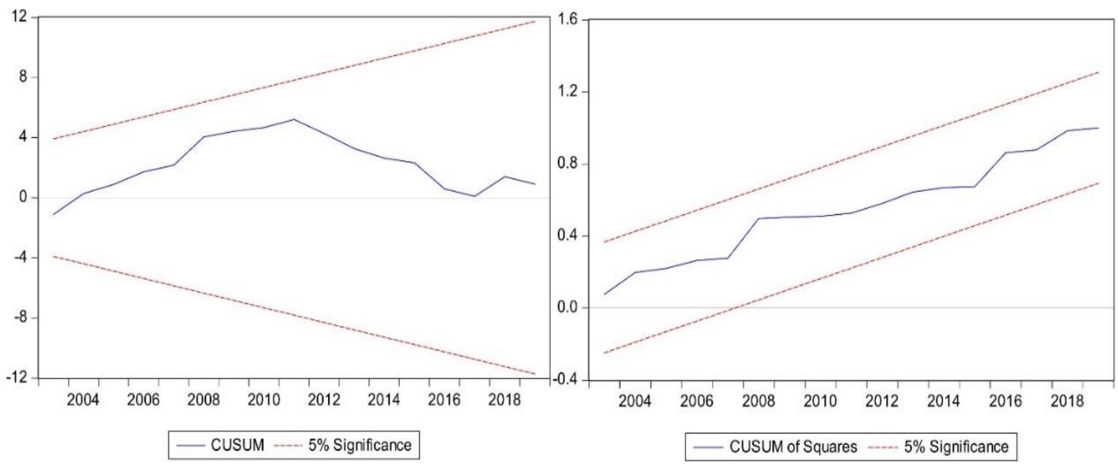


Figure 2 depicts "CUSUM and CUSUM of squares (CUSUMSQ) charts." The CUSUM chart confirmed that the model in this study is precisely stated, and the "CUSUM squares" suggest that the model did not undergo any formational changes over the evaluation time. The CUSUM and CUSUM square. Blue line is model line where as upper and lower red doted lines are upper and lower bounds. Model will be fit if blue line lies in between upper and lower bounds.

The results of the diagnostic tests are shown in Table 3. In this thesis, the "Brush-Pagan-Godfrey of heteroscedasticity test (XBpgth) and ARCH test (XArt)" validated homoscedasticity and revealed no serial correlations in the model. The normality test (XNort) ensures that the model under consideration is regularly distributed, whilst the Ramsey RESET test (XRrt) confirms that the model is suitable and dependable. Mcr, the multicollinearity test, confirmed that the model was multicollinear.

In this analysis, we employed Granger causality with co-integrated testing series to distinguish the short-run from the long-run effects of the variables. Estimated causal correlations between all variables are shown in Table 7. The table also shows that EUSE, EF, and OP are all interconnected in the long run. A causal relationship exists between EG and OP and BSD, EF, and IND. Given the existence of a causal relationship among the factors, we can advocate for the promotion of green energy to facilitate South Africa's long-term energy growth.

The Granger causality testing model is a statistical hypothesis test that determines whether or not a time series is helpful for forecasting the future occurrence of a cause and effect relationship between two variables. Ganger's causation model begins with the assumption that there is no correlation between the independent variables. However, it has been mentioned that the null hypothesis should be rejected if the Probability value, or P-value, is less than 0.05% at any level, and that we have shown evidence that there is no link, so long as the P-Value is greater than 0.05%. The results of these studies, as determined using Granger causality testing models, are summarized in Table 7 above. We agree that, depending on the examination outcome, three possible explanations exist, as follows: A unidirectional nexus is one in which one variable influences another but not the other; a bidirectional nexus is one in which both variables influence one another; and an afloat nexus is one in which neither of the individual variables causes or influences the other in any way. Some individual variables affect others, but not vice versa, making clear that there is a unidirectional nexus between them. The table shows that the correlation between EUSE and OP gangers is significantly higher than the correlation between EF and OP gangers (at 10% vs. 5%). The above analysis suggests a unidirectional association between the chosen markers.

Table 7. Results of the Pairwise Granger causality testing approach.

Null Hypothesis	**F-Statistic**	***p*-Value**
lnEG → *lnEUSE*	1.150	0.334
lnEUSE → *lnEG*	0.769	0.475
lnBSD → *lnEUSE*	1.399	0.267
lnEUSE → *lnBSD*	0.507	0.609
lnEF → *lnEUSE*	0.104	0.902
lnEUSE → *lnEF*	3.456 **	0.049
lnIND → *lnEUSE*	0.392	0.680
lnEUSE → *lnIND*	0.106	0.900
lnOP → *lnEUSE*	2.583 *	0.097
lnEUSE → *lnOP*	0.629	0.542
lnIND → *lnBSD*	1.502	0.244

*Note: *, ** refer to the level of significance at 10%, 5%; lnEUSE = logarithm of energy use; lnEG = logarithm of economic growth; lnEF = logarithm of ecological footprint; lnOP = logarithm of oil prices; lnBSD = logarithm of banking sector development; lnIND = logarithm of industrial structure; SE = Standard Error.*

CHAPTER V

Summary, Conclusions and Policy Recommendations

Summary

Economic activity continue to grow in the twenty-first century. More energy will be needed in practically all countries, emerging and developed alike, to support this growth. Economic growth is directly tied to the availability of energy, as this is required for the manufacturing of goods and provision of services (Gomez & Rodr'guez, 2019; Lu, 2017). However, environmental threats materialized as a result of over emphasis on energy growth. Developing nations require more energy to meet their rising demands as time goes on because it is a critical input in the manufacturing of virtually everything (Sadorsky, 2010). Global energy consumption is expected to rise by 28% between 2015 and 2040, according to the Energy Information Administration (EIA), while consumption in Asia—particularly China and India, neither of which are located in Sub-Saharan Africa—is expected to rise by more than 60% during the same time period. According to the reference case (EIA), global energy consumption is expected to increase by about (50%) between 2018 and 2050 (IEO-2019). Increasing energy use, however, has the potential to halt economic growth if it is not carefully managed. To paraphrase from two sources (Islam et al., 2013; Sadorsky, 2011), the energy crisis being experienced by some populations in sub-Saharan Africa, Pakistan, and Bangladesh will limit the rate of economic progress. Maintaining ecological equilibrium requires striking a compromise between energy consumption and generation.

Many things within a country also shift as its economy develops. For instance, countries with developed and advanced systems benefit from lower borrowing costs, easier access to financial capital, and greater transparency between borrowers and creditors. When taken together, these factors cause a movement of capital across borders, which in turn facilitates the spread of more advanced technologies. That's why things like company fixed investment and energy use contribute to rising energy demand. The growth of the financial industry also leads to a more widely diversified asset allocation, which in turn creates a wealth impact that benefits both businesses and consumers. It follows that progress in the area of finance plays a crucial role in a nation's overall level of progress.

The EIA reports that 90% of the country's crude supply is brought in via imports. Thus, South Africa must rely on imports for the vast majority of its oil needs.

Inevitably, a country like South Africa that imports oil will see its economic growth, current account balance, and other elements affected by the rise in oil prices. For countries like South Africa that import oil, rising crude oil prices mean higher inflation and thus higher interest rates. When we burn fossil fuels, we release carbon dioxide (CO2) into the atmosphere, which has a warming effect. There is a correlation between industrialization and environmental degradation, as both tend to increase with energy consumption.

The study depicts the effect of banking sector development (BSD), ecological footprint (EF), oil price (OP), economic growth (EG), and industrialization (IND) on the Energy use (EUSE) employing Bootstrap ARDL estimations technique on the South Africa economy over the period of the year 1990 – 2019. The main findings from the empirical analyses were the following: the study provides descriptive data on significant factors influencing economic expansion and energy use in South Africa. EUSE, BSD, OP, EG, and IND were some of the variables considered.

Following energy consumption, banking sector growth, oil prices, industrialization, and ecological footprints, the average GDP per capita was shown to be the most influential factor. Half of the observations went below these median values, while the other half fell above them. The highest and lowest values for each variable were indicated by the maximum and minimum signs.

The dispersion of values around the mean was calculated using the standard deviation. The asymmetry and peakiness of the value distribution were analyzed using skewness and kurtosis. According to the results of the Jarque-Bera test, the data set follows a normal distribution.

EUSE, EG, OP, BSD, and EF were found to be stationary at the first difference (I(1)), whereas IND was determined to be stationary at the level (I(0)) after additional examination of their stationarity with ADF Unit Root tests. All variables were shown to be cointegrated by the cointegration tests, indicating a long-term link.

According to the ARDL model, economic growth (EG) significantly raised energy use (EUSE) in both the short and long terms. Short-term effects of ecological footprints (EF) on EUSE were positive, but these effects faded over time. Short-term and long-term effects of the oil price (OP) on EUSE were unfavorable. The long-term effects of both banking sector development (BSD) and industrialization (IND) were negative and inconsequential, whereas the short-term effects were favorable but insignificant.

In robustness analyses using a variance decomposition component analysis, we were able to identify the various shocks to energy use and their respective contributions across time. Analysis of the impulse response function revealed both the immediate and cumulative effects of the various factors on power usage. Some variables were found to have long-term causal links based on pairwise Granger causality testing.

The results indicate that both economic expansion and ecological footprints significantly affect South Africa's energy use. The cost of crude oil is another major factor that affects how much power is consumed. However, more progress in the financial and industrial sectors is required to properly control and optimize energy consumption.

Conclusions

From 1990 through 2019, this study analyzed the relationship between a number of variables and South Africa's energy consumption (EC), including oil prices, ecological footprints, banking sector growth, industrialization, and economic growth. Because of its importance to the region's economy, researchers focused specifically on South Africa. Empirical research demonstrates that oil prices, ecological footprints, the modernization of the financial sector, GDP growth, and economic development all contribute to a rise in energy consumption in most countries. Based on the data, researchers calculated a linear relationship between production and energy use. Short-run and long-run co-integration were found for OP, EF, BSD, IND, EG, and EC when the data was analyzed using McNown's recently developed "ARDL" lag model. All variables showed a positive correlation with EC in South Africa, with the exception of OP and BSD, which had a negative effect on the energy sector but were still significant.

Energy use increases by 0.426% and 0.418% for every 1% increase in EF and IND, respectively, from what we see in the results. As a result, growing economies and increased energy use have negative effects on the natural world. If a country's ecological footprint is larger than its biocapacity, however, the Global Footprint Network (2019) classifies the country with the largest CO_2 emissions as having an ecological deficit. This conclusion is supported by the findings of both Nathaniel et al. (2021) and Kutlar (2022).

Both the coefficients and the point and interval estimates backed up the hypothesis that OP and BSD were negatively correlated. If the price of oil goes up by one percent, this would indicate that short-term energy consumption would drop by 0.153 percent and long-term use would fall by 0.269 percent. Both Abumunsher et al.

(2020) and Ali et al. (2022) support this idea. Long-term energy consumption was positively associated with banking sector expansion, however the correlation was small. Thus, for every 1% increase in banking sector development, there is a 0.161% decrease in energy use. These findings support the arguments of Mielnik et al. (2002) and Ozili (2022), who contend that a developed financial sector will help firms become more energy efficient by encouraging them to modernize their industrial technologies and machinery. In light of these results, it is evident that a strong banking system, conscientious energy consumption, and a growing economy are all necessary for the energy sector in South Africa.

Policy Recommendation

First, increasing energy efficiency can help South Africa's economy grow faster and more cleanly. Consequently, environmentalists, governments, and stakeholders in South Africa should prioritize the utilization of energy from renewable sources above fossil fuels. To achieve this goal, economists, government officials, and environmentalists should collaborate to reevaluate the country's energy policy in light of the variables that pose threats to the environment. Second, energy use, especially dirty energy, is a major contributor to the ecological footprint, which must be mitigated. The government of South Africa needs to put money into green finance options including promoting environmentally friendly technologies and charging businesses environmental levies. Third, businesses and people rely heavily on oil and other fossil fuels like coal and gas to achieve their economic goals. An increase in oil costs leads to less energy being used, which improves the quality of life in the country. The government should look into renewable energy sources to offset the increase in oil prices. This will happen if the country maintains its current rate of economic growth while working toward the SDGs. Finally, politicians must work with companies to create long-term policies and plans to cut energy use, especially from fossil fuels. We propose a shift from fossil fuels to clean energy as a means to this objective. We also suggest that the government and private sectors work together to strengthen the country's R&D division, with a particular emphasis on exploring and developing new technological possibilities. Industrial energy consumption can be lowered by the deployment of such technologies, lessening their negative impact on the environment. South Africa may achieve both economic growth and environmental protection by prioritizing the development of renewable energy sources, decreasing its reliance on foreign oil, and enhancing its energy efficiency. A more sustainable and equitable economy for South Africa would be the result of concerted efforts by policymakers, government, and stakeholders to expand access to renewable energy sources and curb environmental deterioration.

Recommendations for further research

The lack of readily accessible data on the conceptual research model of study is a major constraint of this investigation. The research model can be improved in the future by including more components like R&D, green investment, and any other associated determinants. In addition, this study's findings and generalizability can be validated and improved through similar research conducted in other nations using the same paradigm. Finally, we may use contemporary economic tools like NARDL to evaluate the disparities between the asymmetric and symmetric results.

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