COLLEGE OF SCIENCE AND TECHNOLOGY

AFRICAN CENTER OF EXCELLENCE IN ENERGY FOR SUSTAINABLE DEVELOPMENT

Project:

Energy Consumption and Environmental Sustainability" Evidence of CO2 Emission" (1980-2020)

A Thesis submitted to the African Center of Excellence in Energy sustainable Development (ACE-ESD) In partial fulfillment of the requirement for the degree of masters of science in energy economics.

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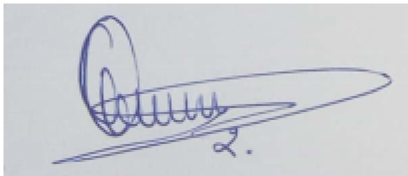
Kigali-Rwanda

DECLARATION

I, the undersigned, declare that this project report is my original work, and has not been presented for a degree in University of Rwanda or any other universities. All sources of materials that were used for the thesis work have been fully acknowledged.

NAME: UMUGWANEZA Julie

Signature



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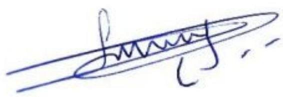
APPROVAL

I certify that the work reported in this research thesis was completed by the candidate under my supervision and with my consent before being submitted.

Name

Dr Aimable NSABIMANA

Signature



Date

31-October 2021

DEDICATION

To my beloved husband Jonathan BAVUGANEZA, my family and relatives who always encouraged me to push on with the writing of this project report whenever I contemplated giving up.

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This work has been made possible thanks to the moral, financial, and technical support of a number of people. First and foremost, I want to express my heartfelt gratitude to Almighty God, to whom I owe my life and all good faith. I thank Him for empowering me throughout my academic career and for allowing me to complete this research project in particular.

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May God continue to bless you all.

Contents

LIST OF ABBREVIATIONS AND ACCRONYMS

UR: University of Rwanda

%: Percentage

GDP: Gross Domestic Product

EC: Energy Consumption

Kw: kilowatt

CO2: Carbon Dioxide

CO2E: Carbon Dioxide Emission

FDI: Foreign Direct Investment

PG: Population Growth

LOI: Level of Industrialization

GHG: Green House Gases

WDI: World Development Indicators

EKC: Environmental Kuznets Curve

ERE: Environmental Regulatory Effects

EAC: East African Community

FE: Fixed Effect

OECD: Organization for Economic Co-operation and Development

SADEC: Southern African Development Community

ECOWAS: Economic Community of West African States

AMU-EAC: Arab Magreb Union and East African Community

CEDEAO: Economic Community of West African States

GWP: Global Warming Potential

IUCN: International Union for Conservation of Nature

UNEP: United Nations Environment Programme

WWF: World Wide Fund for Nature

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Rapid economic growth has led to the current modern world facing a serious threat of climatic change, which has a negative impact on human socioeconomic condition. Greenhouse gas (GHG) emissions from the combustion of fossil fuels and other energy sources are among the major causes of climate change. Due to environmental degradation, environmental issues have become a focal point of discussion in both emerging and developed economies due to environmental deterioration. This adds to concerns about climate change and global warming, which are mostly caused by greenhouse gas emissions. Natural factors (continental movements, volcanic activity, solar radiation, and ocean currents) and direct and indirect human actions, which affect the global atmospheric composition and variability of the natural climate, are frequently linked to these changes.

However the availability of data is the one that made me use the period 1980 to 2020 with Panel data for twenty-seven African countries which is used in this study. Those countries Include: South Africa, Zambia, Kenya, Morocco, Tunisia, Ghana, Madagascar, Malawi, Mauritania, Mozambique, Namibia, Sudan, Uganda, Zimbabwe, Ethiopia, Tanzania, Togo, Rwanda, Nigeria, Mali, Gabon, Djibouti, Senegal, Cameroon, Algeria, Angola, and Egypt Arab rep. over the time period of 1980 to 2020 to run panel model with country fixed effect. These countries were chosen because of their high greenhouse gas emissions, modern economic growth in comparison to developed countries, and limited energy supplies. The World Development Indicators Database provided the data for this study. The empirical investigation for 1980-2020 periods, based on the fixed effects estimation, suggests positive per capita energy consumption in relation to CO2 emission in environmental sustainability.

The results revealed that the degree of industrialization in the country has a positive relation with the CO2 emission due to the fossil fuel consumption and these fuels are emitting a lot of smoke hindering the environmental sustainability. Since the objective of the environmental sustainability policy is not to slow down the economic growth or to reduce the production of certain sector, it is important it allows the wider range of innovative technological solution for environmental issues like usage of renewable clean energy sources in energy sector of economy and usage of energy efficient appliances in given country. One of the important benefits for the countries under this study would be to reduce the dependence on energy imports especially fossil fuels, lower greenhouse gas emission, increase employment in the energy sector and improve innovation in the non-polluting industries. These policies could help to increase their energy efficiency to minimize the energy consumption in general, which in turn reduce their environmental degradation due to higher economic activity and hence environmental sustainability could be achieved.

1.INTRODUCTION

1.1 Background of the study

Rapid economic growth has led to the current modern world facing a serious threat of climatic change, which has a negative impact on human socioeconomic conditions. Future economic prospects significantly depend on the long-term availability of energy from sources that are affordable, accessible, and secure. Some of the major causes of climatic change are greenhouse gas (GHG) emissions from the combustion of fossil fuels and energy sources (Majeed & Mumtaz & al, 2019)

Many countries have struggled to achieve economic growth while simultaneously increasing CO2 emissions, reflecting a global problem. However, the method of "low carbon and green growth" has been a source of increasing worry. That is, the question of whether sustained economic growth can be achieved without growing energy consumption or greenhouse gas emissions has become a topic of special interest. (S.-H., 2012)

Energy is a crucial component in the manufacturing process. It is necessary to achieve a long-term energy supply in order to keep economic activity growing (Stern D. B., 2016). Energy, according to (Brook, 2000), is a necessary component of economic and human development. (Ngepah, 2011)believes that energy has a similar causal effect on macroeconomic variables like poverty and inequality. Improving the quality of energy supply can have a direct impact on human capability functions, perhaps reducing economic inequities. According to (Stern D. B., 2016) access to and use of electricity has a direct impact on economic growth, poverty, and other development outcomes.

It has also been postulated that trade has a significant influence on the environmental quality of the economy. Environmental quality could decline through the scale effect, as increasing trade volume (especially exports) would expand the size of the economy, thereby increasing the extent of pollution. Thus, trade might be a cause of environmental degradation, ceteris paribus. Many economists have long argued that trade is not the root cause of environmental damage.

(Birdsall & Wheeler, Lee & Roland-Host, & Jones, 1995). However, free trade has contradictory impacts on the environment, both increasing pollution and motivating reductions in it.

(Copeland, 2001) (Bushell & Colley, 2017). Some argue that trade may be good for the environment. Trade may improve environmental quality through technological effects. As income rises through trade, environmental regulation is tightened, which spurs pollution-reducing innovation. Furthermore, because trade connects one country to international communities, an underdeveloped economy may rely on technology transfer via foreign direct investment to reduce pollution.

(Antweiler, 2001) I propose a theoretical framework for investigating the relationship between the environment and trade openness via the composition effect empirically. The composition effect explains how the composition of production (i.e., the structure of the industry) influences emissions, which is governed by the degree of trade openness as well as the country's comparative advantage. Depending on the country's resource availability and the strength of its environmental legislation, this influence could be good or negative. The capital–labour effect (KLE) and the environmental regulatory effect (ERE) are two examples of these effects.

The question of how to minimize carbon dioxide (CO2) emissions while maintaining steady economic growth has sparked a heated debate and is one of the major concerns of energy and environmental policy in every corner of the globe.

The Kyoto Protocol, signed in 1997, commits developed countries that have ratified it to reducing greenhouse gas emissions, primarily CO2, by 5.2 percent below 1990 levels over the next decade. Opponents, on the other hand, argue that imposing a collection of so-called "unrealistic" targets would be harmful to the global economy, as well as domestic economic growth, which would result in significant unemployment. Many people argue that even a shortage of energy would have a negative impact on wages. (Masih and Masih, 1998)Over the next several decades, energy consumption is expected to rise, particularly in low-and middle-income countries. Some economists believe that energy consumption will continue to rise, owing to the increased adoption of air conditioners and other energy-consuming assets. (Wolfram et al. & Davis and Gertler, 2015)Meeting this increased demand for energy will be a huge challenge, particularly because fossil fuels continue to provide the majority of the world's energy. With annual emissions of 30+ gigatons, carbon dioxide emissions from fossil fuels are the largest contributor to global greenhouse gas emissions. (IPCC, 2014)Faced with this daunting challenge, policymakers all over the world are focusing on energy efficiency as a way to avoid potentially curtailing energy demand growth. Supporters claim that energy efficiency is a "win-win" situation that pays for itself by lower energy expenditures while also lowering negative externalities. Many environmental organizations and international organizations see energy efficiency as playing a significant role in climate change mitigation.

In terms of caloric content, wood and charcoal provide over 80% of conventional energy. The energy crisis in many heavily populated areas is the loss of forests to meet fuel wood requirements. The illegal removal of wood from forests on mountain slopes has resulted in significant deforestation, flooding, and reservoir siltation. (Dunkerley J. W., 1981)The oil-exporting nations, has justified very large subsidies on kerosene with the claim that the environmental externality associated with wood fuel requires the subsidization of a substitute fuel.

Recently, (Howard, 1980)has claimed that this argument is unsupportable. On the basis of fieldwork evidence from certain areas, he claims that the consumption of wood fuels is insensitive to the price of petroleum fuels. In addition, he notes that higher wood fuel prices provide an incentive for commercial firewood production through spontaneous reforestation.

Due to environmental degradation, environmental issues have become a focal point of discussion in both emerging and developed economies due to environmental deterioration. This adds to concerns about climate change and global warming, which are mostly caused by greenhouse gas emissions. Natural factors (continental movements, volcanic activity, solar radiation, and ocean currents) and direct and indirect human actions, which affect the global atmospheric composition and variability of the natural climate, are frequently linked to these changes.

According to experts, the key reasons of climate change include a rise in human activities as a result of industrialization, an increase in global population growth, and the need to keep up with such changes. (Balint, et al., 2017). In addition, human activities such as deforestation for agricultural and commercial purposes, fossil fuel burning, and changes in land use owing to population growth are all contributing to an increase in greenhouse gas emissions.

Despite its role in encouraging economic progress by increasing the number of goods and services produced, altering lives, and improving society, industrialization has left us with a problem of rising carbon emissions. The demand for energy is increasing in today's globe as a result of rising population and urbanization. This is necessary to stay up with the global economy's continuous changes and transformations. Energy is essential to human life as well as the global economy's social, economic, and environmental development. It is unlikely that mainstream commodities can be produced, delivered, or used without consuming energy. As a result, (Yildirim, 2017)noticed that a lack of energy would have a negative impact on the functioning of various economic sectors, such as transportation and a country's social life. The increased consumption of energy, on the other hand, is posing a threat to the global biosphere. This has resulted in longer droughts, increasing sea levels, and more frequent heatwaves, all of which have serious environmental consequences. Despite widespread understanding of the implications of human actions, (Urry, 2015)noticed an increase in greenhouse gas emissions, such as carbon dioxide (CO2), into the atmosphere.

Similarly, in both developing and developed countries, the demand for economic progress has resulted in environmental deterioration, which is a common side effect of development and industrialization. Any country's economic growth is influenced by a variety of factors, some of which have negative environmental consequences, such as unsustainable natural resource exploitation, pollution, and climate change (Phimphanthavong, 2013). Furthermore, in many countries, rapid urbanization has accelerated economic growth, resulting in an increase in energy consumption.

As a result, the most pressing issue confronting countries especially east African is the rising quantity of carbon dioxide in the atmosphere as a result of increased energy use and economic expansion. Due to the climate change mitigation targets, the use of energy and the resulting GHG emissions receives a lot of focus ((Wang et al., Piatowska and Wodarczyk, & Soava et al.). In the study of the connections between electricity, economy, and climate, the manufacturing, service, and household sectors are taken into account (Yao et al., Chen et al., & Zhang et al., 2019) In this regard, the household sector is critical because it accounts for a large portion of overall final energy consumption. Furthermore, in order to determine the most suitable policy interventions for a given context, multiple effects leading to improvements in energy use and CO2 emissions in the household sector must be isolated. The continuous deterioration of global environmental quality poses a serious threat to the ASEAN region's long-term viability; according to the Climate Risk Index, five of the twenty countries most vulnerable to climate change are from the ASEAN region. The increased use of primary energy sources such as coal and natural gas and oil tends to raise CE in the country, worsening the regional climate change profile (Marquardt, 2016). The energy sector is the largest contributor to global GHG emissions, and the ASEAN region has become the largest contributor to global warming due to its heavy reliance on traditional energy sources (Silitonga et al., 2018).

1.2 Research gap

The current research realized that unless the population growth, other variables have been used to analyze the carbon dioxide emission

1.3 General Objective

The general objective of this study is to analyze the energy consumption and environmental sustainability, an "Evidence of CO_2 Emission".

1.4. Specific objectives

With respect to the research objectives, the following research questions were formulated:

- Identify the driving forces that affect carbon dioxide emission
- Examine the relationship between outcome variables and its explanatory?

1.5. Scope of the study

The scope is the area where the research is expected to be carried out within. It is simply the boundary of the research indicating where the research will not go beyond. The scope of this research is divided into geographical, content and time scope. The details are shown below:

1.5.1. Geographical scope

The current research is being carried out in 27African countries which are South Africa, Zambia, Kenya, Morocco, Tunisia, Ghana, Madagascar, Malawi, Mauritania, Mozambique, Namibia, Sudan, Uganda, Zimbabwe, Ethiopia, Tanzania, Togo, Rwanda, Nigeria, Mali, Gabon, Djibouti, Senegal, Cameroon, Algeria, Angola, and Egypt Arab rep. all these countries are located in African continents.

1.5.2. Time scope

The current research covers the period between 1980-2020.the choice of this time range is because of fact of data availability and variables to be considered in model possess their respective data in this mentioned period.

1.6 Expected outcome and significance of the study

1.6.1 Expected outcome

In this research, there is expectation that after its completion, there will be a significant reduction of CO_2 emission which is the proxy for environmental sustainability. Afterwards, this research expects to see how the energy consumption, foreign direct investment, degree of industrialization, urbanization level, unemployment and net trade can be well used in efficiency way so that their utilization will not harm the environment.

1.7 Significance of the study

The significance of the study is all about the role that the research expects to contribute to different people including the researcher herself, the community and the University. These are shown below:

1.7.1 Significance to the researcher

The current research helps the researcher to know and go in deep in analyzing energy consumption and it increases knowledge about the research variables and their analysis. Moreover, the completion of this research allows the researcher to acquire Masters' Degree in Energy Economics.

1.7.2 Significance to the community

The community will benefit in this research because of fact that the researcher will give recommendations about how to prevent the increase in GHGs (greenhouse gases).

1.7.3 Significance to the University

The university will use the copy of this research project as the reference by the next generation of readers who will work on similar topics

2. LITERATURE REVIEW

The impact of energy consumption and environmental sustainability on CO2 emissions has been well-documented in the econometric energy literature. Various contributions, among other things, focused on different countries, time periods, and proxy variables for macroeconomic and energy indicators. (Saidi, K.and Hammami, S., 2015). In the following paragraphs, we'll go over some of the previous research on the impact of energy consumption, environmental sustainability, and population on CO2 emissions.

Several empirical studies have looked into the causal relationship between economic growth and environmental degradation. The environmental Kuznets curve (EKC) hypothesis explains this causality. This hypothesis assumes that there is a strong and positive relationship between economic growth and environmental degradation (Grossman, 1991). and (Stern D. I., 1994)show that there is a positive relationship between economic growth and environmental degradation. Their research shows that as economic growth increases, so does environmental degradation as measure by environmental degradation.

(Zhang, 2012)use the fixed effects model and the least square generalized linear regression method to evaluate the impact of economic indicators on pollution (CO2emissions) in China from 1995 to 2010. As economic indicators, they use demographic intensity, urbanization, GDP, industrial production, service production, and energy consumption. The study's major findings reveal that demographic intensity, GDP, industrial production, and energy consumption all affect CO2 emissions.

(Alam, 2014)use the generalized method of moments (GMM) to investigate the impact of economic variables (population density, energy resources, energy consumption, and financial development) on pollution (CO_2 emissions) in Malaysia between 1975 and 2013. They conclude that increased energy use and financial development result in higher Co2 emissions.

2.0 Definition of the Key concepts

2.1 Energy consumption

In human life, energy is essential. Humans relied on natural energy flows, animal and human power for heat, light, and work before the industrial revolution, and yearly energy use per capita did not exceed 0.5 tonnes of oil-equivalent (toe). Between 1971 and 2010, the global total primary energy supply more than doubled, owing primarily to the use of fossil fuels (IEA, 2012)

Between 1850 and 2005, worldwide energy output and consumption increased by more than 50 times, from 0.2 billion to 11.4 billion toe (IEA 2007). The majority of this happened in industrialized cultures that had come to rely significantly on energy's rapid availability. People in these societies now use more than 100 times the amount of energy that their forefathers used before humans discovered to harness the energy potential of fire (UNDP, 2000)

2.2 Sustainability and sustainable development

Environmentalist movements underwent a significant transition a few decades ago. In the early 1980s, it was proposed that environmental protection does not conflict with development (IUCN, 1991)while simultaneously noting that the consequences of poverty and misery can be harmful to the environment. The concept of sustainable development was born out of the desire for people to live dignified lives combined with environmental concerns.

It is necessary to analyze the many views and understandings of the ideas in order to determine sustainability. There is no universally agreed-upon definition of sustainability. Its meaning is heavily influenced by one's attitude toward environmental management. Its interpretation also differs depending on many assumptions about human nature, society as a whole, and the relationship between society and nature (Ozkaynak, Devine, and Rigby 2004), all of which have a significant impact on its operationalization.

Despite the lack of a universally accepted definition, the concept is far from useless and has served as the framework for policy formulation in recent years. One could argue that sustainability is relatively hypothetical state compared to the current way of life especially in western world. The concept of sustainability can be interpreted as representing an objective rather than qualifying a state. Such perspective allows identifying the trend by evaluating if a socio-economic is getting closer to or moving or moving away from an ideal.

2.3 CO_2 (Carbon Dioxide)

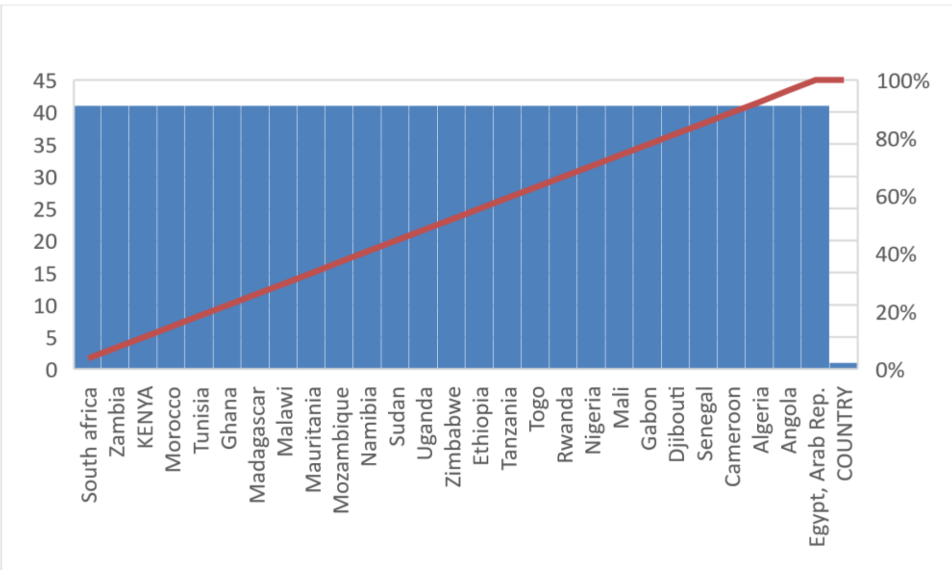
It is a colorless, odorless gas produced by burning carbon and organic compound and by respiration. It is naturally present in the air and it is absorbed by plants in photosynthesis.

2.3.1 CO2E (Carbon Dioxide Emission)

Global climate change is mostly caused by carbon dioxide emissions. It is commonly acknowledged that, in order to avoid the worst effects of climate change, the world must reduce emissions as soon as possible. However, how this obligation is shared across regions, countries, and individuals has been a never-ending source of debate in international forums.

The many ways in which emissions are compared, such as annual emissions by country, emissions per person, historical contributions, and whether or not they compensate for traded commodities and services, have sparked this discussion.

Figure 1:The share of CO2 Emission in Africa in metric per ton

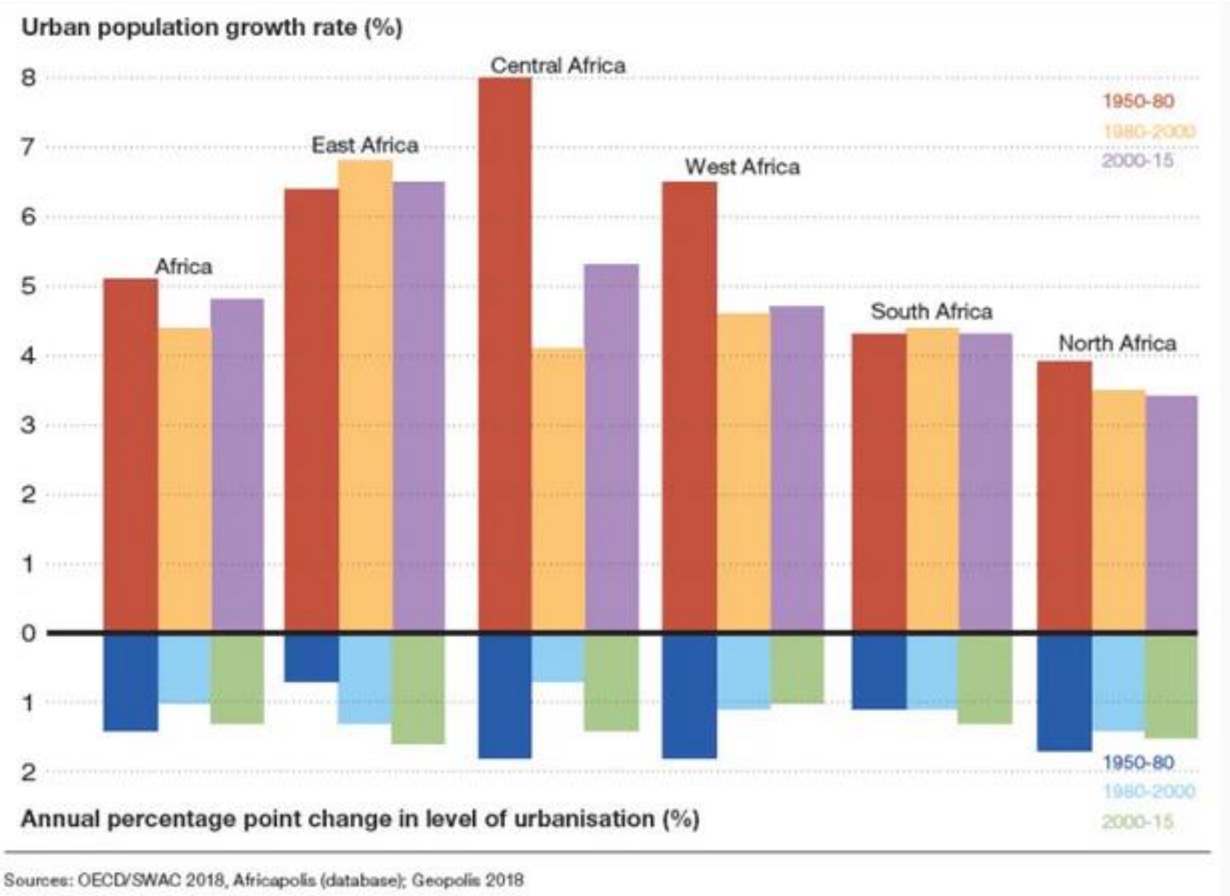


Source: Author's compulation

2.4 Population Growth and Urbanization

When thinking about development, one of the most important aspects to consider is population dynamics. The world's population has grown at an unparalleled rate in the last 50 years. After expanding slowly for most of human history, the world's population has more than doubled in the recent half-century, reaching 6 billion in late 1999. Africa has had the fastest urban growth rate in the last two decades, at 3.5 percent per year, and this trend is predicted to continue through 2050. According to projections, some African cities will account for up to 85% of the population between 2010 and 2025.

Figure 2:Growth of Urbanization in Africa (1950-2015)



Indeed, the rates of urbanization in African subregions have changed greatly throughout time (Figure 2). Central and West Africa had the most fluctuating urban population growth rates throughout the time covered by the analysis, whereas East, Southern, and North Africa had more steady growth rates. Central Africa urbanized rapidly from 1950 to 1980, but then became one of Africa's slowest urbanizing regions from 1980 to 2000. East Africa has continually had one of the world's fastest-growing urbanization rates.

2.5 Overview of Greenhouse Gas Emissions

Both human and natural greenhouse gases have been classed as atmospheric gaseous components. These elements are known to absorb and emit infrared radiation at specified wavelengths within the range of wavelengths emitted by the Earth's clouds, atmosphere, and surface. ((Paiva S. V., 2014) and ((Hossain H, 2012)). Stated that greenhouse gases continue to be a major contributor to climate change and global warming. This is in line with (Resnik's, 2018)statement that the negative effects of greenhouse gas-induced climate change on human health, the atmosphere, and society are numerous. As a result, ((Meltzer, 2016)estimated that over 150,000 people die each year as a result of environmental pollution. Despite the fact that there are numerous greenhouse gases, CO2 is gaining in popularity due to its long-term presence in the atmosphere and its usage as a baseline for calculating the global warming potential (GWP) of other greenhouse gases. ((Rahman, 2017)also stated that between 1990 and 2013, greenhouse gas concentrations increased by 34%, with CO2 emissions accounting for over 80% of this increase. This corresponds to the claim made by (Amri, 2017)that CO2 emissions have risen significantly from 67 million to 134 million metric tons.

Climate change has become one of the most important challenges in recent years. The climate is already warming, as evidenced by rising worldwide average temperatures, widespread melting of snow and ice, and rising global average sea level. Increased GHG emissions owing to human activities have resulted in a significant increase in atmospheric GHG concentrations since pre-industrial times. Global GHG emissions are increasing at a 1.4 percent annual rate (IPCC 2007).

Since the early 1970s, global GHG emissions have almost doubled, and are expected to increase by more than 70% between 2008 and 2050 under current policy. Energy-related GHG emissions have historically been dominated by the OECD's richer developed countries, therefore the rise in GHG concentration from the industrial revolution to present is mostly attributed to economic activity in these countries (OECD 2008). CO2 is considered to be the major contributor to global warming. CO2 concentration in the air is responsible for more than 60% of the greenhouse gas content. The power generating and road transport sectors have emitted the most CO2, followed by industry, homes, and the service sector (EEA 2006). Since 1971, global carbon dioxide emissions have increased by 106 percent, or 1.9 percent each year on average.

2.6 Review of the related literature

There have been three research strands in order to empirically analyze the relationship between economic development, energy use, and carbon pollution, which is used as a surrogate variable for environmental quality (Sari, 2003). The first line of investigation focuses on the connection between environmental pollution and economic development. The majority of the research on environmental quality and economic development focuses on proving the existence of an environmental Kuznet's curve (EKC). Due to the climate change mitigation targets, the use of energy and the resulting GHG emissions receives a lot of focus ((Wang et al., Piatowska and Wodarczyk, & Soava et al.).

We'll go over some of the previous research on CO2 emissions and the effects of economic growth, energy consumption, capital, financial development, and population. The causal relationship between economic growth and environmental degradation has been studied in a number of empirical investigations. This causation is supported by the environmental Kuznets curve (EKC) theory. This hypothesis assumes that economic growth and environmental degradation have a strong and positive link. According to (Grossman, 1991) and Selden and Song (1998), the relationship between economic growth and environmental deterioration is positively significant (1994). Their findings reveal that when economic growth accelerates, environmental degradation, as assessed by environmental degradation, accelerates as well.

CHAP 3. Methodology, Data source and Descriptive statistics

3.1. Data and Variable Collection

The East African Community, the Arab Maghreb Union, the Common Market for Eastern and Southern Africa, the Southern African Development Community, the Economic Community of West African States, and the Community of Sahel-Saharan States are the six major trading blocs in Africa, with their members listed in Table 1. Because of their similar sizes, the East African Community and the Arab Maghreb Union were merged. Yao Hongxing (Yao Hongxing, 2021) Due to the availability of data, the period 1980 to 2020 was chosen. Table 2 lists the variables that were chosen, as well as the measurement unit, time period, and sources.

The present research employs panel data for twenty-seven African countries, including South Africa, Zambia, Kenya, Morocco, Tunisia, Ghana, Madagascar, Malawi, Mauritania, Mozambique, Namibia, Sudan, Uganda, Zimbabwe, Ethiopia, Tanzania, Togo, Rwanda, Nigeria, Mali, Gabon, Djibouti, Senegal, Cameroon, Algeria, Angola, and Egypt Arab rep. over the time period of 1980 to 2020 to run panel model with country effect. The selection of these countries is based on the high greenhouse rate, low economic growth compared to developed countries and the low energy resources. Data for this research were retrieved from the World Development Indicators Database. The descriptions and details of the studied variables are reported in Table 2.

Table 1: *Table 1:List of selected countries in various trading blocs.*

African Regional Economic Blocks	**Abbreviation**	**Selected countries**
Arab Maghreb Union & East African Community	**AMU-EAC**	Algeria, Burundi, Kenya, Tanzania, Uganda, Rwanda, Mauritania, Tunisia
Economic Community of West African States	**ECOWAS**	Gambia, Ghana, Mali, Nigeria, Senegal, Sierra Leone, Togo
Sothern African Development Community	**SADEC**	Angola, Madagascar, Malawi, Mozambique, South Africa, Zimbabwe, Zambia
Community of Sahel-Saharan States	**CEN-SAD**	Benin, Burkina Faso, Cote d'Ivoire, Egypt, Gambia, Ghana, Mali, Mauritania, Morocco, Nigeria, Senegal, Sierra Leone, Sudan, Togo, Tunisia.

Data source: https://doi.org/10.1371/journal. pone.0253457

Table 2:Measurement units of the study variables and data collection source.

Variables	**Measurement unit**	**Period**	**Source**
CO2 Emission	(In Metric per ton)	1980-2020	(WDI)
Energy consumption	(Kw per capita)	1980-2020	(WDI)
Foreign Direct Investment	(% of GDP)	1980-2020	(WDI)
Level of Industrialization	(% of GDP)	1980-2020	(WDI)
Population Growth	(%)	1980-2020	(WDI)
Urbanization level	(% of total population)	1980-2020	(WDI)

Unemployment	(% of total labor force)	1980-2020	(WDI)
Employment	(% of total employment)	1980-2020	(WDI)
Population, total	(	1980-2020	(WDI)
Net trade	(BoP, current US$)	1980-2020	(WDI)

Data source: Author's compulation

3.2 Model Specification

To achieve our objective and derive the linkage between energy consumption and environmental sustainability for achieve the study objective we estimate the following equation since there are repeated observations at the country level, we will use a fixed-effects (FE) method to estimate and evaluating the effect of energy consumption on the sustainability of the environment includes estimating the following conditional outcome equation:

$$\boldsymbol{Y_{\pi t=}\alpha_{\pi} + BX_{\pi t} + \delta EC_{\pi t} + \varepsilon_{\pi t} +} \text{…………………... } \mathbf{(1)}$$

The above equation for fixed effects (country and survey year), Where $Y_{\pi t}$ is outcome variable of interest indicating the environmental sustainability (CO2 emission) of a given country. The term π is a country fixed effects while t denotes for survey year fixed effect. The country effect absorbs all time invariant observable and unobservable country attributes that could affect energy consumption in the country. On the other hand, the year fixed effect is being used to account for time varying characteristics which can influence energy consumption. Another variable of interest $EC_{\pi t}$ (Energy consumption in the country).

The model contains also the time varying country characteristics represented by $X_{\pi t}$. The country characteristics include (Foreign Direct Investment, Level of Industrialization, and Urbanization level, Unemployment, Employment, Pop Tot and Net Trade) and $\varepsilon_{\pi t}$ is an unobserved factor affecting the sustainability of the environment indicator $Y_{\pi t}$. In this study, CO2 Emission was the dependent variable, while EC, FDI, LOI, PG, urbanization level, unemployment, employment, total pop were the explanatory variables used as determinants of CO2 Emission in Africa's trading blocs. Thus, following the work of the function for the study was modeled as below:

$$\mathbf{CO2emiss} = \mathbf{f}(\mathbf{EC}, \mathbf{FDI}, \mathbf{LOI}, \mathbf{PG}, \mathbf{URBAN}, \mathbf{UNEMPLOY}, \mathbf{EMPLOY}, \mathbf{POP\ TOT}, \mathbf{NET\ TRADE})\ (2)$$

Therefore, to resolve the issue of the lack of homoscedasticity, the transformed multivariate CO2emiss model was written as:

$$CO_{2emission_{\pi t}} = \alpha_{\pi} + \delta EC_{\pi t} + \beta_1 FDI_{\pi t} + \beta_2 LOI_{\pi t} + \beta_3 PG_{\pi t} + \beta_4 URBAN_{\pi t} + \beta_5 UNEMPLOY_{\pi t} + \beta_6 EMPLOY_{\pi t} + \beta_7 POP - TOT_{\pi t} + \beta_8 NET\ TRADE_{\pi t} + \varepsilon_{\pi t} (3)$$

Where:

π: stands for each selected countries in the study (1, 2… N),

$\varepsilon_{\pi t}$: error term

t: denotes the year of survey

α_{π} : is the slope coefficient.

and β_1, β_2, β_3, β_4, β_5, $\beta_{6,}$ β_7 β_8 and β_9 are the coefficients to be determined for Energy Consumption, Foreign Direct Investment, Level of Industrialization, and Urbanization level, Unemployment, Employment, Pop Tot and Net Trade, respectively.

3.3. Source of Data

The aim of this study is to analyse energy consumption and environmental sustainability "Evidence of CO2 Emission". The data for this study was sourced from the World Bank (World development indicators), a reliable and credible database. It is the primary World Bank collection of development indicators, compiled from officially recognized international sources. In addition, it presents the most accurate and current global development data available and includes national, regional and global estimates.

CHAPTER 4. RESULTS AND DISCUSSIONS

This section entails the analysis of the results where the results from table 4 to table 6 describe the Equation (1) results. The first part is the Baseline regression model analysis of the energy consumption and CO2 emissions in Africa (4.2), the second is the fixed effects regression model analysis of the energy consumption and CO2 emissions in Africa (4.3), and the third is the fixed effect regression model analysis of the energy consumption and CO2 emissions in Africa including regional trade blocks in (4.4), whereas 4.1 shows the descriptive statistics of the data used in the study.

4.1 Descriptive statistics

This section describes the basic variables of the data in my study. Where it provides simple summaries about mean, standard error, minimum and maximum. And typically distinguished from inferential statistics. With descriptive statistics you are simply describing what is or what the data shows.

Table 3:Descriptive Statistics

	Mean value	Stand error	Minim	Maxim
CO_2 emission	1.05	1.73	0.03	9.92
Per capita energy consumption	615.01	944.81	3.51	4851.69
Foreign direct investment	2.60	3.91	0.00	40.17
Industrialization	25.83	11.18	4.47	72.72
Population growth	3.33	4.28	-6.77	37.21
Urbanization level	38.45	18.46	4.72	90.09
Unemployment	11.93	7.65	0.30	33.29
Employment	13.04	7.40	2.47	33.73
Total population	24800000	29100000	358960	206000000
SADEC	0.30	0.46	0	1
EAC	0.26	0.44	0	1
CEDEAO	0.14	0.39	0	1
Others	0.30	0.46	0	1
Observations	1107			

Table3 above reports the descriptive statistics of the variables used in this study. Where the CO2 emissions (CO2) are measured in per capita metric tons, energy consumption (EC) is measured as kW per capita, foreign direct investment (FDI) as a percentage of gross domestic product, the level of industrialization (IND) as a percentage of gross domestic product, population growth

(POPgr) as a percentage of the population, unemployment (UNEMPL) as a percentage of the total labor force, employment as a percentage of the total employment, While others indicate whether the country is a member of the South African Development Community noted as (SADEC), a country member of the East African Community(EAC), CEDEAO indicates whether the country is a member of other economic and development communities, like the Arab Maghreb Union (AMU), the country is a member of the economic community of West African States noted as ECOWAS, and the total population in the sample period from 1980 to 2020.

Over the sample period and across the 27 countries, the mean value of CO2emissions is 1.05 metric per ton of CO_2 equivalent, which has a high global warming potential. The CO_2 emissions vary between 0.03 and 9.92 metric tons. The degree of variability is also witnessed by the standard deviation of 1.73 metric per ton of CO_2 emissions, indicating that the data is not scattered away from the mean value. The mean value of energy consumption is 615.01 kW per capita and the variation of the energy consumption is from 3.51 and 4851.69 kW per capita while the degree of variability indicates that the energy consumption deviates from its mean value by 944.81 Kw per capita.

From the descriptive statistics across all countries, the mean value of foreign direct investment is 2.60 percent of the gross domestic product (GDP) and the variation is in between is 0.0 and 40.17 percent of the gross domestic product (GDP), while the degree of variability shows that the foreign direct investment is scattered away from its mean by 3.9 percent of the gross domestic product (GDP). The statistics described above reveal that industrialization has a mean value of 25.83 percent of the gross domestic product (GDP) with a variation range between 4.47 and 72.72 percent of the gross domestic product (GDP), while the degree of variability indicates that industrialization deviates from its mean value by 11.18 percent of the gross domestic product.

From the statistics description, the mean value for population growth across all the sampled countries in the period is 3.33 percent in which the variation of the population growth is -6.77 and 37.21 percent with the degree of variability shows that the population growth scattered from its mean value by 4.28 percent. Table 3 reports that the urbanization level across the sampled countries has a mean value of 38.45 percent of the total population with a variability of 4.72 and

90.09 percent of the total population, while the degree of the variability reveals that the urbanization level deviates from its mean value by 18.46 percent of the total population. The statistic shows that the unemployment rate across all the sampled countries has a mean value of 11.93 percent of the total labor force, with a variation of between 0.30 and 33.29 percent of the total labor force, while the degree of variability indicates that the unemployment rate is scattered from its mean by 7.65 percent.

From the statistics revealed, the employment rate, measured as the percentage of the total population, has a mean value of 13.04 percent of the total population, with a variation range between 2.47 and 33.73 percent of the total population, while the degree of variability shows that the employment rate deviates from its mean value by 7.40 percent. The statistics indicate that the total population across all sampled countries has a mean value of 24.8 million people, with a variation of 358960 and 206 million people, while the standard deviation, indicating the degree of the variability, reveals that the total population deviates from its mean value by 29.1 million people. The statistics indicate the percentage of the countries' members in the economic blocks, especially EAC, ECOWAS (CEDEAO), SADEC, and others across all the countries sampled in this study.

From the statistics describe above reports that among the sampled countries , 30 percent of these countries are the member of SADEC economic community with the degree of variability indicates that the percentage of the country members deviates from its mean value by 46 percent of all sampled countries, 26 percentage of these countries are members of EAC with the degree of variability indicates that the percentage of the country members deviates from its mean value by 44 percent of all sampled countries while 14 percent of the countries are members of CEDEAO economic community with the degree of variability indicates that the percentage of the country members deviates from its mean value by 39 percent of all sampled countries and the 30 percent of them are members of the other economic and development communities. In my study I find that energy consumption reduced the FDI and this is in same context with what Aimable et al (2019) have found in their studies.

4.2 Baseline regression analysis of the energy consumption and CO_2 emission.

This section of baseline regression analysis of the energy consumption and CO_2 emission shows the estimated values from the unconditional baseline regression model of energy consumption and CO_2 emissions, where carbon dioxide emission increased due to an increment of per capita energy consumption.

Table 4:Baseline model of the energy consumption and CO2 emission in Africa

Variables	(1)	(2)	(3)	(4)
Per capita energy consumption (Kw)	0.002***	0.002***	0.002***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)
Foreign Direct Investment (FDI)		-0.055**	-0.058*	-0.030
		(0.024)	(0.029)	(0.024)
Degree of Industrialization in country		0.047**	0.011	0.155
		(0.020)	(0.010)	(0.097)
Yearly population growth in country		-0.020***	0.001	0.020**
		(0.005)	(0.006)	(0.009)
Urbanization level in the country (%)			0.029***	0.033***
			(0.008)	(0.007)
Unemployment level in country (%)			-0.012	0.001
			(0.012)	(0.012)
Yearly net trade in the country (log)				-1.187**
				(0.421)
Population x Industrialization level				-0.009
				(0.006)
Population x net trade in the country				0.073***
				(0.024)
Constant	0.260	-0.796**	-1.093***	-1.551***
	(0.164)	(0.378)	(0.342)	(0.371)
Observations	1107	1107	1107	1107
R-squared	0.729	0.821	0.947	0.956

Notes: The outcome variable is the CO_2 Emission expressed in the metric per tons in the 27 African countries between 1980-2020. In all specifications, we impose the robust standard errors and they are reported in the parentheses; the significance levels are reported *** p<0.01, ** p<0.05, * p<0.1 respectively.

Table 4 reports the estimation results from the unconditional baseline regression model of energy consumption and CO_2 emissions.

The column (1) entailing the model relating the percapita energy consumption and CO_2 emission indicates that when the percapita energy consumption is increased by one kW percapita, this is associated with a 0.2 point percentage increase in the CO2 emission, and this is significant at p 0.01. This contradicts what was found in the study carried out by Shanty O. et al. 2019.

The results from column (2) indicates that when the percapita energy consumption is increased by one kW percapita this is associated with incline in the CO_2 emission by 0.2 point percentage holding the other factors fixed and this is significant at $p<0.01$, the additional 1 percentage increase of foreign direct investment on the gross domestic product is associated with the decline of 5.5 point percentage metrics per ton of CO_2 emission and this is significant at $p<0.05$, the results from column(2) indicates that the incline of 1 percentage of degree of industrialization is associated with the increase in the CO_2 emission by 4.7 point percentages metrics per ton and this is significant at $p<0.05$, while the additional of 1 percentage on the yearly population growth is associated with the decline of 2 point percentage of metric per ton of the CO_2 emission and this is significant at $p<0.01$ when other factors are held fixed.

From the model estimation results in column (3) revealed that when the percapita energy consumption is increased by one kW percapita this is associated with incline in the CO_2 emission by 0.2 point percentage holding the other factors fixed and this is significant at $p<0.01$, the additional 1 percentage increase of foreign direct investment on the gross domestic product is associated with the decline of 5.8 point percentage metrics per ton of CO_2 emission and this is significant at $p<0.1$, the results reports that when the urbanization level in the country is increased by 1 percent this is associated with the incline of 2.9 point percentage metric per tone of the CO_2 emission holding other factors fixed and this is significant at $p<0.01$.

The results from the column(4) revealed that when the percapita energy consumption is increased by one kW percapita this is associated with incline in the CO_2 emission by 0.1 point percentage holding the other factors fixed and this is significant at $p<0.01$, while the additional of 1 percentage on the yearly population growth is associated with the decline of 2.0 point percentage of metric per ton of the CO_2 emission and this is significant at $p<0.05$, the results reports that when the urbanization level in the country is increased by 1 percent this is associated with the incline of 3.3 point percentage metric per tone of the CO_2 emission and this is significant at $p<0.01$. The results showed that when the yearly net trade in the country is increased by 1 unit this is associated with the decrease of 1.19 point percentage on the CO_2 emission metrics per ton and this is significant at $p<0.05$. surprisingly when the overall industrialization level in the country is raised by 1 percent the CO_2 emission metrics per ton will be declined by 0.9 point percentage while the incline of 1 percentage of the overall net trade in the country is associated with the incline of 7.3 point percentage on the CO_2 emission metrics per ton and this is significant at $p<0.01$.

4.3 FE regression model analysis of the energy consumption and CO2 emission in Africa

This part entails the fixed effect regression model analysis of the energy consumption and carbon dioxide emission in Africa especially look at the county's effect and yearly fixed effect of the outcome variables.

Table 5:The energy consumption & CO2 emission in Africa (country & year fixed effects)

VARIABLES	(1)	(2)	(3)	(4)
Per capita energy consumption (Kw)	0.001	0.001	0.001**	0.001*
	(0.000)	(0.000)	(0.000)	(0.000)
Foreign Direct Investment (FDI)		-0.010*	0.004	0.006
		(0.005)	(0.007)	(0.007)
Degree of Industrialization in country		0.021*	-0.012	-0.060
		(0.011)	(0.009)	(0.128)
Yearly population growth in country		-0.033	0.015	0.061
		(0.067)	(0.023)	(0.055)
Urbanization level in the country (%)			-0.000	0.005
			(0.013)	(0.014)
Unemployment level in country (%)			-0.010	-0.012
			(0.010)	(0.011)
Yearly net trade in the country (log)				1.117
				(0.726)
Population x Industrialization level				0.003
				(0.008)
Population x net trade in the country				-0.067
				(0.044)
Constant	0.912***	0.488	1.515*	1.299
	(0.251)	(0.335)	(0.865)	(1.124)
Observations	1107	1107	1107	1107
R-squared	0.931	0.935	0.989	0.990
Country FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES

Notes: The outcome variable is the CO_2 Emission expressed in the metric per tons in the 27 African countries between 1980-2020. In all specifications, we impose the robust standard errors and they are reported in the parentheses; the significance levels are reported *** $p<0.01$, ** $p<0.05$, * $p<0.1$ respectively.

The table 5 above reports the estimation results from the conditional baseline regression with year and country fixed effects model of energy consumption and CO_2 emissions. The results from column (2) show that an additional 1% increase in foreign direct investment in the gross domestic product is associated with a decrease of 1.0 point percentage metrics per ton of CO2 emissions, which is significant at p 0.1. The results from column (2) show that an increase of 2.1 point percentage metrics per ton of CO2 emissions is associated with an increase in CO2 emissions, which is significant at p 0. The results from the column (3) revealed that when the percapita energy consumption is increased by one kW percapita, this is associated with a 0.1 point percentage increase in the CO2 emissions, and this is significant at p 0.05. This agrees with what was found by Kozluk & Zipperer, 2015. The results from column (4) revealed that when the percapita energy consumption is increased by one kW percapita, this is associated with a 0.1 point percentage increase in CO2emissions, and this is significant at p 0.1. This is the same as the findings from the study by De Santis & Lasinio (2015).

4.4 FE regression model analysis of the energy consumption and CO2 emission in Africa including regional trade blocks

This part reports the estimation results from the conditional baseline regression model, when there is an include of the regional economic trade blocks or communities with a fixed effect.

Table 6:The energy consumption & CO2 emission in Africa (Regional Trade Blocks)

Variables	(1)	(2)	(3)	(4)	(5)
Per capita energy consumption (Kw)	0.623***	0.467***	0.817***	0.641***	0.852***
	(0.168)	(0.110)	(0.184)	(0.181)	(0.249)
Foreign Direct Investment (FDI)	0.011	-0.001	0.029	0.006	0.004
	(0.045)	(0.046)	(0.043)	(0.041)	(0.037)
Degree of industrialization in country	0.308	0.204	0.193	0.323	0.108
	(0.190)	(0.221)	(0.190)	(0.190)	(0.187)
Yearly population growth in country	0.060***	0.032	0.066***	0.059***	0.042*
	(0.018)	(0.021)	(0.019)	(0.017)	(0.020)
Urbanization level in the country (%)	0.038**	0.060***	0.052**	0.037**	0.073***
	(0.016)	(0.015)	(0.019)	(0.016)	(0.015)
Unemployment level in country (%)	0.155***	0.122***	0.136***	0.156***	0.103***
	(0.030)	(0.020)	(0.031)	(0.030)	(0.020)
Yearly net trade in the country (log)	-3.409**	-3.117**	-2.750**	-3.482***	-2.477**
	(1.189)	(1.182)	(1.208)	(1.190)	(1.086)
Population x Industrialization level	-0.020*	-0.014	-0.013	-0.021*	-0.008
	(0.011)	(0.013)	(0.011)	(0.011)	(0.011)
Population x net trade in the country	0.218***	0.197**	0.177**	0.222***	0.155**
	(0.071)	(0.070)	(0.072)	(0.071)	(0.065)
SADEC Membership		1.092**			1.036**
		(0.485)			(0.470)
EAC Membership			1.209		1.822*

			(0.782)		(0.877)
ECOWAS Membership				0.228	1.071*
				(0.435)	(0.606)
Constant	-6.641***	-6.237***	-8.402***	-6.723***	-9.296***
	(1.527)	(1.051)	(1.626)	(1.626)	(1.941)
Observations	1107	1107	1107	1107	1107
R-squared	0.858	0.878	0.867	0.858	0.895
Year FE	YES	YES	YES	YES	YES

Notes: The outcome variable is the CO2 Emission expressed in the metric per tons in the 27 African countries between 1980-2020. The ECOWAS stands for the Economic Community of West African States, SADEC is designed to represent the Southern African Development Community while the EAC is denoting the East African Community. In all specifications, we impose the robust standard errors and they are reported in the parentheses; the significance levels are reported *** $p<0.01$, ** $p<0.05$, * $p<0.1$ respectively.

Table 6 above reports the estimation results from the conditional baseline regression model, including the regional economic trade blocks/communities with a fixed effect. The results from the column(1) revealed that when the percapita energy consumption is increased by one kW percapita this is associated with incline in the CO_2emission by 62.3 point percentage holding the other factors fixed and this is significant at $p<0.01$, while the additional of 1 percentage on the yearly population growth is associated with the incline of 6.0 point percentage of metric per ton of the CO_2 emission which is significant at $p<0.01$ and this is the same as what found by Saidi & Hammami 2015, the results reports that when the urbanization level in the country is increased by 1 percent this is associated with the incline of 3.8 point percentage metric per tone of the CO_2 emission which is significant at $p<0.05$.

The results revealed that when the unemployment level in the country is increased by 1 percent then this is linked to the increase of CO_2 emission metrics per ton by 15.5 point percentage when other factors are held constant and this is significant at $p<0.01$. The results showed that when the yearly net trade in the country is increased by 1 unit this is associated with the decrease of 3.41 point percentage on the CO_2 emission metrics per ton and this is significant at $p<0.05$ while the incline of 1 percentage of the overall net trade in the country is associated with the increase of 21.8 point percentage on the CO_2 emission metrics per ton when other factors are held constant and this is significant at $p<0.01$ which accords what found in the study carried out by Saidi & Hammami 2015.

The results from the column (2) discovered that when the percapita energy consumption is increased by one kW percapita, this is associated with an incline in the CO_2emission by 46.7 percent, holding the other factors fixed, and this is significant at p 0.01. Interestingly, the results report that when the urbanization level in the country is increased by 1 percent, this is associated with an incline of 6.0 point percentage metric per tone, which is significant at p 0.01.

The results revealed that when the unemployment level in the country is increased by 1 percent, then this is linked to the increase in CO_2 emissions metrics per ton by 12.2 percent when other factors are held constant, and this is significant at p 0.01. The results showed that when the yearly net trade in the country is increased by 1 unit this is associated with the decrease of 3.12 point percentage on the CO_2 emission metrics per ton and this is significant at $p<0.05$ while the incline of 1 percentage of the overall net trade in the country is associated with the increase of 19.7 point percentage on the CO_2 emission metrics per ton and this is significant at $p<0.05$ however which accord the findings from the study by Rauf et al., 2018, when the country is a member of SADEC this is associated with the increase I the CO2 emission by 1.1 metrics per ton when other factors are held constant which is significant at $p<0.05$ and this goes in line with the logic that most of the countries in SADEC regional trade block are highly industrialized and their economy rely mostly on industry sector and this sector is higher contributor to the incline in the CO2 emission metrics per ton in the region .

The results from the column (3) revealed that as the percapita energy consumption is increased by one kW percapita, this is related to an incline of 81.7 percent in the CO2emission, which accords with the findings from the study by Rafndadi & Ozuturk (2017). Interesting, the results report that when the urbanization level in the country is increased by 1 percent, this is related to an incline of 5.2 percent, which is significant at p0.05. The results discovered that when the unemployment level in the country is increased by 1 percent, then this is linked to the increase in CO_2 emissions metrics per ton by 13.6 percent when other factors are held constant, and this is significant at p 0.05. The results showed that when the yearly net trade in the country is increased by 1 unit this is related with the decrease of 2.75 point percentage on the CO_2 emission metrics per ton and this is significant at $p<0.05$ while the incline of 1 percentage of the overall net trade in the country is related with the increase of 17.7 point percentage on the CO_2 emission metrics per ton and this is significant at $p<0.1$ on the other hand, when the country is a member of EAC this is associated with the increase in the CO2 emission by 1.21 metrics per ton when other factors are held constant and this goes in line with the fact that most of the countries in EAC regional trade block are developing countries and they trying to develop the industry sector and this sector is influencing the incline in the CO2 emission metrics per ton in the region .

The results from column (4) show that as the percapita energy consumption is increased by one kW percapita, this is related to an incline in the CO2 emissions by 64.1 point percentage, holding the other factors constant. This is significant at p 0.01. However, the additional 1 percent in the yearly population growth is associated with an incline of 5.9 point percentage of metric per ton of CO_2 emissions when other factors are held constant. This is significant at p 0.01. The results also show that the amidst the other factors are held constant, the other factors, the other factors, the other factors, the other factors, the CO2e, the CO2e, which is significant at p0.01. Interestingly, the CO2 by a 5.9 percent. The results discovered that when the unemployment level in the country is increased by 1 percent, then this is linked to the increase in CO_2 emissions metrics per ton by 15.5 percent when other factors are held constant, and this is significant at p 0.01 which accords with the finding in the study by Wang et al. 2016.

The results showed that when the yearly net trade in the country is increased by 1 unit, this is related to an increase of 3.48 points percent on the CO_2 emission metrics per ton, and this is significant at p 0.01. Interestingly, when the overall industrialization level in the country is raised by 1 percent, the CO_2 emission metrics per ton will decline by 2.1 percent, which is significant at p 0.1. On the other hand, when the country is a member of ECOWAS, the CO_2 emission metrics per ton will increase by 0.23 metrics per ton when other factors are held constant. This goes in line with the fact that most of the countries in the ECOWAS regional trade block are developing countries.

The results from column (4) show that as the percapita energy consumption is increased by one kW percapita, this is related to an incline of 85.2 percent in the CO2 emissions, which is significant at p 0.01. However, the additional 1 percent in the yearly population growth is associated with an incline of 4.2 percent of metric per ton of CO_2 emissions when other factors are held constant, and this is significant at p 0.1. This is the same as the findings from the study by Rafndadi & Ozuturk & Ozuturk 2017 study by Rafndadi & Ozuturk & Ozuturk & Ozuturk. The results discovered that when the unemployment level in the country is increased by 1 percent, then this is linked to the increase in CO_2 emissions metrics per ton by 10.3 percent when other factors are held constant, and this is significant at p 0.01.

The results showed that when the yearly net trade in the country is increased by 1 unit this is related with the decrease of 2.48 point percentage on the CO_2 emission metrics per ton and this is significant at $p<0.05$ while the incline of 1 percentage of the overall net trade in the country is related with the increase of 15.5 point percentage on the CO_2 emission metrics per ton and this is significant at $p<0.05$ and this is the same as the findings from the study of Rauf et al., 2018 on the other hand, when the country is a member of ECOWAS this is associated with the increase in the CO2 emission by 1.07 metrics per ton which is significant at $p<0.1$,when the country is a member of EAC this is related to the rise of 1.82 metric of CO2 emission per ton and this is significant at $p<0.1$ while as the country become the member of the SADEC community this is related to the increase of 1.04 metrics of CO2 emission per ton when other factors are held constant and this goes in line with the fact that most of the countries in regional trade blocks above are developing countries and they participate in the energy market like spot market through supply or demand focusing of balancing the energy market and this energy sector is influencing the incline in the CO2 emission metrics per ton in the regions through energy supply and consumption.

CHAPTER 5: CONCLUSION AND RECOMMENDATION

Although the environmental benefits of the renewable energy have been extensively studied, the environmental sustainability of the energy consumption have received a less attention, especially in Africa. In this study we have analyzed the causal relationship between the energy consumption and CO2 emission for the African countries, by using panel data analysis and the regression equation for an individual analysis on the selected African countries as members of different regional trade blocks and economic communities. The empirical investigation for 1980-2020 periods, based on the fixed effects estimation, suggests positive per capita energy consumption in relation to CO2 emission in environmental sustainability. The results revealed that the degree of industrialization in the country has a positive relation with the CO_2 emission due to the fossil fuel consumption and these fuels are emitting a lot of smoke hindering the environmental sustainability, the level of urbanization in the country is positively influencing the CO_2 emission and this relation is negatively affecting the sustainability of the environment while the yearly net trade in the country is negatively affecting the greenhouse gases emission which interestingly influence positively the environmental sustainability within the country, however being a member of the regional trade block and economic communities for the country this leads to the increase of the greenhouse gases in the environment and this hinder the environmental sustainability of the given country as the member countries they participate in the common market of the energy commodity through either supply or energy consumption (imports and exports) and trying to balance the market and this will affect the sustainability of the environment for theses country members.

Since the objective of the environmental sustainability policy is not to slow down the economic growth or to reduce the production of certain sector, it is important it allows for the wider range of innovative technological solution for environmental issues like usage of renewable clean energy sources in energy sector of economy and usage of energy efficient appliances in given country. One of the important benefits for the countries under this study would be to reduce the dependence on energy imports especially fossil fuels, lower greenhouse gas emission, increase employment in the energy sector and improve innovation in the non-polluting industries. These policies could help to increase their energy efficiency to minimize the energy consumption in general, which in turn reduce their environmental degradation due to higher economic activity and hence environmental sustainability could be achieved.

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