

**IMPACTS OF ENERGY CONSUMPTION,  
NATURAL RESOURCE USE AND EDUCATION  
ON ENVIRONMENTAL DEGRADATION IN  
AFRICA**

**OSUNTUYI BUSAYO VICTOR**

**UNIVERSITI SAINS MALAYSIA**

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NATURAL RESOURCE USE AND EDUCATION  
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AFRICA**

by

**OSUNTUYI BUSAYO VICTOR**

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# **KESAN PENGGUNAAN TENAGA, PENGGUNAAN SUMBER ASLI DAN PENDIDIKAN KE ATAS DEGRADASI PERSEKITARAN DI AFRIKA**

## **ABSTRAK**

Dunia telah mengalami kemerosotan alam sekitar yang teruk selama ini. Kesan kemerosotan alam sekitar ke atas ruang geografi bumi tidak dapat dinafikan membimbangkan, dan pihak berkepentingan alam sekitar bimbang. Tesis ini menyiasat kesan penggunaan tenaga, penggunaan sumber asli dan pendidikan terhadap kemerosotan alam sekitar di Afrika dari 1990 hingga 2017. Pertama, ia menyiasat kesan penggunaan tenaga, penggunaan sumber asli dan pendidikan terhadap pencemaran. Kedua, ia melihat bagaimana penggunaan tenaga, penggunaan sumber asli dan pendidikan mempengaruhi kemerosotan alam sekitar. Ketiga, ia mengkaji kesan penyederhanaan pendidikan terhadap pencemaran alam sekitar (CO<sub>2</sub>) dan kemerosotan alam sekitar. Kajian ini menggunakan beberapa teknik ekonometrik, termasuk Ralat Piawai Driscoll-Kraay, Dataran Terkecil Biasa Biasa yang Diubah Suai Sepenuhnya dan Dataran Terkecil Biasa Biasa Dinamik. Penemuan mendedahkan bahawa penggunaan tenaga memburukkan lagi pencemaran dan kemerosotan alam sekitar. Kajian itu tidak dapat mengesahkan hipotesis EKC, membayangkan bahawa pertumbuhan ekonomi tidak menyelesaikan masalah alam sekitar Afrika. Menurut penemuan kajian, penggunaan sumber semula jadi mengurangkan pencemaran sambil memburukkan lagi kemerosotan alam sekitar. Tambahan pula, penemuan menunjukkan bahawa semua peringkat pendidikan memberi kesan negatif terhadap pencemaran alam sekitar di Afrika, kecuali kualiti pendidikan, yang tidak mempunyai kesan. Namun, penemuan mendedahkan bahawa pendidikan tidak mengurangkan kesan penggunaan tenaga terhadap pencemaran

alam sekitar, tetapi ia mengurangkan kesan penggunaan sumber semula jadi terhadap pencemaran alam sekitar di Afrika. Dalam nada yang sama, dapatan menunjukkan bahawa pendidikan rendah memburukkan kemerosotan alam sekitar manakala pendidikan menengah memperbaikinya. Begitu juga, penemuan mendedahkan bahawa semua peringkat pendidikan menyederhanakan kesan penggunaan tenaga terhadap kemerosotan alam sekitar, manakala kualiti pendidikan menyederhanakannya dengan baik. Sementara itu, pendidikan rendah menyederhanakan kesan penggunaan sumber asli dengan baik, manakala pendidikan tertiar menyederhanakannya. Sebaliknya, pendidikan menengah dan kualiti pendidikan tidak mengurangkan kesan penggunaan sumber asli terhadap kemerosotan alam sekitar. Oleh itu, kajian itu mengesyorkan dasar yang berkesan untuk membawa penurunan drastik dan tepat pada masanya dalam kemerosotan alam sekitar tetapi memberi amaran bahawa kerajaan Afrika tidak seharusnya menyekat pertumbuhan dengan menguatkuasakan undang-undang alam sekitar yang ketat yang menjejaskan potensi pertumbuhan masa depan. Ia juga mengesyorkan agar Afrika mengurangkan pergantungannya kepada bahan api fosil dan menggalakkan tenaga boleh diperbaharui dan teknologi cekap untuk memupuk pertumbuhan ekonomi yang mesra alam. Akhir sekali, kajian itu mengesyorkan agar negara Afrika menetapkan matlamat untuk memelihara sumber semula jadi dengan mengubah kurikulum pendidikan mereka untuk memasukkan pengetahuan, kemahiran dan minda alam sekitar untuk membolehkan amalan cekap tenaga yang mengurangkan pencemaran dan kemerosotan.

**IMPACTS OF ENERGY CONSUMPTION NATURAL RESOURCE USE  
AND EDUCATION ON ENVIRONMENTAL DEGRADATION IN AFRICA**

**ABSTRACT**

The world has suffered severe environmental deterioration over the years. The impact of environmental degradation on the earth's geographical space is undeniably alarming, and environmental stakeholders are concerned. This thesis investigates the impacts of energy consumption, natural resource use and education on environmental degradation in Africa from 1990 to 2017. First, it investigates the impacts of energy consumption, natural resource use and education on pollution. Second, it looks into how energy consumption, natural resource use and education affect environmental degradation. Third, it examines the moderating impacts of education on environmental pollution (CO<sub>2</sub>) and environmental degradation. The study employs several econometric techniques, including Driscoll-Kraay Standard Error, Fully Modified Ordinary Least Square and Dynamic Ordinary Least Square. The findings reveal that energy consumption worsens environmental pollution and degradation. The study could not confirm the EKC hypothesis, implying that economic growth does not solve Africa's environmental problems. According to the study's findings, natural resource use reduces pollution while exacerbating environmental degradation. Furthermore, the findings show that all levels of education negatively impact environmental pollution in Africa, except education quality, which has no effect. Still, findings reveal that education does not mitigate the impacts of energy consumption on environmental pollution, but it does mitigate the impacts of natural resource use on environmental pollution in Africa. In the same vein, the findings show that primary education worsens environmental degradation

while secondary education improves it. Similarly, the findings divulge that all levels of education unfavorably moderate the impacts of energy consumption on environmental degradation, whereas education quality favorably moderates it. Meanwhile, primary education favorably moderates the effects of natural resource use, whereas tertiary education unfavorably moderates them. Conversely, secondary education and education quality do not mitigate the effects of natural resource use on environmental degradation. Therefore, the study recommends effective policies to bring about a drastic and timely decline in environmental degradation but warns that African governments should not stifle growth by enforcing stringent environmental laws that jeopardize potential future growth. It also recommends that Africa reduce its reliance on fossil fuels and promote renewable energy and efficient technologies to foster environmentally friendly economic growth. Finally, the study recommends that African countries set goals for preserving natural resources by transforming their education curriculum to include environmental knowledge, skills, and mindsets to enable energy-efficient practices that reduce pollution and degradation.

## CHAPTER 1

### INTRODUCTION

#### 1.1 Background to the study

Environmental degradation and climate change are major global challenges in achieving sustainable growth and development. The world has suffered severe environmental deterioration over the past few decades. Undeniably, the impact of ecological distortions and environmental degradation on the earth's geographical space is alarming, causing environmental stakeholders and environmentalists to be highly concerned. These problems have resulted in environmental disasters from being just a bunch of environmental issues. Due to that, countries are under pressure, striving to address environmental crises and simultaneously sustain economic growth (Munir et al., 2020). Fundamentally, it is believed that the destruction of many countries ecosystems is the consequence of human actions, including rapid industrialization, population growth, economic expansion, urbanization and excessive consumption of fossil fuels (Destek & Aslan, 2020; Ehigiamusoe, Guptan, et al., 2020; Eyuboglu & Uzar, 2021; Mohsin et al., 2021; O. Usman et al., 2020). Undoubtedly, one of the major contributors to environmental pollution and degradation is carbon dioxide (CO<sub>2</sub>) emissions (Castellanos et al., 2021; Ehigiamusoe et al., 2020). As a result, carbon (CO<sub>2</sub>) emissions have been used to quantify the environmental impacts of human activities (Ali et al., 2019; Danish et al., 2019; Khan et al., 2021; Usman et al., 2020; Zhang et al., 2021).

CO<sub>2</sub> emissions are a primary driver of climate change, resulting in air pollution and global warming (Abokyi et al., 2019; Ehigiamusoe & Lean, 2019;



Sirag et al., 2018). For instance, in recent years, air pollution and the global average temperature have been increasing enormously; natural disasters and smoggy weather have occurred frequently, with attendant effects on human health and sustainable development (Wang et al., 2019). As a result, countries have become concerned about reducing CO<sub>2</sub> emissions to combat environmental challenges. Understanding the dynamics of CO<sub>2</sub> emissions is crucial to decarbonize energy systems and to mitigate global warming. Therefore, the goal of transitioning to a low-carbon economy has become crucial for human survival and overall environmental sustainability. This desire resulted in the implementation of various climate policies, and numerous global efforts have been made to reduce the harmful effects of global warming (Amuakwa-Mensah & Adom, 2017; Lean & Smyth, 2010a). Some notable efforts are the Kyoto Protocol of 1997, the Paris Convention of 2015, and the Sustainable Development Goals (SDGs) of 2015. These efforts aim to reduce greenhouse gas (GHG) concentration in the atmosphere, reduce the pace of climate change, and achieve sustainable growth.

On the other hand, ecological footprint (EFP) has been developed to measure environmental degradation in the literature. The phrase “appropriated carrying capacity” was coined by Rees (1992) to explain a society’s sustainability, which was later dubbed EFP by Wackernagel and Rees (1996). The EFP says how much land and water are required to make renewable resources for humans and digest their waste. It is a comprehensive indicator that shows how many different resources are used in a single component, called the global hectare (Syrovátka, 2020).

The EFP serves as a critical indicator for measuring sustainability (Gao & Tian, 2016). It indicates the human utilization of environmental resources for sustainability assessments. The Ecological Footprint measures human demand on nature and measurement that provides countries' ecological balance. It measures the biologically productive areas around the world, land size, and area of water required to produce renewable resources and for waste disposal (Aydin et al., 2019; Syrovátka, 2020) to measure how sustainable the environment would be, considering the way natural resources are being used for production. The ecological footprint helps make the right and responsible decisions about societal natural resources (Zafar et al., 2019). The EFP highlights the importance of land as a source of space, products, and services and a sink for wastes given by the environment to humanity. It quantifies the environmental pressure caused by human consumption (Ozcan et al., 2020; York et al., 2003). As a result, EFP is a comprehensive measure of environmental degradation (Zhang et al., 2021).

Although the EFP and CO<sub>2</sub> are major indicators of environmental quality, they measure different aspects of the environment. CO<sub>2</sub> measures environmental pollution, while EFP indicates environmental degradation (Ozcan et al., 2020). In detail, environmental pollution is the undesirable alteration of the environment caused entirely or mainly by man's activity due to changes in the energy pattern, radiation levels, chemical and physical constitution, and abundance of species. The loss of flora, biological diversity, excessive concentrations of dangerous chemicals in the ambient atmosphere and food grains, and rising risks of environmental accidents and dangers to life support systems all point to a reduction in environmental quality as a result of pollution. Pollution can be classified as air, water, soil/land, noise,

radioactive, or thermal, depending on the type of the pollutants<sup>1</sup> and the resultant pollution of environmental components. Among these pollution forms, air pollution (the focus of this study) is the most dangerous to the environment, humans, plants, animals, and living organisms (Prabhat, 2016). Air pollution is also to blame for climate change due to the increased greenhouse effect, acid rain, and ozone layer depletion, all of which are global environmental issues.

On the other hand, environmental degradation is a process by which the natural environment is destroyed in one way or another, resulting in resource depletion, decreased biological diversity and environmental health. It deteriorates the environment's physical components as a result of human activities. Pollution, biodiversity loss, animal extinction, deforestation and desertification, and global warming are all components of global environmental degradation (Brown et al., 1987). It encompasses air, water, soil, plants, animals, and all other living and non-living elements on earth (Bourque et al., 2005; Maurya et al., 2020; Third World Resurgence, 2000). Therefore, it is clear that environmental pollution is only an aspect of environmental degradation.

The environmental Kuznets curve (EKC) hypothesis by Grossman and Krueger (1991) has been employed in the environmental literature to identify the determinants of environmental pollution and degradation. The EKC hypothesizes an inverted "U" shaped relationship between economic growth and environmental pollution/degradation. The EKC postulates that environmental pollution/degradation in the early stages of economic development tends to increase due to increasing

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<sup>1</sup> The term "pollutant" refers to any chemical, biological, or physical substance released into the environment by humans and has adverse effects. Pollutants can be anything from toxic metals to radionuclides to organophosphorus compounds.

economic output. This process continues until a certain level of growth is attained, after which economic growth and environmental pollution/degradation start to decline.

However, the environmental impacts of economic growth depend on the scale, technique, or composite effects. The scale effect suggests that the environment deteriorates as economic activities increase due to the increased use of natural resources. The technique effect suggests that technological advancements and diversification cause an increase in economic activities and reduce environmental degradation. The composition effect suggests that the proportion of pollution-intensive products in production may reduce as the economy grows (Sarkodie, 2018; Solarin & Lean, 2016). Many studies have been carried out on the EKC hypothesis from theoretical and empirical perspectives. Many of the studies found a link between environmental quality and economic growth.

Undoubtedly, economic growth drives natural resource extraction (Danish et al., 2020). Many natural resources are extracted to meet production needs as the economy grows. Natural resources such as fishing grounds, croplands, forests, and grazing lands provide capital for production (Hassan et al., 2019; Xue et al., 2021). Nevertheless, the more a country increases its productive capacity, the more the environment deteriorates (Danish, Baloch, Mahmood, & Zhang, 2019; Sarkodie, 2018). The continuous depletion<sup>2</sup> of natural resources and their unsustainable use, particularly in developing nations, generates severe environmental consequences, such as water shortage, deforestation, climate change and reduces the land's ability to

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<sup>2</sup> A large number of natural resources are depleted through mining, deforestation, and agriculture.

produce (Danish, Baloch, Mahmood, & Zhang, 2019; Wu et al., 2017; Xue et al., 2021).

Energy is another factor identified as a driver of environmental pollution and degradation (Azlina et al., 2014). In every respect, energy consumption is a distinctive feature of growth and an essential catalyst for development (Abokyi et al., 2019; Adedoyin et al., 2020; Azam et al., 2019; Law & Sek, 2021; Lean & Smyth, 2014; Shahbaz & Lean, 2012; Shijin Wang et al., 2019). However, excessive energy use to foster economic growth could be detrimental to the environment (Al-Mulali, Ozturk, et al., 2015; Lean & Smyth, 2010a; Munir et al., 2020; Xu et al., 2020). In this respect, using non-renewable energy sources such as fossil fuels eventually negatively results in declining environmental quality (Adedoyin et al., 2021; Zhang et al., 2021). As a result, there have been various environmental problems such as environmental pollution, environmental degradation, global warming, and a slew of other complexities that pose challenges to human life and global economic growth.

There are two primary sources of energy, namely renewable and non-renewable energy sources. Renewable energy is environmentally friendly energy that comes from natural processes that are continuously being replenished. It is inexhaustible in duration but limited in the quantity of energy available per unit of time (Energy Information Administration (EIA), 2019). Renewable energy sources include biomass, geothermal, wind, wave, hydroelectric, and solar energy. Non-renewable energy sources, on the other hand, cannot be renewed soon after use, and their reserves are limited in nature. The consumption rate of non-renewable energy is more extensive than its regeneration rate. Non-renewable energy includes fossil

fuels<sup>3</sup>. Fossil fuel consumption has hitherto dominated energy use in the world. The excessive dependence on fossil fuels results in undesirable CO<sub>2</sub> emissions, significantly affecting the atmospheric environment and climate change (Aydin, 2019; Lin & Agyeman, 2019; Wang et al., 2019). Ordinarily, countries with much renewable energy should usually have less CO<sub>2</sub> emissions than countries with many non-renewable energy resources, but this is not always the case. Still, such an outcome depends on their consumption choices between renewable and non-renewable energy.

As it becomes increasingly clear the extent to which human activities have affected the environment, attention has begun to turn to education and the need to tap its potential. According to the United Nations Educational, Scientific and Cultural Organization (UNESCO, 2002), education is one of the vital tools which enables people to make informed and rational decisions about consumption choices that ultimately impact the environment. The role of education in sustainable consumption and environmental quality was echoed in the 21st Agenda of the 1992 Rio de Janeiro Earth Summit, which was further stressed in the United Nations “2005 to 2014 Decade of Education for Sustainable Development” Programme. Furthermore, education makes people interested in the environment and enables them to support and promote environmental protection<sup>4</sup> (UNESCO, 2015).

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<sup>3</sup> Fossil fuels are oil, coal and natural gas.

<sup>4</sup> Additionally, more education can improve environmental awareness and regulations concerning natural resources usage and energy consumption, thereby improving environmental quality. Inglesi-Lotz & Morales (2017) explains how education could affect energy consumption. First, education increases the awareness level in any economy. This increased awareness could enable energy consumers to make informed and better decisions concerning energy consumption, which, in turn, may lead to a reduction in energy consumption. For instance, developing nations with less education may consume more energy that is not friendly to the environment in order to catch up with developed nations.

The literature has also argued that education empowers people to reconsider their consumption behavior and lifestyles that are harmful to the environment, facilitates the efficient use of resources, and aids a better understanding of environmental problems and complex environmental concepts (Ulucak & Bilgili, 2018). Education could directly affect the environment by creating awareness and encouraging individuals to protect their environment. For instance, educated individuals are likely to be more concerned about the environment and support environmental policy decisions. Education could also affect the environment by moderating energy consumption and natural resource use. Certainly, education plays an essential role in determining a country's usage of natural resources and its dependence on a particular energy source (Balaguer & Cantavella, 2018).

Noticeably, education is a primary channel of knowledge, values, and skills acquisition, changing humans' environmental behaviors and attitudes to address climate change and environmental degradation challenges. Indeed, education provides an endless entryway to information and contributes to a better understanding of complex environmental messages. Correspondingly, education raises environmental awareness, fosters a deep sense of responsibility, steers people away from environmentally harmful behavior, motivates individuals to use environmental resources more efficiently, and supports environmental policies

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In contrast, education could make developed nations to reduce the consumption of such energy. Education enables energy consumers in developed nations to process complex information about energy usage and pricing, thereby substituting dirty energy for a more environmentally friendly one. Besides, rural dwellers may use less efficient energy, but as their level of education increases, these individuals might migrate to urban areas where they could substitute less efficient energy for more efficient ones such as electricity. Education also facilitates the adoption of clean and efficient technologies (Balaguer & Cantavella, 2018; Williamson, 2017).

(Chankrajang & Muttarak, 2017; Debrah et al., 2021; Harring et al., 2020; McCright, 2010; Tang et al., 2021; UNESCO, 2021; Zhang et al., 2021).

Education promotes pro-environmental conduct and behavior in various circumstances. For instance, it is noted that educated individuals are more inclined to reduce, reuse, and recycle (Ferrara & Missios, 2005; López-Mosquera et al., 2015; Smith, 1995; Zen et al., 2014). People with education are more likely to make better consumption choices, such as using natural resources efficiently, exhibiting energy-saving, buying eco-labeled and energy-efficient items (Blend & Ravenswaay, 1999; Ma et al., 2013; Pronello & Camusso, 2011; Wijaya & Tezuka, 2013).

Furthermore, better-educated people are more likely to support green electricity and sacrifice financial well-being to enrich the environmental quality and report environmental concerns (De Silva & Pownall, 2014; Xiao et al., 2013). They are equally likely to support sustainable resource use, emissions reduction policy, renewable energy and environmental protection through higher payment of taxes (Bigerna & Polinori, 2014; Kotchen et al., 2013; Zorić & Hrovatin, 2012).

However, education could generate adverse effects on the environment and pro-environmental behavior, such as unsustainable use of natural resources, increasing the consumption of non-renewable resources and access to polluting technologies, which leads to negative repercussions on the environment (Balaguer & Cantavella, 2018; Ek & Söderholm, 2008; Johnston et al., 2001; Teisl et al., 2008). For instance, in nations with low levels of education, a boost in enrolment would accelerate the consumption of non-renewable energy resources, causing environmental damage. Increased knowledge in these nations increases the use of



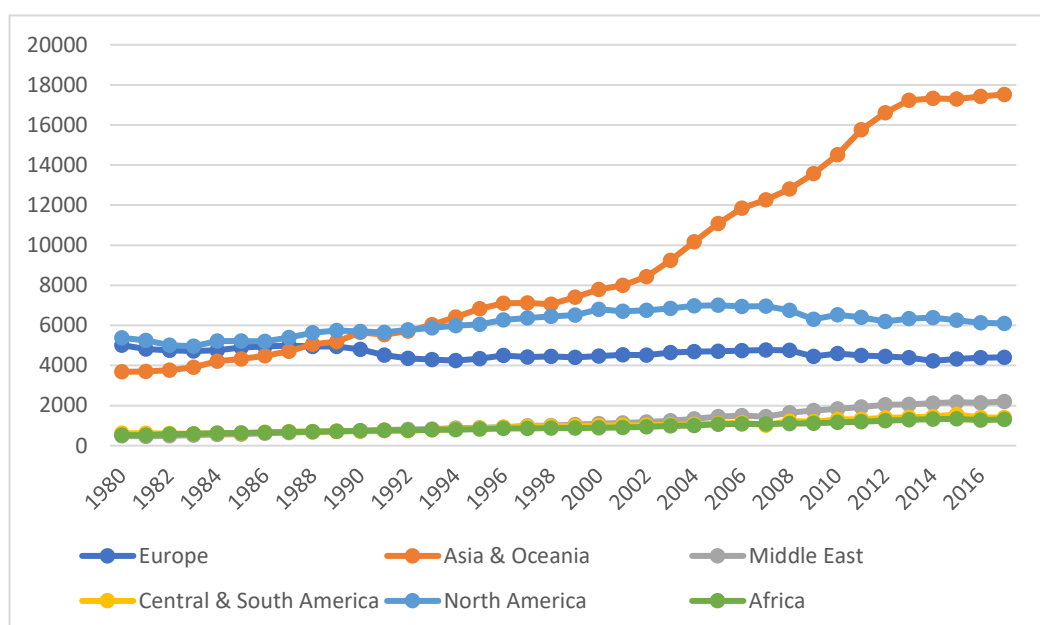
environmentally damaging products (Mahalik et al., 2021). In other words, educational attainment may contribute to environmental deterioration by increasing energy-intensive activities such as transportation, manufacturing and facilitating access to polluting technologies in these economies (Zafar et al., 2021). Therefore, depending on the level of development, education may have varying moderating effects on the environment via energy consumption in different economies (Inglesi-Lotz & Morales, 2017; Tang et al., 2021; Zafar et al., 2021).

Investigating education's direct and moderating roles is vital to understanding how it can inspire people to use environmental resources to improve environmental quality, particularly in Africa. Examining the impact of education on Africa's environment is imperative, as the region is the most vulnerable to the adverse effects of climate change. African's temperature is projected to rise more rapidly than the global average, rising to 4–6°C this century (UNDP, 2018). Nevertheless, Africa has the highest school exclusion rate globally, with over 20% of primary-school-age children deprived of the right to education, according to UNESCO 2019 reports. Therefore, it is against this background that this study examines the impacts of economic growth, energy consumption and natural resource use, as well as the roles of education on Africa's environment.

## **1.2 Environmental Situation in Africa**

The consumption of fossil energy is the primary source of the emission of atmospheric pollutants. The consumption of fossil energy generates not only CO<sub>2</sub> emissions but also industrial emissions such as industrial dust, sulfur dioxide, nitrogen oxides, and soot, which negatively impact the environment and its

sustainability (Wang et al., 2019). About one-sixth of proven natural gas reserves in Africa are linked with oil (IEA, 2014). Associated natural gas is usually burnt from oil. This burning process associated with gas from oil extraction is called gas flaring (Hafner et al., 2018). CO<sub>2</sub> emissions, sulphur, nitrogen oxides, hydrocarbons and ash, photochemical oxidants and hydrogen sulphide (H<sub>2</sub>S), and particulate matter are hazardous pollutants from gas flaring (Ouedraogo, 2017). The diagram in Figure 2 reveals the trend of CO<sub>2</sub> emissions in Africa and other continents.



**Figure 1.1 Trend of CO<sub>2</sub> emissions in the World**

Source: (EIA, 2020)

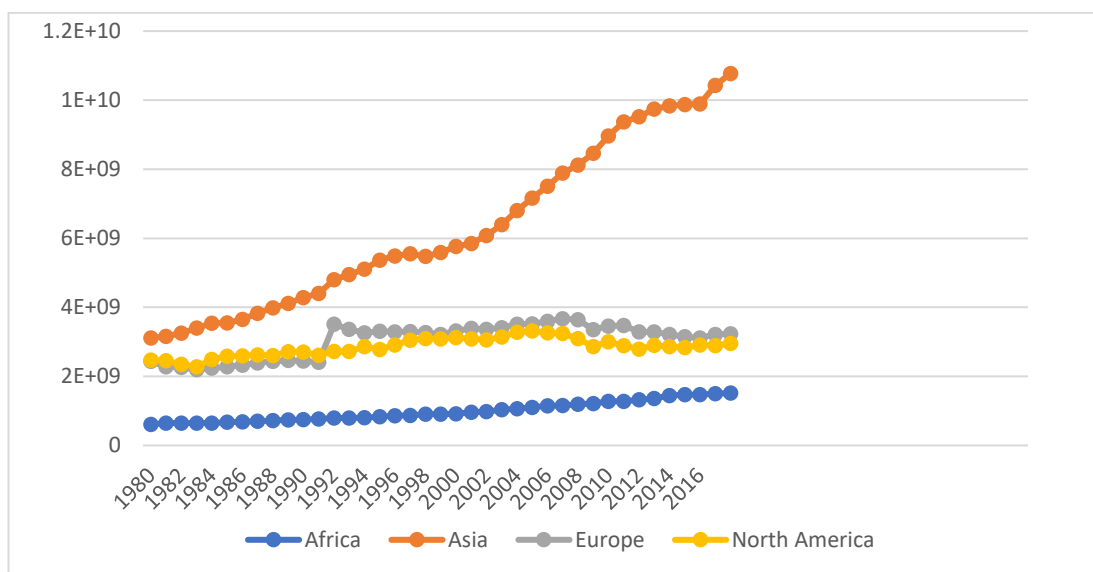
CO<sub>2</sub> emissions from energy-related activities in Africa account for about 2% of cumulative emissions globally and are expected to increase to 4.3% in 2040 (IEA, 2019). According to available records from EIA (2020) and, as shown in fig. 2, CO<sub>2</sub> emissions, which were 529.495 million metric tons in 1980, increased to 755.577 million metric tons in 1990 and 892.402 million metric tons in 2000. Further

increases of 1164.284 million metric tons and 1308.813 million metric tons were recorded in 2010 and 2017.

Indoor and outdoor air pollution are major health issues in Africa. Outdoor pollution is a serious problem in rapidly urbanizing Africa. The growing number of used cars and inadequate road infrastructure exacerbate traffic congestion and air pollution. In addition, forest fires and dust, specifically during desert dust storms, pollute outdoor air. Other sources are the production of cement and mining. Urban and rural areas where solid fuels are used for cooking and heating suffer from indoor air pollution. Open fires or traditional stoves are occasionally used to burn wood, animal waste, charcoal, and coal. Due to the inefficient combustion of these fuels and inadequate kitchen ventilation, indoor air pollutant concentrations are frequently 10-30 times higher than WHO guidelines. Women and children are disproportionately affected by such emissions. Human diseases associated with indoor air pollution include acute respiratory infections such as asthma, bronchitis, laryngitis and rhinitis (United Nations Development Programme, 2013).

The Africa Ecological Footprint Report identifies two concerning trends that, if not addressed by policymakers, are likely to have serious environmental consequences. First, the Africa Living Planet Index demonstrates a roughly 40% reduction in biodiversity over the previous four decades. This decrease indicates the degradation of the natural systems that underpin Africa's current and future development. Second, rapid population growth and growing prosperity are shifting consumption habits, expanding Africa's ecological footprint - the amount of land needed to produce the resources its people use. Although Africa's ecological footprint is

anticipated to double by 2040 if nothing is done, the continent is in an ideal position to respond to environmental degradation (African Development Bank, 2012). The diagram in Figure 2 shows the trend of ecological footprint in Africa and other continents.



**Figure 1.2 Trend of Ecological Footprint in the World**

Source: Global Ecological Footprint (2021)

Environmental degradation in many parts of Africa constitutes a serious problem. The Eastern African sub-region drylands have low rainfall and are highly vulnerable to drought and desertification, particularly in the Horn of Africa. Rapid population growth and rising food demand, combined with high rainfall variability and regular drought, pressure farmers to clear more natural vegetation and cultivate more marginal soil than ever. The reduction of fallow periods and the high rainfall intensity led to desertification, land degradation and soil erosion (UNEP 2002). The exploitation of natural resources, largely illegal and without any environmental impact assessment to reduce environmental effects, has also had significant

implications for the African climate. In addition, the use of hazardous chemicals is prevalent in Africa. Due to Africa's agricultural dominance, chemicals such as Agrochemicals (herbicides, insecticides, acaricides, rodenticides, nematicides, avicides, fungicides, and fertilizers) are increasingly used. Industrial growth and petroleum production also account for the health risks associated with exposure to toxic industrial waste (United Nations Development Programme, 2013; United Nations Environment Programme, 2005).

Environmental degradation is gradually resulting in socio-economic problems in Africa. Famines and food insecurity have been two of the most visible and severe consequences. Recurring famines have occurred in Africa due to irregular rainfall and prolonged droughts. Pastoralists and peasants are frequently confronted with famine, malnutrition, and livestock starvation (Third World Resurgence, 2011). Climate refugees are also increasing in Africa. Due to droughts, peasants and nomads migrated to cities and refugee camps to avoid starvation. Climate refugees make up around 10% of the over 300,000 refugees in Dadaab, northern Kenya (Sanders, 2009).

### **1.3 Energy Consumption in Africa**

Africa is blessed with energy and natural resources, which naturally influence its environment. These resources are not evenly spread across the continent's geographical regions <sup>5</sup> and are at different development stages. Africa is endowed with renewable and non-renewable energy resources to meet African energy requirements. However, renewable energy resources remain almost untapped in

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<sup>5</sup> The five geographical regions of Africa are North Africa, Southern Africa, Central Africa, West Africa, East Africa

Africa despite these potentials. Modern renewable energy sources such as solar, hydro, geothermal, wind, and non-traditional solid biomass still account for a minimal proportion of the energy mix in Africa (Ouedraogo, 2017). The potential of Solar energy alone is thought to provide more than the energy needed in the region. However, only a small portion of the existing potential has been tapped into (United Nations Environment Programme (UNEP), 2017).

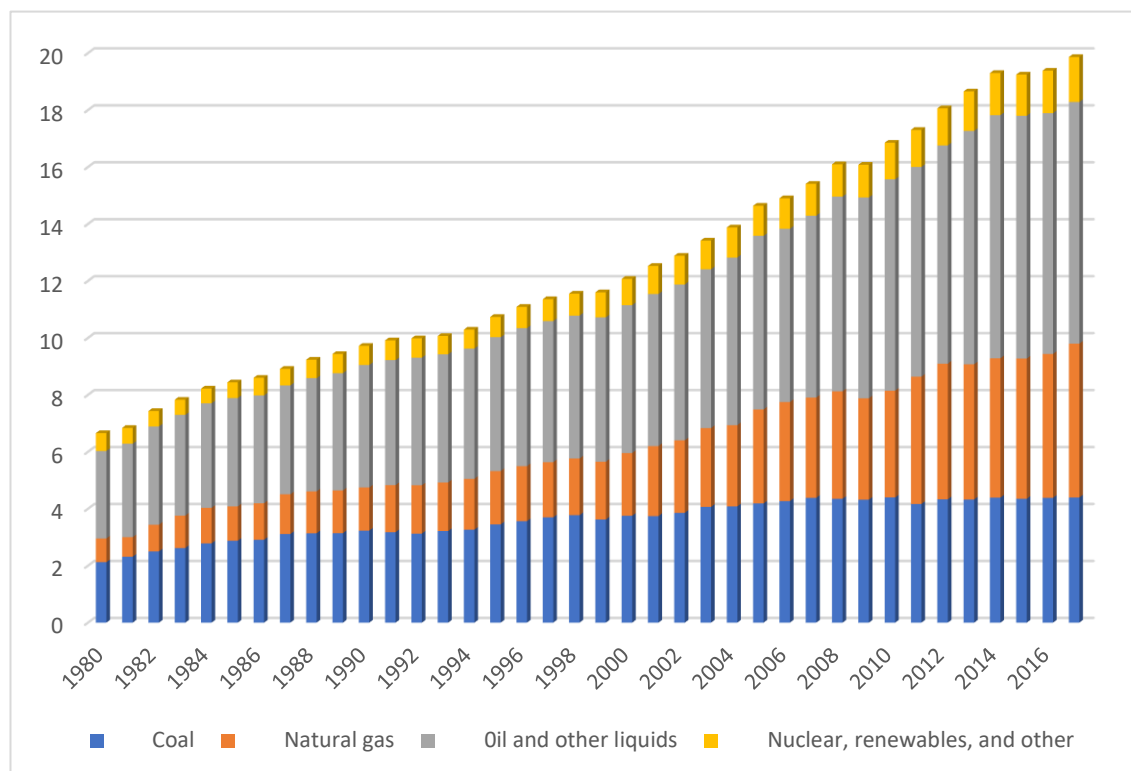
Fossil fuels are essential energy sources and dominate the energy consumption structure of Africa<sup>6</sup>. Africa continues to use fossil energy to attain economic growth, despite the negative impacts on the environment and biological life across the continent. The higher fossil energy usage over renewable energy sources might indicate an ineffective policy framework to control Africa's environmental quality.

Many countries in Africa rely on non-renewable energy, particularly fossil fuels. The diagram in Figure 1 shows that fossil fuel consumption is a significant energy source in the region's energy consumption structure. According to available data from the International Energy Agency (IEA) (2019), on average, fossil fuel consumption accounts for over 90% of total energy consumption in Africa, while nuclear, renewable and other sources account for the remaining. Modern renewables

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<sup>6</sup> Africa has an abundance of proven crude oil, coal, and natural gas reserves. Africa's proven crude oil reserves are estimated to be 62.6 billion barrels. In 2012, the region produced over 6 million barrels per day of liquid fuels, accounting for approximately 7% of total global oil output. Africa has proven natural gas reserves of 221.6 trillion cubic feet. In 2011, Africa produced 1.69 trillion cubic feet of natural gas, accounting for 1% of global natural gas output (EIA, 2013). The region coal reserves represent about 3.6% of the world's coal reserves, with South Africa having about 95% of the total coal reserves in Africa (AfDB, 2014). Coal reserves are also concentrated in Botswana and Mozambique, but South Africa is one of the countries with the largest producers of coal after Indonesia, Russia, India, the USA, Canada, Australia, and China (Boutabba et al., 2018; Ouedraogo, 2017).

such as hydroelectricity, solar, geothermal, and wind are limited in the region. Oil consumption is growing across the region, and the transport sector mainly drives it. Oil is used for power generation and backup generators in Africa. Due to frequent outages, backup generators form a significant part of the total installed power capacity. Backup generators in Africa provided more than 80% of the estimated 16 terawatt-hours (TWh) of electricity demand by the service industry in 2012 (UNEP, 2017). Gasoline and diesel are used to fuel backup generators to provide power during a power cut. However, diesel is used more than gasoline for backup generators and transport. On the other hand, some households use liquefied petroleum gas (LPG) and kerosene as substitutes for other energy sources. LPG is produced from natural gas and crude oil processing, while kerosene is an oil refining (Hafner et al., 2018; UNEP, 2017). Figure 1 shows the energy consumption in Africa.



**Figure 1.3 Energy Consumption in Africa**

Source: (EIA, 2020)

Coal is one of Africa’s primary energy sources, but its consumption in the region is low compared to the rest of the world. Coal consumption in Africa is linked to power production, except for South Africa, where coal has other uses. South Africa has vast coal reserves, which provide about 70% of its total primary energy use, mostly for electricity, as synthetic diesel for the transport sector and coal gas for the residential and industrial sectors. Coal is also used to produce electricity in Botswana, Mauritius, Niger, and Zimbabwe. The criticism of pressure groups and United Nations International agencies against the consumption of coal as a result of its adverse effect on the environment is making countries in Africa commit to the reduction in its consumption to curb the level of CO2 emissions (Adedoyin et al., 2020; Hafner et al., 2018).



Natural gas consumption used to be the least among fossil fuel consumption in Africa, but it has undoubtedly gained significance over the years. Natural gas consumption is mostly for power production in Nigeria and industrial uses, whereas it is used solely to produce synthetic liquid fuels in South Africa (Hafner et al., 2018). Natural gas is cheaper than oil when it comes to power production, and it is the cleanest alternative to oil and coal, but it requires complex infrastructure to handle it in terms of transportation, either in its compressed (CNG) or liquefied (LNG) form. Nigeria is the largest consumer of natural gas in Africa.

More strikingly and despite the vast energy resources, Africa is still confronted with enormous energy problems such as insufficient energy infrastructure, low access to modern energy, inefficiency in energy usage, and the inability to meet its people's energy requirements. About 30% of Africa's population has access to energy, and about 80% of this figure does not have access to modern energy. Approximately 634 million people have no electricity access, while about 792 million people cook with traditional energy sources (British Petroleum (BP), 2018). The region can generate 28% of gigawatts of energy, but only 24% of the region has access to electricity (World Economic Forum (WEF), 2016). The scarcity of electricity has affected Africa's economic growth and hindered the achievement of sustainable living standards. It has also led to the region's excessive use of fossil fuels (Ssali et al., 2019).

#### **1.4 Natural Resources in Africa**

Africa has abundant natural resources, including minerals, forests, wildlife, water, and arable land. The continent of Africa has a large share of the natural

resources in the world. The continent has the world's largest arable landmass, second-largest tropical forest, longest river (the Nile) and a range of minerals in different parts of the region. Africa is one of the world's largest gold, platinum, and diamond producers. Democratic Republic of Congo, South Africa and Zimbabwe produce a substantial amount of the world's gold for making jewelry and currency. Vast reserves of other minerals such as bauxite, copper, chromium, cobalt, platinum, pozzolana, titanium, graphite, tobacco, iron ore, phosphates, aluminum, nickel and uranium are also found in Africa. Forest and trees in Africa provide timber, fruits and vegetables (African Development Bank (AFDB), 2016). Specifically, Africa holds 10% of renewable internal freshwater sources, 30% of the world's mineral reserves, 40% of its gold, 65% of its arable land, and 90% of its chromium platinum (UN, 2018). Africa is home to the largest reserves of diamonds, cobalt, uranium, and platinum in the world (UN, 2018). Many countries in Africa depend on natural resources for their wealth creation. For instance, over 70% population in Africa, particularly those in Sub-Saharan Africa, depend on woodlands and forests. However, a substantial part of these resources has been exploited in unsustainable ways, while other parts are lost through illegal logging, mining, wildlife trade, and fishing, among others (UN, 2018; UNEP, 2016). The increasing depletion and the unsustainable use of natural resources in the region have profound environmental implications<sup>7</sup> (Danish et al., 2019; Hanif, 2018; Hanif et al., 2019). A large number of natural resources consumed through agriculture, deforestation, and mining impact the environment. These economic activities accelerate the depletion of natural resources and increase their harmful effects on the environment in Africa.

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<sup>7</sup> These include water shortage, deforestation, endangerment of wildlife, pollution, climate change among others.

## 1.5 Economic Growth in Africa

Africa's economy has grown slower than the world average of 3.5% per year since 2010, with average annual GDP growth of 3.1%. Sub-Saharan Africa's per capita GDP is less than a third of the global average. South Africa and Nigeria account for a sizeable economic activity in Africa. They account for 12% and 17%, respectively. The reliance of some African countries on commodities has significantly influenced their growth. The more this reliance, the bigger the drop in commodity prices in 2014; the bigger the drop, the more difficult it was to get back up. On the other hand, Kenya, Ethiopia, and Rwanda quickly grew their economies thanks to their booming service sectors and public investments (African Union Commission/Organisation for Economic Co-operation and Development, 2018). Nigeria slowly pulled out of the recession that was caused by a combination of production outages (caused by conflict) and low oil prices (IEA, 2019)

However, the sub-Saharan African economy has grown by more than a third since 2010, making more than \$4.3 trillion in 2018. South Africa and Nigeria's economy isn't growing as quickly as it should. GDP in other parts of the world has grown the fastest since 2013. African GDP growth was expected to rise to 4% in 2019, up from an estimated 3.3% in 2018, making Africa the second-fastest-growing continent after Asia. For example, Ghana's GDP was expected to climb by about 9% in 2019, twice the growth rate in emerging economies and far ahead of global growth (International Monetary Fund (IMF), 2019). A list of the top 10 fastest-growing economies in Africa for 2018 included Côte d'Ivoire, Ethiopia, Rwanda, Tanzania, and Senegal (AFDB, 2019). Foreign direct investment into Africa climbed 11% to \$46 billion in 2018, reversing declines in 2016 and 2017, and rose by 13% to \$32

billion in sub-Saharan Africa (United Nations Conference on Trade and Development (UNCTAD), 2019). The contribution of various sectors to employment and GDP varies greatly between countries, but in Sub-Saharan Africa, the low share of industrial employment stands out (IEA, 2019).

## **1.6 Education in Africa**

The African Union places education at the top of its development agenda and wants to ensure equitable and inclusive access to education for all, particularly as it relates to sustainable development and global citizenship. Africa is committed to universal access to primary education and long-term investments in higher education and has made significant advancements in increasing school enrollments in the past two decades (UNICEF-AUC, 2021). Education in Africa has grown a lot in the last few years. Between 1971 and 2015, the median number of children who finished primary school in each country rose from 27% to 67%. The percentage of children who complete lower secondary school increased dramatically across countries, from 5% in 1971 to 40% in 2015. These are huge increases, but they also show how far Africa still has to go. Despite significant progress in enrolling children in school, out-of-school children remain high (UNICEF-AUC, 2021).

However, even though there have been great strides in education throughout Africa, a sizable section of the population is still unable to read or write. In 2018, over one-third of those aged 25-64 were illiterate, while one-fifth of those aged 15-24 were also unable to read and write. The average adult literacy rate across Africa ranges from 52% in Western Africa to 79% in Southern Africa. Roughly a third of Western Africa's adult population is illiterate, where nearly one adult in two is

illiterate. Central Africa likewise has a severe illiteracy problem, with one in three persons unable to read or write (UNICEF-AUC, 2021).

**Table 1.1 Literacy Rate in Africa**

<b>Region</b>	<b>Adult Literacy Rate (%), 2018</b>
Central Africa	67.5
Eastern Africa	71.1
Northern Africa	71.8
Southern Africa	78.7
Western Africa	51.5
<b>Africa</b>	<b>66.0</b>

Source: (UNICEF-AUC, 2021)

African governments spend, on average, 4.1% of their GDP on education, which is somewhat more than the lower end of the benchmark. This figure is quite similar to the 4.3% worldwide average. However, statistics at the national level reveal significant discrepancies. The percentage varies throughout the continent, from 3.1% in Central Africa to 5.9% in Southern Africa. The number is less than 4% in more than half of all African nations. It is significant to highlight that the level of public funding is still fairly low or modest, even in those nations that have attained the threshold of 4% of GDP. Some African nations' inadequate public funding of education may be attributed to insufficient budgetary provision, while in others, it's more directly tied to a lack of emphasis placed on education spending. Both of these variables often work together. Admittedly, due to the high percentage of school-age people and the growing backlog in access to inclusive, high-quality education, Africa still needs to make significant investments to improve the learning environments for students already enrolled in school to meet the ever-growing demand (UNICEF-AUC, 2021).

## 1.7 Problem Statement

Energy consumption has increased in Africa over the years, but fossil energy is still the largest in its energy consumption structure. Countries in Africa depend substantially on fossil fuels. Fossil fuels are used massively in every economic sector to meet energy needs and foster economic growth. However, given the expected increase in the population<sup>8</sup> of Africa, there is a risk that fossil energy consumption will increase in the future, with its attendant effects on the environment. After many years of consumption, the effects of fossil fuels will be CO<sub>2</sub> emissions, and its continuous consumption might lead to a surge in environmental pollutants in Africa.

Though Africa's contribution to global CO<sub>2</sub> emissions is small compared to other continents, Africa is warming faster than the rest of the world, and temperatures are expected to increase to 3–4 degrees Celsius this century (UNEP, 2016). Africa is the most vulnerable continent to the adverse effects of climate change. The climate change Vulnerability index of Maplecroft (2015) revealed that some African countries are at the highest risk of the negative impacts of climate change. Africa is highly dependent on the agricultural sector, accounting for most of its revenue and employment. The adverse effects of climate change, such as high temperature and variability in rainfall, might affect the fundamental of human life such as food production, access to water, human health, land, and natural resources, which might lead to food insecurity, urban drift, social unrest, as well as incessant

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<sup>8</sup> Africa is expected to account for 50% of global population growth between now and 2050. Among major regions, Africa has the fastest population growth rate. SSA population is expected to double by 2050. Even if there is a significant drop in fertility levels, Africa will still be immense population growth. It doesn't matter what happens in the future regarding fertility; many young people on the continent now will become adults and have kids in the next few years (UN, 2020).

clashes over inadequate land and water resources. These adverse effects may also hinder economic growth, deteriorate the climate and ecological systems, and threaten environmental sustainability if nothing is done to mitigate them.

Additionally, Africa is experiencing an alarming rate of environmental degradation, resulting in famines, economic and social upheaval, and resource-based conflicts. Temperatures in the region have been rising, but rainfall has decreased, leading to rapid deforestation, loss of flora and biodiversity, desiccation and desertification. The potential consequences of increasing environmental degradation might be difficult to predict. However, there is little doubt that they will threaten human security in Africa. Therefore, environmental degradation is a concern that needs to be looked at more closely and integrated into Africa's overall sustainable economic development strategy.

Furthermore, the use of natural resources in Africa has been growing due to the pursuit of economic growth and development. However, the unsustainable ways in which natural resources are being exploited in Africa by its growing population might harm the environment and be dangerous to continue with such a trend. Therefore, examining how natural resources might impact the environment is imperative to ensure that natural resource usage does not surpass regenerative capacity for Africa to benefit from nature's ecological services now and in the future.

Despite the apparent roles of education in growth-energy-environment relationships, its inclusion has not drawn much interest in African literature. Only a few studies have examined education as one of the determinants of environmental quality and mainly focused on the direct relationship between education and the