ENVIRONMENTAL IMPACTS OF MACROECONOMIC INDICATORS IN THE ECONOMIC COMMUNITY OF WEST AFRICAN STATES

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ENVIRONMENTAL IMPACTS OF MACROECONOMIC INDICATORS IN THE ECONOMIC COMMUNITY OF WEST AFRICAN STATES

AHMED MALUMFASHI HALLIRU

A thesis submitted in fulfilment of the
requirements for the award of the degree of
Doctor of Philosophy

Azman Hashim International Business School
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NOVEMBER 2021

DECLARATION

I declare that this thesis entitled *"Environmental Impacts of Macroeconomic Indicators in the Economic Community of West African States"* is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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Date	:	24 NOVEMBER 2021

DEDICATION

This thesis is dedicated to my mother who has scarified her entire resources towards my educational development.

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ABSTRACT

Since the post-World War II period, the world's per capita income has continued to rise except from 2006 until 2008 due to the global financial crisis. Coincidently, there is increasing concern about the environmental cost associated with increased global economic expansion as global temperatures scale-up and climate change become visible. Against this backdrop, this research intended to examine the relationship between economic growth and environmental degradation and other macroeconomic and social indicators in the Economic Community of West African States (ECOWAS) region. The motivations for this research stem from the fact that countries worldwide struggle to achieve sustainable development goals (SDGs), of which fighting climate change and reducing environmental degradation are among the focus. According to UNESCO and ECOWAS Commission (2019) reports, the West African region has been identified as the most prone to climate change and environmental degradation in the world. Therefore, research such as this one would go a long way in providing a guide for policy formulation to address environmental threats and climate change in the region that receives little attention from previous empirical studies. To achieve the objectives of this study, panel data spanning from 1970 until 2019 is used, and panel quantile regression that provides robust estimates were compared to the traditional Ordinary Least Square (OLS) estimations. The empirical findings revealed that a U-shaped relationship exists between economic growth and environmental degradation. In the long run, the findings implied that sustaining economic growth would increase environmental degradation in the region and it is not supported by the environmental Kuznets curve hypothesis. Also, population explosion and energy poverty are inimical to environmental quality. However, FDI inflows play a significant role in reducing environmental degradation, which contrasts with the pollution-haven hypothesis. Similarly, human capital development supports a clean environment in the region. From this study, policy implications for promoting literacy on the environment and paramount research and development (R&D) on a clean environment would increase environmental awareness. In addition, relying on economic growth alone would not address the menace of environmental degradation unless population explosion and energy poverty issues are equally addressed.

ABSTRAK

Semenjak pasca Perang Dunia II, pendapatan per kapita dunia terus meningkat kecuali bagi tempoh 2006 hingga 2008 disebabkan oleh krisis kewangan global. Pada masa yang sama, terdapat peningkatan kesedaran mengenai isu alam sekitar yang dikaitkan secara langsung dengan peningkatan pertumbuhan ekonomi global, seperti peningkatan suhu global dan perubahan iklim yang agak ketara. Berdasarkan situasi berkenaan, penyelidikan ini dilaksanakan bertujuan untuk menilai hubungan antara pertumbuhan ekonomi dan kemerosotan alam sekitar dengan penunjuk makroekonomi dan social berkaitan di rantau Komuniti Ekonomi Negara-negara Afrika Barat (ECOWAS). Motivasi kajian ini berpunca daripada fakta bahawa negara-negara di seluruh dunia berusaha ke arah mencapai matlamat pembangunan mapan, di mana focus utama adalah untuk memerangi perubahan iklim dan mengurangkan kemerosotan kelestarian alam sekitar. Berdasarkan laporan UNESCO dan Suruhanjaya ECOWAS, wilayah Afrika Barat telah dikenal pasti sebagai rantau paling terdedah kepada perubahan iklim dan kemerosotan alam sekitar di dunia. Justeru, kajian seperti ini dapat membantu dalam menyediakan panduan untuk penggubalan dasar bagi memerangi ancaman alam sekitar dan perubahan iklim di rantau ini yang kurang mendapat perhatian oleh kajian empirikal terdahulu. Bagi mencapai objektif kajian ini, data panel merangkumi tahun 1970 sehingga 2019 digunakan dengan mengaplikasikan regresi panel kuantil yang memberikan anggaran yang lebih menyeluruh berbanding regresi tradisional Pengganda Kuasa Dua Terkecil (OLS). Penemuan empirikal membuktikan bahawa hubungan berbentuk-U wujud antara pertumbuhan ekonomi dan kemerosotan alam sekitar. Dalam jangka masa panjang, penemuan mendapati bahawa pengekalan pertumbuhan ekonomi akan menyumbang kepada peningkatan kemerosotan kelestarian alam sekitar di rantau ini dan ia tidak disokong oleh hipotesis keluk alam sekitar Kuznet. Begitu juga dengan pertambahan populasi dan kekurangan sumber tenaga yang bertentangan dengan kualiti alam sekitar.Walau bagaimanapun, aliran masuk FDI memberikan peranan signifikan dalam mengurangkan kemerosotan alam sekitar dan ini berbeza dengan hipotesis kawasan pencemaran (*pollution-haven hypothesis*).Begitu juga, pembangunan modal insan menyokongkualiti alam sekitar bersih di rantau ini. Daripada kajian ini, implikasi polisi untuk menggalakkan kesedaran terhadap alam sekitar ditambah dengan kepentingan penyelidikan dan pembangunan (R&D) tentang alam sekitar yang bersih akan meningkatkan kesedaran terhadap alam sekitar. Tambahan lagi, kebergantungan pertumbuhan ekonomi terhadap kualiti alam sekitar tidak akan dapat menangani ancaman kemerosotan alam sekita rmelainkan isu pertambahan penduduk dan kekurangan sumber tenaga ditangani secara sama rata.

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LIST OF ABBREVIATIONS

ECOWAS	-	Economic Community of West African States
EKC	-	Environmental Kuznets Curve
GDP	-	Gross Domestic Product
IEA	-	International Energy Agency
CO_2	-	Carbon Dioxide Emissions
GHG	-	Greenhouse Gas
IPCC	-	Inter-governmental Panel on Climate Change
GFN	-	Global Footprint Network
FDI	-	Foreign Direct Investment
SDGs	-	Sustainable Development Goals
WAEMU	-	West African Economic and Monetary Union
WAMZ	-	West African Monetary Zone
ADB	-	African Development Bank
IMF	-	International Monetary Fund
PHH	-	Pollution Haven Hypothesis
VECM	-	Vector Error Correction Model
ARDL	-	Autoregressive Distributed Lag Model
TY	-	Toda-Yamamota
FE	-	Fixed Effect Model
REM	-	Random Effect Model
DOLS	-	Dynamic Ordinary Least Square
FMOLS	-	Fully Modified Ordinary Least Square
GMM	-	Generalized Method of Moment
POLS	-	Pooled Ordinary Least Square
OLS	-	Ordinary Least Square
UTM	-	UniversitiTeknologi Malaysia

LIST OF SYMBOLS

$\neq$	-	NoCausality
$\leftrightarrow$	-	Bidirectional Causality
$\rightarrow$	-	Uni-directional Causality
Δ	-	Changes

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CHAPTER 1

INTRODUCTION

1.1 Background of the Study

The world economy has achieved a remarkable progress in the last few decades proving good conditions for increased economic growth and socio-economic development in many countries (Thao, 2018). The impressive world economic growth has been attributed to human and physical capital development and improvement in technology since the industrial revolution (Mazur et al. 2015). In addition, technology has eased and improved agricultural production leading large cultivation of land as well as greater agricultural outputs. Economic growth has therefore turn to be a norm worldwide and the major target set by governments around the world is to expand the economy, raise the national income and employment levels and get their people out of poverty (Wang et al. 2018). To a larger extent this goal is being achieved as evident in the consumption of luxury products such as vehicles and aircrafts, electric and electronic products, textiles and leather products, and light consumer goods.

However, rising affluence concurrently exist with tremendous increase in energy consumption globally. This is because energy is required for the booming industrial production as well as aiding the consumption of today's luxury products. According to World Bank (2020), fossil fuel energy remained the dominant contributor in the world's energy consumption mix representing 81% of total energy consumption. This demonstrates the world's dependency on fossil fuels, likeoil, coal, and natural gas even in recent times despite its devastating environmental consequences. Burning of fossil fuel escalate the concentration of greenhouse gasses in the atmosphere particularly carbon dioxide (CO_2) emissions. CO2 emission from fuel combustion largely influences greenhouse Gas emissions accounting for 78% of the total GHG in the world which heats oceans and atmosphere (IPCC, 2018).

Despite the international agreements as enshrined in the Kyoto protocol in 1997 to cut the major greenhouse gasses emissions still it continue to rise (Bilgili et al. 2016).

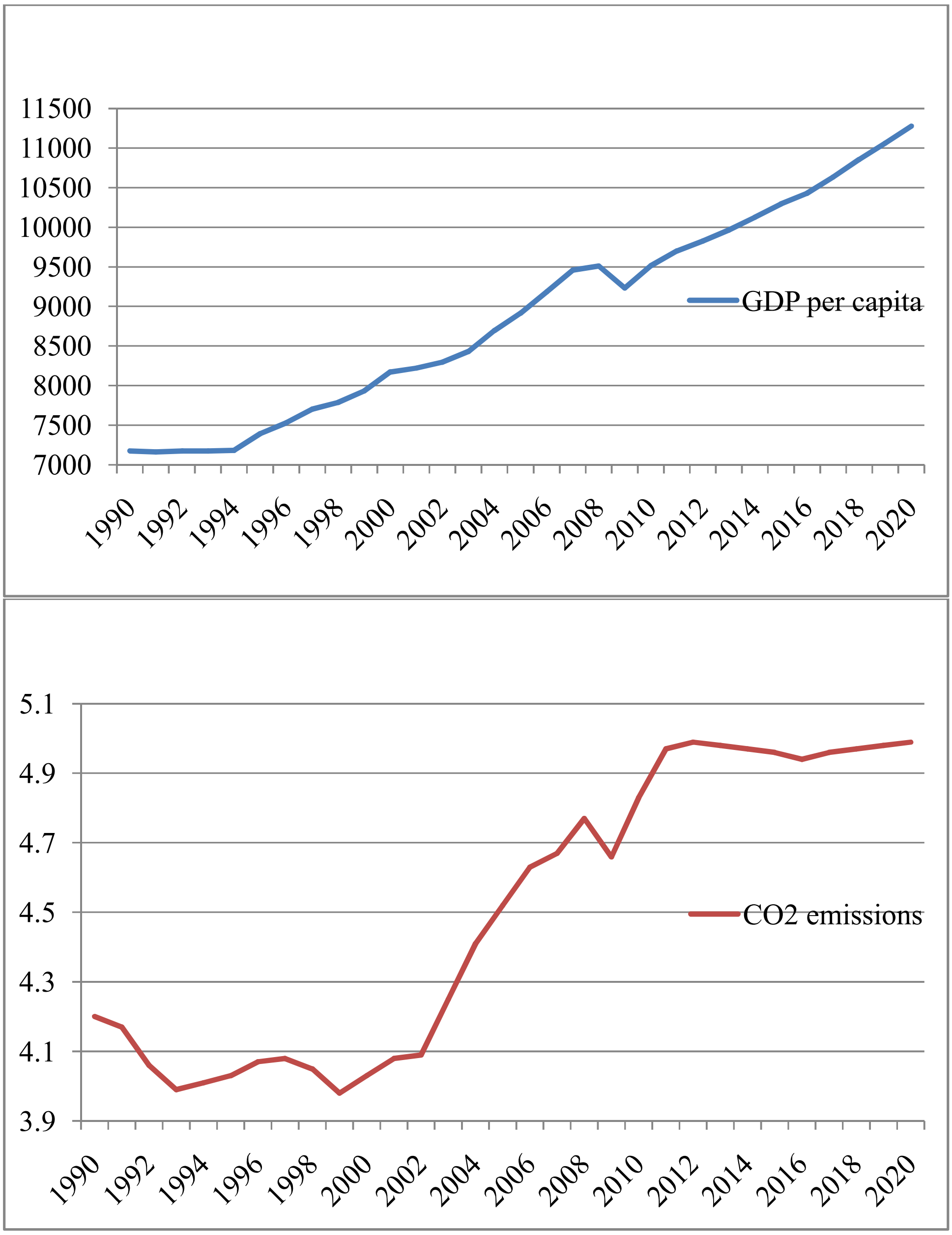

Figure 1:1 Trends in World GDP per capital and CO2 emissions
Source: World Bank (2020)

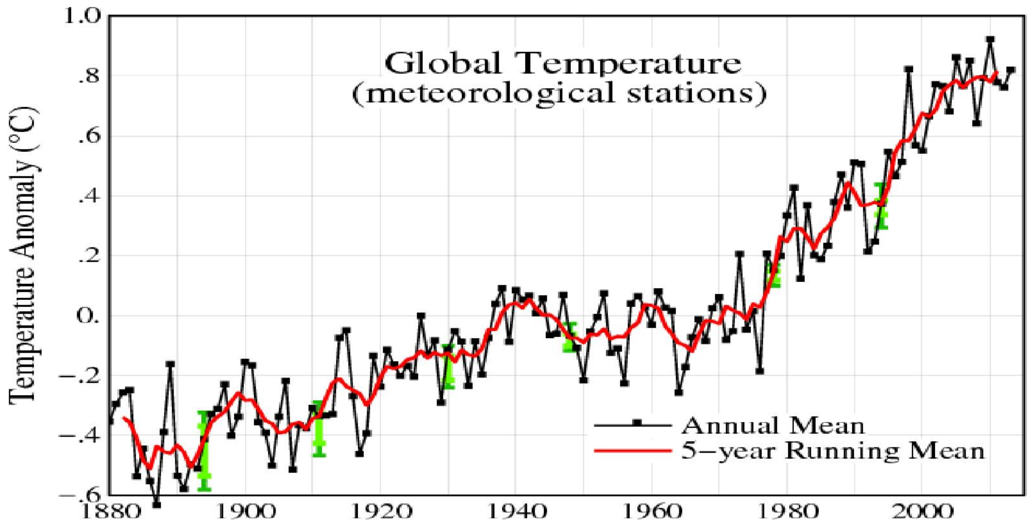

Figure 1:2 Global Average Temperature
Source: World Bank (2020)

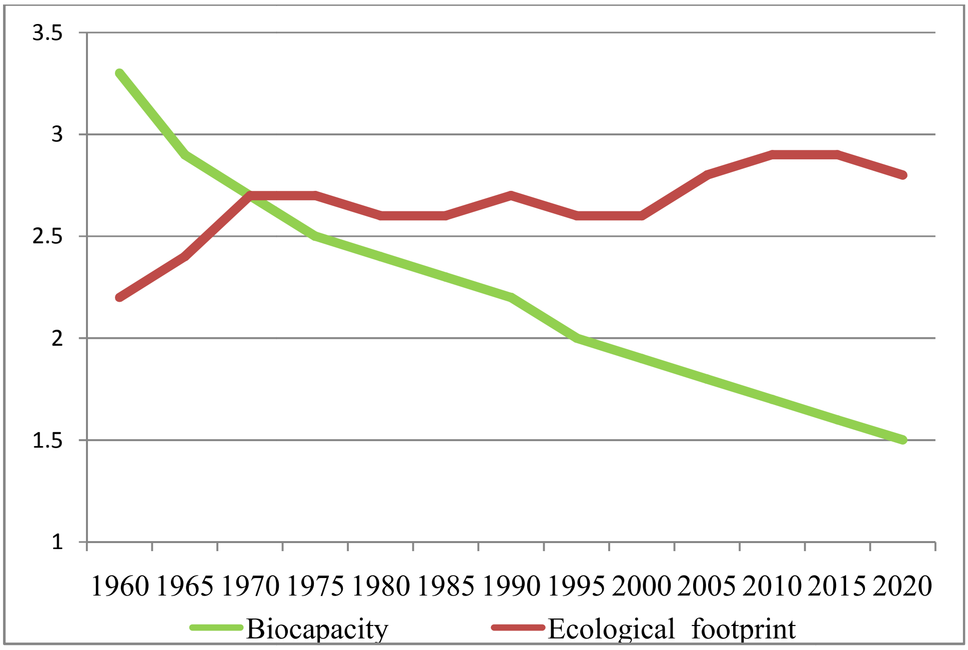

Figure 1:3 World Ecological Footprint and Biocapacity
Source: Global Footprint Network (2020)

Given the above scenario, economic growth has already exceeded the environmental limit and the world environment has turned red with additional 0.6 earth is required for humanity to survive as shown in figure 1:3. With current rate of degradation twice size of world environment resources will be needed by 2030 to support humanity and climate change is inevitable (GFN, 2018). Consequently, sustainable development is threatened and therefore the main target of international bodies is to environmental degradation.

Environmental degradation is more pronounce in West African sub-region than any other region of the world due to over dependence on natural resource exploitation. The high rate of resource utilization has serious negative impact on the environment. It is a widely known fact that natural resources are the assets of every nation, enabling countries to progress to a higher level when used efficiently. In economic sense, natural resources are the key to the progress of a country because they are factors of production provided by nature, which is, soils, forests, grassland, air, water, minerals, fuels, etc. However, increased depletion of natural resources is a severe threat that worsens environmental degradation which is currently measured by ecological footprint as oppose to CO2 emissions. Ecological footprint is described as the use of land and water for production of all the resources consumed by humans and for elimination of the waste generated by the population of a particular area. Increased pressure on the ecological footprint results from greater demand for consumption and usage involved in attaining economic advancements and changing social factors especially population explosion and energy poverty in these countries. Rapid population growth in West African increases pressure on land for building and agricultural production while energy poverty increase the reliance on bio-fuel which deplete forest reserve and consequently increase the ecological footprint.

There has been a surge in the empirical studies devoted to identifying the major factors affecting environment mostly focusing on economic growth and other macroeconomic indicators such as trade openness, foreign direct investment. Therefore, this study contributes to the literature by incorporating macroeconomic indicators along with social factors, in particular the population expansion, human capital and energy poverty in the EKC framework. This approach will expand environmental literatures in analyzing the EKC and highlight the importance of a comprehensive approach in designing policies to mitigate environmental degradation.

1.2 Problem Statement

In recent years, the issue of environmental degradation and climate change become a major world-wide concern as it cause major changes in ecosystem and a rise of sea level that may threaten lives of 50% of the world population mostly in developing countries like ECOWAS where food crisis is hitting around 18 million people in the region, severe flooding displaces more than 7 million people (OXFAM, 2019). Despite the fact that West African sub-region the region has experienced rapid economic expansion as consequence of natural resources exploitation such development is associated with high environmental cost as CO2 emissions gradually increases in most of the countries as depicted in Figure 1.1. Although CO2 emissions grow slowly in ECOWAS region in the past it is likely to accelerate in recent time due to higher economic growth and increased industrialization. Population explosion and increasing rate of urban population, vehicle, electrical and electronic appliances imports has increased the demand for petroleum as source of power leading to more petroleum combustion. The state of environment in ECOWAS is quite alarming and the region has been identified to be the most risk-prone to climate change (ECOWAS Commission, 2020).

Already the effect of climate change in the region has reflected in extreme variation in rainfall, late rainfall onset and early cessation, reduction in growing season length, droughts and depletion of surface water sources with a significant impact on the regional economies that are largely agro-based. It has been projected that agricultural yields would decline by 20–50 percent in semiarid areas. This development is dangerous to agricultural and livestock production which provide the sources of livelihood for the vast already-poor families. With population growth rate of 2.4% annually, the highest in the world, over dependence on natural resources as major sources of livelihood increases in the region. In addition, the high rate of energy poverty affecting about 65% of population in the region increase dependence on bio-fuel for cooking seriously deplete the forest reserve which further aggravates environmental degradation.

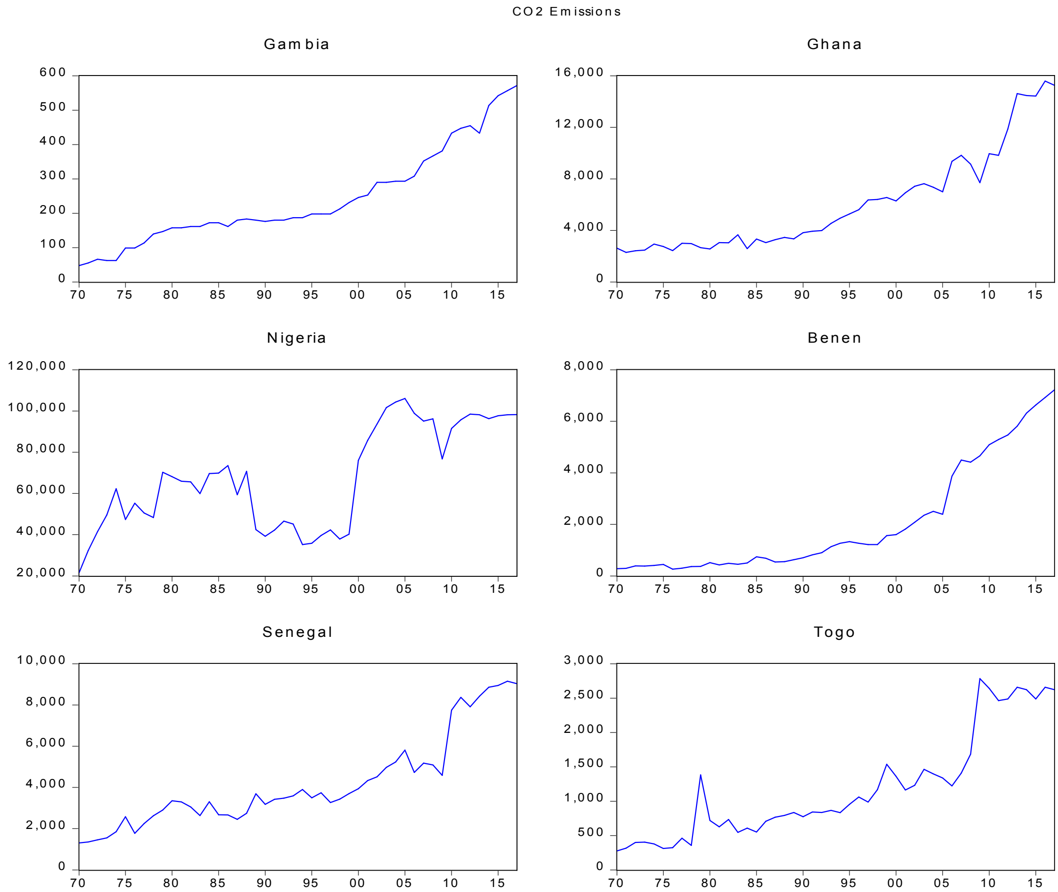

Figure 1:4 Trends in CO2 emissions in ECOWAS Countries

Source: World Bank (2020)

Notwithstanding these substantial changes in environmental condition, promoting economic growth, trade, energy security and FDI inflows is paramount especially for open and resource endowed nations of West Africa that depends on primary products export as source of foreign exchange needed for finance development efforts. Therefore, analyzing the nexus of economic growth and environmental degradation is important for achieving the Sustainable Development Goals (SDGs) especially in ECOWAS region which is identified to be the most prone to climate change and its devastating effects. The little efforts made in the previous studies to analyze the issue focussed on macroeconomic factors as determinants of environmental degradation ignoring the changes in the social structures that becomes the major driving forces on environment. This gap could possibly explain why addressing the problem still remained a challenge particularly in ECOWAS region. This study intends to fill the gap by simultaneously incorporating the macroeconomic indicators and social fundamentals in the analysis of environmental degradation. This triangle approach will highlight the importance of designing comprehensive environment policies in the region and elsewhere.

1.3 Research Questions

In line with the discussion above on the relationship between economic growth and environmental condition, the following research questions are asked:

(a) Are there significant short and long run elasticities among environmental degradation and its determinants in ECOWAS countries?

(b) Is there strong evidence of an inverted U-shaped relationship between environmental degradation and its determinants in ECOWAS countries?

(c) Is there strong evidence of pollution haven hypothesis between environmental degradation and its determinants in ECOWAS countries?

(d) Are there significant causal relationships between environmental degradation and its determinants in ECOWAS countries?

1.4 ResearchObjectives

Base on the research questions this study set the following objectives:

(a) To analyse theexistence of a significant short and long run elasticities exists among environmental degradation and its determinants in ECOWAS countries.

(b) To investigate whether strong evidence of an inverted U-shaped relationship exists between environmental degradation and its determinants in ECOWAS countries.

(c) To investigate the evidence of pollution haven hypothesis exists between environmental degradation and its determinants in ECOWAS countries.

(d) To examine the dynamic panel causal relationships between environment degradation and its determinants in EWCOWAS countries.

1.5 Significance of the Study

There is increasing debate in the literature on the relationship between economic growth and environmental degradation with mix findings being reported by different authors. In this connection, this study will align to the existing literatures by analysing the impact of economic growth on environment degradation in the short and long runs. Yet it is of particular significance because it will explore other social fundamentals that might influence economic growth and environment and therefore expand the extant literature and practice in the area.

As the issue of environmental degradation remains one of the major challenges countries face currently policymakers are equally engaged in developing policies that simultaneously promote economic growth and environmental sustainability. This is particularly important in the context of developing countries like ECOWAS where mounting anthropogenic pressure exposes the region to climate change and its devastating effects on millions of people. Therefore findings from this study will substantially provide guide for policymaking and understand whether economic growth would automatically clean environment after reaching the income threshold or other sustainable development efforts are required.

A number of local and international bodies are making efforts to have a better understanding of the critical issue of environmental degradation in ECOWAS region where climate change had already impacted adversely on the lives of millions of people. This study will go a long way in exposing a new approach in assessing and understanding the environmental issues and its influencing factors in the region by these bodies.

1.6 Organization of the Study

This work is organized into six chapters and with each chapter containing sections. Chapter one provides the introduction highlighting the problem statement and the research questions and objectives. Chapter two gives an overview of the ECOWAS economy and its environment. It begins by describing the history of the community right from formation and the two economic blocs that operate. The economic growth in the region is highlighted from the perspective of GDP growth rate and per capita income. Population growth and urban development are discussed as well as poverty and income inequality. The external sector of the region is extensively discussed in terms of exports and imports commodities, trade partners as well as the exchange rate regimes. FDI is highlighted and the direction of the FDI in the region. An overview of the environmental conditions is also given concerning climate change, carbon dioxide emissions and deforestation. Environmental and energy policies are later discussed.

Chapter three is dedicated to literature review comprising both theoretical and empirical studies. Environmental assessment frameworks and theory such as the environmental Kuznets curve (EKC) hypothesis. Also growth, conservation, feedback and neutrality hypotheses are discussed and past empirical studies are reviewed as well. Literature gaps are highlighted from the review of the past studies and the efforts by this study to fill in such gaps is pointed. Chapter four provides be the methodology of the study. The variables of the study are mentioned and explained as well as the sources and type of the data. Preliminary tests are stated such as unit roots, co-integration. The theoretical framework of the study is explained and model specifications are outlined in order to achieve the objectives of the study. In chapter five gives the empirical results for the estimated models as well as the hypothesis test results. Chapter six conclude the thesis with policy implications and recommendations.

CHAPTER 2

OVERVIEW OF ECOWAS REGION, ECONOMY AND ENVIRONMENT

2.1 Introduction

An overview of ECOWAS economy and its environmental condition is given in this chapter. The overview of the economy is done from the perspective of economic growth rate and income per capita. Given the increasing significance of population and population growth in the region, population growth is examined as well as poverty. Urbanization issues as well as human and physical capital development are also highlighted. The role of international trade and FDI inflows in promoting growth in ECOWAS have been recognized, thus exchange rate, imports, exports, intra-regional trade and FDI inflow is discussed in this chapter. Lastly, the environmental conditions are highlighted regarding CO2 and SO2 emissions and deforestation as well as the threats to environment from mining, oil and gas explorations, bush meat and overharvesting.

2.2 Overview of ECOWAS Region

ECOWAS is a group of countries located in the western part of African continent who came together to form a community. It was established on 28th May, 1975 after signing the Treaty of Lagos with sole aim of promoting economic integration among member countries. ECOWAS consist of 15 members namely Benin, Burkina Faso, Cabo Verde, Cote d'Ivoire, Gambia, Ghana, Guinea, Guinea Bissau, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone and Togo. Among them there are eight French-speaking countries, two are Portuguese speaking, while five are English-speaking. The major aim of the body is to engender cooperation and integration among member states as well as forming a common market and monetary union through the elimination of trade barriers and mobility of labour. This would help in raising living standard, economic stability, strengthen relationship and promote the development of the continent. The treaty of ECOWAS recognises the need to harmonise and coordinate national and regional policies as well as the promotion of programmes, projects especially in agriculture, natural resources and environmental protection (ECOWAS Commission, 2019).

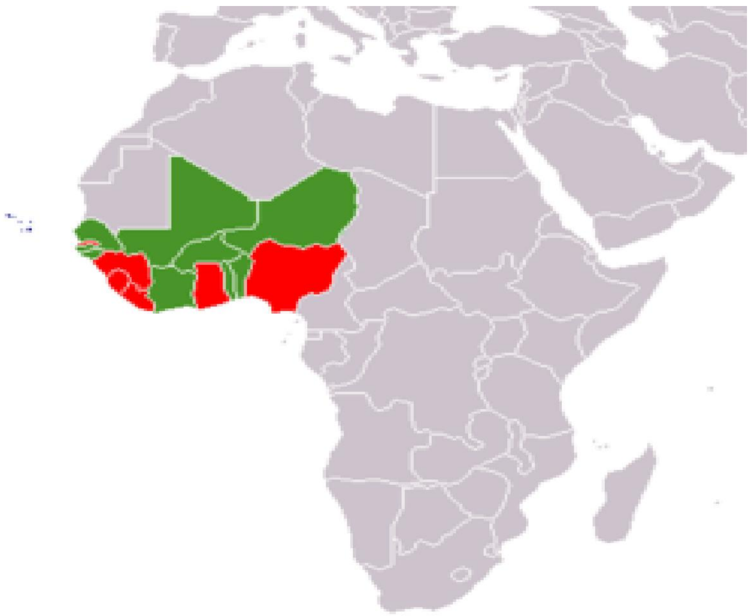

Figure 2.1 ECOWAS Region and the its Two Economic Blocs

(red)	West African Monetary Zone (English Speaking)
(green)	West African Economic and Monetary Union (French Speaking)

West Africa has a very big land area of about 5,114,162 km^2 (1,974,589 sq ml), with different ecosystem stretching across the east and west parts of the region. From the north it is bordered by Sahara Desert and the south consist of coastal areas with mangroves, tidal estuaries, and moist rainforests. Off the west and south coast is the marine ecosystem of the seas washing the coastline. Between the rainforest and the desert found the Sahel zone with grassland and shrub forest. The region has three landlocked countries (Burkina Faso, Mali and Niger) in the Sahel zone and they constitute about 50% of the region's land mass while the rest of the twelve West African countries are in the coastal zone.

The region is a home to about 305 million people and has the fastest growing population in the world. It is the most populated region in Africa and maintain an average annual population growth rate of 2.7%.People's livelihood in the region depends largely on the natural resources like forest, wildlife, pastures, water and agricultural lands. A significant portion of ECOWAS population lives in urban areas and its urban system increases rapidly. The growing urban fabric is mounting serious pressure on the available natural resources with negative effects on environment (ECOWAS Commission, 2018).

Two economic blocks exist in the region. The first, which comprises of eight members, was established in 1994 with an acronym WAEMU referring to West African Economic and Monetary Union using single currency called CFA. The second bloc is called West African Monetary Zone (WAMZ) established in the year 2000 with six member countries and majority English speaking (former British colonies) working toward adopting a common currency called the Eco. There are two institutions that implement policies in the community namely the ECOWAS Commission and ECOWAS Bank for Investment and Development (EBID).

2.3 Overview of the ECOWAS Economy

Agriculture and mining are the main stay of ECOWAS economy. Major agricultural crops are cocoa, rubber and cotton and the region is the world largest producer of cocoa largely produce by Ghana and Cote d'Ivoire. With an average output of 600,000 tons annually Mali is the main cotton producer in the region and ECOWAS maintain six position in global cotton production. In terms of minerals production, crude oil is the leading product in the region largely produced by Nigeria with about 2.2 million barrels per day. In recent years, oil was also discovered in ECOWAS countries like Cote d'Ivoire, Ghana and Niger. Other important minerals are gold, iron ore, manganese and uranium.

Nigeria's economy is considered to be the powerhouse of ECOWAS constituting about 70 percent of the region's GDP due to its large oil wealth and concentration of big companies. According to African Development Bank, (2017) Nigeria has 44 out 55 or 88% of biggest companies in ECOWAS. The financial system is as well dominated by Nigeria having the biggest banks and the stock market in the region followed by Ghana. In terms of economic growth ECOWAS is the fastest growing economy in the African continent. In 2015 it account for 40% of Sub-Saharan African's GDP and 28% of African's GDP at current price. Over the last few years, economic growth in the region has been quite impressive with an average GDP growth rate of 5% over 2000-2014. Although the region's economic performance was poor in 2016 this was purely due to sharp fall in the price of crude oil in the international market which affect Nigeria, the giant of the region.

2.4 Growth Domestic Product

ECOWAS economic growth over the period especially from the early 2000 as reflected in its high rate of economic growth. Between the years 2000 and 2017 ECOWAS region maintained an average real economic growth rate of 5%.Real growth rate in the region was 6.5% over the period 2006-2008 and it increased to 7.3% in 2009-2011 and thereafter declined to 5.6% over the period 2012-2014(IMF, 2016). Economic growth in the region surpassed the African average of 5.6% and this excellent performance was driven by the dynamism of Nigerian economy being the largest oil exporter in the region. In the same vein, the unprecedented region's economic growth rate of -0.2% in 2016 was largely due to sharp decline in the oil price of more than 50% in the year 2016 which affected Nigeria being the ECOWAS economic giant (controlling about 70% of the region's GDP).Such huge oil price drop led to a dwindled export revenue, depreciation of Nigeria's local currency (naira) by about 50% and decline in Nigeria's real GDP to -1.7% which dragged down the average real GDP for the region as well.

Interestingly, if Nigeria is removed the rate of economic growth in the region would be 5.3% and 6.6% in the 2016 and 2017 respectively (Figure 2.2) and this indicate that other member states in ECOWAS region maintained a positive momentum. For example, the rate of real GDP growth in Cote d'Ivoire was 8%, Senegal 6.6%, Togo 5.3% for the same period. Others like Sierra Leone grew at 4.3%, Guinea at 3.8% and Cape Verde at 3.6%. This clearly indicated that the negative growth rate recorded by Nigeria in 2016was not a general but an isolated phenomenon even though Benin Republic was affected due to its close ties with Nigeria border and economy.

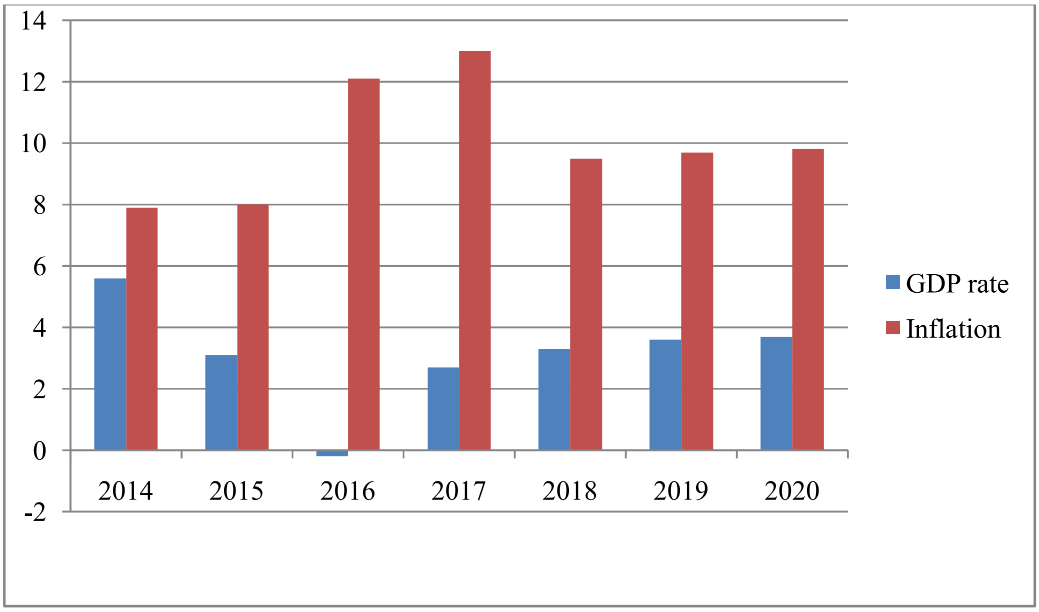

Figure 2.2 ECOWAS Inflation, GDP Growth
Source: African Development Bank (2020)

ECOWAS region maintained low level of inflation at 5.53% in 2010which is below the African average of 7.40%. In most of the countries in the region inflation rate remained within single digit especially in WAEMU member states. This was due to adoption of strict rules for financing fiscal deficit using monetary instruments by their common Central Bank (BCEAO). Furthermore, there was exchange rate stability due to CFA convertibility guarantee by the France treasury. Up to the year 2015 inflation remained within single digit pegged at 8% but a year later in 2016 the economies in the region began to experience a double digit inflation around 12.1% and slightly increased to 12.5% in 2017 (figure 2.2 above). Mlachila et al.(2013) observed that the unprecedented economic performance achieved in ECOWAS region in recent time is attributable to higher commodity prices, good macroeconomic management, trade, discovery and exploitation of crude oil in additional member states and debt relief. Furthermore, huge inflow of FDI and aid into the region as well as increased capital investment (physical and human) has helped strengthened and promotes higher growth (ADB, 2017; IMF, 2018).

Similarly, decline in the rate of economic growth in ECOWAS region also affected nominal GDP as well as per capita income. For example, nominal GDP in the region was 367.0 billion US dollar over the period 2006-2008 and increased to 480.5 and 665.7 for the period 2009-2011 and 2012-2014 respectively (figure 2.3). The region nominal GDP shrunk slightly to 637.4 billon US dollar during the early period of economic recession in Nigeria in 2015 but when the recession manifested in 2016 nominal GDP sharply declined to 571.4 in 2016.

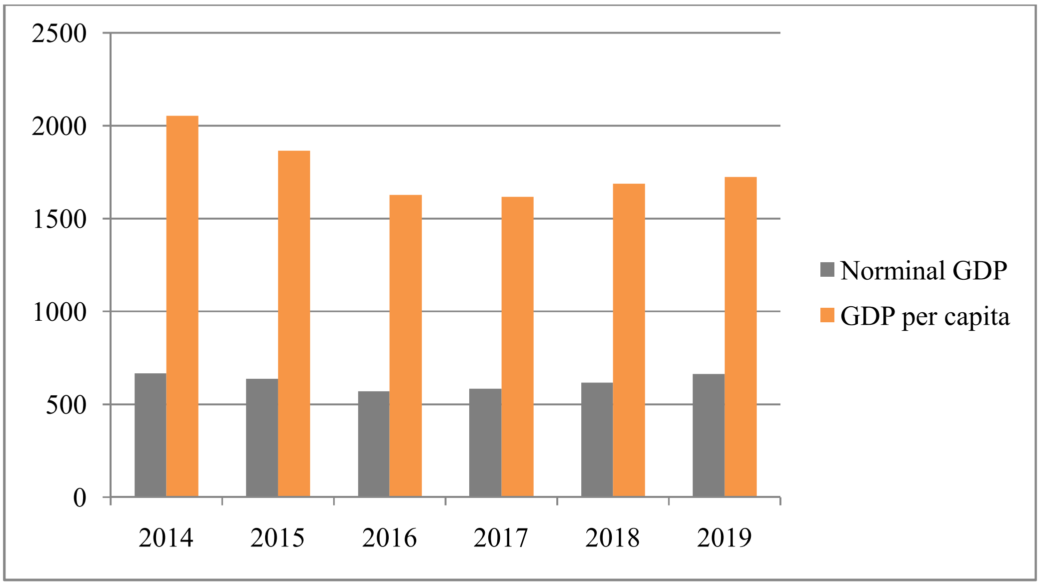

Figure 2.3 ECOWAS Nominal GDP and GP per capita (current USD price)
Source: African Development Bank (2020)

Per capital income also maintained similar pattern within the same period. In the period 2006-2008 per capita income in the region was 1331.8 US dollar which rose to 1606.7 and 2054.4 US dollar for the periods 2009-2011 and 2012-2014 respectively and there after declined to 1628.5 US dollar in 2016 when the economic recession in Nigeria took its full weight (figure 2.3).In terms of economic structure in ECOWAS, the service sector shows remarkable improvement and has overtaken the agricultural sector in terms of contribution to GDP in recent time. For example, in

2010 the share of service sector in GDP was 41.90% while that of agriculture was 37.80%. Notwithstanding that development, the agricultural sector remains the major source of livelihood for majority of ECOWAS population providing food and employment.

In addition, high commodity prices in the international market serve as a strong incentive for increase agricultural production couple with good rainfall and policies (ADB, 2017).Conversely, the manufacturing sector in the region is at the backward in terms of GDP contribution. In 2010 the sector's contributed only 6.60% to GDP and this low performance would not be unconnected with low capital development, huge infrastructure gap and under developed financial system in the region (IMF, 2016).

2.5 Population Growth, Urbanization and Poverty

Representing 17% and 30% of Africa's surface area and population respectively, West Africa (or ECOWAS) is the most densely populated area on the continent. Its population growth is the fastest in African continent and this has resulted to a quadrupled increase in population from 70 million to 301 million people between 1950 and 2010 (figure 2.4).The region maintains this trend thereafter as its population increased to 327 million people in 2013 representing 40 percent increase compared to its population in the year 2000. If the current rate of population growth rate of 2.4 is maintained ECOWAS population will be around 806 million people in the next thirty years (UNESA, 2018). The most rapidly growing population in recent years is that of Niger and Liberia with Burkina Faso and Sierra Leone following them. Increase in population has been uneven between countries and within countries with coastal areas witnessing higher growth than Sahel regions. In big cities population has increased 100 percent and small cities in savannah have tripled their population.

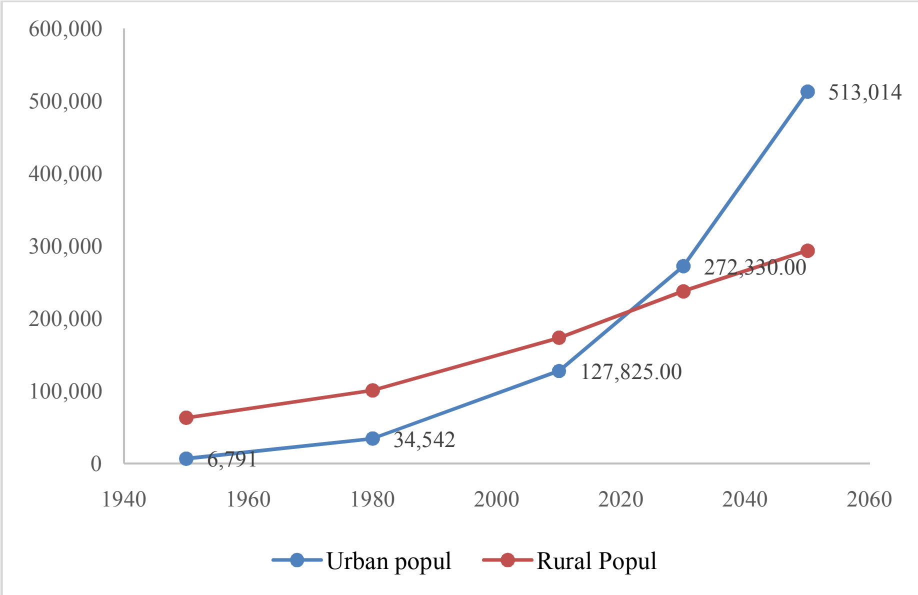

Figure 0:4 ECOWAS Rural and Urban Population in Millions
Source: UNESA, 2019

ECOWAS countries experience mass exodus of people out of rural areas to urban cities making its urbanization growth rate as one of the highest in the continent. It is estimated that two out of three persons in ECOWAS urban cities are rural migrants and the high rate of rural-urban migration would not be unconnected with the limited and declining job opportunities, food threat and poor social amenities in rural areas. ECOWAS urbanization rate has exceeded the African average and this trend will continue but a slower rate. In 1960 the region's urban population was only 6.7 million but in 1980 it rose to 25.5% and this represent about 34.5 million people (figure 2:4). By the year 2010 urban population in the region will be 127.8 million representing 123% increase compared to the year 1980. The urban percentage is projected to be 53.4% by the year 2030 meaning that the region will house 272.3 million people. By the year 2050, urbanization will rise to 63.6% (around 513 million) with Nigeria and Cote d'Ivoire absorbing the larger percentage due to intra-regional migration from Sahel in search of jobs (ECOWAS Commission, 2018).

One of the most disturbing phenomenon in ECOOWAS is high rate of poverty and inequality. Majority of the countries are within the low-income countries and only Senegal, Nigeria, Ghana, Cote d'Ivoire and Cabo Verde are within the middle-income economies (World Bank, 2017). Poverty is prevalent both in rural and urban areas with millions of people living in hunger and unable to put food on table due to lack of income. It has been estimated that 60 percent of ECOWAS population are living on less than 1 US dollar per day making the region one of the hardest hit by poverty in the world. With the exception of Ghana and Cabo Verde all the countries in the region falls among the 46 in the world with low Human Development Index (UNDP, 2018). ECOWAS countries are also characterizes by high income inequality as indicated by their GINI index and this reflect the fact that vast amount of income in the region is concentrated in the hands of a very few individuals. With the exception of Cabo Verde, Nigeria and Ghana (with GINI index of 0.505, 0.488 and 0.427 respectively) the remaining thirteen countries are characterizes with a very high income inequality. Furthermore, inequality has reflected in poor access to quality education, health care services, portable drinking water, good sanitation, ICT as well as increasing rate of asset disposure by households such as land and livestock to make daily living.

2.6 Budget Deficit and Public Debt among ECOWAS Countries

Budget deficit has serious implications on the implementation of macroeconomic management policies and the overall performance of an economy. ECOWAS deficit-GDP ratio over the period 2012-2014 was 2.2% but it deteriorated to 4% a year later in 2015 exceeding the maximum threshold of 3% set by the community. As a result, some initiatives were taken to ensure a more prudent management of the economy such as Planting for Food and Jobs, One District, One Factory, National Digital Addressing System. This has begun to yield fruits as fiscal deficit reduced to 5.9% of GDP in 2017 from 9.3% in 2016 and some countries are place at the target of achieving 3% budget deficit by 2019 (ADB, 2018). The region's rising budget deficit is a reflection of its member countries position in recent years. For example, Benin that used to be a model in terms of fiscal discipline recorded a budget deficit of 7.5% in 2015 against the average 1% in 2014; Gambia's budget deficit amount to 6.5% in 2015 and jumped up to 7.5% in 2017; in Liberia budget deficit reached 11.4% and 7.1% in the 2015 and 2016 respectively. But all these situations would not be unconnected with the fact that the size of the public sector in ECOWAS member states is large and the increasing need for public spending to stimulate economic activities and promote growth is well appreciated by policy makers. ECOWAS debt-GDP ratio in 2016 was 4.5% a slight increase from 2015 but declined to 3.8 in 2017.

Public debt in ECOWAS region has been on the increase since 2008. The debt to GDP ratio in the region was 17% over the period 2002-2008 moving to 18% and 19% over 2009-2011 and 212-2014 respectively. Debt-GDP ratio jumped to 22% in 2015 and increased to 24% in 2016 and thereafter retained the same trend in 2017. Public debt varies between member countries with some maintaining a level quite below the region's threshold (for example, Nigeria 12% and 15% in 2015 and 2016) while other recorded a high that may not be economically sustainable (for example, Ghana 71% in 2015; Togo 63% in 2016; Senegal 57% in 2016). Large public debt in the region is not surprising considering the trends of budget deficit of the member states that is largely finance through borrowing both from domestic and foreign sources.

2.7 EWCOWAS Trade and FDI Inflows

Trade consists of imports and exports of goods and services in the region. The external sector consists of the items being exported by the region as well as the destinations of the sectors. It also deals with the intensity of the exports (percentage of exports to gross domestic products). Imports also come under the external sector in terms of its sources and the items involved as well as its intensity (percentage of imports to gross domestic product). In addition, it highlights the issue of current account balance which show the relationship between exports and imports of a country. The issue of exchange rate and exchange rate regime also come under this section.

The growth and development of exports (viewed as the percentage of export to GDP) is highly crucial for ECOWAS economy because it generate revenue for government as well as providing foreign exchange and market for local goods. ECOWAS export as percentage of GDP in 2010 was 29.23% and it rose to 32.61% in 2011. The major export commodities in the region are crude oil, cocoa, cotton, rubber, wood, edible fruits, fish and shellfish, and precious stone. Crude oil account for 75% of region's exports, cocoa and cocoa food represent 15%, precious stone account for 3%, fish and shellfish 2%, cotton 1percent, edible fruit 1%, rubber 1%, plastics 1%, wood and wood products 1%. There is serious variation in the exports share among the member countries as well. For example, Nigeria alone account for 77% of the ECOWAS exports due to crude oil deposit, Cote d'Ivoire 10%, Ghana 4%, Senegal 2%, Mali 1.7% and the remaining share the rest 0f 5.3%. ECOWAS exports destinations are Europe carrying 28%, Americas receive 34%, Asia 16%, and Middle East 0.3%.

The issues discussed above highlight the fact ECOWAS as a region is highly exposed to external shocks due to lack of diversity in its exports. According to African Development Bank (2017) 10 commodities makes 80% of regions exports and these commodities are purely primary agricultural goods. Therefore, exports diversification and value addition becomes a necessary option for improving the region's competitiveness and export performance. In addition, promoting intra-regional trade would help boost exports to member states so that imports into the region as well as transaction cost can be reduced because of the existence of common currency which helps in reducing transaction cost.

In 2010 ECOWAS import was 48% of GDP and it rose to 53.20% in 2011 exceeding the African average of 38.40%. ECOWAS total imports are dominated by fuels representing 24%. Motor vehicles, tractors and cycles is the second major imports in the region followed by machinery, mechanical appliances and boilers as the 3rd in the imports list. Electrical appliance is the 4th, cereals is the 5th, plastics is the 6th, iron and steel is the 7th, cast iron occupy 8th position and pharmaceutical and fish are the 9th and10th respectively. In terms of individual country imports, Nigeria dominates with 41% of the region's imports. Ghana constitute 18%, Senegal 10%, Cote d'Ivoire 10% and the remaining eleven countries together make 11% of the regions imports. With respect to regional blocs WAEMU constitute 36% of regions import while West African Monetary Zone makes 64%.

From the analysis of exports and imports in ECOWAS it can be understand that imports have outweigh exports in the region. The result of high import and low export is the negative current account balance. ECOWAS average current account balance was -8.27% of GDP in 2009 and it rose to -12.17% in 2011 due largely to poor performance by countries such as Cabo Verde, Gambia, Liberia and Sierra Leone where it exceeded -20% of GDP in each of the countries. ECOWAS current account balance was 0.1 over the period 2012-2014 and it deteriorated drastically to -4.2 in 2015 triggered by a worsening export performance of Nigeria following the decline in global oil price. Although the region's current account balance improved thereafter due to reduction in Nigeria's external deficit following oil price rebound, but it still recorded negative balance of -2.2 and -2.0 in the year 2016 and 2017 respectively.

A number of factors can be attributed the abysmal trade performance of ECOWAS region. First, the volatility of world commodity prices, for example, the fall in the world price commodities like cocoa, coffee, cotton, and petroleum which are the major export commodities in the region. Second, the changes in the value of world's major currency, particularly US dollar relative to French franc in which most of the region's commodities are traded. Decline in the US dollar against French franc and large subsidies granted to farmers in Europe and North America significantly reduce the competitiveness of region's exports in the world market as the case in 1992 and this substantially reduce the export revenue that accrues to ECOWAS (Hallet, 2008; ECOWAS Commission, 2016).Third, increase in imports and decline in official transfers affect the trade balance in the region. Since 2007 imports has increase by about 4% of GDP but conversely official transfers decline by about 2% of GDP (IMF, 2016).

ECOWAS set, as one its objectives, the promotion of intra-regional trade to mitigate external trade shocks. West African Clearing House was established in 1975 as part of strategies to achieve such mentioned goal. Trade liberalization scheme was also launched in 1990 and the abolishing of tariffs on export products among the community members (ADB, 2018). A greater part of the goods traded among the member countries are food and food-related products. Food commodities like milk, edible products and preparations, sugar, beverages, cooking oil, fish and livestock are the major products traded within the region. Unfortunately, ECOWAS goal of promoting and developing intra-regional trade has not recorded significant improvement for the fact that it represents between 8 to 11% of region's total trade. For example, intra-regional trade was only 8.26% of total trade in 2010 and it declined to 8.19% in the following year 2011. The African Development Bank (2018), however, noted that a large chunk of trade activities within the region is not being captured by the official statistics.

The World Bank (2018) corroborated this by stating that about 80% staple food trade is not captured in the official trade record. There exist a large number of trading activities taking place in the informal sector especially in agricultural commodities where women enterprises play a significant role and mostly ignored. Although ECOWAS try to abolish within the member states, non-tariff barriers such as divergent customs system, rules of-origin, difficulties in accessing trade-enhancing financial services such as insurance and guarantees, Infrastructural deficit especially in the energy and transportation sectors and road blocks are serving as obstacles to the development of intra-regional trade (ADB, 2017; IMF 2018).

In terms of FDI inflows, ECOWAS region succeeded in attracted substantial amount in the last two decades exceeding the Sub-Saharan African average. Foreign direct investment inflow into ECOWAS region was 5.97% of GDP in 2010 and it rose to 7.59% in 2011 which is far above the SSA average of 2.60% in the same year. This performance is due to measures put in place by member countries to attract FDI as a means of bridging saving and investment gap in the region as well as correcting the weak balance of payment position. In addition, the discovery of oil and minerals in some member countries in the region and political stability tremendously help in attracting huge amount of FDI into the region.

There are serious variations in the inflow of foreign direct investment among ECOWAS member states with some (for example, Liberia, Ghana, Niger, Sierra Leone and Nigeria) dominating in the race. According to IMF (2018) political stability in Liberia following the recovery from civil war, discovery and production of crude oil in Ghana and Niger, giant iron ore project in Sierra Leone had helped significantly in attracting FDI in those countries. However, members like Togo, Guinea, Cote d'Ivoire and Burkina Faso) performed poorly in attracting foreign direct investment into their economies. In terms of FDI inflow into various economic sectors the oil and gas seems to be the preferred areas even though these sector contributes less to GDP compared to agriculture and service sectors.

2.8 ECOWAS Environmental Challenges

West Africa is blessed with abundant natural resources but only a tiny fraction of these resources are being tapped and developed. But of great concern is the increasing level of environmental degradation and resource depletion by human activities which is posing a serious threat to the long term development interest of the region. Land degradation cause by erosion and desertification has led to the loss of vast arable land. Degradation of water resource and aquatic ecosystem, forest depletion are another concern in ECOWAS and the importance of these resources to the national development is not known to majority of people due to high level of illiteracy. In addition, the proliferation of extractive industries is destroying vegetation and farmland as well as increasing environmental pollution.

Mineral extraction such as diamond, gold, oil and gas has also increase in significance in ECOWAS economy and the regional governments have prioritise this sector in a bid to diversify their economies and provide jobs to the teeming population. In order to promote the growth of this sector policies and strategies are developed and this has attracted large number of people, local and foreign firms into mining activities. Unfortunately, these activities are causing severe damage to environment in form of forest destruction, leaching, chemical spills, large open pits, land degradation and biodiversity destruction. This negative development is likely to worsen given the large number of illegal artisanal mining in the region and poor governance (USAID, 2016).

CO2 emissions intensity in the region is less compared to the industrialized nations like Japan, USA, China, and is even below that of the Sub-Saharan Africa (SSA) average. The World Bank (2017) reported that ECOWAS rate of CO2 emission was 2.14 part per million (PPM) per year in 2010 and this figure is low compared to 10.08 and 19.81 recorded by UK and USA respectively over the period 1965-2009. Figure 2.8 below indicate an increasing trend in the average CO2 emissions in ECOWAS region from 2006 until 2018. Carbon dioxide emission in the region was 8829 in 2006 it went up to 8891 and 9793 in the year 2010 and 2012 respectively. It maintained an upward trend in 2014 until 2018 when it reached 10804. It is therefore important for the regional governments to identify the factors that drives carbon dioxide emission and deploy measures to curb it just like the leading industrialized nations like USA and China are taking the issue more serious than ever before. Sulphur dioxide (SO2) emission is another environmental pollutant in ECOWAS region. It is as a result of combustion of fuel which may change rainfall pattern when it forms aerosols particles. According to EEA (2015) sulphur dioxide is hazardous to aquatic ecosystems, crops and vegetation as well as forest because it could acidify rain, lakes and soil. Figure 2.9 below shows the sources of SO2 in the region with the highest amount 78 percent coming from the processing of fuel, 18 percent from fuel combustion, 1 percent and 1 percent from coal combustion and smelting respectively while other sources makes 2 percent. The main culprit in sulphur dioxide emissions in the ECOWAS region is Nigeria which almost generates about 75 percent of the total amount emitted. This is the reflection of the facts that Nigeria belongs to OPEC cartel with large oil industries, and the largest producer and consumer of fuel in the region.

ECOWAS SO_2 emissions is quite low relative to other regions of the world particularly industrialized nations like USA, UK and China where average SO2 concentration reached 22147.7, 4070.7 and 14224.6 respectively over the period 1960-2005. This amount is extremely higher relative to that of ECOWAS member states like Cote d'Ivoire, Senegal and Benin that recorded mere 20.1, 20.5 and 2.5

respectively. Even the West African giant economies, Nigeria and Ghana, had a far low amount (361.7 and 18.8 Gg respectively) over the same period but this does not mean that ECOWAS governments should relax and wait for economic growth for fix environmental challenges automatically (Omotor, 2016).

In response to the growing concern for the increased level of sulphur emissions in the ECOWAS region the community works toward achieving a harmonized fuel and vehicle emission standard. The region as a whole import about 80% of its fuel requirement as refine and this give the member states an advantage in choosing the source of the import so that a cleaner fuel should come to the region (ECOWAS Commission, 2018). Since the mid-2017 the community agreed to import low sulphur fuel at 50 PPM. Thus importation of cleaner fuel would help improve air quality by reducing the amount of sulphur emission in the region. Member countries have started embarking on policies in this direction, for example, Cote d'Ivoire pursue strong strategy for the importation of cleaner fuel and have already limit the age for imported vehicles to five years starting 2018 and a similar policy is being pursued by other countries like Nigeria.

One of the highly disturbing phenomenon in ECOWAS region is removal of natural forest due to increasing demand for housing, administrative and commercial structures, mining of minerals, agriculture and pastureland. Large agricultural land is required to produce food for the increased population in the region, global commodity price serve as an incentive for more plantation and mining activities, while increasing quest for the promotion and development of bio-fuel triggers deforestation. ECOWAS region face a declining trend in the forest land. The forestland as percentage of total land had declined from 30.87 in 2004 to 30.55 in 2006 and it further went down to 30.22 and 29.89 in the year 2008 and 2010 respectively. By the year 2014 the forestland as percentage of total land was 29.58 declining to 29.43 and 29.27 in 2016 and 2018 respectively. With a rate of annual deflation of 1.17 percent ECOWAS is highest World over in terms of deforestation rate. The capacity of the region's forest to serve as a major sink for Greenhouse Gases (GHG) have seriously weakened due to massive deforestation over the years. According to Allan et.al., (2012) many ECOWAS countries have witnessed high influx of foreign companies who have bought and cleared large land area for both plantation and mining and with poor regulations and corruption this development could entails a lot of threat to environment.

2.9 ECOWAS Energy Development Policies

Nearly two-third of the region's population depend on traditional biomass (firewood and charcoal) as sources of energy and in some countries it represents about 80% of final energy consumption. Traditional biomass has continued to be the major source of energy especially in the rural areas where 75% of the population lack access to electricity. Energy gap is acute in ECOWAS with about 200 million people in the region lacking access to electricity. The regional government has set target of connecting 75% of its population to grid electricity by 2030 but even if that is achieved still around 127 million people would continue to use firewood and charcoal as sources of energy and this will intensify the rate of forest depletion and the consequence environmental degradation in the region(UNESA, 2018).

Rapid growth, population increase and improved standard of living in ECOWAS have resulted in increased demand for energy in the region. Increased level of industrialization leads to higher energy demand for productive activities, increased population and urbanization leads to more energy demand for household use and administrative structures. Therefore, the challenge for energy access and security is more enormous than ever before and the regional government is working vigorously to overcome the challenge. In response to this the community in July 2013 adopted the Energy Efficiency Policy (EEP). Other policies and strategies adopted are the Renewable Energy Policy (REP), creation of West African Power Pool which provides option for the financing of renewable energy by private sector. In addition, ECOWAS Centre for Renewable Energy and Energy Efficiency and building of West African Gas Pipeline. Increased energy access and efficiency will significantly reduce cost of production thereby making firms more competitive, increase household savings, and reduce poverty and reliance on tradition sources of energy. The ultimate goal is the achievement of economic growth with improved energy security and healthcare, low pollution and gas emissions and environmental protection.

Figure 2.5shows the renewable energy production target for ECOWAS 2020 and 2030. Wind energy is production is targeted at 836 MW in 2020 and will reach 2314 MW by 2030. Solar energy production will reach 1082 MW in 2020 and it will substantially increase to 5502 MW by 2030. Small-scale hydro energy production will increase from 3102 MW to 9654 MW in 2020 and 2030 respectively. Biomass energy production target is 3330 MW for 2020 and 11758 MW in 2030 and will become the largest renewable energy source in the region.

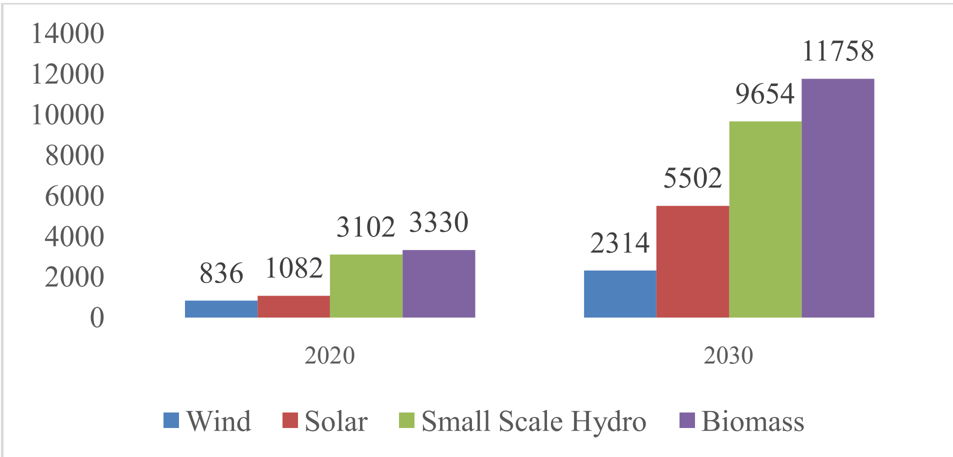

Figure 0:5 ECOWAS Renewable Energy Target (in GWh) 2020 and 2030
Source: EREP(2020)

ECOWAS renewable energy production target is feasible given the vast potentials of green energy as well as technical and economic potentials for the development of clean energy with the support it receive from Austria and Spain governments as well as UNIDO.The resources are well distributed across the countries and this implies that the region could meet its grid and off-grid energy service needs. For example, solar resources are abundant in countries like Burkina Faso, Niger, and Mali that are close to Sahara as well as northern part of Ghana and Nigeria. In the coastal zone there are wind potentials in Gambia, Cape Verde, Senegal, Mali, Ghana and Nigeria. Biomass resources are almost there in all the

ECOWAS countries while small-scale hydro potentials in the southern part in countries like Togo, Guinea, Sierra Leone, Cote d'Ivoire, Liberia and Guinea Bissau.

The creation of energy centre in 2010 has led to a remarkable achievement in the region. Already countries like Ghana, Senegal, Mali and Burkina Faso have made considerable achievements in the area of bio-fuel and many more countries and the regional energy bodies are working to capitalise on the success of these countries to achieve their own target. The centre is a specialized and independent agency of ECOWAS mandated to champion the development of clean energy and dismantling barriers in circulating green energy technology that will go along way in creating regional renewable energy market. The centre also provide policy, legal and regulatory framework, knowledge management, capacity development and business and investment promotion with the assistance of the government of Austria and Spain as well as UNIDO.

2.10 Chapter Summary

Agriculture, minerals and mining activities are the major economic activities in ECOWAS providing vast employment opportunities to the teeming population. In recent years' economic growth in the region is quite impressive despite the low level of savings and investment as well as high public debt due to growing fiscal gap. The increasing growth rate is attributable to improved macroeconomic management, economic reforms, debt relief, favourable commodity prices and return of democratic regimes in member states. In addition, trade, discovery and exploitation of crude oil in additional member states, huge inflow of FDI and aid into the region as well as increased capital investment (physical and human) has helped strengthened and promotes higher growth.

Population grows rapidly in ECOWAS with growth rate faster than any other region in the African continent. Its population has more than tripled in five decades with countries like Niger, Liberia, Burkina Faso and Sierra Leone witnessing the highest growth. Increase in population has been uneven between countries and within countries with coastal areas witnessing higher growth than Sahel regions. In big cities population has increased 100 percent and small cities in savannah have tripled their population. Urbanization rate in the region is also the highest in the continent due to massive rural-urban migration. Social unrest, food insecurity, limited jobs and lack of basic amenities are the major factors explaining rural-urban migration in the region. Rapid population growth has led to increasing level of poverty and inequality. Extreme poverty is felt both in the rural and urban areas with a significant size of the population unable to put food on table. Already 60 percent of the population are living below poverty line making it the worst hit by poverty in the world. Apartfrom Ghana and Cape Verde, all the ECOWAS members are among the 46 countries in the world with low Human Development Index.

Trade development and FDI inflows played a crucial role to the growth and development of the region helped in mobilizing huge foreign exchange required for development purposes. Major export products in the region are crude oil, cocoa, rubber, wood, fruits, fish and precious stone. Crude oil and cocoa makes almost 80 percent of the exports and this has expose the region to the external shocks. Thus, the region needs concerted efforts towards diversifying its export base and increasing value addition as a way of mitigating external shocks. ECOWAS import is high exceeding the African average of 38.4% and the imports are dominated by fuels, motor vehicles, machinery, electric appliances and plastics. Few countries (Nigeria, Ghana, Senegal, Cote d'Ivoire) dominated both exports and imports in the region and the remaining eleven countries taking an insignificant share. Foreign direct investment inflow in the region increased substantially due to measures put in place by member countries to attract FDI as a way of bridging investment gap and correcting balance of payment problem. But FDI inflow into various economic sectors is uneven with the oil and gas seems to be the preferred areas even though these sectors contribute less to GDP compared to agriculture.

Trade pattern and FDI inflow does not favour environment in ECOWAS due to the fact that both exports and imports are dominated by environmentally sensitive products. Although carbon dioxide ($CO2$) emissions grow slowly in ECOWAS region in the past it is likely to accelerate in recent time due to higher growth recorded increased level of industrialization which is increasing energy demand. Another disturbing phenomenon in ECOWAS region is removal of natural forest due to increasing demand for housing, administrative and commercial structures, mining of minerals, agriculture and pastureland. The state of environment is quite alarming and the region has been identified to be the most prone to the risk of climate change (IPCC, 2013). Already climate change in the region has reflected in extreme variation in rainfall, late rainfall onset and early cessation, reduction in growing season length, droughts and depletion of surface water sources with a significant impact on the regional economies that are largely agro-based. With the current temperature level of 2^0C and projected warming above 4°C addressing climate change issues is of top priority for the regional governments and ECOWAS community.

CHAPTER 3

LITERATURE REVIEW

3.1 Introduction

This Chapter discussed the concept of environmental degradation as well as assessment approaches. Then review of theoretical and empirical literatures on environmental degradation is done. It proceed to analyze the determinants of environmental degradation as per this study is concern. Anteweller et al. (2005) decomposition effects (the scale, technique and composition effects) as the main channels through which economic growth impact on environment is also discussed. The chapter thoroughly discussed the main hypotheses concerning environmental degradation starting with the contribution of Grossman and Krueger (1991) such as the Environmental Kuznets Curve hypothesis (EKC), Factor Endowment Hypothesis (FEH), Pollution Haven Hypothesis (PHH), Race-to-the-Bottom Hypothesis as well as the Porter Hypothesis. The second section provides a review of empirical literatures on the relationship between economic growth environmental degradation base on inverted U-shaped, N-shaped, U-shaped and Monotonic pattern. In addition, studies base on the four strands of causal hypotheses, namely the conservation hypothesis, the growth hypothesis, the feedback hypothesis and the neutrality hypothesis are explored. Finally, the gaps in the empirical studies are highlighted.

3.2 Concept of Environment Degradation

The United Nations define environmental degradation as the depletion of the environmental resources due to human activities and natural disasters. International Strategy for Disaster Reduction also defined environmental degradation as the decline in the value of environment to meet its ecological and socio-economic needs. Issues under environmental degradation includes deforestation, land degradation, desertification, land, air and water pollution, rising sea level, loss of biodiversity, ozone depletion and climate change (Agyemang, 2013). Although some of these issues are due to natural disasters majority of them are as a result of human activities and lifestyle which if not changed would cause untold and unprecedented damage to the environment and affect the present and future generation (WCED, 1987).

Over the past 20 years now negotiations on the climate change and environmental degradation have been on at the international level but the issue is taken more seriously in recent times as the world biggest polluters became convinced that the earth is becoming hotter, wetter and wilder. In 1972 United Nation for the first time prepared conference in Stockholm drawing attention on need to protect human environment. Brundland meeting was held in 1987 where sustainable development was launched and the Rio Summit followed in 1992 which endorsed the framework called United Nations Framework Convention on Climate Change (UNFCCC). The developed nations were urged to bear larger part of the burden for combating human-induce climate change. Five years later, a major milestone was achieved in 1997 following the adoption of Kyoto Protocol in Japan under which industrialized nations were given target for reducing Green House Gas emissions.

Later in 2009 Copenhagen Summit was called and it was agreed that global temperature should be kept below 2^oC. Other efforts include Cancun meeting in Mexico in 2010 where it was agreed to establish Green Climate Fund. Similarly, Durban platform in 2011, Warsaw gathering in Poland 2013 and Lima 2014 in Peru are convened to discuss ways to tackle the climate change and environmental degradation. Consequently, these gathering and conferences led to a confrontation of interest between environmentalists and development economists since early 1990s. The evolving environmental issues brought concern to economists about sustaining economic production while environmental resources are getting depleted. This development sparked theoretical and empirical researches on the nexus between economic growth and environmental degradation.

3.3 Environmental Degradation Assessment Approaches

3.3.1 Stress-Response Approach

The Stress-Response framework was developed through a joint initiative between the United Nations Statistical Office and Canada in the mid-1970s. This framework focuses on the environmental impact of human activities. The point under this framework is that human activities have accelerated beyond the absorption capacity of the environment and the environment response from such has negative effects in human wellbeing. Comolet (1992) observed that this framework is used in policy analysis in relation to the environment by the Department of Education and Child Development (DECD). But this framework for environmental assessment suffers from a major limitation for ignoring other causes of stress on environment other than human activities.

3.3.2 Pressure-State-Response Approach

In 1994 the Organization for Economic Cooperation and Development (OECD) developed another framework called Pressure-State-Response assessment framework in trying to overcome the limitations of the stress-response framework. PSR framework takes account of the pressures which explain the extent of human efforts to rescue environment after exceeding its limit. Pinter et al., (1999) argues that the "state" is the baseline condition of the environment given by the unaffected areas from human activities such as expansion of settlements, renewable and non-renewable resource depletion and land degradation, water and air pollution. In line with this, Gallopin (1997) opine that the "response" implies the effect of environmental stresses and the human actions that follows as a response like environmental regulations, international conventions, development of advanced technology, economic expenditures, etc. used to shield environment. This framework has gained international acceptance and is adopted by many regions and international bodies such as World Bank in its Land Quality Indicator programmes, OECD in its analysis of degradation and pollution of natural environment, and European Environmental Agency in assessing member states environmental problems.

3.3.3 Driving Force-State-Response Approach

The United Nations Commission for Sustainable Development (UNCSD) in 1997 developed the Driving Force-State-Response framework in a bid to correct the limitations of SR and PSR frameworks. The DSR framework changed the term “pressure” and use “driving force” to capture the social, economic and institutional aspects which are considered as the driving force of environmental degradation. As such DSR framework has systematically outline information on sustainable development for easy consumption by its users and this is the novelty of the framework (European Environmental Agency (EEA), 1999). DSR framework was adopted by the World Bank indicators of environmental sustainability in 1995 because of its comprehensiveness and this make it more relevant for developing countries whose economies are in transition and need to harmonize economic growth and environmental sustainability (UNCSD, 1997).

3.3.4 Driving Force-Pressure-State-Impact-Response (DPSIR) Approach

The Driving Force-Pressure-State-Impact-Response framework was the initiative of European Environmental Agency of the European Union in their bid to capture environmental problems in their development efforts. The DPSIR framework is an improvement over the previous frameworks because it encompasses the features of the previous frameworks and introduced another feature or indicator. This new framework has five features or indicators namely the driving forces, the pressures, the states, the impact and the response with each indicator having different meaning and application. The “driving forces” are the changes in social structures such as poverty, population growth and literacy level, changes in preferences and consumption pattern and migration that affect the environment positively or negatively. The “pressures” entails the human actions carried directly on the environment beyond its absorption capacity like excessive extraction of natural resources, emissions of Sulphur and carbon dioxide, gold, ore smelting, and use of fluorocarbons.

The "states" denotes the changes in the environmental conditions such as desertification, rising sea level, soil erosion, deforestation, rising global temperature, global warming, ozone layer depletion, acidic rain. "Impact" relates to the consequences that follow the changes in the state of the environment like declining agricultural output, food insecurity, climate-change induce crop damages, malnutrition, high mortality, and other climate-change induce sicknesses. "Responses" relates to the actions taken by the society as a way correcting the environmental problems and ensuring a path to sustainable development. Such actions include the introduction of polluter pays principles, environmental conservation awareness and campaigns, environmental capacity building and energy taxes in response to environmental challenges. Thus, the driving force-pressures-state-impact-response framework becomes a more comprehensive framework because it takes into account all issues related to the environment assessment particularly for developing countries and hence this study adopts it because it addresses the major issues in the ECOWAS countries.

3.4 Theoretical Framework of the Study

Economic theory indicates that the nexus between income and environment is enshrined in the environmental Kuznets curve (EKC) hypothesis. The EKC theory of economic growth and environment followed a published work in the American Economic Review Journal of March 1955 by a Russo-American economist, Simon Kuznets who argued that the nexus of economic development and income inequality maintain an inverted U-shaped pattern over time. Kuznets (1975) argued that at the early stage income inequality increases as per capita income rises and after reaching certain threshold income level then income inequality falls. This means that at nascent stage of economic development income distribution becomes more unequal but as economic growth increase further it would reduce the income inequality and this relationship is popularly called the Kuznets Curve. Later on, academic works borrowed from this explanation in describing the relations between income and environmentnow popularly called Environmental Kuznets Curve initially labelled by Panayotou in 1993.

Grossman and Krueger (1991) made the early work on the EKC hypothesis explaining that in the early period of a nation economic prospect, rising national income increase the scale of economic activities and all things being equal increase the level of pollution (the scale effect). But after reaching certain threshold income level, decline in pollution level will be experienced, first because of the fact that environmental regulation encourages the use of clean technology by firms (technical effect) and secondly due to economic restructuring that shift the economy from manufacturing led to clean service sector-led which pollute less (composition effect). Therefore, the EKC hypothesis postulates an inverted U-shaped pattern between income growth and environmental pressure as depicted in figure 3.1

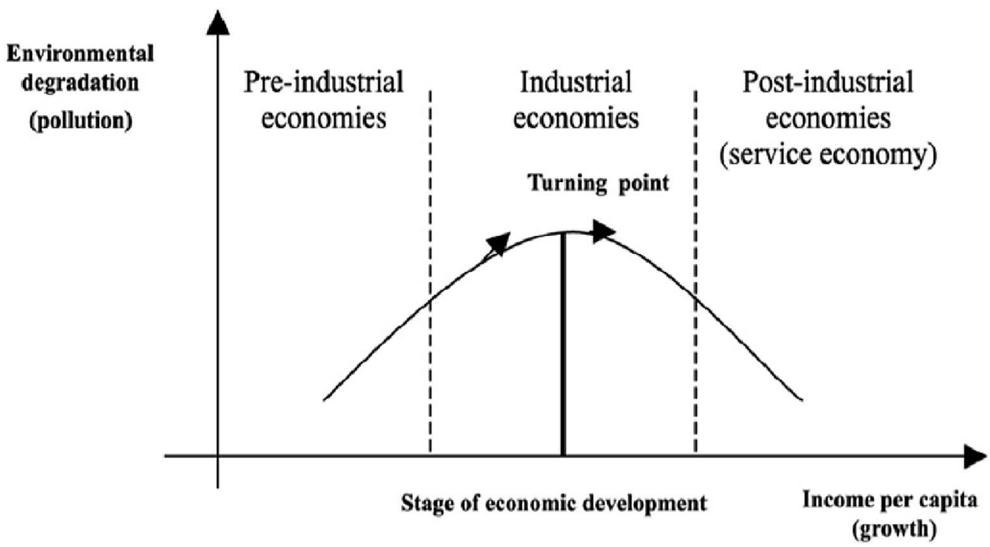

Figure 3:1 Environmental Kuznets Curve (EKC)

The political dimension of EKC explain that environmental quality is a luxury good and authorities do not accord priority to it at the nascent stage of economic development due to low level of national income rather they aim at raising living standard through promoting economic growth. But environmental quality become a normal good once citizens achieve certain living standard and mount pressure on their government to take measures toward reducing pollution. In response, environmental regulations will be enacted such as polluter pay principle to make firms internalize the full cost of pollution.

The EKC hypothesis has now become an important tool for policy making and had gained popularity among trade proponents and researchers in the area of environment. But empirical results on the nexus of economic growth and environment are mixed and this generates arguments among researcher about the possible explanation of the different shapes and the turning point revealed by such findings. One possible explanation regarding the varying pattern of growth and environment relationship is that economic growth comes from different sources and each economic activity might generate different level of pollution. Another powerful mechanism influencing empirical results on EKC are the increasing return to abatement, threshold effects and income effects, Copeland and Taylor (2004). Panayotou (1997) suggested for a comprehensive measure of economic development as well as the importance of incorporating relevant factors that explain the growth-environment nexus. He stressed that paying attention only on scale and composition effect while overlooking the abatement effect of higher income in empirical models tends to yield wrong conclusions. He therefore emphasized the need for strong environmental policies in addressing environmental problems. Again, different choice of pollution indicator might fail to establish the inverted U-shape pattern in EKC studies. For example, carbon emission failed to show an inverted U-shape in some studies but rather increase at continuously decreasing rate due to cross-border externalities that kill incentive to regulate emissions.

3.5 Theoretical Literatures

Economic literatures traced three major channels in which economic growth impact on the environmental conditions and these channels are the scale effect, technique effect and composition effect (Anteweiler et al., 2001and Copeland and Taylor, 2004). Firstly, growth leads to intensive production which harms environmental quality (scale effect). Mostly pollution comes from production process associated with energy consumption therefore, holding the technique and composition effects constant, growth would not only pollute environment but also deplete forest reserve as demand for land increases occasioned by increase in agricultural exports demand. Secondly, the technique effects explained the fact that environmental quality exhibit the nature of normal good such that rise in income would reduce emission and improve environmental quality (Lopez et al., 2007). This happens because with increased income governments, especially under a democratic regime, would introduce stricter environmental regulations in response to the increased citizen's demand for environmental standard. This tendency is more for high income nations as they value cleaner environment more than the low income nations. Thirdly, the composition effect explain how economic growth changes the economic composition under the assumption that natural capital is associated with dirty products while production of clean products is more intensive in human capital (Lopez and Islam, 2008).

Therefore, pollution will be more in economies that focus on production of natural capital-intensive products while an economy that shift its production away from capital-intensive goods will pollute less depending on where the economy's comparative advantage lies. Countries endowed with large deposit of natural resources are likely to specialize in natural resource-intensive industries. They tend to increase the exploitation of natural resources with an increased demand for exports due to trade openness. Thus with poor property right definition and weak enforcement of environmental regulation, rise in income would lead to environmental degradation via deforestation and waste generation. The composition effect of economic growth on environment is explain by the pollution haven hypothesis that postulates that the effect of trade-induced growth shift pollution intensive industries to countries that has poor environmental regulations.

Therefore, the EKC hypothesis could be explained that industrial development will initially cause more emissions of pollutant but further development results in rising income and demand for better health and environmental quality and emissions eventually decline. This suggests that rapid economic growth is one way to combat global emissions problem. In other words, economic growth is the cause as well as the cure for environmental problem hence the best way to achieve a clean environment is to be rich (Beckermen, 1992). Panayotou (1993) opined that there is no need to accord particular attention to environment but rather suggest that what is important is to explore factors that promote economic growth like economic restructuring, price reform and trade openness then environmental degradation will automatically be taken care of without any regulations or international pressure. Ekins (2000) corroborated this adding that economic growth and environment are friends such that the former is a prerequisite for achieving the latter.

There are a number of criticisms levelled against the EKC hypothesis. First, with the pioneering work of Grossman and Krueger (1991) a large number of studies have been carried out in order to test the validity of the EKC hypothesis but limited studies have shown support for the inverted U-shaped pattern (Gallagher, 2005). Stern, (2004) maintained that only a few pollutants (like sulphur dioxide and suspended particles) follow the EKC. In line with this World Bank (1992) corroborated this position stating that the EKC hypothesis is highly doubtful when many pollutants like energy use, water pollution, carbon dioxide (CO2), municipal waste and carcinogenic chemicals are used as indicators of environmental degradation. According to Nordstroem andVaughan (1999) it is not surprising when pollution decrease or increase along with income since the EKC only holds for certain set of pollutants like as local air pollutants but not for carbon dioxide (CO2) which is a global air pollutant.

Secondly, the EKC hypothesis assume that environment get cleaner only with an increase in income but the increasing world trends in outsourcing activities occasioned by globalization could change the Inverted U-shaped growth-environment relationship. A country can therefore succeed in cleaning its environment by simply importing pollution-intensive products from other countries. Drawing from this argument, industrialized countries might have witnessed improved environmental quality irrespective of the level of income by adopting outsourcing. If this happen, pollution does not decrease in the global context but rather shifted to other regions or countries of the world. Thirdly, the EKC hypothesis is also attack on the ground that it assumes a one-way causality from income to environment. Stern et al. (1994) argues that estimating a one-way causality is absolutely wrong since income and environment are jointly determined given their bidirectional influence. This point can be well understood considering the fact that environmental resources are the main source of economic activities and therefore resource depletion (environmental degradation) would definitely weaken future production (economic growth) Arrow et al. (1995). On the other hand, exceeding the absorption capacity of the environment for waste discharges, due to expansion in production (economic growth), would leads to pollution which is dangerous to human and reduce environmental resource availability and productivity.

The EKC has also been criticized on the ground that most of the studies validating EKC hypothesis concentrated on the developed countries especially OECD with little presentation from poor and developing countries (Gallagher, 2005). This explain why results from empirical studies that capture less developed countries appears ambiguous and most cases fail to validate the hypothesis of environmental Kuznets curve (Stern, 1998). Other observers opined that most of the damages done in the first period of economic prosperity can hardly be reversed like deforestation, loss of clean and portable water, pollution related deaths, biological and genetic diversity loss.Notwithstanding the criticism mentioned above the EKC theory has remained popular in analyzing the nexus of income and environmental pressure and this study adopt it as an underpinning theory.

Antweiler et al. (2001) later advanced the literature arguing that the latter did not explain the channels via which trade-induced economic growth impact on environment. Hence they identified three channels (the scale effect, the technique effect and the composition effect) through which economic growth affect environment. These channels are discussed below.

3.5.1 The Scale Effect

The first channel through which economic growth affects environment is through the increased volume of economic activities (scale effect). Economic growth represent an increase in both productions of goods and services in an economy and given the composition and production technique, increase in the level of economic activities would lead to a rise in environmental degradation. The point here is this, increase in production requires additional inputs such as raw materials and energy as well as services like transport, commerce, logistics, sewerage, etc. In addition, labour demand, employment and investment will increase as well. Therefore, economic linkages will be created such that booming manufacturing sector would stimulate further expansion of infrastructure, residential and non-residential buildings, agriculture and forestry. In the same way, activities in the service sector will be gingered such as transportation (land, air and sea), hotels, communication, restaurants, real estate, logistics, health and education, business services, banking and insurance.

Thus, rapid economic activities create employment and stimulate business and household consumption of energy, minerals and forest resources thereby leading to environmental degradation in terms of air, water and land pollution, and forest depletion. For example, rising production activities requires more transportation service thereby polluting air, increase agricultural exports leads to more demand for agricultural land and application of fertilizer that pollute land and water. Also increased exports of forest products entail mass deforestation. Eventually, the assimilative ability of nature to absorb pollution emissions and other externalities would be eroded.

3.5.2 The Technique Effect

Environmental quality is considered to be a normal good and therefore at initial period of economic development people do not have preference for higher environmental quality due to low income. The authorities as well do not accord priority to environmental issues while drawing policies rather focus on promoting economic growth and employment (Dasgupta et al. 2002). But as income continue rising people consume more and more goods until diminishing marginal utility set in after achieving certain level of income. Then people begin to be more environmentally conscious and attach preference to a more quality environment. They would exert pressure on government to introduce stringent regulation to check pollutant activities. Thus a positive relationship exists between income and environmental quality implying that with higher income people could afford to pay for quality environment and the government is more capable to maintain quality environment. Increasing economic growth that comes with international trade expansion brings a country to the technology frontier that allows for efficient and environmentally friendly production methods.

As government imposes penalty on environmental polluters, producers seeks to replace the existing environmentally hazardous technology with a cleaner and friendly one. Also firm's phase-out outdated and dilapidated technology and industrial changes will be triggered with the implication that those producers who cannot afford the new and advanced technology are phase out. In addition, consumers become more rational in their choices of the goods they consume by increasing demand for environmentally friendly goods and therefore only firms that can respond to such needs remain competitive in the market. According to Maccarney et al, (2005) income-induce demand for environmental standard reduces emissions intensity per GDP unit and promote environmental quality.

3.5.3 The Composition Effect

The economic development of a country goes through transformation phases beginning with the dominance of primary sector in the early stage of development. At this point, the major economic activities as well as source of income comes from primary sector such as agriculture, forestry and minerals extraction like oil and gas, tin, copper, gold, uranium and other minerals. Likewise, the exports of a country are largely dominated by primary products which provide foreign exchange. Gradually, incomes made from primary commodity export couple with capital inflow from advanced nations due to trade openness stimulate the development of manufacturing sector. The development of the manufacturing sector changes the composition of outputs and exports from primary commodity-base to manufactured-base. Again rapid increase in population that comes with economic transformation and high demand in the external sector supported by government policy leads to emergence of strong manufacturing sector. Consequently, the share of agriculture in the gross domestic product as well as total employment will decline and that of the manufacturing sector increases significantly.

At later period of economic progress, the demand for auxiliary activities of service sector increase due to large industrial activities and population growth. Eventually, the service sector becomes the major source of employment and income and its share in GDP outweigh that of the manufacturing. At this point, a country will experience low level of environmental pollution as it progresses from dirty manufacturing to clean service economy (Arrow et al., 1995). The scenario can be well understood that clean goods are more likely to be produced in human capital resource-based economies while dirty goods are produced in natural resource-based economies.

3.6 Empirical Literatures

Literatures identified a number of factors that determines the level of environmental degradation and how factors are linked with the environment. Below are the factors use in this study and how they affect environmental condition.

3.6.1 Ecological footprint

The ecological footprint (EF) is the dependent variable in this research. The data for ecological footprint is obtained from Global Footprint Network (GFN). Ecological footprint is an indicator that captures thecropland, grazing land, Forestland, fish grounds, built-up land, and carbon footprint. According to Guidebook to the national footprint account (2020), cropland summarizes the Footprint of cropland embodied in both crop and livestock products; grazing land summarizes the Footprint of pasture grass embodied in livestock products; forestland summarizes the Footprint of forestland embodied in primary and processed forest products; fish grounds summarizes the Footprint of marine and inland water areas embodied in fish and other aquatic products; built-up land summarizes the Footprint associated with buildings, infrastructure, and hydroelectric reservoir area; and the carbon footprint summarizes the carbon Footprint of fossil fuel combustion (both domestically emitted and embodied in traded goods) and an additional bunker fuel carbon tax.

3.6.2 Economic Growth and Environment

Economic growth brings about rise in economic activities and all things being equal increase the level of pollution (the scale effect) because energy is required in most of the production processes. But after reaching certain threshold income level, decline in pollution level will be experienced, first because of the fact that environmental regulation encourages the use of clean technology by firms (technical effect) and secondly due to economic restructuring that shift the economy from manufacturing led to clean service sector-led which pollute less (composition effect). With increased income demand for goods and services rise paving way for further industrial production. However, with the proliferations of industrial production natural resources extraction and energy demand increased as both are key for industrial and human survival. For example, while crude oil and gas extraction rapidly increased to provide the required energy for industries and households, forest resources are important raw materials for manufacturing sector and household's consumption. Consequently, environmental degradation in form of pollution, land degradation and forest depletion is increasing at a high scale.

The attention of macroeconomic policymaker world over has been focused on promoting economic growth since the post- World War II period. Economic growth, as measured in terms of change in gross domestic product (GDP), remain the crucial target achieving which would translate into improvement of overall wellbeing of the populace. Interestingly, remarkable results have been recorded in terms of economic growth in many countries of the world yet this development at the same time increased concern about the environmental cost associated with such increased growth. In other words, what environmental and ecological costs are being incurred as prices for such growth world over? The pioneering work of Grossman and Kruger (1991) was the first attempt to answer such question where they postulated the environmental Kuznets curve (EKC) hypothesis which established an inverted U-shaped pattern between economic growth and environmental degradation. The EKC hypothesis argues that environmental degradation in a temporary phenomenon that would be corrected in the long run after the economy attains certain threshold income level.

Arguing from the above perspective, Anteweiler (2001) maintained that the relationship between economic growth and environmental degradation could be positive or negative depending on the magnitudes of the transmission channels (the scale, technique and composition effects). In other words, environmental impact of economic growth could be positive or negative depending on the dominating effect these three channels. This is evident from the empirical studies that produced mixed and inconclusive results. For example, Stern and Common (2001) analyzing the relationship between economic growth and environmental degradation in different countries of the world found that even though most countries exhibit EKC pattern there are some that failed to validate that hypothesis. Al-Mulali et al. (2015) study for 93 countries and Onafowora and Owoye's (2014) for 8 countries (Japan, South Korea, China, Mexico, Egypt, Nigeria, South Africa and Brazil) reported that EKC does not hold for some countries. However, Thao (2018) study for 51 countries and Kilic and Balan (2018) study for 151 countries over 1996-2010 all validated the EKC hypothesis. The above studies succeeded in analyzing the nexus between economic growth and environmental degradation from the global perspective drawing countries cross the world. Such approach could have some limitations in portraying the issue because combining countries with different level of economic development might result in giving misleading results. Therefore, there is the need to analyse countries base on their level of economic development.

To account for differences in the level of economic development of countries some are done. For example, Narayan and Narayan (2010) analyzing the effect of economic growth on CO_2 emissions reported that while EKC hypothesis is valid for

Middle East and South Asian panels the results from the other developing countries are mixed. Contrarily, Jaunky (2011) examining the relationship between economic growth and CO2 emissions for high income countries over 1980-2005 found a monotonic relationship. Such finding is corroborated by that of Rodriguez and Boquete (2014) for 15 OECD countries over 1980-204. But Al-Mulali and Ozturk (2016) study for 27 advanced countries found that economic growth helps clean environment in the long run thus validating the EKC hypothesis. But Sarkodie and Strezov (2019) have some reservations on EKC hypothesis conducting study for five developing countries. Their study found that a U-shape pattern holds for India and South Africa. The study of Jebli et al. (2016) for OECD countries over 1980-2010 using fully modified OLD and dynamic OLS also validate the EKC hypothesis. Similarly, Churchill et al. (2018) analyzing OECD countries over 1870-2014 confirmed that economic growth is a cure for environmental degradation in the long run. But while analysing the same OECD countries over 1975-1998 using pooled mean group Zarzoso and Marancho (2004) found that the relationship between economic growth and environment follow N-shaped pattern. This is corroborated by the recent studies by Halkos and Polemis (2017) for OECD over 1970-2014 and Lorente et al. (2018) for Europe over 1985-2016. Notwithstanding the attempts by these works in classifying countries on their level of economic advancement, they have ignored the regional peculiarities of the countries. For example, some regions are desert, some tropical forest, and even the climatic condition differs cross the world which could influence the environmental condition as well. Thus, there is the need for studies that capture regional features.

In order to account for that, some empirical studies focused on different regions in the world as in the case of Arouri et al. (2012) study on MENA over 1981-2005 where they found that economic growth enhances environmental condition thus validating the EKC hypothesis. Farhani and Shahbaz (2014) analyzing MENA countries over 1980-2009 employing FMOLS and DOLS established that economic growth is a cleaner for environment in the long run. Such findings contradict that of Atici (2012) for ASEAN countries over 1970-2006 and Apergis and Ozturk (2015) for Asia who found N-shaped pattern where economic growth harms environment at the early stage, later clean it after attaining certain threshold income level but again worsen environment due to a sustained increase in income level. In a study conducted by Al-Mulali and Tang (2013) in GCC countries over 1980-2009, they found a monotonic relationship between economic growth and CO2 emissions. Similar findings were reported by Omri (2013) for MENA over 1990-2011 using GMM and Bekhel et al. (2017) for GCC over 1980-2011.

To account for heterogeneous nature of countries some studies focused on single country study, yet evidence on the EKC are mixed. For example, Iwata et al. (2010) study for France over 1960-2003 employing ARDL validate the EKC hypothesis. Studying Brazil over 1980-2007, Pao and Tsai (2011) confirmed that the relationship between economic growth and CO2 emissions follows an inverted U-shaped pattern. Similar findings were reported by Boutabba (2014) for India over 1971-2008 and Yavuz (2014) Turkey over 1960-2007. In a contrasting results from USA by Millimet and Stengos (2003) and Friedl and Getzner (2003) for Austria, the relationship between economic growth and environmental degradation follows N-shape pattern. Also, Lee and Mukherjee (2008) study for USA and Akbostanci et al. (2009) are all in support of N-shape relationship. While considering for a threshold cointegration relationship, Fosten et al. (2012) study for UK over 1830-2003 confirmed the EKC hypothesis and this was later reaffirmed by Sephton and Mann (2013) for Spain over 1857-2007.The study of 7 ASEAN countries by Salman et al. (2019) is in line with EKC hypothesis. In Sharp contrast, the more recent study by Destek and Sinha (2020) reported a U-shaped pattern in OECD countries. Similarly, another recent work Pontarollo and Munoz (2020) examine the relationship between economic growth and environmental degradation in Ecuador and they documented the existence of U-shaped pattern which is in opposite to the EKC hypothesis and their finding is supported by Xu et al. (2020) for China. But the recent findings of Feng and Wang (2020) in China and Pacca et al. (2020) for 150 countries reported that economic growth has insignificant impact on CO2 emissions.

Considering the above contradictory arguments and mixed findings, the empirical literatures on the relationship between economic growth and environmental degradation are summarized in the following sections base on the inverted U-shaped relationship, N-shaped relationship, U-shaped relationship, as well as monotonic pattern. Also, empirical studies base on conservation, growth, feedback and neutrality hypotheses are reported as below.

3.6.2.1 Inverted U-shaped Relationship between GDP and Environment

An inverted U-shaped relationship reflect a situation in which environmental degradation increase at the initial stage of economic development but after reaching certain level of income (turning point) environmental degradation declines. There are many empirical studies that validated the existence of an inverted U-shaped relationship economic growth and environmental quality in different countries and regions of the world. For example, Fodha and Zaghdoud (2010) confirm the existence of an inverted U-shaped relationship for Tunisia using vector error correction model. Leitao (2010) employing fixed effect model found an inverted U-shaped relationship for 94 countries. Baycan (2013) findings for EU-25 validate an inverted U-shaped relationship and Yildirim (2013) also found similar results for 32 countries. Donfovet et al. (2013) study EU countries over 1961-2009 and the results confirm an inverted U-shaped relationship. Ozturk and Acaravci (2013) using ARDL found inverted U-shaped results for Turkey. Similar findings were reported by Shafiei and Salim (2014) for 29 OECD countries,Lopez-Menendez et al. (2014) for EU-27, Apergis (2016) for EU-13, Duan et al. (2016) for ASEAN-5, Al-Mulali et al. (2016) for Europe, East Asia and the Pacific, South Asia and Americas, Bello et al. (2018) for Malaysia over 1971-2016. Table 3.1 below provides a summary of the empirical studies that validated the inverted U-shaped relationship between economic growth and environmental quality.

Table 0:1 Summary of Empirical Studies on Inverted U-shaped Relationship

Authors & Year	Nation/ region	Method	Factors	Findings
Bardi and Hfaiedh (2021)	MENA	1990-2016	Y, CO2	EKC Valid
Zhang, J. (2021)	China	1992-2017	Y, CO2	EKC Not Valid

Zhang, J. (2021)	China	1990-2015	Y, CO2	EKC Valid
Murshed, M. (2021)	South Asia	1997-2016	Y, CO2	EKC Not Valid
Boubellouta and Kusch-Brandt(2021)	174 Countries	2016 Period	Y, CO2	EKC Valid
Murshed (2021)	Bangladesh	1996-2018	Y,FDI URBAN, E, Y CO2	EKC Valid
Destek and Sinha (2020)	OECD	1980-2014	Y, CO2	EKC Not Valid
Xu et al. (2020)	China	2007-2016	HP, Y, TR, EC	EKC Not Valid
Pontarolla and Munoz (2020)	Equador	2007-2015	LC, Y, POP	EKC Not Valid
Destek and Sarkodie (2019)	Singapore	ARDL	CO2, Y, FD	EKC Valid
Thao (2018)	51 Countries 2001-2012	Two-way Fixed Effect	CO2, Y, FDI, TR	EKC Valid
Wang et al. (2018)	China 2001-2012	FMOLS, DCM	CO2, Y, Reg, Conglomerat	EKC Valid
Yang et al. (2017)	Russia 1998-2013	OLS	GHG, Y,	EKC Valid
Jebli et al. (2016)	OECD 1980-2010	FMOLS & DOLS	CO2, Y, RE,NE	EKC Valid
Kasman and Duman (2015)	EU 1992-2010	Panel Cointegration	CO2, Y, E, TR, FD	EKC Valid
Omri et al. (2015)	MENA 1990-2011	Panel Cointegration	CO2, Y, E, TR, FD	EKC Valid
Al-Mulali et al. (2015)	93 Nations 1980-2008	Panel Cointegration	CO2, Y, E, TR, FD	EKC Valid
Farhani et al. (2014)a	10 MENA 1990-2010	FMOLS, DOLS	CO2, Y, TR,	EKC Valid
Yavuz (2014)	Turkey 1960-2007	FMOLS, VECM	CO2, Y, E	EKC Valid
Shahbaz et al. (2014)a	UAE 1975-2011	ARDL	CO2, Y,	EKC Valid
Wang (2013)	19 Nations 1870-2001	Fixed and Random Effect	CO2, SO2, Y	EKC Valid
Saboori et al. (2012)	Malaysia 1980-2009	ARDL, VECM	CO2, Y	EKC Valid
Richmond and Kaufmann (2006)	36 Nations 1973-1997	FE, RE	CO2, Y, E	EKC Valid

Grossman and Krueger (1991)	NAFTA	CGE	SO2, Y,	EKC Valid

Notes: CO2= carbon dioxide emissions, Y=GDP, TR=trade openness, FDI=foreign direct investment, FD=financial development, URB=urbanization, POP=population, E=energy consumption, TECH, technology, SO2=sulphur, NO2-nitrogene oxide, INST=institutional quality, RE=renewable energy, NRE=non-renewable energy, M=import, X=export, COR=Corruption.

3.6.2.2 N-shaped Relationship between GDP and Environment

Table 0:2 Summary of Empirical Studies on N-Shaped Pattern.

Authors & Year	Country/region	Method	Variables	Findings
Halkos and Polemis (2018)	USA 2000-2012	W-DEA	CO2, SO2, NOx, Y	N-pattern
Lorente et al. (2018)	Europe 1985-2016	HC model	GHG, Y,E	N-pattern
Hao et al. (2018)	China 2006-2015	POLS, Spatial FE, Time-Period FE	CO2, Y, POP	N-pattern
Ajmi et al. (2015)	3 Countries 1960-2010	VAR	CO2, Y	N-pattern
Akbostanci et al. (2009)	Turkey 1968-2003	Pooled EGLS	PM_{10}, CO2, SO2, Y	N-pattern
Lee and Mukherjee (2008)	US 1900-1994	FE	CO2, NO2, Y	N-pattern
Musolesi (2006)	109 nations 1959-2001	Bayesian Approach	CO2, Y	N-pattern
Zarzoso and Marancho (2004)	22 OECD 1975-1998	PMG	CO2, Y	N-pattern
Zaim and Taskin (2000)	OECD 1980-1990	FE, RE	CO2, Y	N-pattern

Notes: CO2= carbon dioxide emissions, Y=GDP, TR=trade openness, FDI=foreign direct investment, FD=financial development, URB=urbanization, POP=population, E=energy consumption, TECH, technology, SO2=sulphur, NO2-nitrogene oxide, INST=institutional quality.

There are other researchers that use a cubic function in their studies in order to establish the existence of N-shaped pattern between economic growth and environmental degradation. The N-shaped relationship explain that economic growth initially leads to environmental degradation (increased pollution) but after reaching certain level of income pollution decline and again rise as a country's income level reach its peak.

Zarzoso and Marancho (2004) using PMG method found N-shaped pattern for 22 OECD countries. Poudel et al. (2009) found N-shaped pattern for Latin American countries over 1980-2000. Similar results were reported by Atici (2012) for ASEAN over 1970-2006; Ajmi et al. (2015) for 3 countries; Apergis and Ozturk (2015) for Asia using GMM method; Halkos and Polemis (2018) for USA over 2000-2012. Table 3.2 gives the summary of empirical studies that found N-shaped pattern between economic growth and environmental degradation

3.6.2.3 Monotonic Relationship between GDP and Environment

The relationship between economic growth and environmental degradation could be monotonic decreasing or increasing in pattern. A monotonic decreasing relationship occur when at the early stage of economic growth environmental degradation declines and still maintain a declining trend as rising income is sustained. Conversely, a monotonic increasing pattern is a situation in which environmental degradation continue to exhibit a rising trend even after a country achieve higher income level. In other words, environmental degradation continues to increase irrespective of rising level of income. There are many empirical studies that confirmed such pattern for different countries and regions of the world. For example, Panayotou et al. (2000) confirm a monotonic increasing pattern for 17 countries over 1870-1994. Bagliani et al (2008) reported N-shaped pattern for a sample of 141 countries. Narayan and Narayan (2010) study for 43 countries of the world over 1980-2004 using fully modified OLS established a monotonic increasing pattern. Similar findings were reported by Omri (2013) for MENA over 1990-2011; Zakarya et al. (2015) for BRICS; Shahbaz et al. (2016) for 181 countries; Mitic et al. (2017) for 42 countries over 2002-2011. On the contrary, Al-Mulali and Tang (2013) found a monotonic decreasing pattern for GCC over 1980-2009 using fully modified OLS and this was corroborated by Bekhel et al. (2017) findings for GCC over 1980-2011 using ARDL technique. Table 3.3 shows the summary of empirical studies that found a monotonic relationship.

Table 0:3 Summary of Empirical Studies on Monotonic Pattern.

Authors & Year	Country/region	Method	Variables	Findings
Gui et al. (2019)	China 2006-2015	Spatial Panel	MSW, Y, URB Hcpt	Monotonic Increasing
Ito (2017)	42 nations 2002-2011	GMM	CO2, Y	Monotonic
Shahbaz et al. (2016)	181 nations	FMOLS	CO2, Y	Monotonic Increasing
Rodriguez and Boquete (2014)	15 OECD 1980-2004	OLS	CO2, Y, E	Monotonic Increasing
Alkhathlan and Javid (2013)	KSA 1980-2011	ARDL	CO2, Y	Monotonic Increasing
Jaunky (2011)	H Income Nations 1980-2005	System GMM	CO2, Y	Monotonic
Azomahou et al. (2006)	100 nations 1960-1996	Local kernel regression	Y, CO2	Monotonic
Panayotou et al. (2000)	17 nations 1870-1994	FGS	CO2, Y	Monotonic Increasing

Notes: CO2= carbon dioxide emissions, Y=GDP, URB=urbanization, POP=population, E=energy consumption, HCPT=human capital, MSW=municipal solid waste.

There are other strands of empirical studies that attempted to examine the causal relationship between economic growth and environmental degradation. These literatures are grouped into four: growth hypothesis; conservation hypothesis; feedback hypothesis; neutrality hypothesis. The growth hypothesis postulate that pollution causes economic growth and therefore a country can accelerate its economic growth without polluting its environment. The conservation hypothesis states that economic growth causes pollution and environment can only be protected by slowing the rate of economic growth. In other words, any attempt to slow down pollution will result in decreasing economic growth. The feedback hypothesis argues that there is bi-directional causality between economic growth and environmental degradation. In other words, economic growth causes environmental degradation and in turn environmental degradation causes economic growth. The neutrality hypothesis on the other hand states that there is no causality between economic growth and environmental degradation, meaning that neither of them causes one another.

The first strand of literatures in this direction is the growth hypothesis which argues that environmental degradation is causing economic growth. In other words, there is a uni-directional causality between economic growth and environmental degradation with the causality running from environmental degradation to economic growth. Empirical studies abound in the growth hypothesis such as Menyah and Walde-Rufael (2010) for South Africa over 1965-2006 using ARDL framework. Alam et al. (2012) confirm the growth hypothesis for Bangladesh using ARDL and VECM method and these findings was corroborated by Sabori et al. (2012). Shahbaz et al (2015) using fully modified OLS also validate the conservation hypothesis for high income countries. The summary of the growth hypothesis is given in Table 3.4.

The second strand of literatures falls under the conservation hypothesis which postulate that economic growth causes environmental degradation. For example, Ang (2007) using vector error correction model validated the conservation hypothesis for France over 1960-2000.Jalil and Mahmud (2009) used autoregressive distributed lag model (ARDL) in China over 1975-2005 and their results support the conservation hypothesis and the results of Fodha and Zaghdoud (2010) also corroborated their findings.Shahbaz et al. (2015) analysed middle income countries over 1975-2012 using fully modifies OLS and their results shows that economic growth causes pollution. Interestingly, Lachehbeh et al. (2015) investigated the casual relationship between economic growth and pollution for Algeria and the results validated the conservation hypothesis.Acheampong (2018) using world data over 1990-2014 found that economic growth granger cause pollution. Similarly, Alsamara et al. (2018) study GCC countries over 1980-2017 using fully modified OLS and panel mean group and the empirical findings reveals that economic growth granger cause pollution. Table 3.5 provides the summary of the conservation hypothesis literatures.

Table 0:4 Summary of Empirical Studies on Growth Hypothesis.

Authors & Year	Country/region	Method	Variables	Findings
Omri (2014)	54 Nations 1990-2011	GMM	CO2, Y, FD	CO2 → Y
Alam et al. (2012)	Bangladesh	VECM, ARDL	CO2, Y, E	CO2 → Y
Sabori et al. (2012)	Malaysia 1980-2009	ARDL	CO2, Y	CO2 → Y
Menyah and Walde-Rufael (2010)	South Africa 1965-2006	ARDL	CO2, Y, E	CO2 → Y
Ozturk and Acarvci (2010)	Turkey 1968-2005	ARDL	CO2, Y, E	CO2 → Y
Ang (2008)	Malaysia 1971-11999	TY Causality	CO2, Y, E	CO2 → Y

Notes: CO2= carbon dioxide emissions, Y=GDP, TR=trade openness, FD=financial development, E=energy consumption.

The third strand of literatures validated the feedback hypothesis of bi-directional causal relationship between economic growth and environmental degradation. In other words, economic growth granger causes environmental degradation and also environmental degradation causes economic growth. Empirical studies that confirmed feedback hypothesis include Choe (2003) for 80 countries over 1971-1995 using panel vector autoregressive technique.Halicioglu (2009) using autoregressive distributed lag model found a bi-directional causal relationship between economic growth and pollution for Turkey over 1960-2005.Interestingly,Omri (2013) study for 14 MENA countries over 1990-2011 confirmed a feedback hypothesis and this is also corroborated by the results of Al-Mulali et al. (2013) for Latin America and Carribbeans over 1980-2008. In line with this also, Mirza and Kanwal (2017) and Alege et al. (2018) both found a bi-directional causal link between economic growth and pollution for Pakistan and South Africa respectively. Table 3.6 gives the summary of studies base on feedback hypothesis.

Table 0:5 Summary of Empirical Studies on Conservation Hypothesis.

Authors & Year	Country/region	Method	Variables	Findings
Kocak and Sarkgunesi (2018)	Turkey 1974-2013	DOLS, Bootstrap	CO2 Y, E, FDI	Y → CO2
Acheampong (2018)	Globe 1990-2014	GMM, PVAR	CO2, Y, E	Y → CO2
Pao and Tsai (2011)	Brazil 1980-2007	ECM	CO2, Y	Y → CO2
Jaunky (2011)	H Income Nations 1980-2005	System GMM	CO2, Y	Y → CO2
Nasir and Rehman (2011)	Pakistan 1972-2008	VECM	CO2, Y	Y → CO2
Iwata etal. (2010)	France 1960-2003	ARDL VECM	CO2, Y, E	Y → CO2
Lotfalipour et al. (2010)	Iran 1967-2007	Toda Yamamota	CO2, Y	Y → CO2
Jalil and Mahmud (2009)	China 1975-2005	ARDL	CO2, E, Y, TR	Y → CO2
Ang (2007)	France 1960-2000	VECM	CO2, Y, E	Y → CO2

Notes: CO2= carbon dioxide emissions, Y=GDP, TR=trade openness, FDI=foreign direct investment, FD=financial development, E=energy consumption, SO2=sulphur oxide,RE=renewable energy, NE=non-renewable energy.

The last strand of literatures are bases on the neutrality hypothesis which postulate that economic growth neither causes environmental degradation nor does pollution causes economic growth. For example, Soytas et al. (2007) study for United States of America found no causal link between economic growth and environmental degradation. Again, Soytas and Sari (2009) study confirmed the neutrality hypothesis for China over 1960-2007. Other studies that revealed no causal relation between economic growth and environmental degradation include Zhan and Cheng (2009) for China over 1960-2007; Shahbaz et al. (2015) for low income countries; Hassan et al. (2018) for Pakistan over 1970-2014. The summary of literatures base of neutrality hypothesis is given in Table 3.7.

Table 0:6 Summary of Empirical Studies on Bi-directional Causality.

Authors & Year	Nation/region	Method	Variables	Findings
Alege et al. (2018)	S/Africa 2001-2014	Granger Causality	CO2, Y, RE	Y ↔ CO2
Shahbaz et al. (2015)	India 1971-2012	ARDL, LS	CO2, Y, E, TR, FD	Y ↔ CO2
Omri (2015)	MENA 1990-2011	GMM	CO2, Y, TR, FD	Y ↔ CO2
Kasman and Duman (2015)	EU 1992-2010	Panel Cointegration	CO2, Y, E, TR, FD	Y ↔ CO2
Al-Mulali et al. (2015)	LA &Carribbean 1980-2010	FMOLS	CO2, Y E	Y ↔ CO2
Farhani et al. (2014)	10 MENA 1990-2010	FMOLS, DOLS	CO2, Y, TR,	Y ↔ CO2
Saleh et al. (2014)	Globe	VECM	CO2, Y	Y ↔ CO2
Omri (2013)	14 MENA 1990-2011	VECM	CO2, Y, E	Y ↔ CO2
Gosh (2010)	India 1971-2006	ARDL, VECM	CO2, Y	Y ↔ CO2

Notes: CO2= carbon dioxide emissions, Y=GDP, TR=trade openness, FDI=foreign direct investment, FD=financial development, E=energy consumption, RE=renewable energy, NE=non-renewable energy.

Table 0:7 Summary of Empirical Studies on Neutrality Hypothesis.

Authors & Year	Country/region	Method	Variables	Findings
Hassan et al. (2018)	Pakistan 1970-2014	ARDL	EF, Y, URB	Y ≠ CO2
Katircioglu and Celebi (2018)	Turkey 1960-2013	VECM	CO2, Y, E,	Y ≠ CO2
Shahbaz et al. (2015)	Globe 1975-2012	FMOLS	CO2, Y, E FDI	Y ≠ CO2
Shahbaz et al. (2015)	Low Income 1975-2012	FMOLS	CO2, Y, E FDI	Y ≠ CO2
Zhang and Cheng (2009)	China 1960-2007	TY causality	CO2, Y, E, POP	Y ≠ CO2
Soytas and Sari (2009)	China 1960-2007	TY causality	CO2, Y, E	Y ≠ CO2

Soytas et al. (2007)	USA 1960-2004	TY causality	CO_2, Y, E, L GFCF	Y ≠ CO_2

Notes: CO2= carbon dioxide emissions, Y=GDP, TR=trade openness, FDI=foreign direct investment, FD=financial development, E=energy consumption, GFCF= gross fixed capital formation.

3.6.3 Trade Openness and Environment

Theoretically, trade openness may contribute to environmental degradation through three channels. According to the first mechanism, higher trade openness is associated with increased energy consumption, which ultimately increases CO2 emission (Bosupeng, 2016). In addition, There is increased transportation activities in order to carry the imported goods fromone place to other. Therefore, increase in imported goods would require transportation machinery to consume more fuel and thus, raise carbon emissions. Import may raise energy consumption for products like refrigerators, air conditioners, dishwashers and automobiles, etc. (Sadorsky, 2012). In addition, increase in trade would deplete natural resources, which would ultimately downgrade the environmental quality (Schmalensee et al., 1998).

The effect of trade openness on environment could either be positive or negative. The Porter hypothesis claimed that trade is beneficial to environment because it promotes competition among firms world over. As environmental regulation and trade standard increases, firms are compelled to seek for more efficient methods of production in order to increase productivity and become competitive in the global market. Thus producers work hard to put significant amount of funds to improve their capability in the area of research and development (R&D) and become more innovative. Therefore, both developed and developing countries seeking comparative advantage will first work toward increased productivity and greener technology and with the presence of multinational companies in both the former and the latter environmental quality will overall be improved and become a common goal. At the end the assumption of trade-off between trade-induced growth and environmental quality will not hold rather both can be achieved simultaneously (Porter and van-der-Linder, 1995).

On the other hand trade openness can be detrimental in cases where race-to-bottom situation occur. This is happens when trade openness promote global competition pushing countries to relax environment regulation in order to maintain their global market status. In developing countries this could occur when they relax environment regulation to attract manufacturers to relocate their industries from developed to developing countries so that opportunity will be created for developing countries to have comparative advantage in the production of pollution-intensive goods thereby becoming globally competitive (Panayotou, 1993). Worried about the improving global market share for the developing countries, the developed countries will as well relax their regulation relating to environment in order to keep investment at home and maintain their status in the global market. In the long run, trade openness will push world producers into a competitive global market in which countries struggle to dominate one another by compromising environmental standard.

Al-Mulali and Sheau-Ting (2014) argued that trade openness enhanced CO2 emissions in 189 countries between 1990–2011. Moreover, Bosupeng (2016) found bidirectional causality between export and carbon emissions implying that export growth increase carbon emission in 37 countries using a dataset of 1960–2010 where he used Toda and Yamamoto causality approach. Rahman (2017) found that export has a worsen impact on environmental quality in 11most polluted Asian countries over a time period 1960–2014. However, the study of Chang et al. (2018) concluded that higher export of manufacturing goods are linked with lower carbon emissions in a panel of 65 industrialized and emerging countries over a period of 1981–2012. In addition, Liddle (2018) concluded that trade significantly increase consumption-based emissions in a panel of 102 countries over a time period from 1990 to 2013. Amri (2018) analyzing the effect found that trade openness has a significantly positive impact of environment degradation in Tunisia over 1975-2014 and this is in line with Ozatac et al. (2017) and Adu and Denkyirah (2018).

3.6.4 Foreign Direct Investment and Environment

Theory states that FDI can relate positively with the environment in some cases and the opposite could equally hold in other instances. There are two opposing arguments regarding the relationship between FDI and environmental degradation. The first argument is based on the pollution-haven hypothesis which shows that some countries operate tight environmental regulation compared to other nations. Therefore the major determinant of industry location in the world is the cost of compliance. All things being equal, pollution intensive industries will move to countries with poor regulation where they can emit pollution and other externalities. In other words, manufacturing firms will be attracted into countries with less stringent environmental regulations. Developed nations tend to have restricted policiesthat could add to cost of production and thus dirty industries would sneak into poor countries with loose policies to find a safe-haven. Policy makers in poor nations are obsessed with the idea that economic growth would later clean environment automatically as the EKC argued.

The other argument states that the presence of foreign firms is beneficial to the host country environment as they come with advanced technology, financial resources and managerial skills(Zarsky, 1999; Albornoz et al., 2009). This is based on the pollution-halo hypothesis. According to the Pollution Halo Hypothesis globalization is the main vehicle that accelerates the diffusion of clean technologies and indirectly trade serves as the most important shield for environment in developing economies (Taylor, 2005). Increasing trade openness will spur additional demand for green consumption making multinational firms to come up with more superior technology and management practice for outstanding performance while domestic firms learn and copy from them thus industry and environmental standard are lifted concurrently. Notwithstanding this, the developing countries should not seat back on the assumption that multinational corporations will always do well for their environment, appropriate regulations are needed to make firms internalize the whole environmental cost of production by enforcing polluter pay principles. This is because there is no guarantee that multinational corporations purely come from highly environment regulated countries with clean technology. Table 3.8 provides the summary of studies base on pollution-haven hypothesis while Table 3.9 give the pollution-halo hypothesis.

Table 0:8 Summary of Studies on Pollution Haven Hypothesis

Authors & Year	Country/ region	Method	Variables	Pollution haven
Bardi and Hfaiedh (2021)	MENA	1990-2016	Y, FDI, COR, CO2	Yes
Dhrifi et al. (2020)	Globe 1970-2017	ARDL	CO2, Y, FDI, FD	Yes
Abban et al. (2020)	Global Panel 1980-2018	ARDL	CO2, Y, FDI, FD	Yes
Shahbaz etal. (2018)	BRICS, NEXT 11 1992-2016	CCE-MG	CO2, Y, FDI, FD	Yes
Koçak1 & Şarkgüneşi (2018)	Turkey 974–2013	DOLS, Bootstrap	CO2, FD	Yes
Shahzad etal. (2017)	Pakistan 1971-2011	ARDL	CO2, TR, FD	Yes
Ahmed et al. (2017)	5 SA 1971-2013	FMOLS	CO2, Y, TR	Yes
Baek (2016)	ASEAN 1981-2010	ARDL	CO2, FDI	Yes
Ertugrul et al. 2016	Developing 1971-2011	ARDL, VECM	CO2, Y, E, TR	Yes
Seker et al. (2015)	Turkey 1974-2010	ARDL, VECM	CO2, FDI	Yes
Zakarya et al. (2015)	BRICS 1990-2012	FMOLS, DOLS	CO2, Y, FDI	Yes
Shahbaz et al. (2015)	Global panel 1975-2012	FMOLS DH causality	CO2, FDI	Yes
Lee (2013)	G20 1971-2009	FE	CO2, FDI	Yes
Al-Mulali (2012)	Middle East 1990-2009	FMOLS, VECM	CO2, Y, FDI	Yes
Lan et al. (2012	China 1996-2006	FE, RE	CO2, FDI	Yes
Pao and Tsai (2011)	BRICS 1980-2007	OLS, VECM	CO2, Y, FDI	Yes

Notes: CO2= carbon dioxide emissions, Y=GDP, TR=trade openness, FDI=foreign direct investment, FD=financial development, POP=population, E=energy consumption, SO2=sulphur.

Table 0:9 Summary of Empirical Studies on Pollution Halo Hypothesis

Authors & Year	Country/ region	Method	Variables	Polution halo
Shahbaz et al. (2019)	MENA	1990-2015	CO2, Y, FDI	Yes
To et al. (2019)	Asia	1980-2016	CO2, Y, FDI	Yes
Shahbaz etal. (2018)	BRICS, NEXT 11 1992-2016	CCE-MG	CO2, Y, FDI, FD	Yes
Adewuyi and Awodumi (2017)	WA 1980-2010	3SLS	CO2, Y, TR	Yes
Shahbaz et al. (2017)	Globe 1980-2014	FMOLS	CO2, Y, TR	Yes
Hakimi and Hamdi (2016)	Tunisia and Marocco 1971-2013	OLS	CO2, Y, FDI	Yes
Hao and Liu (2015)	29 Province China 1995-2011	GMM	CO2,Y, FDI	Yes
Dogan et al. (2015)	OECD	DOLS, DH causality	CO2, TR	Yes
Asghari (2013)	MENA 1980-2011	FE, RE	CO2,Y, FDI	Yes
Al-mulali et al. (2013)	GCC 1980-2009	FMOLS	CO2, E, FDI	Yes
Al-mulali andTang (2013)	GCC 1980-2009	FMOLS, VECM	CO2,Y, FDI	Yes
Tamazianet al. (2009)	BRIC, USA, Japan 1992-2004	Random Effect	CO2,Y, FDI	Yes

Notes: CO2= carbon dioxide emissions, Y=GDP, TR=trade openness, FDI=foreign direct investment, FD=financial development, POP=population, E=energy consumption, SO2=sulphur.

Empirical studies analyzing the impact of FDI on environment produced mixed findings. Some validate the pollution-haven hypothesis while other are in favour of pollution-halo hypothesis. For example, Acharyya (2009) study for India over 1980-2003 shows that FDI has positive relationship with CO2 emissions. These findings are in contrast with that of Dogan et al. (2015) for OECD, Tang and Tan (2015).He (2006) examined the effect of FDI on CO2 emissions in China and the findings revealed that FDI significantly increase CO2 emissions. Also, Mahmood, et al. (2019) analyzed the factors that influence CO2 emissions in Egypt and the findings reveal that FDI helps in cleaning environment by reducing carbon emissions. Contrarily, a more recent study by Dhrifi, et al. (2020) have also reveal that FDI causes carbon emissions in a global panel of developing countries thus confirming the pollution haven hypothesis consistent with Abban et al. (2020). The study by Destek and Sinha (2020) and Pontarollo and Munoz (2020) found a U-shaped relationship indicating that FDI harm environment in the long run. Table 3.8 and 3.9 provides the summary of the two hypotheses.

3.6.5 Financial Development and Environment

Financial development can have positive or negative impact on environment. Financial sector provide loan for firm to expand production which will increase energy consumption and pollution. Likewise, financial sector provide access to fund for households to acquire energy consuming household equipments that would rise pollution. On the other hand, financial sector could finance the development of renewable energy projects that help in addressing environmental challenges. In addition, financial sector do support the development of human capital by providing fund for household to finance education and support research and development efforts of firms. Empirical studies report different impact of financial development on environment. For example, Katircioglu and Taspinar (2017) use DOLS to analyze the relationship between financial development and environmental degradation and found that financial development harm environment. Solarin et al. (2017) explored the impact of financial development on CO2 emissions in Ghana employing the bounds testing approach and found that financial development increase CO2 emissions. This is supported by Shahzad et al. (2017) and Chen and Lei (2018). In contrast, Salahuddin et al. (2018) explored the impact of financial development on CO2 emissions in Kuwait using DOLS estimator and traced that financial development reduces carbon emissions.

3.6.6 Population Growth and Environment

Population growth can be a strong driver of economic growth but it has the potential to exacerbate problems such as slum formation, poor water supply, and sewage disposal which contribute to environmental degradation. In addition, population growth affects the environmental quality through increased pressure on agricultural land in response to growing demand for food. More land also need to be cleared to erect residential building to house the increasing number of people living in a country. Population explosion mounts serious pressure on forest reserve especially less and developing countries where families rely on forest resources for food and firewood. The demand for energy also increases with expansion in population size and most of the energy is generated from non-renewable sources such as coal, oil and natural gasses that generate pollution. Population growth could also undermine environmental quality by rising demand for transportation which increases fossil fuel consumption. Al-Mamun et al. (2014) examined the relationship between population and carbon emissions the study revealed that population growth contributes to environmental pollution. Sarkodie and Awusu (2016) analyze the drivers of carbon emissions in Ghana over 1971-2013 and they found that population growth exert a significant positive effect on environmental degradation. This consistent with Rahman (2017) who found that population growth aggravate environmental degradation in 11 Asian countries. Salman et al. (2019) show that the impact of population is positively associated with carbon emissions at the selected quantile levels, which is consistent with the hypothesis of population. The finding is in line with Zhu et al. (2016a, 2016b) for ASEAN-five and Rahman (2017) for 11 Asian countries.

3.6.7 Human Capital and Environment

Investment in human capital through research and development (R&D) enables a country to gradually remove obsolete technologies and replace it with environmentally sound ones which would contribute towards improving environmental quality. Increase in literacy rate raise the citizens awareness on the importance of environmental standard and this will make people to pressurize authorities to enact laws that lead to a strict control of pollution level. But in the opposite case, human capital might impede environmental quality because growing level of education increase the taste of the citizens for the consumption of luxury energy consuming goods like vehicles, air condition, refrigerators, and electronic products and this would have negative impact on environment. Increasing demand for education leads to erecting more institutions of learning resulting in higher demand for energy. Education may also increase the productivity of labour leading to output and economic expansion. In this connection, Cleeve et al. (2015) studying sub-Saharan African countries documented that human capital attract efficiency seeking FDI and this might help reduce environmental degradation. Su and Liu (2016) also reported that human capital promotes economic growth through facilitating technology transfer stemming from FDI and this might enhance environmental quality. Hua et al. (2018) analyzed the relationship between human capital and environmental degradation along with other explanatory variables and they found that human capital reduce environmental degradation.

3.6.8 Energy Poverty and Environment

There is globally consensus that access to modern forms of energy and services is critical to socio-economic development of a country and where it is lacking both humanity and environment would suffer (UNDP, 2005; WHO, 2006). Notwithstanding its significance vast number of people around the world is lacking access to modern energy, a situation that is term energy poverty. Energy poverty is a global challenge but it is more pronounced in developing countries of Africa, in particular, West African region where about 60% of the population lack access to electricity. Energy poverty impact negatively on environment by increasing the reliance of solid fuel as energy source the burning of which generate pollution. Using solid fuels for cooking lead toincreased anthropogenic emissions with devastating impacts on health due to indoor air pollution (Lacey et al., 2017).

In addition, increasing demand for solid fuel leads to depletion of forest since the fuel-wood comes from forest thereby increasing the level of environmental degradation. Energy poverty has significant health implication as burning fuel-wood generate hazardous smoke leading to sickness and consequent erosion of income. With poor income the chance of accessing modern energy is further eroded and reliance on environmentally harmful energy increase. Energy poverty tremendously limits economic activities to traditional methods such as iron smelting, irrigation, etc. thereby narrowing the scope for expansion and income generation which could have negative effects on environment. Studies such as Malla, 2013; Tang and Liao, 2014; Sadath and Acharya, 2017 all reported the negative impact of energy poverty on the socio-economic wellbeing of people.

3.7 Factor Endowment Hypothesis (FEH)

The Factor Endowment Hypothesis is rooted under the Heckscher-Ohlin theory which argues that relative factor endowment is the main determinant of international trade pattern. Considering capital and labour as the only factors of production, countries that are endowed with relatively abundant capital will specialize in the production and exporting of capital-intensive goods while countries with relatively large endowment of labour will specialize in the production and exportation of labour-intensive goods. This hypothesis contends that countries that are abundantly endowed with natural and material resources would specialize in resource-intensive industries. They produce and export products for which they have large resource endowment and given the increased level of trade openness they increase the extraction of natural and mineral resources. Cole and Elliott (2003) asserted that capital-intensive industries are more pollution intensive therefore following this argument developed countries that are have abundant capital will have comparative advantages in capital-intensive polluting industries that degrade environment.

In addition, countries with poor enforcement of environmental standard and lack of clear definition of property right will experience more pollution and deforestation and hence higher environmental degradation. According to Lopez and Islam, (2008) there is also the possibility of a country having a false comparative advantages under which a country specializes in the production and export of natural resource-intensive goods due to lack of property rights on resources and institutional failures. Given this circumstance, increase in trade openness will reduce income and environmental quality.

3.8 Literature Gap

Although there are a large number of empirical studies that endeavoured to analyze the nexus between economic growth and environmental degradation, these studies focus on CO_2 emissions as an indicator of environmental condition. CO2 emissions is only one aspect of environmental condition relating to air pollution therefore focussing on CO2 emissions ignore other environmental aspects like water pollution, land degradation and deforestation. Thus there is the need for using a comprehensive indicator of environmental degradation in the empirical analysis. To fill in such gap, this study used ecological footprint being a more comprehensive measure that account for the level of consumption of water resources, land, air, fishing ground and forest reserves. Ecological footprint is a comprehensive measure for ecological sustainability because it indicates the carrying capacity of the earth for sustainable economic growth. Secondly, in the pursuit of economic growth natural resources such as forest, minerals, land and water resources are consumed and this is an indication that focusing on CO2 emissions only would limit the focus of sustainable development within industrial activities and ignoring other human-induce environmental damages (Rashid et al., 2018).

In addition, the previous studies mostly focus on the impact of the macroeconomic indicators (economic growth, financial development, foreign direct investment, energy consumption and trade openness) on environmental degradation. The impact of social fundamentals such as population explosion, human capital and energy poverty as driving forces for environment particularly in less and developing countries are not captured. In this study the effect of these social fundamentals are simultaneously analyzed with the macroeconomic indicators.

From the methodological point of view, the previous studies used regression techniques that focus on mean estimate of environmental degradation. Estimation of the mean of the dependent variable show its behaviour over the whole period under review but does not show how the dependent variable respond to changes in the independent variables at different percentile (level of development). This study uses panel quantile regression that provides median estimate indicating the response of environment to its determinants at different levels of development and also indicates the speed of adjustment in correcting for temporary disturbances.

3.9 Chapter Summary

This chapter reviewed the theoretical and empirical literatures on the relationship between economic growth and environment degradation starting with the work of Grossman and Krueger (1991, 1993) who first introduced the environmental Kuznets hypothesis (EKC) which portrayed an inverted U-shaped relationship between economic growth and environmental degradation. The EKC hypothesis was further developed by Anteweller et al. (2005) decomposition effects that traced the scale, technique and composition effects as the main channels through which economic growth impact on environment is also discussed. In addition, the EKC hypothesis could not be well articulated without a clear understanding of the Factor Endowment, Pollution Haven, Race-to-Bottom and Porter Hypotheses as well as the causality hypotheses. Yet, the empirical studies on the relationship between economic growth environmental degradation reviewed above provide mixed results. While some established an inverted U-shaped pattern others revealed N-shaped and Monotonic pattern. The differences in the empirical results could be attributed to the differences in methodological approach. But more important is the combination of variables that are used in the studies.

Availability of production factors plays a key role in influencing outputs (economic growth) and thereby environment in any economy and to this end labour and capital are prominent as usually depicted in Cobb-Douglass production function. Empirical studies have purely focused on the role played by financial development as a form of capital in shaping economic growth and environment relationship ignoring other forms of capital such as human and environmental Resource capitals. Human capital plays a key role in economic growth through improving factor productivity as argued by the endogenous growth theory. Also, environmental resource capital (bio-capacity) is another factor that has been overlooked by previous studies despite the key role it plays in influencing both economic growth and environmental condition. Natural resource capital affects environment in two ways. First, it affects environment through the scale effect since natural resources serves as key inputs in the production of goods. Second, natural environment is a source of sink for pollutants generated from the production and consumption of goods. Thus, environment resources abundance should also be considered as a factor of production, using the same argument as in the case of labour and finance. Therefore, this study intend to fill the literature gaps by modelling environmental degradation by taking into considerations the roles played by human and natural resource capitals among the factors that influence environmental condition.

CHAPTER 4

RESEARCH METHODOLOGY

4.1 Introduction

Having extensively reviewed the theoretical and empirical literatures on the relationship between economic growth and environmental degradation in the previous chapter, the next task to be carried out in this chapter is to identify the variables (determinants) of environmental degradation as explained by the literatures. Next, the variables to be used in modelling environmental degradation will be described with their proxies and explanation will be provided as to how each of the variables affects the phenomenon being investigated (environmental degradation). The nature of the data and its sources will also be clearly stated. Before proceeding, models are specified and testable hypotheses are formulated in order to achieve the objectives of the study. Lastly, the analytical techniques to be deployed in the study are explained in details and justifications for the use of such techniques are given.

4.2 Definition of Variables and Data Sources

This study uses annual data from 1970-2019 for six countries in West Africa sub-region namely Benin, Gambia, Ghana, Nigeria, Senegal and Togo. There are reasons why the choice of the countries is restricted to six. First, data availability is major reason for the selection because some countries like Liberia and Seira Lione are not having available data due probably to civil wars they undergone for a long time. Again, some countries that have not witnessed civil war are not having the data for the variables intended to be used in this study. Second, these six countries cover a larger part of the economic activities in the region, for example, Nigeria alone constitute 70 percent of the region's GDP and the country together with Ghana makes about 81 percent of region's export dominated by crude oil. Therefore, these countries together will give good picture of economic activities taking place in the region. Third, population pressure is one of the major drivers of environmental degradation and these selected countries combined constitute about 75% of the region's population. Four, the selected countries generate larger of the greenhouse gasses in the region with about 85 percent of sulphur dioxide coming from these countries. Therefore, the choice of these countries is enough to analyze the issue of economic growth and environmental degradation in the region.

The choice of the variables used in the study is guided by literatures and the appropriate measurements and proxies are utilized to ensure that the results obtained from the analysis of the data are valid for achieving the objectives of the study. The dependent variable in this study is environmental degradation where carbon dioxide emissions and ecological footprint are used as proxy. On the other hand, the independent variables are economic growth, trade openness, foreign direct investment, financial development,population, human capital, and energy poverty. Table 4.1 below provides details of the variables:

Table 0:1 Variables Measurements and Data Sources

Variables	Definitions	Sources
CO2	Carbon dioxide emissions (metric tons per capita)	WDI
EF	Ecological Footprint (in million global hectares)	GFN
GDP	Economic growth per capita (2010 constant USD)	WDI
TO	Trade openness (exports + imports % of GDP)	WDI
FDI	Foreign Direct Investment (in million USD)	WDI
FD	Financial development (domestic credit % of GDP)	WDI
POP	Population (in millions of people)	WDI
HC	Human capital (gross school enrolment)	WDI
EP	Energy Poverty (Number ofPeople without Access to Electricity)	WDI

Note: WDI = World Development Indicators, GFN = Global Footprint Network.

Ecological footprint (EF) is the dependent variable in this research which represent environmental degradation. The data for ecological footprint is obtained from Global Footprint Network (GFN). Ecological footprint indicates the use of land and water for production of all resources consumed by humans and for eliminating the waste material generated by the population.Itis an indicator that captures thecropland, grazing land, Forestland, fish grounds, built-up land, and carbon footprint. According to Guidebook to the national footprint account, cropland summarizes the Footprint of cropland embodied in both crop and livestock products; grazing land summarizes the Footprint of pasture grass embodied in livestock products; forestland summarizes the Footprint of forestland embodied in primary and processed forest products; fish grounds summarizes the Footprint of marine and inland water areas embodied in fish and other aquatic products; built-up land summarizes the Footprint associated with buildings, infrastructure, and hydroelectric reservoir area; and the carbon footprint summarizes the carbon Footprint of fossil fuel combustion (both domestically emitted and embodied in traded goods) and an additional bunker fuel carbon tax.

Economic Growth (GDP) is an explanatory variable in this study.The data is obtained from world development indicators, World Bank.Economic growth brings about rise in economic activities and all things being equal increase the level of pollution because energy is required in most of the production processes. In addition, the unsustainable natural resource exploitation in developing countries induces serious threats to environment including land degradation, deforestation, water scarcity, desertification and air pollution (Denish et al., 2019).

Trade Openness (TO) serves as an explanatory variable in this research.The data is also obtained from world development indicators of World Bank. Trade openness may contribute to environmental degradation through increased energy consumption, which ultimately increases $CO2$ emission (Bosupeng, 2016). In addition, There is increased transportation activities in order to carry the imported and exported goods from one place to other. Therefore, increase in imported goods would require transportation machinery to consume more fuel and thus, raise carbon emissions. Import may raise energy consumption for products like refrigerators, air conditioners, dishwashers and automobiles, etc. (Sadorsky, 2012). In addition, increase in trade would deplete natural resources, which would ultimately downgrade the environmental quality.

Foreign Direct Investment (FDI) serves as an explanatory variable in this research.The data is obtained from world development indicators of World Bank. Some countries operate tight environmental regulation compared to other nations. All things being equal, pollution intensive industries will move to countries with poor regulation where they can emit pollution and other externalities. In other words, manufacturing firms will be attracted into countries with less stringent environmental regulations. Developed nations tend to have restricted policies that could add to cost of production and thus dirty industries would sneak into poor countries with loose policies to find a safe-haven and thus degrade their environment.

Financial Development (FD) serves as an explanatory variable in this research.The data is obtained from world development indicators of World Bank. Financial sector provide loan for firm to expand production which will increase energy consumption and exploitation of natural resources which increase environmental degradation. Likewise, financial sector provide access to fund for households to acquire energy consuming household equipments that would rise pollution and degrade environment.

Population (POP) serves as an explanatory variable in this research. The data is obtained from world development indicators of World Bank.Population growth has the potential to exacerbate problems such as slum formation, poor water supply, and sewage disposal which contribute to environmental degradation. In addition, population growth affects the environmental quality through increased pressure on agricultural land in response to growing demand for food. More land also need to be cleared to erect residential building to house the increasing number of people living in a country. Population explosion mounts serious pressure on forest reserve especially less and developing countries where families rely on forest resources for food and firewood. The demand for energy also increases with expansion in population size and most of the energy is generated from non-renewable sources such as coal, oil and natural gasses that generate pollution. Population growth could also undermine environmental quality by rising demand for transportation which increases fossil fuel consumption.

Human Capital (HC) serves as an explanatory variable in this research. The data is obtained from world development indicators of World Bank.Investment in human capital through research and development (R&D) enables a country to gradually remove obsolete technologies and replace it with environmentally sound ones which would contribute towards improving environmental quality. Increase in literacy rate raise the citizens awareness on the importance of environmental standard and this will make people to pressurize authorities to enact laws that lead to a strict control of pollution level.

Energy Poverty (EP) serves as an explanatory variable in this research. The data is obtained from world development indicators of World Bank. Energy poverty impact negatively on environment by increasing the reliance of solid fuel as energy source the burning of which generate pollution. Using solid fuels for cooking lead to increased depletion of forest resources which reduce the environmental quality.

4.3 Testable Hypotheses

Base the objectives of this study the following hypotheses are stated in order to achieve the objectives of the study:

H_1: There are significant short and long run elasticities between environmental degradation and its determinants in the ECOWAS countries.

H_2: There is strong evidence of an inverted U-shaped relationship between environmental degradation and its determinants in ECOWAS countries.

H_3: There is strong evidence of pollution haven hypothesis between FDI and environmental degradation in ECOWAS countries..

H_4: There are significant causal relationships between environmental degradation and its determinants in ECOWAS countries.

4.4 Analytical Framework and Model Specification

The global environment is apparently being modified at an unprecedented scale by humans through forest depletion, emission of greenhouse gases and other substances that deplete ozone, altering land cover and biogeochemical cycles (Harrison and Pearce, 2000). In view of this, physical and natural scientists have made efforts to develop advanced models , yet the need for a full understanding of the dynamics of the major influencing factors of global environment is paramount. Appropriate analytical techniques and models that correctly specify the functional form of the relationship between driving forces and environmental impact were apparently needed to break the barrier to social scientific inquiry. With this, the Impact of Population, Affluence and Technology (IPAT) and stochastic impacts by regression on population, affluence and technology (STIRPAT) analytical frameworks of anthropogenic environmental impact emerged.

4.4.1 The Linear Model

The IPAT (Impact of Population, Affluence and Technology) has widely been adopted for analysing the major drivers of environmental change. It identified three major drivers namely: population, affluence (represented by income) and technology. It is recognized as a parsimonious model which identifies precise relationship between key drivers of environmental change. This is because its specification does not provide for independence of the driving factors. To illustrate this, if in a particular country population (P) and technology T remain unchanged over a given period of time while GDP increase, still changes in environmental condition cannot be attributed to economic growth alone but still population and technology do play a part since they contribute in increasing the scale of economic activities. As such, identifying the relative influence of each of the driving factors is difficult.

Although the IPAT framework possess a key strength of being grounded in ecological analysis, it's clear and parsimonious specification as well as having utility for demonstrating how variation in the driving factors can change environmental condition, it major limitation is its inability to allow for hypothesis testing. In addition, it assumes proportionality in the functional relationship in which case a doubling of population, for example, will bring about a doubling of CO2 emissions, all things being equal. Socioeconomic theory requires scientific test of hypotheses concerning the relationship between human-induced factors and environment rather than simple assumption. To illustrate, the environmental Kuznets curve (EKC) hypothesis postulate a non-proportional and non-monotonic effect of economic growth on environmental degradation, suggesting that increase in economic growth may bring about decline in environmental degradation. But IPAT do not provide for this non-monotonic and non-proportional influence of the drivers of environmental change.

To correct this, Dietz and Rosa (1994) modified IPAT by introducing a stochastic term in the model and call it stochastic impacts by regression on population, affluence and technology (STIRPAT). This new model has successfully been used to analyse the effects of major factors that influence different environmental indicators particularly polluting agents. Therefore, this analytical framework is chosen in this study to examine the relationship between economic growth and environmental degradation because this framework captures the social fundamentals like population size.In this study environmental degradation is analysed with data from1970 until 2018. The model is given in mathematical form as:

$$I_t = \alpha P_t^{\alpha_1} A_t^{\alpha_2} T_t^{\alpha_3} \mu_t \quad (1)$$

where, α represent the constant term, *I*is an environmental impact, P is population, *A* represents affluence (income),*T* is technology, α_s are the parameters to estimate, μ is the stochastic term, and *t* is the time period.

There are many indicators of environmental degradation, as provided in different empirical studies. The CO_2 emissions happen to be the most widely used as an indicator of air pollution in most of the previous study concentrating on the EKC because it constitutes the more significant part of the greenhouse gas emissions. According to Allard et al. (2018), the CO_2 emissions account for imports and exports goods emissions. While the per capita income is used to represent affluence; the population is represented by the number of people in a country. Trade and FDI pave way to import advanced technology from developed countries to developing countries. The increased level of trade openness in ECOWAS countries enhances technological diffusion and better skills and aid efficient inputs utilisation. Trade openness is used by recent studies to capture technology, such as Kwakwaet al. (2019).

Environmental degradation can be influenced by other essential factors like financial development in a country. Financial development affects the scale of economic activities by providing firms with loans to expand secure their production levels. As for households, financial development provides access for them to secure loans to finance the acquisition of consumer durables that are energy-consuming. The influence of social fundamentals such as population, human capital and energy poverty are added to capture their influence on environmental degradation. Therefore, Eq. 1 ismodified as follows:

$$CO_{2_{it}} = \delta\, GDP_t^{\alpha_1}\, TO_t^{\alpha_2}\, FDI_t^{\alpha_3}\, FD_t^{\alpha_4}\, POP_t^{\alpha_5}\, HC_t^{\alpha_6}\, EP_t^{\alpha_7} \mu_t \quad (2)$$

where, CO_2 is carbon emissions proxy for environmental degradation, GDP is per capita income,TO is trade openness, FDI represent foreign direct investment, FD is financial development, POP stands for population, HC is human capital, EP is energy poverty. The data sources are mentioned in Table 4.1. The natural logarithm form of all the variables shown in Eq. 2 is taken to aid interpretation of coefficients. In addition, the model is set as panel because it has advantages of controlling for serial correlation and individual heterogeneity inherent in time series and cross-section models. Taking the above into consideration, yield Eq. 3 as:

$$CO_{2_{it}} = \alpha_0 + \alpha_1 GDP_{it} + \alpha_2 TO_{it} + \alpha_3 FDI_{it} + \alpha_4 FD_{it} + \alpha_5 POP_{it} + \alpha_6 HC_{it} + \alpha_7 EP_{it} + \mu_{it} \quad (3)$$

The EKC hypothesis postulates an inverted U-shaped relationship between economic growth and environmental degradation, implying that at the early stage of economic growth environment suffer, but upon achieving a certain threshold income level, environmental degradation falls. Therefore, we add squared GDP to capture EKC as:

$$CO_{2_{it}} = \alpha_0 + \alpha_1 GDP_{it} + \alpha_2 GDP_{it}^2 + \alpha_3 TO_{it} + \alpha_4 FDI_{it} + \alpha_5 FD_{it} + \alpha_6 POP_{it} + \alpha_7 HC_{it} + \alpha_8 EP_{it} + \mu_{it} \quad (4)$$

Since this study intend to improve on the past ones, ecological footprint is also used as an indicator for environmental degradation as follows:

$$EF_{it} = \alpha_0 + \alpha_1 GDP_{it} + \alpha_2 GDP_{it}^2 + \alpha_3 TO_{it} + \alpha_4 FDI_{it} + \alpha_5 FD_{it} + \alpha_6 POP_{it} + \alpha_7 HC_{it} + \alpha_8 EP_{it} + \mu_{it} \quad (5)$$

As a first step in the estimation, cross-sectional dependence in the panel data is tested using Pesaran (2004) Cross-Sectional Dependence (CD) test and the Pesaran and Yamagata (2008) test for the homogeneity condition among the variable exhibit in this study. The homogeneity estimation result is based on the adjusted delta tilde, where the rejection of the null hypothesis will permit for the heterogeneity panel estimation condition. Therefore, both tests are important as it helps in choosing the appropriate unit root tests.

Next, for estimating the long-run relationship among CO_2 emissions,economic growth, trade openness, foreign direct investment, financial development, population, human capital and energy poverty,Pooled OLS (POLS) and Fully Modified OLS (FMOLS) estimation techniques are used. Binder and Coad (2011) opined that the traditional regression techniques may lead to underestimation or overestimation of the important coefficients or could not locate important relationships due to their focus on the mean effects. Therefore, quantile regression introduced by Koenker and Bassett (1978) performs better compared to other techniques. Following Ismail et al. (2018) the panel quantile estimates for carbon emissions (CO2) and ecological footprint (EF) can be specified as in Eq. 6 and 7:

$$Q_{CO2_{it}}(\tau/\chi_{it}) = \beta_i^{(\tau)} + \beta_1^{(\tau)} GDP_{it} + \beta_2^{(\tau)} GDP_{it}^2 + \beta_3^{(\tau)} TO_{it} + \beta_4^{(\tau)} FDI_{it} + \beta_5^{(\tau)} FD_{it} + \beta_6^{(\tau)} POP_{it} + \beta_7^{(\tau)} HC_{it} + \beta_8^{(\tau)} EP_{it} + \mu_{it} \quad (6)$$

$$Q_{EF_{it}}(\tau/\chi_{it}) = \beta_i^{(\tau)} + \beta_1^{(\tau)} GDP_{it} + \beta_2^{(\tau)} GDP_{it}^2 + \beta_3^{(\tau)} TO_{it} + \beta_4^{(\tau)} FDI_{it} + \beta_5^{(\tau)} FD_{it} + \beta_6^{(\tau)} POP_{it} + \beta_7^{(\tau)} HC_{it} + \beta_8^{(\tau)} EP_{it} + \mu_{it} \quad (7)$$

where, $Q_{EF_{it}}(\tau/\chi_{it})$is the τ^{th}conditional quantile of the dependent variable, X_{it}represents the vector of independent variables for each country *i* at year *t* for quantile τ. While the $\beta^{'}$srepresents the slopes of the independent variables for quantile τ if:

$\beta_1 > 0$ and $\beta_2 < 0$, EKC hypothesisholds.
$\beta_1 < 0$ and $\beta_2 > 0$, U-shaped pattern holds.
$\beta_1 > 0$ and $\beta_2 > 0$, monotonically increasing relationship holds.
$\beta_1 < 0$ and $\beta_2 < 0$, monotonically decreasing pattern holds.

Lastly, the equality of the slope coefficient is tested to see if there is a significantly large difference between the slope coefficients of the different quantiles.

For example, when considering the inter-quantile regression between τ=0.10 and τ=0.50, the quantile regression equation can be stated as follows:

$$Q_{0.10}(CO_{2_{it}}) = \alpha_{0.10} + \alpha_{0.10,1}GDP_{it} + \alpha_{0.10,2}GDP_{it}^2 + \alpha_{0.10,3}TO_{it} + \alpha_{0.10,4}FDI_{it} + \alpha_{0.10,5}FD_{it} + \alpha_{0.10,6}POP_{it} + \alpha_{0.10,7}HC_{it} + \alpha_{0.10,8}EP_{it} + \varepsilon_{it} \quad (8)$$

$$Q_{0.50}(CO_{2_{it}}) = \alpha_{0.50} + \alpha_{0.50,1}GDP_{it} + \alpha_{0.50,2}GDP_{it}^2 + \alpha_{0.50,3}TO_{it} + \alpha_{0.50,4}FDI_{it} + \alpha_{0.50,5}FD_{it} + \alpha_{0.50,6}POP_{it} + \alpha_{0.50,7}HC_{it} + \alpha_{0.50,8}EP_{it} + \varepsilon_{it} \quad (9)$$

where, the difference in the quantiles of τ=0.10 and τ=0.50 can be derived as shown in the following Eq. (10):

$$Q_{0.50}(CO_{2_{it}}) - Q_{0.10}(CO_{2_{it}}) = (\alpha_{0.50} - \alpha_{0.10}) + (\alpha_{0.50,1} - \alpha_{0.10,1})GDP_{it} + (\alpha_{0.50,2} - \alpha_{0.10,2})\, GDP_{it}^2 + (\alpha_{0.50,3} - \alpha_{0.10,3})TO_{it} + (\alpha_{0.50,4} - \alpha_{0.10,4})FDI_{it} + (\alpha_{0.50,5} - \alpha_{0.10,5})FD_{it} + (\alpha_{0.50,6} - \alpha_{0.10,6})POP_{it} + (\alpha_{0.50,7} - \alpha_{0.10,7})HC_{it} + (\alpha_{0.50,8} - \alpha_{0.10,8})EP_{it} + \varepsilon_{it} \quad (10)$$

The interrelationship coefficients determined using the quantile regression show the inter-quantile regression, which clearly indicates the difference in the estimated quantile of τ=0.10 and 0.50. Furthermore, the equality of the slope of each coefficient is tested using the Wald test. Whereby, the null hypotheses for equality of slope coefficients for τ=0.10 vs. 0.25, τ=0.10 vs. 0.50,τ=0.10 vs.0.75, and τ=0.10 vs.0.95 are tested. If the null hypothesis is rejected, it is conclude that the relationship between CO_2 emissions and its determinants at the τquantile does not differ from the relationship at the estimated alternative quantile.

4.5 Estimation Procedures

Before estimating the empirical models some pre-estimation tests will be conducted to ascertain the validity of the data and avoid spurious regression. In this regards, unit root tests will be conducted as well as cointegration test using different methods developed by econometricians.

4.5.1 Panel Unit Root Tests

Various unit root tests are developed by the econometricians for panel data analysis and they are discussed as under.

4.5.1.1 Levin, Lin and Chu (LLC)

The LLC was developed by Levin, Lin and Chu (2002) as a panel unit root test premised on the restricted power that individual tests for unit root possess compared to the alternative hypotheses. LLC test developed a number of pooled panel unit root tests that have different specification according to the treatment of individual specific intercept and time trends. It imposes homogeneity on the autoregressive coefficients which show whether there is unit root or not and trends varying cross individual series (Shahbaz et al. 2014). It is expressed as:

$$\Delta y_{it} = \rho_i\, y_{i,t-1} + \sum_{L=1}^{pi} \theta_{iL}\, \Delta_{yit-L} + \alpha_{mi}\, d_{mt} + \varepsilon_{it} \tag{11}$$

where i = 1,…,N; t = 1,…,T; m = 1, 2, 3.

L in eq. 9 is the lag length, *pi* represent heterogeneous optimal lag length. The null hypothesis for LLC is that the time series individually contains a unit root (H0: $\rho i, \ldots = \ldots \rho_n = p = 0$) against the alternative of stationary of individual time series (HA: $\rho i = \ldots \rho_n = \rho < 0$). But one of the limitations of the LLC is its assumption of independence across the cross-section units because if this assumption is violated it may have large size distortion (Baltagi, 2005).

4.5.1.2 Im, Pesaran and Shin (IPS)

The IPS championed by Im, Pesaran and Shin (2003) has less restrictive and powerful test and is developed to overcome the shortcomings of LLC. It averages the ADF statistics cross the groups. IPS can be presented base on panel type ADF unit root test as follows:

$$\Delta y_{it} = \alpha_i + \theta_i y_{i,t-1} + \sum_{j=1}^{pi} \beta_{ij} \Delta y_{i,t-j} + \varepsilon_{it} \tag{12}$$

where $i = 1, 2, 3, \ldots, N$ and $t = 1, 2, 3, \ldots, T$ represent the cross-sectional elements and the time period in the ADF regression respectively, j is the lag length while pi denote the heterogeneous optimal lag length. It is assumed that the error term is independent of I and t and with white noise, normally distributed with heterogeneous cross-sectional variance $_i\sigma$.

The null hypothesis (H_0: = 0, $_i\theta$ $\forall i$) assume that the series in the panel has a unit root while the alternative hypothesis (H_A: < 0; $_i\theta$ i = 1,2,…, N_1 and H_A: = 0; $_i\theta$ i = N_1 + 1, N_1 + 2,…,N) provides some flexibility. IPS has its own shortcomings, for example, it can only be applied for balanced panel data, requires *N* to be small enough relative to *T*.

4.5.1.3 Breitung (2000)

Breitung (2000) tried to address the shortcomings of both LLC and IPS (problem of loss of power when deterministic trend is included in the specification) by formulating a test that is devoid of bias adjustment and has higher power compared to LLC and IPS tests. It differs from LLC in such a way that that $\Delta yi,t{-}L$ is used in obtaining the residuals *it e*ˆ and , 1 ˆ *i t*− *v* that are then adjusted to correct for individual-specific variances. In the last step involves a pooled regression e^*_{it} = $\rho v^*_{I,t-1} + \varepsilon^*_{it}$ then get the t-statistics for the null.

4.5.1.4 Maddala and Wu (1999) and Choi (2001)

Maddala and Wu (1999) and Choi (2001) proposed the Fisher-ADF and Fisher-Phillips Perron panel unit root tests that combine the ρ-values of the test-statistic in all the cross-sectional units as presented in the equation below:

$$P = -2\sum_{i=1}^{N} \ln\rho_i \sim \chi 2_{2N}$$

(11)

In addition, Choi (2001) developed an inverse normal test statistic as:

$$Z = 1/\sqrt{N}\sum_{i=1}^{N} \phi^{-1}(\rho_i) \sim N(0,1) \qquad (13)$$

4.5.2 Panel Cointegration Tests

Having examined the various panel unit root tests that will be used in the previous section, the next step is to conduct cointegration test, that is ascertain whether long run association among the variables in the study. This cointegration tests include Kao (1999) cointegration test and Pedroni(1999; 2000 and 2004) cointegration test.

4.5.2.1 Kao Cointegration Test

Under Kao (1999) both the Dickey-Fuller and Augmented Dickey-Fuller tests for panel cointegration are described base on the null hypothesis of no cointegration and these tests can be built on the following bivariate panel regression model:

$$y_{it} = \alpha_i + \beta X_{it} + e_{it} \qquad (14)$$

From equation 13 above the variables y_{it} and X_{it} are integrated of the first order, that is I(1) but are non-cointegrated. Therefore, ADF type unit root tests for the residual e_{it} are proposed and the DF- type test is calculated as follows:

$$e = \rho e_{it-1} + v_{it} \qquad (15)$$

Similarly, the estimated residual for the ADF is specifies as:

$$\hat{e}_{it} = \rho \hat{e}_{it-1} + \sum_{i=1}^{p} \varphi_j \Delta \hat{e}_{it-j} + v_{itp} \qquad (16)$$

where $\hat{e}_{it} = \tilde{y}_{it} - x_{it}\beta$, $\tilde{y}_{it} = y_{it} - \bar{y}_i$

4.5.2.2 Pedroni Cointegration

The Pedroni (1999, 2000 and 2004) is seems to be the most utilized one among the panel cointegration tests. This test has an edge over Kao test because Pedroni test use idiosyncratic parameters (which differ among the cross-section units) to account for heterogeneity. This test is also an extension of the traditional Engle and Granger (1987) two-step approach to cointegration test based on the ADF and Phillips-Perron principles. In Pedroni cointegration test seven diverse t-statistics are developed to check for cointegration in panel data. The following regression equation is specified following Pedroni (2004):

$$y_{it} = \alpha_i + \delta_i t + \beta_{1i}x_{1i,t} + \beta_{2i}x_{2i,t} + \ldots + \beta_{Mi}x_{Mi,t} + e_{i,} \quad (17)$$

t = 1,2….T, i = 1,2……NIn table 4.2 the summary of the expected hypotheses outcomes are provided. Hypothesis 1 will be tested using fully modified ordinary least square (OLS) and quantile regression. If the estimated results provide statistically significant coefficients, then it can be concluded that there are significant short and long run coefficients which implies that the independent variables significantly impact on environmental sustainability.

Table 4:2 Research Hypotheses

No.	Hypothesis	Empirical Approach
H_1	There are significant short and long run elasticities between environmental degradation and its determinants in ECOWAS countries.	Pooled OLS, FMOLS, Quantile Regression.
H_2	There is strong evidence of inverted U-shaped relationship between environmental degradation and its determinants in ECOWAS countries.	Pooled OLS, FMOLS, Quantile Regression with quadratic models.
H_3	There is strong evidence of pollution haven hypothesis between environmental degradation and its determinants in ECOWAS countries.	FMOLS, Quantile Regression
H_4	There are significant causal relationships between environmental degradation and its determinants in	Slope equality panel quantile causality

	ECOWAS countries.	

Hypothesis 2 will be achieved using FMOLS and quantile regression for the quadratic model. In the quadratic model, if a significant positive sign is reported for GDP and a significant negative sign is reported for GDP^2 an evidence of inverted U-shaped pattern is found which validate the EKC hypothesis. Hypothesis 3 will be achieved using quantile regression. If the estimated results provide a significant positive coefficient for FDI then the null hypothesis is rejected leading to conclusion that an empirical evidence of pollution-haven hypothesis is established and vice-versa.Hypothesis 4 will be tested using the quantile causality techniques. If the empirical results provide significant calculated statistics, then the null hypothesis of no causality is rejected leading to conclusion that a causal relationship do exists.

4.6 Chapter Summary

This chapter address the methodological procedures to be use in order to achieve the objectives of this study. It begins with the description and measurement of the variables to be used in the study and the data sources are given. The chapter proceed to provide the theoretical framework to be used in the study. The environmental Kuznets curve (EKC), IPAT and the STIRPAT frameworks for analysing the driving forces on the environment will guide the analysis in this study. Base on the research questions and objectives of this study, hypotheses are formulated as well. The models to be used in achieving the objectives are then specified accordingly and the pre-estimation procedures are clearly explained as well as the diagnostic/post estimation tests.

CHAPTER 5

RESULTS AND DISCUSSIONS

5.1 Introduction

In this chapter the entire results and discussions there from are reported. The presentation and discussion of results are given in the following sections. Section 5.2 provides the descriptive analysis of the variables of interest in the study. It is followed by the diagnostic tests. Section 5.3 provides the stationarity test analysis. Section 5.4 gives the cointegration tests results while section 5.5 brings the results of the estimated coefficients from the pooled OLS, fully modified OLS and quantile regression. Section 5.6 provides the diagnostic/post-estimation test results of the quantile process estimate and slope equality tests. In section 5.5 wald test results for quantile causality are reported. Lastly, section 5.7 brings the research hypotheses and the conclusions that are drawn there from.

5.2 Descriptive Statistics and Diagnostic Tests

This study utilizes panel data covering 1970 to 2019 for six countries located in West Africa sub-region. Table 5.1 (appendix A) gives the results of descriptive statistics which reveals that the mean value of ecological footprint measured in million global hectares in the lower, median and upper quantiles stands at 6.212, 6.782 and 7.147 with standard deviation of 0.207, 0.121 and 0.098 respectively. The mean of CO_2 emissions measured as kilogram per capital in the lower, median and upper quantiles stand at 0.162, 0.254 and 0.388 with standard deviation of 0.038, 0.027 and 0.043 respectively and it is positively skewed except for the lower quantile. The average income per capita in the lower, median and upper quantiles is UD$2.699, 2. 806 and 3.010with a standard deviations of 0.026, 0.042 and 0.057

respectively. The mean value of trade as percentage of GDP in the lower, median and upper quantiles is 1.54%, 1.76% and 1.86% with the actual value deviating from this mean by 0.17%, 0.03% and 0.03% respectively and it is negatively skewed in the lower and middle quantiles. The mean values of foreign direct investment in the lower, median and upper quantiles stands at 3.044, 7.137 and 7.886 and the actual value deviate from the mean value by 2.719, 0.208 and 2.065 respectively. Similarly, the correlation results are given Table 5.2 (Appendix B.)

Table 5.3 Test of Normal Distribution

Variables	Skewness	Kurtosis	Shapiro-Wilk		Shapiro-Francia	
			Statistics	p-value	Statistics	p-value
EF	0.242	2.429	0.978*	0.000	0.981*	0.001
CO_2	0.984	3.453	0.920*	0.000	0.921*	0.000
GDP	0.482	2.137	0.934*	0.000	0.936*	0.000
GDP^2	0.628	3.636	0.911*	0.000	0.912*	0.000
TO	-1.369	6.497	0.916*	0.000	0.914*	0.000
FDI	-1.490	4.069	0.772*	0.000	0.774*	0.000
FD	-0.886	3.762	0.946*	0.000	0.948*	0.000
POP	0.354	2.669	0.963*	0.000	0.966*	0.000
HC	-0.943	6.000	0.952*	0.000	0.953*	0.000
EP	-0.024	2.561	0.979*	0.000	0.981*	0.001

Notes: *represents significant at 1% level.

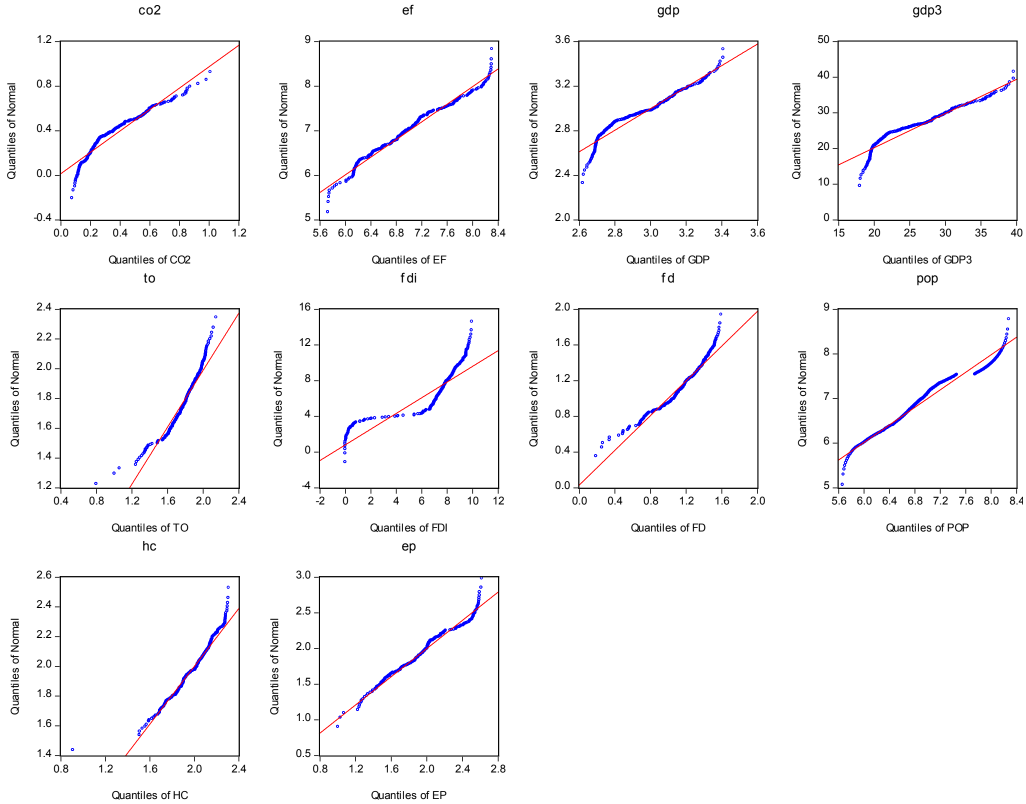

Figure 5.1 Q-Q Plots for Normality Tests

It is paramount to check whether the data is normally distributed or not before the actual implementation of the regression approach (Salman et al., 2018). The normality tests developed by Royston (1992) as well as Royston (1983) are used in this study to test the normality of the data. The two tests have same assumption but only differs in terms of the interpretation of the coefficients. Shapiro-Wilk test, which is a correlation-based algorithm, assumes that the higher the normality of data the more closely its value to 1. As shown in Table 5.3 base on p-statistics the null hypothesis of normality of data could not be accepted leading to conclusion that data is not normally distributed. This result corroborates those of the skewness and kurtosis which portrays values higher than 0 portraying none-normal data. . The kurtosis is used to check the distortion of the data and a value of zero shows that the data has normal distribution while greater values reveals higher distortion of data and vice-versa.

For confirmation sake, this study uses the popular graphical Quantile-Quanttile (Q-Q) normality test to further check the distribution of the data as reported in Figure 5.1. The red line in the graph indicates the expected normal distribution and it can be observed that the proxies for environment are never on the line. Additionally, all the variables (GDP, squared GDP, trade openness, FDI, financial development, population, human capital and energy poverty) do not fall on the red line meaning that these variables are not normally distributed. This condition implies that using the conventional ordinary least square (OLS) regressions might lead to biased estimates and only quantiles regression can overcome such shortcoming.

Table 5.4 Cross-sectional dependence and homogeneity tests

Variables	Statistics	p-value
Pesaran (2004) CD test		
EF	20.711*	(0.000)
CO_2	10.551*	(0.000)
GDP	9.946*	(0.000)
TO	-0.411*	(0.000)
FDI	15.961*	(0.000)
FD	6.091*	(0.000)
POP	2.466*	(0.010)
HC	17.749*	(0.000)
EP	11.050*	(0.000)
Pesaran-Yamagata (2008) test		
$\tilde{\Delta}$	-0.332	0.840
$\tilde{\Delta}$-adjusted	-0.338	0.835

Notes: * represents significance level, and $\tilde{\Delta}$represent the delta statistic

Before proceeding with the unit-root test, the variables are examined for cross-sectional dependence with aid of Pesaran (2004) CSD test which follows an N(0, 1) distribution. Table 5.4 gives the results where null hypothesis is rejectedimplying that each of the series contains cross-sectional dependence. This signifies that shock occurred in one country is transmitted to the others. Further, Pesaran and Yamagata (2008)is adopted to check for homogeneity condition and the result accept null hypothesis of homogeneityimplying that heterogeneity estimation is invalid.

5.3 Stationarity Tests

Stationarity is checked using LLC, IPS, ADF-Fisher and ADF-PP are utilized to confirm the integration order of the series as in Table 5.5. The results revealed that at level the series are not stationary but when converted to first difference the stationarity is achieved. The CIPS is employed to confirm stationarity because it fix cross sectional dependence. CIPS results provided in table 5.6further reaffirmed that stationarity isonly achieved by taking first difference.

Table 5.5 Panel unit root tests

Variable	LLC	IPC	Fisher-ADF	Fisher-PP
At Level				
EF	-1.488	-0.313	19.391	15.906
CO_2	1.612	1.987	12.597	19.623
GDP	2.088	1.813	7.625	7.106
GDP^2	2.403	2.127	9.564	7.431
TO	0.41	-0.174	11.670	15.049
FDI	-0.737	0.541	9.945	17.170
FD	-0.560	-0.562	12.667	12.603
POP	-3.588	1.212	10.170	1.983
HC	-1.124	-1.019	22.745	21.560
EP	-1.011	-0.411	16.825	13.187

At first difference				
EF	-7.445*	-11.057*	123.232*	248.279*
CO_2	-15688*	-16.549*	194.276*	210.116*
GDP	-6.176*	-8.329*	97.328*	160.916*
GDP^2	-5.373*	-8.604*	92.773*	163.978*
TO	-9.831*	-9.399*	94.879*	183.309*
FDI	-21.535*	-20.216*	203.192*	187.101*
FD	-9.761*	-9.151*	99.776*	163.288*
POP	-10.924*	-12.842*	148.904*	21.300*
HC	-10.303*	-10.212*	106.428*	141.377*
EP	-6.374*	-7.836*	84.512*	205.452*

Notes:, *, **, *** represents significance at 1%, 5% and 10%.

Table 5.6 Panel unit root test with cross-sectional dependence

	At level		At first difference	
Variables	CIPS (*t-bar)*	*p-value*	CIPS (*t-bar)*	*p-value*
EF	-0.431	0.333	-2.902*	0.001
CO_2	-0.523	0.699	-3.113*	0.000
GDP	-0.792	0.811	-4.221	0.000
GDP^2	-0.766	0.808	-5.143*	0.000
TO	-0.443	0.352	-4.443*	0.000
FDI	-0.403	0.304	-3.831*	0.000
FD	-0.331	0.975	-4.941*	0.000
POP	-0.583	0.745	-3.884*	0.000
HC	-0.678	0.795	-4.333*	0.000
EP	-0.444	0.360	-5.690*	0.000

Note * denote the rejection of null hypothesis at 1%.

5.4 Cointegration Test Results

Cointegration among the variables in the study is investigated by first taking carbon dioxide emissions to stand for environmental pressure. Pedroni has seven tests of which four are between panels and three are between groups. Out of these seven statistics, four tests could not accept null hypothesis of no cointegration among the variables which means long-run association among them holds as reported in table 5.7 and this is reaffirmed by Kao cointegration.

Table 5.7: Pedroni (2004) and Kao (1999) panel Cointegration tests result

Dependent Variable: CO2 emissions	
Panel v-Statistics	0.893
Panel rho-Statistics	-0.227
Panel PP-Statistic	-3.134*
Panel ADF-Statistic	-1.351***
Group rho-Statistics	-0.493
Group PP-Statistic	-5.330*
Group ADF-Statistic	-1.755**
Kao cointegration test	-1.565***
Dependent Variable: Ecological footprint	
Panel v-Statistics	-0.516
Panel rho-Statistics	-1.071
Panel PP-Statistic	-4.275*
Panel ADF-Statistic	-2.993*
Group rho-Statistics	-0.485
Group PP-Statistic	-4.514*
Group ADF-Statistic	-2.860*
Kao cointegration test	-3.684*

Note *, **, *** represents level of significance at and 1%, 5% and 10% respectively.

Using ecological footprint indicator of environmental pressure, four statistics in the Pedroni test could not accept the null hypothesis as in Table 5.7. Similarly, the

Kao test corroborated the results of Pedroni tests.showing that cointegration exists. Using Johansen test provides evidence for the existence of at least eight cointegration. Furthermore, utilizing Johansen tests as provided in Table 5.8 supported the Kao test. It indicates the null hypothesis of at least 8 eight cointegration among the variables is accepted.

Table 5.8 Johansen-Fisher panel cointegration test results

Hypotheses	Fisher Stat* (from Trace test)	Prob.	Fisher test* (from Max-Eigen test)	Prob.
CO2 emissions				
$r = 0$	451.4*	0.000	208.9*	0.000
$r \leq 1$	216.0*	0.000	133.18	0.000
$r \leq 2$	166.5*	0.000	73.49*	0.000
$r \leq 3$	94.64*	0.000	32.72*	0.001
$r \leq 4$	63.65*	0.000	31.88*	0.001
$r \leq 5$	36.85*	0.000	15.13	0.234
$r \leq 6$	26.33*	0.009	13.54	0.331
$r \leq 7$	19.10***	0.086	10.98	0.531
$r \leq 8$	16.38	0.174	15.02	0.240
Ecological Footprint				
$r = 0$	412.3*	0.000	205.1*	0.000
$r \leq 1$	195.2*	0.000	107.8*	0.000
$r \leq 2$	158.4*	0.000	61.64*	0.000
$r \leq 3$	96.41*	0.000	38.73*	0.000
$r \leq 4$	61.78*	0.000	24.68**	0.016
$r \leq 5$	40.66*	0.000	19.23***	0.083
$r \leq 6$	26.61*	0.008	10.93	0.535
$r \leq 7$	21.35**	0.045	14.03	0.298
$r \leq 8$	15.49	0.215	13.81	0.313

Note *, **, *** shows significance at 1%, 5% and 10% level of significance and the probabilities are computed using an asymptotic χ^2 distribution

Westerlund (2007) cointegration that fixes cross-sectional dependence is equally utilized. Table 5.9 reported that Gt and Pt statistics could not accept the null hypothesis thus confirming existence of long-run association.

Table 5.9 Westerlund cointgeration test results

	Statistic value	z-value	p-value
CO2 emissions			
G_t	-4.024*	-3.029	0.001
G_a	-19.261	-0.604	0.273
P_t	-10.011*	-3.437	0.000
P_a	-16.947	-0.987	0.162
Ecological footprint			
G_t	-4.286*	-3.696	0.000
G_a	-14.932	0.588	0.722
P_t	-9.433*	-2.900	0.002
P_a	-15.545	-0.606	0.272

Note *, **, *** represents significance at and 1%, 5% and 10% respectively.

5.5 Long Run Panel Estimation Results

The estimated coefficients provide information on the responsiveness of the indicators of environmental degradation. The results of the long-run impact of macroeconomic indicators using pooled OLS and FMOLS estimators are reported in Table 5.10. Taking CO2 as indicator for environmental pressure the empirical results indicate that are statistically significant in the Pooled OLS and FMOLS. A 1percent rise in income leads to an increase in CO_2 by 0.25 and 0.78 percent in POLS and FMOLS respectively. The results of the pooled OLS also corroborate with the FMOLS estimates and this is in line with Alshehry and Belloumi (2016) and Wang et al. (2018) in their study of Saudi Arabia and China respectively, significant negative relationship is found between trade openness and CO2 emissions. A percent rise in trade openness reduces pollution by 0.45percent and 0.07percent in the pooled OLS and FMOLS respectively. However, the result contradicts the findings of Bosupeng (2016) and Rahman (2017) who reported that trade increase environmental pressure.In addition, an increase in FDI by 1 percent increase leads to 0.02percent increase in pollution. This implies that the activities of foreign firms are increasing pollution in the host nations. Ren et al. (2014), Baek (2016) and Solarin et al. (2017) documented similar results. Financial development significantly affect and pollution. This implies that increasing private sector credits increase pollution by scaling economic activities as found by Abbasi and Riaz (2016).

In the quadratic models, the results indicate a significant positive relationship between GDP and CO_2 emissions and significant positive relationship between GDP^2 and CO_2 emissions. This result provide evidence of a monotonic link between income and pollution implying that sustained rise in income escalates pollution in these countries. However, the result contrast with Duan et al. (2016) for ASEAN-5, Wang et al. (2018) and Salman et al. (2019).

Using ecological footprint to represent environmental pressure, positive and significant relationship is traced among GDP and ecological footprint. From the linear models, a 1percent increase in economic growth leads to an increase in ecological footprint by 2.64 percent and 0.36percent in POLS and FMOLS estimates respectively. The result is in line with Yang et al. (2017) and Pata (2018). There exist significant relationship between trade openness and ecological footprint. A 1 percent increase in trade openness increase environmental degradation represented by ecological footprint by 0.23percent and 0.13percent in the pooled OLS and FMOLS respectively. This is an indication that trade openness increase environmental degradation by increasing the exploitation of natural resources such as minerals and forest products consistent with Ozatac et al. (2017) and Amri (2018).

Table 5.10 Long run estimates for Macroeconomic Indicators

	Pooled OLS		**Fully Modified OLS**	
	Linear	Quadratic	Linear	Quadratic
Dependent Variable: CO2 emissions				
GDP	0.255*	0.205*	0.783*	0.539*
	(0.000)	(0.000)	(0.000)	(0.000)
GDP^2		0.0.17**		0.060*

		(0.045)		(0.004)
TO	-0.452*	-0.453*	-0.072**	-0.080**
	(0.000)	(0.000)	(0.041)	(0.022)
FDI	0.022*	0.020*	0.028	0.047
	(0.000)	(0.000)	(0.422)	(0.203)
FD	0.237*	0.245*	0.095*	0.078*
	(0.000)	(0.000)	(0.001)	(0.008)
Dependent Variable: Ecological footprint				
GDP	2.641*	2.235*	0.360*	0.031**
	(0.000)	(0.000)	(0.000)	(0.022)
GDP^2		0.139*		0.091*
		(0.000)		(0.000)
TO	0.237*	0.244*	0.135*	0.165*
	(0.001)	(0.000)	(0.000)	(0.000)
FDI	0.009	0.019*	0.290*	0.274*
	(0.123)	(0.000)	(0.000)	(0.000)
FD	-0.214*	-0.148**	-0.006	-0.022
	(0.002)	(0.017)	(0.825)	(0.440)

Note *, **, *** represents significance at and 1%, 5% and 10% respectively.

A positive relationship is found between FDI and ecological footprint. A percent rise in FDI leads to 0.01 percent and 0.29percent rise in environment pressure. This resultis consistent with To, et al. (2019). Most of the multinational firms in the region are engaged in mining activities that not only pollute air but displace waste on land and water in addition to destroying forestland. A significant negative relationship is indicated between financial development and ecological footprint and this implies that increasing credit help enhances environmental quality. One possible explanation for this is that private credit spur economic activities and expand job opportunities in different sectors of the economy thus reducing the heavy reliance of the vast majority of the populace on forest sector as means of livelihood. Shahbaz et al. (2013b) support this finding but contradict Abbasi and Riaz (2016). When the squared GDP is integrated as in the quadratic model a monotonic relationship is traced between income and environment and Gorus and Aslan (2019) all supported this findings.

Table 5.11 Long run estimates for Social Fundamentals

	CO2 emissions		Ecological footprint	
	POLS	FMOLS	POLS	FMOLS
POP	0.426*	0.026*	0.760*	0.988*
	(0.000)	(0.000)	(0.000)	(0.000)
HC	0.388*	0.191*	-0.042	-0.027*
	(0.000)	(0.000)	(0.276)	(0.000)
EP	0.079**	0.142*	0.092*	0.002***
	(0.015)	(0.000)	(0.000)	(0.081)

Note *, **, *** represents significance at and 1%, 5% and 10% respectively, p-values in bracket.

In table 5.11 the results of the impacts of social fundamentals on environment is reported. Using CO2 emissions as an indicator of environmental degradation, a percent change in population leads to 0.42percent and 0.02percent increase in pollution via the POLS and FMOLS models respectively and this is supported by the work of Al-Mamun et al. (2014), Sarkodie and Awusu (2016), Rahman (2017) and Salman et al. (2019). Similarly, human capital relate positively with pollution. A unit change in human capital brings about 0.38% and 0.19% rise in pollution as shown in the POLS and FMOLS models but this does not tally with the findings of Hua et al. (2018) who reported that human capital enhances environmental quality. Again, energy poverty significantly relate with and pollution. A percentage increase in energy poverty leads to 0.07percent and 0.14percent rise in carbon emissions in the POLS and FMOLS models respectively. This result indicates that increase in energy poverty is one of the factors causing pollution in the countries under investigation consistent with the findings of Tang and Liao (2014) and Acharya (2017).

Table 5.12 Long run estimates for Combined Model

	Pooled OLS		Fully Modified OLS	
	Linear	Quadratic	Linear	Quadratic
Dependent Variable: CO2 emissions				
GDP	0.227**	-0.223**	0.609*	-0.374*

	(0.017)	(0.019)	(0.000)	(0.000)
GDP^2		0.205**		0.100*
		(0.030)		(0.000)
TO	-0.376*	-0.375*	-0.066***	-0.053**
	(0.000)	(0.000)	(0.072)	(0.045)
FDI	0.019*	0.027*	0.034**	0.213**
	(0.000)	(0.000)	(0.036)	(0.028)
FD	0.233*	0.231*	0.161*	0.213*
	(0.000)	(0.000)	(0.000)	(0.000)
POP	0.268*	0.283*	0.055*	0.028*
	(0.000)	(0.000)	(0.000)	(0.000)
HC	0.159**	0.155**	0.165*	0.183*
	(0.01)	(0.014)	(0.000)	(0.000)
EP	0.125**	0.401**	0.077*	0.257*
	(0.028)	(0.012)	(0.000)	(0.000)

Note *, **, *** represents significance at and 1%, 5% and 10% respectively.

A percentage increase in population increases environmental degradation by 0.76percent and 0.98percent as reported by the POLS and FMOLS models respectively. Similar findings were reported by Zhu et al. (2016a). Human capital has a significant negative relationship with ecological footprint. A percentage increase in human capital brings about 0.04percent and 0.02percent decrease in ecological footprint and the work of Cleeve et al. (2015) and Hua et al. (2018) supported this finding. A significant positive relationship appears between energy poverty and ecological footprint implying that energy hunger leads to escalating environmental degradation in the countries under investigation.

Table 5.13 Long run estimates for Combined Model

	Pooled OLS		**Fully Modified OLS**	
	Linear	Quadratic	Linear	Quadratic
Dependent Variable: Ecological Footprint				
GDP	0.578*	0.559*	0.231*	0.096*
	(0.000)	(0.000)	(0.000)	(0.000)
GDP^2		-0029*		-0.050**
		(0.001)		(0.046)

TO	0.038*	0.044*	0.172*	0.188*
	(0.002)	(0.028)	(0.000)	(0.000)
FDI	0.019	0.017	0.129	0.148
	(0.200)	(0.320)	(0.420)	(0.154)
FD	-0.050***	-0.060*	-0.071**	-0.063**
	(0.063)	(0.005)	(0.022)	(0.041)
POP	0.931*	1.011*	1.008*	0.992*
	(0.000)	(0.000)	(0.000)	(0.000)
HC	-0.231*	-0.210*	-0.016*	-0.032*
	(0.000)	(0.000)	(0.000)	(0.000)
EP	0.193*	0.173*	0.036*	0.047*
	(0.000)	(0.000)	(0.000)	(0.000)

Note *, **, *** represents significance at and 1%, 5% and 10% respectively.

Table 5.12 reports the results of the long-run impact of macroeconomic indicators and social fundamentals on CO2 emissions using pooled OLS and FMOLS estimators. In the linear models GDP relates significantly withpollution. Specifically, a percent change in income brings about 0.22percent and 0.60percent increase in pollution in POLS and FMOLS respectively. This result indicates that economic growth is reducing environmental quality consistent with Sarkodie and Strezov (2019). Increase in trade openness by 1percent reduces pollution by 0.37percent and 0.06percent in the pooled OLS and FMOLS respectively consistent with Zhang et al. (2017).A positive relationship is found between FDI and pollution. A percentincrease in FDI results in 0.01percent and 0.03percent increase in pollution via the POLS and FMOLS models respectivelyconsistent with Shahbaz, et al. (2019).Financial development relate positively with. A percent change in financial development increase pollution by 0.23percent and 0.16percent in the models of POLS and FMOLS respectively. This implies that increasing private sector credits increase pollution via the scaling economic activities consistent with the findings of Ziaei (2015), Abbasi and Riaz (2016) and Chen and Lei (2018).Population relate significantly with carbon emissions. In specific terms, a percentage increase in population leads to 0.26percent and 0.05percent increase in pollution via the POLS and FMOLS models respectively. This finding is consistent with Salman et al. (2019). Similarly, human capital significantly relate with CO2 emissions. A percentage change in human capital brings about 0.15percent and 0.16percentrise in pollution via the POLS and FMOLS. This result is consistent with the findings of Su and Liu (2016). Again, a unit change in energy poverty brings about 0.12percent and 0.07percent rise in carbon emissions in the POLS and FMOLS models respectively. This result indicates that increase in energy poverty is one of the factors causing pollution in the countries under investigation.

In the quadratic models, the results indicate a significant negative relationship between GDP and CO_2 emissions and significant positive relationship between GDP^2 and CO_2 emissions. This result provides evidence of a U-shaped pattern between income and pollution as against the inverted U-shaped pattern suggested by EKC hypothesis. This result is in line with previous findings of Sarkodie and Strezov (2019).The gradual shift from labor-intensive to physical capital-intensive production approach in the region requires more energy consumption which raises carbon emissions. The studyof Kwakwaet al. (2019)in West Africadocumented similar finding with this study. Destek and Sinha (2020) from their recent study also received a U-shaped EKC condition OECD countries based on the economic growth and ecological footprint.

When ecological footprint stand for environmental degradation, a positive and significant relationship is found between GDP and ecological footprint as reported in Table 5.13. From the linear models, a percent change in income increase ecological footprint by 0.57percent and 0.23percent in POLS and FMOLS estimates respectively. Similarly, unit change in trade openness increase environmental degradation by 0.03percent and 0.17percent in the pooled OLS and FMOLS respectively. This is an indication that trade openness increase environmental pressure due to increased level of exploitation of natural resources such as minerals and forest products consistent with Kasman and Duman (2015) and Adu and Denkyirah (2017). West African countries heavily rely on the export of natural resources as means of generating foreign exchange and therefore exploitation of these resources tremendously increased over the years. A positive relationship is found between FDI and ecological footprint. A 1 percent increase in FDI leads to 0.01percent and 0.29percent increase in environmentpressure. A significant negative relationship is indicated between financial development and ecological footprint and this implies that increasing credit help enhances environmental quality. One possible explanation for this is that private credit spur economic activities and expand job opportunities in different sectors of the economy thus reducing the heavy reliance of the vast majority of the populace on forest sector as means of livelihood. This result is in line with Charfeddine and Khediri (2016) and Salahuddin et al. (2018) but contradict Shahzad et al. (2017) and Chen and Lei (2018). Panel B provides the quadratic model in which an inverted U-shaped relationship is indicated between economic growth and ecological footprint. The work of Churchill et al. (2018) reported similar findings. The empirical results further reveal that population increase environmental degradation with a significant impact. A percentage increase in population increases environmental degradation by 1.01percent and 0.99percent as reported by the POLS and FMOLS models respectively.A percentage increase in human capital brings about 0.21percent and 0.03percent decrease in ecological footprint and this is supported by Hua et al. (2018). A significant positive relationship appears between energy poverty and ecological footprint implying that energy hunger leads to escalating environmental degradation consistent with. A percentage increase in energy poverty degrade environment by 0.17percent and 0.04percent via POLS and FMOLS respectively. Energy poverty is worrisome in West Africa.

5.5.1 Quantile Regression Results and Discussions

In Table 5.14 the panel quantile estimation results are reported and it indicates mixed results in the relationship between measuresof environmental degradation (CO2 emissions and Ecological footprint) and its determinants (economic growth, trade openness, foreign direct investment, financial development, population, human capital and energy poverty) in different quantiles. The results indicates that GDP has a significant positive impact on pollution in lower and middle quantiles but squared income has negative impact and this suggest an inverted U-curve consistent with the findings of Churchill et al. (2018), Pao and Chen (2019) and Destek and Sarkodie (2019). However, in the upper quantiles relate negatively with pollution while squared GDP has significant positive relationship with carbon emissions. These results suggest that U-curve pattern holds between income and pollution in the higher emission countries and this contradict the EKC hypothesis that postulate an inverted U-shaped relation between economic growth and environmental degradation. Charfeddine and Mrabet (2017) and Sarkodie and Strezov (2019) documented similar findings.

Table 5.14 also providesthe panel quantile estimation results for ecological footprint and it indicates mixed results. The results indicates that income has negativeimpact on ecological footprint in the lower and middle quantiles while squared income has positive impactconsistent with the findings ofKeho (2015a) and Kwakwa et al. (2019) and the most recent studies of Xu et al. (2020). The results suggest that the scale of economic activities in countries with low ecological footprint have surpassed the technique effect. However, in the upper quantiles income exert positive impact on ecological footprint while squared income has negative sign. Churchill et al. (2018), Pao and Chen (2019) and Destek and Sarkodie (2019) are in support of the findings of this study.

The first possible explanation why the EKC hypothesis does not hold for the West African countries under investigation is that the early stage of economic growth of these countries was characterized by dominance of agriculture and labour intensive methods of production which had help maintain low carbon economy. However, the countries are now gradually becoming more urbanized and industrialized indicating the move toward the second stage of economic growth. For example, the Sahel research group (2019) opined that between 2015 and 2040 West African population will double and urban areas will absorb greater portion. Similarly, according to ECOWAS Commisson (2018) currently half of the population are living in urban areas and that urbanization in the region will range around 46.2% to 63.8% by 2030 implying that more than half the region’s population will live in urban areas. Countries like Senegal, Benin, Ghana and Nigeria have reach 47.7%, 47.9%, 56.7% and 51.2% urbanization level respectively (African Development Bank, 2019). The increased urbanization and industrialization requires extensive energy consumption given large transportation networks, residential complex and increase industrial production leading to rising carbon emissions. Secondly,with rising population pressure and increasing poverty level, the priorityof policymakers might have shifted towards promoting rapid economic growth as means of alleviating poverty that has become endemic in the region. According to OXFAM International (2019), 55% of the population is living on less than US$1a day, in some countries like Nigeria 65% of the population live on less than US$1.25 a day.Under this circumstance, environmental quality may be seen as a luxury goods while raising income becomes the priority. Third, natural resource abundance is the key component of the economic growth in the region and they largely depend on the extraction of these resources for exports expansion. As noted by Akram, et al. (2020), the unsustainable exploitation of natural resources in developing countries poses severe threat to environment particularly regarding the escalation of CO_2 emissions.

Table 5.14 also indicates that trade openness relates positively with pollution revealing that trade escalate pollution in all the quantiles. The previous study of Denkyirah (2018) support that trade increase pollution. Similarly, in panel B trade openness exert positive impact on ecological footprint in the lower and upper quantiles. This results is not surprising given that trade in West Africa largely consist of energy consuming products such as Motor vehicles, machinery and electrical appliances. Fuel alone account for 24% of the region imports while about 75 percent of export is crude oil (ECOWAS Commission, 2016).

Table 5.14 Panel quantile regression estimates

Variables	**Quantiles**				
	τ=0.10	*τ=0.25*	*τ=0.50*	*τ=0.75*	*τ=0.95*
Dependent Variable: CO2 emissions					
GDP	0.155***	0.134**	0.197*	-0.351*	-0.350***
GDP^2	-0.042*	-0.030*	-0.013**	0.007**	0.077***
TO	0.174*	0.221**	0.265*	0567	0.615**
FDI	0.024*	0.027*	0.018**	0.012	-0.001
FD	0.116	0.154	0.212*	0.309*	0.407*
POP	0.199*	0.227*	0.334*	0.269**	0.180*
HC	-0.157**	-0.183**	-0.256*	0.116*	0.077*
EP	0.038**	0.045*	0.089**	0.011**	0.065*

Dependent Variable: Ecological Footprint

GDP	-0.335*	-0.445*	-0.447*	0.609*	0.638*
GDP^2	0.053*	0.040*	0.017*	-0.025**	-0.010**
TO	0.033*	0.031*	0.050	0.029	0.039*
FDI	-0.017*	-0.016*	-0.012*	-0.019*	-0.016*
FD	-0.101*	-0.088*	-0.037	-0.023	0.042
POP	0.811*	0.928*	0.990	1.095*	1.085*
HC	-0.069	-0.197*	-0.198**	0.285**	0.271***
EP	0.100**	0.143*	0.165*	0.202*	0.223*

Note: *, **, *** represent significant at 1%, 5% and 10% l level of significance respectively.

Table5.14shows that there is significant positive relationship FDI and CO2 emissions in the lower and middle quantiles. This implies that the activities of multinational firms are detrimental to the host communities and the works of Kivyiro and Arminen (2014) and Sarkodie and Strezov (2019) supported this finding. However, in the upper quantile the result indicate negative effect of FDI on pollution suggesting that carbon emissions declines with increase in foreign investment inflows in the host countries. In panel B, FDI relate negatively with ecological footprint in lower, middle and upper quantiles suggesting that foreign firms assists in addressing ecological footprint in the host countries and the result of this study is supported by Adewuyi and Awodumi (2017) but contrast with To et al. (2019). The new discovery of oil and minerals in West African states and political stability tremendously help in attracting huge amount of FDI into the region. However, vast portion of the FDI inflows goes to oil and gas sectors as the preferred areas.

Table5.14 indicatesthat financial development significantly relate withpollution in the middle and upper quantiles suggesting that increasing availability of funds spur economic activities with a degrading impact on environment. In panel B, financial development relates negatively with ecological footprint in the lower quantiles suggestng that financial development helps in addressing ecological footprint the lower quantiles and Salahuddin et al. (2018) documented similar finding.

Table5.14results indicates that population relate positively with and carbon emissions suggesting that population is increasing pollution and the work ofAl-Mamun et al. (2014) and Rahman (2017) supported this result. Similarly, the impact of population on ecological footprint is significantly positive in all the estimated quantiles as depicted in panel B.This provides evidence that increasing population in the region is escalating all forms of environmental pressures. ECOWAS population growth rate (2.4) is the fastest in African continent and this has resulted to a quadrupled increase in population from 70 million to 327 million people between 1950 and 2018. With current population growth rate ECOWAS population will be around 806 million people in the next thirty years (UN ESA, 2019) and population explosion have increases environmental pressure.

Table5.14 indicates that human capital relate negatively with ecological footprint suggesting that increasing education level helps in reducing environmental degradation consistent with Su and Liu (2016) . But in the higher quantiles education has positive relationship with ecological footprint suggesting that increasing literacy leads to more environmental degradation. With increased demand for education inECOWAS educational institutions increase as well and these new structures and facilities demand energy for smooth running and this raises emissionsin the air (Katircioglu et al., 2020). Second, rising literacy increased people's taste and demand for energy-consuming products.

Table5.14 shows that energy poverty plays a positive impact on CO2 emissions and its impact is significant in the lower, middle and upper quantiles. Similarly, in panel B energy poverty has significant positive impact on ecological footprint in all the estimated quantiles and this suggests that energy poverty contributes to environmental degradation in the region. Energy poverty in ECOWAS is acute and it has serious implications for the regional environmental sustainability. Nearly two-third of the region's population depend on traditional biomass as sources of energy and in some countries it represents about 80% of final energy consumption. Traditional biomass has continued to be the major source of energy especially in the rural areas where 75% of the population lacks access to electricity. With about 200 million people in the region lacking access to electricity, the regional government has set target of connecting 75% of its population to grid electricity by 2030 but even if that is achieved still around 127 million people would continue to use firewood and charcoal as sources of energy (UN ESA, 2018) and this will intensify the rate of forest depletion and the consequence environmental degradation in the region.

5.6 Summary of Quantile Estimates

In Table 5.15 the summary of the panel quantile estimated coefficients in the CO2 equation are reported. Overall, GDP series has a positive sign in low and middle quantiles, while the GDP squared series has the opposite sign and this indicate an inverted U-shaped relationship. However, in the high quantiles GDP has negative sign while squared GDP has positive sign and this suggest a U-shaped pattern. Furthermore, trade openness series indicate a positive sign in all the quantiles while foreign direct investment has positive signs in the low and middle quantiles but inconclusive result for the high quantiles. Financial development has inconclusive results in the low quantiles while a positive sign in the middle and high quantiles. Population series is found to have positive sign in all the estimated quantiles, human capital has negative sign in the lower and middle quantiles but positive sign in the high quantiles. Energy poverty indicates positive sign in all the quantiles.

Table 5.15 Summary of quantile regression estimations (CO2 emissions)

Quantiles	Low (r=0.05 until 0.30)	Middle (r=0.40 until 0.60)	High (r=0.70 until 0.95)
GDP	+	+	−
GDP^2	−	−	+
TO	+	+	+
FDI	+	+	/

FD	/	+	+
POP	+	+	+
HC	−	−	+
EP	+	+	+

Note: − means the variable has negative relationship with CO2 emissions in the quantile
+ means the variable has positive relationship with CO2 emissions in the quantile
/ means no significance relationship between the variables

In Table 5.16 the summary of the panel quantile estimated coefficients in the ecological footprint equation are reported. GDP series has a negative sign in low and middle quantiles while squared GDP series has positive sign and this indicate a U-shaped relationship. However, in the high quantiles GDP has positive sign while squared GDP has negative sign and this suggest an inverted U-shaped pattern. Furthermore, trade openness series indicate a positive sign in the low quantiles but inconclusive results in the middle and high quantiles. Foreign direct investment has negative signs in the low, middle and high quantiles. Financial development has negative sign in the low quantiles but inconclusive results in the middle and high quantiles. Population series is found to have positive sign in the estimated low and high quantiles but inconclusive result in the middle quantile. Human capital has negative sign in all the quantiles, energy poverty indicate positive signs in all the quantiles.

Table 5.16 Summary of quantile regression estimations (Ecological footprint)

Quantiles	Low (r=0.05 until 0.30)	Middle (r=0.40 until 0.60)	High (r=0.70 until 0.95)
GDP	−	−	+
GDP^2	+	+	−
TO	+	/	/
FDI	−	−	−
FD	−	/	/
POP	+	/	+
HC	−	−	−
EP	+	+	+

Note: − means the variable has negative relationship with CO2 emissions in the quantile
+ means the variable has positive relationship with CO2 emissions in the quantile

/ means no significance relationship between the variables

Figure 5.2 reveals that GDP increases rapidly from lower up to the middle quantiles while GDP^2 decreases from lower up to the middle quantiles. Conversely, GDP shows a declining trend in the upper quantile while GDP^2 depicts a rising trend. The slope FDI, trade and energy poverty are rapidly declining from the middle up to the upper quantiles. Financial development has a rapidly increasing trend from the lower through the middle and upper quantiles. The trend for population slightly increases from lower to the middle and upper quantiles. Slope coefficients of human capital are decreasing from the lower to the middle quantiles after which it maintain a rising trend in the upper quantiles.

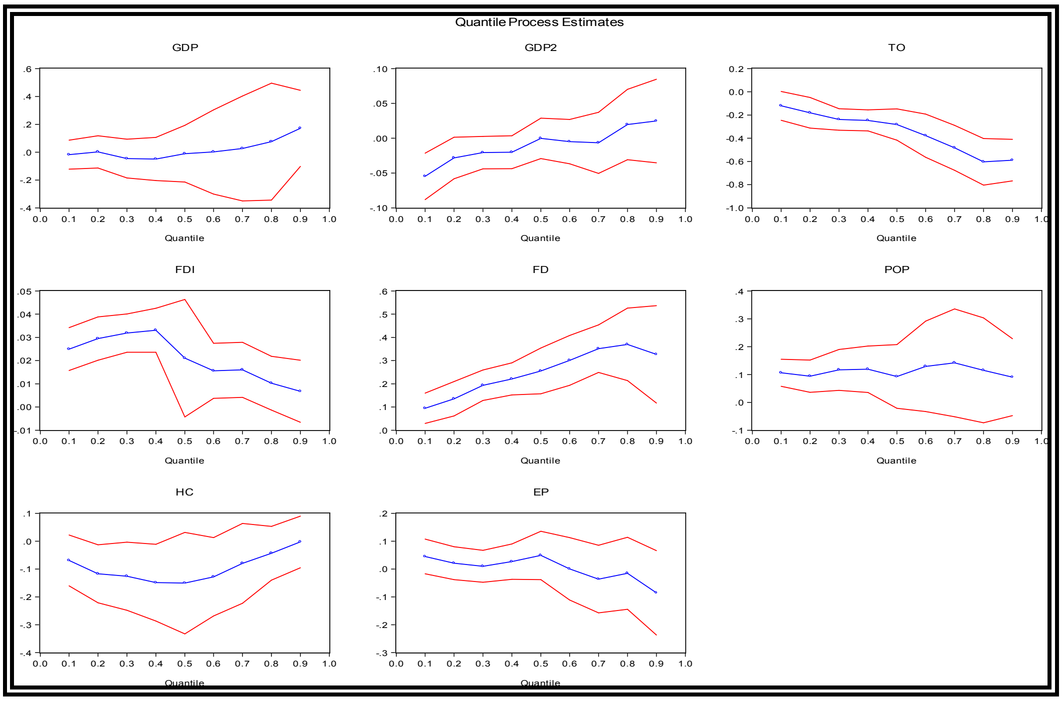

Figure 5.2 Quantile Process Estimate (CO2 emissions)

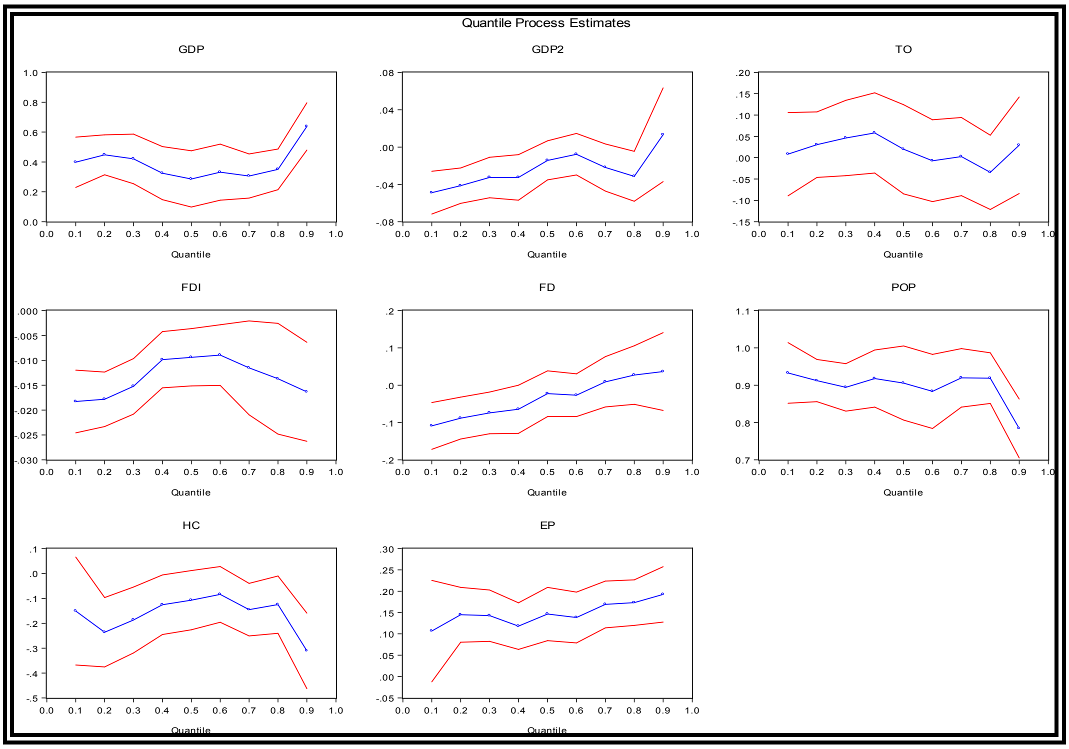

Figure 5.3 Quantile Process Estimate (Ecological Footprint)

Figure 5.3 reveals that GDP decreases slightly from lower up to the middle quantiles while GDP^2 increases from lower up to the middle quantiles and this implies that a U-shaped pattern exists between economic growth and ecological footprint in the lower and middle quantiles. However, in the upper quantiles GDP shows a rising trend to the right tail while GDP^2 depicts a declining trend and this suggest an inverted U-shaped relationship exists in the upper quantiles. The slope coefficient of trade openness slightly increases in the lower quantiles but sharply decline thereafter to the upper quantiles. FDI sharply increases at the lower quantiles stabilizes a while in the middle quantile and decline in the upper quantiles. Financial development depicts a rising trend from the lower through the middle and upper quantiles. Population has a slightly deceasing trend in the lower quantiles stabilizes in the middle quantile but sharply decline in the extreme upper quantiles. The trend for human capital slightly increases from lower to the middle quantiles. Slope of energy poverty are increasing mildly from the lower to the middle and upper quantiles

Tables 5.17 (appendix C) gives the slope equality test results. When CO_2emissions is considered as dependent variable the null hypothesis of slope equality at the 10^{th} and the 25^{th} quantiles is accepted for all the CO_2 determinants. The null hypothesis is rejected at the 10th and the 50^{th} quantiles for economic growth andsquared economic growth squared series and also at 10^{th} and the 75^{th} quantiles for economic growth, squared economic growth and energy poverty. The null hypothesis is also reject at 10th and the 95^{th} quantiles for economic growth,squared economic growth, foreign direct investment and financial development.

5.7 Panel Quantile Causality Analysis

The causal relationship between carbon emissions and the independent variables are analyzed using the Wald test as reported in Table 5.18. The result indicates a unidirectional causal relationship between GDP and CO2 emissions in the low and middle quantiles with the causality running from GDP to emissions consistent with the studies by Kwakwa et al. (2019) for Ghana and Salahuddin et al. (2020) for South Africa. However, in the high quantiles bidirectional causality is reported and this is in line with the previous findings of Alege etal. (2018). However, a unidirectional causality running from squared GDP to carbon emissions in the low, middle and high quantiles are documented. Furthermore, bi-directional causality exists between trade openness and carbon emissions in the low quantiles consistent with Farhani (2014). However, in upper quantiles a unidirectional causality running from trade openness to CO2 emissions is documented and this is in line with Boutabba (2014), Omri et al. (2015). The panel quantile causality indicates that there is bidirectional causality between FDI and carbon emissions at lower and middle quantiles. Tang and Tan (2015) found a similar result from Vietnam, with an existence of bidirectional causality running between FDI and CO2 emissions, and a unidirectional causal link running from energy consumption to CO2 emissions. Xie et al. (2020) empirical results also confirm the existence of pollution-haven and pollution-halo hypotheses for emerging countries. In addition, Pao and Tsai (2011) for BRICS countries and Omri et al. (2014) for 54 countries all found bidirectional causal relationship between FDI and CO2 emissions. However, in the high quantiles there exists a unidirectional causality from foreign direct investment to carbon emissions consistent with Shahbaz (2019) who found a unidirectional causality runs from FDI to CO2 emissions.

The empirical results further reveal that a unidirectional causal link exists between financial development and carbon emissions. In the high quantiles the causality runs from carbon emissions to financial development while in the low and middle quantiles the causality runs from financial development to carbon emissions and previous studies of Boutabba (2014), Alsamara et al. (2018) reported similar findings. There exists bidirectional causal link between population and carbon emissions in the low quantiles but unidirectional causality running from population to emissions. Also, there is bi-directional and unidirectional causality between human capital and CO2 emissionsin the low and upper quantiles respectively.

Table 5.18 Wald test for panel quantile causality (CO_2 emissions)

	Quantiles				
Hypotheses	**r=0.10**	**r=0.25**	**r=0.50**	**r=0.75**	**r=0.95**
$GDP \neq CO_2$	3.203***	5.830**	4.733**	5.529**	6.033**
$CO_2 \neq GDP$	0.136	1.526	0.138	3.011**	4.995**
$GDP^2 \neq CO_2$	5.264**	8.101*	3.066***	7.992*	5.372**
$CO_2 \neq GDP^2$	1.071	2.029	1.093	0.807	1.823
$TO \neq CO_2$	8.278*	4.998**	6.677**	6.819*	3.101***
$CO_2 \neq TO$	12.088*	10.526*	1.557	1.302	0.929
$FDI \neq CO_2$	7.557*	6.977**	8.989*	37.638*	22.077*
$CO_2 \neq FDI$	4.119**	5.535**	3.782**	0.087	1.119
$FD \neq CO_2$	10.882*	7.010*	9.788*	1.939	0.693
$CO_2 \neq FD$	0.656	1.001	0.892	4.995**	7.440*
$POP \neq CO_2$	18.636*	22.622*	12.028*	42.301*	5.892**
$CO_2 \neq POP$	21.744*	14.099*	0.332	2.120	0.192
$HC \neq CO_2$	6.091*	8.555*	5.022**	3.163***	6.733**
$CO_2 \neq HC$	15.338*	10.712*	12.241*	0.636	1.771
$EP \neq CO_2$	27.524*	9.727*	2.862	0.228	0.052
$CO_2 \neq EP$	4.706**	3.966**	13.100*	11.546*	3.920**

Note: *, **,*** denote the rejection of null hypothesis of no causality at 1%, 5% and 10%

respectively. ≠ mean does not cause.

Table 5.19 provides the causal relationship between ecological footprint and its determinants using the Wald test. The result indicates bi-directional causal relationship between economic growth and ecological footprint in the low quantiles but in the middle and high quantiles there exists a unidirectional causality running from GDP to ecological footprint consistent with the studies by Nza (2018) for Cote d'Ivoire, Appiah et al. (2019) for Uganda and Joshua et al. (2020) for South Africa. However, a unidirectional causality running from squared GDP to ecological footprint in the low quantiles but in the middle and high quantiles bidirectional causality holds. Furthermore, a unidirectional causality exists between trade openness and ecological footprint in the low quantiles consistent with Kasman and Duman (2015). However, in the middle quantile bidirectional causality is documented and this is supported by the previous study by Farhani (2014). The panel quantile causality indicates that there is bidirectional causality between FDI and ecological footprint at lower quantiles. Tang and Tan (2015) found a similar result from Vietnam, with an existence of bidirectional causality running between FDI and CO2 emissions. Pao and Tsai (2011) for BRICS countries and Omri et al. (2014) for 54 countries all found bidirectional causal relationship between FDI and CO2 emissions. However, in the middle and high quantiles there exists a unidirectional causality from foreign direct investment to ecological footprint consistent with Shahbaz (2019).

Table 5.19 Wald test for panel quantile causality (Ecological footprint)

	Quantiles				
Hypotheses	**r=0.10**	**r=0.25**	**r=0.50**	**r=0.75**	**r=0.95**
GDP ≠ EF	7.398*	10.228*	18.227*	14.802*	9.336*
EF ≠ GDP	3.206***	5.344**	0.218	0.882	1.530
GDP^2 ≠ EF	12.455*	9.742*	16.047*	23.739*	8.645*
EF ≠ GDP^2	1.810	0.044	7.944*	17.006*	11.347*
TO ≠ EF	9.503*	8.300*	3.167***	0.637	1.173
EF ≠ TO	0.533	1.922	5.663**	0.939	1.055

FDI ≠ EF	5.706**	4.033*	4.222**	12.277*	32.810*
EF ≠ FDI	8.555**	15.964*	0.733	2.011	1.097
FD ≠ EF	1.237	0.222	4.728**	12.047*	21.333*
EF ≠ FD	0.229	1.345	1.388	0.693	1.272
POP ≠ EF	7.711*	9.019*	2.003	1.838	0.455
EF ≠ POP	1.007	0.332	0.811	3.987**	7.830*
HC ≠ EF	2.001	1.176	4.215**	6.003*	12.566*
EF ≠ HC	8.287*	9.029*	1.881	0.732	0.349
EP ≠ EF	6.522**	8.333*	4.383**	5.559**	9.022*
EF ≠ EP	1.777	0.540	0.887	6.330*	8.827*

Note: *, **,*** denote the rejection of null hypothesis of no causality at 1%, 5% and 10% respectively. ≠ indicated does not cause.

The empirical results further reveal that a unidirectional causal link exists between financial development and ecological footprint in the middle and high quantiles and this result is supported by Shahbaz et al. (2018) but contrast with Omri (2015) who reported no causal link between the two variables. However, a neutral causality is found in the low quantiles. There exists unidirectional causal link between population and ecological footprint in the low quantiles with the causality running from population to emissions. However, in the high quantile the causality runs from ecological footprint to population while neutral causality holds in the middle quantile. Also, there is unidirectional causal link between human capital and ecological footprint in the low quantiles. But in the middle and high quantiles a unidirectional causality running from human capital to ecological footprint exists. There is unidirectional causality between energy poverty and ecological footprint in the low and middle quantiles. But in the high quantiles bidirectional holds between energy poverty and ecological footprint.

In Table 5.20 the summary of wald test for panel quantile causality is reported. It provides evidence of unidirectional causality between economic growth and CO2 emissions in the low and middle quantiles while bidirectional causality is evident in the high quantiles. Furthermore, unidirectional causal links between squared GDP and carbon emissions is documented. There exists bidirectional causal link between trade openness and CO2 emissions in the low quantiles while unidirectional link holds in the middle and high quantiles. Bidirectional causality exists between FDI and emissions in the low and middle quantiles but in the high quantiles unidirectional causality holds. A unidirectional causal link exists between financial development and emissions in the low, middle and high quantiles. In the low quantiles there is bidirectional causality between population and carbon emissions. Bidirectional causality exists among human capital and pollution in the low and middle quantiles but inidirectional causality holds in the high quantiles.

Table 5.20 Summary of wald test for panel quantile causality

Quantiles	Low (r=0.10 until 0.25)	Middle (r=0.50)	High (r=0.75 until 0.95)
Dependent Variable: CO2 emissions			
GDP	→	→	↔
GDP^2	→	→	→
TO	↔	→	→
FDI	↔	↔	→
FD	→	→	→
POP	↔	→	→
HC	↔	↔	→
EP	↔	→	→
Dependent Variable:Ecological footprint			
GDP	↔	→	→
GDP^2	→	→	↔
TO	→	↔	≠
FDI	↔	→	→
FD	≠	→	→
POP	→	≠	→
HC	→	→	→
EP	→	→	↔

Note: → means unidirectional causality between the two variables
↔ means bidirectional causality between the two variables
≠ means no/neutral causality between the two variables

Furthermore, bidirectional causality between economic growth and ecological footprint in the low quantiles holds while unidirectional causality is evident in the middle and high quantiles. A unidirectional causal links between squared GDP and ecological footprint is documented in the low and middle quantiles but there is bidirectional causality in the high quantiles. There exists unidirectional causal link between trade openness and ecological footprint in the low quantiles, bidirectional causal link holds in the middle quantiles and neutral causality in the high quantiles. Bidirectional causality exists between FDI and ecological footprint in the low quantiles but in the middle and high quantiles unidirectional causality holds. A unidirectional causal link exists between financial development and ecological footprint in the middle and high quantiles but neutral causality in the low quantiles. In the low and high quantiles there is unidirectional causality between population and ecological footprint while neutral causality holds in the middle quantile. Unidirectional causality exists between human capital and ecological footprint in the low, middle and high quantiles. Energy poverty has unidirectional causality with ecological footprint in the low and middle quantiles but bidirectional causality is documented in the high quantiles.

5.8 Decisions on Research Hypotheses

In this section the research hypotheses of this study are tested and conclusions are drawn. The hypotheses are tested in line with the research questions and objectives of the study. Base on the results and discussions given in the previous section, the decisions on the hypotheses are summarized as in Table 5.21

Hypothesis 1 (H_1) test the existence of significant long run elasticities between environmental degradation and its determinants in ECOWAS countries. The significant positive or negative coefficients indicate the responsiveness of environmental degradation due to changes in each regressor in the study. The decision on this hypothesis is based on the elasticities obtained from the quantile regression. Since the elasticities for each variable are significant, this hypothesis is accepted leading to conclusion that there exist significant long run elasticities between environmental degradation and its determinants in ECOWAS countries.

Table 5.21 Decisions on Research Hypotheses

	Hypotheses	Decisions
H_1:	There are significant long run elasticities between environmental degradation and its determinants in ECOWAS countries.	Accepted
H_2:	There is strong evidence of inverted U-shaped relationship between economic growth and environmental degradation in ECOWAS countries.	Rejected
H_3:	There is strong evidence of pollution haven hypothesis between FDI and environmental degradation in ECOWAS countries.	Rejected
H_4:	There are significant causal relationships between environmental degradation and its determinants in ECOWAS countries.	Accepted

Hypothesis 2 (H_2) test the existence of a strong evidence of inverted U-shaped relationship between economic growth and environmental degradation in ECOWAS countries. The significant positive or negative signs of economic growth and squared economic growth variables are used indicate the shape of the environmental Kuznets curve (EKC). Since the coefficients of GDP are negative while those of squared GDP are positive in the quantile regression for ecological footprint this hypothesis is rejected. Therefore, it is concluded that the inverted U-shaped relationship does not exist for ECOWAS countries.

Hypothesis 3 (H_3) test the existence of a strongevidence of pollution-haven hypothesis between FDI and environmental degradation in ECOWAS countries. The significance of the elasticities of FDI indicated the positive or negative responsiveness of environmental degradation to changes in foreign direct investment. The decision on this hypothesis is made by the significant sign of the FDI coefficient from the quantile regression for ecological footprint. Since the signs of the FDI coefficient are significantly negative this hypothesis is rejected and it is concluded that pollution-haven hypothesis does not hold for ECOWAS countries.

Hypothesis 4 (H_4) test the existence of significant causal relationships between environmental degradation and its determinants in ECOWAS countries. The decision on this hypothesis is made by the results of the wald test for panel quantile causality which indicate the causal influence of each variable on environmental degradation. Since the results indicate significant causal influence of all the variables on environmental degradation this hypothesis is accepted.

5.9 Chapter Summary

In this chapter the results of the preliminary analysis in the relationship between environmental degradation and its determinants (economic growth, trade openness, foreign direct investment, financial development, population, human capital and energy poverty) is discussed under which the descriptive statistics and correlation analysis are done. Further, the panel unit root tests are conducted in order to ascertain the order of integration of the series and this is done to avoid spurious estimation. After confirming that all the variables are integrated of order I(1), cointegration tests are conducted to check the existence of a long-run association among the variables. The results confirmed the existence of a long-run relationship among the variables. To obtain the estimated coefficients pooled OLS and fully modified OLS regression techniques are utilized. Then the panel quantile regression technique is used to obtain the influence of the regressors across the distributional quantile of the environmental degradation. The estimated results indicates the existence of U-shaped pattern between economic growth and environmental degradation as opposed to the inverted U-shaped relationship postulated by the EKC hypothesis when ecological footprint is considered as proxy for environmental degradation. Furthermore, the empirical results reveals that foreign direct investment helps in reducing environmental degradation and this dost not validate the pollution-haven hypothesis for ECOWAS countries. Diagnostic tests are conducted to ascertain the normality using Shapiro-Francis test, the stability of the parameters with the aid of quantile process estimated and the slope equality test. The direction of causality among the variables is determined using wald test for quantile causality and the results confirmed strong causal relationship between environmental degradation and its determinants. Finally, the objectives of this research are achieved by highlighting the decisions on the research hypotheses.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

In the previous chapter the findings of this study are presented and discussed in line with the objectives of the study. However, the current chapter provide conclusions base on the findings of the study and policy implications are highlighted regarding environmental degradation in the West African sub-region. The contributions of this study are mentioned to portray the uniqueness of this study. Like other research efforts, this study is not free from limitations and these are highlighted. Lastly, recommendations are offered in order to help policy makers address environmental challenges in the region and directions for future studies are provided. The chapter is organized as follows. Section 6.2 summarizes the major findings this study. Section 6.3 provides the policy implications of from the findings. Section 6.4 gives the contributions as well as the limitations of this study. Lastly, section 6.5 proffers recommendations and direction for future research.

6.2 Summaryof Major Findings

As the issue of climate change occupies international discussions, analyzingfactors that significantly shape environmental conditionwould tremendously assist in deigning sound environmental policies to address climate change especially in West African region which has been identified most prone the climate change. Predominantly, increased economic activities are mentioned as the main cause of environmental change. In recent years, West African sub-region recorded rapid growthcompared to other regions in Africa. Real GDP growth rate over 2000 to 2014 remained above 5% and this performance rise to 5.3% in 2016

(ECOWAS Commission, 2019). This impressive economic performance has translated intohigh employment, income and industrial growth. However, the regions environment is paying high price for such rapid economic development which consequently increases the concern for climate changes.

The concern that rising growth performance might conflict with the goals of sustainable development have raised efforts by researcher to analyze the nexus betweenincome growth and environmental pressure. Following the theoretical argument of the environmental Kuznets curve (EKC) hypothesis championed by Grossman and Krueger (1991 many studies attempted to shade more light on the subject. The EKC hypothesis provide that the relationship among income and environment follow an inverted U-curve meaning that indicating that environmental pressure persist along with increased economic fortunes up to a particular point after which it subside. The popular variables that influence environment from the literatures are economic growth, trade, foreign direct investment, energy consumption and population growth and these are extensively investigated in terms of their effect on carbon emissions as an indicator of environmental condition in the previous studies. However, unlikethe past studies this utilizes ecological footprint as an indicator of environment because it is a more comprehensive measure of environment that captures the consumption of land, air, water and forest resources. In addition, this study extends the literature by accounting the effect of human capital and energy poverty on environment in West African being largely ignored in the previous studies. To this end, data are sourced from World Bank and Global Footprint Network over the period 1970-2018.

The results of the preliminary investigations reveals that the data is not normally distributed base on the Q-Q plot and the Shapiro-Wilk and Shapiro-Francia tests (see Table 5.3). Utilizing the Pesaran CD test for cross sectional dependence, that indicates a strong cross-sectional dependence among the panel (see Table 5.4). Given this, unit root test is examined using the LLC, IPS, Fisher-ADF, Fisher-PP and CIPS techniques and the results provide evidence of unit root at level but became stationary after taking first difference (see Table 5.5 and 5.6). to verify whether long run association exist among the variables, this study utilizes Kao, Pedroni, Johansen-

Fisher and Westerlund cointegration approaches and all the tests confirmed that cointegration exists among variables in the study (see Tables 5.7, 5.8 and 5.9). having established a long run association among the variables in this study the long run elasticities are estimated using the pooled OLS and fully modified OLS and the results indicate that a significant long run influence of the regressors on environmental degradation (see Table 5.12).

Considering the fact that the preliminary investigations revealed that the data used in this study is not normally distributed, this study further adopted quantile regression technique that is robust to outliers and work perfectly with none-normal data. The results revealed that all the variables in the study have significant influence on ECOWAS environment (see Table 5.13). It was found that economic growth is exerts a stronger influence on carbon emissions followed by trade openness, financial development and population especially in the upper emissions countries. However, upon adopting ecological footprint as indicator of environmental condition, the results confirmed that population is the major environmental driving factor in the region with a deteriorating impact. Similarly, energy poverty complements population in harming the regional environment. Interestingly, financial development and FDI inflows in the region support the region's sustainable development as very lower environmental degradation. Surprisingly, human capital development is compounding environmental pressure and this reveals that the growth of literate population raise the citizens taste for energy consuming goods and services. Thus, it calls for increasing efforts toward the development of green R&D in pursuit of human capital development existing side by side with promoting school enrolment. Overall, the estimated results provided evidence for the existence of U-shaped relationship between economic growth and environmental degradation as opposed to the inverted U-shaped pattern postulated by the environmental Kuznets curve hypothesis. This suggests that environmental pressure in ECOWAS countries increases along with a sustained rise in income. This implies that, left alone, economic growth will not address environmental pressure in the region rather it need to be complemented with other policies such as addressing energy poverty and comprehensive human capital development that will ensure clean environment.

In conclusion, this study accepted that there is significant ling-run association between environmental degradation and its determinants as well as significant elasticities in ECOWAS countries. However, it is concluded that there is no strong evidence of an inverted U-shaped relationship between economic growth and environment degradation rather a U-shaped pattern was established. In addition, it is concluded that there is no evidence of pollution-haven hypothesis in ECOWAS countries rather pollution-halo is evident. This suggests that foreign firms are assisting in cleaning environment in the region through the adoption of advanced technology and better managerial skills. Lastly, it is concluded that there are significant causal relationships between environmental degradation and its determinants in ECOWAS countries.

6.3 Policy Implications

The aforementioned findings have important policy implications for policies-makers in ECOWAS countries to improve on the existing policies and strategies aims at tacking environmental degradation and climate change and place the region on the path of sustainable development. The policy implications base on this study can be summarized as below:

First, the estimated results indicate that the elasticity of economic growth is an important determinant of environmental degradation in ECOWAS region. The policy implication for the U-curve pattern between income and environmental pressureentails that rising income would not grantee sustainable development.Sustained economic development need to be accompanied with tight environmental regulations and development of clean energy from renewable sources.

Second, the estimated results indicate that the elasticity of trade openness is significantly positive in explaining carbon emissions across the lower, middle and high emissions countries in the region and the policy implication for this that trade liberalization would aggravate environmental pressure. Free trade is not the best option for this region rather it needs to be checked to ensure the flow of environmentally friendly goods. This will go a long way in protecting the environment and ensure that the West African region is not treated as a dumping ground for the developed countries.

Third, the estimated results indicate that the elasticity of foreign direct investment is significantly negative in explaining ecological footprint in the region in all the estimated quantiles. The policy implication of this is that continues FDI inflows would go a long way in addressing the environmental pressure by bringing the modern production techniques and managerial skills that are friendly to environment. Of course most of the countries in the region fall under the class of less developed countries such that capital inflows would augment the locally available capitals needed for infrastructure investment and avail the local firms with the opportunity to access modern technology.

Four, the estimated results indicate that the elasticity of financial development is significantly positive in explaining carbon emissions in the region in the middle and upper quantiles. The policy implication of this is that increased private sector credits would scale up economic activities and consequently energy consumption thereby increasing environmental pressure. The detrimental effect of financial development calls for governmentto increase incentives for banks to give priority to environmentally friendly projects.

Five, the estimated results indicate that the elasticity of population is significantly positive in explaining environmental degradation in the region in all the estimated quantiles. The policy implication of this is that increased population explosion would mount environmental pressures in all countries of the region. Increased population would raise energy demand, land and forest deflation with an untold damage to environment. There is need to slow the pace of population growth through the appropriate policies that discourage large family sizes.

Six, the estimated results indicate that the elasticity of human capital is significantly negative in explaining environmental degradation in the region in all the estimated quantiles. The policy implication of this is that raising literacy level increases the awareness about environmental standard among citizens such that they mount pressure on authorities to enact and enforce environmental laws. In addition, increase literacy level enhances the adoption of advanced technology by local firms as well as increasing labour productivity and production efficiency.

Seven, the estimated results indicate that the elasticity of energy poverty is significantly positive in explaining environmental degradation in the region in all the estimated quantiles. The policy implication of this is that lack of energy access will strongly increase environmental pressure in the region due to heavy reliance on fossil and wood-fuels.

6.4 Recommendations

Some recommendations can be put forward base on the discussion of results from this study in ECOWAS region.

First, sustainable development should be given priority as against pure economic growth promotion. To this end, promoting renewable energy and energy efficiency in the region is important through option such as public-private partnership (PPP) that has the potential for bridging investment gap.

Second, there is the need for a comprehensive human capital developmentthat promote environmental awareness, skills acquisition, green R&D as against mere increasing the school enrolment. By so doing, knowledge acquired could be translated into increased productivity, technological advancement that are friendly with environment.

Third, countries in the region, especially the low-emissions ones, need to shift their trade policies toward achieving a low-carbon economy target by reducing massive energy-intensive imports and encourage the exchange of goods that bring technology transfer. Beyond this, it is relevant to promote trade policies that prioritise green development, such as green certification, quotas, tax exemption for green imports and investment, both for local and foreign firms, while at the same time diversifying the regional exports that is predominantly 80% of crude oil and cocoa.

Four, the high level of energy poverty in the region should be addressed to significantly reduce over reliance on fossil and wood fuels that presently characterizes the region. The countriesshould redouble efforts towards changing their energy mix toward renewable energy. The establishing Centre for Renewable Energy and Energy Efficiency (ECREEE) in 2010, adoption of Energy Efficiency Policy (EEP) in 2013, Renewable Energy Policy (REP) and the creation of West African Power Pool (WAPP) are good steps in the right directing that would yield the desired results in the future. This trend can be sustained by attracting cleaner FDI to supplement and bridge the resource gap in the region that later increase total factor of productivity and energy efficiency as has been practiced in developed countries, such as Japan.

6.5 Research Contributions

The contributions of this study are in the areas of literature and methodology. A number of literatures have devoted to verify this hypothesis base on single country or group of countries but results appears to be mixed. While some validated the hypothesis others could not validate it in the area or region they focused on. The major reasons being the differences in the combination of variables used in the studies or the analytical techniques adopted. For example, many studies have extended the EKC hypothesis by adding important variables such as trade openness, foreign direct investment, financial development, energy consumption, population and urbanization. However, the impact of energy poverty on environmental degradation is scarcely investigated despite the fact that this issue is of great concern for developing countries especially those in West African region. Therefore, this study makes great contribution to address such issue which will aid the formulation of robust policies aim at tackling environmental degradation in the region. In addition, the study integrates the role of human capital in the EKC model because itis scarcely highlighted in the previous studies.

From the methodology perspective, this study employs panel quantile regression technique which as an edge over the traditional regression techniques such as ordinary least square (OLS). Most of the previous studies used OLS method of analysis which assumes the error terms to have zero mean, constant and normally distributed. But these assumptions are not true in real economic life since the data of socio-economic indicators may have different distributional patterns (De Silva et al., 2016). In order to deviate from the previous studies in terms of methodology, quantile regression is adopted in the present work. Quantile regression estimation technique overcomes the limitations of the ordinary least square (OLS) approach considering the fact that even with the failure of the tradition regresstion assumption it provide a robust results. It describes the entire conditional distribution of the dependent variable and provides one solution to each quantile. It does not make any assumption about the presence of moment function. Again, it provides more accurate and robust findings in the presence of outliers and heavy tailed distributions as well as being effective even with non-normal error terms and do not consider any distributional assumptions (Zhu et al., 2016).

Another important contribution of this study is that it focuses on West African region. The ECOWAS region receives little attention by previous literatures that analyses economic growth-environment nexus.Predominantly, past literatures have paid attention to developed nations and Asian countries ignoring West Africa despite its high risk of climate change. Therefore, this study offers an important contribution by focussing on West Africa in view of the urgent need to fight climate change.

6.6 Limitations of the Research

This study made efforts to provide a comprehensive and robust analysis of environmental degradation in ECOWAS countries with some recommendations on how to improve the situation in the region. However, it is not devoid of limitations such as that of data and time constraints which are beyond the control of the author. ECOWAS consists of 15 member countries but this study focus on only six countries in the region due to data unavailability for some member countries. Some countries have undergone civil wars which have disrupted data access while data for some important variables used in this study is not available for other countries.

This study focuses on total environmental degradation in the region but does not consider sector-specific or industry-specific cases of environmental degradation due to time constraint. Due to time constraint, this study could not analyze environmental issue in disaggregated terms as it affect the industrial, household and transport sectors. It is paramount to study different aspect of environmental degradation so that effective and sector specific policies can be implemented in the region.

Furthermore, this study produced model that represent ECOWAS in order to analyze environmental degradation in the region as a whole. Despite the fact that the countries in the region share common features to al larger extent, there is some degree of heterogeneity among them in term of resource endowment, population size and political history. For example, some countries are land-locked while others bordered by sea. Some are former British colonies while others are French colonies. These peculiarities cannot be fully represented by using aggregated model thus the need for country-specific analysis to effective designing and implementation of policies in different countries.

6.7 Directions for Future Research

Future research in the region should be conducted to extend the results of this study by focusing on sector-specific environmental issues such as agriculture, industry, transports and residential so that a clear picture for each sector can be portrayed and comprehensive policies can be designed and implemented regarding the their growth and its impact on environment. This is because the growth and expansion of each sector might be driven by different factors likewise their impact on environment.

In the future country-specific analysis should be made to take into account the peculiarities of each country or group. For example, the land-locked countries should be examined separately while those close to sea can be grouped together. In terms of resource endowment, the oil producing countries need to be examined separately as these economies produce more pollution and other environmental pressures than the non-oil producing countries. The region comprises of two economic blocs of English-speaking (former British colonies) and French-speaking (former French colonies) and the implementation of policies in the region is to a certain extent influenced by this feature. Therefore, future research should endeavour to identify and focus on this feature by dividing the countries base on the two economic blocs.

There are different forms of environmental degradation such as air pollution, water pollution, land degradation, deforestation. Therefore, the impact of economic growth on these forms of environmental degradations should be separately analyzed in the future to come up with policies that address each issue.

In terms of the methodology future studies should adopt quantile autoregressive distributed lag model (QARDL) to analyze the nexus between income growth and environmental pressure. Such technique is robust even with mixed order of integration of series.

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Appendix A. Quantile Descriptive Statistics Results.

Table 5.1

Quantile	Mean	Median	Min	Max	Std dev	Kurt	Skew
EF							
$\tau = 0.25$	6.212	6.205	5.730	6.520	0.207	3.025	-0.716
$\tau = 0.50$	6.782	6.820	6.530	6.960	0.121	2.054	-0.484
$\tau = 0.75$	7.147	7.150	6.970	7.350	0.098	2.254	0.228
$\tau = 0.95$	7.851	7.800	7.360	8.310	0.283	1.838	0.123
CO2							
$\tau = 0.25$	0.162	0.180	0.080	0.210	0.038	1.791	-0.354
$\tau = 0.50$	0.254	0.250	0.220	0.310	0.027	2.561	0.658
$\tau = 0.75$	0.388	0.390	0.320	0.470	0.043	1.970	0.106
$\tau = 0.95$	0.640	0.600	0.480	1.010	0.193	3.407	0.965
GDP							
$\tau = 0.25$	2.699	2.700	2.620	2.740	0.026	3.788	-0.686
$\tau = 0.50$	2.806	2.800	2.750	2.890	0.042	2.021	0.513
$\tau = 0.75$	3.010	3.030	2.900	3.090	0.057	1.853	-0.389
$\tau = 0.95$	3.216	3.195	3.100	3.410	0.093	2.009	0.537
GDP2							
$\tau = 0.25$	7.329	7.355	6.830	7.500	0.139	4.366	-1.152
$\tau = 0.50$	7.837	7.770	7.510	8.340	0.262	2.015	0.582
$\tau = 0.75$	8.723	8.720	8.360	9.030	0.181	1.957	-0.010
$\tau = 0.95$	10.143	9.980	9.050	11.620	0.754	1.948	0.373
TO							
$\tau = 0.25$	1.543	1.620	0.800	1.700	0.178	6.640	-1.818
$\tau = 0.50$	1.766	1.765	1.710	1.810	0.032	1.870	-0.231
$\tau = 0.75$	1.860	1.855	1.820	1.910	0.030	1.680	0.204
$\tau = 0.95$	1.991	1.990	1.920	2.150	0.051	3.357	0.738

FDI							
$\tau = 0.25$	3.044	2.010	0.001	6.720	2.719	1.281	0.228
$\tau = 0.50$	7.137	7.170	6.750	7.490	0.208	2.065	-0.069
$\tau = 0.75$	7.886	7.850	7.500	8.390	0.250	2.044	0.413
$\tau = 0.95$	9.049	9.020	8.410	9.950	0.479	1.700	0.261
FD							
$\tau = 0.25$	0.781	0.790	0.190	1.030	0.202	3.475	-0.962
$\tau = 0.50$	1.113	1.110	1.040	1.180	0.043	1.887	0.033
$\tau = 0.75$	1.259	1.260	1.190	1.340	0.052	1.503	0.048
$\tau = 0.95$	1.446	1.430	1.350	1.600	0.068	2.127	0.459
POP							
$\tau = 0.25$	6.156	6.195	5.670	6.530	0.265	1.812	-0.317
$\tau = 0.50$	6.704	6.705	6.540	6.850	0.090	1.891	-0.109
$\tau = 0.75$	7.018	7.010	6.860	7.210	0.095	2.072	0.193
$\tau = 0.95$	7.790	7.885	7.220	8.280	0.346	1.631	-0.343
HC							
$\tau = 0.25$	1.740	1.760	0.910	1.870	0.141	1.534	-3.003
$\tau = 0.50$	1.935	1.930	1.880	2.010	0.038	2.251	0.623
$\tau = 0.75$	2.065	2.060	2.020	2.120	0.031	1.725	0.212
$\tau = 0.95$	2.200	2.175	2.130	2.310	0.060	1.743	0.516
EP							
$\tau = 0.25$	1.493	1.520	1.010	1.710	0.161	3.606	-0.866
$\tau = 0.50$	1.859	1.870	1.720	1.960	0.072	2.064	-0.447
$\tau = 0.75$	2.036	2.020	1.970	2.150	0.048	2.782	0.838
$\tau = 0.95$	2.408	2.435	2.160	2.620	0.152	1.701	-0.022

Appendix B. Correlation Analysis

Table 5.2

	EF	CO2	GDP	GDP^2	TO	FDI	FD	POP	HC
EF	1.000								
CO2	0.707	1.000							
	(0.000)								
GDP	0.894	0.798	1.000						
	(0.000)	(0.000)							
GDP^2	0.671	0.527	0.554	1.000					
	(0.000)	(0.000)	(0.000)						
TO	-0.396	-0.182	-0.330	-0.233	1.000				
	(0.000)	(0.001)	(0.000)	(0.000)					
FDI	0.363	0.422	0.465	0.403	0.083	1.000			
	(0.000)	(0.000)	(0.000)	(0.000)	(0.157)				
FD	0.098	0.148	0.029	0.109	0.549	0.040	1.000		
	(0.000)	(0.000)	(0.620)	(0.062)	(0.000)	(0.490)			
POP	0.979	0.727	0.874	0.736	0.388	0.389	0.089	1.000	
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.128)		
HC	0.336	0.286	0.179	0.421	0.115	0.280	0.111	0.384	1.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.050)	(0.000)	(0.059)	(0.000)	
EP	0.518	0.322	0.457	0.290	0.068	0.493	0.107	0.488	0.562
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.069)	(0.000)	(0.000)

Appendix C. The Wald test for the equality of slopes

Table 5.17

	0.10 vs. 0.25	0.10 vs. 0.50	0.10 vs. 0.75	0.10 vs. 0.95
Dependent Variable: CO2 emissions				
GDP	-0.045	-0.254***	-0.387**	-0.494**
	(0.697)	(0.091)	(0.024)	(0.030)
GDP^2	-0.013	-0.040*	-0.044*	0.083*
	(0.173)	(0.001)	(0.000)	(0.001)
TO	-0.073	-0.061	0.022	0.117
	(0.111)	(0.325)	(0.723)	(0.262)
FDI	0.003	0.006	0.002	0.031*
	(0.471)	(0.217)	(0.603)	(0.000)
FD	0.001	-0.045	-0.076	-0.172*
	(0.956)	(0.321)	(0.149)	(0.002)
POP	0.007	0.056	0.027	-0.050
	(0.883)	(0.441)	(0.777)	(0.560)
HC	0.034	-0.010	-0.049	0.127
	(0.691)	(0.940)	(0.703)	(0.200)
EP	-0.018	0.003	0.113*	0.061
	(0.448)	(0.940)	(0.008)	(0.397)
Dependent Variable: Ecological footprint				
GDP	-0.077	-0.048	-0.220	-0.144
	(0.472)	(0.718)	(0.306)	(0.750)
GDP^2	-0.017***	-0.037*	-0.031	-0.048
	(0.100)	(0.007)	(0.131)	(0.285)
TO	0.062	0.092	0.054	0.057
	(0.400)	(0.313)	(0.594)	(0.702)
FDI	-0.002	-0.005	-0.001	-0.006
	(0.336)	(0.168)	(0.877)	(0.649)
FD	-0.055	-0.143*	-0.131**	-0.222
	(0.113)	(0.000)	(0.024)	(0.141)

POP	-0.173**	-0.288**	-0.324*	-0.266
	(0.042)	(0.013)	(0.009)	(0.130)
HC	0.214**	0.295**	0.321*	0.221
	(0.018)	(0.021)	(0.006)	(0.150)
EP	-0.088**	-0.141*	-0.147*	-0.149*
	(0.041)	(0.007)	(0.001)	(0.001)

Note: *, **, *** denote the rejection of null hypothesis at 1, 5 and 10% levels of significance respectively.

LIST OF PUBLICATIONS

Halliru A. M., Loganathan N., Hassan, A. A. G., Mardani, A. and Kamyab, H. (2020). Re-examining the environmental kuznets curve hypothesis in the economic community of West African states: A panel quantile regression approach.*Journal of Cleaner Production*,276, 10 December 2020, 124247https://doi.org/10.1016/j.jclepro.2020.124247

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