NEAR EAST UNIVERSITY

INSTITUTE OF GRADUATE STUDIES

DEPARTMENT OF ECONOMICS

ECOLOGICAL FOOTPRINT AND ENVIRONMENTAL DEGRADATION: DOES FINANCIAL DEVELOPMENT IMPROVE RENEWABLE ENERGY?

Ph.D THESIS

Thomas Abuobeleye AKPANKE

Nicosia

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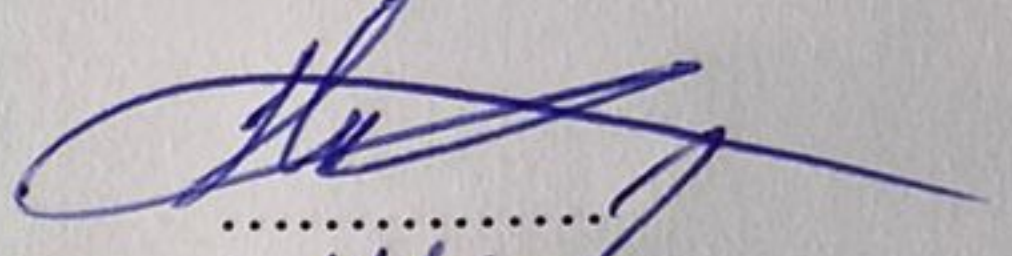
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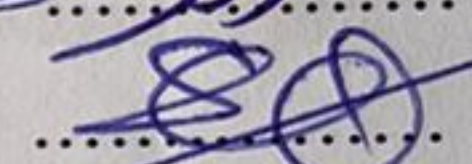
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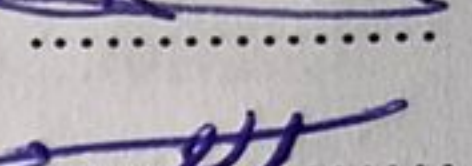
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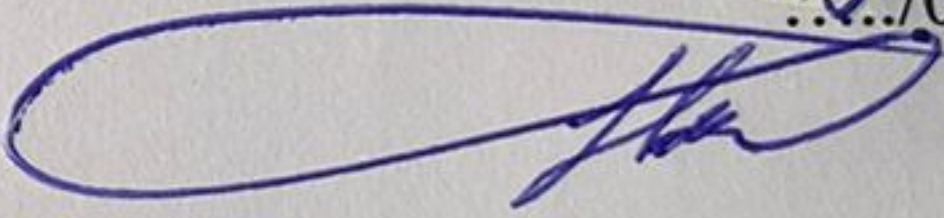
January, 2024

Approval

We certify that we have read the thesis submitted by **Thomas Abuobeleye AKPANKE** titled **"Ecological footprint and environmental degradation: Does financial development improve renewable energy?"** and that in our combined opinion it is fully adequate, in scope and in quality, as a thesis for the degree of Philosophy of Doctorate.

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Declaration

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Acknowledgments

Abstract

Ecological footprint and environmental degradation:
Does financial development improve renewable energy?

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Ph.D, Department of Economics

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Environmental degradation is a major concern across the world and it is exacerbated through the usage of non-renewable energy, which emits carbon content in the air. Thanks to the usage of renewable sources that are friendly to the environment. The present research is an attempt to examine the major factors that affect the environment, either positively or negatively, together with the main factors responsible for improving the development of renewable energy. The present study employs the dataset of the G7 countries, E7 countries and fifteen West African nations, to ensure a comparative analysis on whether different economic regions attain the same, or different findings. The main novelty of the present research is that it seeks to examine the effect of forest resources on the environment, together with investigating the role played by foreign direct investment and financial development among these three economic regions. The CS-ARDL, panel ARDL, fixed effects and random effects methods are employed for data analysis. The major findings depicts that forest resources, renewable energy and energy efficiency negatively affects carbon emissions, while Gross Domestic Product and non-renewable energy positively affects carbon emissions in the three regions under research. The findings on the factors that influence renewable energy are mixed across the three economic regions. Financial development is essential in enhancing renewable energy development, while foreign direct investment does not present any significant effect and inflation rate negatively influences the development of renewable energy. The policy recommendations in the present research are also given.

Key Words: Environmental degradation; Renewable Energy; Forest resources; Financial development; Economic growth

Özet
Ekolojik ayak izi ve çevresel bozulma:
Finansal gelişme yenilenebilir enerjiyi geliştiriyor mu?

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Ph.D, Ekonomi Bölümü

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Çevresel bozulma, dünya çapında önemli bir endişe kaynağıdır ve havaya karbon içeriği yayan yenilenemeyen enerjinin kullanılmasıyla daha da şiddetlenmektedir. Çevreye dost yenilenebilir kaynakların kullanımı sayesinde. Bu araştırma, çevreyi olumlu ya da olumsuz etkileyen ana faktörleri, yenilenebilir enerjinin gelişimini iyileştirmekten sorumlu ana faktörlerle birlikte inceleme girişimidir. Bu çalışma, farklı ekonomik bölgelerin aynı veya farklı bulgulara ulaşıp ulaşmadığına dair karşılaştırmalı bir analiz sağlamak için G7 ülkeleri, E7 ülkeleri ve on beş Batı Afrika ülkesinin veri setini kullanmaktadır. Mevcut araştırmanın ana yeniliği, bu üç ekonomik bölge arasında doğrudan yabancı yatırım ve finansal gelişmenin oynadığı rolün araştırılmasıyla birlikte, orman kaynaklarının çevre üzerindeki etkisini incelemeyi amaçlamasıdır. Veri analizinde CS-ARDL, panel ARDL, sabit etkiler ve rastgele etkiler yöntemleri kullanılmaktadır. Başlıca bulgular, araştırılan üç bölgede orman kaynakları, yenilenebilir enerji ve enerji verimliliğinin karbon emisyonlarını olumsuz yönde etkilediğini, Gayri Safi Yurtiçi Hasıla ve yenilenemeyen enerjinin ise karbon emisyonlarını olumlu yönde etkilediğini göstermektedir. Yenilenebilir enerjiyi etkileyen faktörlere ilişkin bulgular, üç ekonomik bölgede karışıktır. Genel olarak konuşursak, finansal gelişme, yenilenebilir enerji gelişimini artırmada esastır, ancak doğrudan yabancı yatırım önemli bir etki göstermez ve enflasyon oranı, yenilenebilir enerji gelişimini olumsuz etkiler. Mevcut araştırmadaki politika önerileri de verilmektedir.

Anahtar Kelimeler: Çevresel bozulma; Yenilenebilir enerji; Orman kaynakları; Finansal gelişme; Ekonomik büyüme

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List of Abbreviations

3SLS:	Three-stage Least Squares
ADF:	Augmented Dickey-Fuller
AMG:	Augmented Mean Group
ARDL:	Autoregressive Distributive Lag
ASEAN:	Association of Southeast Asian Nations
BM:	Broad money
BRICS:	Brazil, Russia, India, China, and South-Africa
CCEMG:	Common Correlation Effect Mean Group
CE:	Carbon emission
CEE:	Central and Eastern Europe
CIS:	Commonwealth and Independent States
CO2:	carbon-dioxide
CPI:	Consumer Price Index
CD:	Cross-sectional dependence
CS-ARDL:	Cross-sectionally Augmented Autoregressive Distributive Lag
DF:	Dickey-Fuller
DOLS:	Dynamic Ordinary Least Squares
E7:	Emerging seven countries
ECOWAS:	Fifteen West African nations
ECT:	Error Correction Term
ED:	Environmental degradation
EE:	Energy efficiency
EG:	Economic growth
EFP:	ecological footprint
EKC:	Environmental Kuznets Curve
EMT:	Ecological modernization theory
EPU:	Economic policy uncertainty
EU:	Energy use
ETT:	Environmental Transition Theory
FD:	Financial development
FDC:	Frequency Domain Check

FDI:	Foreign Direct Investment
FE:	Fixed effects
FL:	Forest land
FMOLS:	Fully Modified Ordinarily Squares
G7:	Seven developed countries
GDP:	Gross Domestic Product
GHG:	Greenhouse gases
GMM:	Generalised Method of Moments
GLS:	Generalised Least Squares
INFL:	Inflation rate
NARDL:	Nonlinear Autoregressive Distributive Lag
NWS:	New Member States
NRE:	Non-renewable energy
NREC:	Non-renewable energy consumption
OECD:	Organization of Economic Community Development
OLS:	Ordinary Least Squares
POLS:	Panel ordinarily square
POP:	Population
PP:	Phillips Perron
PSC:	Private sector credit
RE:	Renewable energy
REC:	Renewable energy consumption
SO2:	Sulphur dioxide
SDGs:	Sustainable development goals
SG:	Second-generation
SSA:	Sub-Saharan African
SSP:	Shared Socio-Economic Pathways
UK:	United Kingdom
UN:	United Nations
VAR:	Vector autoregressive
VECM:	Vector Error Correction Model

CHAPTER I
Introduction

Environmental degradation (ED) has emerged as one of the major problems in the world. The world is to this day suffering from various forms of environmental degradation and most of them are a result of using energy sources that are not safe to the environment. To this end, quite a good number of studies have been done to ascertain the impact of energy sources to the environment. The empirical findings depicts that non-renewable energy (NRE), a source of energy is one of the most critical type of energies, that is responsible for degrading the surroundings through carbon emission (CE) in the air (Deka et al., 2023a; Akadiri & Adebayo, 2022; Banga et al., 2022). NRE is not safe to the environment because one of its major types, fossil fuel, contains some carbon compounds in it, which are emitted into the atmosphere during use. Therefore, NRE use has been criticised and various nations are recommended to shun the use of NRE and sought for those energy sources that are good for the surroundings. It is very important for nations to identify those energy sources that are clean to the surroundings and recommend them to be banned in order to avoid the continuous degradation of the environment. The continuous usage of energy sources that degrade the surroundings is not good for society since these sources of energy cause harm to the environment and are also responsible for global warming, health problems, droughts, hunger and poverty across the globe (Becker & Fischer, 2013; Banga et al., 2022). Therefore, it is very essential to devise ways that can help in eradicating global warming effects, droughts and hunger, that is affecting countries across the globe, by coming up with alternative sources of energy better clean to the environment.

In as much as, NRE sources are not safe to the surroundings because of the presence of the carbon components that are emitted to the atmosphere during use. Empirical studies have indicated that NRE is responsible for enhancing the economic performance of a country through raising the country's Gross Domestic Product (GDP). The empirical results provided in the research of Adedoyin et al. (2021); Kadir et al. (2023); De Oliveira and Moutinho (2022) shows that NRE is crucial in promoting economic growth (EG) of nations. Empirical findings also depict that other nations, such as China have relied mostly on the use of NRE in order to boost

the economic performance of their nations (Qin et al., 2021). Qin et al. (2021) actually depicts that China has improved from being a developed nation to becoming an emerging economy through the vast use of NRE, which has enabled it to improve its GDP. However, it can be observed that the improvement in their economic performance of China with NRE has been attained at the expense of environmental degradation, since China is one of the greatest emitters in the world. Therefore, in as much as the NRE gives a significant positive effect on the economic performance of a country it is observed that it causes serious problems to the environment. The positive effect of NRE on the economic performance of a nation, together with the negative impact of NRE to the environment causes governments to arrive at a dilemma, whereby they become indecisive on what policies to follow. Should they follow policies that are responsible for enhancing the economic performance of a country, while ignoring the negative effects of NRE? Therefore, it is essential to come up with studies that examine the source of energy, which does not result in a trade-off either to protect the environment or to enhance economic performance.

While renewable energy (RE) is responsible for degrading the surroundings through emitting the carbon content in the environment, various studies have shown that RE is clean and safe to the environment and can be used as an alternative source of energy that is clean (Ajide & Mesagan, 2022; Akram et al., 2022; Bhat, 2018). Due to the friendly effect of RE on the environment, the aforementioned studies have encouraged countries to shift from the use of those energy sources that cause harm to the surroundings to the use of RE which is clean and safe to the environment. RE is not just safe to the environment, but it can be used repeatedly without getting finished, hence it's the best source of energy to use compared to NRE which is exhausted once it's used (Deka et al., 2022). RE do not just provide a negative impact on CE, which indicates that it reduces the emission of carbon to the environment, hence improving the quality of the environment. It provide a strong superb effect on the economic growth of economies (Balsalobre-Lorente & Leitao, 2020; Kadir, et al., 2023; Asif et al., 2021; Bayard & Gavriletea, 2019, among others). Therefore, it is observed that while RE is crucial in improving the quality of the environment across the globe, it is also responsible for improving economic performance of various nations. Thus, it is essential for economies to come up with ways that are responsible for enhancing the sources of RE in order to protect the environment,

enhance the health of the citizens of the country, as well as avoiding droughts which are caused by the use of NRE. Therefore, promoting the use of RE in their nations is important.

The empirical observations of the studies that were done in the past investigated the factors that are responsible for promoting RE resources in order to enhance a clean environment. These empirical findings are very crucial considering the postulations provided in the section above which shows that RE sources are vital for reducing the CE and hence improve the environmental quality. Therefore, it is necessary to come up with research that investigates the factors that promote the development of RE sources, so that RE sources can be improved and be readily available for use across the globe. The studies of Deka et al. (2023b); Mukhtarov, Yuksel and Dincer (2022); Akpanke, Deka et al. (2023a); Mukhtarov (2022) provided that financial development (FD) and EG are the main factors that promotes the development of RE sources across nations. While economic growth and FD have been observed to improve the sources of RE across nations, energy prices, rate of inflation and oil prices have been identified major factors that deters the development of a RE sources in various nations (Deka, et al., 2023b, Akpanke et al., 2023a; Mukhtarov et al., (2022). Therefore, it is clear that in order for regions to improve the sources of RE and at the same time enhance the quality of the environment, through the use of clean energy, it is essential to use financial advancement, together with the positive effects of economic growth in order to develop RE sources. Thus, a country that has advanced financial resources, as well as a high economic growth, is at an advantage of improving the sources of RE. Likewise, it is also essential to stabilise the inflation rate, the prices of oil, together with energy prices in order to enhance the improvement of sources RE across the globe. The present research adds to literature on the factors that enhance the sources of RE together with those that disrupts RE development, by undertaking a comparative analysis of the emerging seven countries (E7), seven developed countries (G7) and the fifteen West African nations (ECOWAS).

However, the findings of other empirical studies that has been done in the past shows that RE does not significantly impact the growth of the economy, neither does it produce a strong positive impact on the EG of nations, but rather a negative

impact (Bhat, 2018; Bayard & Gavriletea, 2019). For example, De Oliveira and Moutinho (2022) depicts that RE does not give any significant impact to the economic performance of a country. On the other hand, other studies depict that RE gives a strong negative effect on the performance of a nation's economy, see for example, Afroz and Muhibbullah (2022). The presence of mixed outcomes on the impact of RE on the performance of a nation's economy is the cause of concern among various nations, hence the need to come up with research that ascertains the true position on effect of RE sources on the performance of these nations' economy. This is so because if RE negatively influences the performance of a country's economy or does not significantly influence the performance of a country's economy, then this causes nations to avoid using RE energy sources, since this will affect the performance of a nation's economy. It is also paramount to ascertain the effect of RE on the performance of a nation's economy in order to persuade nations to adopt renewable sources of energy for the purpose of preserving the environment and at the same time improving the nation's economic performance.

In a bid to find ways that can significantly enhance environmental quality, natural resources have also been identified as one of the main factors that are responsible for enhancing environmental quality. Natural Resources, such as trees and grass are scientifically known for protecting the environment from land degradation. Trees and grass bind the soil together with their roots and cover it with their leaves and branches, hence protecting the soil from erosion. On top of that, trees and grass sheds their leaves which when composed will help to add nutrients to the soil. On top of protecting the soil from wash and wear, green plants through the scientific process of photosynthesis are responsible for making their food through the intake of carbon dioxide (CO_2) which is used as a raw material to produce the food of the plants, hence trapping the CO_2, which is in the atmosphere. The empirical studies that are provided for in the past research indicate that natural resources are essential in improving environmental quality (Abid et al., 2022). The postulations of Abid et al. (2022) are also supported through the empirical findings that are provided in the research of Ali et al. (2022), as well as in Amer et al. (2022), which was the importance of natural resources in improving the quality of the surroundings. However, it is observed that a dearth in literature is present in the research that examines the importance of natural resources, such as trees in

improving the quality of the surroundings. We also observed that trees, unlike RE sources, capture the carbon content that is available in the environment, thereby reducing the amount of carbon that is present in the air. RE sources improve the quality of the environment in the fact that it stops further emission of carbon into the air. However, it is worth noting that carbon content has already been emitted to the environment by the past usage of NRE sources, hence there is a need to come up with ways that can help trapping the carbon content that is present in the atmosphere, hence improving the quality of the environment. Among the ways that may be useful in trapping the carbon content that is available in the environment, improving natural resources by planting trees, which capture the carbon content through the process of photosynthesis, is vital. Therefore, the present study aims to cover the gap that is present in the literature by coming up with a study that includes natural resources in examining the impact of the factors that can reduce the emission of carbon in the atmosphere, hence promoting environmental quality.

Aim of the study

This study is aimed at:
- Investigating the role of forest resources in reducing the amount of carbon that is emitted into the air.
- Examining the impact of RE on the emission of carbon in the air among the E7, G7 entire 15 West African countries.
- Examining the role played by FD development in enhancing the development of RE among the E7, G7 and 15 West African countries.
- Investigating the impact of EG on the development of RE sources of the G7, E7 and fifteen West African countries.
- Examining the impact of NRE on the degradation of the environment of the G7, E7 and 15 West African countries.

Originality and main novelty of the research

The originality and novelty of the present research is given as follows:

- The present study provides a comparative analysis on the factors that affect CE and the factors that impacts CE among the three world economic regions, that is, the G7, E7 and the 15 West African countries.

- The present research includes forest resources in ascertaining its impact on the emission of carbon among the G7, E7 and the 15 West African nations, a study that has been partially done by past researches in other regions, hence feathering the growing body of literature.

- The present research further investigates the impact of RE on the emission of carbon among these three world economic regions considering the presence of mixed and contradicting findings that are presented in the studies of past research. Therefore, this research is essential in ascertaining the exact relationship that exists between RE and the emission of carbon for the purpose of making proper policies in this region.

- The current study also seeks to ascertain the effect of FD and EG on the development of RE among these three economic regions, hence furthering the growing literature on the factors which improve RE development.

- Unlike past studies which analysed the factors which impact RE, the present research includes Foreign Direct Investment (FDI) to ascertain its impact on RE. Poor countries that do not have financial resources to promote RE sources require other alternative factors that can improve the development of RE in their regions. Therefore, the West African countries and emerging economies that are not financially strong compared to developed countries may take advantage of FDI in order to enhance RE development.

- Unlike past researches that use energy prices in investigating on how it deters RE development, the present research uses inflation rate to proxy energy prices and hence examine its impact on RE development.

Research Questions

In line with the study aim presented above, the present study tries to answer the research questions listed below:

- Do forest resources play an essential role in reducing the emissions of carbon among the G7, E7 and 15 West African nations?
- Does RE play an essential role in lowering the emissions of carbon among the three world regions under research?
- Does NRE provide an asymmetric impact on the CE among the G7, E7 and the 15 W African countries.
- What is the role of EG and FD in enhancing the development of RE sources among the G7 E7 and 15 West African countries?
- Is there any significant asymmetric effect of RE and FD on the development of RE among the three world economic regions under steady.
- Does inflation rate give a strong impact on the RE development of the three world economic regions and what can be done to enhance the development of RE sources among these regions?

Research Strength

The strengths of the present research are given as follows:

- The present study is a comparative analysis of the three world economic regions, hence giving results that are applicable to the world over.
- The present research uses the contemporary methods of analysing data, such as the Cross-sectionally Augmented Autoregressive

Distributive Lag (CS-ARDL) in Chapter 6, which presents long-run outcomes, which are essential for making policies, and gives robust outcomes regardless of the existence of cross-sectional dependence (CD).

- The panel Autoregressive Distributive Lag (ARDL) tools, that is, the Pooled Mean Group (PMG) and Mean Group (MG) methods, which overcomes dynamics and heterogeneity in the model are used for data analysis in Chapter 7.

Research Limitations

The limitations of the present research are given as follows:

- The study is limited in the sense that it only considers three world regions, leaving out the other regions. However, these regions are among the major ones. Moreover, we have considered developing nations by including the West African nations, the emerging economies by considering the E7 economies, and the developed countries by including the G7 countries, thus a representative sample is attained.
- The research is also limited because it only considers CO2 emission to proxy environmental degradation, leaving out the other factors of ecological footprint. However, the emission of carbon has been identified as the main factor among other factors of ecological footprint (EFP), which greatly degrades the environment.

Structure of the Thesis

The structure of this Thesis is given as follows. Chapter 2 presents literature review on ED. The theories of ED are outlined, explained and criticised accordingly. Moreover, the empirical findings of past studies on the factors that affect ED are explained and criticised. Chapter 3 provides a literature review on the determinants on RE. We explore on the various indicators that promote or reduce RE; hence, examining the various ways that can be followed to promote RE, in line with past studies findings. Chapter 4 eplains FD, a major determinant of RE generations, as

given in the empirical studies explained in Chapter 3. Chapter 5 explores on the various factors that are related to FD, such as economic growth, among others. Chapter 6 provides a case study of ED in the E7, G7 and ECOWAS countries. A comparative analysis on how the ED in these regions is alleviated is presented. Chapter 7 gives an empirical study on the factors affecting RE development in the E7, G7 and ECOWAS countries. Lastly, in Chapter 8 we discuss the empirical findings of Chapter 6 and 7, comparing them with the findings of past research. Policy recommendations and future studies recommendation as well as the conclusion is given.

CHAPTER II

Literature Review on Environmental Degradation

Theories on Environmental Pollution

The "Environmental Kuznets Curve (EKC)" theory is one of the most popular theories of the degradation and Pollution of the surroundings (Shafik, 1994; Ma et al., 2021; Stern et al., 1996; Grossman & Kruger, 1995; Arouri et al., 2012; Seldon & Song, 1994). The EKC theory in line with the postulations of the aforementioned research shows that EG and ED are linked through the U like shaped link, which is upside down. This upside down U like shaped presented in the EKC theory, depicts that ED increases in the first instance because of EG increases in the country (Majeed & Luni, 2019). However, an increase in ED because EG has increased does not last forever. When the peak on the EKC is arrived at, further EG rise is linked with a drop in ED. Past researches have indicated that the first EKC part, which is upward sloping, is usually associated with a time when the country heavily depends on harmful energy, like NRE to enhance EG (Akpanke, et al., 2023b; Deka, Bako et al., 2023). Therefore, calls from environmentalists and the change of the economy from using NRE to RE which is not dangerous to the environment and enhance EG is the main reason behind the achievement of a turning point and a subsequent falling part of the EKC curve (Akpanke, et al., 2023b). Kuznets (1955) is known for first presenting the foundations of the EKC theory where he postulated that the inequality of income and income are connected in a U like shaped connection, which is upside down. Therefore, the postulations given in the study of Kuznets (1955) forms the basis of the EKC theory. Poor nations are always income oriented at the beginning, trying to achieve high EG levels. They are more concerned about butter that is the basic needs such as food for the people. In addition, at this point harmful activities to the surroundings can be engaged in to attain high EG, after having attained these basic food and shelter necessities they now look to other needs such as protecting the environment to attain better health. The theory presented by Abraham Marslow in what they termed the hierarchy of needs supports this assertion where lower basic

needs are sought to be met first before moving to higher level needs (see for review, Akpanke et al., 2023b). The EKC theory is supported in the studies of Khan et al. (2019); Chang (2010);Rahman and Mamun (2016); Hussain et al. (2012); Wahab et al. (2020); Safi et al. (2021); Jardon et al. (2017).

The Environmental Transition Theory (ETT) is amongst the most vital ED theories, which has been so far given in the literature. The ETT theory ascertains that economies have a tendency of facing challenges related to ED as they improve in their EG because of the massive demands of energy. The theory further alludes that the enhancement of the economy and the improvement of the surroundings are dynamically linked (Akpanke et al., 2023b). The difficulties linked to the environment as per the postulations of the ETT theory are given in two distinct stages. The first stage is when the challenges on the surroundings are brown agenda linked, that is, water supply problems, sewage issues as well as sanitation problems are faced. In the second phase EG connects to increase and the problems related to the grey agenda among cities emanates. The grey agenda problems faced in the second stage includes such problems as pollution to the surroundings from auto and industries. The third stage is that of post-industrial economies who often face green agenda challenges related to the surroundings, like the increase in the waste in urban areas, the emission of greenhouse gases (GHG) and thinning of the ozone layer. Studies such as Majeed and Luni (2019) give a significant correlation between the act of moving to the global stage from the local one with the act of moving from one environmental issue to another. The ETT suggests an improved long-run relationship arising from technological advancement, due to clean technology use, accompanied with environmental regulations and policies that are stricter.

The Ecological modernization theory (EMT) is another crucial theory of environmental degradation, which was founded in the 1980s at Free State University. The pioneers of the theory focused more on technological innovations to help in achieving environmental sustainability. The Ecological modernization theory puts more emphasis on the internalisation of environmental problems through political, social and economic institutions (Magazzino, 2017). This theory is of the view that both market and the state can come together and engage their combined efforts in protecting the environment. There are basically five clusters

which forms the basis of the EMT in presenting solutions to environmental degradation. (1) Technology and science is the anchor of solutions to the environment. (2) The modernization of political reforms on enhancing regulations and policies of environmental reforms. (3) Ecological reforms to be achieved through the support of market dynamics and economic agents. (4) Environmental quality is achieved through the abandonment of some cultural and social practices, to pave way for new ideas. (5) Social movements public and private organisations to be modernised in a way that promotes environmental reforms (Majeed & Luni, 2019). The study of Yang et al. (2018) found political modernization to significantly impact pollution in various ways, while Hashmi and Alam (2019) give the presence of negative links between emissions and environmental regulations. However, technology is observed to negatively affect environmental quality (Wang & Wei, 2020).

Empirical findings on the factors affecting Environmental degradation

The empirical findings on the relationship that exist between environmental degradation and its determinants has been widely done in the literature. While there is a wide range of studies that have examined the determinants of environmental degradation in the past, different findings have been observed on how those determinants affect environmental degradation. For example, other studies have indicated that RE significantly reduces the CE; hence reducing environmental degradation across the world, see Deka et al. (2023a); Banga et al. (2022); Adedoyin (2021); Akadiri et al. (2022). However, in the midst of a wide range of studies that shows that RE has a strong negative effect on CE. Other studies have provided that there is no positive significant effect on CE indicating that RE does not significantly improve the quality of the environment. The aforementioned studies have also indicated that NRE and EG are the major factors that degrade the surroundings due to the emission of carbon. There are also many other factors that has been employed to understand their effect on the environment such as energy efficiency and population size amongst many others, and there various observations outcomes indicated that energy efficiency is crucial in reducing environmental degradation since it reduces the emission of carbon in the air (Deka et al., 2023a). Therefore, it's clear from the postulations of previous research that no consensus

has been arrived at on how these factors affect environmental degradation. In this section we therefore examine the various empirical findings that have been postulated by the past studies on the effect of various factors on environmental degradation, hence giving us a position on how to understand the major factors that affect environmental degradation. Providing a deep literature review on the factors that affect environmental degradation, in this present study we will also enable the researcher to identify the research gap that exists in the literature and hence seek to cover that gap.

To begin with, in a study that was done in Turkey by Malik (2021), through the use of a data set that ranges from 1970 to 2014 by employing the Generalised Method of Moments (GMM) and the Three-stage Least Squares (3SLS) models. The findings that were presented in this study indicated a significant two-way string link between the series economic growth and the usage of energy, economic growth and the emission of CO_2, the use of energy and the emission of CO_2. These findings are essential in supporting the findings that were presented in the past studies, hence showing that these variables significantly influence each other. In addition to that, Malik (2021) depicted that the EKC hypothesis does not exist due to the presence of a monotonically rising association between economic growth and the emission of carbon.

Ben Mberek, Saidi and Feki (2018) also presented a research that was done in the four Mediterranean countries together with the inclusion of Turkey, Italy, Spain and France by making use of the dataset that ranges from 1980 to 2012. The researcher of Ben Mberek, Saidi and Feki (2018) made use of the Granger causality test, Vector Error Correction Model (VECM) and the Pedroni and Kao test of cointegration. Firstly, the findings of the cointegration test as per the Pedroni and Kao test indicated that the series that were used in the study have a strong long-run link. The long-run outcomes that were presented by the VECM indicated that EG presented a significant long-run effect on the emission of carbon among the four countries. However, it was observed that the findings that were presented by the VECM and the Granger causality analysis on the link between RE and the growth of the economy were contradictory, hence the feedback analysis was supported. Ben Mberek, Saidi and Feki (2018) depicted that the outcomes presented in their

research had significant effects on the policies connected to the economy and on energy use due to the fact that economic growth was obtained not to be improved by RE.

In the research that was done by Mughal et al. (2022) in the Asian economies by making use of the data set that ranges from 1990 to 2019 and employing the Fully Modified Ordinarily Squares (FMOLS) method, its empirical findings indicated that the quality of the environment among the South Asian countries has been worsened. Mughal et al. (2022) also presented individual country findings and in the case of Bangladesh CO2 emission was observed to be positively impacted through the use of NRE, technological innovation index and RE. Mughal et al. (2022) further confirmed the EKC hypothesis in the South Asian region by paying attention to the positive and negative values of GDP and its square root, respectively. In the South Asian economies GDP has also been observed to cause the emission of carbon and the utilisation of energy together with the growth of the nation has been observed to be linked through a two way relationship, Mughal et al. (2022).

In addition to the above-mentioned findings, Mershed, Rahman, Alam, Ahmad and Dagar (2021) examined the factors that impacts EFP across South Asian by employing the GMM, panel ordinarily square (POLS), random effects, fixed effects (FE), FMOLS and Dynamic Ordinary Least Squares (DOLS) models. The study of Murshed et al., (2021) accounted for CD, structural breaks issues and slope heterogeneity issues in the data set to obtain its major findings and revealed that environmental regulations have a direct or indirect effect in lowering EFP across the region. The findings of the research further verified that pollution haven hypothesis, as well as the EKC through the elasticity estimates. Murshed et al., (2021) further provided that the use of NRE and RE, respectively raises and lowering EFP. The joint effect of RE and environmental regulation has been observed to be essential in reducing EFP among South Asian countries. Of great importance on the findings presented by Murshed et al., (2021) is the significance of environmental regulations in reducing the negative effects to the surroundings by the use of NRE, FDI influence and EG, while enhancing the positive effects of RE on the environment. The findings of Murshed et al., (2021) also shows that the

impacts that are related to country specific results on environmental regulations on the EFP are less or more homogeneous in relation to the findings of the panel estimates.

The research of Mingran et al. (2018) that was done in China employed the vector autoregressive (VAR) methods with the dataset that ranges from 1990 to 2016. In the empirical findings of Mingran et al. (2018), a long-run correlation that is strong has been observed to exist between the variables industrial economic growth, the emission of sulphur dioxide (SO2) and the use of energy in the industry of China. These findings were obtained to tally with the status quo that existed in China's level of industrial development. In addition to that, Mingran et al. (2018) postulated that industrial development in China has been more dependent on the consumption of resources and this has severely damaged the environment, hence leading to a development pattern that is not sustainable. As a result, Mingran et al. (2018) recommended the government to promote the development of the economy in a coordinated manner, as well as to ensure sustainable development, through the limited use of resources, which ensures that less pollution is attained and high standard of ecological security is achieved.

In another research, by Mujtaba and Jena (2021) in India, which was done by employing the Nonlinear Autoregressive Distributive Lag (NARDL), approach with a data set that ranges from 1986 to 2014. The findings depicted that raising the growth of the economy has a strong impact of lowering the emission of CO_2, whereas reducing the growth of the country would tend to raise the emission of CO_2. Mujtaba and Jena (2021) provided that these outcomes support the presence of a significant inverted u-shaped link between the emission of CO_2 and the growth of the country. In addition to that, the outcomes presented in the research Mujtaba and Jena (2021) depicts that oil price has positive and negative shocks and presents a superb effect on the emission of CO_2. The pollution haven hypothesis is also supported by the findings observed on the effect of FDI inflows on the emission of CO_2.

In a different research that was done in Argentina by employing the Auto-aggressive Distributive Lag (ARDL) method, for a data set that ranges from 1971

to 2016. The findings observed show that the long-run estimations depict a significant link between the generation of renewable electricity, the globalisation of the nation, urbanisation, the growth of the country and CO2 emissions that are energy based, Murshed et al. (2021). The outcomes presented in this research also showed that improving the output of renewable electricity shares is observed to significantly deter emissions, but urbanisation together with the globalisation of the economy boost emissions. Furthermore, Murshed et al. (2021) observed that the combined effect of the generation of renewable electricity together with the globalisation of the economy gives a joint significant effect in reducing emissions of CO2 that are energy production related. The empirical findings of this study further authenticated the validity of the EKC hypothesis. The causality analysis according to Murshed et al. (2021) shows a unidirectional effect from the generation of RE, growth of the economy, globalisation of the country and urbanisation, to the emission of CO2 which is related to energy production.

Mahjabeen et al. (2020) in a research that was done in the D8 countries through the use of the ARDL model, FMOLS and DOLS techniques by employing the data set that ranges from 1990 to 2016, the outcomes shown by the panel ARDL method shows that the variables that were employed in the study were significantly cointegrated. On the other hand, the findings that were presented by the FMOLS technique shows that the use of RE positively affected EG together with the degradation of the environment. Mahjabeen et al. (2020) also showed that protecting the quality of the environment is achieved through the stability of institutions. Due to the findings presented in this research Mahjabeen et al. (2020) suggested a blending of the two types of energy sources together with a gradual transition in attaining the use of RE. Mahjabeen et al. (2020) also emphasised on the wise implementation of policies together with the technological advances in order to preserve, produce and transmit the production of RE.

In another study that was done in China, which employed the quantile regression method by using the data set that ranges from 1990 to 2017. The abundance of fossil fuel has been observed to exert a large impact on the growth of the economy in the case of the intermediate quantile provinces since these provinces processes large petroleum and produces more coal gas, Liu et al. (2021).

Furthermore, the outcomes presented in the study of Liu et al. (2021) depicts that the emission of CO2 in the higher quantiles have the largest effect from the use of fossil energy since these provinces use more oil and coal. Further to that, Liu et al. (2021 depicted that in the 50th to the 75th and in the upper quantiles the effect is observed from RE abundance to economic growth is high because the industries of RE growth in this region are growing fast. The research also observed that the effect of RE abundance on the emission of CO2 across all the quantiles is positive, hence indicating its insignificant role in reducing the emission of CO2. Liu et al. (2021) recommended each quantile province to come up with the rules that can specifically promote RE growth, hence actively reduce environmental degradation and promote economic growth in those specific quantiles.

Liu et al. (2021) also examined the major factors that affect the emission of CO2 in the North East Asian countries by employing the FMOLS and the DOLS method on the data set that ranges from 1995 to 2014. The empirical findings of the long-run estimates depicted that both sources of energy, that is, RE and NRE, together with urbanisation tend to raise the emission of CO2, whereas the growth of the country was observed to reduce the emission of CO2. The study of Liu et al. (2021) further employed the Granger causality technique in order to examine the link that exists between the series selected. The findings of the Granger causality technique depicts the existence of a two way causal link on the use of NRE and the emission of CO2, whereas the other variables were observed to exhibit a unidirectional association. According to the empirical findings observed in the study of Liu et al. (2021), recommendations were put in place to ensure that the government allocates resources in the urban areas in a reasonable and smart manner. Policy makers have also been called to extend more attention on the sources of energy that is renewable, in such a way that enables NRE to be more efficient and RE to be more popularised.

The research that was done by Lin et al. (2021) in China, that used the nonparametric additive regression model, shows the availability of an inverted U-shaped association on the variables EG and the abundance of fossil energy in the eastern region of China, which is observed to be caused by changes in cooking investments, oil processing and coal mining. The findings of the study also provides

the presence of a positive U-shaped association which is nonlinear, of fossil energy abundance on EG in the central region of China, Lin et al. (2020). The aforementioned findings in this study depicts that the abundance of fossil fuel does not play a strong effect in enhancing the development of the economy in China during the early stages while its effects are not significant in the later stages. The findings of Lin et al. (2020) further depicts the availability of a positive U-shaped association from the abundance of fossil fuel to the emission of CO_2 in the central and eastern regions of China, which is aligned to changes in the oil and coal use at various stages. However, in the western region the findings show that the abundance of fuel exhibits a significant inverted U-shaped effect, which is nonlinear on the emission of CO_2 due to phase difference in the use and production of oil and natural gas.

Another study was done in the BRICS countries and it employed Fourier ARDL model on the data set that ranges from 2000 to 2019, Li et al. (2022). According to the findings of Li et al. (2022), China and Brazil provided a strong long-run link between the series economic development, emission of CO_2 and health expenditure. In this study, the emission of CO_2 was taken as the dependent variable while the other variables, such as the growth of the economy and the expenditure on health were presented as the independent variables. The short-term outcomes presented in the study of Li et al. (2022) depicted that in the case of India the emission of CO_2 and the expenditure on health have a significant negative causal association. In the case of other BRICS countries, a unidirectional association was observed between the variables growth of the country's economy, expenditure in health and the emission of CO_2.

Khan et al. (2022) examined the factors that are responsible for improving the growth of the economy, as well as the sustainability of the environment among the top 10, as well as the selected countries that are close to the bottom from the sustainable development goals (SDGs) index 2021. The research of Khan et al. (2022) used the data set of these countries from 1990 to 2016 and employed the random effects, as well as the panel generalised least squares regressions. The panel cointegration technique of Westerlund was also employed to examine the availability of a long-run link among the series. The findings of the panel

cointegration technique by Westerland indicated that the series employed in the study had a significant long-run association. The research's main findings depict that the development of transformative and world energy trilemma seems to enhance the development of the economy and the sustainability of the environment, Khan et al. (2022). Many financial assets investment together with the usage of energy has been observed to enhance economic development but worsens the sustainability of the environment. Khan et al. (2022) suggested that the aforementioned outcomes in this research indicate that nations have to enhance the coherence in energy policy, as well as integrating the actions of energy policy through means of balancing the dimensions of energy trilemma in a bid to help improve the energy system.

Khan et al. (2022) also examined the impact on the EG and the emission of carbon in the high income, as well as the low income nations by employing the GMM technique on a data set that ranges from 2002 to 2019. The findings presented in the research of Khan et al. (2022) shows that all the series employed in the research had a significant effect on the emission of carbon, as well as the growth of the economy. The results of the study further presented that trade openness, FD and the receipts on international tourism had a tendency of raising development of a country's economy, while reducing the emission of CO_2, Khan et al. (2022). Furthermore, the findings of Khan et al. (2022) depict that tourism arrivals together with RE lowers the emission of CO_2, whereas tourism exports and economic growth are the main factors that are responsible for enhancing the emission of carbon. The findings were also observed to be different in countries with different income levels. The EKC hypothesis was also observed to hold in the high-income level countries while in the low-income level countries it did not hold. Khan et al. (2022) showed shows that the enhancement of FD in tourism lowers the level of emission but improves the growth of the country's economy, whereas the use of RE has the tendency of lowering both economic development and the emission level.

Khan et al. (2022) examines the factors that are responsible for influencing the emission of carbon among the Eeast Asian economies by making use of the FMOLS technique on the data set that ranges from 1997 to 2020. Khan et al. (2022)'s findings presented in their research depict that GDP, trade, and economic

policy uncertainty (EPU) gives a strong positive correlation on the emission of carbon in the East Asian countries. The findings further indicated that the use of a RE together with FDI have the effects of boosting the quality of the surroundings in this region, Khan et al. (2022). The causality test employed in the research of Khan et al. (2022) further indicated the existence of a two-way association between EPU and the emission of CO2, the use of energy and the emission of CO2, the growth of the country's economy and the emission of CO2, and trade and the emission of CO2. Khan et al. (2022) further employed the FMOLS model to check if the results of the Granger causality technique are robust.

Habiba et al. (2021) also examined the factors that impact the emission of CO2 among the G-20 countries and developing nations by employing the Common Correlation Effect Mean Group (CCEMG) model, as well as the Durbin-Hausman Test. With the dataset that ranges from 1981 to 2017, Habiba et al. (2021) show that the index of the stock market development lowers the emission of carbon when the whole sample is used and in the case of the developed countries, but it raises the emissions of carbon in developing nations. The findings also depicts that the financial institution development index raises the emissions of carbon in the sample of developed countries and that of the full sample, while in the case of developing countries it is observed to be insignificant, Habiba et al. (2021). In addition to that, the usage of RE was observed to lower the effect of environmental degradation in all the panels.

Hanif (2018), did a research in the Sub-Saharan African (SSA) countries by employing the systems GMM technique on the data set that ranges from 1995 to 2015. The research show that the factors that significantly raise the emission of CO2 are the use of solid fuels, as well as fossil fuels, for the purposes of expansion of urban areas and cooking. The findings presented in the research of Hanif (2018) presented an association that is U-shaped and inverted in form among the emission of CO2 and economic growth per capita. Therefore, in the SSA countries the EKC hypothesis is confirmed especially among the low income and middle-income economies. Hanif (2018) further depicts that using RE sources enhances the quality of the air by reducing the emission of carbon, hence reducing toxic gases to meet households.

In the research of Gulistan et al. (2020) which employed 112 nations from 1995 to 2017 with the FE model and the Generalised Least Squares (GLS) technique the existence of the EKC hypothesis was confirmed. This study further confirmed the level of income at the turning point, hence enabling the improvement in the quality of the environment for the selected sample countries, Gulistan et al. (2020). The study according to its major findings of the overall sample depicted that tourism, the use of sources of energy and the growth of the country's economy harms the environment, while trade openness does not present any significant effect. Gulistan et al. (2020) also presented that the findings that were obtained from the sub samples were mixed. Gulistan et al. (2020) Furtherfurther elaborated in line with the outcomes of the research that various and crucial steps need to be considered by the government as well as the international environmental agencies in protecting the environment, via the utilisation of energy in a way that is efficient and implementing sustainable tourism.

In addition to the outcomes presented above, Fu et al. (2021) in a study of the top ten best performing nations in the world by employing the Fuzzy-TOPSIS method, presented Denmark as a country that is a ranked first in energy efficiency since it has a score of one in the energy security. Fu et al. (2021) further show that Denmark is ranked number seventeen in terms of environmental sustainability and number eleven in energy equity. In contrast to the outcomes presented in the case of Denmark, Germany has been observed to dominate all the top 10 performers through environmental and energy progress, while the United Kingdom (UK) has been observed to be strong in the realms of social progress. Fu et al. (2021) alluded that holding other things constant, a higher price of energy depicts a higher level in the shortage of energy sources, hence promoting working towards the cheaper RE sources. Moreover, the act of paying an extra dollar to the company for promoting less emission enables carbon valuation to lower GHG emissions, Fu et al. (2021).

The study of China, which employed the factor decomposition method for the data set that ranges from 2000 to 2019 of Gong et al. (2022), depicted the major force of the emission of $CO2$ as economic growth. Gong et al. (2022) further postulate that the use of energy together with the intensity greatly impacts the

emission of CO2 for a range of a few years while the latter has a more effect than the former. The findings of this study further presents that the elasticity decoupling between the growth of the country's economy and the emission of CO2 has moved from weak decoupling to growth and then back to weak decoupling. Gong et al. (2022) further observed that the observed weak decoupling in the present research would tend to further increase towards the short-term as well as the medium-term.

Furthermore, Dash et al. (2021) in a research of the Brazil, Russia, India, China and South-Africa (BRICS) countries taking into consideration the data set that ranges from 1965 to 2019 depicted that a rise in per capita income together with rising population size positively impacts pollution in this region. The findings further showed that improvements in the industrialization led to investment in the production among the BRICS economies greatly impacting pollution, as well as reduction in the standards of the environment, Gong et al. (2022). Gong et al. (2022) also depicts that the use of natural resources by people, because of an increase in EFP, has caused higher intensity emission in the period. The usage of hydroelectric power has also been observed to cause more pollution, in as much as it improves growth among the BRICS economies.

Chen et al. (2021) did a research in the BRICS economies by employing the data set that ranges from 1990 to 2019 and employing the Augmented Mean Group (AMG), as well as the CCEMG technique. The study findings depict that the use of energy has a tendency of worsening the quality of the surroundings through the high emissions of CO2. Economic growth is also observed as the major factor that impacts the emission of CO2, whereas the growth of the population together with urbanisation observed are main predictors of CE, Chen et al., (2021). The causality test employed in this research depicts that a significant bidirectional causal effect among the variables CE and EG, EG and the use of energy, population growth and economic growth, urbanisation and the use of energy, and between urbanisation and EG exists.

Cetin et al. (2018) examined the major factors that contribute to the emission of carbon in Turkey by using the data set that ranges from 1960 to 2018 and employing the VECM, as well as the Granger causality technique. The findings of

their research depicted the existence of a long-run association between real income per capita, use of energy per capita, FD, the openness of trade and the per capita CE. The findings further indicated that the emission of carbon is mainly determined with the use of energy, FD, economic growth and trade openness. Cetin et al. (2018) also depicts that in the case of Turkey, according to the findings of their study, the EKC hypothesis is validated in both short- and long-run.

A study by Apeaning (2021) used 134 countries, employed the data set that ranges from 1995 to 2015 and used the decomposition analysis and Shared Socio-Economic Pathways (SSP). Their findings depicts that in the case of less mature developing nations energy system is found to be causing more CE at a higher rate when compared to developed nations. The findings presented in the research of Apeaning (2021) further assures that in the emerging economies a transition that is progressive towards weak decoupling is present. Apeaning (2021) further indicated that when a comparison is undertaken between developed and developing nations, developing nations have low decoupling and decarbonization signs. Developing nations have been observed to be promoted to achieve decoupling through a mix emission factor, conventions, efficiency of structural technology drivers and intensity deterioration, Apeaning (2021).

Adedoyin et al. (2021) studied the Central and Eastern Europe (CEE), Commonwealth and Independent States (CIS), and New Member States (NMS) by employing the data set that ranges from 1992 to 2014 and employing the GMM method. Their results provides that one of the conditions towards becoming a European Union (EU) member includes diversification in the use of renewables, as well as the protection of the environment and energy security, which has been observed as one of the ambitious energy policy. The findings presented in the study Adedoyin et al., (2021) postulated that a rise in the generation of RE as a tendency of raising the emission of CO2 among the CIS and CEE economies. However, it has been observed that raising the generation of RE has a tendency of decreasing the emission of CO2 among the NMS nations.

The empirical findings that have been provided so far in this section on the major determinants of environmental degradation have indicated that the main

factors that improve the quality of the surroundings are RE, energy efficiency and environmental policy, among many others. However, the findings that are provided in this section depicts that mixed findings have been observed on the influence of RE and the efficiency of energy on the environment. Other findings depict that RE and energy efficiency are the major factors that reduce environmental degradation. However, it is observed that few other researches depict that RE and energy efficiency does not have any significant effect on the environment in other regions, while in other regions they actually exacerbate environmental degradation. This shows that there is no consensus on the findings that are provided in the past studies on how RE and energy efficiency can impact environmental degradation. However, most studies show that they improve the quality of the surroundings. As a result, there is a need to do more research in examining the exact impact of RE and energy efficiency on the environment. Therefore, the present study seeks to further the literature on the effect of the efficiency of energy and RE on the surroundings by examining three major world economies, that is, the G7, E7 and 15 West African countries. The findings of this literature research also depicted that economic growth or GDP and the use of fossil fuels, among many other factors, such as FD and trade openness, are the major factors that are responsible for degrading the environment. While these factors have been depicted to worsen the quality of the environment by further degrading it, other few researchers have indicated that these factors may also have an impact of improving the quality of the environment. However, there is a bit of consensus on the findings presented in the literature of past research due to the overwhelming evidence that shows that these factors are harmful to the environment. The literature review presented on the factors that are affecting the environment has presented a dearth of the studies that have examined the influence of forest resources on the environment. There is still more work that is required to be done to understand how forest resources can affect the environment. This is so because green plants, such as trees and grass use CO_2 during the process whereby they make food, which is known as photosynthesis, hence trapping the CO_2 that is in the atmosphere. As a result, this is essential to come up with an innovative research that examines the influence of forest resources in lowering CE in the air. Past researchers have concentrated on promoting the utilisation of RE for lowering the emission of CO_2 in the air. However, it must be noted that some CO_2 content has been already accumulated in the atmosphere due

to the vast usage of fossil fuels by countries in the past and the usage of RE will not have an impact of capturing this carbon content that is in the atmosphere. As a result, it is essential to come up with some research that seeks to come up with policies that can be used in order to capture the carbon content that is in the atmosphere. Therefore, this is the major novelty of the present research.

Table 2.1 Summary on the empirical findings of environmental degradation

Author	Region	Model	Findings
Asif et al. (2021)	99 world countries 1995 – 2017	DOLS, FMOLS, Fixed Effects models	NRE and RE consumption gives a strong effect that is positive on economic growth
			The relationship of the growth of the economy differs because of income, and regional classifications
			Labour and capital the control variables in the model are observed to provide a positive significant effect on EG
			Energy consumption play a vital role in boosting development and growth of economies
			Wide range use of NRE however tends to result in the stress of the environment.
			RE is given as the vital energy source which encourages economic growth with no harm being inflicted to the environment

Table 2.1 Continued….

Apeaning (2021)	134 countries 1995 – 2015	Decomposition Analysis, Shared Socio-economic Pathways (SSP)	Energy system in less mature developing countries is observed to be carbonising at a faster rate in comparison two developed countries
			A progressive transition towards weak decoupling is observed in emerging economies.
			In comparison to developing countries, developing countries have very low signs of decarbonization and decoupling.
			In developing countries, the major points towards achieving decoupling are deterioration of intensity and structural technological drivers' emission factor conversions efficiency and fossil fuel mix.
			Co2 = GDP/capita, total pollution, emission factor, the mix of fossil fuel, conversion efficiency, GDP's final energy intensity

Table 2.1 Continued….

Amirnejad et al. (2021);	MENA countries	GMM	The EKC hypothesis existence is observed on the association between GDP per capita and image forest depletion
	2005 – 2017		Healthcare expenditures trouble clothes incidence end energy forest depression observed to be increased buy carbon emissions
			healthcare costs and energy depletion have a positive relation with energy demand urbanisation is also observed to raise energy depletion and the costs of healthcare
			Healthcare costs and super closes instances in the MENA region increased by the consumption of fossil fuel
Akram et al. (2022)	Mexico, Indonesia, Nigeria and Turkey (MINT)	Novel hidden panel cointegration, Panel ARDL	energy efficiency, together with RE strongly lowers CE
			CE is positively influenced through the reduction of energy efficiency
	1990 – 2014		CE is greatly reduced with the positive influence of energy efficiency

Table 2.1 Continued….

Ali et al. (2020)	100 countries 1995 – 2017		There is long-run causality for GDP in countries with free politics
			Political stability benefits the economy
			Total reserve and FD have a bi directional causality with GDP
			The RE led growth hypothesis is confirmed through the outcomes of the present research
			In countries with less political freedom GDP is observed to be in significantly affected by RE and total reserves
Alexeev and Chih (2021)	US	Ordinary Least Squares (OLS), FE, Spatial dependence technique	Price shocks strongly influence economies
			Negative and positive price shocks do not give a strong asymmetric effect

Table 2.1 Continued….

Alam et al. (2022)	Oman 1972 – 2019	GH cointegration, Variance Inflation Factor; ARDL, DOLS, FMOLS	A long-run association among the variables carbon productivity level, FD, energy efficient, energy consumption, is observed
			High financial development and energy consumption are observed to reduce carbon productivity, whereas energy efficient boost CE
Alper et al. (2022)	top 10 countries of carbon emissions 1970 – 2017	Fourier bootstrap ARDL cointegration, Fourier bootstrap Toda-Yamamoto causality methods	A significant long-term association between EG, economic globalisation, the utilisation of energy, and EFP is observed
			In general energy utilisation and EG in the long run affect EFP negatively, while economic globalisation provides a positive impact

Table 2.1 Continued….

Akadiri and Adebayo (2022)	India 1970 – 2018	NARDL	India is the largest emitter of CE in line with the International Energy Agency
			NRE has a strong positive influence on CE
			The consumption of RE reduces CE
			Financial development favourable shock enhance CE
			economic growth is positively related to CE
Ahmad et al. (2019)	Myanmar 1990 – 2016	ARDL, DOLS, FMOLS, GH cointegration	Total energy use do not give a strong influence on EG
			RE use significantly promotes EG, while NRE gives a negative effect
			In the availability of the inefficiency in technology NRE is counterproductive
			labour force fosters economic growth

Table 2.1 Continued....

Akram et al. (2021)	BRICS countries 1990 – 2014	Quantile regression analysis	Energy efficiency fosters EG
			The effect of energy efficiency across all quantiles is positive and significant
			RE consumption is found to decrease economy growth significantly
			A two-way causal effect between EG and RE consumption is observed
			Energy efficiency causes renewable energy consumption
Abbasi et al. (2021)	UK 1970 – 2019	ARDL, Frequency Domain Check (FDC)	Economic growth industrial value-added natural resource depletion stimulates the emissions of carbon dioxide in the short run
			Industrial value added, the utilisation of energy and population growth boost the sustainability of the surroundings in the long-run
			FDC model supports the short-medium- and long-run causality

Table 2.1 Continued….

Adedoyin et al. (2020)	NMS; CEE; CIS 1992 – 2014	GMM	European Union membership conditions include Environmental Protection energy security and diversification using renewables, which is seen as an ambitious energy police objective
			Increase in renewable energy generates rise in carbon dioxide emissions in CEE and CIS nationals, by 0.02 and 0.04% respectively
			It's however findings in a drop in carbon emissions of NMS nations
			In the CIS and NMS countries the EKC hypothesis is upheld
			The EKC hypothesis is not upheld in CE countries
			Environmental degradation across the blocks is different

Table 2.1 Continued….

Ahmad et al. (2020)	China 2001 – 2017	Modified STIRPAT	Investment in energy induce the effect of emission promotion
			The effect of emission curtailment is pioneered through EG.
			As compared to emissions promotion effect the emissions curtailment effect are slightly stronger
			Economic performance deterioration's effect is exacerbated through SO2 emissions
			the effect of Economic performance enhancement is exceeded by the economic performance deterioration's effects
			A two-way effect is determined between growth in gross regional product and emissions SO2
			A bilateral causal association between gross regional product growth end energy investment is observed

Table 2.1 Continued….

Adom et al. (2021)	51 African countries	GMM	Energy efficiency improvement induces economy growth
	1991 – 2017		in countries with high income inequality, it is compromised
			Energy efficient total effect on economy's growth is low in countries that have high income equality compared to those with law income equality
Afroz and Muhibbullah (2022)	Malaysia	NARDL	The asymmetric effect of NRE use and RE on economy growth in the long- and short-run, is determined
	1980 – 2018		Positive shocks of NRE in the short- and long-run are more than RE's positive shocks are less than NRE positive shocks in both long- and short-run
			EG in Malaysia is relying more on many renewable energies than RE use
			Reduction in RE consumption improves EG while that of NRE decreases EG

Table 2.1 Continued….

Ahmad et al. (2020)	China 2005 – 2014	GMM	The existence of bilateral positive causal association between economy growth and energy investment is asserting Economic growth and energy investment have significant bilateral quality
			energy investment and pollutant emissions have significant bilateral causality
			Pollutant emissions and energy investment have a negative bidirectional causal link
Adebayo (2021)	Japan 1970 – 2015	ARDL, DOLS, FMOLS	Energy use globalisation carbon emissions and urbanisation triggers economy growth
			Economy growth and trade openness have no significant link
			Positive core movements between their regressors and economic growth is observed
			Additional causality from energy use and carbon emissions to economy growth is observed

Table 2.1 Continued….

Author	Country/Period	Methodology	Findings
Adewuyi and Awodumi (2021)	South Africa, Nigeria 1981 – 2015	Simultaneous Equations Models, Threshold Regression analysis	Sustainable growth is not established in South Africa and Nigeria Sectorial and aggregate outputs are increased by keeping petroleum import pick up its above the threshold in Nigeria hence improving Environmental Quality
Ahmed et al. (2022)	South Asian Nations 2000 – 2018	FMOLS, DOLS	Green economy growth is positively impacted by the production of green innovation clean energy end green trade
Arain et al. (2020)	China 1979 – 2017	Morlet wavelet analysis	Overtime and frequency the variables connections progress Economic condition is enhanced by the consumption of RE and inward FDI Environmental degradation is also enhanced by inward FDI

Table 2.1 Continued….

Aslan et al. (2021)	17 Mediterranean countries	Panel Quantile regression	In low growth levels the tourism led growth hypothesis is validated while divisions from the hypothesis is observed after the middle growth level
	1995 – 2014		Economic growth is supported by energy consumption
			all explanatory variables have a bidirectional causality with GDP
Asiedu et al. (2021)	26 European countries	Granger causality test	A long-run link between EG, carbon monoxide, RE, and NRE is observed
	1990 – 2018		RE and economic growth have bi directional causality
			RE and many renewable energies have a unit directional causality
			energy and carbon emissions have a unidirectional causality

Table 2.1 Continued….

Ashraf et al. (2021)	BRIs South Asian countries 1984 – 2019	ARDL	Decreasing carbon emissions and increasing economic development is enhanced by fair political institutions due to the positive interaction between carbon emissions and institutional quality
			Institutional quality economic freedom trade and the consumption of energy invigorates economy growth
Asif et al. (2021)	99 world countries 1995 – 2017	FMOLS, DOLS, FE	RE is observed to impact economic growth positively
			Labour in capital significantly affect economic growth positively
			NRE negatively affects the environment

Table 2.1 Continued….

| Ali et al. (2020) | 33 European countries 1996 – 2017 | FMOLS, Westerlund bootstrap cointegration, Pedroni cointegration | Environmental degradation is negatively impacted by energy innovation in a significant way GDP and environmental degradation have a U shape significant relationship validating the EKC policies |

This Chapter has explored on the various determinants of ED, according to the postulations of past studies. The literature on the determinants of ED has indicated RE as the key factor that is essential in alleviating ED. Therefore, in Chapter 3, which follows, we explore on the various determinants of RE, in line with the postulations of past studies. We outline the evidence provided for by past researches, compare it and contrast it and scertain the main determinants of RE as supported by the state of the art studies.

CHAPTER III

Literature Review on Determinants of Renewable energy

Many studies have been undertaken in the past to examine the factors that are responsible for affecting RE across various regions of the world. Among these studies which examined the factors that affect RE across the world includes researchers such as Mukhtarov et al. (2022); Usman et al. (2021); Al-mulali et al. (2015); Ali et al. (2015); Musa et al. (2021); Chang (2015); Usman, Jahanger et al. (2021), among others. However, some researchers that have analysed the factors that promote RE development across various regions of the world have been observed to give different outcomes. In as much as these studies have provided findings that are a bit different from one another, there is a bit of consensus on the positive effect of FD and EG on RE development, see Mukhtarov et al. (2022); Deka et al. (2023b); Akpanke et al. (2023a), just to mention a few. However, some questions have been raised since not all nations have financial resources that are readily available to improve the development of RE. Financially strong countries can take advantage of the financial sources to develop RE sources, Usman et al. (2021). Some countries such as developing countries, for example the SSA countries, do not have rich financial assets that can enable them to improve the development of RE. This research is an attempt to analyse the effects of FDI on the development of RE in the three regions of the world, that is, the G7, E7 and fifteen West African countries. However, more attention is being paid to the fifteen West African countries that are developing countries, to see if FDI can help in improving RE development in these countries that are not financially resource strong, Akpanke et al. (2023a). More attention is also being paid to the E7 countries that do not have more financial resources when compared to developed nations, Deka et al. (2023b), while the G7 countries are being employed for control purposes.

To begin with, the study that was done in Turkey by Mukhtarov et al. (2022), by making use of the data set that ranges from 1980 to 2019, It has been observed that FD has played a major role in influencing sustainable RE use in Turkey. This shows that FD in Turkey has played a major role in improving the RE resources. Mukhtarov et al. (2022) further provides that an improvement in the RE projects in

Turkey plays an essential role in handling the global warming effects. In that regard, Mukhtarov et al. (2022) has advocated for the government to try and subsidise the projects that are meant to improve RE sources, as well as giving a tax advantage to those industries that are responsible for improving RE resources so that countries can be able to transition from the use of fossil fuel, to RE use. Mukhtarov et al. (2022) also postulated that the macroeconomic factors are essential in improving the development of RE in Turkey. The paper further provided an essential insight on asserting the impact of FD, together with Consumer Price Index (CPI) and EG in the case of Turkey. This research used CPI in order to represent the prices of energy, hence making it different from other past researchers that used energy prices in their research.

In addition to the research of Mukhtarov et al. (2022) that was done in Turkey, Saygin and Iskenderoglu (2021) in the research that was done in the 20 emerging countries, the findings that are provided in the literature shows that FD is essential in improving the development of RE has been supported in this study. Saygin and Iskenderoglu (2021) postulated that in the case where FD is proxied by stock market and the banking variables, show that FD does not provide any strong effect on the determination of RE in the twenty emerging economies. Saygin and Iskenderoglu (2021) further provided that in the case where FD is proxied by stock market capital, its impact on the development of RE among the twenty emerging economies is observed to be significant and positive. This shows that the proxies of FD provide a mixed and different impact on RE development. For example, in the aforementioned study while stock market capital a proxy of FD gives a positive and strong influence on the development of RE among the twenty emerging economies it is also observed that stock market and banking resources does not impact RE development in a significant way, Saygin and Iskenderoglu (2021). Therefore, it is essential to understand all the proxies of FD that strongly promote the development of RE so that those factors can be utilised towards improving RE. The factors that do not give a strong link on the development of RE can then be excluded in the policies that are thought to enhance the development of RE.

In a study that was done in the Organization of Economic Community Development (OECD) by Koksal et al. (2021), it has been observed that the proxies

that are related to the financial system among the OECD countries are not strongly linked to the development of RE in this region. This shows that the proxies of FD in the OECD countries according to Koksal et al. (2021), does not play a significant role in enhancing the development of RE. Therefore, it is essential to devise ways on how to improve RE development in this region since RE is essential in promoting the quality of the environment. Despite the fact that this study observed a weak link between the proxies of financial system and the development of RE among the OECD economies, the overall results generally showed that the proxies of FD have a positive link with the development of RE in this region, Koksal et al. (2021). This shows that FD is essential in raising the development of RE, hence it has to be promoted. However, Koksal et al. (2021) depicted that the inefficiency of the financial system gives its insignificant outcomes on the development of RE. This is also supported by the findings that were done by Fangmin and Jun (2011) which depicted the availability of a significant positive correlation among the development of finance, the RE projects total energy output, together with financial intermediation level.

In the research that was done by Kim and Park (2016) it was observed that those nations that have financial markets that are well developed, have a tendency of experiencing growth in the sector of RE because they have easy access to financial resources. This research indicates that it is essential for countries to develop their markets and be recognized in the international market for acquiring the sources of finance that can help them to improve RE. In addition to the observance that shows that, FD is essential in improving the sector of RE, Kim and Park (2016) also observed that FD has a tendency of leading to the reduction of the emission of CO2 because of its role in improving RE. Thus, it is essential to enhance finance in a nation in order to curb the effects of CE, hence improve the quality of the environment.

In addition to that, the research of Usman et al. (2021) provided that financially resource rich nations have a tendency of having an improvement in their EFP since this is used to improve RE sources in those respective countries. The study further provided that natural resources, together with FD have a tendency of increasing EFP, whereas RE and globalisation have a tendency of reducing it,

Usman et al. (2021). Usman et al. (2021) provided the interaction that is observed between the use of RE with natural resources and the development of the financial system with globalisation tends to improve the quality of the surroundings. The study of Usman et al. (2021) further emphasised on the improvement of the structures of natural resources, financial improvement, as well as the upgrade of the usage of RE sources.

In another study that was done among the developing countries, together with the upper middle income nations by Shahbaz et al. (2021), it has been observed that the development of the financial system in these regions together with the usage of RE exhibits for a strong relationship in the long-run. The study further depicted that the development of the financial system has a tendency of increasing the demand on the consumption of RE sources, Shahbaz et al. (2021). However, the research showed that the growth of the economy among these countries have a strong negative influence on the usage of RE. This depicts that the economic development in this region does not enhance the usage of RE. It is also observed that the CPI gives the effect on the RE use that is not statistically significant, Shahbaz et al. (2021). The study findings depicted that the development of the financial system also triggers the demand of an environment that is friendly through the utilisation of energy that is not harmful to the surroundings. Furthermore, RE is ascertained to decrease the emissions of GHG.

In another study that was done in India Eren et al. (2019) it was observed that the variables RE, the growth of the economy and the development of the financial system exhibit for a strong long-run link. Actually, the findings depicted that the development of the financial system, together with the growth of the economy gives a positive impact on the utilisation of RE sources, Eren et al. (2019). It was further ascertained that the consumption of RE and the growth of the economy in India are both driven by FD in the long run. In support of the postulations that are given in the research of Eren et al. (2019), Assi et al. (2020) in a study of the ASEAN region depicted that FD, economic freedom, innovation environmental pollution, together with real GDP per capita are the main factors that affects the utilisation of RE. Assi et al. (2020) further provided that the improvement of the financial system in the ASEAN region do not give any strong

effect on the development of RE, while the freedom in the economic situation and environmental pollution provides a negative correlation with the consumption of RE in this region.

In another study that was done by Qin et al. (2021) in China, it was observed that RE development is achieved through the development of the financial system of China, which has a tendency of attaining the carbon neutrality goal in this country. Qin et al. (2021) further provides that the transformation of China from low-income nation to an emerging one has caused an increase in the emission of CO_2 due to the utilisation of energy that is harmful to the surroundings, such as fossil fuels. As a result, China has been determined as the greatest emitter in the world due to its policies that are meant to improve the growth of the economy by using energy that is not clean, Qin et al. (2021). Thus, the findings of the study presented that the electricity from RE sources, the enhancement of the financial system and human capital have a tendency of reducing the emission of carbon in China, Qin et al. (2021). These findings are also supported by the research of Wang et al. (2021) which show that the development of the financial system and the growth of the economy of China have a tendency of enhancing the use of RE in the short-run. Khan et al. (2020), Anton and Nucu (2019) further supported these findings by providing that the development of the financial system gives positive effects on the utilisation of RE. However, the outcomes of the long-run estimations provided for by Wang et al. (2021) depicts that economic growth improves RE, but the development of the financial system reduces the use of RE sources.

On their relationship between FDI and the use of RE, Khan et al. (2019) depicted that FDI is observed to negatively affect the utilisation of RE. This shows that FDI does not provide any strong effect in improving the enhancement of RE among countries, but rather it turns to decrease RE development. These findings are also supported by the postulations that are given in the study of Akpanke et al. (2023a) which provides that in the fifteen West African countries FDI negatively affects the development of RE. Therefore, these researches depict that FDI is not essential in promoting the development of RE in countries that do not have financial resources that can improve the development of RE. Thus, it is essential for these countries to seek for those factors that can promote RE development rather than to

concentrate on the FDI, which will rather reduce RE development. However, in a research that was done by Shabhaz et al. (2021) which show that the growth of the economy together with the development of the financial system improves the demand of RE, FDI has been observed to be positively linked with the demand of RE. These results are not in support with the results of the former research that has been highlighted earlier on in this paragraph, hence indicating that there is still required more work to be done to ascertain the actual impact of FDI on the development of RE.

In the research of Musa et al. (2021) in a study that was done in Europe which was meant to examine all the factors that are responsible for improving RE development, it was observed that the use of RE together with FD are strongly related in affecting the performance of the environment. The study also depicted that the use of energy, together with FD, to the use of RE is very essential in the European region, Musa et al. (2021). The study further provided that the quality of the institution could be very essential to reduce the impact of economic growth and tourism to the performance of the environment, Musa et al. (2021).

In this section of the study we observed that there are various factors that affect the development of RE across various regions of the world. Among these are important factors that improve RE development, that is, the enhancement of the financial sector, the growth of the economy and FDI. The present research in this section has observed that the impact of these major factors of RE development have been observed to give different effects on RE development. On the effect of FD and the growth of the economy, many studies have provided overwhelming evidence which shows that these factors improve the development of RE. However, there are few other studies that have depicted that the growth of the economy, and the development of the financial sector do not strongly impact the development of RE or reduce the development of RE. Of great importance is the influence of FDI on the improvement of RE, where past findings have not ascertained the actual effect of FDI on RE. The results on the influence of FDI on RE development have been observed to be contradictory. Whereas, other studies have indicated that FDI has a tendency of reducing RE enhancement, while the other studies indicated that FDI is essential in promoting the enhancement of RE. While FD has been observed by

many studies as essential in promoting the demand of RE, other studies have provided that this can only be possible in countries that are rich financially. Therefore, there is a need to ascertain other factors that can improve the development of RE in regions that are not financially rich, hence the need to ascertain the effect of FDI on RE. The present research is an attempt to further the body of literature in understanding how FDI influences the development of RE in the three major economic regions that is the G7, E7 and the fifteen West African countries.

Table 3.1 Summary on the factors affecting renewable energy

Author	Region	Model	Findings
Mukhtarov et al. (2022)	Turkey 1980 -2019	ARDL	FD gives a significance positive influence on RE use, which is sustainable
			Global warming issues are significantly handled through the rise in RE related projects
			Fossil fuel must be abandoned and the government should subsidies projects meant to generate RE
			The development of RE projects is strongly enhanced through macroeconomic indicators
Musa et al. (2021)	Europe		FD and RE are found to be positively connected towards the performance of the environment
			The stability of finance towards the use of RE is vital

Table 3.1. Continued….

Saygin & Iskenderoglu (2021)	20 Emerging nations	No effect is found to exist of FD on RE in this region when the factors used to represent FD are stock and banking market
		RE is raised by the stock market capital factor of FD in this region
Koksal et al. (2021)	OECD	A poor link between the factors representing financial system with RE is observed
		On overall basis a positive significant connection of FD and RE is found
		An insignificant effect of financial efficiency is found
Kim and Park (2016)		Well developed financial markets amongst developed nation significantly promotes RE projects since they find it easy to get access to external finance
		FD is key in lowering CO2 emissions because of the influence of financial markets on RE

Table 3.1. Continued…

Shahbaz et al. (2021)	Developing nations. Upper middle income	FD and RE are strongly connected in the long-run
		The usage of RE is strongly improved through an improvement in FD
		RE is discouraged through raising EG
		CPI do not provide a statistically significant influence on RE
		FD induces a rise in the demand of sources of energy that are safe
Ji & Zhang (2019)	China	Financial issues have been identified as the major constraints on the revolution of the energy system in China
		The growth of China's RE is connected to 42.42% of FD
		The most vital determinant of RE development is capital, while FDI is second

Table 3.1. Continued…

Eren et al. (2019)	India	EG, RE and FD are strongly connected in the long-run
		FD and EG enhances the usage of RE
		EG and RE are driven through FD in the long-term
Assi et al. (2020)	ASEAN	RE is not enhanced through improvement in FD in this region
		RE is negatively correlated with economic freedom and the pollution of the surroundings
Wang et al. (2021)	China	In the long-term RE is enhanced by EG and decreased by FD
		FD and EG are essential in improving RE in the short-term of China
Qin et al. (2021)	China	FD is essential in promoting the development of RE in China, hence attain the goal of lowering CE in this region, since it is greatest emitter in the world
		CE are limited through human capital, RE and FD

Table 3.1. Continued…

Anton & Nucu (2019)			RE is raised through FD
Khan et al. (2019)			FDI, EG and the innovation in technology reduces the development of RE
			FD results in GHG
Khan et al. (2020)			FD promotes the improvement of RE
			RE lowers CO2 emission
Shahbaz et al. (2021)			RE use and FD are strongly connected
			RE and FDI are connected positively
			EG raises the use of RE
Akpanke et al. (2023a)	E7 1990 - 2019	Panel ARDL	FD raises the use of RE
			FDI do not enhance the use of RE
			EG is vital in raising RE use
			Inflation rate is not favourable for raising RE

In Chapter 4, which follows, we explore on FD of different countries and regions of the world. In this Chapter, we observe that FD is key in raising RE development of a country. Therefore, it is necessary to examine the FD status of various regions of the world. We compare the regional FD to have a glimpse on which regions exhibit strong FD that can be useful when making policies in

raisingRE development. As highlighted in this Chapter, FD enhances RE development, but this can only be possible if the country has a strong FD. Thus, examing the different statuses on the FD of different countries and regions is vital.

CHAPTER IV

Financial Development

In Chapter 3 above, we observed that FD is the main factor that is essential in raising RE among various world regions (Shahbaz et al., 2021; Khan et al., 20220; Koksal et al., 2021). Due to this reason, it is vital to explore the various aspects of FD across all economic regions in order to have a full understanding of this topic. This chapter begins by explaining the structure of financial development, followed by examining if FD is essential for all economies, examining the differences between FD and economic development and finally exploring the differences in FD of developing and developed nations.

The structure of financial development

The financial structure of an economy is divided into two main subgroups, that is, the stock market based and the bank based financial system, Ndikumana (2005). These two main branches of financial system structure have been long observed as essential for every country, but a debate exists on which type of financial system is most crucial between the two (Levine, 2001). At the centre of financial structure of the financial development of a nation, is financial intermediation that is vital in facilitating the transactions between the lenders and the borrowers in the market, Ndikumana (2005). In this respect, banks play a very crucial role as the financial intermediation in the financial market, as they link lenders who want to save their money with borrowers who want to get money for investment purposes. Banks are trusted because the central bank and the government regulate them; hence, the risk of default is always reduced. When faced with liquidity problems the central bank with its function as the lender of last resort is always there to provide support to the banks by lending to them at a specified discount rate. Moreover, the central bank through its regulatory power, in what is known as the reserve required ratio, specifies the percentage of deposits which banks are required to keep as cash in order to meet demand deposits, Mankiw (2010). Financial markets too are essential in acting as the financial intermediaries in the financial market by providing a room whereby lenders invest in securities

that bring interest at a specified period, say a month or year and on the other hand provide funds to borrowers who want to take up some investments.

While there exist two major types of the structure of financial development in various economies of the world, empirical studies examined if these two types of financial development structure affects the economic growth of a nation in the same way or different way. There are many studies that has been done in the past to ascertain the structure of the financial system on its impact on the economic activities of a country and these studies have revolved around the comparative merits and demerits of the stock markets versus the banks in raising the growth of the economy, Ndikumana (2005). Literature provides that the traditional researches have concentrated more on the comparison of nations that had previously dominated the bank based type of financial system, such as Japan and German, with those that were dominantly based on the stock market type of financial systems, such as England and United States, Ndikumana (2005). Therefore, the research that was done on Japan and German, which were previous bank based dominated financial systems, investigated the role that is played by banks, as they are involved in the management and ownership of corporations, together with the influence of bank firms' connection on resource allocation efficiency, the overall economic performance, productivity and the supply of credit. The empirical findings provided from these studies that seek to give a comparative analysis on the effects of bank based financial systems and stock market based financial systems, have found it difficult to come to a general conclusion on the merit and demerits of banks and stock markets' effects on the economic growth of nations. This so because the four countries that were considered had a same pattern of economic performance in the long run, Ndikumana (2005).

Of great importance is the findings that were provided in the empirical research that was done in recent studies. Recent studies have indicated that both stock markets and banks are crucial in enhancing the economic growth of a nation. Rather, Ndikumana (2005) provided that both stock markets and banks types of financial systems are complementary in the enhancement of the economic performance of the country. Levine (2001) provided that seeking to observe the different impact of banks and the stock markets types of financial system on the

economy can be somewhat analytically useless. Levine (2001) provided that a more sound comparative analysis on the structure of the financial system can be between the law and finance view on one side and the financial service view on the other side. Levine (2001) provided that the financial service view considers the role that is played by the financial system in improving the imperfections that are existing in the market, as well as giving the major private sector services, hence promoting the economic growth of a country, see also Levine (1995); Merton (1995). It is imperative that the financial system is responsible for enhancing the performance of the economy through its role of assessing opportunities that are related to investment, as well as controlling corporations, together with the lowering of the cost of mobilising resources and lowering risk management (Levine, 1997). It is acute that the continuous development of the financial systems help them to become in a position of efficiently delivering such services, hence improving the performance of the economy, Ndikumana (2005). Therefore, the financial services view provides that the fact that the financial system is bank based predominantly or stock market based is not relevant in providing the outcomes to the economy.

Laporta et al. (1998; 1997) is the father of the law and finance view, which gives emphasis on the role that is played by the rights of investor and creditor in the financial intermediation. It has been observed that in nations where these rights are enforced in an effective manner by the legal system, the efficient provision of these services by the financial system to the private sector is enhanced. In addition to that, the major determining factor of financial development has been observed to be the lack of system quality. This depicts that if the system of a country is strong and reliable in enforcing laws then financial development is enhanced. The above accession is supported by the empirical studies that were done in the studies of Laporta et al. (1998; 1997); Levine (1999; 1998). The law in finance view according to the postulations of past studies depicts that when a legal environment, which is appropriate, has been established this will help in facilitating the development of stock markets and banks, which are therefore responsible for enhancing the economic growth of the country.

The importance of financial development in different economies and the difference between financial and economic development

Empirical studies that have been done to ascertain the effect of financial development on the economy are many in the literature. Some of the studies that have examined the effect of financial development on the economic growth of nations include King and Levine (1993a, b). There is a great consensus in the literature among the empirical studies that has been done in the past on the positive effect of financial development on the economic growth of countries (Rajan & Zingales, 1998; Ndikumana, 2005, 2000). The aforementioned studies have indicated that financial development is essential in raising various economic activities, such as employment investment, economic growth and productivity (see also, Levine, 1997; Levine et al., 2000; Beck et al., 2000, among various researches). These various studies have indicated the dependence and expansion of the financial system in a country as a result leading to growth in the economy of the country. Inasmuch as the direction of the causality has not been ascertained, the aforementioned studies indicate that financial development positively improves the economic growth of the country. Therefore, it is clear that financial development is essential in raising the economic situation of a country.

There is a thin line of difference that exists between financial development and economic development. Previous studies, rather indicated that these factors are significantly related, see in the section above Ndikumana (2005). Therefore, the evidence that is provided for in the literature of past studies depicts that financial development is the major factor that leads to economic development. Thus, financial development is a determinant of economic development in such a way that a rise in financial development leads to high economic development of a nation. It must be noted that financial development is a result of the innovativeness and the development of the two major financial systems that are the stock market based and the bank based financial systems (Ndikumana, 2005).

Economic development is usually proxied by economic growth that is the percentage change in the GDP of a nation in a specific time horizon (Mankiw, 2010). This shows that the economic development of a country is determined by the

factors that affect the economic growth of a nation, which are the factors that are responsible for enhancing the GDP of a country. GDP in an economy is constituted of four major components: consumption investment, government spending and the net exports, Mankiw (2010). This shows that if the consumption spending in a country increases, this would tend to improve the economic development of a country. In the same lines, an increase in the government spending and in the investment of an economy has the potential to improve the economic development of a country. Net exports is the difference between exports and imports that is normally referred to as the trade balance, Mankiw (2010). This means that the GDP of a country increases when exports to other countries increases at a relatively higher rate than the imports of the country. Thus, an increase in imports in an economy has a tendency of reducing the GDP, hence decreasing its economic development.

According to the postulations of past research, it is observed that differing opinions on the significance of the financial development on economic growth are given. Hicks (1969); Bagehot (1873) is of the view that financial development is a major factor that is useful for improving the industrialization of England, for use in the production of goods and services in various industries. The findings provided for by the aforementioned scholars depict that financial development is essential in improving economic growth. Schumpter (1912) is of the view that banks which are the other type of financial system in an economy improves greatly in the innovation of the technology through funding and identifying the best entrepreneurs who can be successful in making use of the production processes and products that have been innovated. However, in the research of Robinson (1952) it is provides that entrepreneurship is always the leader while finance follows. The postulations of Robinson (1952) indicate that financial development is not the one that affects or improves economic development but rather it is economic development, which triggers the development in the finance of an economy. Economic development is known for inducing the demand in the various types of finance, which causes the financial system to respond in line with such demands. While various researchers provide that financial development improve economic growth on one hand, economic development is the one that is responsible for improving financial development on the other hand. Other studies provide for a no crucial relationship

between economic and financial development. Lucas (1988) is of the view that Economists are more content about the relationship that exists between financial development and economic growth, whereas development economists query on the effects of the financial system on economic growth. The view that is given by Lucas (1988) is also supported in the study that was done by Chandavarkar (1992). Therefore, in line with the postulations that have been provided for in the previous researches, we can see that there is a relationship that exists between financial development and economic development, such that financial development affects economic development and on the other side economic development also improves the financial system of a country. Therefore, it is essential to come up with ways that can improve the financial system of a country in order to improve its economic growth or improve the economic development of the country in order to come up with more demand for finance hence improve the financial system.

The differences of Financial Development in Developed and Developing countries

In this section we compare the financial development between developed and developing countries to understand and see whether these two sets of country groups exhibit the same amount of financial development or not. Because the financial system is structured into two types, that is, the bank based financial system, as well as the stock market based financial system. Therefore, we use stocks traded to proxy the stock market financial system in both the developing and the developed countries and we use the number of commercial banks per 100,000 adults to represent the bank based financial system in both regions. The sub Saharan African countries have been used to resemble the developing countries, since most of the developing countries come from the sub Saharan African countries. Because some other countries, such as South Africa and Nigeria have a higher income and are not part of developing countries, therefore we utilise the value of the sub Saharan African countries excluding high income economies. In addition to that, the OECD countries have been used to resemble the developed countries since most of the countries that belong to this group are developed countries. Table 4.1 in this section presents the data of the sub Saharan African countries, which are used to resemble the developing countries, and the OECD countries, which are used to resemble the developed countries to make a comparison of these two regions on how their financial development differs. The first two columns in Table 4.1 give

information on the total stock traded as a percentage of GDP in these two regions, that is the sub Saharan African countries and the OECD.

Table 4.1 Comparing financial development of SSA and the OECD countries

	Stocks traded, total value (% of GDP)		Commercial bank branches (per 100,000 adults)	
Year	SSA	OECD	SSA	OECD
1994	6.1955	31.8603		
1995	6.3678	35.1983		
1996	10.6886	42.3042		
1997	16.0626	58.5586		
1998	20.3195	77.1764		
1999	25.4380	107.5599		
2000		157.6001		
2001	13.1354	116.6948		
2002		90.1758		
2003		82.0020		
2004	18.6034	90.0879	1.49	27.825
2005	20.9852	110.8458	1.55	26.15
2006	27.7426	132.2520	1.64	27.62
2007		174.4367	2.045	28.66
2008		163.0539	2.45	27.68
2009		125.0557	2.89	25.935
2010		125.3867	3.345	25.495
2011		127.6808	3.49	24.125
2012		101.2827	3.765	24.07
2013		105.9477	3.88	23.055
2014		116.8954	4.12	22.09
2015		141.1227	4.545	22.1
2016		141.2994	4.36	21.61

Table 4.1. Continued…

2017	134.3468	4.44	20.71
2018	113.6265	4.27	20.285
2019	84.7940	4.1	19.81
2020		4.31	18.48

Source: World Bank Development Indicators

The information presented in Table 4.1 shows that in the sub Saharan African countries the percentage of stock traded per GDP increased from 6% in 1994 to 25% in 1999, whereas in the OECD countries it increased from 61% in 1994 to 107% in 1999. From 2004 to 2006 in the sub-saharan African market, the stock traded as a percentage of GDP increased from 18% to 27%, whereas in the OECD countries it increased from 90% to 132%. This information is a clear indication that developed countries have a relatively higher financial development when compared with developing countries. We can also observe that the information for the sub Saharan African countries from 2007 until 2020 on this stock traded as a percentage of GDP is not available, whereas that of the OECD countries is available in the World Bank databases. This is so because sub-saharan African countries are developing countries, which sometimes do not have technologies to collect the data and store.

Now turning onto the bank based financial system information, as given by the number of commercial bank branches per 100,000 adults in Table 4.1, we observe that in the sub Saharan African countries the number of commercial bank branches per 100,000 adults, from 2004 to 2020, increased from 1.47 to 4.3. In the OECD countries it decreased from 27.8 to 18.48, during the same period. We observe that the number of commercial bank branches in the sub-saharan African countries was increasing during this period. According to the information, provided in Table 4.1, it is observed that its value is relatively low compared to the OECD countries. Table 4.1 also depicts that the number of commercial bank branches per 100,000 adults in this region has reduced since 2004 until 2020. However, inasmuch as financial development in the OECD region has been observed to be decreasing it is relatively higher compared to that of the developing countries. Therefore, we

conclude that financial development in developing countries is low when compared to that of developed countries as given by the information in Table 4.1; however, it is increasing while that of the developed countries is decreasing. Whether the financial development of the developing countries is going to continue increasing until it catches up with that of the developed countries is the million-dollar question.

In this Chapter, we observe that different regions exhibit different FD; some have strong FD while others have a relatively weaker one. In Chapter 5, which follows, we explore on the various factors affecting FD development. Chapter 5 seeks to answer questions on what can be done to improve FD of a country. What are the major determinants of FD? This is important considering that FD is vital in raising RE development. Thus, FD should be improved in order for it to provide a significant effect on RE development.

CHAPTER V

Financial development and other macroeconomic factors

FD is a very crucial factor in the economic realms of a country as provided in the previous chapter. This Chapter continues in the same lines with that of Chapter 4 by further investigating the effect of FD with various other macroeconomic factors, such as, human capital, investment and globalisation. We first begin by discussing the relationship of FD and human capital, followed by investigating the effect of FD on the investment of a country, and finally the relationship between financial globalisation and FD.

The impacts of Financial Development, investment, and Human Capital

In order to assert the effect of financial development on investment, it is very crucial to separately analyse the effect of the two types of the structure of the financial system that is banks and stock market based types of initial system as explained in the Chapter 4 above. Therefore, in this section we begin by examining the relationship that exists between the bank types of financial system with investment and later examine the stock market based type of financial system on its relation with investment.

Banks and Investment: The study that was done by Ndikumana (2005) depicts that banks play a fundamental role in enhancing the domestic investment of a country in many diversities. Banks are known for increasing the amount of money that is available in the pool of savings for the purpose of investment. Before the emergence of financial intermediation, it was difficult to link lenders to borrowers; hence, the cost of connecting lenders and borrowers was very high. However, after the emergence of intermediaries, such as banks, the cost of collecting money from savers who come from different locations and have different needs ensures that the financial intermediaries cut these costs through what is known as economic scale in the gathering and processing of information. Due to the presence of these financial intermediaries it can be observed that the potential saving rate together with the capital levels of income countries that have developed banking systems tend to have a high investment and saving rate (Pagano, 1993).

Banks also play a very crucial role in reducing the risk of liquidity, therefore increasing its capacity to promote investment in a country (Bencivenga & Smith, 1991; Diamond & Dybvig, 1983). Making an investment is not something that is easy, but rather it is a commitment that requires more capital to be committed for a long period. Therefore, investors on the other hand are required to make a commitment in their investments for a longer time. Time savers are not willing to lend their money to investors for a longer time since they are concerned about liquidity issues in their portfolios of assets. As a result, it can be observed that there exists a trade-off between investors who want to take up long-term investments with savers who are willing to lend their funds for just a short period for the purposes of liquidity. Due to the presence of a trade-off that exists between the preferences of investors and those of servers, the banks are responsible for facilitating a trade-off that exists between liquidity and returns through the process of pooling savings, that is, banks have the power to borrow funds in the short term and lend funds for the long period to investors. While the banks can play a pivotal role in solving this trade-off that exists between liquidity and the returns from assets, a country that has a banking system that is not well developed may find it difficult to harness projects that are profitable to the investment due to the presence of insufficiency funds. Therefore, it is vital to ensure that once banks are developed, resources are allocated in a more reasonable manner together with a healthy balance in the long-term and short-term investment among the companies in the private sector.

Literature also provides that even intermediaries in the financial system have a crucial role, which they play in lowering the costs of information processing and acquisition on the investment activities prevailing in the economy, as well as the control of the funds that exist in the market (Diamond, 1984). It is also observed that large firms that exist in the market have the capacity of receiving funds from investors that are not in a position of managing their funds alone in the company. Therefore, in this situation it is the duty of banks to act as the delegated monitors on the behaviour of these companies and their managers. By doing so they act on behalf of various investors that have put their funds together and invested in the company. Because banks have the ability to monitor these large companies, the incentive of investors to trust their savings which they have put in the company,

hence the improvement of funds across various projects of the company. Therefore, it is observed that a banking system that is well developed in the country has a tendency of inducing more volumes of funds that are invested in various sectors of the economy followed by an efficient capital allocation in the financial system.

Banks have their specialisations in the provision of financial assets that are customised and tailored towards the specific needs of individual companies. Banks remain the major source of external finance for borrowers who do not have much access to the financial markets, for example small and new companies. In the words of Merton (1995), financial markets are one of the most efficient firms that are alternative to the intermediaries in the case that standardised terms are available on the products; they can also manage to cater for a wide range of customers and are good at assessing the prevailing in the market of goods and services. Intermediaries are also observed to be more suitable in the case that the volume of the product is relatively low. The creation of new firms together with the facilitation of the financing of existing companies has been depicted as one major role of banks. There has been evidence that has been provided in the postulations of past studies which shows that small firms are more reliant on the finance obtained from banks as compared to bigger companies (Fazzari et al., 1988). In addition to that, it has been also observed that in the countries that are well-industrialised credit supply shocks by banks through the innovations in the monetary policy significantly impacts the investment of those companies that are more dependent on the bank, such as smaller companies (Gertler & Gilchrist, 1994). As a result, it is crucial to expect a strong and close relationship that exists between aggregate investments with the lending from the bank.

Banks are also vital in the provision and innovation of financial products that are new in the market because they are the financial innovators and they offer products that are customised to the market. New products that have been invented by the banks can be transferred into the financial market via a process known as financial innovation spiral, a process by which financial markets and banks are complementary to each other (Merton, 1995). Therefore, it is observed that banks in the innovative creation process of Schumpeter are vital in the financial sector due

to their role of adventure in new instruments of finance and in the real sector due to the role of providing finance to entrepreneurs who are more innovative.

Despite the significance of the bank based financial system, critics argued that it comes along with a greater number of weaknesses and drawbacks especially on their role to promote economic and investment performance. It is observed that banks may be lowered towards getting more profits via the information, which they would have collected on profitable investment projects, thereby lowering the returns to companies. When banks reduce the payoffs due to the companies whose investment perspectives are high, this may cause companies to undertake less innovative projects (Rajan, 1992). Moreover, it is observed that banks may also have a tendency of exhibiting buyers towards prudence. In Japan for example, the empirical evidence shows that companies that are closely related to a major bank makes use of less innovative technologies and exhibit very low rates of profits as compared to those companies that does not have close relationships to a major bank. This supports the aforementioned point that banks have a tendency of taking some parts of the profits from the companies that they work with (Merck & Nakamura, 1999; Weinstein & Yafeh, 1998). In addition to that, further criticism is provided on the presence of close bank company connections that have precluded competition in the market of credit, thereby lowering the ability of the banks to ensure that corporate governance efficiency is attained. It has also been observed that firms are propped up by banks due to their belonging to a group of banks, while the interest of creditors is promoted in a case where business is done with companies that do not belong to any group of banks (Merck & Nakamura, 1999). Inasmuch as, a bank company relationship that is close has a tendency of facilitating easy access to finance this relationship does not significantly lower capital costs nor does they improve firm's investment whose ties with the bank groups are close, see Weinstein and Yafeh (1998).

Stock markets and investment: The empirical evidence that is available in the literature provides for a significant strong effect on the relationship that exists between the activities of the stock market and investment. According to the research that was done by Barro (1990) its empirical findings depict that the variables of the stock market have a strong influence on investment, that is predictive even after

having controlled for future profitability indicators, like past profits and current ones. Therefore, since there exists a significant correlation between the indicators of the stock market with aggregate investment one may tend to ask on what is the exact effect of the stock market on investment.

There are many connections that have been provided for in the empirical findings of past studies and these connections depict that the two indicators are strongly related. Firstly, it must be noted that information on investment profitability is provided for in the stock market. Therefore, the existence of a stock market that is functioning very well causes investment to increase, since it has the capacity of identifying projects that can be funded which are otherwise not going to be considered. It is also observed that the stock market is responsible for influencing investment quality, as well as capital allocation through means of providing finance to those investment activities that are most profitable.

In addition to that, it can also be observed that the stock market is responsible for affecting capital cost, hence its impact on the investment. Thus if the cost of capital is raised in the stock market this would decrease investment which is more reliable on the capital. A rise in the stock market has the tendency of increasing its liquidity thereby increasing risk-sharing opportunities that will have the tendency of lowering the equity funds costs. The above assertion is supported through the empirical postulations that shows that the liberalisation of the stock market comes along with a rise in the valuation aggregate stock market together with a drop in equity capital cost, which will later cause an increase in the investment (Henry, 2000a, b).

The pressure that is exerted on corporate management comes as another way of how the stock market is responsible for influencing investment (Stiglitz, 1985). This is true considering circumstances whereby there are takeover threats or an effective takeover (see, Jensen & Meckling, 1976). In that respect the existence of a stock market that is functioning very well in an economy allows profitability to increase by way of "surviving of the fit" amongst the various corporations that are in the sector. Corporate governance is also affected through stock markets since it

makes it easier for the performance of the firm to be linked with managerial compensation.

Just like anything else, the stock market based systems have their critics that have provided for quite a good number of indicators that limits the potential of stock markets to improve the quality, as well as the volume of investment in an economy. Firstly, it can be observed that the notion that the valuation of the stock market is crucial in guiding through the decision making of investment has its basis on the assumption that the valuation of the market of the profitability of firms proceeds by the company's manager. However, it is observed that when market friction exists, for example asymmetries in the information which may result from speculation that is existing in the market, the profitability of the firm's valuation of the market has the tendency of diverting from the managers. Under these circumstances, a trade-off exists on which evaluation is crucial in decision-making. Some scholars argue that decisions for the purposes of investment should be undertaken based on devaluation of the market, see Fischer & Merton (1984). This argument is supported based on the view that investment in a country has to be raised until the marginal product of capital is equivalent to the return rate, as long as investors that are outside are ready to take up a return that is low. Other scholars have argued that, managers can make the best decision on investment taking into consideration the firm's profitability valuation, see Bosworth (1975). This view provides the stock market as a sideshow that does not provide new information that is useful and helpful to manage in the process of making decisions that are related to investment. Therefore, considering this argument a positive correlation that exists between the returns of stock and investment is a sign of the failure of an economic region to account fully for the fundamentals of economics (Morck et al., 1990). Therefore, the information that is endowed with the manager is greater compared to that of the econometrician, hence the reason behind a significant correlation between investment and the returns of stock. The postulations of various researches have also depicted that stock market's role on investment is limited at the company level (Blanchard et al., 1993).

Inasmuch as, stock markets are responsible for facilitating the collection of information about the available opportunities on investment this information is made available to all participants in the market. Providing information to all the

participants in the market has the problem of free riders, hence investors will see no rationale for them to invest in the collection of information (Stiglitz, 1985). This follows that bank based financial systems have less problems with free riders because banks do not reveal much information to the public about individual projects and companies. Takeovers are facilitated through stock markets but scholars have argued that in such circumstances higher efficiency is not attained. Asymmetries of information are also not eliminated through the full establishment of stock markets. It is observed that insiders may tend to have information that is more than that of outsiders (Myers & Majluf, 1984). As a result, outsiders may find it difficult to outbid those with more information, insiders. Takeovers can also be linked to the economic mechanism of natural selections that are imperfect (Singh, 1975). In the case of the United Kingdom, the survival of large firms was based on the improvement of size and by means of takeovers rather than through profitability improvements, Singh (1997). The other point is that takeovers do not come along with increases in investment amount but simply wealth transfer from the former owners today to new owners. Takeovers that took place in the United States during the 1980s did not come along with great net investment or efficient gains; rather they resulted in high-leverage among the corporate sector (Crotty & Goldstein, 1993). It is also argued that takeovers have a tendency of creating value to their new owners through the redistribution of wealth that is always associated with a disadvantage to the former stakeholders, such as the suppliers and the workers (Shleifer & Summers, 1988). The aforementioned scholar is of the argument that hostile takeovers tend to cause a breach in the implicit contracts, hence exposing stakeholders' orders to great problems. In addition to that, Shleifer and Summers (1988) is of the view that takeovers come along with value distribution and value creating effects, while the former is observed to be more dominant than the latter. Managers at the expense of investments that are long-term affect microeconomic performance through takeovers in a negative way due to the emphasis on short-term returns.

In line with the postulations of the scholars provided above, it is observed that while investment and financial development are related, these factors are also related through capital accumulation, Nkemgha et al. (2023). According to the postulations that was given in the study of Chenery and Strout (1996), investment

in an economy is necessitated through the accumulation of capital that is also obtained from various developmental assistants, such as financial development and economic development. This assertion shows that capital accumulation is a product of financial development in such a way that financial development improves capital accumulation in the economy that in turn leads to high-level investment in a country. Therefore, financial development is fundamental for improving the capital accumulation of a country that in turn enhances investment, investment that in turn improves the economic growth of an economy. The findings of the aforementioned studies is supported by the postulations which is given in the researches of Oluwatobi et al. (2016); Bekana (2019); Malik (2020) which shows that the complementary effect of institutional quality and human capital is vital on the association that exists between financial development innovation. This shows that human capital is vital in bridging the association between financial development and innovation.

The Relationship between Financial Development and Financial Globalization

Firstly, it is important to understand what financial globalisation is in order to examine its relationship with financial development. In the previous sections, we have ascertained what financial development is and we have seen how it relates to various factors such as innovation and capital accumulation. Financial globalisation according to Schmukler (2004) is a situation whereby the financial system of a country fuses with that of the external institution and financial markets. The association between financial globalisation and financial development has emerged as an issue of great concern in the past three decades since it poses some merits to the financial sector of the domestic country and its economy, see Balcilar et al. (2019); Tesega (2022). There is a strong consensus on the assumption that countries exhibiting high financial globalisation are subject to improvements in their financial systems, Tesega (2022). This is so because financial globalisation enables the dissemination of the best procedures and practices around the globe which has the capacity of improving corporate governance, lowering foreign transaction costs, enhancing the diversification of risk and lowering information asymmetry (Garcia, 2012; Tesega, 2022).

The theory on how financial globalisation can lead to the development of the financial system of a country is covered in the study that was given by Schmukler (2004). The research of Schmukler (2004a, b) provides that factors of financial globalisation, such as, strict market discipline, improvements in technical capabilities, corporate government enhancement, international financial intermediaries' introduction, and international accounting standards adoption are the factors that are responsible for improving the economic growth, financial development and the effectiveness of institutions in a country. The researches of Yeyati and Williams (2011); Kose et al. (2010) provided that the financial industry, as well as the economy of a country have the potential to benefit from financial globalisation directly or indirectly. All nations including developing countries are subject to benefit from financial globalisation regardless of the difficulties they face, Tesega (2022). Schmukler (2004a, b) states that since globalisation improves the financial systems of developing countries, this is its main advantage. Though developing nations are subject to benefit from financial globalisation, it must be understood that their circumstances that revolve around reaching national inter-contextuality might pause some difficulties to ultimately benefit from the whole package.

In addition to that, other research has provided that economic prosperity and investment has not been improved among developing countries, since empirical evidence shows that developing countries that prospered economically are those that were not more reliant on the inflows of capital to their countries (Asongu & Lieven, 2015). The inefficiencies in the financial markets of the domestic country, the labour market, as well as the capital market conditions have cost developing nations to find it difficult to benefit from financial globalisation (Wei, 2018).

In the next Chapter 6, we provide an empirical study on the factors affecting ED in the case of three economic regions, that is, the E7, G7 and ECOWAS countries. While the findings of past studies are presented in Chapter 2, we seek to present a state of the art research that furthers the growing body of literature in this field, and hence provide a key contribution to literature.

CHAPTER VI

Environmental degradation in the G7, ECOWAS and E7 countries

Introduction

Forest resources are vital because they are friendly to the environment, but a gap remains in the association of the two. Due to this reason, it is vital to do more studies on this subject and this can help in providing recommendations to the policies responsible for improving the surroundings. The postulations given in the research that was done by Amer et al. (2021) depicts the importance of natural resources to the surroundings. This is also further supported in the postulations of Ali et al. (2021), together with that of Abid et al. (2021). In addition to that Deka, Bako et al. (2023) and Akpanke et al. (2023b) emphasised that the trees and grass forest resources are crucial in capturing carbon that is present in the air. Therefore, it is vital to make sure that these resources are protected and improved. Jianguo et al. (2021) together with Abid et al. (2021) depicts that natural resources are significant in improving the surroundings in the presence of RE, which is supported by past researches that depicts that RE is the core factor towards attaining an environment that is free from pollution (Bakhsh et al., 2022; Deka et al., 2023a). In that respect we see that forest resources are also vital in the same manner as is RE in making sure that the quality of the surroundings are enhanced in all regions of the world. In fact forest resources such as trees are somewhat more vital in the sense that on top of assisting the soil from wash and wear by soil erosion, they do capture the content of carbon that is trapped already in the air (Akpanke et al., 2023b). As a result if trees and grass are improved through forest preservation, together with the planting of more trees then the world can be ensured of harnessing more carbon that is in the atmosphere, hence making it clean. This research is different to those done in the past with the exception of few recent researches, for instance Deka, Bako et al. (2023); Akpanke et al. (2023b). The research concentrates on the forest resources which traps carbon already in the air than focusing more on how to stop further emission to the air by means of moving from NRE usage to RE usage as presented in the researches done previously (Banga et al., 2022; Boukhelkhal, 2021;

Deka et al., 2022a). The objectives of this study are vital considering that the ai already has more carbon concentrates that cannot be overcome through simply stopping NRE use. Thus, more techniques, innovations and technologies that can help remove these concentrations of carbon in the atmosphere are vital.

This study is devised for covering the gap in the literature on how the forest resources can help in trapping the content of carbon present in air. This association has been partially investigated in Deka, Bako et al. (2023); Akpanke et al. (2023b). These researches have presented that more studies must be presented in the literature to help devise proper policies on what can be done to capture the content of carbon hence clean surroundings are achieved. Therefore, the present research is essential in fostering the literature body to grow. The current research employs a dataset of three different economic regions, that is, the G7, ECOWAS and E7 for the period ranging from 1990 to 2019. The data presented in the three different economic regions is analysed and the outcomes are contrasted for comparison reasons. Therefore, the current research adds to the existing body of literature in three-fold, firstly, it investigates the effect of forest resources on CE, research that has not been widely conducted. Secondly, this research is undertaken in the three different regions of the world, that is, E7, G7 and ECOWAS. The E7 economies include countries such as China, which is the largest emitter and India third largest emitter of carbon, the G7 economies have France and Germany (the EU nations that are amongst the largest emitters). The ECOWAS nations has some countries that are less emitters, to provide a comparative analysis on the impact of resources from the forest and other factors such as RE, among these regions. Thirdly, this research analyses the significance of energy efficiency on CE, among the three different economic regions of the world, a study that has not been widely done. The current research provides robust results in that it employs different methodologies, such as, the CS-ARDL technique that is strong over CD, dynamics and heterogeneity. The research is endeavoured towards giving answers on what is the importance of forest resources in attaining low carbon content in air. What is the significant effect of RE and energy efficiency on CE? Do asymmetry effects exist on the influence of forest resources, energy efficiency and RE among the three economic regions of the world, that is, the E7, ECOWAS and G7 countries?

Brief review

To this date more studies have sought to examine the factors that exacerbates ED and/or lowers it. EFP an index used to represents ED has been investigated to observe its connection with energy use, and a positive connection between them has been given (Abbas et al., 2021; Amer et al., 2022; Ali, Rehman, Rehman & Ntim, 2022). According to Abbas et al. (2021) in the case of Pakistan that used the ARDL, FMOLS and DOLS techniques, for the period that ranges from 1970 to 2018, the use of energy strongly influenced EFP positively. Amer et al. (2022) concurs with the results presented above, in the Gulf Cooperation council case, which provides for a significant positive influence of the use of energy use and EFP. Moreover, the assertion that use of energy promotes EFP is supported in the findings of Ali et al. (2022). Energy use promotes EFP because of the availability of NRE in the total energy supply indicator (Deka et al., 2022a; Banga et al., 2022). This concurs with the outcomes of other research done which indicates NRE positively influences EFP and RE negatively influences EFP. NRE is observed to gives a positive influence on EFP by past empirical researches (Ansari, 2022), while, natural resources together with RE use influences EFP to be lowered (Abid et al., 2022; Ali et al., 2022). In that regard, NRE use because of its dangerous impact to the surroundings should be rejected, and ensures that RE use is promoted since it is the most factor that is safe to the surroundings, must be opted for in order to ensure that the goal of carbon neutrality is attained, and at the same time with attaining high EG.

Moreover, results presented in the studies done previously gives that, RE posits a significant negative influence on CE (Bhat, 2018; Abbas et al., 2021; Matthiesen et al., 2011). Therefore, more evidence points to the fact that NRE exacerbates ED, and RE lowers ED. Thus, it is most vital to enhance countries to move from using NRE towards enhancing RE use if the surroundings are to be successfully protected and hence stop the spread of diseases. In the event that a successful transitioning from using NRE to RE is attained, then ED challenges are mitigated, hence helping in the attainment of the goal of carbon neutrality. In the presence of many studies showing the negative causality of RE on the CE, some empirical evidence is available which indicates that RE together with CE are linked in a strong positive connection, Anser et al. (2021). To be specific, it is depicted in

the results presented by Adedoyin et al., (2021) that RE production raises the CE. Further to that, CE and RE do not present a connection that is strong and significant, Menyah and Wolde-Ruffael (2010). Becker and Fischer (2013) provided that the prices of NRE are less in the short-run than that of RE and this can be presented as the cause for no strong connection among CE and RE. However, it is found that RE is comparatively cheaper in the long-term.

GDP according to Abid, et al. (2022) strongly promotes EF. Rather, Ali et al., (2022) alludes that EG raises the pressure of the ecology. Just as energy use and NRE, posits a significant positive effect on EF, they also positively affect CE (Boukhelkhal, 2021; Asif et al., 2021). The other indicator of environmental degradation, CE, is found to be strongly influence EG (Akadiri & Adebayo, 2022; Bouyghrissi et al., 2021; Abbas et al., 2021; Ben Mberek et al., 2018). GDP growth's positive influence on CE results from using NRE to attain improved EG across various regions. In the presence of the aforementioned situation improvements in EG that comes from using NRE increases CE across such regions that use NRE. In the results found by Boukhelkhal (2021) CE and EG are connected in a strong bi-directional connection and this results in these two factors influencing one another.

Of paramount importance is energy efficiency in lowering ED. The study of Deka et al., (2022a); Akram et al. (2022) provides for a significant negative influence of energy efficiency on ED. This shows that environmental quality is attained by energy in a wise way, making sure that none is wasted and ensuring the highest level of output on every single energy unit is achieved (Deka et al., 2022a). Furthermore, Zakari et al. (2022); Ponce and Khan (2021); Razzaq et al. (2021) give the level of CE to be lowered with energy efficiency. Energy efficiency subsequently increases EG (Razaq et al., 2021), while at the same time Sohag et al. (2021) observed increases in EG because of the rise in energy efficiency levels. Li and Colombier (2009) articulates that enhancing energy efficiency lowers energy use, thereby lowering CE and enhancing environmental quality. Consequently, Mahapatra and Irfan (2021) is of the argument that energy efficiency's influence on CE is non-consistent. Thus, considering these inconsistent results and that not much work has been done to ascertain this association, more work is still needed and this

research will attempt to cover this literature gap. Moreover, of great significance in reducing environmental degradation are the natural resources. In the work of Amer et al. (2022), including that of Ali et al. (2022), and also in Abid et al. (2022) the significance of natural factors in enhancing environment cleanliness is presented. The results of these studies show that natural resources in conjunction with RE are vital for the attainment of a clean and safe environment. The findings given in these studies are crucial especially when the influence of forest resources in trapping the content of carbon in the air is taken into account.

Methodology

Model of the research

The theoretical basis of this study comes from the three major theories of ED explained in Chapter 2, that is, the ETT, EMT and EKC. These theories show that EG, energy sources and technology are essential in ensuring that the surroundings around the world are enhanced. Due to the postulations given in the three theories of ED, this chapter ensures that EG and the two energy indicators are included in modelling CE. The model of the research which is followed in this Chapter is closely linked to the models presented in Akpanke et al. (2023b); Deka, Bako et al. (2023). These studies included the use of RE and NRE, the land which is dedicated towards the growing of trees and grass, that is, the grass, the size of the population, GDP and the efficiency of energy. These factors have been widely used in the models of past studies (Akram et al., 2022; Amirnejad et al., 2021; Akadiri and Adebayo, 2022). However, while they considered most of the factors outlined above, such as, RE, population, NRE, GDP and energy efficiency, they have not managed to consider the significance of forest resources, a very essential connection that should be ascertained. This association has been successfully ascertained in Deka, Bako et al. (2023); Akpanke et al. (2023b), but more empirical evidence is required. In Equation 6.1 the model used in this Chapter is given.

$$CE = f(REC, FR, NREC, GDP \div EU, POP, GDP) \qquad (6.1)$$

Where CE is the emissions of carbon gases in the air. GDP is provided earlier on is Gross Domestic Product. REC represents the percentage of energy that used among countries and in RE. FR is the the percentage of land under forestry. NREC represents the percentage of energy use that comes from NRE. EU represents all the energy that is used in the country regardless of whether it is RE or NRE. POP represents the number of a country's citizens. GDP÷EU is the energy efficiency series. Consequently, the statistical representation of this model is depicted in Equation 6.2.

$$lnCE_t = \beta_0 + \beta_1 lnFR_t + \beta_2 lnREC_t + \beta_3 NREC_t + \beta_4 lnEE_t + \beta_5 lnPOP_t + \beta_6 lnGDP_t + et \qquad (6.2)$$

In Equation 6.2, **ln** is the series log value, EE stands for the series energy efficiency, β_0 is the constant value of the model, while β_1 to β_6 are the coefficients of the respective explanatory series, whereas the error term is represented with **et**.

Data

This research in this chapter uses the data of the G7, ECOWAS and E7 countries that is found from the database of the World Bank and OECD, and is annually from 1990 to year 2019. The data of the series given above is used and the summary of each series is presented in Table 6.1.

Table 6.1 Variables summary

Name of variable	Abbreviation	Type	Measurement	Source
Gross Domestic Product	GDP	Independent	GDP's present value denominated in US$	World Bank
Population size	POP	Independent	Total number	World Bank
Forest resources	FR	Independent	Intensity of use ratio	OECD
Renewable energy use	RE	Independent	% of total final energy use	World Bank
Energy efficiency	EE	Independent	GDP per energy	World Bank
Carbon emissions	CE	Dependent	Per capita metric tons the emission of CO_2	World Bank
Non-renewable energy	NRE	Independent	% of total energy	World Bank

Method

In this Chapter, we follow the Second-generation methods of analyzing panel data. This is done in stages and the following stages are followed.

Firstly, the preliminary analysis of the panel variables is done. The cross-sectional dependence (CD) test of Pesaran (2004) that checks the presence of CD in panel datasets is employed. CD is a common problem that is found in panel data since countries are interdependent with each other, especially through trade. Therefore, running the preliminary CD test is vital, which will enable the determination of the correct method of checking unit root to be identified. After checking the presence of CD in the panel data used in this research, the correct method of testing unit root is identified and used. The present research uses the second-generation (SG) methods of checking unit root, that is, the CIPS and the CADF (Im et al., 2003; Pesaran, 2007). These methods overcome CD and, hence present robust outcomes.

Secondly, the preliminary tests on the model specified in the present research are used. The SG test of cointegration (Westerlund, 2007), slope heterogeneity test (Pesaran & Yamagata, 2008) and the weak CD tests, that is, the Pesaran (2015) scaled Lagrange Multiplier (LM), Frees (1995, 2004) and Friedman (1937) are utilised. Some methods that analyses panel data do not overcome heterogeneity; hence using such methods when this condition is present biassed outcomes will be given. At the same time, some methods cannot present long-term coefficients while others can, hence series that are cointegrated have a long-term connection and must be analysed with methods that are able to present long-term coefficients.

In the second stage of analysisng the rel;ationship presented in the model, the CS-ARDL method is utilised, which overcomes CD problems, heterogeneity problems, and dynamics and gives the long- as well as the short-run model's coefficients. Chudik and Pesaran (2015) pioneered the CS-ARDL method, which is a high-breed method of the well-known ARDL method.

E7 Results

The present research in this Chapter begins by illustrating the findings obtained from the E7 region. The descriptive statistics outcomes are given in Table 6.2 for the E7 region. Table 6.2 presents that all the factors specified, that is, CE, energy efficiency, forest resources, GDP, NRE, population size and RE have a total observation of 210. The number of observations per each factor specified in this section of the research is 210 because of a panel of seven nations for the period that range from 1990 to 2019. CE in Table 6.2 has a mean value of 3.79, median value of 2.61, maximum value of 14.63, and a standard deviation value of 3.34. Moreover, Table 6.2 depicts that energy efficiency has a mean value of approximately 710 000 000, while its median value is approximately 453 000 000. The maximum and standard deviation values of energy efficiency as depicted in Table 6.2 are approximately 4 710 000 000 and 862 000 000, respectively. In the case of forest resources, Table 6.2 depicts that its mean and median values are 2 488 061 and 1 002 265, respectively. Moreover, the maximum and standard deviation values of

forest land as depicted in Table 6.2 are 8 153 116 and 2 750 506, respectively. Furthermore, Table 3.2 depicts that the mean and median values of GDP are approximately 1 390 000 000 000 and 775 000 000 000, respectively. Its maximum and standard deviation values are also given as approximately 14 300 000 000 and 1 250 000 000, respectively. In the case of NRE, its mean is 63.93%, median is 71.88%, maximum is 93.39% and standard deviation is 30.55%. Population size of the E7 nations for the period under study is depicted to have a mean value of approximately 450 million, median value of approximately 183 million, maximum value of approximately 1.41 billion and a standard deviation of approximately 491 million. Lastly, RE is depicted in Table 6.2 to have a mean of 25.81%, median of 22.96%, maximum of 58.65% and standard deviation of 17.93%. The descriptive statistics outcomes are essential in understanding the behaviour or features of each factor employed in a model. The mean and median are usually used to show the average value of a series, but the way of calculating them is not the same. While median is obtained by arranging all observations in ascending or descending order and picking the value that falls at the middle, the mean is calculated by summing up all the observed values of a series and dividing the obtained value by the total number of observations. Both the mean and median as the proxies of the average are essential in showing the average value of a series. The maximum value of course depicts that highest value that has been attained in a series during a given period. It shows policy makers the highest value that may be attained in a series. Standard deviation on the other hand, shows the rate at which the observed values have been deviating from the mean. A large standard deviation shows that the observed values have been deviating much from the mean, while small standard deviation shows that observed values have not been wandering far away from the mean.

Table 6.2 Results of descriptive statistics of E7

	CE	EE	FR	GDP	NREC	POP	REC
Mean	3.787490	7.10E+08	2488061.	1.39E+12	63.93222	4.50E+08	25.81077
Median	2.612499	4.53E+08	1002265.	7.75E+11	71.87859	1.83E+08	22.96188
Maximum	14.63052	4.71E+09	8153116.	1.43E+13	93.39615	1.41E+09	58.65286
Std. Dev.	3.343104	8.62E+08	2750506.	2.25E+12	30.55455	4.91E+08	17.93362
Obs.	210	210	210	210	210	210	210

The CD test results of Pesaran (2015) helps to investigate if any CD is available in the present panel dataset. As outlined earlier on, panel data sets usually have CD problems because countries are always interdependent with each other and if this CD issue is available then the unit root can only be checked through using SG methods that have the capability of overcoming this problem. In the event that no CD is available then first-generation methods are useful. The CD results are given in Table 6.3 and they depict the availability of CD in all the panel series. This therefore an indication that SG methods of investigating the availability of unit root in these series must be utilised.

Table 6.3 CD test results of E7

Variables	CD-test	p-value
CE	18.54 ***	0.000
NREC	22.24 ***	0.000
REC	20.75 ***	0.000
lnPOP	11.83 ***	0.000
lnFR	-3.72 ***	0.000
lnEE	23.53 ***	0.000
lnGDP	22.86 ***	0.000

Note: *** stands for 5% significant

Since CD is available in the panel data set employed, the CIPS and the CADF unit root test methods are utilized and the results are given in Table 6.4. The CIPS and CADF results in Table 6.4 depicts that CE is stationary at level. However, other variables, that is, NRE, log of population, RE, log of forest resources, log of energy efficiency and log oif GDP are stationary at first-difference. As a result, the series used in this chapter have mixed integration orders and methods that accept this condition can be selected.

Table 6.4 Results of unit root of the E7

Variables	CIPS	CADF
CE	-2.606***	-3.194***
NREC	-2.110	-2.239*
REC	-0.826	-1.483
lnPOP	-1.287	-1.006
lnFR	-1.595	-1.274
lnEE	-1.731	-1.829
lnGDP	-2.648***	-2.226
ΔNREC	-6.190***	-2.965***
ΔREC	-4.721***	-2.399**
ΔlnFR	-5.250***	-1.492
ΔlnPOP	-3.309***	-2.430**
ΔlnEE	-6.190***	-3.459***
ΔlnGDP		-3.429***

Note: Δ is the first difference sign; *; **; *** are the 10%, 5%, 1% significant level

The Westerlund (20007) error correction model (ECM) cointegration test is employed and the results are presented in Table 6.5. The results shows that the model has insignificant cointegration, implying the non-existence of a long-run relationship. However, this will be verified by the CS-ARDL method employed for analysing the model's relationship.

Table 6.5 Results of Westerlund (2007) ECM cointegration test of the E7

Statistic	Value	z-value	P-value
Gt	-2.310	0.300	0.618
Ga	-0.280	4.306	1.000
Pt	-3.186	2.043	0.980
Pa	-1.216	2.656	0.996

Note: **; *** are the 10%, 5% and 1% significant level

Slope heterogeneity is also checked with the Pesaran and Yamagata (2008) method in order to ascertain if the model exhibits heterogeneity problems. The slope heterogeneity test outcomes are given in Table 6.6 of this research. These outcomes

show that heterogeneity is present in the model. This research utilises the CS-ARDL method, because it gives robust results when heterogeneity issues are present, CD and dynamics.

Table 6.6 Slope heterogeneity test results

	Statistic	*p-value*
Δ	11.262***	0.000
Δ adj.	13.004***	0.000

Note: Δ is the delta change sign; *** stands for 5% significant

CD in the present research model is checked by employing the Pesaran (2015) scaled LM, Frees (1995, 2004), and Friedman (1937) methods. The findings in Table 6.7 shows that CD is prent in the present model; hence, SG methods of analysisng relationship presented in a model are used.

Table 6.7 CSD results

	Statistic	*p-value*
Pesaran scaled LM	9.622***	0.0000
Friedman	94.750***	0.0000
Frees	1.562***	0.0000

Note: *** stands for 5% significant

The results of the CS-ARDL method in this section of this research are given in Table 6.8. The short-run findings give that, REC, the first lag of CE, first lag of NREC, and energy efficiency and population size exhibit a significant negative impact on CE. The findings show that REC and first lag of CE are significantly related with CE at 5% level, while NREC, energy efficiency and population size are negatively related to CE at 10% level. Therefore, this research study shows that, in the short-run, among the emerging economies, it is REC and the first lag of CE that gives a strong negative impact on CE. A rise in REC and the first lag of CE by a single-unit result in a significant fall in CE by 0.04 and 0.84 units respectively. These findings show that REC remains the major factor that lowers the emissions of CO_2. Moreover, a rise in population size, energy efficiency and NREC in the short-run, by one unit, causes CE to fall by 35.67, 19.29 and 0.05 respectively. This

association is, however, not very strong since it is significant at 10%, however the coefficient values of population size and energy efficiency are very high, hence we argue that energy efficiency is crucial in reducing CE in the E7 region. However, the presence of a negative effect of NREC on CE in the short-run as depicted in Table 6.8 remains questionable. High use of NRE ought to raise CE, because the source of NRE such as fossil fuel contains some carbon particles that during use result in combustion and hence the carbon particles are emitted to the air. As a result, a short-run negative link between these two factors may be explained by alluding that NRE is more detrimental to the environment as more of it is used. The short-run findings of the CS-ARDL technique also shows that GDP positively affects CE. Thus, high EG is usually achieved at the expense of the environment, through the use of energy sources which are not environmentally friendly. A rise in GDP by single percent in the short-run is accompanied by a rise in CE by 0.74%. Forest resources is found to have no strong influence on CE in the short-run, see Table 6.8. Its coefficient value is negative, showing that it might negatively affect CE. Of course, forest resources, trees and grass, are vital in lowering the carbon content in the air, because they take in CO2 and take out O2. The insignificant impact of forest resources on CE may be due to lack of forest resources in the emerging economies to harness the waste produced by NRE sources.

Table 6.8 Results of CS-ARDL technique of the E7

	Coefficient	z-Statistic
Short-run estimations		
L.CE	-0.8367	-6.77***
REC	-0.0390	-2.53**
lnFR	-35.6679	-1.52
lnPOP	-19.2981	-1.84*
lnEE	-0.6369	-1.71*
lnGDP	0.7406	1.89*
L.NREC	-0.0532	-1.76*
ECT(-1)	-1.8367	-14.85***
Long-run estimations		
REC	-0.0205	-2.27**

lnFR	-18.4521	-1.55
lnPOP	-9.5649	-1.98**
lnEE	-0.3676	-1.77*
lnGDP	0.4376	1.98**
NREC	-0.0308	-1.82*
CD Statistic	0.31	0.7571
F-Statistic	7.06***	0.000
R^2	0.99	

Note: * stands for 10% significant; ** stands for 5% significant; *** stands for 1% significant

The long -run adjusted term of CE in Table 6.8 depicts a negative and significant link with CE at 1%. The long-run estimations of the CS-ARDL technique in Table 6.8 also gives that, REC and population size in the emerging economies provides a significant impact on CE at 5% level. A rise in REC by one unit and population size by 1% in the emerging economies is observed to be linked with a fall in the emissions of carbon by 0.02 units and 9.56% respectively. Energy efficiency and NREC are also found to negatively impact CE at 10% significance level. Raising energy efficiency by a single percent and NREC by 1 unit is linked with a fall in CE by 0.37% and 0.03 units respectively. The present outcomes are crucial in that they emphasise the importance of energy efficiency in curbing the effects of CE to the environment. The wise use of energy, making sure it is not wasted is very crucial because the waste of energy is one other cause of emissions of CO2. NREC is expected to positively affect CE, but this is not the case in this study. The explanation behind the negative effect of NREC on CE can be the shift by nations to RE use. Forest resources in the long run is also found to have no significant effect on CE. The coefficient value of forest resources is however negative, giving an implication that forest resources may reduce CE in the emerging economies. The long-run outcomes also show that GDP positively affects CE in the emerging economies. A rise in GDP by 1% is associated with a rise in CE by 0.44%. The findings of the CS-ARDL method in Table 6.8 are robust, because the CD Statistic shows that cross-sectional dependence problems have been corrected for. Moreover, the F-statistic is strong, meaning that all explanatory series have a strong

joint effect on the regressand. The R² is also high, at 99% indicating a good model fit.

The negative significant influence of RE on the impact to the environment in the E7 region is supported by the postulations of past researchers who showed the significance of RE in lowering CE (Akadiri & Adebayo, 2022; Deka et al., 2022; Bhat, 2018). Therefore, RE must be improved in order to reduce CE. The no significant effect of forest resources on the impact to the environment, is not supported by studies which show the significance of natural resources on the environment (Amer et al., 2022). These outcomes are different from some postulations of other previous researches that indicated that CE is positively enhanced through using RE, Anser et al. (2021); Adedoyin et al (2021). The negative effect of population on the environment is supported by the postulations of Deka et al. (2023a). The negative effect of energy efficiency on the environment is also supported by the postulations that indicates that energy efficiency improves the environment through lowering CE (Deka et al., 2022a; Zakari et al., 2022; Akpanke et al., 2023b). Moreover, the positive effect of GDP on CE is supported by researches, which shows that economic growth worsens the surroundings (Abbas et al., 2021; Ben Mberek, Saidi & Rahman, 2018). The negative effect of NRE on the environment is not supported in the literature since most studies depict that it influences CE in a positive way (Deka et al., 2023a; Bakhsh et al., 2022; Boukhelkhal, 2021).

G7 results

This section of the research presents the findings obtained from the sample of the G7 nations. The Table 6.9 presents the outcomes of the descriptive statistics of the indicators CE, GDP, forest resources, RE, NRE, energy efficiency and population size of the G7 economies. The study period is 1990 to 2019, a total of 30 years for the seven nations making it 210 observations per each indicator used. The mean of CE, GDP, forest resources, RE, NRE, energy efficiency and population size are approximately 10.27; 3 920 000 000 000; 34.81; 8.79; 68.76; 655 000 000; and 102 000 000, respectively. These factors are also observed to have standard deviations of approximately 4.80; 4 170 000 000 000; 15.74; 6.65; 29.35; 554 000 000; and 83 000 000, respectively. Table 6.8 also depicts the maximums of the

indicators CE, GDP, forest land, RE, NRE, energy efficiency and population size as approximately, 20.47; 21 400 000 000 000; 68.49; 22.77; 94.63; 2 680 000 000; and 328 000 000, respectively. Descriptive statistics outcomes of indicators depict the features of the indicators used in a study. For example, the mean of an indicator is its average value, that is, the value obtained after summing up all the values of a series and dividing by the number of observations. It shows the average value of a series for a specific given period. The standard deviation also shows how far the series has been fluctuating or deviating from the mean. For example, a large value of standard deviation shows that the series has been wandering away from its average by a great margin, while a small standard deviation value shows that the fluctuation has been low. The maximum value as the name depicts, is the highest possible value attained in a series during the period under consideration.

Table 6.9 Descriptive statistics results of the G7

	Obs	Mean	Std. Dev	Max
CE	210	10.26897	4.804502	20.47193
GDP	210	3.92e+12	4.17e+12	2.14e+13
FR	210	34.80702	15.73756	68.49383
RE	210	8.790817	6.654477	22.7699
NRE	210	68.76402	29.34963	94.6333
EE	210	6.55e+08	5.54e+08	2.68e+09
POP	210	1.02e+08	8.30e+07	3.28e+08

Table 6.10 CD test results of G7

	CD statistic	p-value
CE	22.48***	0.000
lnFR	8.36***	0.000
RE	18.85***	0.000
NRE	24.83***	0.000
lnEE	23.46***	0.000
lnGDP	21.10***	0.000
lnPOP	17.71***	0.000

Note: *** stands for 1% significant

In Table 6.10, the present research presents the outcomes of the CD test (Pesaran, 2004). The CD test investigates if panel data exhibits cross-sectional dependence. Panel datasets are prone to CD because of trade and cooperation among different nations and this poses a challenge of the first-generation techniques of checking unit root. The CD problems in the panel datasets may be overcome by employing second-generation techniques of testing unit root. The Table 6.10 depicts that the panel data series CE, GDP, forest land, RE, NRE, energy efficiency and population size have significant CD. The CD Statistic is high and the p-value is 0 for all series, which is less than 0.01. Therefore, at 1% significance level, the panel data series of the G7 exhibits for CD; hence, the SG methods of unit root should be used.

Table 6.11 of the present research makes use of the CIPS and CADF tools of investigating the presence of unit root in the panel series, since they have significant CD. The CPS results in Table 6.11 depicts that log of forest resources, and log of size of population are stationary in the level. This is not supported by the findings of the CADF method that shows that these variables are not stationary. At first-difference CE, log GDP, RE, NRE, and log of energy efficiency are stationary, see the results of CIPS and CADF in Table 6.11. Therefore, the series tested in Table 6.11 for unit root have different integration orders. Other series are integrated in zero order while others have one integration order. Therefore, it is best to use the ARDL tool that accepts series whose order of integration are zero or one or mixed.

Table 6.11 Unit root test results of G7

	CIPS	*CADF*
CE	-1.026	-1.071
lnFR	-2.534**	-1.891
RE	-0.655	-0.338
NRE	-0.908	-1.244
lnEE	-1.407	-1.807
lnGDP	-1.993	-2.122
lnPOP	-2.667***	-1.832
ΔCE	-5.360***	-3.032***

ΔlnFR		-1.187
ΔRE	-4.915***	-2.745***
ΔNRE	-5.111***	-3.078***
ΔlnEE	-4.600***	-2.999***
ΔlnGDP	-4.636***	-3.483***
ΔlnPOP		-1.612

Note: * stands for 10% significant; ** stands for 5% significant; *** stands for 1% significant

Table 6.12 presents the slope heterogeneity findings. The slope heterogeneity test is used to investigate the presence of slope heterogeneity in the model. Testing for slope heterogeneity in a model helps in devising the best tool of data analysis that overcomes heterogeneity issues. Table 6.12 depicts the presence of significant slope heterogeneity in the model. The present research uses the CS-ARDL tool that overcomes heterogeneity issues.

Table 6.12 Slope heterogeneity results of G7

	Statistic	*p-value*
Δ	15.287***	0.000
Δ adj.	17.652***	0.000

Note: *** is 1% significant level

The present research also tests for the presence of a long-run connection in the model with the Westerlund (2007) ECM tool and the results are presented in Table 6.13. It is observed that the model specified in this section of the research for the G7 nations has insignificant cointegration.

Table 6.13 Westerlund (2007) ECM cointegration results

Statistic	*Value*	*Z-value*	*P-value*
Gt	-0.767	5.697	1.000
Ga	-0.443	4.945	1.000
Pt	-2.239	4.252	1.000
Pa	-0.854	3.663	1.000

Note: ** stands for 5% significant; *** stands for 1% significant

We also test the presence of weak CD in the model by employing the Pesaran (2015) scaled LM, Frees (1995, 2004), and Friedman (1937) tests, see results in Table 6.14. The findings show that there is significant CD in the model presented; hence, we employ SG methods in analysing the relationship of the present model.

Table 6.14 CSD test

Test method	Statistic	p-value
Pesaran	7.061***	0.000
Friedman	78.500***	0.000
Frees	0.962***	0.000

Note: ** stands for 5% significant; *** stands for 1% significant

Table 6.15 presents the findings of the CS-ARDL tool; both short-run and long run outcomes are depicted. Starting with the short-run outcomes, the lag of CE, forest resources and log of population size gives no significant effect on CE in G7 nations as per the dataset and period considered. The insignificant link between first lag of CE, forest resources and log of population size with CE depicts that these series does not provide a significant effect on the CE of the G7 nations. Thus, the high and rising CE in the G7 nations is not explained by its past value, nor is it explained by forest resources or population size, in the short-run. The lag of CE and log of population size have positive coefficients, which might mean a positive effect from these series to CE, but this link is not strong enough to cause any effect. Moreover, the forest resources series has a negative coefficient, which might imply a negative link between forest resources and CE, such that when forest resources increases then CE will be deterred, nonetheless this association is not strong.

RE and energy efficiency have a strong negative effect on CE as depicted in Table 6.15. The findings presented in the Table 6.15 illustrates that when RE and energy efficiency increases by a single unit, this will cause a sharp decrease in the CE of the G7 nations by 0.12 units and 0.00000000456 units. While the coefficient of RE is a bit high, illustrating a strong association, the coefficient of energy

efficiency is a bit low, illustrating a weak association. However, these associations are significant at 5%. Therefore, using RE to foster output production of a country is vital, since RE does not result in CE. Energy should also be utilised in an efficient manner that does not lead to waste. Each unit of energy is vital and if wasted, this may result in more pollution. The series log of GDP and NRE exhibits a strong positive association with CE. The short-run findings of the CS-ARDL tool depicts that, a rise in GDP by a single percentage I would associated with a rise in CE by 2.5% among the G7 nations in the short-run. The positive influence of GDP on CE gives evidence to the type of energy sources that are used to foster economic growth, which are harmful to the environment. When a nation engages in environmentally unfriendly activities to foster economic growth, this will be depicted by a rise in GDP that is linked with a rise in CE as provided in the present study. We also observe that a rise in NRE by a single unit is connected with a rise in CE in the short-run by 0.14 units, among the G7 nations. We observe in these findings that the utilisation of NRE sources remains the major culprit of environmental degradation and nations need to shun the use of this energy source that is harmful.

The long-run estimations result of the CS-ARDL tool are also presented in Table 6.15 and they depict that RE and energy efficiency are the significant indicators which significantly deter the CO2 emissions in the long-run, among the G7 countries. While forest resources has a negative coefficient depicting that it might reduce CE in the long run among the G7 nations, its impact is not statistically strong. The long-run estimations outcomes in Table 6.15 depicts that a rise in RE by a single unit in the long-run has the influence of lowering CE by 0.1244 units, while raising energy efficiency by a single unit in the long-run has a tendency of reducing energy efficiency by 0.00000000485 units. The coefficient value of RE is high enough to give a significant impact while the coefficient of energy efficiency is very low such that its impact on CE is negligible. However, both RE and energy efficiency are significant and they should be encouraged if CO2 emissions are to be deterred.

Table 6.15 CS-ARDL results of G7

	Coef.	z-Statistic	p-value
Short-run estimations			
l.CE	0.0680	1.13	0.257
lnFR	-39.2537	-0.97	0.332
RE	-0.1189	-2.27**	0.023
NRE	0.1422	2.12**	0.034
lnEE	-4.57e-09	-2.45**	0.014
lnGDP	2.5017	3.88***	0.000
lnPOP	7.9562	0.57	0.570
ECT(-1)	-0.9319	-15.54	0.000
Long-run estimations			
RE	-0.1244	-2.21**	0.027
NRE	0.1534	2.28**	0.023
lnEE	-4.85e-09	2.85***	0.004
lnFR	-32.1836	-0.95	0.343
lnGDP	2.8838	3.59***	0.000
lnPOP	7.9112	0.53	0.595
CD Statistic		-1.39	0.132

Note: *; **; *** are the 10%, 5% and 1% significant level

The CS-ARDL method's long-run results also depicts that many renewable energy and GDP have a significant positive influence CE in the case of the G7 countries in the long-run, while population size has a positive quote efficiently but it is insignificant. The CS-ARDL model results shows that if NRE is raised with a single unit this is going to raise CE among the G7 countries by 0.15 units, while rise in GDP by a single percentage causes CE to rise by 2.88 units. These results depict that NRE, RE and GDP are the main culprit causes of CE in the G7 region in the long run. Moreover, the long-run CS-ARDL model's outcomes concur with the outcomes given by the short run estimations. Thus, there is no asymmetric effect on population size, renewable energy, GDP, forest resources, energy efficiency and NRE on RE among the G7 countries. Nevertheless, the long run and

the short-run provide the same results. They show that RE and energy efficiency are vital for reducing CE in both short- and long-run, while NRE and GDP are the major drivers of CE, hence the use of NRE should be shunned. Forest resources represents the forest resources and these forest resources consist of green plants which are scientifically known for taking in CO2 during the process of photosynthesis, hence we expect a negative connection between forest land and CE. While the coefficient value of forest resources for both the short- and the long-run CS-ARDL estimates depicts that this association is not significant at 5% level. Therefore, while forest resources may have a negative effect on CE its impact is not significantly strong, hence has a negligible effect on CE among the G7 economies. Of great importance is CD statistic value when employing CS-ARDL technique considering the fact that the model employed in this research has slope heterogeneity and cross-sectional dependence issues. The CD statistic value provided in Table 6.15 is -1.39 which is insignificant statistically. CD statistic value that is insignificant at 5% level shows that the effects of cross-sectional dependance that existed in the model have been overcome by the use of the CS-ARDL model. Therefore, employing CS-ARDL technique is vital for overcoming the problems of CD in the model.

The results presented in Table 6.15 depicts that RE and energy efficiency reduces the damage of the surroundings in the G7 region. These findings are supported by overwhelming evidence presented in the research done in the past, Razzaq et al. (2021); Akram et al., (2022); Akram et al. (2022); Matthiesen et al. (2011). Therefore, use of RE and efficient use of energy reducing its waste and making the best out of each unit utilized is vital in lowering CE. Results in Table 6.15 also depicts NRE and GDP causes more damage to the surroundings. These findings are in line with the result of past researches (Akadiri & Adebayo, 2022; Deka et al., 2023a; Abbas et al., 2021; Ben Mberek et al., 2018).

ECOWAS results

In this section, we present the findings of the dataset obtained from the 15 West African nations, the ECOWAS region, for the period 1990 to 2019. We begin by presenting the descriptive statistics outcomes in Table 6.16, to understand the various characteristics of the series employed in the research. Table 6.16 depicts that the total number of observations for all the series, CE, forest land, RE, energy efficiency, GDP, NRE and population size are 450. The mean, maximum and standard deviation values of CE are 0.28; 1.14 and 0.227, respectively, see Table 6.16. Therefore, on average the emissions of carbon among the 15 west African nations from 1990 to 2019 was 0.28%, while the maximum was 1.14% and the values of CE during this period among these nations, have been deviating from the mean at a rate of 0.227. We observe that on average, the emissions of CO_2 in the ECOWAS region on average were low. In the case of forest resources its mean is 32.57, a maximum of 88.5 and a standard deviation of 22.07, see Table 6.16. The mean of RE is 68.51, maximum is 95.99 and its standard deviation is 24.27. In the case of NRE its mean is 10.03, with a maximum of 55.16 and a standard deviation of 15.55. The descriptive statistics of the ECOWAS region depicts that RE is used more than NRE. This is supported by the evidence presented in Table 6.16, which depicts that the average use of RE in this region is 68.51 which is higher than NRE which has a mean of 10.03. Therefore, West African nations use less fossil fuels, which are not friendly to the environment and use more RE that is safe to the environment. In addition, energy efficiency has a mean of 28 800 000, a maximum of 716 000 000 and a standard deviation of 77 000 000. GDP among the West African nations, has a mean of 22 000 000 000, a maximum of 547 000 000 000, while population size has a mean of 17 900 000, maximum of 201 000 000 and standard 34 600 000, see Table 6.16.

Table 6.16 Descriptive statistics results of ECOWAS

	Obs	Mean	Std.Dev	Max
CE	450	0.2818	0.2267	1.1426
FR	450	32.5689	22.0693	88.5096
RE	450	68.5146	24.2724	94.9888
NRE	450	10.0316	15.5509	55.1647
EE	450	2.88e+07	7.70e+07	7.16e+08
GDP	450	2.20e+10	7.09e+10	5.47e+11
POP	450	1.79e+07	3.46e+07	2.01e+08

The CD statistics outcomes in this section are presented in Table 6.17. The CD statistic is a vital test when using panel data due to the trade among countries and some interdependence that result in cross-sectional dependence among series. It is vital in ascertaining the best unit root tool to use. Series with a significant CD can be analysed by using the second-generation tools of unit root check, since they have the ability to overcome CD issues, while those panel series with not CD issues may be analysed by employing the first-generation tool. The outcomes presented in Table 6.17 depicts that CE, RE, energy efficiency, population size and GDP exhibit significant CD. The outcomes are significant at a level of 1%. Forest resources and NRE could not be tested for CD because their datasets are not balanced.

Table 6.17 CD test of ECOWAS

	CD statistic	p-value
CE	35.63***	0.000
FL	-	-
RE	41.52***	0.000
NRE	-	-
lnEE	26.63***	0.000
lnGDP	51.00***	0.000
lnPOP	55.71***	0.000

Note: *** stands for 1% significant

The unit root outcomes of the CIPS and CADF tools are presented in Table 6.18. The findings presented by the CIPS technique in Table 6.18 depicts that NRE,

log of forest resources, CE, RE, log of energy efficiency, and log GDP have a significant unit root at level. The outcomes of the CIPS tool are supported by the findings of the CADF tool that depicts that NRE, log of forest resources, CE, RE, log of energy efficiency, and log GDP series have a significant unit root at level. The CADF tool also depicts log population size have no significant unit root at level. The presence of a no significant unit root on population size at level as per the outcomes of the CIPS test is not supported by the CADF findings which depicts that log of population has a significant unit root. NRE, log of forest resources, CE, RE, log of energy efficiency, and log GDP series, as per the CIPS tool have no unit root issues at first difference. This is supported by the postulations of CADF tool that also depicts that these series have no unit root issues after first-difference except for NRE and log of energy efficiency. The outcomes of the CIPS and CADF tools presented in Table 6.18 depicts that the series employed in this section have different orders of integration, while some series are integrated at order 1 others are integrated at order zero. Thus, a technique of data analysis such as the ARDL to which employs series with different orders of integration is used.

Table 6.18 Unit root results of ECOWAS

	CIPS	*CADF*
CE	-1.866	-2.104*
lnFL	-1.088	-1.088
RE	-1.851	-1.906
NRE	0.694	0.725
lnEE	-0.245	0.329
lnGDP	-2.680***	-2.596***
lnPOP	-2.275**	-1.770
ΔCE	-5.425***	-3.070***
ΔlnFL	-4.445***	-1.122
ΔRE	-5.371***	-2.591***
ΔNRE	-1.668	0.020
ΔlnEE	-2.549***	0.146
ΔlnPOP		-2.163*

Note: Δ is the first difference sign; *, **, *** are the 10%, 5% and 1% significant level

This section presents the outcomes of the Pesaran and Yamagata (2008) slope heterogeneity test for the ECOWAS region, considering the data set that is employed in this section. The outcomes pf the slope heterogeneity test are presented in Table 6.19. The findings of the delta statistics of this slope heterogeneity test shows that the series utilised in the model of this present section of the research have a significant slope heterogeneity. Therefore, it is vital to employ a tool of data analysis that overcomes the issues of slope heterogeneity; otherwise, biassed outcomes can be presented.

Table 6.19 Slope heterogeneity results of ECOWAS

	Delta	*p-value*
Δ	16.221***	0.000
Δ adj.	18.731***	0.000

In addition to that, this section of the present research presents the outcomes of the Westerlund (2007) ECM test of cointegration. The cointegration test outcomes are presented in Table 6.20 and they show that no significant association is present in the model. This will be validated by the CS-ARDL model results.

Table 6.20 Westerlund (2007) ECM cointegration results ECOWAS

Statistic	*Value*	*z-value*	*P-value*
Gt	-2.657	0.721	0.765
Ga	-0.238	7.328	1.000
Pt	-3.846	5.697	1.000
Pa	-1.188	5.219	1.000

Note: *; **; *** are the 10%, 5% and 1% significant level

In Table 6.21 weak CD is tested in the model by employing the Pesaran (2015l scaled LM, Frees (1995, 2004), and Friedman (1937) methods. The findings in Table 6.21 depicts the presence of significant CD in the model; hence we employ SG methods to annalyse the relationship presented in the present model.

Table 6.21 Weak CD test

Test method	Statistic	p-value
Pesaran	19.439***	0.0000
Friedman	87.202***	0.0000
Frees	2.570***	0.0000

This section employs the CS-ARADL technique because the series used have mixed order of integration, have significant cross-sectional dependence, exhibit for a significant slope heterogeneity and are significantly cointegrated. The CS-ARDL tool is a vital model since it overcomes cross-sectional dependence issues, heterogeneity issues and accepts the use of series whose order of integration is zero or one. Moreover, the CS-ARDL method provides the long- and short-run estimations of the model, hence is essential taking into consideration the fact that the series considered in this research have a significant cointegration relationship.

The results provided in Table 6.22 of the CS-ARADL method, according to the short-run estimations depicts that the first lag of CE, energy efficiency and RE use gives a negative influence on CE in the West African nations which is strong, while GDP portrays a strong positive influence on CE in this region. Other series, such as population size, NRE and forest reources according to the short-run estimations of the CS-ARDL method, do not present any strong influence on CE in the West African countries.

The short-run estimations outcomes in Table 6.22 depicts that, increasing the lag of CE with a single unit has the influence of lowering CE in the West African nations by 1.02 units. This association is strongly significant at the level of 1% depicting the importance of past CE in enhancing the reduction of future CE. Therefore, high emissions of carbon in the past among the West African nations has induced these countries to lower their future CE. In addition to that, the findings in Table 6.22 presents that raising energy efficiency with a single percent has the influence of lowering the emissions of carbon in the West African nations by 0.33%. The connection between CE and energy efficiency among the West African nations,

as per the short-run estimations, is strong and significant at the level of 1%. This depicts that the wise utilisation of energy ensuring that any wastage is a minimised among the West African nations is vital in lowering the emissions of carbon in this region. Therefore, it is essential to ensure efficiency in the utilisation of energy a vital resource of economic growth. The outcomes provided in Table 6.22 also depicts that enhancing RE with one unit among the West African nations has the influence of lowering the emissions of carbon by 0.0079 units. While the coefficient value of RE on its effect on CE is relatively low, these results are strong at the level of 1%, indicating the importance of RE in lowering the level of carbon content in the air. Therefore, it is essential for nations to seek the utilisation of RE sources that are safe to the environment. While RE and energy efficiency are shown to strongly lowers CE in the short-run among the West African nations, GDP is singled out is the chief culprit which promotes the emissions of carbon in this region. GDP has been long observed to present a positive effect on the emissions of carbon among various nations due to the utilisation of energy sources and the practise of various activities that are dangerous to the environment in a bid to attain high economic growth. As a result, it is essential for nations to resort to those activities that are not harmful to the environment as well as the utilisation of energy that is safe to the surroundings, such as RE in their bid to raise the growth of their economies. Engaging in harmful activities and the utilisation of energy sources that emit carbon content in the air, has some side effects of promoting the emissions of carbon, hence global warming issues arise. While population size and forest resources have a negative coefficient implying their negative effect on CE among the West African nations, this relationship is not strongly significant. Therefore, forest resources and population size in as much as they have and negative effect on CE this effect is not strong enough to cause any significant impact. NRE is also observed to exhibit a positive coefficient which depicts that it might positively affect CE in this region, but these outcomes are not strongly significant at 5% level hence a negligible impact of NRE on CE is observed.

Table 6.22 CS-ARDL results of ECOWAS

	Coef.	z-Statistic	p-value
	Short-run estimations		
l.CE	-1.0238	-18.83***	0.000
lnFR	-0.1658	-0.80	0.426
RE	-0.0079	-4.18***	0.000
NRE	0.0007	0.46	0.648
lnEE	-0.3322	-4.14***	0.000
lnGDP	0.3729	4.02***	0.000
lnPOP	-2.8024	-1.06	0.288
ECT(-1)	-2.0238	-37.22***	0.000
	Long-run estimations		
RE	-0.0039	-4.18***	0.000
NRE	0.0004	0.55	0.580
lnEE	-0.1613	-4.44***	0.000
lnFR	-0.0713	-0.78	0.436
lnGDP	0.1805	4.30***	0.000
lnPOP	-1.2477	-1.07	0.286
CD Statistic		-1.91*	0.0563

Note: *; **; *** are the 10%, 5% and 1% significant level

The long-run CS-ARDL method estimations outcomes concur with the outcomes given in the short-run estimations that shows that energy efficiency and RE are essential in lowering CE in the West African region. The long-run estimation outcomes also support the short-run estimation outcomes by providing GDP as the main factor that promotes CE in this region, while population size, forest resources and NRE do not influence CE strongly. According to the long-run CS-ARDL method estimations, raising energy efficiency with a single percentage has the influence of lowering the emissions of carbon among the West African nations by 0.16%. The energy efficiency's influence on the emissions of carbon in this region is observed to be significant at the level of 1%, hence a strong association between energy efficiency and CE exists in the West African nations. The long-run CS-ARDL method's outcomes also show that increasing RE with a single unit has

the effect of reducing the emissions of carbon by 0.004 units. While the coefficient value of RE on its impact on CE is relatively small, these outcomes are significant at the level of 1% implying a strong association between the series. As a result, the wise utilisation of energy making sure that no energy is wasted, as well as the utilisation of renewable sources of energy is essential among the West African nations for reducing CE.

While RE and energy efficiency are the most crucial factors which enhance environmental wellness among the West African nations, GDP is observed to promote the emission of carbon in this region. Raising GDP by a single percentage is observed to be linked with a rise in CE by 0.1805%. As explained earlier on, GDP is positively associated with the emissions of carbon, due to the utilisation of energy sources that are dangerous to the surroundings in the production process that is responsible for raising the growth of the economy as well as engaging in activities that are dangerous to the surroundings in order to achieve high EG. Therefore, it is vital to shun from energy use that is dangerous to the surroundings, as well as shunning the activities that harm the environment for attaining high economic growth, by using sources of energy such as renewables that are safe to the environment and ensuring the wise utilisation of energy sources. While the coefficient value of NRE is positive, its association with CE is not statistically significant. NRE is generally known for promoting the emissions of carbon because it emits carbon in the atmosphere. Thus, the insignificant influence of NRE on CE in the West African nations depicts that economies in this region have shifted from the use of NRE to using renewables that are safe to the environment. The coefficient value of forest land and population size are also negative, according to the CS-ARDL model's long-term estimations in Table 6.22 depicting that these series may reduce the emissions of carbon in the air. However, this association is not statistically significant and their impact is not strong. The findings of the long run and the short-run CS-ARDL method's estimates presented in Table 6.22 shows that no asymmetric exists on the effect of the explanatory series on the dependent series. Both long run and short-run outcomes present similar outcomes. We observed that the CD statistic value of the results shown in Table 6.22 of the CS-ARADL model is statistically insignificant at the level of 5% depicting that the CS-ARDL tool has

successfully overcome the issues of CD; hence, these findings are robust and reliable for policy implications.

The negative long run link between RE and energy efficiency which depicts that these factors improves the quality of the surroundings through lowering CE is supported by various researches done in the past Zakari et al. (2022); Akpanke et al. (2023b); Abbas et al. (2021); Akram et al. (2022); Matthiesen et al. (2011). Therefore, the use of RE should be encouraged in the ECOWAS region; energy efficiency should be enhanced too. The positive effect of GDP on CE is also in line with past studies findings (Bouyghrissi et al., 2021; Abbas et al., 2021; Ben Mberek et al., 2018). The insignificant effect of NRE on CE is not supported by studies that indicate that this factor raises CE (Akadiri & Adebayo, 2022; Deka et al., 2023a). In addition to that, the results that depict that FR does not enhance CE in the ECOWAS is supported by the results presented in Akpanke et al. (2023b). The insignificant effect of population size on the CE is also not supported by researches that give a significant negative link between the two.

Summary

- Energy efficiency is observed to be responsible for improving the quality of the environment among the E7, G7 and the fifteen West African countries.

- RE is also determined as the major factor that is responsible for improving environmental quality in these three economic regions.

- Forest resources are essential in lowering environmental degradation, hence the need for countries to come up with policies that can improve the planting of trees and maintaining forest resources.

- NRE is determined as the main culprit which causes a bit of environmental degradation among the E7, G7 and the fifteen West African countries, hence should be shunned and nations should move towards the use of RE.

- GDP is also determined as one of the factors which promote ED due to the use of energy which is to the surroundings in the process of promoting economic growth.

CHAPTER VII

Renewable energy development in the E7, G7 and ECOWAS countries

Introduction

GHG and CO2 emissions are largely blamed for causing global warming, which causes drought, hunger and starvation in the world. GHG and CO2 emissions come from fossil energy and are not friendly to the environment (Mukhtarov et al., 2022; Shahbaz, et al., 2020; Salim & Rafiq, 2012; Deka et al., 2022). Due to global warming problems, the world has started to promote the use of RE which is clesn to the air. Nations are working towards improving RE projects to achieve future low carbon goal. Government can improve RE projects through tax advantage towards such projects or by subsidizing sectors, which promotes the production of RE sources, Mukhtarov, et al. (2022). At the same time, the government may also increase tax on those projects that uses fossil energy as a way of discouraging negative externalities. RE sources are expensive, Becker and Fischer (2013) and nations with less financial resources suffers a drawback in RE development.

The current study examines the relationship between RE consumption and FD in the emerging economies. The G7 countries and ECOWAS countries are also examined and their results are compared with those of the E7 countries. The current study is crucial because past studies concentrated on examining the relationship between FD, RE and EG in financially rich countries that can fund RE projects with their rich financial sources (Kim & Park, 2016; Usman et al., 2021; Mukhtarov et al., 2022). Macroeconomic indicators such as economic growth also play a significant role in increasing RE consumption in the world. Few studies on the financial development, RE and economic growth relationship in developing and emerging economies, with less financial power to promote RE, have been undertaken. In the emerging economies, FD, RE and economic growth relationship has been done in Turkey; see for instance, Mukhtarov, et al. (2022), and Pata (2018); in China et al. (2019), Qin, et al., (2021), Wang et al. (2021); and in India,

Eren et al. (2019). Studies conducted in one single country provides less significant contribution to the literature. Therefore, another study in the E7 that provides significant contribution to literature, should be done to understand FD, economic growth and RE relationship.

The current study is crucial in the sense that it considers 7 emerging economies, China, Russia, Brazil, India, Indonesia, Mexico and Turkey that have transformed from low-income nations to emerging economies. Transforming from low-income nations to emerging nations by E7 economies causes high-rise in CO2 and GHG emissions, since fossil energy is widely used to achieve high economic growth. A very good example is China, which is considered as the largest emitter of CO2 due to its reliance on fossil energy for economic growth purposes (Qin, et al., 2021). The current study is also crucial because the total growth rate of energy in emerging economies is expected to grow so rapidly in the future, for example, in India energy is expected to experience a growth rate of 129% by 2035 (Eren, et al., 2019). Emerging economies are not rich financially, therefore, there is need to understand all the issues around improving RE projects in these countries (Mukhtarov, et al., 2022; Ji & Zhang, 2019). Past studies shows that FD has a positive significant impact on RE development (Mukhtarov, et al., 2022; Musa, et al., 2021; Saygun & Iskenderoglu, 2021; Koksal, et al. 2021; Usman, et al., 2021; Eren, et al., 2019; Qin, et al., 2021).

There is more than enough evidence pointing to the fact that nations with strong and rich financial systems can fund and promote RE projects. RE development in turn reduces GHG emissions and global warming. The study by Shahbaz, et al., (2021), which employed foreign direct investment, observed that RE and FDI are positively linked. On the other hand, other studies have observed a poor link between FD and RE development. For example, a study by Koksal, et al. (2021) showed that financial system proxies are poorly linked to RE consumption in the OECD countries. Another study by Assi et al. (2020), also observed that FD do not significantly affect RE consumption in the ASEAN. Besides FD, macroeconomic factors also help enhance RE development (Mukhtarov, et al., 2022). GDP or EG is one macroeconomic indicator that positively impacts RE development, Al-Mulali, Ozturk and Lean (2015); Wang, et al. (2021); Chica-

Olmo, et al. (2020); Shahbaz, et al., (2021); Dogan, et al. (2020); Wang and Wang (2020).

To the best of our knowledge, the current study is among the first to use a panel of seven E7 to analyse the association that exists between RE and financial development. Past studies concentrated on single countries among emerging countries like Turkey, China and India whose results might not give major contribution to literature. The findings of the E7 countries are also compared with those of the G7 and ECOWAS countries. The study also employs FDI, in a bid to understand if emerging economies, may utilize foreign investment to promote RE projects. This study also employs CPI to proxy energy prices, Mukhtarov, et al. (2022). In this research, Pooled Mean Group (PMG), ,Mean Group (MG) method are used because they overcome heterogeneity and dynamics in the model. The findings of the PMG and MG methods are also verified with the Random Effects and Fixed Effects methods.

Financial development and Renewable energy

The connection between FD and RE was undertaken through numerous research. Researches on the connection between FD and RE was carried out in diverse rareas of the arena. For instance, in EU, Al-Mulali, et al. (2015); Musa, et al., (2021); within the OECD, Koksal, et al. (2021); Usman and Makhdun (2021) within the BRICS-T. Within the MENA area, Charfeddine and Kahia (2019); within the ASEAN area, Assi, et al. (2020); Pata (2018), in Turkey Mukhtarov, et al. (2022), in China, Wang, et al. (2021); He, et al., (2019); Qin, et al., (2021); Ji and Zhang (2019), and in India, Eren, et al. (2019). Many researches supplied that financially wealthy regions can use economic power to improve RE of their nations and hence lessen the harming of the surroungings, Usman, et al., (2021). In contrast to growing nations, with not strong economic systems to fund RE power projects, they apply fossil gasoline power to develop economically thereby negatively affecting the surroundings. An awesome instance is China which emwrged from a low-income to an emerging-income country via using fossil power. China is now one among the most CO2 emitters, Qin, et al., (2021).

Research observed FD to present a positive impact on RE intake (Mukhtarov, et al., 2022; Musa, et al., 2021; Koksal, et al. 2021; Eren, et al., 2019; Usman, et al., 2021; Qin, et al., 2021). More proof is determined in studies at the significance of FD in growing sustainable RE power initiatives, intended to attain the goal carbon neutrality. Consequently, GDP improvement circuitously reduces CO2 emissions and as a result global warming, via the improvement in RE power initiatives. Usman, et al., (2021) depicts that FD collectively with RE power condense the harmful of the surroundings, whilst Usman, Alola and Akadari (2021) depicts that the high quality of the surroundings is advanced by means of shocks to RE from FD. However, Assi, et al. (2020) within ASEAN area, and inside the OECD, Koksal, et al. (2021) found that FD has no great impact on RE intake. MENA area is likewise associated by poor FD and RE. On this regard, countries must endevour toward enhancing RE power projects through getting exceptional alternative strategies to promote them to attain low carbon.

EG and Renewable energy

GDP increase and RE intake's relationship is vital to governments, economists, and policy makers for correct rules recommendations. There is numerous research in field that have been done to apprehend on the connection between RE intake and GDP growth. Wide range of research in study presents that RE intake and GDP increase are positively connected (Mukhtarov, et al., 2022; Al-Mulali, et al., 2015; Usman, et al., (2021); Charfeddine & Kahia, 2019; Shahbaz, et al., 2021; Shahbaz, et al., 2021; Wang, et al., 2021; Khan, et al., 2019;). The research of, Shahbaz, et al., (2021); Eren, et al., (2019); Wang, et al. (2021); Usman, et al. (2021) presents that EG gives a positive effect on RE improvement. For countries to enhance RE improvement and subsequently lessen the impact of global warming, they need to enhance more GDP growth which in flip facilitates improve in RE power resources, Li and Lee (2022); Rahman and Sultana (2022); Chen, et al. (2022). This is so because RE intake presents negative influence on the emissions of CO2 (Adedoyin, et al., 2021; Wang, et al., 2022; Wei, et al., 2022; Karaaslan & Camkaya, 2022). However, different researches presents that EG has

a terrible influence on RE intake see as an instance, Khan, et al. (2019); Shahbaz, et al. (2021); De Oliveira and Moutinho (2022). GDP growth is not the only factor that enhance RE power, different empirical research additionally determined that RE intake has a positive influence on EG. This indicates that if countries turn to the usage of RE then this may move an extended way in enhancing GDP improvement (Namahoro, et al., 2021; Chica-Olmo, et al., 2020; Chen, et al., 2022; Ivanovski, et al., 2021; Shahbaz, et al., 2020; Rahman & Velayutham, 2020; Wang & Wang, 2020). Therefore, empirical proof available in literature up to now suggests the presence of a bilateral relationship among EG and RE use.

Macroeconomic factors and Renewable energy

The connection among macroeconomic factors and RE is vital. Mukhtarov, et al. (2022) supplied that new research that includes distinct factors have to be carried out to apprehend on how RE power projects may be progressed. Macroeconomic elements have an essential position to play in enhancing RE improvement. Previous research on Consumer Price Index (CPI) and RE intake association, supplied that a rise in CPI or inflation has the impact of deterring RE power intake (Deka & Dube, 2021; Deka, et al., 2022). Consequently, countries need to work in the direction of decreasing excessive and growing inflation rate to permit an improvement on the RE power resources. Different researches inclusive of Shahbaz, et al. (2021) offers that CPI do not have an effect on RE power in a significant manner. Consequently, there is need for additional studies to be carried out to examine RE and inflation rate association in lots of different areas. Deka, et al. (2022); Deka & Dube (2021) tested RE and foreign rate of association, and discovered that a stable rate of forex enables as a result RE power intake.

The presence of a longer-term relationship among RE and different macroeconomic elements which includes globalization, CO2 emissions, real earnings, urbanization, exchange openness, material intake, natural resources and industrialization simply to say some had been examined (Pata, 2018; Doǧan & Seker, 2016; Kim & Park, 2016; Mico, et al., 2022. Pata (2018) articulates that urbanization collectively with FD and EG has the impact of promoting

environmental downgrade in Turkey. Furthermore, the research by means of Usman and Balsalobre-Lorente (2022) offers that industrialization, total reserve, and monetary improvement have an insignificant impact on the pollution of the air. The effect of numerous different macroeconomic factors on environmental quality has not been completely studied and most of the available researches gives unique outcomes. As a result, there may be impending need for correct research that examines environmental quality, RE, and numerous macroeconomic factors association. By developing such research, this could go an extended manner in supporting governments, economists, environmentalists, and policy makers in developing with proper policy implementations that may be used for the cause of attaining carbon neutrality goal.

Data and Methodology

Model

Due to the work of Mukhtarov, et al. (2018); Chang (2015); Ali, et al. (2015) who provided a framework that explains energy use as a function of economic growth, FD and energy prices. Mukhtarov, et al. (2022); Eren, et al. (2019) modelled RE use as a function of EG and FD. Mukhtarov, et al. (2022) used CPI to proxy energy prices. In this study, we model RE as a function of GDP, FD, FDI, fossil energy, and rate of inflation. Thus, the model framework in this study is given in Equation 7.1:

$$RE = f(GDP, FD, FDI, INFL) \qquad (7.1)$$

Where, RE represents the use of renewable energy. FDI is employed to represent foreign direct investment. FD is the financial development and is proxied with broad money (BM) and private sector credit (PSC). INFL is the rate of inflation, measured as a percentage of presents CPI, which is used to represent prices of energy. NRE is the use of fossil energy and GDP is Gross Domestic Product.

Sample Data

This chapter considers dataset of three different World economic regions, that is, the E7, the G7, and the fifteen West African countries. The data used is annual data and is for the period that ranges from 1990 to 2021 that was taken from the databases of the World Bank. Table 7.1, summarizes the variables employed in this study, their measurement, type and source.

Table7.1 Variables summary

Variables	Measurement	Type	Source
RE	% of total final energy	Dependent	World Bank
PSC	% of GDP	Independent	World Bank
GDP		Independent	World Bank
BM	% of GDP	Independent	World Bank
FDI	Net inflows, % of GDP	Independent	World Bank
INFL	% of base year 2010	Independent	World Bank

Method

The method used in this chapter follows the first-generation methodologies of running data and is done in stages. The first stage of preliminary testing tests the variables for unit root test and the model cointegration. This Chapter differs from the Chapter 6, which uses the second-generation methods because of the presence of CD. We use the Fisher type and Im-Pesaran-Shin methods of testing unit root in the model. Testing for unit root is fundamental in determining the order of integration of the variables. We also use the Kao, Pedroni and Westerlund test of checking cointegration in the model. These methods of checking cointegration in the model are the first-generation methods, in line with the methodology followed in this research.

In the second stage we employ the panel ARDL techniques, thatbis, PMG, and MG methods, which accepts variables with mixed integration order . These

methods also provide long and short run outcomes, hence asymmetric effects can be determined. Equation 7.2 presents the statistical panel ARDL representation.

$$RE_t = \beta_0 + \sum_{i=1}^{p} \beta_{1i} \Delta RE_{t-i}$$

$$+ \sum_{i=1}^{q} \beta_{2i} \Delta INFL_{t-i} + \sum_{i=1}^{q} \beta_{3i} \Delta BM_{t-i} + \sum_{i=1}^{q} \beta_{4i} \Delta PSC_{t-i}$$

$$+ \sum_{i=1}^{q} \beta_{5i} \Delta FDI_{t-i} + \sum_{i=1}^{q} \beta_{6i} \Delta lnGDP_{t-i} + \beta_{7i} RE_{t-1} + \beta_{8i} INFL_{t-1}$$

$$+ \beta_{9i} BM_{t-1} + \beta_{10i} PSC_{t-1} + \beta_{11i} FDI_{t-1} + \beta_{12i} lnGDP_{t-1} + \beta_{13i} ECT_{t-1}$$

$$+ et \tag{7.2}$$

Equation 7.2, gives β_0 which is the constant of the model; Δ represents first-difference of series in the short-run; β_{1i} - β_{6i} are the short-run coefficients; β_{7i} - β_{12i} are the long-run coefficients; β_{13i} is the error correction term (ECT)'s coefficient; while et is the white noise error term. The FE and the random effects methods are also employed to verify the the panel ARDL results.

E7 results

In this section of the research, we begin by presenting the outcomes of the emerging seven economies, to see how RE use is impacted by the explanatory variables, FD, inflation rate, GDP and FDI. We begin by presenting the outcomes of the descriptive statistics of the series. Table 7.2 presents the outcomes of the descriptive statistics in the emerging seven economies for the series RE, inflation rate, GDP, private sector credit, FDI and broad money. It is observed in Table 7.2 that all the series employed have 217 number of observations. This is so because this section constitutes of seven countries, that is, the emerging seven economies, for the annual period ranging from 1990 to 2020. Thus, multiplying 31 years with seven gives 217. The descriptive statistic outcomes in Table 7.2 are the mean, standard deviation and median. The mean and median values are the average values of a series, but are calculated using different methods. While the mean value is

obtained by summing up all the series and divide by the number of observations, the median value is obtained by arranging the series observations in ascending or descending order and picking the middle value. The standard deviation shows how the observations of each series have been diverting from the mean overtime. The findings of the descriptive statistics in Table 7.2 depicts that the mean of RE use is 26.48, while its standard deviation is 17.25, with a median value of 24.23. We also observed that private sector credit has a mean of 48.58, standard deviation of 35.33, and a median of 36.99. In addition to that, inflation rate is observed to have a mean of 83.52%, standard deviation of 50.42% and a median of 81.26%. Furthermore, broad money has a mean of 64, standard deviation of 43.04 and a median of 49.1. FDI is also observed according to the findings provided in Table 7.2 to have a mean of 36 billion, standard deviation of 55.6 billion and a median of 19.2 billion, see table 7.2.

Table 7.2 Descriptive statistics outcomes E7

	RE	INFL	PSC	BM	GDP	FDI
Mean	26.48326	83.52474	48.57989	64.03331	1.51E+12	3.60E+10
Median	24.23179	81.26116	36.98679	49.10006	8.62E+11	1.92E+10
Std. Dev.	17.24590	50.41831	35.33219	43.04234	2.44E+12	5.56E+10
Observations	217	217	217	217	217	217

Table 7.3 in this section uses the Fisher type and the Im-Pesaran-Shin techniques, which happen to be the FG techniques of testing unit root. The outcomes of unit root presented by the Fisher type and Im-Pesaran-Shin tool presents that the series, RE, GDP, inflation rate, broad money and private sector credit have a significant unit root at level see Table 7.4. The Fisher type and Im-Pesaran-Shin tools present that FDI has no significant unit root at level. In addition to that, the findings presented by the Fisher type and Im-Pesaran-Shin tools depict that the series, private sector credit, RE, broad money, inflation rate and GDP have no significant unit root in the first-difference form. Therefore, the series FDI is integrated of order 0, whereas private sector credit, RE, broad money, inflation rate and GDP are integrated of order one. Thus, since the series employed in the present

research have mixed integration orders, the ARDL tool that accepts series with such conditions is employed.

Table 7.3 Test of unit root outcomes of E7

	Fisher-type	**Im-Pesaran-Shin**
REC	-0.397	0.157
lnGDP	-1.599	2.157
FDI	2.363***	-1.889**
INFL	-2.313	10.237
BM	-1.449	0.847
PSC	-1.054	1.646
ΔREC	34.012***	-7.187***
ΔlnGDP	21.404***	-6.465***
ΔINFL	4.884***	-1.735**
ΔBM	29.488***	-6.958***
ΔPSC	18.285***	-6.100***

Note: Δ is first difference operator; *** is 1% significant; ** is 5% significant; * is 10% significant

Table 7.4 Cointegration results for E7

	Statistic	**p-value**
Kao test		
Modified DF	-2.263**	0.012
DF	0.811	0.209
ADF	0.688	0.246
Unadjusted modified DF	-3.231***	0.001
Unadjusted DF	0.396	0.346
Pedroni test		
Modified PP	-0.119	0.452
PP	0.075	0.470
ADF	-0.122	0.451

Note: *** is 1% significant; ** is 5% significant; * is 10% significant

In addition to that, the findings of the cointegration techniques are presented in Table 7.4. The Pedroni test and Kao test are used to examine the existence of

cointegration relationship among the series in this section. The findings of the Pedroni test depicts that the series used in the model in this section are not significantly cointegrated. This is supported by the findings presented by the ADF, DF and the unadjusted DF statistic values of the Kao test. However, the findings of the modified DF and an adjusted modified DF presents that this series presented in the model in this section have a strong call integration association. However, we argue that the series are not strongly cointegrated; hence, no significant long-run connection exists between the series in the model.

The present research in this section employs the panel ARDL method to examine the connection that exists between RE and its explanatory series, among the emerging economies. The panel ARDL technique used are the Pooled Mean Group and the Mean Group tools. The findings of the PMG and the MG tools are presented in Table 7.5. According to the long-run estimates of the PMG tool, rate of inflation and broad money statistically reduce RE among the emerging economies. The findings show that increasing broad money and rate of inflation by a single unit, in the long run has the effect of lowering the use of RE by 2.51 units and 0.49 units respectively. This shows that inflation do not promote the use of renewables. High rate of inflation deters the utilisation of RE and this is not a pleasant outcome considering the importance of RE in fostering the quality of the environment. Therefore, the level of inflation should be kept at a stable rate or minimised in order to raise the use of RE. The findings of the MG tool also support the findings of the PMG, which depict that broad money significantly reduces RE use in the long run among the emerging economies. Broad money is a proxy of FD and in this case, FD is observed to deter the use of RE. However, private sector credit another variable which proxies FD is observed according to the PMG outcomes to provide a significant positive impact on FD in the emerging seven countries at the significant level of 10%. The findings show that raising private sector credit by a single unit has the effect of raising the use of RE sources by 1.339 units. While the coefficient value of private sector credit according to the PMG results is high, its significance is not strong as observed by p-value which is above 5%, but lower than 10%. Due to the positive effect of private sector credit on RE according to the PMG results in the emerging seven economies, we allude that RE

is essential in raising renewable use. The series FDI and GDP do not significantly enhance RE use in the E7 economies, according to the long-run estimations.

Table 7.5.

PMG and MG results of E7

	Coef.	z-Statistic	p-value
		PMG	
	Long-run estimates		
BM	-2.5149	-3.29***	0.001
PSC	1.3390	1.70*	0.089
FDI	0.4607	0.94	0.348
INFL	-0.4931	-3.23***	0.001
lnGDP	-1.5779	-0.22	0.823
	Short-run estimates		
ECT-1	-0.1667	-6.72***	0.000
BM	0.3838	3.05***	0.002
PSC	0.0183	0.06	0.956
FDI	-0.9268	-2.52**	0.012
INFL	0.4433	2.84***	0.005
lnGDP	3.7318	1.38	0.168
		MG	
	Long-run estimates		
BM	-2.9651	-1.98**	0.048
PSC	-1.1486	-0.20	0.838
FDI	4.7471	0.84	0.401
INFL	0.7061	1.55	0.120
lnGDP	-14.7776	-1.06	0.287
	Short-run estimates		
ECT-1	-0.3085	-5.66***	0.000
BM	0.5131	1.91*	0.056
PSC	-0.2439	-0.48	0.628
FDI	-0.4979	-1.15	0.248
INFL	0.4288	2.35**	0.019
lnGDP	3.0419	0.61	0.541

Hausman Chi²	0.00

Additionally, the ECTs of the MG and the PMG tools is negative and significant at the level of 1%. An ECT that is negative and significant implies that the series employed in the model will tend to converge towards a long-run equilibrium. The rate of adjustment towards a long-run equilibrium, according to the PMG tool, is 16.67%, whilst according to the MG technique is 30.85%. These rates of adjustment are below 50%; hence, a longer time will be taken to adjust to a long-run equilibrium. The short-run MG and PMG techniques' results concur that broad money and inflation rate provides a significant positive effect on RE use among the emerging seven countries. The findings show that if broad money is allowed to raise by a single unit this will result in an increase in RE use by 0.384 units and 0.51 units respectively, according to the MG and PMG outcomes. Moreover, raising inflation rate by a single unit is observed to be associated by an increase in the use of RE by 0.44 units and 0.43 units, according to the MG and PMG results respectively. While inflation rate is observed to reduce the use of RE in the long run, in the short-run it raises RE use. Thus, there is asymmetric effects of broad money and inflation on RE use, for long- and short-run. The short-run PMG results do not support with outcomes presented in the long-run estimations, which shows that private sector credit positively affect RE. While the long-run outcomes depict for the presence of a significant association between private sector credit and RE, the short-run outcomes depicts that this association is not statistically significant. FDI is also observed to negatively impact RE use in the short-run according to the PMG outcomes, but the MG outcomes shows that this relationship is not statistically significant. GDP is also observed not to provide a statistically significant impact on RE in the short-run.

The Hausman test shows that PMG is efficient compared to the MG method. The results in Table 7.5 which shows that PSC positively enhance RE in the E7 region supports the postulations of past studies which depicts that FD is essential in improving RE development (Mukhtarov et al., 2022; Mukhtarov, 2021; Akpanke et al., 2023; Saygin & Iskenderoglu, 2021; Musa et al., 2021; Koksal et al., 2021). However, the findings depicted by broad money differs from those of PSC and are

supported by other past studies, for example, Assi et al. (2020); Wang et al. (2021); Koksal et al. (2021), among others. FDI only provides a negative effect in the short run and an insignificant positive effect in the long run. This is supported by the postulations of past researches, such as, Deka et al. (2023b); Akpanke et al. (2023). Inflation rate gives a negative long run significant effect and a positive short run effect on the development of RE. This shows that inflation rate deters RE development; hence, concurs with the postulations of Akpanke et al. (2023). GDP does not enhance RE in both long and short run in the E7 region. However, these findings does not support the postulations of trusted studies which shows the importance of economic growth or GDP in improving RE development, see Mukhtarov et al. (2022); Shahbaz et al. (2021); Wang, Zhang and Zhang (2021).

Table 7.6.

RE and FE outcomes of E7

	RE: Dependent variable	
	Coefficient	*t-Statistic*
	Fixed Effects	
lnGDP	3.194	3.86***
FDI	-0.649	-0.89
INFL	-0.130	-4.97***
BM	-0.359	-4.08***
PSC	0.1597	2.19**
F-statistic		14.90***
Wald Chi^2		13.43***
	Random Effects	
lnGDP	0.389	0.20
FDI	-0.396	-0.56
INFL	-0.111	-4.04***
BM	-0.246	-3.33***
PSC	0.119	1.77 *
Wald Chi^2		69.53***

Hausman Chi^2	0.00

Note: *** is 1% significant; ** is 5% significant; * is 10% significant

The random effects and fixed effects tools of data analysis are also employed in this section to verify the outcomes presented by the panel ARDL tools, see Table 7.6. According to the fixed effects outcomes, GDP and private sector credit are the core indicators in raising the usage of RE among the E7 economies. The random effects method also concurs that private sector credit positively impacts RE use, but these results are statistically strong at 10% level, hence depicting that the outcomes are not strong. The fixed effects method results shows that raising GDP by a single percent has the effect of raising RE in the E7 economies by 3.19%. This shows that economic growth is essential for promoting the use of RE in the emerging economies. Thus, if nations work towards achieving or improving the growth of their economy this is going to be utilised towards encouraging the use of RE. The random effects outcomes provide a coefficient of GDP that is positive implying that GDP should positively encourage the use of RE, however, these outcomes are not statistically significant. The results of the FE technique also show that raising private sector credit by a single unit has the effect of raising RE in the emerging economies by 0.1597 units, while the random effects technique shows that raising private sector credit by a single unit will increase RE by 0.119 units. Private sector credit is a proxy of FD, thus its positive effect of on RE implies that FD is essential in improving the use of RE among the E7 economies.

Furthermore, broad money and inflation are observed to statistically reduce the use of RE among the emerging economies according to both findings of the FE and the random effects methods. According to the fixed effects outcomes increasing inflation rate by a single unit has the effect of lowering the use of RE by 0.13 units, while the random effects method outcomes show that increasing inflation rate by a single unit reduces RE by 0.111 units. These outcomes shows that inflation rate is not favourable for raising the use of RE. High inflation rates deter the use of RE among the E7 economies. They fixed effects outcomes also shows that raising broad money by a single unit has the effect of lowering the use of RE by 0.359 units, while the outcomes of the random effects tool show that increasing broad money by a single unit will significantly reduce renewable energy

by 0.246 units. Therefore, broad money a proxy of FD is not favourable in raising the use of RE. FDI, as presented by the fixed effects and random effects tools do not provide a strong effect on the use of RE.

The results in Table 7.6 which depicts that GDP improves RE supports the postulations of past researches which emphasizes on the importance of GDP in raising RE, Mukhtarov et al. (2022); Shahbaz et al. (2021); Wang, Zhang and Zhang (2021). The insignificant effect of FDI in raising RE development is supported by the postulations of Deka et al. (2023b); Akpanke et al. (2023). However, this is in contrast with the findings of other researches that shows that FDI is essential in improving the consumption of RE, Shabhaz, Sinha et al. (2021). Similar to the findings of the panel ARDL, Table 7.6 depicts that BM reduces RE development, while PSC enhances it. This is supported by the research of Assi et al. (2020); Wang, Zhang and Zhang (2021); Koksal et al. (2021) which shows that other proxies of FD reduces RE development. The positive effect of PSC is also supported by the research which shows that FD improves FD (Mukhtarov et al., 2022; Mukhtarov, 2021; Akpanke et al., 2023; Saygin & Iskenderoglu, 2021).

G7 results

In this section of this study, we provide the outcomes obtained by employing the dataset of the G7 countries. We start by showing the descriptive statistics results of the G7 economies for the series GDP, broad money, RE, private sector credit, inflation rate and FDI. According to the descriptive statistics given in Table 7.7, each series has 210 observations, because the dataset employed is from 1990 to 2019, thus making a total of 30 years, multiplied by the seven countries gives 210 observations. The outcomes presented in Table 7.7 depicts that the mean of GDP is 3.92 trillion, whilst its standard deviation is 4.17 trillion and its maximum value is 57.7 trillion. Moreover, RE is depicted to have a mean value of 8.79, is standard deviation of 6.65% and a maximum value of 22.77%. Private sector credit has a mean value of 100.48, a maximum value of 217.76 and a standard deviation of 64.49, while broad money is observed to have a mean of 66.6, maximum value of 251.19 and standard deviation of 77.26. We also observed that inflation rate has a mean of 92.06, maximum value of 119.62 and standard deviation of 14.54, whereas

FDI has a mean of 1.91, a maximum value of 12.76 and standard deviation of 2.09. The mean value of all the series reflects the average value of the respective series. Thus, on average the series provided in Table 7.7 of the G7 economies has the average values during the period 1990 to 2019 is provided in the table. The maximum value refers to the highest value of a series during a given period while its standard deviation is the rate at which the observations of a series deviate from the mean. A high standard deviation means that the series has been observed to deviate much from the mean value, while a low standard deviation reflects that the series has not been diverting from the mean value with a greater margin.

Table 7.7.

Descriptive statistics results of G7

	Obs	Mean	Std. Dev.	Max
GDP	210	3.92+12	4.17+12	5.77+13
RE	210	8.790817	6.654477	22.7699
BM	210	66.60422	77.25507	251.1995
PSC	210	100.4849	64.48756	217.7609
FDI	210	1.910967	2.0906	12.76319
INFL	210	92.06465	14.53866	119.6227

In this section of the study, we employ the Fisher-type and Im-Pesaran-Shin techniques of testing unit root. The findings presented in Table 7.8 in this section of the Fisher-type and Im-Pesaran-Shin techniques of checking unit root presents that, the series RE, private sector credit, GDP, broad money and inflation rate have significant unit root in the level form. However, these series are observed to exhibit no significant unit root at first-difference. We also observed that the series FDI has no significant unit root in its level form according to the findings given in Table 7.8 of the Fisher-type and Im-Pesaran-Shin Techniques. This shows that the series that are used in the model of this section in this research study have different integration orders. While FDI exhibit for 0-integration order, the other series private sector credit, inflation, RE, broad money and GDP exhibit for one integration order. Therefore, a technique of data analysis that accepts series that have mixed order of integration should be adopted in this section.

Table 7.8.

Unit root results G7

	Fisher-type	Im-Pesaran-Shin
lnGDP	0.2969	0.2301
RE	4.4447	7.6326
BM	2.1912	-
PSC	1.1181	0.8033
FDI	-5.0840***	-4.1845***
INFL	-0.5223	0.0766
ΔlnGDP	7.5312***	-5.6584***
ΔRE	-9.5972***	-6.4227***
ΔBM	-6.6744***	-
ΔPSC	-9.2605***	6.3443***
ΔINFL	7.6346***	-5.5887***

Note: *** is 1% significant

We also check for the presence of a cointegration connection among the series presented in the model of this section by utilizing the Westerlund, Pedroni and Kao tests. The outcomes of the Westerlund, Pedroni and Kao tests of checking cointegration relationship among the series in the model are presented in Table 7.9. The findings depict that the series presented in the model have no significant cointegration relationship. While the two statistics of the Kao technique, such as the modified DF and the unadjusted modified DF presents the presence of a strong cointegration connection among the series, the other statistics such as the DF, ADF and the adjusted DF statistics of the Kao technique presents that the series are not significantly cointegrated. Moreover, the PP statistics of the Pedroni test presents that the series have a significant cointegration relationship, but this is not in supported with the outcomes presented by the modified PP and the ADF statistics of the Pedroni test, which shows that the series are not significantly cointegrated. The Westerlund variance ratio statistic also presents that the series presented in the model of this section exhibit for a significant cointegration association. Nonetheless, we observed that these statistical results of the cointegration

techniques employed in this section, which shows that there is no significant cointegration relationship overpowers those statistics that presents for a significant cointegration association among the series, hence we conclude that the series in the model do not exhibit for a significant cointegration association.

Table 7.9.

Cointegration results G7

	Statistic	p-value
Kao Test		
Modified DF	-6.2170***	0.0000
DF	-0.6612	0.2542
ADF	-0.6506	0.2577
Unadjusted modified DF	-6.3913***	0.0000
Unadjusted DF	-0.7048	0.2405
Pedroni test		
Modified PP	-0.4269	0.3347
PP	1.9810**	0.0238
ADF	-0.1589	0.4369
Westerlund Test		
Variance ratio	1.8339**	0.0333

Note: *** is 1% significant; ** is 5% significant; * is 10% significant

In this present research, under this section, the panel ARADL technique is employed to examine the relationship that exists between RE and its explanatory variables. The panel ARDL technique is employed in this section because the series employed have mixed order in integration as depicted by the outcomes of unit root test. The panel ARDL techniques employed in this section are the PMG and the MG tools, which presents both short-term estimates and long-run estimates of the model.

According to the findings presented in Table 7.10 broad money a proxy of FD and inflation rate are observed to exhibit for a positive effect that is significant on RE in the long run. Both the MG and the PMG method results concur that broad

money and high inflation rate raises the use of RE in the long run among the G7 countries. Raising broad money by a single unit in the long run is associated with an increase in the use of RE among the G7 countries by 0.029 units and 0.013 units, according to the outcomes of the PMG and the MG tools respectively. Moreover, if inflation rate is allowed to rise by a single unit in the long-run this will have the effect of raising RE use by 0.212 or 0.256 units among the G7 countries, as per the PMG and the MG results respectively. Therefore, it is observed that broad money, a proxy or FD is essential in raising the use of RE hence FD should be enhanced among countries in order to raise the use of RE. While high inflation rate is observed to be associated with, an increase in the use of RE, this is somewhat questionable because high rates of inflation are not healthy for the economy.

In addition, the outcomes presented in Table 7.10 shows that private sector credit and GDP negatively impacts the use of RE among the G7 countries in the long-run. Both the outcomes presented by the PMG and the MG technique concurs that these indicators negatively impact the use of RE. The outcomes present that if private sector credit is raised by a single unit this will have the impact of lowering RE use among the G7 countries by 0.025 units and 0.021 units, according to the findings of the PMG in the MG techniques respectively. Moreover, raising GDP by a single percentage is associated with a drop in the use of RE by 3.5 7% and 2.88%, according to the PMG and the MG outcomes respectively. Therefore, the findings presented in Table 7.10 of the PMG and the MG tools of panel ARDL technique depicts that private sector credit and high GDP is not conducive for encouraging the use of RE among the G7 countries. Private sector credit is another proxy of FD that is presented in this research, thus while broad money presents a positive impact on RE the other proxy of FD is observed to negatively impact RE. High economic growth is also observed to be associated with a drop in the use of RE implying that economic growth does not foster RE use among the G7 countries.

The findings of the ECT for both the MG and the PMG are positive and significant at the level of 1%. The ECT is essential in ascertaining the association that exists between the series in a long run relationship. It shows whether the series are going to converge or diverge in the long run, as well as indicating the rate of adjustment towards a long-run association. In this case a positive insignificant ECT

implies that the series employed in the model will not converge but rather diverge, hence no long run significant association exists between the indicators, and this supports the outcomes of the cointegration techniques presented above. The findings of the short-term estimates of the MG and the PMG techniques depicts that the series, GDP, inflation rate, broad money, FDI and PSC do not exhibit for a significant impact on RE use in the short-run, among the G7 countries. The outcomes of the short-run estimates are not statistically significant at 5% level; hence, no strong association exists between the variables. Thus, the MG and PMG method results show that significant asymmetric exist in the long- and short-run. While the short-run outcomes present a no significant effect on the explanatory variables on the use of RE the long run outcomes presents that the explanatory variables employed significantly increased RE use. In the long run, it is only FDI which do not significantly impact RE among the G7 economies. Both the MG and the PMG method's outcomes, according to the long run estimates, depict that FDI, at the level of 5% level, do not impact the use of RE. Thus, FDI in line with the MG and the PMG method results do not affect the use of RE in both long and short run estimates.

Table 7.10.

PMG and MG results of G7

	Coef.	z-Statistic	p-value
	PMG		
	Long-run estimates		
BM	0.0288	8.99***	0.000
PSC	-0.0245	-9.03***	0.000
FDI	-0.0011	-0.02	0.987
INFL	0.2116	14.99***	0.000
lnGDP	-3.5699	-6.00***	0.000
	Short-run estimates		
ECT-1	0.8105	8.58***	0.000
BM	0.0103	1.09	0.277
PSC	0.0017	0.11	0.913
FDI	0.1635	1.46	0.144
INFL	0.3192	1.58	0.114
lnGDP	-1.8406	-0.48	0.631
	MG		
	Long-run estimates		
BM	0.0126	1.95*	0.051
PSC	-0.0214	-3.05***	0.002
FDI	-0..3828	-1.76*	0.079
INFL	0.2555	4.56***	0.000
lnGDP	-2.8847	-2.16**	0.031
	Short-run estimates		
ECT-1	0.9919	27.57***	0.000
BM	0.0181	1.78*	0.075
PSC	-0.0269	-1.47	0.141
FDI	-0.1857	-1.29	0.198
INFL	-0.1402	-0.98	0.329
lnGDP	-3.926	-0.95	0.344

Hausman Chi²	0.00

Note: *** is 1% significant; ** is 5% significant; * is 10% significant

The findings in Table 7.10 which shows that BM improves RE development in the G7 region is supported by the past studies postulations which shows that FD enhances RE development (Musa et al., 2021; Koksal et al., 2021). Moreover, the negative effect of PSC on RE development in the G7 region is also supported by past studies postulations which shows that FD reduces RE development, Wang, Zhang and Zhang (2021); Koksal et al. (2021).Therefore, some proxies of FD improves RE development, while other proxies deters it. Thus, proxies which enhances RE development should be identified and enhanced. The negative effect of FDI on FD in the G7 countries is supported by the findings presented in the research of Akpanke et al. (2023). The negative effect of inflation rate also shows that it deters RE development in the G7 region, similar to the findings of Akpanke et al. (2023). The negative effect of GDP on RE is also supported by Khan et al. (2019); Shabhaz, Topcu, Sarigul and Vo (2021). However, these findings does not support the postulations of trusted studies which shows the importance of economic growth or GDP in improving RE development, see Mukhtarov et al. (2022); Shahbaz et al. (2021); Wang, Zhang and Zhang (2021).

Table 7.11.

Random and Fixed Effects results of G7

	Coef.	*t-Statistic*	*p-value*
	Random Effects		
BM	0.0046	0.48	0.633
PSC	0.0177	2.30**	0.022
FDI	-0.0855	-0.70	0.487
INFL	0.1591	4.50***	0.000
lnGDP	-2.8329	-1.96**	0.050
Wald Chi2		76.72***	
F-Statistics			
	Fixed Effects		
BM	0.0060	0.61	0.540
PSC	0.0179	2.31**	0.022
FDI	-0.0916	-0.74	0.461
INFL	0.1499	3.96***	0.000
lnGDP	-2.4076	-1.54	0.125
F-Statistics		15.15***	
Hausman Chi2		0.00	
p-value		-	

Note: *** is 1% significant; ** is 5% significant; * is 10% significant

We also present the outcomes of the FE and the random effects outcomes in Table 7.11 of the G7 countries in order to check the robustness of the outcomes that are presented in Table 7.10 of the PMG and the MG techniques. The findings of the FE and random effects tools presented in Table 7.11 concurs that private sector credit and inflation rate exhibit for a significant positive influence on the use of RE

among the G7 countries, while the random effects technique depicts that GDP negatively impacts the use of RE among the G7 countries. The findings depict that if private sector credit is allowed to raise by a single unit this will have the impact of raising the use of RE among the G7 countries by 0.018 units, according to both findings of the FE and random effects metghods. The outcomes that show the relationship between private sector credit and RE are significant at the level of 5%, indicating that this association is strong. Private sector credit is employed in this research to represent FD, hence a positive association between private sector credit and the use of RE implies that FD is essential in fostering the use of RE among the G7 countries. Moreover, raising inflation rate by a single unit result in an increase in RE by 0.15 and 0.16 units, according to the FE and random effects respectively. This implies that inflation rate, if allowed to rise will tend to foster the use of RE, but inflation is not okay for the economy since it destroys the buying power of the customers.

Moreover, allowing GDP to increase by a single percentage according to the random effects outcomes cause the use of RE to drop by 2.83%. The outcomes of the random effects technique which shows a significant negative association between GDP and the use of RE concurs with the outcomes given by the PMG and the MG techniques. While the coefficient value of GDP as presented by the fixed effects outcomes, is negative this is not statistically significant. Broad money and FDI are also observed not to provide a strong influence on RE use among the G7 countries, according to the outcomes of both the random effects and the fixed effects technique. While the findings of broad money depict a positive coefficient, which implies that the series should enhance RE use, this is not statistically significant. The coefficient of FDI is also negative for both random effects and fixed effects outcomes, implying that FDI should reduce the use of RE, but this is not statistically significant.

ECOWAS Results

This section presents the outcomes of the West African nations. We begin by presenting the findings of the descriptive statistics in Table 7.12, to understand the characteristics of the series employed. The descriptive statistics presented in

Table 7.12 depicts that each series presented has 480 observations. This is because annual data of 15 West African countries from 1990 to 2021 is used. The mean of GDP is 23.6 billion, the maximum is 547 billion, while the standard deviation is 73.9 billion. FDI has a mean of 3.39%, maximum of 103.34%, and the standard deviation is 8.51%. Inflation rate is also observed to have a mean of 83.61%, maximum of 103.34% and a standard deviation of 8.51%. Private sector credit has a mean of 12.92, maximum of 72.57 and a standard de4viation of 11.71. Moreover, broad money has a mean of 24.55, maximum of 125.29 and standard deviation of 17.85. RE has a mean of 64.23%, maximum of 94.99 and a standard deviation of 28.77. The mean is the average of a series that is obtained by adding all values of a series and divide by the number of observations. It helps in understanding how the series has been performing on average over a period. The maximum is the highest value observed in a series over a given period, while the standard deviation is the rate at which the observations of a series diverts from the mean.

Table 7.12.

Descriptive statistics results of ECOWAS

	Mean	Std.Dev.	Max.	Obs.
GDP	2.36E+10	7.39E+10	5.47E+11	480
FDI	3.3940	8.5134	103.3374	480
INFL	83.6106	57.4825	354.3041	480
PSC	12.9282	11.7148	72.5667	480
BM	24.5512	17.8532	125.2995	480
RE	64.2325	28.7729	94.9888	480

The Fisher-type and Im-Pesaran-Shin tools are employed to check unit root in the variables. The findings presented in Table 7.13 depicts that FDI, according to the Fisher-type and Im-Pesaran-Shin, has no significant unit root in its level form. This implies that FDI has zero order of integration. The unit root outcomes of the Fisher-type and Im-Pesaran-Shin tools presented in Table 7.13 concurs that the series broad money, inflation rate, private sector credit, GDP and RE have a significant unit root in the level form, whilst at first-difference the series are observed to exhibit no significant unit root. Therefore, the series broad money,

inflation rate, private sector credit GDP end RE have one order of integration. Thus, the series employed in this research exhibits for a mixed order of integration, implying that a model of data analysis that accepts series with mixed order of integration has to be employed.

Table 7.13.

Outcomes of unit root of ECOWAS

	Fisher Type	**Im-Pesaran-Shin**
RE	-3.607	7.795
INFL	-0.324	7.947
lnGDP	-2.743	5.114
FDI	9.722***	-4.821***
MB	-0.881	3.233
PSC	-0.850	1.201
ΔMB	45.333***	-11.216***
ΔRE	45.2543***	-11.674***
ΔPSC	35.175***	-10.233***
ΔINFL	21.258***	-5.447***
ΔlnGDP	41.272***	-10.791***

Note: ** is 5% significant level; * is 10% significant level; *** is 1% significant level, Δ represents first difference of a series

We also present the outcomes of the cointegration technique by employing the Pedroni test and the Kao test, in Table 7.14. The outcomes shown in Table 7.14 of the Kao test shows that the statistic outcomes of the modified DF, ADF and an adjusted modified DF depict that the series employed in the present model of this section have a significant cointegration relationship at the significant or 5% level. The DF and the unadjusted DF statistics of the Kao test depicts that the series are significantly cointegrated at the level of 10%. In addition, the outcomes of the Pedroni test depicts that only the modified PP statistics presents a significant cointegration among the series presented in the model, while the PP and ADF statistic of the Pedroni test depicts that the series have no significant cointegration. Thus, we conclude that the series presented are significantly cointegrated, hence along-run association between this series is inevitable.

Table7.14.

Cointegration results

	Statistic	P-value
Kao test		
Modified DF	-3.5023***	0.0002
DF	-1.5853*	0.0564
ADF	-2.0607**	0.0197
Unadjusted modified DF	-3.4387***	0.0003
Unadjusted DF	-1.5598*	0.0594
Pedroni test		
Modified PP	2.5338***	0.0056
PP	-0.0119	0.4952
ADF	-0.3476	0.3641

Note: ***; **; * are the 1%, 5% and 10% significant levels

This section of the current research employs the panel ARDL techniques to examine the relationship that exists between RE and the explanatory series specified in the model of the West African nations. The PMG and the MG tools are the panel ARDL techniques employed in this section and their results are presented in Table 7.15. The outcomes presented in Table 7.15 of the PMG and the MG depicts that broad money negatively impact RE among the West African nations in the long-run. The PMG and the MG, according to the long-run estimates concurs that broad money, a proxy of FD, reduces RE use in this region. The findings shows that if broad money is allowed to increase by a single unit, this will have the effect of raising RE by 2.52 units and 2.97 units respectively, according to the PMG and the MG outcomes. The outcomes are significant at the level of 5% depicting a strong association between the series. This shows that FD as proxied by broad money does not foster RE use among the West African nations. While broad money negatively affects RE in this region, private sector credit another proxy of FD, according to the findings of the PMG tool is gives a significant positive influence at the level of 10%.

The findings shows that if private sector credit is allowed to raise by a single unit, this is going to cause RE to also rise by 1.34 units in the long-run. While private sector credit is observed to foster RE in the long run, the statistical significance is not strong at the level of 5%. The findings also depict that inflation rate negatively impacts the use of RE in the West African countries, according to the PMG model, while the MG technique depicts that inflation rate is not significantly associated with RE. The PMG outcomes depicts that raising inflation rate by a single unit in the long run is associated with decreasing the use of RE by 0.49 units. The outcomes are significant the level of 1% depicting that high rate of inflation is not favourable for encouraging RE. Thus, it is essential to lower or minimise the level of inflation rate among the West African nations in order to foster RE use. The outcomes of the PMG and MG tools in Table 7.15 concurs that FDI and GDP do not significantly impact the use of RE in this region. While the coefficient values of GDP are negative implying that this series may reduce RE, this relationship is not statistically significant. The coefficient values of FDI are positive, as per the long run estimates, but this is not significant, hence no strong association exists between the series.

Table 7.15.

Results of Panel ARDL of ECOWAS

	Coefficient	*z-Statistic*
	PMG	
	Long-run Estimations	
lnGDP	-1.578	-0.22
FDI	0.461	0.94
INFL	-0.493	-3.23***
PSC	1.339	1.70*
BM	-2.515	-3.29***
	Short-run Estimations	
ECT(-)	-0.167	-6.72***
lnGDP	3.732	1.38
INFL	-0.927	-2.52**
INFL	0.443	2.84***
PSC	0.018	0.06
BM	0.384	3.05***
	MG	
	Long-run Estimations	
lnGDP	-14.778	-1.06
FDI	4.747	0.84
INFL	0.706	1.55
PSC	-1.149	-0.20
BM	-2.965	-1.98**
	Short-run Estimations	
ECT(-)	-0.308	-5.66***
lnGDP	3.042	0.61
FDI	-0.498	-1.15
INFL	0.429	2.35**
PSC	-.244	-0.48
BM	0.513	1.91*
	Hausman test	

Chi²	35.49***

Note: ***; **; * are the 1%, 5% and 10% significant levels

Furthermore, the outcomes of the ECT of the MG as well as the PMG techniques depicts that it is negative and significant at the level of 1%. As mentioned in the previous section the ECT shows if the series in the model gives a strong long-run connection and its coefficient depicts the rate of adjustment towards a long-run equilibrium. Thus, a negative insignificant ECT implies that the series will tend to converge in a long-run equilibrium. Therefore, the outcomes depicted in Table 7.15 depicts that the series employed in the present model have a significant long-run association and will tend to converge. The rate of adjustment towards an equilibrium in the long run is observed to be 16.7% and 30.8%, according to the PMG and the MG tools respectively. Short-run estimations of the PMG and the MG in Table 7.15 also shows that inflation rate is responsible for raising RE. High rates of inflation in the short-run are observed to be associated with rising use of RE. The outcome shows that when inflation rate is allowed to increase by a single unit this will have the effect of raising RE by 0.44 units and 0.43 units, as per the outcomes of the PMG in the MG tools respectively. Thus, high level of inflation in the long run fosters the use of RE, but this is not similar to the long-run outcomes which shows that inflation rate negatively impacts RE. Thus, there is asymmetric effect on the impact of inflation rate on RE considering both the short run in the long run outcomes.

Broad money hads a strong positive influence on the use of RE in the West African nations, according to both the MG and the PMG methods' outcomes. Increasing broad money by a single unit in the short-run is associated by raising the use of RE by 0.38 units and 0.51 units, as per the PMG and MG tools' outcome respectively. This shows that broad money, a proxy of FD is responsible for fostering the use of RE in the short-run, but this is not the case in the long run, which presents for a significant negative impact. Thus, broad money presents asymmetric effects on the use of RE. The short-term findings of the PMG tool also depict that FDI gives a significant negative effect on RE use in the short-run. Raising FDI by a single unit is associated with reducing the use of RE by 0.93 units. However, the MG tool in as much as it offers a negative coefficient its outcomes

are not statistically significant. Private sector credit and GDP are observed to exhibit for a no strong association with RE in the short-run. Both PMG and MG tools depicts that private sector credit and GDP do not affect the use of RE.

The MG method which is efficient in presenting robust results in Table 7.15 as per the Hausman test depicts that BM negatively affect RE development. This concurs with the findings of Assi et al. (2020); Wang et al. (2021); Koksal et al. (2021). The insignificant effect of GDP on RE is not supported by the postulations of Mukhtarov et al. (2022); Shahbaz et al. (2021); Wang et al. (2021), which shows the presence of a significant positive influence. Akpanke et al. (2023) also support the insignificant effect of FDI and the positive short run effect of inflation rate.

Table 7.16.

Random and Fixed Effects results of ECOWAS

	Coef.	z-Statistic	p-value
	Random Effects		
BM	-0.0971	-0.62	0.538
PSC	0.2421	1.08	0.281
FDI	0.3779	2.72***	0.006
INFL	-0.1164	-4.89***	0.000
lnGDP	-8.4275	-5.00***	0.000
Wald Chi2		135.70***	
	Fixed effects		
BM	0.0472	0.30	0.763
PSC	0.4046	1.83*	0.067
FDI	0.3898	2.86***	0.004
INFL	-0.0584	-2.34***	0.020
lnGDP	-16.4036	-7.83***	0.000
F-Statistics		36.29***	
Hausman Chi2		0.00	

The current section, in this research, also employs the FE and random effects methods in order to verify if the panel ARDL results are robust. The findings of the fixed effects and random effects models are presented in Table 7.16 and they show that FDI positively impacts the use of RE, while inflation rate and GDP negatively affect the use of RE in the West African nations. Private sector credits and broad money, the proxies of FD in this research study, do not influence the use of RE in this region. The findings in Table 7.16 depicts that raising FDI by a single unit has the effect of increasing the use of RE by 0.38 units and 0.39 units as per the random effects and the fixed effects tools, respectively. The outcomes are significant at the level of 1%, indicating that there is a strong positive association that exists between FDI and the use of RE in this region. Therefore, encouraging FDI in the West African nations helps in raising the use of RE. Moreover, raising inflation rate by a single unit has the effect of lowering the use of RE by 0.12 units and 0.06 units, as per the outcomes presented by the FE and random effects respectively. This shows that if inflation is allowed to increase to a higher rate, is not conducive for fostering the use of RE. Thus, a low level of inflation or stable inflation rate must be maintained in the West African nations for the purpose of raising the use of RE. Raising GDP by a single percentage is also associated with a drop in the use of RE by 8.43 percent or 16.4%, as per the random effects and FE tools respectively. The findings of the random effects and FE tools depict that high economic growth among the West African nations lowers the use of RE. The outcomes are statistically significant at the level of 1%.

The Hausman test shows that the random effects method results are robust. The insignificant effect of the two proxies of FD, BM and PSC, is not supported by the postulations of past researches. This so because past studies have shown that FD is essential in improving RE development across countries (Mukhtarov et al., 2022; Mukhtarov, 2021; Akpanke et al., 2023; Saygin & Iskenderoglu, 2021; Musa et al., 2021; Koksal et al., 2021). While other studies have shown that FD negatively affect RE development, Assi et al. (2020); Wang et al. (2021); Koksal et al. (2021). The positive effect of FDI on FD in the ECOWAS is supported by the postulations of Deka et al. (2023b); Akpanke et al. (2023). Thus, FDI help in the development of RE of west African nations. Moreover, the negative effect of inflation rate supports the postulations of Deka et al. (2023) which provides that the rate of

inflation deter the development in RE. The negative effect of GDP on RE in the ECOWAS is also supported by Khan et al. (2019); Shabhaz et al. (2021). However, these findings does not support the postulations of trusted studies which shows the importance of economic growth or GDP in improving RE development, see Mukhtarov et al. (2022); Shahbaz et al. (2021); Wang et al. (2021).

Summary

- The proxy of FD, that is, PSC and broad money gives mixed outcomes across the three regions that is the ECOWAS, E7 countries and the G7 countries, as well as across the methodologies that are employed.
- Overall, it is observed that FDI is essential in improving the development of RE.
- FDI is observed to provide a no significant effect on the development of RE, however the fixed effects and the random effects methods shows that FDI improves the improbvement of RE in the fifteen West African countries.
- Inflation rate is observed to discourage the development of RE in the three economic regions considered in this research showing that it should be stabilized or reduced in order to promote the enhancement of RE.
- The outcomes of the present research also depicts that GDP does not promote the development of RE.

CHAPTER VIII

Discussion Conclusion and Recommendations

Discussion

Environmental degradation

The current results as presented in Chapter 6 are essential to enviromentalists, governments and economists among many professionals. These outcomes can also be used to devise the best policies that can be used to foster the enhancement in the quality of the surroundings. In addition, the research questions intended to be answered in the research are also answered through the utilization of these outcomes. The study outcomes are in support with the outcomes of past researches on the crucial influence of RE on the CE (Akadiri & Adebayo, 2022; Deka et al., 2022; Bhat, 2018; Abbas et al., 2021; Akram et al., 2022; Matthiesen et al., 2011). No asymmetries are presented on the connection between the CE and RE among the E7, G7 and ECOWAS regions. RE consumption is depicted in the previous studies as vital in reducing ED, due to its beneficial to the environment. The only drawback on the side of RE in fostering that ED is because of the prices of these sources which has been determined as exorbitant (Fischer & Becker, 2013). Despite the high prices of RE, this has been depicted as correct only in the short-term, but in the long-term it has been depictyed that RE is relatively affordable than NRE since the long-term value will consider the impact of NRE to the surroundings. Thus, since the longer-term cost is relatively low, then using RE is recommended. The outcomes currently presented in this research are different from some postulations of other previous researches that indicated that CE is positively enhanced through using RE, Anser et al. (2021). Further to that, Adedoyin et al (2021)'s findings depicts that the production of RE raises the CE. Other previous researches have also been found to provide that these factors have no strong connection, Menyah and Wolde-Ruffael (2010). It must be noted that studies done in different regions of the world that have conditions that are different, or the utilization of method of analysing data that are different usually results in the presentation of different outcomes and this may be the cause of the observation of different findings. Energy efficiency also lowers CE in these regions, hence supporting Razzaq et al. (2021); Akram et al., (2022); Deka et al. (2022a); Zakari

et al. (2022); Akpanke et al. (2023b); Ponce and Khan (2021); Deka, Bako et al. (2023) who alluded that ED can be solved through energy efficiency.

This study also shows no significant association between forest resources and CE as per the CS-ARDL technique. However, the PMG model shows that forest resources negatively impact CE in the E7, while the random and fixed effects results depicts that it positively impacts CE in the ECOWAS. The forest resources' negative coefficients in the three regions given with the CS-ARDL method and the negative significant effect as depicted by PMG tool in the E7 nations shows that CE can be strongly lowered with forest resources. Therefore, the cutting down of trees to be used for timber purposes perpetuates the ED. As a result the present study postualtions concurs with the outcomes given in Amer et al. (2022); Deka, Bako et al. (2023); Ali et al., (2022); Akpanke et al. (2023b). These outcomnes show that the quality of the surroundings can be enhanced through the enhancement of natural resources. Furthermore, NRE's positive influence on CE is supported by past studies (Akadiri & Adebayo, 2022; Deka et al., 2023a; Bakhsh et al., 2022; Boukhelkhal, 2021). In that regard, it is recommended to ensure that NRE is dropped towards the more friendly RE by countries. Economic growth is also presented as vital in enhancing CE and this is supported through the postulations of Ali et al. (2022) which depicts that the pressure on the ecology is increased through economic growth. Furthermore, Akpanke et al. (2023b) and Deka et al. (2023a) that EG raises CE. To add to that, many other past studies pointed to the significant positive influence of EG on CE (Akadiri & Adebayo, 2022; Balsalobre-Lorente & Leitao, 2020; Bouyghrissi et al., 2021; Abbas et al., 2021; Ben Mberek et al., 2018), in line with what is postulated in this research.

Renewable Energy

The findings that are presented in the Chapter 7, which examined the factors that affect RE development among the G7 countries, E7 countries and the fifteen West African nations are essential in coming up with the policies that can be used to improve RE development in these countries. The findings also assist in giving answers to the questions that are provided in the introduction of the present research. It is essential to understand and determine the major forces that improves RE due to its friendliness to the environment hence help in reducing the effects of global warming. The present research findings are mixed across the three world economic regions that is the E7, G7 and the fifteen West African countries as well as across the methods of data analysis that have been employed. In the fifteen West African countries as well as the E7 countries broad money a proxy of FD gives a strong negative long-run effect on RE development. This depicts that broad money in the long run among the 15 West African countries as well as the E7 nations does not promote the development of regional energy rather it reduces RE development. The MG and PMG methods' findings in the fifteen West African countries, as well as the E7 countries depicts that broad money a proxy of FD positively impacts RE development in this region. This shows that broad money only improves RE development in these regions in the short-term while in the long-term it tends to reduce RE development. However, the findings obtained from the G7 countries depict that broad money in the long run improves RE development. The findings shows that broad money has a positive significant effect on RE development in the G7 countries considering the long-run findings, as well as in the E7 countries and G7 countries considering the short-run findings. These results support the postulations of past studies which depicts that FD is essential in improving RE development across countries (Mukhtarov et al., 2022; Mukhtarov, 2021; Akpanke et al., 2023; Saygin & Iskenderoglu, 2021; Musa et al., 2021; Koksal et al., 2021). In addition to that, it is also observed that PSC another proxy of FD in this research study gives a positive effect on RE development in the E7 countries, as well as thefifteen West African countries according to the PMG results in the long-run. This is also supported by the findings of the fixed effects and random effects methods that was that private sector credit significantly improves the development of financial system in these two regions. However, in the case of G7 countries private

sector credit is observed to give a negative effect on FD from the PMG and MG findings while the random effects and fixed effects outcomes defects that private sector credit significantly improves the development of the financial system in this region. Again, we observe mixed outcomes on the effects of a private sector credit another proxy or FD in this present study. While the proxy of FD are essential in improving the development of RE sources, it is observed that some of these proxies have a tendency of providing a no significant effect or a negative effect on RE development. This is in support of the findings that are given in the study of Assi et al. (2020); Wang et al. (2021); Koksal et al. (2021), among others. Overall, in line with the findings that are presented in this research it is recommended that the proxy of FD are improved in order to enhance the development of RE sources.

In contrast to the findings that are presented in the research that was done in the past the present study shows that GDP does not have any significant effect on improving RE development in the fifteen West African countries, the E7 economies, as well as the G7 countries. There is consent on the methodologies that are used in the present research that shows a no significant relationship and a somewhat negative weak effect of GDP on RE development in this region. This was that GDP among the 15 West African countries the emerging seven countries and the G7 countries does not significantly improve the development of RE. The present findings are in support of the postulations of past studies which shows that economic growth gives a negative significant effect on the development of RE (Khan et al. (2019); Shabhaz et al., 2021). However, these findings does not support the postulations of trusted studies which shows the importance of economic growth or GDP in improving RE development, see Mukhtarov et al. (2022); Shahbaz et al. (2021); Wang et al. (2021).

The findings on the effect of FDI on the development of RE among the fifteen West African countries, the E7 countries as well as the G7 countries are mixed. However, it is generally observed that FDI does not improve the development of RE in this regions. There is overwhelming evidence which shows the presence of a no or negative significant effect of FDI on the development of RE. While the fixed effect and the random effects methods depicts that FDI helps in improving the development of RE among the fifteen West African countries the

PMG and MG model shows the presence of a no significant effect of FDI on the development of RE. These findings which shows the presence of a no or negative effect on of FDI on the development of RE concurs with the outcomes that are presented in the studies of past research which shows that FDI does not significantly improve the development of RE, Deka et al. (2023b); Akpanke et al. (2023). However, this is in contrast with the findings of other researches that shows that FDI is essential in improving the consumption of RE, Shabhaz, Sinha et al. (2021). Therefore, there is still more work to be done to ascertain the exact effect of FDI on the development of RE due to the presence of mixed outcomes in the literature. The rate of inflation is also observed to deter the improvement of RE development in the fifteen West African countries, as well as the E7 countries in the long run while in the short-run it is observed to significantly improve RE development. However, in the G7 countries inflation rate is observed to play a crucial role in improving the development of RE. The findings which shows that inflation rate deters the development of RE concurs with the outcomes that are presented in the studies of Akpanke et al. (2023), Therefore, the rate of inflation among countries must be stabilized or lowered in order to allow the improvement in RE.

Conclusion

There various implications, both from the practical and theoretical part that are given in line with the postulations of this research. To begin with, it is shown that ED is greatly lowered through energy efficiency. Raising energy efficiency among the G7, ECOWAS and E7 regions lowers the content of carbon that is available in the air. Energy efficiency entails that the amount of energy that is used to produce products is lowered through avoiding the wastage of energy, hence preventing the environment from degrading. Therefore, it is essential to ensure that products in the industrial process are produced through the use of minimal energy use, thus the large quantity of output is produced with few energy units. Thus, it is seen that ED can be propagated through the the waste of energy in the industries. Secondly, the theoretical postulations given in the past by previous researches depicts that RE is vital in enhancing the quality of the surroundings. As a result, the goal of carbon neutrality is promoted through the RE. Thirdly, it is ascertained in the present study that the presearvation and planting of more forest resources is essential in enhancing the quality of the surroundings. Some laws towards preserving trees and other forest resources must be put in place. Quotas must also be placed on companies that produces timber. This research, thus, recommends the use of RE, planting of more trees and improvement of energy efficiency to achieve the goal of carbon neutrality. It is essential for the presented research to be furthered among other world regions in order to ensure the correct policies are given.

Moreover, the findings presented in this present research are vital in fostering the growing body of literature on the various factors responsible for raising the use of RE among countries. The analysis presented in this research provides a comparative analysis on the impact of FD proxies, GDP, inflation rate and FDI among the three world economic regions, that is, the G7, E7 and West African nations. The PMG and MG techniques, which are that panel ARDL techniques are used to present the short-run and long-run estimates, whilst that random effects and the fixed effects techniques are used to check the robustness of the short-run panel ARDL tools. Mixed findings are observed across the three regions and among the data analysis tools employed. There is overwhelming evidence which shows that FDI has no significant effect on RE in the E7, G7 and

West African regions. However, in the West African region, the random and fixed effects tools give strong results that shows the importance of FDI in fostering RE in the short-run. Inflation rate is observed to reduce RE use in the long run among the E7 and West African nations, but in the G7 nations, it raises RE use. The short-run findings depict that inflation rate increases RE use in all regions, while the random effects and fixed effects tools depict that high inflation rate negatively impacts RE in the G7 and West African nations. Thus, high levels of inflation are not favourable for fostering RE use. We also present that GDP do not significantly enhance the use of RE in the E7 and G7 nations both in the short- and long-run, while it promotes RE in the short-run among west African nations. Thus, West African nations may take advantage of economic growth to promote RE. The proxies of FD, broad money and private sector credit gives mixed effects among the three regions, both positive and negative outcomes are presented. This research encourages the use of FD and economic growth to foster RE use among the three regions, while inflation should be stabilised. The findings presented in this research of the present research are vital in fostering the growing body of literature on the various factors responsible for raising the use of RE among countries. The analysis presented in this research provides a comparative analysis on the impact of FD proxies, GDP, inflation rate and FDI among the three world economic regions, that is, the G7, E7 and West African nations. The PMG and MG techniques, which are that panel ARDL techniques are used to present the short-run and long-run estimates, whilst that random effects and the fixed effects techniques are used to check the robustness of the short-run panel ARDL tools. Mixed findings are observed across the three regions and among the data analysis tools employed. There is overwhelming evidence which shows that FDI has no significant effect on RE in the E7, G7 and West African regions. However, in the West African region, the random and fixed effects tools give strong results that shows the importance of FDI in fostering RE in the short-run. Inflation rate is observed to reduce RE use in the long run among the E7 and West African nations, but in the G7 nations, it raises RE use. The short-run findings depict that inflation rate increases RE use in all regions, while the random effects and fixed effects tools depict that high inflation rate negatively impacts RE in the G7 and West African nations. Thus, high levels of inflation are not favourable for fostering RE use. We also present that GDP do not significantly enhance the use of RE in the E7 and G7 nations both in the short-

and long-run, while it promotes RE in the short-run among west African nations. Thus, West African nations may take advantage of economic growth to promote RE. The proxies of FD, broad money and private sector credit gives mixed effects among the three regions, both positive and negative outcomes are presented. This chapter encourages the use of FD and economic growth to foster RE use among the three regions, while inflation should be stabilised.

Policy Recommendations

Policy recommendations for the E7 countries

- RE should be utilized to reduce ED in the E7 countries.

- Forest resources must be promoted to enhance the quality of the environment.

- Energy efficiency must be promoted to improve environmental quality.

- Sources of energy and activities that worsens ED, but improves economic growth must be shunned.

- NRE must continue to be shunned in favor of RE sources

- Economic growth should be enhanced because of its positive effect on RE development. An increase in GDP promotes RE, showing its effectiveness in raising RE.

- FDI cannot be dependent upon in enhancing RE in the E7 countries

- Inflation rate must be kept at minimum levels since high inflation rate lowers RE development in this region

- FD has mixed effects in the E7 region. Broad money must not be relied on in fostering RE development because of its negative effects, while private sector credit can be used to improve RE development

Policy recommendations for G7 countries

- RE must be promoted in the G7 countries because of its favorable impact on the environment

- NRE must be shunned on this region because it worsens ED

- Energy efficiency should be promoted in order to ensure environmental quality is attained in the G7 countries

- Forest resources should be enhanced because of their negative effect on CE in this region

- GDP should be enhanced through using using clean fuels. The use of polluting fuels and harmful activities to foster economic growth should be shunned because it worsens ED.

- Population size must be reduced to reduce the amount of carbon emitted in the air.

- FD presents mixed effects on RE development in the G7 countries. Broad money can be utilised to enhance RE development, while private sector credit cannot promote RE in the G7 region

- FDI cannot be utilised to enhance RE development in the countries.

- High inflation rate can foster RE development in the G7 countries, but this may result in economic uncertainties in the counytries.

- Economic growth cannot be relied in enhancing RE development in the G7 countries.

Policy recommendations for ECOWAS countries

- RE must be improved in the ECOWAS countries because of its negative effect on CE

- NRE should be discouraged in order to reduce CE in the EVOWAS countries

- Energy efficiency should be be enhanced in these countries in order to enhance the quality of the environment on the ECOWAS countries

- Activities that harms the surroundings, but enhance economic growth must be shunned in the ECOWAS countries

- Population size must be maintained and lower levels to foster environmental quality

- FD proxies also presents asymetric effects on RE in the ECOWAS countries. Broad money cannot be used to foster RE, while private sector credit enhances RE development; hence, can be utilized to for RE development.

- FDI should be promoted in the ECOWAS countries because it promotes RE debelopment

- Inflation rate must be stabilised because of its negative effect on RE development

- Economic growth must be improved such that it can enhance RE development in the ECOWAS countries

Future studies recommendations

Future studies are recommended to consider the following points in order to further the growing body of literature:

- More work needs to be done to ascertain the effects of forest resources on the degradation of the environment in various regions of the world in order to come up with proper policies across all regions.
- It is also essential to consider EFP index in order to understand the factors that are responsible for improving the environment, hence feature studies are recommended to use the EFP index rather than using only CE a proxy of EFP.

- There is still more work that is needed to be done in ascertaining the effect of FDI on the development of RE and future studies are encouraged to further examine the exact effect of FDI on RE development.

- The effect on of FD on RE development needs to be examined further due to the existence of mixed outcomes in the present research.

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PLAGIARISM REPORT
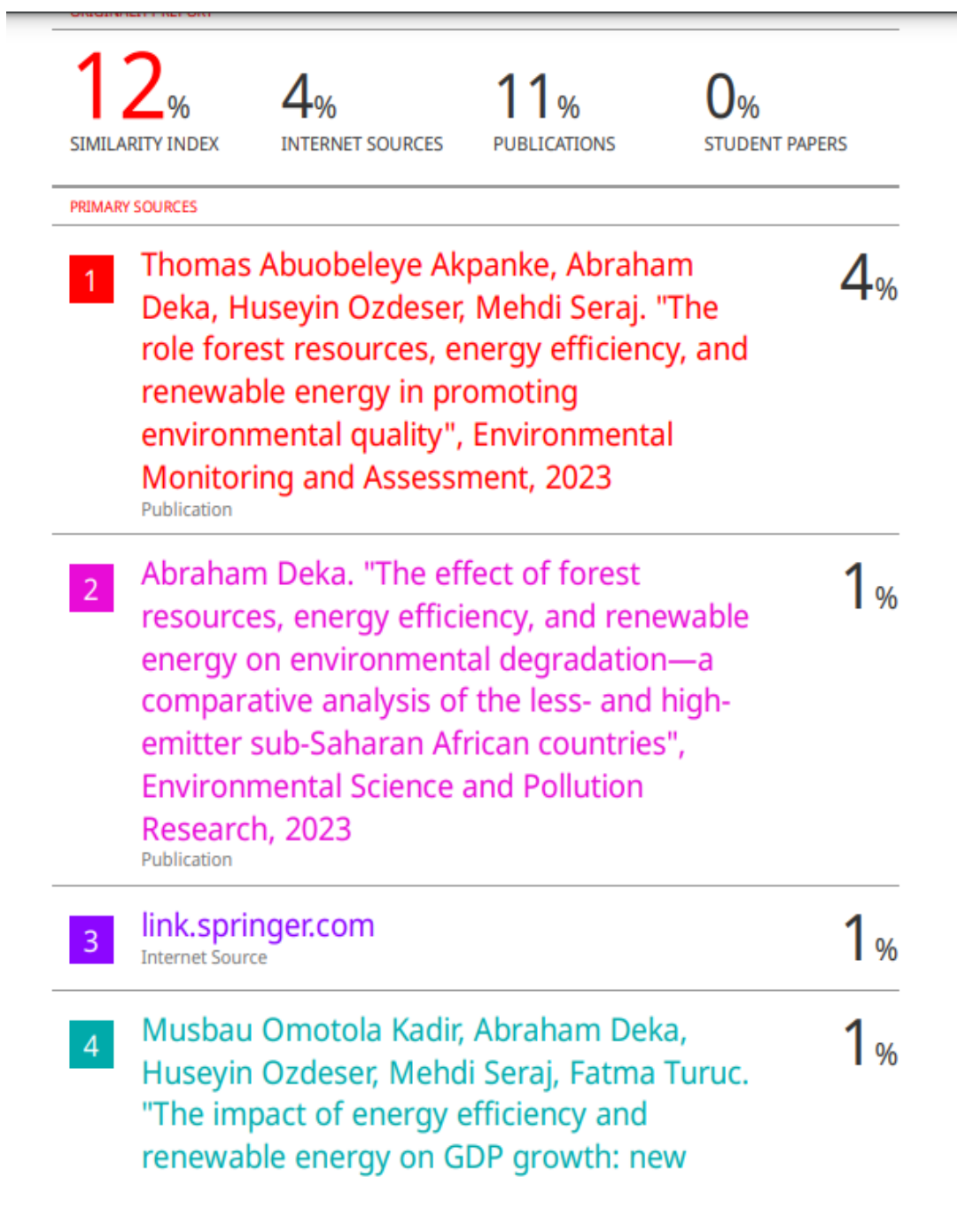
ETHICS COMMITTEE APPROVAL

NEAR EAST UNIVERSITY

SCIENTIFIC RESEARCH ETHICS COMMITTEE

02.03.2023

Dear Thomas Abuobeleye Akpanke

Your project **"Ecological Footprint And Environmental Degradation: Does Financial Development Improve Renewable Energy"** has been evaluated. Since only secondary data will be used the project does not need to go through the ethics committee. You can start your research on the condition that you will use only secondary data.

Prof. Dr. Aşkın KİRAZ

The Coordinator of the Scientific Research Ethics Committee